Columbia River System Operations
Final Environmental Impact Statement

Appendix F
Vegetation, Wetlands, and Wildlife

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CHAPTER 1 - INTRODUCTION

This appendix covers vegetation, wetlands, and wildlife within the CRSO study area. This includes wildlife habitat, wildlife species, and special status plant and animal species (excluding fish). Wildlife communities and habitat vary widely over the Columbia River basin and the study area used to describe existing conditions within the affected environment; however, many elements are common throughout the study area. These common elements are discussed in this introduction. Project-and reach-specific information are provided in Section 2.0. Special status species are discussed in Section 3.0 and references are identified in Section 4.0.

This Appendix also describes the study area and the tools and methods used to describe existing conditions and potential effects. Developed lands such as roads, towns, and other urban and industrial areas are not discussed in this Appendix. These developed areas provide low value to wildlife. Figure 2-1 identifies the projects considered in the CRSO study within the context of the Columbia River Basin.

1.1 STUDY AREA

The study area used to describe existing conditions and assess the range of potential impacts to vegetation, wetlands, and wildlife is based on the H&H model extent boundary. The area of analysis extends upstream of each project dam to the maximum operating pool or the U.S. border with Canada. The downstream extent of the study area is defined by either the maximum operating pool of the next downstream CRSO project or where the effects of an alternative are no longer analyzed. Chapter 3 Section 3.13 provides maps for the study areas by Project.

1.2 LAND COVER TYPES AND BROAD WILDLIFE HABITAT CATEGORIES

Six land cover types are defined for this study: upland, open water, wetlands, coastal, barren (i.e., reservoir drawdown zone), and , islands.

Land cover types in the study area that would not be affected by any of the proposed alternatives and/or that are of little to no value to wildlife (i.e., developed lands) are not discussed in this appendix. The land cover types that are the focus of this analysis are those that include vegetation and wildlife habitat elements that are sensitive to changes in water surface elevation (WSE) and river flows. The proposed alternatives are most likely to affect these attributes as a result of varying project operations and changes in the availability, accessibility, and distribution of these habitats affect a wide variety of wildlife species. Changes in habitat were calculated for all alternatives, including the no action alternative. The EIS presents only MO3 and the no action alternative because the changes in habitat acreages were negligible for MO1, MO2, and MO4. For MO1, MO2, and MO4, changes to the habitat composition was analyzed qualitatively based on changes in inundation levels of greater than 1 foot and focusing on land cover types where changes would have the greatest effect. A general description for each of the six land cover types is provided below. Table 1-1 shows the vegetation/wildlife habitat types within each of the land cover types.

Land cover and vegetation and type are used in this study as proxies for wildlife habitat. This is considered a reasonable approach given the size of the study area and the importance of evaluating regional and study-area wide effects of the project. Therefore, for the purpose of this analysis, the term “habitat type” (e.g. wetland or upland forest) is considered a vegetation type used by wildlife groups for breeding, nesting, feeding, or sheltering. Vegetation types are differentiated from one another by their structure, form, and species composition. Generally speaking, vegetation can broadly be defined by dominant plant species which co-occur in an area and which are shaped by climate patterns, substrate types and disturbance regimes. 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 study area: the Northwest Habitat Institute (NWHI) land cover classifications and the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI). These datasets were combined in a geographic information system (GIS) environment where the digital NWI data provided the source for all wetland habitats in the study area and the NWHI dataset was the source for identifying all other habitat types across the study area.

In addition to the NWHI and NWI datasets, the analysis used estimates of the ordinary high water (OHW) level under existing conditions to define the spatial extents of the Columbia River channel and that of the major tributaries channel. The 50 percent annual exceedance probability (AEP) water surface profile, generated by the USACE for all of the detailed hydraulic reaches and the pools at Libby, Hungry Horse, and Dworshak reservoirs, are used as a proxy for OHW. This profile was used to define the extents of the river channel under normal conditions and does not reflect out-of-bank flow conditions. The AEP profile also extends to the operational pools as well, which are not influenced by river flow but rather project operations and the water level downstream of a dam. Often linked with the 2-year water level, the 50 percent AEP profile represents water surface elevations that have a 50 percent chance of being exceeded on a given year.

1.2.1 Northwest Habitat Institute Land Cover

The NWHI data layer was developed through a collaborative, science-based and peer-reviewed approach to synthesize comprehensive vegetation communities into 32 unique land cover classifications across the Columbia River Basin (Johnson and O’Neil 2001). The 32 unique habitat types were classified according to standards developed by the U.S. Federal Geographic Data Committee (FGDC), Vegetation Subcommittee to support the U.S. National Vegetation Classification (http://usnvc.org/). Both the FGDC standards and classification are maintained through a partnership sponsored by the FGDC to bring together federal agencies and non-profit organizations, including the Ecological Society of America, NatureServe (FGDC 2006). The goal of the classification is to develop, implement and manage a scientifically credible system to classify vegetation across the nation.

The Johnson and O'Neil habitat types are classified by plant associations assessed from remotely sensed aerial imagery using the FGDC recognized vegetation classification system (Grossman et al. 1998; Anderson 1998). The classification system uses consistent metrics to catalogue vegetative communities which are similar to one another into larger-order groupings, and includes agricultural and urban land cover types. Johnson and O'Neil (2001) used these habitat types and additional data about wildlife species using these habitats to establish a statistically relevant matrix of wildlife-habitat associations.

1.2.2 National Wetland Inventory Maps

The NWI data and digital maps are developed in collaboration with USGS and are a publically available resource providing information on the abundance, distribution, and physical characteristics of wetlands across the United States. The NWI maps are produced from high altitude aerial imagery in conjunction with other data sources and field observations where wetlands are identified based on vegetation, visible hydrology and geographical characteristics.

The NWI maps are developed using aerial imagery and the resulting maps are dependent on the resolution of the imagery and accuracy of the data interpretation. For example, submerged aquatic vegetation or seagrasses are not consistently detected in aerial imagery and therefore cannot be mapped or included as part of the dataset. However, the NWI dataset is the most consistent and widespread source of wetland data available for the purpose of mapping wetland habitats at the scale of this analysis. The NWI dataset was therefore used to locate and identify wetlands across the Columbia River Basin, with the exception of submerged aquatic vegetation.

1.2.3 Regulatory Definitions

In developing the land cover type definitions and the approach used in the CRSO EIS, the team was mindful of both regulatory and scientific standards and the various ways that the information developed as part of this analysis will be used in the CRSO EIS and related environmental reviews and compliance. Therefore, some key definitions for wetlands and other waters of the United States (US) are discussed below.

1.2.3.1 Wetlands

There are two federal definitions of wetlands.

- USFWS Definition

  The USFWS defined wetlands as transitional areas "between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water" and must have one or more of the following attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substate is predominantly undrained hydric soil; and 3) the substrate is nonsoil and is saturated with water or covered b shallow water at some time during the growing season of each year" (Cowardin et al. 1979). This definition is used to broadly identify wetland habitats in order to identify potential wetland areas for planning purposes based on aerial imagery and aerial photographs. The imagery data is managed by the USFWS on the National Wetland Inventory (NWI) Maps. The wetland areas are approximated and are not verified from field observations.

- Cowardin system

  The Cowardin system (1979) classifies wetlands into different types, many of which are found throughout the Columbia River Basin, based upon the driving hydrologic regime: marine, estuarine, lacustrine, riverine, and palustrine. Estuarine wetlands and tidal marshes are associated with brackish waters near the Columbia River Estuary at the mouth of the Columbia River and the Pacific Ocean. Lacustrine wetlands are vegetated fringes that do not cover more than 30 percent of a lake or reservoir. Riverine wetlands are vegetated shallow areas below the river or stream shoreline where there is persistent or seasonal vegetation. Examples may include cattail fringes, willows, and lily pads or unvegetated cobble-bars and mudflats. Palustrine wetlands are wet areas that rely on groundwater or seasonal flooding from a river. Examples of palustrine wetlands include marshes, swamps, bogs, or fens.

1.2.3.2 Clean Water Act, Section 404

The second definition concerns Section 404 of the Clean Water Act, where wetlands are defined as "those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support….a prevalence of vegetation typically adapted for life in saturated soil conditions." This definition narrows wetlands to a distinct boundary based on three parameters: soil characteristic, hydrology regimes, and vegetation.

1.2.3.3 Definitions Used in the CRSO EIS

For the purposes of this analysis, wetland are identified using the latest version of NWI maps and updated 2013 Cowardin et al. system (FGDC 2013; USFWS 2016). The NWI maps are used to identify and differentiate between broad wetland types across the Columbia River Basin. Field verification of wetland boundaries would be needed prior to Section 401 certification and permitting, if additional actions are warranted.

1.2.3.4 Waters of the United States

The regulatory definition of waters of the US includes the wetlands discussed above. It also includes open waters in reservoirs and open waters in rivers and streams.

1.3 THE "RIPARIAN" CONUNDRUM

The terms "riparian," "riparian zone," and "riparian vegetation" are useful for some purposes but can also be confusing. Some people refer to woody vegetation that occurs along rivers and streams as "riparian" vegetation. Other people consider both woody and herbaceous vegetation along rivers and streams to be riparian vegetation. For still others, the term riparian simply means an area proximate to a river or stream. Riparian zones are transitional areas between a flowing and non-flowing bodies of water and the upland terrestrial habitat. Riparian zones are frequently inundated and can contain wetlands. In addition, 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. A "Classification of Wetlands and Deepwater Habitats of the United States" was developed by the Wetlands Subcommittee of the Federal Geographic Data Committee and published in August 2013. This system is in increasing use among Federal agencies and includes vegetation along rivers and streams. For this reason, in the CRSO EIS, we will use the NWI nomenclature to refer to wetlands, including those that occur along rivers and streams. In the NWI system, woody vegetation that occurs along a river or stream which is influenced by the presence of that waterway (typically seasonally inundated) is called Palustrine forested or Palustrine scrub-shrub. Similarly emergent herbaceous vegetation along rivers and streams is identified as palustrine emergent. Since this vegetation can also occur in around isolated ponds and lakes, in this report we may also specify whether the vegetation occurs along rivers and streams or around a pond or lake. These areas are commonly seasonally flooded.

1.4 LAND COVER TYPES USED IN THE CRSO EIS

1.4.1 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 the purpose of this analysis, all lands that are not classified as riparian, wetland, open water, islands, or urban or developed lands are considered uplands. Uplands in the study area include coniferous and hardwood forests, woodlands, grass and scrublands, shrub-steppe, and pasture or agricultural lands. Upland vegetation and wildlife habitat types are identified throughout the study area using the NWHI data and are shown, together with brief descriptions, in Table 1-1.

1.4.2 Barren (Drawdown Zone)

In the Barren cover type, this study focuses on the Drawdown Zone. This is shoreline habitat surrounding reservoirs which is characterized as having no permanent vegetation. A lack of vegetation is generally associated with increased potential for erosion and fluctuating water levels due to reservoir operations. When reservoirs are filled with water, the barren zone is not present, or present only as a minor fringe around the perimeter of the lake. As projects are operated and reservoirs are drawn down, the area surrounding the lake is exposed which may act as a physical barrier to wildlife for the duration the area is exposed.

1.4.3 Wetlands

Wetlands areas are vegetated habitats that are influenced by perennial or seasonally intermittent surface or groundwater. These habitats are usually a transitional area between upland habitats (described above) and wetland habitats (described below) which are characterized with woody tree or shrub species dominating the vegetation community.

Furthermore, depending on climatic conditions, riparian vegetation may exhibit increased species diversity or support more vigorous or robust growth forms relative to adjacent upland vegetation, and species composition may differ dramatically between riparian and upland habitats. Because vegetation communities within 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. Defining wetlands requires consideration of both ecological and regulatory perspectives. There are two Federal definitions of "wetlands."

1.4.3.1 Wetlands – Forested and Scrub-Shrub

Forested and scrub-shrub wetlands provide important feeding, sheltering and breeding or nesting habitat for fish and wildlife. This vegetation stabilizes river and stream channel banks and reduces erosion. Along rivers and streams this vegetation serves other important ecosystem functions, including providing a shade canopy over stream channels to reduce temperatures, vegetation along the banks may slow surface water and filter sediments to improve water quality. Woody wetlands support a high diversity of fish and wildlife.

1.4.3.2 Wetlands – Emergent Herbaceous

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. conifer or deciduous) or 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. Wetland vegetation can persist under seasonal or permanent inundation, although some vegetation communities can also tolerate extended periods of drying during a portion of the year or multiple years. Wildlife use of wetland habitats varies, where some species are dependent on wetlands for their entire lifecycle, whereas other species are incidental and occur

1.4.4 Water

The Water cover type includes rivers and streams, lakes, reservoirs, bays and estuaries. In the study area, the water cover type (also referred to as "Open Water") is composed primarily of the Columbia River and its major tributaries, and project reservoirs. This cover type is found throughout the length of the study area. A suite of wildlife species and groups (e.g. birds, mammals, and fish) use open water as primary foraging habitats, migration corridors, or temporary refuge from predators. In some location of the study area, open water habitats are available seasonally, but freeze over, and are therefore inaccessible to terrestrial or avian wildlife, in the winter.

Aquatic vegetation that is submerged for its entire lifecycle provide important food resources and shelter for several classes of vertebrates, including mammals, birds, fish, reptiles, and amphibians. Within each of these classes are many species. Aquatic invertebrates also find occupy areas of aquatic vegetation as well as the sediments and water column. Similar to wetland, submerged aquatic vegetation communities are dependent on water depths and inundation patterns, light availability, and flow conditions.

1.4.5 Islands

Island are bodies of land completely surrounded by water. In the CRSO study area islands occur in reservoirs and also in the Columbia River. Individual islands or groups of islands may contain one of the cover types identified above, or it may contain a mosaic of these cover types.

Depending on the size, elevation, and available habitat types, islands can support a wide variety of plant and wildlife species. For example, islands may provide important breeding habitat for nesting colonial water birds where terrestrial predators do not have ready access to the island. However, the availability of island habitats to support wildlife is dependent on pool elevations and whether habitats are inundated during part of the year. If islands are inundated, the timing or seasonality, water depth, and the duration of inundation are important factors influencing habitat value and use by wildlife. The H&H model results provide information on the timing, depth and duration of inundation for purpose of describing seasonal availability of these habitats for different wildlife species for some islands in the study area (Table 1-1).

Table 1-1. Land Cover, Vegetation and Wildlife Habitat Types

Habitat Type	Brief Description
Uplands	
Agriculture, Pasture, and Mixed Environs[1]	Cropland, orchards, vineyards, nurseries, pastures, and grasslands modified by heavy grazing; associated structures.
Alpine Grasslands and Shrublands[1]	Grassland, dwarf-shrubland, or forb dominated, occasionally with patches of dwarfed trees.
Eastside (Interior) Grasslands[1]	Coniferous forests and woodlands; Douglas-fir commonly present, up to 8 other conifer species present; understory shrub and grass/forb.
Eastside (Interior) Canyon Shrublands[1]	Mix of tall (5 ft) to medium (1.6 foot) deciduous shrublands in a mosaic with bunchgrass or annual grasslands.. Canopies almost always closed. Mallowleaf ninebark a major dominant.
Eastside (Interior) Mixed Conifer Forest[1]	Coniferous forests and woodlands; Douglas-fir commonly present, up to 8 other conifer species present; understory shrub and grass/forb.
Lodgepole Pine Forest and Woodlands[1]	Lodgepole pine dominated woodlands and forests; understory various; mid- to high elevations.
Montane Mixed Conifer Forest[1]	Valley bottom to mid-elevation forest belts of Douglas-fr, western larch, grand fir, ponderosa and lodgepole pine, and western hemlock.
Ponderosa Pine and Eastside White Oak Forest and Woodlands[1]	Ponderosa pine dominated woodland or savannah often with Douglas-fir; scrub, forb, or grass understory; lower elevation forest.
Shrub-steppe[1]	The major vegetation on average sites in the Columbia Plateau.
Upland Aspen Forest[1]	Quaking aspen (*Populus tremuloides*) is the characteristic and dominate tree in this habitat.

Habitat Type	Brief Description
Westside Lowland Conifer-Hardwood Forest[1]	Low-elevation. The most extensive habitat in the lowlands on the westside of the Cascades, except in southwestern Oregon. Forest, or rarely woodland, dominated by evergreen conifers, deciduous broadleaf trees, or both. Western hemlock, Douglas-fir are the most characteristic species and one or both are typically present. Others: western redcedar, Sitka spruce, red alder, bigleaf maple.
Westside Oak and Dry Douglas-Fir Forest and Woodlands[1]	Primarily found in the Willamette valley, Puget Lowlands, and Klamath Mountains ecoregions. Forest or woodland dominated by evergreen conifers, deciduous broadleaf trees, evergreen trees. Canopy structure varies from single to multi storied. Dominated by one or more of the following: Douglas-fir, Oregon white oak, Pacific madrone, lodgepole pine, California black oak.
Water	
Riverine Open Water	Defined as the river bank to river bank at Ordinary High Water, approximately 2-year water event. See also Wetlands – Emergent Herbaceous, Riverine (described below).
Reservoir Open Water	Defined as the reservoirs' full pool. Note that habitat included in this category may overlap with habitat included under Wetlands – Emergent Herbaceous, Lacustrine (described below).
Estuarine Open Water	Defined as the shore to shore at Ordinary High Tide.
Wetlands - Forested and Scrub-Shrub	
Palustrine Forested[2]	The Class Forested Wetland is characterized by trees. Trees are defined as woody plants at least 20 ft in height. All water regimes are included except subtidal.
Eastside (Interior) Riparian Wetlands[1]	Along perennial and intermittent rivers and streams. Also appears in impounded wetlands and along lakes and ponds. Shrublands, woodland and forest, less commonly grasslands; often with multilayered canopy with shrubs, graminoids, forbs below. Black cottonwood, quaking aspen, white alder, peachleaf willow are dominate. May include water birch, shining willow, and mountain alder. Each can be the sole dominate in the stands. Conifers can occur in this habitat but rarely in abundance,
Montane Coniferous Wetlands[1]	Forested wetlands or floodplains with a persistent winter snow pack, ranging from moderately to very deep. Forest or woodland (>30% tree canopy cover) dominated by evergreen conifers; deciduous trees may be co-dominate; understory dominated by shrubs, forbs, grasses. Pacific silver fir, mountain hemlock, Alaska yellow-cedar on the westside; Engelmann spruce, subalpine fir, lodgepole pine, western hemlock or western red cedar on the eastside.
Westside Riparian Wetlands[1]	Characterized by wetland hydrology or soils, periodic riverine flooding, or perennial flowing freshwater. Typically occupies patches or linear strips within a matrix of forest or regrowing forest. Red alder is the most widespread tree species. Other deciduous broadleaf trees that commonly dominate or co-dominate include black cottonwood, bigleaf maple, Oregon ash, white alder, some willows...
Palustrine Scrub-shrub[2]	The Class Scrub-Shrub Wetland includes areas dominated by woody plants less than 20 ft tall. The "shrub" life form actually includes true shrubs, young speciments of tree species that have not yet reached 20 ft in height, and woody plants (including tree species) that are stunted because of adverse environmental conditions. All water regimes except subtidal are included.
Wetlands - Emergent Herbaceous	
Lacustrine[2]	Permanently flooded lakes and reservoirs, and intermittent lakes. Typically, there are extensive areas of deep water and there is considerable wave action. Islands of Palustrine wetlands may lie within the boundaries of Lacustrine wetlands. The Lacustrine System includes wetlands and deepwater habitats with all of the following

Habitat Type	Brief Description
	characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergent, emergent mosses or lichens with 30 percent or greater areal coverage; and (3) total area of at least 20 acres. Similar wetlands and deepwater habitats totaling less than 20 acres are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin equals or exceeds 8.2 ft at low water.
Palustrine Emergent[2]	Palustrine wetlands may be situated shoreward of lakes, river channels, or estuaries; on river floodplains; in isolated catchments; or on slopes. The Emergent Wetland Class is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. All water regimes are included except subtidal and irregularly exposed.
Riverine Emergent Nonpersistent[2]	The Riverine System includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergent, emergent mosses, or lichens, and (2) habitats with water containing ocean – derived salts of 0.5 pt or greater. Nonpersistent emergent are emergent hydrophytes whose stems and leaves are evident above the water surface, or above the soil surface if surface water is absent, only during the growning season or shortly thereafter. During the dormant season, there is no obvious sign of emergent vegetation.
Estuarine Emergent[2]	Tidal wetlands that are usually semienclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The salinity may be periodically increased above that of the open ocean by evaporation. Occur from the mouth of the river or bay upstream from the ocean to where ocean-defived salts measure less than 0.5 ppt during the period of average annual low
Barren	
Drawdown Zone	The shoreline surrounding reservoirs which is characterized by having no permanent vegetation. When reservoirs are completely filled with water, the barren zone is not visible.
Islands	
River Islands	Islands are present in parts of the Columbia River. Substrate, vegetation, and suitability as wildlife habitat also vary, and may be typical of herbaceous wetlands, foresterd and scrub-scrub wetlands, or uplands cover types.
Reservoir Islands	Islands are present in some reservoirs. Substrate, vegetation, and suitability as wildlife habitat also vary, and may be typical of herbaceous wetlands, foresterd and scrub-scrub wetlands, or uplands cover types.

[1] Wildlife habitat classification
[2] National Wetlans Invetory wetlands classification

Approximate acreages of the different plant communities in the study area by reach is shown in the table below (Table 1-2).

Table 1-2. Acreages of Land Cover, Vegetation and Wildlife Habitat Types located in the Study Area.

Habitat Type	Total Acres	Region A			Region B		Region C		Region D			
		HH	Lib	Alb	GC	CJ	Dw	4LSR	MC	JD	Dal	Bon
Uplands												
Agriculture, Pasture, and Mixed Environs1	206,581	29,661	40,076	8,272	12,852	4,956	404	4,059	19,596	9,425	1,079	76,202
Alpine Grasslands and Shrublands1	1,721	69	340	1,199	0	0	113	0	0	0	0	0
Eastside (Interior) Grasslands1	30,220	11,860	5,369	6,480	3,488	0	1,344	0	0	0	0	1,679
Eastside (Interior) Canyon Shrublands1	43	0	0	0	0	0	0	0	0	43	0	0
Eastside (Interior) Mixed Conifer Forest1	50,405	6,687	12,243	22,936	3,151	0.1	5,219	0	0	0	0	169
Lodgepole Pine Forest and Woodlands1	1,226	395	642	137	52	0	0	0	0	0	0	0
Montane Mixed Conifer Forest1	736	131	9	0	0	0	0	0	0	0	0	596
Ponderosa Pine, Eastside White Oak Forest, Woodlands1	40,837	226	11,410	7,618	17,054	28	3,488	11	58	96	2	846
Shrub-steppe1	132,313	35	0	0	16,719	3,956	1,863	26,885	41,551	30,210	8,773	2,321
Upland Aspen Forest1	4,271	2,542	1,160	439	130	0	0	0	0	0	0	0
Western Juniper, Mountain Mahogany Woodlands	319	0	0	0	0	0	319	0	0	0	0	0
Westside Lowland Conifer-Hardwood Forest1	83,798	20	515	24	0	0	42	0	0	0	0	83,197
Westside Oak and Dry Douglas-Fir Forest and Woodlands1	821	0	0	0	0	0	0	0	0	0	0	821
Total Acres of Uplands in Study Area	*553,291*	*51,626*	*71,764*	*47,105*	*53,446*	*8,940*	*12,792*	*30,955*	*61,205*	*39,774*	*9,854*	*165,831*
Water												
Open Water	600,568	28,824	34,011	106,067	79,983	18,496	15,190	33,181	51,306	45,083	6,776	181,651
Wetlands - Forested and Scrub-Shrub												
Palustrine Forested2	26,810	795	1,908	2,434	74	1	9	52	949	350	51	20,188
Eastside (Interior) Riparian Wetlands1	19,248	12,285	1,413	1,443	74	643	0	662	2,286	356	28	58
Montane Coniferous Wetlands1	24,626	0	0	19,430	565	0	0	0	0	0	0	4,631
Westside Riparian Wetlands1	39,625	0	0	0	0	0	0	0	0	0	0	39,625
Palustrine Scrub-shrub2	15,250	663	838	1,009	51	18	62	45	704	266	38	11,559
Total Acres of Forested and Scrub-Shrub Wetlands	*125,559*	*13,743*	*4,159*	*24,316*	*764*	*662*	*71*	*759*	*3,939*	*972*	*117*	*76,061*
Wetlands - Emergent Herbaceous												
Palustrine Emergent2	66,332	3,507	3,044	20,299	364	134	35	160	1,603	683	68	36,435
Estuarine Emergent2	6003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6003
Coastal												
Coastal Dunes and Beaches	170	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	170
Coastal Highlands and Islets	387	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	387
Barren												
Drawdown Zone	*	*	*	*	*	*	*	*	*	*	*	*
Islands												
Islands	*	*	*	*	*	*	*	*	*	*	*	*

[1] Northwest Habitat Institute
[2] National Wetlands Inventory wetlands classification
*Unable to determine acreage

1.5 INTRODUCED AND INVASIVE PLANTS IN STUDY AREA

Introduced and invasive plants are present throughout the study area. They occur most often disturbed lands. The land cover and vegetation type descriptions do not capture the presence of these species. A review of published and unpublished literature was conducted to identify introduced and invasive species expected to occur through out the CRSO study area.

Cheatgrass (*Bromus tectorum*) is a widespread, non-native species that often invades areas following heavy grazing and/or fire and replaces native plant species. Other widespread invasive species include Dalmatian toadflax (*Linaria dalmatica*), knapweed species (*Centaurea* spp.), Russian thistle (*Salsola tragus*), mullein (*Verbascum thapsus*), clover, and several species of the mustard family (Brassicaceae).

In forest and scrub-shrub wetlands common introduced plant species include Himalayan blackberry (*Rubus armeniacus*), St. John's wort (*Hypericum perforatum*), whitetop/hoary cress (*Cardaria draba*), reed canarygrass (*Phalaris arundinacea*), Siberian elm (*Ulmus pumila*), purple loosestrife (*Lythrum salicaria*), clover species (*Trifolium* sp.), kochia (*Kochia scoparia*). Common introduced invasive trees often found near waterways, include Russian olive (*Elaeagnus angustifolia*), black locust (*Robinia pseudoacacia*).

1.6 WILDLIFE

The Columbia Basin provides important habitat for a diversity of wildlife species. Hundreds of wildlife species use the Columbia River, estuary, and tributaries for breeding, nesting, feeding, and sheltering, including amphibians, reptiles, birds, and mammals. For the analysis, species were grouped into the following broad categories: birds, mammals, reptiles and amphibians, and invertebrates. Information was gathered from published and unpublished reports and discussions with local professional wildlife biologists. The reach writeups below provide species information for each project.

1.6.1 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, and 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*).

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 U.S. river system free of these mussels (Oregon Live 2018). Strict boating inspection and widespread educational materials and training are essential to keeping these species out of the system. Oregon and Washington have both established rapid response plans for these mussels (WDFW 2014, ODFW 2013).

Throughout the study area, the action agencies are involved with cooperative weed management efforts, invasive species prevention and eradication, and vegetation treatments. The alternatives proposed herein would not change or impact their ability to continue with these efforts or affect their ability to conduct invasive species management efforts at Projects or participate on cooperative weed management efforts. 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.

The following list of invasive fish and wildlife species describes all species that may be found within the study area (Table 1-3). If these species are present in the study area, they may require control measures. These species include:

Table 1-3. Invasive Fish and Wildlife Species that Could be Present in the Columbia River System Operations Study Area

Common Name	Scientific Name
American bullfrog	*Rana catesbeiana*
Apple Maggot	*Rhagoletis pomonella*
Asellid Isopod	*Caecidotea racovitzai*
Asian Clam	*Corbicula fluminea*
Black Rat	*Rattus rattus*
Brown Rat	*Rattus norvegicus*
Calanoid Copepod	*Eurytemora affinis*
Chinese Mystery Snail	*Cipangopaludina chinensis*
Common Carp	*Cyprinus carpio*
Common Snapping Turtle	*Chelydra serpentine*
Eurasian Collard Dove	*Streptopelia decaocto*
European ear snail	*Radix auricularia*
European Starling	*Sturnus vulgaris*
Feral Horses	*Equus ferus*
Feral Sheep	*Ovis aries*

Common Name	Scientific Name
Feral Swine	*Sus scrofa*
Flathead Minnow	*Pimephales promelas*
Golden Shiner	*Notemigonus crysoleucas*
Goldfish	*Carassius auratus*
Grass Carp	*Ctenopharyngodon idella*
Gypsy Moth	*Llymantria dispar dispar*
House Sparrow	*Passer domesticus*
Mute Swan	*Cygnus olor*
New Zealand Mudsnail	*Potamopyrgus antipodarum*
Northern Crayfish	*Orconectes virilis*
Nutria	*Myocastor coypus*
Red Swamp Crayfish	*Procambarus clarkia*
Red-Eared Slider	*Trachemys scripta elegans*
Rock Pigeon	*Columba livia*
Siberian Prawn	*Exopalaemon modestus*
Virginia Opossum	*Didelphis virginiana*
Western Mosquitofish	*Gambusia affinis*

Species that have not yet become established in the Mid-Columbia River regional planning area but have the potential to be introduced include the Asian Carp, Emerald ash borer, European chafer, longhorned beetles, northern snakehead fish, and overbite clam. At this time zebra mussels (*Dreissena polymorpha*) and quagga mussels (*D. rostriformis*) have not been reported in the Columbia River system. The Corps conducts surveys (veliger sampling) in the study area, and the Idaho State Department of Agriculture conducts boat inspections to monitor for thes species.

A review of published and unpublished literature was conducted to identify these plant species (Table 1-4). The most common noxious and invasive weed species are:

Table 1-4. Most Common Noxious and Invasive Weed Species in the Columbia River System Operations Study Area

Common Name	Scientific Name
Black Locust	*Robinia pseudoacia*
Bull Thistle	*Cirsium vulgare*
Canada Thistle	*Cirsium arvense*
Cheatgrass	*Bromus tectorum*
Common Brassbuttons	*Cotula coronopifolia*
Dalmatian Toadflax	*Linaria dalmatica*
Diffuse Knapweed	*Centaurea diffusa*

Common Name	**Scientific Name**
Waterweed	*Elodea spp.*
Eurasian Milfoil	*Myriophyllum spicatum*
Flowering Rush	*Butomus umbellatus*
Himalayan Blackberry	*Rubus armeniacus*
Japanese Knotweed	*Reynoutria japonica*
Medusahead	*Taeniatherum caput-medusae*
Puncturevine	*Tribulus terrestris*
Purple Loosetrife	*Lythrum salicaria*
Reed Canary Grass	*Phalaris arundinacea*
Russian Knapweed	*Centaurea repens*
Russian Olive	*Elaeagnus angustifolia*
Scotch Broom	*Cytisus scorparius*
St. John’s Wort	*Hypericum perforatum*
Tansy Ragwort	*Jacobaea vulgaris*
Western False Indigo	*Amorpha fruticosa*
Whitetop	*Lepidium draba*
Yellow Starthistle	*Centaurea solstitialis*

CHAPTER 2 - PROJECTS AND REACHES

2.1 HUNGRY HORSE DAM, FLATHEAD LAKE AND UPPER FLATHEAD RIVER

2.1.1 Study Area

The study area used to describe the existing conditions and assess the range of potential impacts for wildlife and habitat features includes lands associated with Hungry Horse Reservoir, the South Fork Flathead River below the dam, and the Flathead River from the confluence with the South Fork to Flathead Lake. The study area is within the Flathead River Subbasin within the Pend Oreille Watershed. The South Fork basin covers 1,663 square miles and originates in the Bob Marshal Wilderness south of Glacier National Park in northwestern Montana and is the most western tributary of the Columbia River (Figure 2-1). The Flathead Basin is located in a broad valley of northwestern Montana, between two ranges of the Rocky Mountains.
The Flathead River is formed by three main tributaries originating along the west slope of the continental divide. These tributaries join before flowing into Flathead Lake.

The land surrounding Hungry Horse Reservoir and the South Fork Flathead River below the dam is managed by the Flathead National Forest. Downstream of the town of Hungry Horse, MT, the land surrounding the Flathead River is mostly privately owned. The affected environment includes the river reaches below the dam because of the potential for operations to affect water quality, flow, and other hydrologic conditions in the South Fork Flathead and Flathead rivers downstream of the dam.

The study area encompasses a wide diversity of habitats from around the reservoir, through the valley bottom, to Flathead Lake. These habitats, in turn, provide niches for a diverse array of birds, mammals, amphibians, and reptiles. Approximately 308 species of birds, 69 species of mammals, eight species of amphibians, nine species of reptiles, and 23 species of fish occur in the Flathead watershed (Northwest Power Planning Council, 2000, p. 22; Ratti 1990; CSKT 2000). Table 1-3, above, displays the land cover, vegetation, and habitat types acreages in the study area.

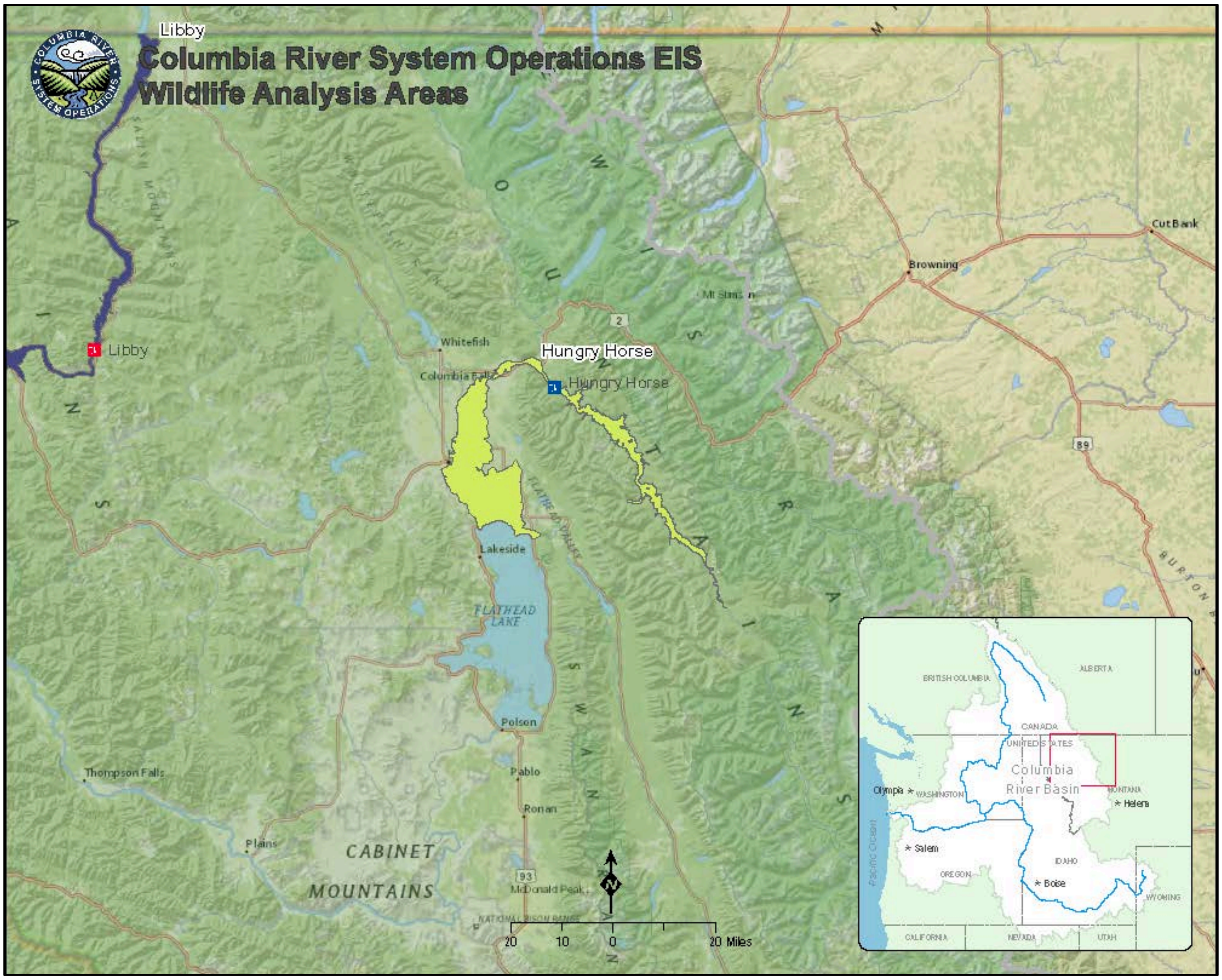

Figure 2-1. Hungry Horse Dam, Flathead Lake and Upper Flathead River

2.1.2 Land Cover

2.1.2.1 Uplands

The upland areas surrounding Hungry Horse study area support many diverse habitats. Upland grasslands, meadows and floodplain terraces are dominated by bluebunch wheatgrass, rough fescue, Idaho fescue, and blue grass. Upland shrubland is dominated by the presence of several species including serviceberry, bitterbrush, Rocky Mountain maple, *ceanothus*, and snowberry. Alpine forests dot the uppermost rims, along the side slopes and valley floors cool moist forests of Douglas-fir, larch, and ponderosa pine are interspersed with western hemlock and western red cedar. The understory is characterized by serviceberry, red-osier dogwood, and chokecherry.

Upland habitat along the Flathead River below the town of Hungry Horse is dominated by agricultural lands and urban areas. Within the 200-year event inundation area there are no upland habitat subcategories.

2.1.2.2 Barren Zone/Drawdown Area (Hungry Horse Reservoir only)

The extent of the barren zone, or drawdown area at Hungry Horse depends upon the season and operations for flood risk management (FRM). It extends from high pool elevation, around 3558 to 3559 to a low elevation around 3512 to 3520.

2.1.2.3 Wetland – Forested and Scrub-Shrub

In the Hungry Horse study area there are approximately 13,743 acres of Forested and Scrub-Shrub wetland habitat. It is dominated by deciduous shrub and deciduous tree cover types with a dense understory of grasses, forbs and shrubs. The overstory is a mix of montane riparian composed primarily of black cottonwood and willows with western hemlock, ponderosa pine, and western red cedar.

2.1.2.4 Wetlands – Emergent Herbaceous

There are 3,507 acres of emergent wetland habitat in the study area.

The MFWP 2016 Report on Aquatic Invasive Species Monitoring detected many common species in this study area, including: reed canary grass, common water moss, water mudwort, *Chara* spp., white waterbuttercup, slender leaved pondweed, puzzlegrass, leafy pondweed, white-stemmed pondweed, horned pondweed, Potamogeton spp., slender water-nymph and water smartweed (MFWP 2017).

2.1.2.5 Water

There are 28,824 acres of opern water in the study area which provides habitat for waterfowl and other wildlife. Communities of aquatic plants are similar to those found downstream at Flathead Lake. The species commonly found are pondweed, parrotweed, duckweed, and the invasive *Elodea*, knotweed, and milfoil. Curly leaf pondweed and flowering rush, both invasive plants, are found in the Flathead River near Fennon Slew (MFWP 2017).

2.1.2.6 Islands

There are 11 islands, providing mostly coniferous habitat, within Hungry Horse Reservoir, totaling 334 acres. The islands are ringed by barren areas during drawdowns. The South Fork Flathead Riverbelow the dam does not have islands. The Flathead River in the study area may have islands, or channel braiding, but none of the alternatives influence the island habitat within the Flathead.

2.1.3 Wildlife

2.1.3.1 Birds

Montana Partners-In-Flight Bird Conservation Plan (MPIF, 2000) classified breeding bird species based on their priority for conservation actions within the state. Table 2-1 lists the highest priority breeding bird species that are found in the Flathead River subbasin along with their habitats and abundance. All neotropical migrant birds are also considered target species, as are wood ducks, common goldeneye, and sandhill cranes.

Table 2-1. Bird species in the subbasin considered a high priority for conservation

Species	Priority[1]	Habitat	Abundance
Common Loon	I	Wetland	Uncommon
Horned Grebe	II	Wetland	Uncommon
Trumpeter Swan	I	Wetland	Rare
Harlequin Duck	I	Riparian	Uncommon
Barrow's Goldeneye	II	Wetland, riparian	Uncommon
Hooded Merganser	II	Wetland, riparian	Common
Bald Eagle	II	Wetland, riparian	Common
Northern Goshawk	II	Forest	Uncommon
Peregrine falcon	II	Wetland, riparian	Rare, unique
Ruffed grouse	II	Riparian	Common
Columbian Sharp-tailed grouse	II	Riparian	Extirpated
Long-billed Curlew	I	Grassland	Uncommon
Flammulated owl	I	Forest	Rare
Black swift	II	Riparian	Unique, rare
Vaux's swift	II	Riparian, forest	Common
Calliope hummingbird	II	Riparian, forest, shrubland	Abundant
Lewis's woodpecker	II	Forest	Rare
Red-naped Sapsucker	II	Riparian, forest	Abundant
Williamson's Sapsucker	II	Forest	Uncommon
Three-toed woodpecker	II	Forest	Common
Black-backed woodpecker	I	Forest	Uncommon
Pileated woodpecker	II	Forest	Common
Olive-sided flycatcher	II	Forest	Common
Willow flycatcher	II	Riparian	Common
Hammond's flycatcher	II	Forest	Abundant
Cordilleran flycatcher	II	Riparian	Uncommon
Brown creeper	I	Forest	Uncommon
Winter wren	II	Forest	Common
Veery	II	Riparian	Uncommon
Red-eyed vireo	II	Riparian	Common
Lazuli bunting	II	Riparian, shrubland	Common
Brewer's sparrow	II	Shrubland	Rare
Grasshopper sparrow	II	Grassland	Rare

[1]Priority Levels from Montana Bird Conservation Plan: Level I species exhibit declining populations and require conservation plans; Level II species are under fewer threats; may be declining or stable but still must be monitored.

RAPTORS

Great horned owls, goshawks, red-tailed hawks, ospreys, and bald eagles are represented near the reservoir. Areas used for feeding and resting by eagles include portions of the river below the dam and the upper end of the river valley above the reservoir (USACE et al., 1995).

WATERBIRDS, SHOREBIRDS AND WATERFOWL

Waterfowl seen at the project area include the Canada goose, mallard, wood duck, Barrow's goldeneye, common merganser, and a variety of other dabbling and diving duck species (USACE et al. 1995). Some shorebird species seasonally inhabit the dam area for feeding and as a rest stop during southern migration. Species include the common snipe, spotted sandpiper,and lesser yellowlegs (USACE et al. 1995). Island, backwater sloughs, and gravel bars are used by Canada geese for nesting, brooding and loafing sites. Riparian and mixed forest, islands, bottomland meadows, and riparian shrubland in the project area offer suitable nesting habitat for a variety of duck species. Cavity nesting species use cottonwood and conifer trees in bottomland forest types. The mallard was the most common breeding waterfowl species using bottomland meadows, riparian shrublands, and beaver pond areas prior to the project, but is far less numerous now. The harlequin duck is known to nest along swift streams and rivers in northwestern Montana including the Flathead River (USACE et al. 1995).

The Flathead River and delta at Flathead Lake provides an important migratory stopover area for migrating birds and is an Audubon Important Bird Area, a critical area for bird conservation. During migration over 220 species use the open water of the river, delta, and slough. The area is an important refueling stop for tens of thousands of Central and Pacific migratory birds with northern pintail, American wigeon, tundra swan, and Canada goose being the most common. Offshore habitats are important overwintering areas for to 2,000 mixed diving ducks each year as well as both tundra and trumpeter swans. It is also a major staging and roosting area for gulls during both spring and fall migration (Audubon 2018).

PASSERINES

The bird life of the area is representative of coniferous forests, including such species as the mountain chickadee, woodpeckers, swallows, wrens, bluebirds, finches, red-breasted nuthatch, common flicker, American robin, hermit thrush, red-eyed vireo, fox sparrow, pine siskin, and dark-eyed junco (USACE et al. 1995). Island wildlife includes common flickers, belted king fishers, and several other species of small birds (USACE et al. 1995). The gray jay, cliff swallow, poorwill, rufous hummingbird, pileated woodpecker, dipper, western meadowlark, and northern oriole are a few of the many non-game birds that can be found in the Flathead region. Species such as the white-winged crossbill, northern shrike, and the common redpoll use the region during the winter (USACE et al. 1995).

GALLINACEOUS BIRDS

Ruffed grouse, spruce grouse, and blue grouse are all known to occur in the South Fork drainage. The ruffed grouse and blue grouse are common in the riparian areas, while spruce grouse are common in coniferous forests along the valley walls. Ruffed grouse prefer open hardwood stands with moderately dense herbaceous and sapling understory for courtship, nesting and broods. Blue grouse typically breed in open stands of conifers interspersed with openings of herbaceous cover (USACE et al. 1995)

Spruce grouse inhabit mixed coniferous forests, generally preferring subalpine spruce-fir and lodgepole pine. Spruce grouse also inhabit spruce-fir forests interspersed with fire induced serial stands of western larch and lodgepole pine (USACE et al. 1995).

Wild turkey, ring-necked pheasant, and ruffed grouse are the principal game birds of the Flathead Riverbasin (USACE et al. 1995).

2.1.3.2 Mammals

TERRESTRIAL

The pine marten inhabits mature coniferous timber with small openings. Bottomland and lower valley slopes of old growth with fire-caused openings, provide the most preferred of marten habitat. Lynx prefer the dense seral stands of lodgepole pine due to the high densities of showshoe hare, their preferred prey. Snowshoe hares reach their highest densities in these seral forests. Other mammals include weasel, skunk, and raccoon (USACE et al. 1995).

Black bears are present along the riparian areas and lower benches. The large cottonwood trees located along the bottoms provide preferred type of denning sites. The riparian zones provide abundant lush vegetative forage during the spring, and an abundant late summer and fall food supply of berries and mast. Grizzly bears also reside in the project area. Grizzly bears select low level riparian areas after spring emergence because of the available succulent forage. In some areas big game carrion is an important source of spring food. During the summer period grizzly bears move up to higher elevations as the snow recedes. The fall period is spent in preparation for denning and the bears are forced back down to the lowland habitats for available food. The mountain lion is known to occur in a variety of upland and bottomland areas (especially white-tailed deer habitat) where they feed on deer and elk. The bottomland and open shrubland slopes offer important winter range for prey species (USACE et al. 1995).

During the winter, elk require habitats that provide food, escape cover and thermal cover. Elk prefer habitats that support mountain maple, serviceberry, willow, chokecherry, dogwood, and ceanothus. Elk of the project area are not limited in the availability of summer range.
A scattered population of mule deer exists around the project area. The deer are widely distributed in the summer with use in all the drainages. During the winter, the deer tend to concentrate on the open shrublands along south- and westfacing slopes where abundant forage is located. The white-tail deer population uses a wide variety of habitats throughout

spring, summer, and fall. Winter ranges are in the south and west facing slopes along the east side of the drainage. Fires during the early portion of this century created extensive shrublands and conifer regeneration which, when combined with adjacent thermal cover, provide excellent winter range. The further succession of thick lodgepole pine stands has caused a slight decline in white-tail deer numbers (USACE et al. 1995).

The intermixture of forest, grassland, cropland and water in the Flathead River and valley provide excellent cover and forage for white-tailed deer; the main large animal of the valley. The white-tailed deer use a wide variety of habitats throughout the year. Elk and moose are also present in stable but smaller populations (USACE et al. 1995).

Black bears are present along the riparian areas and lower benches. The large cottonwood trees located along the bottoms provide preferred denning sites. The riparian zones provide abundant lush vegetative forage during the spring, and an abundant late summer and fall food supply of berries and mast. The mountain lion is known to occur in a variety of upland and bottomland areas, where they feed on deer and elk (USACE et al. 1995).

AQUATIC

The most common aquatic animals of the area include beaver, muskrat, river otter, and mink. Beaver prefer riparian habitats along the South Fork and its tributaries, which has traditionally supported moderate populations of beaver. Optimal habitats for beaver are those areas where willow or poplars are available along permanent water courses (generally the larger tributaries). Muskrat probably use aquatic and streamside habitats along both the South Fork and its tributaries. Otters appear to be numerous along the river and use both the river and its tributaries. Backwater sloughs, streams, lakes, reservoirs, and beaver dens could also be important habitat for otters. Mink occur along the South Fork where they forage in riparian vegetation, overhanging banks, and log jams (USACE et al. 1995).

Muskrat, river otter, beaver, and mink use habitats along the upper Flathead River and along the north shore of Flathead Lake. Muskrats prefer slough and pond habitats and avoid the braided river section (USACE et al. 1995).

2.1.3.3 Reptiles and Amphibians

Amphibians are present in many of the wet habitats, especially wetland and riparian habitats. Species include the Columbia spotted frog, western toad, Rocky mountain tailed frog, chorus frog, long-toed salamander and tiger salamander. Two species of garter snakes (common and western terrestrial), prairie rattlesnake, bull snake, racer, and rubber boa also occur.

2.1.3.4 Invertebrates

Biotic diversity is severely reduced and community composition is grossly altered in the South Fork of the Flathead River, as caused by Hungry Horse Dam (Perry and Graham 1981). Invertebrate fauna is dominated by Dipterans (true flies). Other invertebrates include mayflies, stone flies, and caddisflies. In comparison to the South Fork, other portions of the Flathead River have diverse invertebrate populations and communities (Perry and Graham 1981).

2.1.3.5 Introduced and Invasive Species

Wildlife Aquatic Invasive Species have not been recorded in the reservoir or the Flathead River within the study area (Schmidt and McLane 2017).

2.2 LIBBY DAM AND LAKE KOOCANUSA

2.2.1 Study Area

The study area used to describe existing conditions and assess the range of potential impacts to wildlife and habitat features includes Libby Dam, Lake Koocanusa and the Kootenai River (Figure 2-2). The study area is within the Middle Kootenai and Lower Kootenai watersheds of the Kootenai River Basin, an international watershed encompassing nearly 18,000 square miles of British Columbia, northwest Montana and northern Idaho. The upstream extent of the study area includes Libby Dam, and the maximum pool of Lake Koocanusa and potentially affected tributary mouths, north to the U.S. – Canada border. Downstream extent includes the Kootenai River as it flows through the canyon and braided reach of Montana, the meandering reach of Idaho, north until the U.S. – Canada border. Cover, vegetation, and habitat types for this study area are identified in Table 2-2.

Libby Dam is entirely within the Northern Rocky Mountains region. The Rocky Mountains are characterized by rugged mountains, numerous river valleys and canyons, small glacial lakes, and large, low elevation lakes or reservoirs. Primary upland vegetation consists of xeric and mesic forests with Douglas-fir, western hemlock, lodgepole pine, ponderosa pine, Englemann spruce and western redcedar. Wetland and riparian areas are scattered but can be locally significant to wildlife.

In the northernmost segment of Lake Koocanusa, the reservoir is approximately two miles wide and the gorge is characterized by sloping, rolling terrain with extensive flat areas at or below pool level. The town of Rexford, Montana, is nearly seven miles south of the border and is an approximate geographic place mark for the change in the reservoir width. Downstream of Rexford, Lake Koocanusa occupies a narrow gorge averaging one mile in width. The gorge consists of steep, coniferous forests with flat benches at the mouths of tributary streams. Downstream of Libby Dam the land is characterized by relatively flat terraces between the river banks and steep, mountain slopes. The Kootenai River Valley can be described by the rugged, heavily forested, northwest-oriented mountain ranges separated by narrow linear valleys.

Table 1-2 above shows the acres of the different habitat types within the Libby Dam study area.

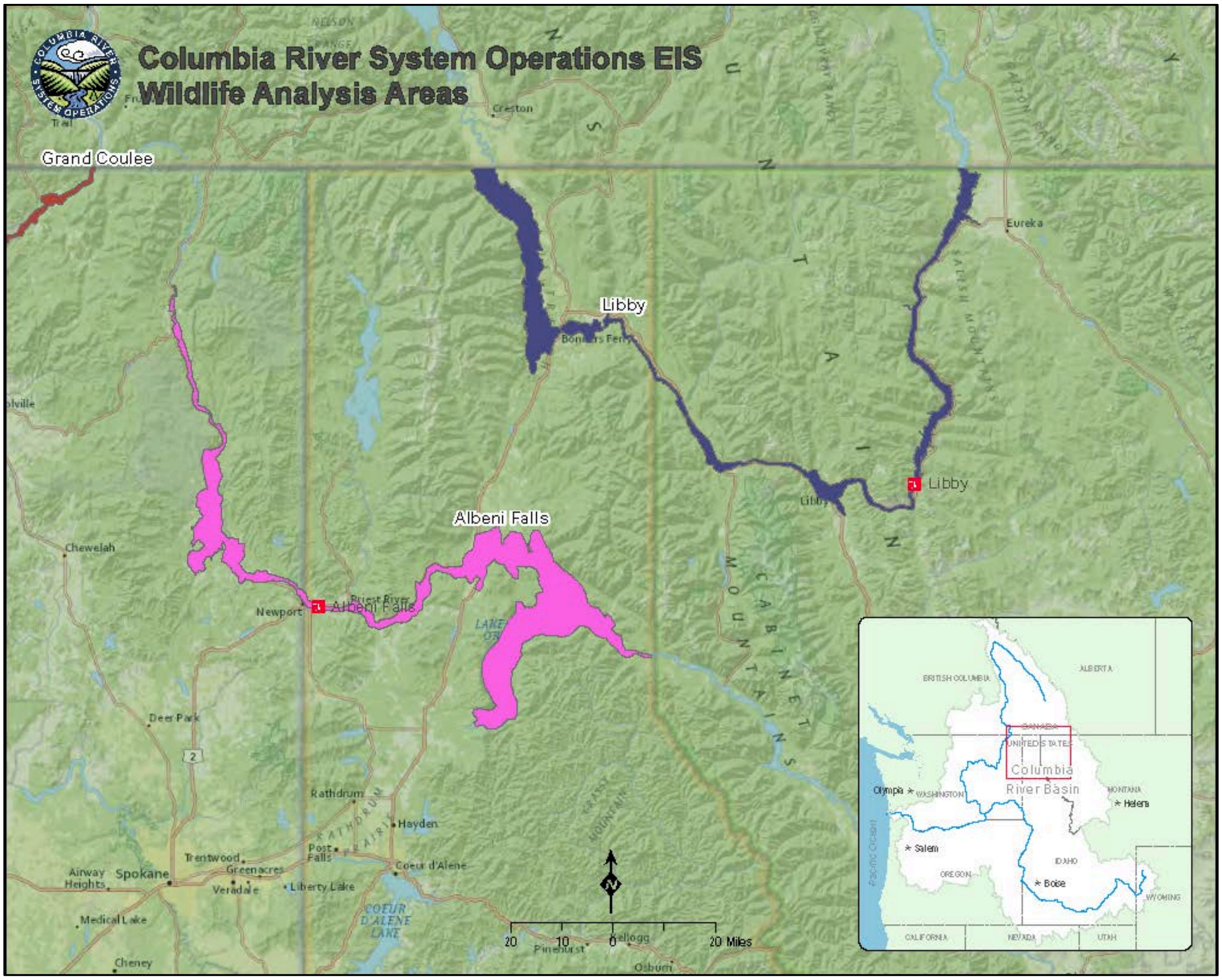

Figure 2-2. Libby Dam and Lake Koocanusa

2.2.2 Land Cover

2.2.2.1 Uplands

There are two forest systems that occur in the study area: Rocky Mountain Lodgepole Pine Forest and Rocky Mountain Ponderosa Pine Woodland and Savanna. Fire is frequent is these forests and stand-replacing fires force pines to rapidly colonize and develop into dense, even-aged stands. Ponderosa pines occur on warm, dry, exposed sites in the foothills of the Rocky Mountains at the ecotone between grasslands or shrublands, and more mesic coniferous forests. The ponderosa pine system is characteristic of an open forest with a grassy understory. Prolonged drought, beetle kill and exotic invasion rapids change the system dynamics.

The most prevalent grassland system in the study area is the Rocky Mountain Lower Montane, Foothill, and Valley Grassland system. They occur in small meadows, large open parks surrounded by conifers, and as extensive foothill and valley grasslands.

Wildfires are more prevalent in the xeric forest types. In the year 2000, two large fires burned on the banks of Lake Koocanusa within the Kootenai National Forest. The Stone Hill and Cliff Point fires burned nearly 20,000 acres about 65 miles northeast of Libby (Small and Tanke 2009). The area is in post-fire recovery, however burn scars remain. Early successional plant species have since colonized the areas, improving the habitat quality for wildlife.
The northernmost reach of the fires nearly burned the Montana Highway 37 side of Koocanusa Bridge, which spans the reservoir (Montana Office of Tourism 2018).

2.2.2.2 Lake Koocanusa and Libby Dam Habitat

Lake Koocanusa lies in a valley between north-south trending mountain ranges. Consequently, the forested slopes above the river are predominantly east and west-facing slopes. The aspect of the slopes at Libby Dam predominantly controls the ability of vegetation to colonize in the hot, dry summers. South-facing slopes receive the highest amount of sunlight per day, and are the hottest and driest. Vegetation on these slopes is sparse and includes ponderosa pines, and relatively few understory plans, including roses and ninebark. Ground cover is composed of primarily grasses and other herbaceous plants.

In contrast, north-facing slopes receive little to no direct sunlight, and tend to be cooler and steeper. These slopes receive moisture from morning dew and typically do not dry in the afternoon. Slopes with greater moisture-holding abilities have higher plant diversities with lush, dense vegetation. North-facing slopes tend to contain 85 percent Douglas-fir and 15 percent western larch, with a large number of understory plants including serviceberry (*Amelanchier alnifolia* and *Amelanchier utahensis*), ocean spray (*Holodiscus bicolor*) and shade tolerant herbaceous and woody plants.

The east- and west-facing slopes tend to show a gradation of community makeup encompassing a wide range of variability within the Douglas-fir/western larch/ponderosa pine (*Pinus ponderosa*) association. West-facing slopes are generally slightly drier than east-facing and are more open in structure. East- and west-facing slopes have the greatest diversity of vegetation; common understory plants include mallow-leaf ninebark (*Physocarpus malvaceus*), snowberry (*Symphoriocarpos albus*), kinnikinnick (*Arctostaphylos uva-ursi*), longleaf and creeping Oregon grape (*Berberis nervosa* and *B. repens*), ocean spray, mock azalea (*Rhododendron menziesii*) and serviceberry. Due to high plant diversity and the increased availability of habitat and food resources, more wildlife are present on these slopes.

South-facing slopes along the Kootenai River are characterized by scattered, open stands of ponderosa pine, and a limited amount of Douglas-fir. Understory species are bitterbrush (*Purshia* sp.), western serviceberry, chokecherry, Oregon grape and white spiraea (*Spiraea betulifolia*) and Douglas spiraea (*Spiraea douglasii*). Major forbs present yarrow (*Achillea millefolium*), arrowleaf balsamroot (*Balsamorhiza sagittata*) and dogbane (*Apocynum* sp.) with bluebunch wheatgrass (*Pseudoroegneria spicata*) and rough fescue (Festuca campestris) grasses mixed in.

North-facing slopes in the Lower Kootenai are densely timbered with mountain maple, Douglas-fir, western larch and lodgepole pine. Understory shrubs consist of mock orange (*Philadelphus coronarius*), ninebark, snowberry and kinnikinnick. Forbs include heartleaf arnica (*Arnica cordifolia*), Sego lily (*Calochortus* sp.), lupine (*Lupinus* sp.) and yarrow. The predominant grass in the various meadows on the Kootnenai is pine grass with inclusions of brome (*Bromus* sp.) grasses, bluegrass (*Poa pratensis*), Junegrass (*Koeleria macrantha*), Idaho fescue (*Festuca idahoensis*), needlegrass (*Nassella* sp.), and bluebunch wheatgrass.

Floodplain surfaces suitable for natural recruitment and establishment of native trees and shrubs are limited due to the altered hydrology and lack of flood disturbance. The small patches of floodplain that do exist are covered with woody vegetation and a mix of invasive reed canarygrass (*Phalaris arundinacea*) and other non-native grasses. Non-native grasses reduce bank margin roughness, out-compete woody vegetation and reduce potential for sustainable large woody debris recruitment from the banks. Wetland habitat exists in small fragments in lower elevations along the Kootenai River.

Spotted knapweed (*Centaurea stoebe*) is prevalent in this area, with this highest recorded populations in northwestern Montana. Dalmatian toadflax (*Linaria dalmatica*) has invaded the entire state of Montana and occurs in the Libby Dam vicinity. Sulphur cinquefoil (*Potentilla recta*) can grow on the stony soil of exposed slopes near the drawdown zones of Libby Dam (CISM 2014).

There are many species in the family Asteraceae that have the potential for invading the drier, disturbed grassland habitats surrounding Lake Koocanusa. These species include diffuse knapweed (*Centaurea difusa*), yellow starthistle (*Centaurea solstitialis*), common tansy (*Tanacetum vulgare*), and hoary false-alyssum (*Berteroa incana*) (MNHP 2018).

2.2.2.3 Barren Zone/Drawdown Area

Bare sand and mud are exposed during the fall, winter and spring drawdown, and potentially during summers when the reservoir does not refill entirely. Erosion can be a serious problem, particularly during winter wind storms when the substrate is dry. Most of the barren zone which is non-vegetated, has low diversity or provides habitat for non-native invasive plant species.

Gravel bars and some portions of the shorelines are intermittently exposed during low flows and comprise a majority of barren area acreage. Water fluctuations have contributed to increased shoreline erosion of the Kootenai River, particularly in the Idaho reach upstream of Bonners Ferry. Erosion is caused by varying flows through the winter months; a mechanism of bank erosion is high flows resulting in ice forming high on the river banks. As the flow drops, the ice falls and takes bank soils with it.

2.2.2.4 Wetlands – Forested and Scrub-Shrub

Riparian plant species in riparian areas include cottonwood, willow, red-osier dogwood, mountain alder (*Alnus* sp.), birch (*Betula* sp.), serviceberry and ninebark. Riparian areas provide resources and habitat for wildlife and readily available freshwater. These areas produce a rich variety of foods including buds, twigs, catkins, seeds, and fruit. Stream-supported trees provide perches and nesting spots for ospreys and bald eagle. Waterfowl nest among the grasses and/or dense vegetation growth associated with these habitats. Most of the riparian areas around Lake Koocanusa are associated with the tributary streams flowing into the reservoir (USACE et al. 1995). There are 4,159 acres of Forested and Scrub-Shrub wetlands in the study area.

Riparian habitat is discontinuous along the Kootenai River. Habitats (within the floodplain) can be divided into coniferous and deciduous forests. Coniferous forests consist of Douglas-fir and western redcedar. Understory species include Oregon grape, Rocky Mountain juniper (*Juniperus scopulorum*), and Canadian buffaloberry (*Shepherdia canadensis*). Dominant deciduous overstory species include black cottonwood, alder and willow. Understory vegetation includes dogwood (*Cornus* sp.), gooseberry (*Ribes* sp.), chokeberry, ninebark, and serviceberry. Immediately downstream of Libby Dam is the canyon (or confined) reach of the Kootenai. Most of the canyon reach is a geologically restricted channel. Because there are many steep canyon walls, the floodplain is narrow and essentially devoid of wetlands and linear riparian strips.

Along the meandering reach of the Kootenai River in the Okanogan Highlands is primarily agricultural lands. The construction of dikes and levees have effectively disconnected the river from the surrounding floodplain (KTOI 2009).

Small tributaries and streams are typically dominated by Drummond's willow (*Salix drummondiana*), alder, or redosier dogwood shrublands. Lower gradient streams are lined with Geyer's willow (*Salix geyeriana*), Bebb's willow (*Salix bebbiana*), thinleaf alder (*Alder incana*) and rose spirea (*Spiraea douglasii*). Understory vegetation is a lush mix of mesic forbs and graminoids (IDFG 2017).

2.2.2.5 Wetlands – Emergent Herbaceous

The dominant aquatic vegetation type along Lake Koocanusa is emergent vegetation, comprising about 4% of the total shoreline (VAST 2017). Emergent Vegetation generally refers to grasses, horsetail (Equisetum sp.), sedge, or other plants tolerant of flooding (VAST 2017). There are 3,044 acres of Emergent Herbaceous Wetlands in the study area.

Downstream of Libby Dam through the canyon reach of the Kootenai, there are many steep canyon walls which restrict the floodplain extent; therefore, this reach is devoid of wetlands. The canyon reach flows through the Kootenai National Forest. There are several wetlands near the town of Troy, Montana. Wetland types include freshwater emergent wetlands, freshwater ponds and freshwater forested/shrub wetland (NWI). Near the town of Libby, Montana, there are also several wetland areas beyond the banks of the Kootenai. The middle distinct river reach is the braided reach. This reach extends from the confluence with the Moyie River, near the town of Moyie Springs, Idaho, to the town of Bonners Ferry, Idaho. Several distinct channels, islands, and numerous gravel bars were created due to the relatively broad floodplain

This subbasin includes the meander reach which flows north through Idaho, downstream of Bonners Ferry, to the Canadian border. The river gradient flattens and the floodplain widens to create a single channel. The Kootenai National Wildlife Refuge is located in the meander reach of the river, and is within the study area. The Kootenai National Wildlife Refuge near the Selkirk Mountains of northern Idaho was established as a migratory waterfowl refuge. Five miles west of Bonners Ferry, the refuge contains 2,774 acres of wetlands, meadows, riparian forests and cultivated agricultural fields. Wetlands along the Kootenai River and Myrtle Creek include open-water ponds, seasonal cattail-bulrush marshes, tree-lined ponds and rushing creeks. The refuge provides habitat for over 220 bird species including bald eagles, mallards, northern pintail, and teal. Forty-five species of mammals utilize the refuge habitat, including moose, elk, deer, bear and otter (USFWS 2015).

The Kootenai National Wildlife Refuge and the remnants of the Kootenai River floodplain contain depressional wetlands. Depressional wetlands are any wetlands found in a topographic depression and include vernal pools, old oxbows, disconnected river meanders and constructed wetlands. These wetlands support emergent marsh or tree or shrub-dominated swamps. Marshes are composed of broad-leaf cattail (*Typha latifolia*), tall bulrush species (*Schoenoplectus* sp.), panicled bulrush (*Scirpus microcarpus*), and other emergent species. Swamps are characterized by western redcedar, Engelmann spruce, rose spirea, and thinleaf alder. Reed canarygrass is the most abundant invasive plant on the Refuge, forming dense monocultures in seasonally flooded wetlands, wet pastures, and the understory of open canopy riparian forests (USFWS 2015). Swamps with high-water table may contain devilsclub (*Oplopanax horridus*) and American skunkcabbage (*Lysichiton americanus*). Amphibians, including the western toad, waterbirds, marshbirds, and waterfowl all use depressional wetlands for breeding and foraging habitats (IDFG 2017).

2.2.2.6 Water

The Kootenai River downstream of Libby Dam is characterized by a combination of riffles, pools and slow moving, broad, meandering river sections. The reach between Fisher River and Libby Dam offers a variety of habitats including deep water, shallow rapids and mid-stream islands and side channels. This reach is deficient in the following habitat features: cover, complexity, spawning substrate, and macroinvertebrate habitat. Cover and complexity in the form of wood-formed pools is sparse. The supply of large wood to the reach has been eliminated by the dam, which has resulted in reduced channel boundary roughness and simplification of edge habitat. There are 34,011 acres of Open Water in the Libby study area.

Didymosphenia geminata, a non-native aquatic stalked diatom also known as “Didymo” or “rocksnot”, has become established at a nuisance/noxious density in the Kootenai River downstream of Libby Dam. Unlike most algae, *Didymosphenia geminata* biomass increases in low-nutrient conditions via stalk formation, and dominates stream surfaces by covering substrate with mat formations up to three inches thick in the Kootenai River. This in turn blocks sunlight and can interrupt ecological processes, which decreases habitat quality and reduces the abundance and diversity of native flora and fauna. Increases in these dense blooms coincide with a decline in trout density in the Kootenai River downstream of Libby Dam (USACE et al. 1995).

Filamentous algae and pond lily (*Nuphar* sp.) are common in the Kootenai River ecosystem, where flows are slack and water is shallow.

There are many invasive plant species capable of spreading into Lake Koocanusa and the Kootenai River, such as reed canary grass and curly-leaf pondweed (*Potamogeton crispus*), which is a noxious weed that spreads from plant fragments remaining of boat trailers and recreational equipment. Pondweed is spreading rapidly and is present in neighboring counties.

Eurasian water-milfoil (*Myriophyllum spicatum*) inhabits open waters of reservoirs and tolerates moving water, and is present in Lincoln County. It is likely that this water-milfoil species has invaded Lake Koocanusa. Eurasian water-milfoil spreads through boat trailers but also waterfowl. It can also disperse between water bodies through wind and water flow. Eurasian milfoil displaces native aquatic plant communities by forming thick underwater stands of tangled stems and mats of vegetation. The American water-lily (*Nymphaea odorata*) inhabits lakes, ponds, and valleys and has been recorded in the county (MNHP 2018).

Aquatic invasive plant species found specifically in the Idaho segment of the Kootenai River include Eurasian watermilfoil, flowering rush, and curly pondweed. These aquatic species often form dense mates that prevent the establishment of native plants and degrade wildlife and fish habitat (IDFG 2017). These species degrade upland, wetland and riparian habitats.

One of the most abundant invasive plants in the study area is reed canarygrass (*Phalaris arundinaceae*). While reed canarygrass is native to the Pacific Northwest, an aggressive hybrid used as a forage grass species, has outcompeted the native species. The invasive forms dense monocultures in seasonally flooded wetlands, wet pastures, and the understory of open canopy riparian forests (USFWS 2015). Yellow iris (*Iris pseudacorus*) grows in marshes and wet meadows, and has been recorded in southern Lincoln County. Salt-cedar (*Tamarix ramosissima*) is a deciduous shrub with small pink flowers that inhabits meadows along rivers, streams, ponds, and plains. Salt-cedar is invading Montana east to west and may invade Lincoln County in the near future.

2.2.2.7 Islands

A diversity of plant species create island habitat within Lake Koocanusa. Overstory species include Douglas-fir, western larch and western redcedar. The understory consists of Rocky Mountain juniper, common juniper (*Juniperus communis*), birch, ninebark, snowberry and Oregon grape. These islands support a limited range of wildlife species.

The Yarnell Islands in Lake Koocanusa can be accessed for recreational purposes. At high water levels there are two islands, and at low water level there is just one (assessed www.Libbymt.com). Visitors launch from the boat ramps and can camp at one of eight primitive campsites. Due to the recreational capacities of these islands and disturbance caused by visitors, the habitat quality for wildlife is reduced. Other islands known to have existed in Lake Koocanusa but are now seasonally or permanently inundated include Cedar Island, Kins Island, Murray Island, and Whites Island (USGS 2018a).

Islands developed from the gravel bars on the Kootenai River are maintained in early successional stages through water level fluctuations. A variety of shrubs, forbs, and grasses do eventually colonize these areas and include willow, sweetclover (*Melilotus* sp.), cocklebur (*Xanthium* sp.) and thistle (*Cirsium* sp.). The bars and vegetated islands are vital habitat for numerous shorebirds, ducks, and geese.

2.2.3 Wildlife

Typical wildlife species in the Northern Rocky Mountains Region include mergansers, sandpipers, waterfowl, osprey, bald eagles, beaver, otter, deer, elk, and bighorn sheep. Deer and elk eat the twigs and foliage of Oregon grape, snowberry, ponderosa pine, and Douglas fir. White-tailed deer show a preference for kinnikinnick, the fruit of which is also eaten by blue grouse. Red squirrels are insectivorous during spring and summer, but rely upon seeds of Douglas fir and ponderosa pine during fall and winter. Black bears feed upon berries, tubers, insects, small mammals, and honey. Several bat species breed in the Kootenai River Basin and are commonly seen at dawn and dusk when they are out foraging for insects. Although the understory vegetation is diverse, the overstory vegetation is primarily composed of coniferous trees, and the bird life is therefore representative of a coniferous forest. Common species include mountain chickadee, red-breasted nuthatch, northern flicker, American robin, and dark-eyed junco.

2.2.3.1 Birds

RAPTORS

Great-horned owls, goshawks, and red-tailed hawks inhabit the forests surrounding the reservoir.

Osprey and bald eagles perch in the tall bankside cottonwood and Douglas-fir trees along the riparian areas below the mouth of the Fisher River, and bald eagles nest along the Fisher and Kootenai Rivers in Montana. Migratory and wintering concentrations of bald eagles occur below Libby Dam. Great-horned owl, goshawk, red-tailed hawk, and short-eared owl are other common raptors that inhabit the area.

WATERBIRDS, SHOREBIRDS AND WATERFOWL

No colonial nesting birds are known to occur in the Kootenai River (USACE et al. 1995). Some shorebird species seasonally use the Kootenai River area for feeding and as a rest stop during southern migration. Species include the common snipe, spotted sandpiper, and lesser yellowlegs. Common snipe and spotted sandpiper may nest near the river. The Kootenai River Basin lies primarily within the Pacific Flyway. Mallards, harlequin ducks, pintail, American widgeon, teal, gadwall, goldeneye, American coot, common merganser, tundra swan, and Canada goose constitute the principal waterfowl species. The ten mile reach of the river below Libby Dam does not receive heavy use by waterfowl, although occasionally flocks of up to 30 waterfowl feed and rest on the slower moving backwater areas near the river islands, Harlequin ducks nest in smaller tributary streams, and possibly along the Kootenai River as well. Canada goose and duck nesting occurs on some of the river islands and among the grasses and/or dense vegetation growth associated with these habitats.

PASSERINES

The bird life of the area is representative of coniferous forests including species such as the mountain chickadee, woodpeckers, swallows, wrens, bluebirds, finches, red-breasted nuthatch, common flicker, American robin, hermit thrush, red-eyed vireo, fox sparrow, pine siskin, and dark-eyed junco (USACE et al. 1995). Most of these species are insectivorous, but red-breasted nuthatches also eat Douglas-fir and ponderosa pine seeds. Additional species include downy and pileated woodpeckers, common nighthawk, western tanager, cordilleran flycatcher, American robin, Swainson’s thrush, northern flicker, house sparrow, and Steller’s jay. River habitats support belted kingfisher, redwing blackbird, yellow warbler and the American dipper, while island wildlife include common flickers and belted kingfishers.

GALLINACEOUS BIRDS

Ruffed and blue grouse are known to occur around Lake Koocanusa along an elevational gradient. These upland game birds prefer to eat the kinnikinnick fruit. Ruffed grouse are the most common species occurring at lower elevations, while the blue grouse prefer more mountainous areas (USACE et al. 1995).

Upland game in Kootenai River basin include ruffed, blue and spruce grouse, ring-necked pheasants, and mourning doves. Chukar, sharp-tailed grouse and Hungarian partridges also occur in the basin. Agricultural lands near Bonner’s Ferry support moderate number of ring-necked pheasants and migrating mourning doves. The wild turkey can also be found along the river.

2.2.3.2 Mammals

TERRESTRIAL

Commons mammals around Lake Koocanusa include raccoon, cottontail rabbits, porcupine, marten, bobcat, weasel, coyote, mountain lion and black bear. Local small mammals include shrews, voles, bushy-tailed woodrat, deer mouse and the house mouse. In the past decade, gray wolves have been tracked inhabiting the forested uplands in the northern reaches of Lake Koocanusa near the Canada border. Occasionally badger are sighted along the reservoir and tributaries. Big horn sheep have been reported into the mountains east of Lake Koocanusa and near Kootenai Mountain. Reservoir island mammals include red and flying squirrels, along with small mammals like mice and voles.

Survey work was conducted at Libby Dam in 2011 to document bat activity and diversity. The presence of bats and associated guano at the visitor center was a public annoyance and Corps biologists wanted to encourage them to roost away from the public. Nine-species were documented: little brown myotis, long-eared myotis, California myotis, western small-footed myotis, Yuma myotis, silver-haired bat, hoary bat, Townsend’s big-eared bat and big brown bat. Surveys were conducted at five sites on Corps property including the Downstream Trail, Ripley, Souse Gulch, the Visitor Center, and a warehouse. The trail captured the greatest number of bat calls, with all nine species detected (USACE 2012).

Weasels, skunks and raccoons are abundant along the Kootenai River. Martens use heavily forested localities at higher elevations and wooded areas at lower elevations. Fishers have been spotted along the smaller tributaries near the town of Libby. Northern flying squirrels have also been reported in Libby (MNHP 2018).

Higher elevations of the slopes are the preferred summer range of deer, sheep and elk. The lower bottomland elevations provide winter habitat for big game. The north- facing slopes are generally used for escape and bedding cover by big game, primarily because of the lack of sunlight to the forest floor (due to the denser overstory vegetation). In addition, these slopes in the project area tend to be relatively steep, which likely discourages use by big game predators to some degree. The availability of grass on south-facing slopes makes them important seasonal feeding areas for mule deer and elk. White-tailed and mule deer favor the snowberry for its shoots and foliage, but also eat the shoots and foliage of Oregon grape, Ponderosa pine, and Douglas-fir. White-tailed deer also show an additional preference for kinnikinnick fruit. Moose seek the bottomlands for the twigs and foliage of the red-osier dogwood, willows, alder and birch. A moderate number of mountain lions, and black and grizzly bear are found throughout this region.

Principal big game animals in the Kootenai River basin are white-tailed deer, mule deer, elk, black bear and moose. Less common species are grizzly bears, mountain goats, bighorn sheep, and woodland caribou. Grizzly bears inhabit the roadless backcountry of the extreme northeast and northwest corners of the basin. Black bears can be found from the Douglas-fir forests of the mountains to the wet meadow riparian areas by the river. White-tailed deer are abundant within the region with the largest concentration inhabiting the river basins and bottomlands.

Mule deer are less numerous and found at higher elevation in scattered herds. Elk herds are small, widely dispersed, and occur primarily in the Moyie and Fisher rivers' drainages, and the Dunn Creek drainage. Elk also occur in the Boulder Creek and Alexander Creek drainages. Herds use the north and east facing slopes at higher elevations. Moose prefer the bottomlands along lakes and streams and early successional habitat. Winter range is restricted to narrow areas along the Kootenai River and the lower reaches of lateral drainages on south and west facing slopes. Migration to winter range generally occur during late October or early November. During normal winters elk and sometimes moose, are in direct competition with deer for food and cover on winter range.

AQUATIC

American mink, river otter and muskrats reside along the shore of Lake Koocanusa. However, populations remain small due to the extensive barren drawdown area between the water in the reservoir and shoreline vegetation during most of year (i.e. when the reservoir is less than full).

Beaver, muskrat, mink and river otter constitute the principal mammals inhabiting the Kootenai River basin. Beaver colonies are found primarily along the Kootenai mainstem downstream of Bonners Ferry and along certain gradient tributaries. Diked agricultural lands near Bonners Ferry support the bulk of muskrat populations. Small number of mink and river otters occur along main watercourses in the timbered areas of the basin.

2.2.3.3 Reptiles and Amphibians

Amphibians around the reservoir include a few species of salamanders (*Ambystoma* sp.), frogs (*Rana* sp., *Lithobates* sp., and *Pseudacris* sp.), and the western toad (*Anaxyrus boreas*). Reptiles include the painted turtle (*Chrysemys picta*), common garter snake (*Thamnophis sirtalis*), rubber boa (*Charina bottae*), western skink (*Plestiodon skiltonianus*), and the northern alligator lizard (*Elgaria coerulea*). Amphibians inhabiting land along the river include a few species of salamanders and frogs, including the Pacific tree frog (*Pseudacris regilla*), and the western toad. The western tiger salamander (*Ambystoma mavortium*) has been spotted in the Lower Kootenai. Reptiles include the painted turtle, garter snake, rubber boa, western skink, and the northern alligator lizard. Amphibians are closely tied to the river and its sloughs while reptiles can be found from upland coniferous forests to the mats of emergent plant bed in river sloughs.

Terrestrial snake species include the North American racer (*Coluber constrictor*) and the terrestrial garter snake (*Thamnophis elegans*). These species occur in a wide variety of habitats including grasslands and coniferous forests, and do not require emergent wetland or riparian habitat (MNHP 2018).

The Corps conducted a species inventory for reptiles and amphibians near Libby Dam in 2013. The survey was conducted to determine presence of suitable habitat for the Montana state-listed Coeur d'Alene salamander. Fifteen sites on Corps-managed land near Libby Dam and along the upper Kootenai River were surveyed. Three amphibian species and two reptile species were detected. These species include the long-toed salamander (*Ambystoma macrodactylum*), western toad, Pacific tree frog, Western skink and terrestrial garter snake. The western toad and western skink are both considered species of concern by Montana State (Lucas 2013).

The American bullfrog (Lithobates catesbeianus) are a non-native invasive species found in both Montana and Idaho. American bullfrogs live in larger bodies of quiet water and are voracious feeders. In the Northwest they have so far been unable to invade colder, higher elevation waters. However, in the Bitterroot Valley, bullfrogs have virtually wiped out native amphibians from the low valley ponds and wetlands. Bullfrogs have been implicated in extirpations of native frogs and turtles, and declines in waterfowl production as they often consume ducklings (MNHP 2018).

2.2.3.4 Invertebrates

TERRESTRIAL

Bumblebees are commonly seen around the reservoir and Kootenai River gathering pollen and nectar from flowering understory shrubs and forbs. Three species have been documented within the past five years: two-from bumble bee (*Bombus bifarius*), fuzzy-horned bumble bee (*Bombus mixtus*) and the half-black bumble bee (*Bombus vagans*) (MTNHP).

The meadow slug (Deroceras laeve) and the subalpine mountainsnail (Oreohelix subrudis) have been reported near Libby Dam (MNHP 2018). Common terrestrial invertebrates include ants, termites, grasshoppers, crickets, and beetles (Bug Guide 2018).

AQUATIC

The Kootenai River from Libby Dam to the Idaho state line continuing downstream towards Bonners Ferry, Idaho, can be classified as a Large Intermountain Glaciated Valley River type. This Aquatic Ecological System has diagnostic aquatic macroinvertebrate species characterized by main channel, fast current stonefly and caddisfly species: giant salmonfly (*Pteronarcys californica*), golden stone (*Hesperoperla pacifica), Brachycentrus americanus, Arctopsyche grandis, Hydropsyche, Glossosoma, Lepidostoma* and the tipulids: *Hexatoma and Antocha*. Mayflies are diverse in this system and contain many genera, including: *Baetis, Ephemerella, Serratella, Rhithrogena, Drunella and Epeorus* (MNHP 2018).

As the Kootenai becomes sediment-impaired, degraded or dewatered, the waters warm and the macroinvertebrate communities shift to mayfly (*Baetis tricaudatus* and *Plauditus sp.*), caddisfly (*Brachycentrus sp*. and *Amiocentrus aspilis*), beetle (*Optioservus sp., Narpus sp.* and *Lara sp.*) and dipteran species. Additional indicator species include net-spinning caddisflies (*Hydropsyche),* snail-cased caddisflies *(Helicopsyche borealis),* and black flies *(Prosimulium*)

(MNHP 2018). These macroinvertebrates support large bodied sucker, trout, and minnow species.

A diversity of dragonflies, darters, and meadowhawks occur on Lake Koocanusa. These species include the white-faced meadowhawk (*Sympetrum obtrusum*), striped meadowhawk (*S. pallipes*), black meadowhawk (*S. danae*), variegated meadowhawk (*S. corruptum*), Canada darner (*Aeshna canadensis*), paddle-tailed darner (*A. palmata*), black-tipped darner (*A. tuberculifera*), shadow darner (*A. umbrosa*) and the zigzag darner (*A. sitchensis*).

Populations of the pearlshell mussel have been reported in the Kootenai River, but populations may be in decline due to the loss of their native host fish the Western Cutthroat Trout (MNHP). Signal crayfish occur in the tributaries.

The virile crayfish (*Orconectes virilis*) is native to eastern Montana but has been invading westward. They are found in permanent bodies of water deep enough not to freeze solid or experience low oxygen levels. The non-native species have been included on the Global Invasive Species database due to their impacts on native species. There is the potential for other non-native crayfish to be introduced into the Lake Koocanusa and the Kootenai River. These species include the rusty crayfish (*Orconectes rusticus*) and red-swamp crayfish (*Procambarus clarkii*).

2.3 ALBENI FALLS DAM AND PEND OREILLE LAKE

2.3.1 Study Area

The study area used to describe the existing conditions and assess the range of potential impacts for wildlife and habitat features includes lands associated with the Albeni Falls Dam and includes Pend Oreille Lake and immediately upstream into the Clark Fork River where it enters the lake, along with the reach from Albeni Falls Dam downstream to the top of the maximum pool at the upstream extent of Frank D. Roosevelt Lake (formed by Grand Coulee Dam). Much of Pend Oreille Lake is surrounded by the Idaho Panhandle National Forests. Habitat types in the study area are described above in the introduction summarized in Table 2-2. Wetland communities comprise about 22 percent of the Albeni Falls study area and 4 percent of Pend Oreille lake shoreline.

The Clark Fork-Pend Oreille River Basin is a mountainous area dominated by conifer forests, situated mainly in western Montana but also in portions of northern Idaho, northeastern Washington, and two small areas in British Columbia, Canada (Figure 2-3). The basin comprises a total area of 25,960 square miles, of which 24,200 square miles are upstream of the Albeni Falls Dam. Approximately 80 percent of the basin area is covered by coniferous forests. At higher elevations (above 3,600 feet), mature forests are dominated by Douglas fir, western redcedar, western hemlock, subalpine fir, grand fir, and western white pine. At lower elevations, ponderosa pine, lodgepole pine, and western larch dominate.

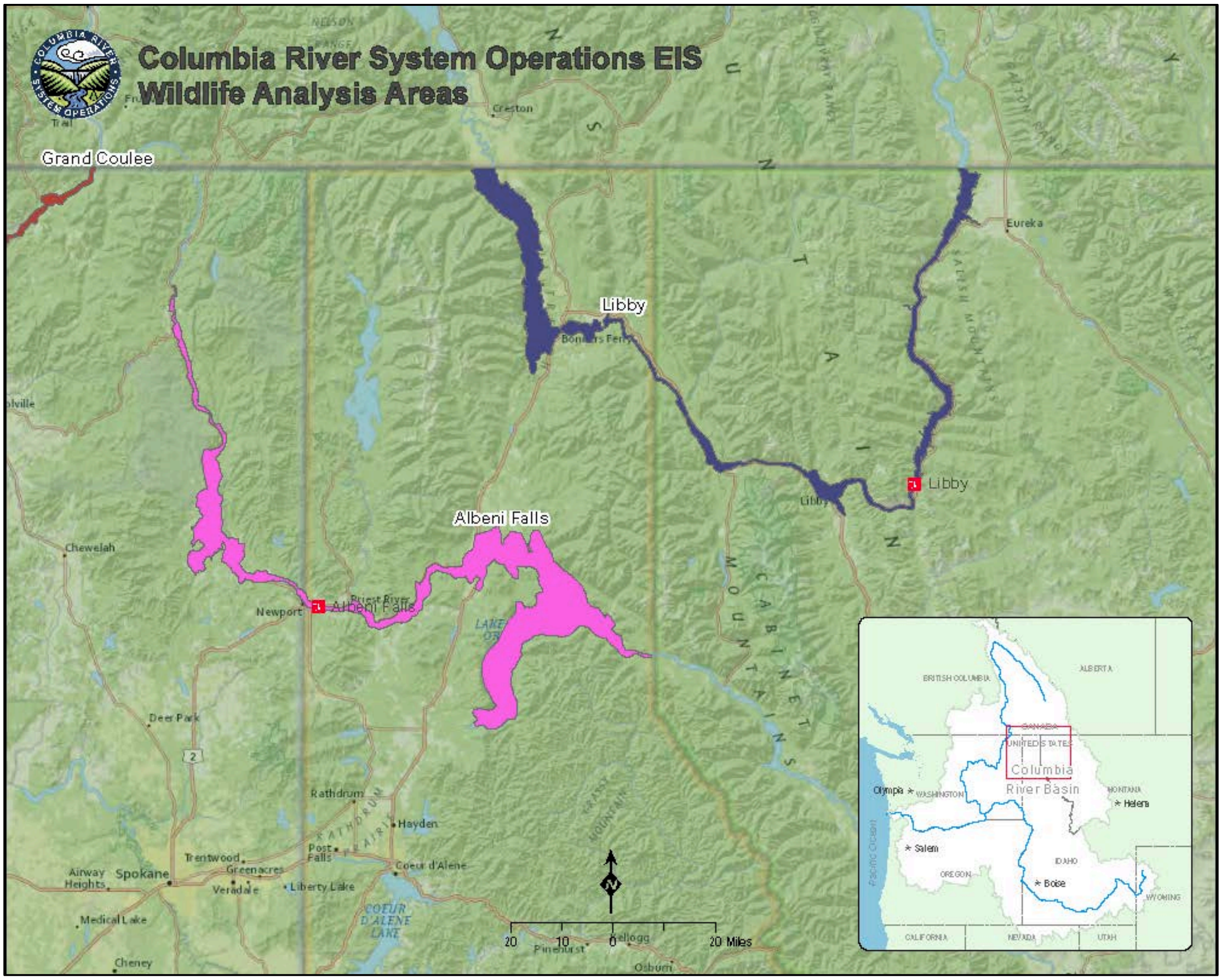

Figure 2-3. Albeni Falls Dam and Pend Oreille Lake

Lake Pend Oreille is a natural lake. Though construction of Albeni Falls Dam did not raise the level of the lake over natural elevations, operations of the dam have dramatically changed the natural environment of the lake by altering hydrology.

At the summer lake elevation of 2062.5 feet the shoreline is heavily influenced by humans. This includes the presence of human-made structures such as retaining walls, riprap bank protection, boat ramps, and imported sand beaches. In these areas, vegetation includes lawns and ornamental plantings. Some portions of the shoreline remain in a more natural condition and include features such as native rock or gravel bars, and herbaceous and forested wetlands. These natural areas may be particularly sensitive to fluctuations in lake level.

Nine Wildlife Management Areas are located along the shores of Pend Oreille Lake or on tributaries immediately upstream of the lake and within the study area. A list of these areas and their terrestrial, water and total acreage is provided in Table 2-2. No USFWS or State Fish and Game lands are located in the immediate vicinity of the lake. The 4,046 acres of project lands at Pend Oreille Lake that are licensed for wildlife management to the Idaho Department of Fish and Game (IDFG) are largely wetlands, consisting primarily of wet meadows, shallow marsh, deep marsh, and submerged aquatic beds (USACE 2017).

Table 2-2. Wildlife Management Areas at Lake Pend Oreille (Carlisle and Miller 2015)

Property	Terrestrial Acreage	Water Acreage	Total Acreage
Priest River WMA[1]	51.1	86.3	137.4
Riley Creek WMA[1]	78.4	120.1	198.4
Strong Island WMA	18.9	11.8	30.7
Hoodoo Creek WMA	47.8	34.2	82.0
Morton Slough WMA and Morton Slough Access Area	98.3	303.6	401.9
Hornby Creek WMA	9.2	21.7	30.9
Ponder Point WMA	5.1	0.5	5.6
Pack River WMA	126.8	1,247.1	1,374.0
Clark Fork WMA	573.7	735.5	1,309.2
Totals	**1,093.2**	**2,588.9**	**3,682.0**

[1]Includes associated Recreation Area acreage.

2.3.2 Land Cover

Table 2-2, above, shows the acres of the different habitat types within the Albeni Falls Dam study area.

2.3.2.1 Uplands

At lower elevations, including near the water's edge, ponderosa pine (*Pinus ponderosa*) and western larch (*Larix occidentalis*) dominate, with western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), and grand fir also prevalent. Northern Idaho coniferous forests are highly diverse and typically include multiple coniferous species, along with deciduous species in many areas. Common deciduous trees in the area include paper birch (*Betula papyrifera*), aspen *(Populus tremuloides*), willow (*Salix* spp.), black cottonwood (*Populus balsamifera* ssp. *Trichocarpa*), and red alder (*Alnus rubra* Bong.). Most of the forests around Pend Oreille Lake are second growth, ranging from 15 to over 100 years old. Forest understory is well established in open canopy forests. Alder, hawthorn (*Crataegus* spp.), snowberry (*Symphoricarpos albus*), dogwood (*Cornus sericea* L.), and service berry (*Amelanchier alnifolia*) predominate. These areas are important nesting and feeding habitats for numerous large and small birds and mammals (USACE, Seattle District 2017). Most of the forest in the study area is second growth and most of the forested area is grazed by livestock. About one-fourth of the basin area is devoted to farming.

Terrestrial non-native invasive plants are also present along the shoreline and in the vicinity of the lake. Common plants include: yellow devil hawkweed (*Hieracium floribundum*), diffuse knapweed (*Centaurea diffusa*), spotted knapweed (*Centaurea bierbersteinii*), dalmation toadflax (*Linaria dalmatica*), yellow hawkweed (*Hieraceium pretense*), sulfur cinquefoil (*Potentilla recta*), bull thistle (*Cirsium vulgare*), Canada thistle (*Cirsium arvense*), and St. Johnswart (*Hypericum perforatum*).

2.3.2.2 Barren Zone/Drawdown Area

The Pack River delta and the Clark Fork River delta are barren during the winter drawdown period. In addition, much of the shoreline in the northern portion of the lake is exposed and barren during the drawdown. Soils of the Clark Fork delta are sandy. The remainder of the barren areas of the lake are primarily fine-textured. Recent soil stabilization, increased elevation, and planting efforts in Clark Fork River delta have focused on restoring ecosystem health. The delta will be discussed further under Riparian Habitat.

Wave and wind erosion have had dramatic effects, particularly in areas where shoreline vegetation has been lost. Seasonal fluctuations may be the greatest cause of erosion, resulting in sloughing of banks that become waterlogged in summer, then collapse under their own weight as the reservoir drops in elevation.

2.3.2.3 Wetlands – Forested and Scrub-Shrub

More moist conditions exist along lands immediately adjacent to the Lake. Reflecting this, the composition of the surrounding forest shows areas with significant inclusions of deciduous trees. Common deciduous trees in these forests include paper birch, aspen, willow, black cottonwood, and red alder. Shrubs include various willows and red-osier dogwood. There are approximately 24,300 acres of Forested and Scrub-Shrub wetlands, of which approximately 1,400 are Eastside Riparian Wetlands.

Some areas along the shore are wetlands dominated by trees and/or shrubs. Typically called a swamp, wooded wetland, or forested wetland. This includes portions of the Clark Fork delta, which has been the focus of soil stabilization and rehabilitative planting with native trees, shrubs, and herbaceous plants for ecological restoration. The soils are saturated during the growing season and at certain times of the year standing water is common. Waterlines are visible on the trunks of trees and rocks. Common woody plants include western red cedar black cottonwood, and paper birds. Shrubs include common snowberry, red-osier dogwood, Sitka alder, and Wood’s rose.

2.3.2.4 Wetlands – Emergent Herbaceous

Wetlands occur throughout the shoreline of Pend Oreille Lake and comprise about 4% of the landcover, most of which are on ACOE project lands. As discussed above, roughly 3,780 acres of the project lands are licensed for wildlife management to the IDFG. An extensive discussion of wetland habitat and vegetation around the Lake can be found in the 1983 Albeni Falls Dam EIS. In general, functional wetlands around the lake, including in the Clark Fork Delta, have largely disappeared from elevations between 2062.5 and 2055 feet due to holding the summer lake elevation to 2062.5 for several months.

Wetlands that still exist between 2051 and 2056 feet elevations are the lacustrine, littoral type. Native species likely to occur within this band include Chara (*Char*a sp.), northern watermilfoil (*Myriophyllum sibiricum*), coontail (*Ceratophyllum demersum*), elodea (*Eloda Canadensis*), leafy pondweed (Potamogeton foliosus) and other native pondweeds (*Potamogeton* and *Stuckenia* spp.). Wet meadows may be populated by sedge and rush, shallow marsh commonly supportcattail and reed canary grass, and deep marsh may containwater lily.

Flowering rush is an emergent aquatic perennial considered an invasive noxious weed. This species was first confirmed in the lake in 2008, covering nearly 12 acres at the Clark Fork Driftyard. In 2011, the plant had increased its extent to approximately 20 acres in the Clark Fork Driftyard area. Other smaller infestations exist around the lake and the Pend Oreille River. It is found in riparian zones, wetlands, and aquatic environments to depths of about 13 feet, including a few plants found in Oden Bay (Hull 2011). Transport through water and ice have been identified as important dispersal mechanisms for flowering rush (Eckert et al. 2003). It probably originated from sources upstream as most of the upstream water bodies have substantial populations of rush within the largest population in Flathead Lake (Parkinson et al. 2010). Fluctuating lake water levels and, in particular, drawdowns that expose unvegetated sediments provide ideal sites for its establishment (Delisle et al. 2003). Therefore, existing Albeni Falls Dam operations, especially during spring refill and fall drawdown, likely contribute to the spread of flowering rush around the lake.

Numerous wetlands exist downstream of Albeni Falls Dam. These areas are periodically inundated at higher river flows. As discharge varies, wetlands, particularly littoral wetlands, may alternatively be dewatered and inundated. In the study area, there are approximately 20,300 acres of emergent herbaceous wetlands.

2.3.2.5 Water

There are approximately 106,067 acres of open water in the study area. Lake Pend Oreille is one of the largest and deepest natural lakes in the United States. In shallower portions of the lake submerged aquatic beds cover roughly 8,000 acres. The beds are dominated by chara (*Chara* spp.) and stonewort (*Nitella* spp.), and also include pondweed (*Potamogeton* spp.) and arrowhead (*Saggitaria latifolia*).

Pend Oreille Lake and River upstream of Albeni Falls Dam are impacted primarily by two invasive aquatic plants, Eurasian watermilfoil (*Myriophyllum spicatum*) and flowering rush (*Butonmus umbellatus*). These plants are discussed in greater detail below. Curly-leaf pondweed (*Potamogeton pseudacorus*) is also present (Lake Commission 2018). In some herbaceous wetlands around the lake, yellow-flag iris (*Iris pseudacorus*) and reed canarygrass (*Phalaris arundinacea*) are present. These introduced invasive species outcompete and displace the native vegetation.

Eurasian watermilfoil is a rooted perennial dicot and is considered an invasive noxious weed. Watermilfoil was identified in the Pend Oreille River upstream of Albeni Falls Dam in 1992 (Dupont and Bennett 1993). It is currently located in most bays throughout the lake and numerous areas along the shoreline of the Pend Oreille River. Eurasian watermilfoil has been found at depths of 3 to almost 30 feet, with most at 6 to 25 feet (Madsen and Wersal 2008). It is primarily spread through the water (the plant is easily broken and the floating parts can easily re-establish at other locations). Eurasian watermilfoil can be killed by freezing and desiccation (i.e. by exposure of the substrate above water in winter).

2.3.2.6 Islands

Islands in the deeper parts of Pend Oreille Lake are all composed of rock. Over geologic time these rock islands have become forested, primarily by coniferous trees. They are characterized by having steep slopes rising abruptly out of the water. The forests are all rather small, generally less than a few acres with the exception of Warren Island, which is close to 80 acres in size. By contrast, the delta areas (i.e. Clark Fork, Pack River, Priest River) have relatively large, low-lying islands composed mainly of river sediments, and dominated by broad-leaved deciduous trees (for list of species see riparian vegetation, this section). In addition, except where stabilized by recent restoration efforts, these islands are rapidly being eroded by the high summer lake levels, due to seasonal fluctuations, and to wind and wave action along the island shorelines. Approximately 1,000 acres of islands occur in Lake Pend Oreille, including the Clark Fork delta.

2.3.3 Wildlife

2.3.3.1 Birds

A large number of birds, some of which are permanent residents, are found in and around the lake, which is a major stopover area for migratory waterfowl in both spring and fall. Some species of waterfowl and bald eagles overwinter on the lake because the lake does not freeze over its entirety. Numerous species of birds, including upland gallinaceous birds, and birds of prey, nest near the lakeshore (Carlisle, et al. 2015).

Surveys conducted from August 2014 to June 2015 resulted in detection of 157 bird species. During the June surveys, 3,383 individual birds of 113 species were identified. The ten most abundant species were Canada goose, common yellowthroat, song sparrow, yellow warbler, cedar waxwing, tree swallow, California gull, red-eyed vireo, willow flycatcher, and gray catbird. During the June 2-15 aquatic transect surveys, 399 birds of 27 species associated with aquatic/wetland habitats. The ten most abundant species were Canada goose, Ring-billed gull, western grebe, great blue heron, California gull, osprey, spotted sandpiper, mallard, bald eagle, and double-crested cormorant.

Overall bird density was comparable across regions and primary habitat types. Several species were more abundant in either the eastern or western regions as well as in certain primary habitats. For example, most individual species showed a higher density in the eastern half of the area whereas black-capped chickadee, brown-headed cowbird and cordilleran flycatcher were found in higher densities in the western half.

RAPTORS

Turkey vulture is among the most common raptor observed at Lake Pend Oreille. Bald eagles and osprey are relatively numerous. Other species observed include: Peregrine falcon, Swainson's hawk, Northern harrier, Cooper's hawk, red-tailed hawk, and American kestrel. Five species of owl have been observed near the Lake: Northern pygmy owl, barred owl, Western screech, Northern saw-whet owl, and great horned owl.

Owls and hawks nest in riparian trees and open woodlands, and hunt small birds and mammals in forested areas and open grasslands. Riparian cottonwood areas and nearby evergreen forests are important nesting habitats for the osprey, whereas shallow water habitats are of particular importance as foraging areas. The osprey is an area resident from mid-March through October. Bald eagles winter in large numbers around the lake from October through March. The perch in tall trees and snags in riparian habitat or on surrounding hillsides. Their major food sources are spawned kokanee salmon, weakened waterfowl, and carrion.

WATERBIRDS, SHOREBIRDS AND WATERFOWL

During surveys conducted in 2014 and 2015, 21 species of waterbird were observed at Lake Pend Oreille (Carlisle, et. al. 2016). Among these are various grebes, gulls, coots, American avocet, great blue heron, American white pelican, double-crested cormorant, and American bittern. Great blue herons are a resident species and may nest near the lake, preferring a large riparian cottonwood grove in the Clark Fork Delta. Although several species of gulls have been reported in the area, but most are noted as migrants or uncommon summer residents.

Eleven species of shorebird have been observed at Lake Pend Oreille. These include various sandpipers, plovers, and Virginia rail. The largest shorebird populations occur during migration, with the greatest concentrations occurring in spring when the shoreline mudflats are most extensive and northward migrating shore birds pass through. Nesting species include killdeer and spotted sandpiper.

Lake Pend Oreille supports large flocks of migratory and resident waterfowl, especially in the deltas. Twenty-five species of waterfowl, including Canada goose, tundra swan, mallard, pintail, redhead, three species of teal, American wigeon, and wood duck, are prominent. Lake Pend Oreille is a major spring and fall stop for migratory waterfowl of the Pacific Flyway. The fall and winter waterfowl surveys conducted by IDFG indicate numbers of duck and Canada geese peak each year in November at an estimated 24,000 ducks and 2,200 geese. Concentrations of redhead ducks, which use (principally) Oden Bay through early winter, have numbered as many as 17,000 birds, estimated by IDFG to be almost 98 percent of the statewide count and approximately 20 percent of the total Pacific Flyway redhead population. The concentrations at Oden Bay are believed to be due to extensive stands of chara and nitella (benthic algae), on which they feed.

While most waterfowl species are migrants or winter residents only, several species of ducks (including mallard, American wigeon, and three species of teal), and the Canada goose nest on and around the lake. Permanent and summer resident 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 shallow water and abundant food supply make the principal areas at Morton Slough, Pack River, Oden Bay, Hoodoo Creek, and Clark Fork River. Ellisport Bay, Sandpoint Bay, and the Pend Oreille River between the Highway 95 long bridge and Dover Peninsula particularly attractive for resting and feeding by both resident and migratory waterfowl.

PASSERINES

Eighty four species of passerines have been observed at Lake Pend Oreille. Nesting species in riparian habitats and delta islands include warbling vireo, yellow warbler, common yellowthroat, thrushes, swallows, bobolink, and numerous others. Red-winged blackbirds, long-billed marsh wrens, American bitterns, and sora rails are the most common breeding passerine species in marsh areas. The mix of species in coniferous forests differs. Common species include red-breasted nuthatch, solitary vireo, yellow-rumped warbler, golden-crowned kinglet, western tanager, and many others. Wintering passerine species are Jess abundant and include ravens and dippers. While not classified as Passerines, five species of woodpecker have been observed at Lake Pend Oreille, as well. These are hairy woodpecker, downy woodpecker, northern flicker, pileated woodpecker, red-napped sapsucker. Downy woodpecker is known to nest in riparian habitats and delta islands

GALLINACEOUS BIRDS

These birds generally prefer upland habitats for food, cover, and nesting, but may be found in riparian cover as well. Gallinaceous birds occurring near Lake Pend Oreille include ruffed grouse, mourning dove, rock pigeon (not native), California quail, Merriam's turkey, and the Eurasian collared-dove (not native). Blue grouse are abundant at higher elevations (Carlisle et al., 2016).

2.3.3.2 Mammals

TERRESTRIAL

Large mammals in the vicinity include elk, moose, mule and white-tailed deer, mountain goat, bighorn sheep, and black bear. Coyotes, fox, lynx and badger have been identified in the forests around the lake. The large mammal species generally spend their summers in the forested mountains and come to lower elevations in the winter months, but they have been reported in areas around Lake Pend Oreille at all times of year. White-tailed deer spend both summer and winter seasons in forested and open lands near the Lake and prefer habitat in the Clark Fork and Pack River Deltas. Mountain goats winter in small numbers on the hills and bluffs bordering the lake near Bay View at the extreme southern end of the lake. A sparse population of grizzly bear and mountain lion is also present in the Lake Pend Oreille region. Raccoon, Marmot, mink, and weasel are found in the area, as are shrew, mice, squirrels, and rabbits. Idaho University professor Barry Keller reported populations of Townsend's big-eared bat near Lake Pend Oreille during the summer (Minard 2000). Other bats are expected to be present in the study area.

AQUATIC

Aquatic mammals including beaver, river otter, muskrat, and mink may be found in study area. The river otter is uncommon, and beaver, muskrat, and mink are not abundant. Beaver activity is higher in slough and river areas than in the Lake. Muskrat are found primarily at the Pack River Delta. Mink den in riparian habitats and along tributary drainages, but forage chiefly in marsh areas.

2.3.3.3 Reptiles and Amphibians

The variety of aquatic, riparian and upland habitats supports several species of reptiles and amphibians but in numbers notably less than in warmer regions of the United States. According to the IDFG, approximately 14 species live in the northern Idaho Panhandle Region (IDFG 1994). Of the reptiles, there are several species of lizards, non-poisonous snakes, and native painted turtle (*Chrysemys picta*). Amphibians common in the area are Pacific chorus frogs (*Pseudacris regila*) and western toads (*Bulo boreas*), both of which live near water. Other amphibians in the area are Pacific tree frog, leopard frog, Pacific giant salamander, tiger salamander, tailed frog, long toed salamander (*Ambystoma macrodactylum*), and Coeur d'Alene salamander (*Plethodon idahoensis*). Populations of painted turtles, western skink and alligator lizard, rubber boa, gopher and garter snakes are present in numbers notably less than in warmer areas of the United States. Invasive bullfrogs are present at the Lake.

2.3.3.4 Invertebrates

Common insects present in the study area include dragonflies, mosquitos, butterflies and moths. Asian clams (*Corbicula fluminea*) are present in Ellisport Bay (near the town of Hope) and Sam Owen. This infestation has the potential to expand or be transported via boat to another parts of the lake. There is also an invasive crayfish that has spread down from the Clark Fork River (Lakes Commission 2018). At this time zebra mussels (*Dreissena polymorpha*) and quagga mussels (*D. rostriformis*) have not been reported in the Columbia River system.
The Corps conducts surveys (veliger sampling) in the reservoir, and the Idaho State Department of Agriculture conducts boat inspections to monitor for thes species.

2.4 GRAND COULEE DAM AND LAKE ROOSEVELT

2.4.1 Study Area

The study area used to describe the existing conditions and assess the range of potential impacts for wildlife and habitat features includes lands associated with the Grand Coulee Dam and the maximum pool at the upstream extent of Frank D. Roosevelt Lake (Figure 2-4). Grand Coulee Dam forms Franklin D. Roosevelt Reservoir, a 151-mile long lake with 660 miles of shoreline and a surface area of more than 82,000 acres at full pool (elevation 1,290 feet) (USBR 1977; 1984). The study araea includes the reservoir up to the Canada/US border, and the river reaches influenced by the Project, including the lower reaches of the Sanpoil River (nine miles), Spokane River (32 miles), Colville River (two miles). Kettle River (11 miles), and about 20 to 30 miles of other tributary streams, (USBR 1976). Land cover, vegetation, and habitat types in the study area are identified in Table 1-2.

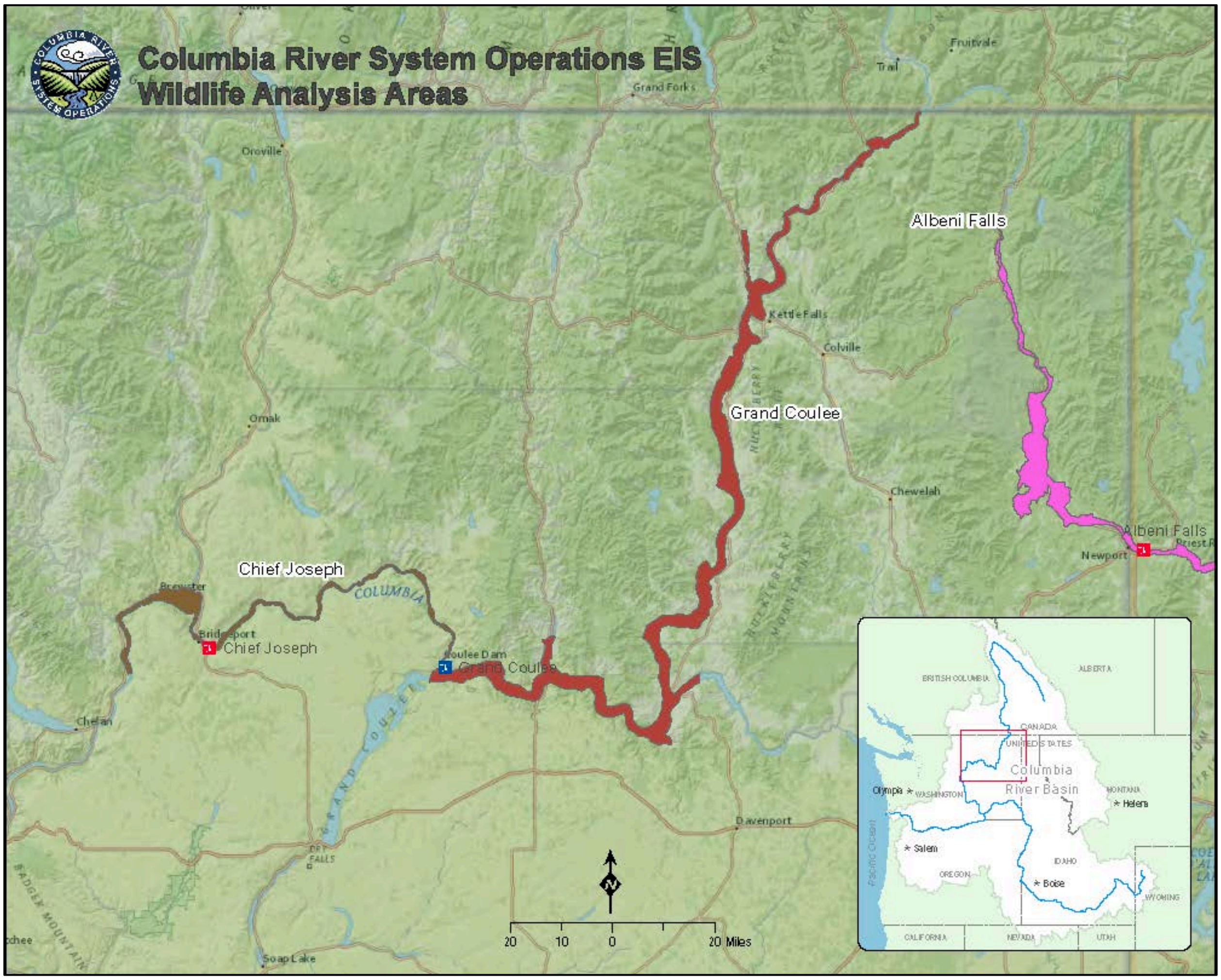

Figure 2-4. Grand Coulee Dam and Lake Roosevelt

Roosevelt Lake is noteworthy for its history of landslide activity along many miles of reservoir shoreline (Jones and Peterson, 1961). The annual cycle of soil saturation, followed by extensive drawdown and lesser short-term fluctuations, has led to continued erosion and slumping of the soil mantle on steeper slopes prevalent in this major river canyon. The steep, unstable shoreline substantially limits habitat development and use by wildlife (Creveling and Renfrow, 1986).

2.4.2 Land Cover

Table 1-2, above, shows the acres of the different habitat types within the Grand Coulee Dam study area.

2.4.2.1 Uplands

The extensive Roosevelt Lake environment overlaps two very different ecological and physiographic zones (USACE et al., 1995)). The southern reaches of the reservoir are in the Columbia Basin (Franklin and Dyrness, 1973) and are characterized by shrub-steppe vegetation. Northern reaches, which extend to the Canadian border, lie within the Okanogan Highlands and are characterized by forest vegetation. The area and vegetation are further described in USACE et al. 1995.

The lower (southern) reach of Roosevelt Lake from the dam (RM 596) to RM 634 is shrub-steppe and runs east-west, generally with bitterbrush communities on north-facing slopes and sagebrush communities on south-facing slopes. Rabbitbrush is common in much of this area. Between RM 634 and 675, the reservoir runs north-south and ponderosa pine and bitterbrush are characteristic, with serviceberry on dry sites and redstem ceanothus in moist areas and on north-facing slopes. From RM 675 to 706, the vegetation can be characterized as open stands of ponderosa pine/pinegrass habitat, with Douglas-fir and ponderosa pine occurring on north-facing slopes. Bitterbrush occurs in the lower part of this reach, but not in the upriver portion. Canyon slopes are heavily vegetated with redstem and evergreen ceanothus and serviceberry. Rogers (1941) describes the upper reach (RM 706-745) forest as largely second growth ponderosa pine, Douglas-fir and western larch, with a grass shrub understory. Sumac is abundant in some sites. Nearer the Canadian border, there is a mixed forest of paper birch, aspen, lodgepole pine, and Douglas-fir.

2.4.2.2 Barren Zone/Drawdown Area

Acreage of exposed, unvegetated soil present at different drawdown levels can be calculated from an elevation/acreage model for the project.

Widlife and wildlife habitat along the reservoir shoreline are influenced by project operations and level of drawdown.

The average inshore slope below full pool and upper reaches of the reservoir are relatively gradual (5 to 8 degrees), but varies substantially from site to site and decreases in an upstream direction. However, nearer to the dam the area below full pool becomesteep (approximately 45 degrees). More gradual sloped areas may become exposed mudflats or wetlands during drawdown of the pool.

2.4.2.3 Wetland - Forested and Scrub-Shrub

Roosevelt Lake lacks extensive riparian habitat. With few exceptions the pre-impoundment riparian vegetation at Grand Coulee, especially large-branched deciduous trees of high wildlife value, has not been re-established on the shoreline of the reservoir (USACE et al. 1995). Based on habitat mapping, there are 764 acres of Forested and Scrub-Shrub wetlands in the study area, inclusive of riparian and coniferous wetlands.

Dry climate, reservoir drawdown, wave action, steep shoreline slopes and related erosion and landslide activity are principal factors preventing riparian re-establishment (USACE et al. 1995). Reservoir shoreline vegetation is perched well above the water level during the spring drawdown and the early portion of the growing season. As a consequence, despite a moister climate in the northern reaches, riparian areas are typically associated with small streams and spring areas where the source of water is from precipitation, snow melt, or ground water discharge rather than reservoir. These areas are also typically more gently-sloping and protected from erosion forces, and are characterized by silt accumulation. Opportunities to establish further riparian zones at Lake Roosevelt appear limited (USACE et al. 1995).

The primary cottonwood riparian stands occurring in the northern portion of the reservoir are composed of an understory of birch, alder, red-osier dogwood, alder buckthorn, and lesser shrubs such as thimbleberry, poison ivy and Wood's rose (USACE et al. 1995).

The great scarcity of riparian habitat along Roosevelt lake is an indication of the lack of suitable sites, soil conditions and the detrimental effects of the water regime. Based on these problems and projections from the literature and current knowledge, riparian stands are probably in relatively stable condition at present, with no evidence of expansion.

2.4.2.4 Wetlands – Emergent Herbaceous

Emergent wetlands are also limited in extent at Lake Roosevelt. They are restricted by the steep shorelines, seasonal drawdowns, and shorter-term fluctuations that also influence other habitat types. There are approximately 360 acres of emergent wetlands within the study area. These occur along the reservoir shoreline primarily in embayments, the mouths of small streams, and in the confluences of larger tributary streams. Areas containing significant wetland types include the mouths of the Colville River and Kettle River and nearby upper reservoir shallows. Most other wetlands are small and scattered in isolated areas such as Mill Creek (Spokane River arm), Big Sheep Creek, Fifteenmile Creek, Onion Creek, Spring Creek, and other sites.

2.4.2.5 Water

At full pool Lake Roosevelt provides 80,000 acres of open water surface area.

Fluctuating reservoir levels in Lake Roosevelt prevents growth of submerged aquatic vegetation. The steeply-sloping nearshore areas in much of the reservoir are another obvious limiting factor (USACE et al. 1995). Although some submerged plant beds are known to establish during extended high water elevations, these are very limited according to local experts.

Approximately 46 acres of shallow water area occur within the study area. This is where submerged plants such as waterweed (*Elodea* sp.) may develop to varying degrees.

2.4.2.6 Islands

There are 28 islands in Lake Roosevelt which provide approximately 130 acres of island habitat Much of the island acreage is classified under NWI as uplands. These areas are commonly the tops of hills or ridges that were isolated by water in the reservoir. The islands support no riparian vegetation (USACE et al. 1995).

Islands were historically important in this area, receiving use by aquatic mammals, shorebirds, waterfowl, and other species. They were particularly important as secure nesting sites for Canada geese and as deer fawning areas. Islands are still important in the reservoir, but their value and use by wildlife is limited by the annual spring drawdown. Vegetation development is inhibited, the barren drawdown zone restricts wildlife use, and some islands become more accessible to predators. There evidently is little Canada goose nesting on remaining islands (USACE et al. 1995).

2.4.3 Wildlife

About 350 species of wildlife are found in the vicinity of Roosevelt Lake (USACE et al. 1995). There are approximately 75 species of mammals, 200 species of birds, 15 species of reptiles and 10 species of amphibians in the Lake Roosevelt area (Lake Roosevelt Forum, 2018). Many of these use the riparian, wetland, and island habitats along the reservoir shoreline for part or all of their life requisites (USACE et al. 1995).

The overall wildlife values of Roosevelt Lake are limited because of the Lake's storage function and substantial seasonal drawdowns which have adversely affected shoreline habitat development and use. Important habitats are generally confined to tributary stream reaches, embayments and backwaters, and islands. Conditions are much less favorable on the main pool where steep, eroding banks are prevalent. Islands are important in part because only 28 remain from a pre-dam count of 114. In general, riparian and wetland habitats exist only as small, scarce units scattered throughout the reservoir.

2.4.3.1 Birds

RAPTORS

Raptors such as: osprey, golden eagle, bald eagle, prairie falcon, red-tailed hawk, northern harrier, and American kestrel (Lake Roosevelt Forum, 2018) are present and fairly common throughout the study area.

Bald eagles are an important reservoir area resource, with a recent wintering population estimate of about 250 birds in the Roosevelt Lake area. Reservoir use appears to be increasing based on winter surveys, and nesting has been increasing from 8 to 24 territories during the time period of 1994 to 2000 (Stinson, et al. 2007). Although the bald eagle is well-known at the reservoir, other raptors such as golden eagle and prairie falcon commonly use cliff sites in the area. There is relatively low use of the shoreline by osprey for nesting.

Several important areas for raptors include:

The lower Kettle River between Barstow and the confluence near Kamloops is generally recognized as an important site for a variety of wildlife species. Its backwater areas and bayous contain riparian stands and shallows with emergent wetland vegetation, which provides for waterfowl, common bald eagle prey, and is a bird concentration area. The Keller area is known for its bald and golden eagle nest sites, and Sterling Valley to Hawk Creek butte which is known for osprey nests. Hawk Creek is also known for its Bald eagle perching sites. Other notable areas for raptors include Whitestone Rock, the Sandpoil River, areas around Gifford Ferry and Kettle Falls.

WATERBIRDS, SHOREBIRDS AND WATERFOWL

Water birds include: mallards, pintails, teal, goldeneyes, redhead canvasback, western grebe, coot, lesser scaup, common merganser, common loon, and Canada geese.

Shorebirds include: plovers, northern killdeer, spotted sandpiper, gulls, snipe, common grebes and yellowlegs (Lake Roosevelt Forum 2018).

Great Blue heron and bank swallow are representative colonial nesting birds at Grand Coulee. Herons use a wide range of habitat types and are a familiar resident at Roosevelt Lake (USACE et al. 1995).

Bank swallows may have benefited from the creation of the reservoir and the increased insect foraging area over water (USACE et al. 1995). Populations of these colonial species are also believed to be relatively stable in numbers, since the reservoir has been in place for many decades.

Shorebird use of Roosevelt Lake is limited and related mostly to the water level during spring and fall migration. Numbers of species may use the lake and surrounding barren zone at that time. Species likely to nest include killdeer and spotted sandpiper (USACE et al. 1995).

While waterfowl use of Roosevelt Lake is noteworthy, the reservoir is not generally considered by local biologists to be a major waterfowl resource management area. Production is substantially limited by the scarcity of islands, wetland habitat, and shoreline usable for waterfowl activities, as well as by the severe spring drawdowns. The most significant use appears to be in open water areas as a resting or wintering area for migrants, however density of wintering ducks is also considered low because of cold winter conditions and lack of adequate food supplies (USACE 1992).

Characteristic waterfowl species or groups identified for Grand Coulee are Canada goose, mallard, and diving ducks such as scaup. Nesting and feeding habitat for geese and mallards is said to be very limited (USACE et al, 1995). Riparian habitat used for duck nesting is in very short supply as are wetlands and other feeding areas. Islands, which are of particular importance as secure nest sites for geese, support little nesting because of their limited occurrence and the drawdown problems of land bridging and barren mudflat formation which lead to predation and restricted use.

Shallower areas in upper reaches and tributaries support some seasonally flooded emergent wetlands that are potential nesting and grazing areas. However, drawdowns are particularly damaging to these areas since islands are more easily bridged and the more gently-sloping shoreline is separated from the vegetation by large expanses of barren soil. In other parts of the reservoir, steep and eroding banks are common place and are a barrier to shoreline use by geese with goslings or duck broods. Waterfowl use of the reservoir is mostly as a temporary stopover during migration periods.

Although riparian and wetland habitat has established slowly at Lake Roosevelt, the reservoir has been in place and under a similar operating regime long enough that these habitats have probably reached a certain degree of equilibrium. There is no information suggesting significant trends in waterfowl use.

PASSERINES

Passerines include swallows, finches, jays, chickadees, kinglets, ravens, magpies, robins, sparrows, blackbirds, and juncos.

The downy woodpecker, red-winged blackbird, and yellow warbler are considered representative of nongame bird species at Roosevelt Lake. They primarily use riparian and emergent wetland habitats potentially impacted by changes in operational water regimes. Their nesting and feeding activities in relation to trees, shrubs, emergent aquatic vegetation, and other factors are important in determining their survival and density at the reservoir.

The Lincoln area is notable for upland species that include Lewis' woodpecker.

GALLINACEOUS BIRDS

Grassland birds include western sage grouse, Columbia sharp-tailed grouse, mourning dove, blue grouse, band-tailed pigeon, pheasant and turkey.

Game birds such as chukar, Hungarian partridge, mourning dove, ring-necked pheasant, and California quail eat a variety of seeds, agricultural grasses (i.e wheat, oats, and corn) and insects. The pheasant and quail are found most commonly near agricultural lands and generally do not venture far into shrub-steppe areas. Upland game birds such as sharp-tailed grouse, ring-necked pheasant, and California quail may also harvest the catkins of willows, alders, and birches, and also eat the new buds. The upper (northern) end of Lake Roosevelt can also support some numbers of grouse such as blue, ruffed, and/or spruce.

2.4.3.2 Mammals

TERRESTRIAL

Large mammals include black bear, elk, mountain lion, whitetail deer, mule deer, and moose. California Bighorn Sheep were recently introduced to the area. Smaller mammals include: beaver, river otter, muskrat, mink, badger, raccoon, skunk, bobcat, coyote, red fox, porcupine, cottontail rabbits, ground squirrels, chipmunks, yellow-bellied marmot, pika, bats, gophers, rats, and deer and house mice.

Representative species of mammals include the porcupine, least chipmunk, yellow pine chipmunk, striped skunk, bushy-tailed woodrat, deer mouse, sagebrush voles, cottontail rabbits, yellow-bellied marmots, bobcats, badgers, coyotes, cougar, and several species of mice, and bats. Most of these are resident in the conifers. Mammals found in the shrub-steppe habitats of the project area (i.e. bobcat, badger, coyote) are predators, feeding primarily on rodents, as well as bird eggs and carrion. Rabbits and marmots eat grasses and herbaceous plants, and in winter may eat bark and twigs of woody plants as well. Marmots are restricted to rocky areas where they can find refuge among the many tunnels in the rocks. Small mammals such as the sagebrush vole and least chipmunk feed primarily on green vegetation (USACE et al. 1995).

Prior to the construction of Grand Coulee Dam, lower elevation areas of the Columbia River corridor were critical winter range habitat for big game. Low elevation areas around the reservoir are important for deer wintering areas, and in some areas, for elk winter range. Riparian or shoreline areas containing deciduous or evergreen trees are used by big game for feeding, fawning, summer and winter thermal cover, and as corridors (USACE et al. 1995).

Big game species are not as dependent as other wildlife species on habitats bordering the reservoir, but may still be significantly affected by habitat losses or changes in human use and disturbance patterns caused by reservoir operation. For these reasons, deer and elk foraging and wintering are considerations when reservoir operations change (USACE et al. 1995).

AQUATIC

The beaver and otter are representative of the aquatic mammals at Lake Roosevelt. This wildlife group must be able to travel between the water body and terrestrial vegetation, and thus can be significantly affected by reservoir operation. The shoreline interface is a critical component of aquatic mammal habitat suitability. Islands are also of importance when present (USACE et al. 1995).

At present, most shoreline at Roosevelt Lake is of little value to aquatic mammals because of its steep ness and instability (erosion), and lack of vegetation. Additionally, drawdown of the reservoir in more gently-sloping areas creates large, barren mudflats which separate water and vegetated shoreline, in creasing the animals' energy expenditure and vulnerability to predation, or even preventing use of an area. Otter can also be affected by loss of aquatic invertebrates such as crayfish, a primary food source (USACE et al. 1995).

Barnaby Island and Barnaby Creek areas near the reservation line are noted for suitable shoreline habitat for species such as beaver, muskrat, and some otter use occurs in and near the mouths of tributary streams (Lake Roosevelt Forum 2018).

2.4.3.3 Reptiles and Amphibians

Reptiles and amphibians found in the Lake Roosevelt watershed include sage brush lizard, western rattlesnake, gopher or bull snake, western terrestrial garter snake, bullfrog, western toad and various salamanders (Lake Roosevelt Forum 2018). In the Colombia River System Operation Review EIS the spotted frog and long-toed salamander were selected as representative species when analyzing potential effects of reservoir operation modifications on amphibians at Roosevelt Lake because these species have both an aquatic larval stage and a terrestrial adult stage (USACE et al., 1995). Very small seasonal ponds and pools can be used by long-toed salamanders and small permanent ponds can be used by spotted frog during breeding season. Increased drawdowns or fluctuations can remove these sources of water that provide oviposition and larval development sites for these and other amphibian species. Other species include western skink and Pacific chorus frog (USACE et al. 1995).

2.4.3.4 Invertebrates

A study conducted by the State Of Washinton's Department of Ecology in 1986 sampled the aquatic macroinvertebrates of Lake Roosevelt and the Colombia River. It found that the vast majority of the invertebrates present were true flies, more specifically the Family Chiromidae. The abundance was fairly low, as was the diversity, as measured by the Shannon Index (Johnson 1991). In studies done by the Bonneville Power Administration, measureing the biota of Lake Roosevelt, a total of 10 benthic macroinvertebrate families from 7 orders were found in the substrate samples from Lake Roosevelt, and a total of 2 benthic macroinvertebrate orders were found in emergence traps (Voeller 1993). These included Diptera, Odonata, Amphipods, snails, clams, worms, and Trichoptera (Voeller 1993)

2.5 CHIEF JOSEPH DAM AND RUFUS WOODS LAKE

2.5.1 Study Area

The study area used to describe the existing conditions and assess the range of potential impacts for wildlife and habitat features extends from just below Grand Coulee Dam downstream below CJD to Wells Dam, located about midway between the communities of Pateros and Chelan (see Figure 2-5). The study area extends laterally out from the midline of the river to include lands adjacent to the Columbia River, CJD, RWL, and the mouths of its primary tributaries. The lateral extent of the study area has been determined based on H&H modeling. The largest of the tributaries are: Nespelem River (the primary tributary that persistently flows into RWL) which enters RWL; Foster Creek, which enters the Columbia River at CJD and Okanogan River, which enters the Columbia River from the north, 5 miles east of Brewster, between the Wells Dam (downstream) and CJD (upstream).

The study area is entirely within the Columbia Plateau Ecoregion. CJD and RWL lie in a steep-sided canyon of the Columbia River valley which ranges in width from two to four miles. The north side of the valley rises sharply to the Okanogan Highlands, 1,000 feet or more above the Columbia River. The south side of the valley rises in a series of terraces and benches climbing to the Columbia Plateau surface. The majority of the shoreline is treeless with a dry land shrub-steppe cover. Numerous canyons and deep draws support isolated stands of pine and deciduous trees and shrubs. Rangeland and irrigated orchards on upland benches and sixteen project wildlife mitigation sites along the lakeshore provide patches of greenery. Table 1-2 identifies the land cover, vegetation, and wildlife habitat types and associated acreages in the study area.

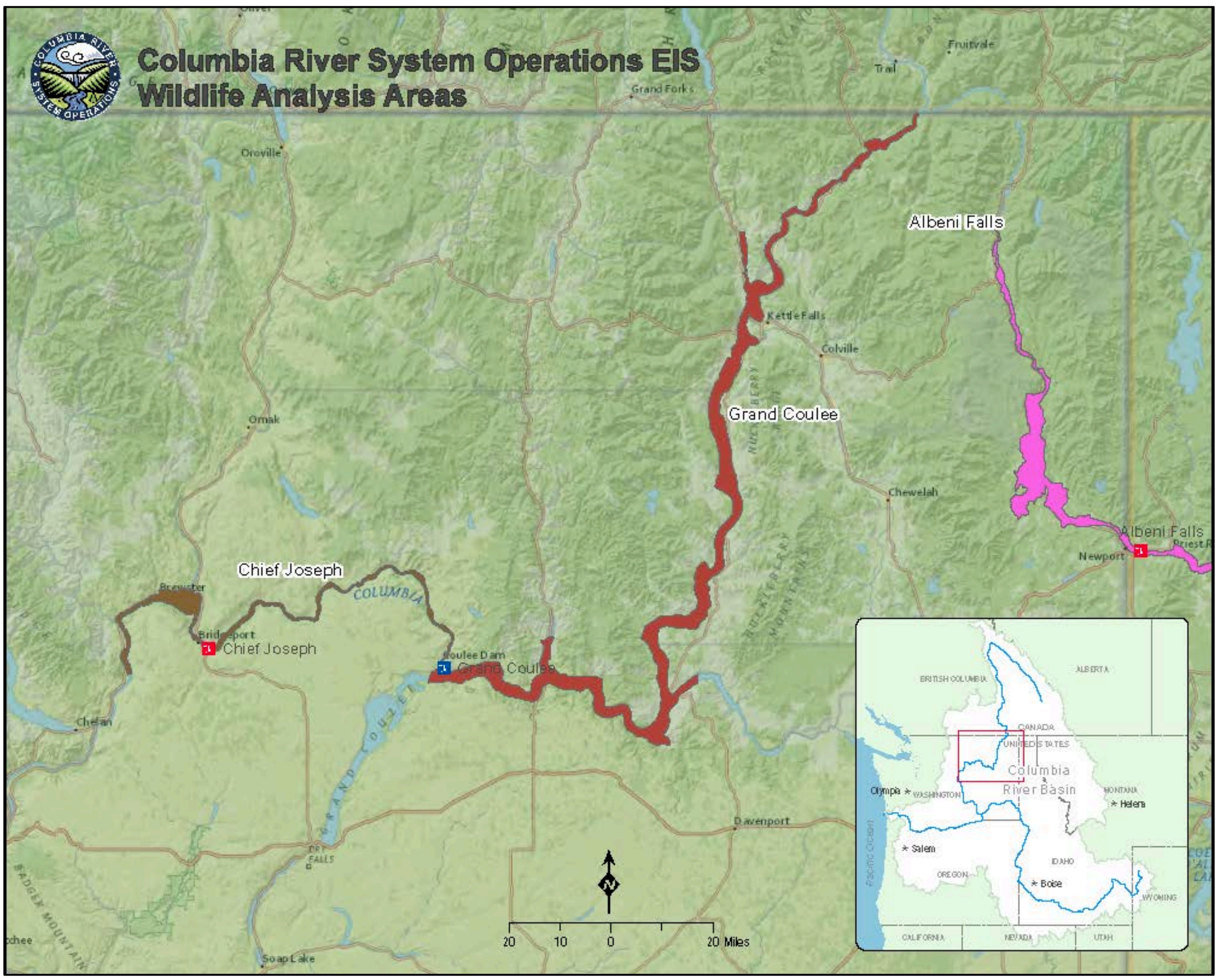

Figure 2-5. Chief Joseph and Rufus Woods Lake Study Area.

2.5.2 Land Cover

2.5.2.1 Uplands

Shrub-steppe habitat is the most extensive cover type along RWL except where interrupted by rock out-crops, drainages, or human development. There are approximately 4,000 acres of shrub-steppe habitat in study area. Shrub-steppe plant and animal species must be capable of dealing with arid conditions and wildfire. Soils tend to be sand to loam-sand and highly vulnerable to wind/water erosion. The shrub component is dominated by big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus nauseosus*), serviceberry (*Amelanchier alnifolia*), currant species (*Ribes* spp.), and antelope bitterbrush (*Purshia tridentata*) while Idaho fescue (*Festuca idahoensis*), Indian ricegrass (*Achnatherum hymenoides*), Sandberg bluegrass (*Poa secunda*), Thurber's needlegrass (*Achnatherum thurberianum*), needle-and-thread (*Hesperostipa comata*), sand dropseed (*Sporobolus cryptandrus*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and bottlebrush squirrel tail (*Elymus elymoides*) make up the primary native grass species. Common forbs include arrowleaf balsamroot (*Balsamorhiza sagittata*), yarrow (*Achillea millefolium*), various buckwheats (*Eriogonum* spp.), blanket flower (*Gaillardia aristata*), various parsleys (*Lomatium* spp.), and lupine species (*Lupinus* spp.).

Ponderosa pine savannah is similar to the shrub-steppe habitat and composed of much the same shrub, grass, forb, and non-native species. However, Ponderosa pine savanna typically occurs where soil is slightly higher. Like shrub-steppe habitat, pine savanna has been identified as a priority habitat in the region due to threats of conversion to farming and other development (IWJV 2005). Along RWL, savannah is mostly found in the upstream extents towards Grand Coulee Dam. There are approximately 30 acres of Ponderosa pine forest in the study area. As the name implies, the primary tree component of this habitat is Ponderosa pine (*Pinus ponderosa*), often with serviceberry (*Amelanchier* spp.), bitterbrush (*Purshia tridentate*), elderberry (*Sambucus* spp.), snowberry (*Symphoricarpos albus*), and Wood's rose (*Rosa woodsii*). The sparse spatial arrangement (low stocking density in the tree and shrub layers) is often maintained by intermittent fire, minimal precipitation, and topography resulting in canopy coverage ranging from 10 to 60 percent. As with forest and scrub-shrub wetlands and emergent herbaceous wetlands, Ponderosa pine savannas can produce and sustain trees and therefore are suitable for the production of snags. WDFW has identified areas with copious and dispersed snags (and logs) as priority habitat. Snags are a unique and important part of the ecosystem. Ants, termites, and other insects colonize dead trees and provide food for woodpeckers and bears. Bats also utilize snags for roosting.

Grasses identified in Section 1.0 Introduction, that are common to disturbed areas are likely present in the CJD study area. Similarly, forested and shrub-shrub wetlands in the study area are expected to include at least some of the introduced invasive species common to these (see Section 1.0). Introduced Russian olive (*Elaeagnus angustifolia*), elms, and yellow-flag iris (*Iris pseudacorusis*) have been documented from the study area (USACE 2015).

2.5.2.2 Barren Zone (Drawdown Zone)

Barren areas are sparse along RWL, due to only one to two foot daily fluctuations. Those barren areas that exist are on the steep slopes that are also areas of chronic erosion. Landslides and erosion are common on the steep canyon walls, which are partially filled with thick deposits of fine-grain sediments. Glacial lake and old landslide deposits tend to slough more easily than other materials, but well-drained sands and gravels tend to be quite stable, even if of considerable height. Several major prehistoric and historic landslides have occurred in the project area. The post-glacial Bridgeport Slide occurred upstream of the project. It is presently administered and monitored by USACE and public access to the area is discouraged. Slides along the upstream portion of RWL became active during the middle and late 1940's. They slowed after 1953, due to lesser tailwater fluctuations, probably as a result of the raised lake levels at Grand Coulee Dam. In 1970, construction for the third powerplant at Grand Coulee precipitated additional sliding. Measures to control those slides are under study by the Bureau of Reclamation. Furthermore, impoundment of RWL has caused slides near Bridgeport State Park and upstream of China Creek (RM 575) on the south bank. Reservoir operation and upland irrigation have resulted in a lesser degree of sloughing along the reservoir periphery. Riprapping to stabilize the slide area is currently being tested.

2.5.2.3 Wetlands – Forested and Scrub-Shrub

There are approximately 660 acres of Forested and Scrub-Shrub in the study area. They occur in areas with permanent or intermittent inundation: draws, seeps, upland depressions, creeks, along the edge of water bodies, and downhill of irrigation runoff.

2.5.2.4 Wetlands – Emergent Herbaceous

Common plants present in local wetlands include cattails (*Typha latifolia*), horsetail (*Equisetum* spp.), bulrush (*Schoenoplectus* spp. or *Scirpus* spp.), and sedges (*Carex* spp.), as well as the majority of species (both native and non-native) found in forested and scrub-shrub wetlands.

Based on mapping for this study, there are approximately 130 acres of Emergent Herbaceous Wetlands in the Chief Joe Dam study area. The fluctuation of Rufus Woods Lake is monitored closely to minimize drastic fluctuations in water levels. Despite this, wetlands have only formed at a few locations, almost always at alluvial fans or at a stream/river confluence.

2.5.2.5 Water

Rufus Woods Lake consists of approximately 18,500 acres of open water. Aquatic vegetation in Rufus Woods Lake is not abundant because the rocky shoreline, steep slopes in many areas, and the water level fluctuations effectively limit available habitat. A narrow band of aquatic vegetation is present along much of the shoreline of the reservoir. Five species of submerged aquatic plants have been observed in the lake, including elodea (*Elodea* spp), Eurasian watermilfoil (*Myriophyllum spicatum*), sago pondweed (*Stuckenia pectinata*), curly leaf pondweed (*Potamogeton crispus*), and watercress (*Nasturtium officinal*e). Excepting watercress, which has been observed only at RM 575.2, these species have been observed the entire length of the lake, from RM 591 downstream. The most abundant aquatic plant in the lake is elodea, and Eurasian watermilfoil is more abundant than sago pondweed and curly leaf pondweed.

Three of the five species of submerged aquatic plants present in the study area are introduced invasive species. These are Eurasian watermilfoil, curly leaf pondweed, and watercress. Some species or elodea are also introduced invasive plants. Sago pondweed, although a native species, is categorized as weedy.

2.5.2.6 Islands

There are several islands in Rufus Woods Lake. Two of them were constructed by USACE as mitigation to replace goose nest sites lost to the pool raise. Most of the islands are small, and are often used by geese for nesting. Buckley Bar, near RM 587, is about 40 acres in size and is wooded with small juniper trees. This island is used by Canada geese and other birds for nesting, and by mule deer for fawning.

2.5.3 Wildlife

2.5.3.1 Birds

In 2015, a study was conducted to record the number of breeding birds at CJD (USACE 2016). Sixty-eight different species were detected during the four consecutive weeks of point counts on the CJD project. The birds were observed in the following habitats: Irrigated, for Riparian, and Shrub-Steppe. Table 2-4 and Table 2-5 denote the habitat generalists and habitat specialists, respectively, observed during the four-week period.

RAPTORS

Raptors common to the CJD study area include Northern harrier, northern goshawk, red-tailed hawk, osprey, American kestrel, merlin, bald eagle, golden eagle, western screech owl, great horned owl (Bentler 2014). Live Ponderosa pines are the primary nesting structures for bald eagles along RWL. Golden eagles can nest in pines; however, they tend to nest in rock cliff faces bordering the lake. Eagles utilize snags for hunting, fishing, or resting. Snags, especially those with a large diameter (≥ 12 inches diameter), also provide nesting locations for the cavity nesting American kestrel.

WATERBEIRDS, SHOREBIRDS AN WATERFOWL

Waterbirds, such as killdeer, spotted sandpiper, great egret, American white pelican, sandhill crane, and great blue heron, Canada goose, common loon, tundra swan (Bentler 2014) are present in the CJD study area. Several waterfowl species including mallard, common merganser, American widgeon, and Canada geese utilize wetlands in the study area for feeding, nesting, cover, and breeding.

PASSERINES

Common passerines in the CJD study area are those that nest near water: yellow-breasted chat, yellow warbler, and eastern kingbird. Western kingbird and finches also utilize pines in eastern Washington for nest building. Other bird species that utilize wetlands in the RWL area for nesting and breeding include the red-winged blackbird and common loon.

GALLINACEOUS BIRDS

Sharp-tailed grouse are found at the edge of pine zones in the CJD study area (Table 2-3 and Table 2-4).

Table 2-3. Generalist avian species recorded in 2015 CJD survey.

Common Name	Scientific name	Common Name	Scientific name
American crow	*Corvus brachyrhynchos*	European starling	Sturnus vulgaris
American goldfinch	*Spinus tristis*	Horned lark	Eremophila alpestris
American kestrel	*Falco sparverius*	House finch	Carpodacus mexicanu
American robin	*Turdus migratorius*	House wren	Troglodytes aedon
American wigeon	*Anas americana*	Killdeer	Charadrius vociferus
Barn swallow	*Hirundo rustica*	Mallard	Anas platyrhynchos
Bewick's wren	*Thryomanes bewickii*	Mourning dove	Zenaida macroura
Black-capped chickadee	*Poecile atricapillus*	Northern flicker	Colaptes auratus
Brewers blackbird	*Euphagus cyanocephal*	Northern rough wing swallow	Stelgidopteryx serripe
Brown headed cowbird	*Molothrus ater*	Red breasted nuthatch	Sitta canadensis
Bullock's oriole	*Icterus bullockii*	Ring-necked pheasant	Phasianus colchicus
California quail	*Callipepla californica*	Red-tailed hawk	Buteo jamaicensis
Canada goose	*Branta canadensis*	Say's pheobe	Sayornis saya
Cedar waxwing	*Bombycilla cedrorum*	Song sparrow	Melospiza melodia
Chipping sparrow	*Spizella passerina*	Tree swallow	Tachycineta bicolor
Cliff swallow	*Petrochelidon pyrrhono*	Violet-green swallow	Tachycineta thalassin
Common merganser	*Mergus merganser*	Warbling vireo	Vireo gilvus
Common raven	*Corvus corax*	Western kingbird	Tyrannus verticalis
Common yellow throat	*Geothlypis trichas*	Western wood pee wee	Contopus sordidulus
Coot	*Fulica americana*	White-crowned sparrow	Zonotrichia leucophry
Dark-eyed junco	*Junco hyemalis*	Yellow rumped warbler	Setophaga coronata

Table 2-4. Specialist species recorded in 2015 CJD Survey, and the habitat associated.

Species Common Name	Scientific Name	Habitat type	Irrigated	Riparian	Shrub-Steppe
Bald eagle	*Haliaeetus leucocephalus*	Wetland, shoreline, Ponderosa pine	X		
Black-headed grosbeak	*Pheucticus melanocephalus*	Hardwood forest, riparian	X	X	
Belted kingfisher	*Megaceryle alcyon*	Wetlands, sandy river banks	X	X	
Brewer's sparrow	*Spizella breweri*	Steppe, grassland		X	X
Common loon	*Gavia immer*	Lakes, bays, oceans		X	
Eastern kingbird	*Tyrannus tyrannus*	Steppe, ag, wetlands, hardwoods	X	X	
Great blue heron	*Ardea Herodias*	Marshes, low elevation irrigated ag	X		
Grasshopper sparrow	*Ammodramus savannarum*	Steppe, grassland			X
Gray catbird	*Dumetella carolinensis*	Riparian, steppe near rivers	X	X	
Hairy woodpecker	*Picoides villosus*	Hardwood forest		X	
Lark sparrow	*Chondestes grammacus*	Steppe, grassland, Ponderosa pine			X
Lazuli bunting	*Passerina amoena*	Riparian		X	
MacGillivary's warbler	*Geothlypis tolmiei*	Low dense undergrowth		X	
Marsh wren	*Cistothorus palustris*	Fresh and brackish marshes		X	
Nashville warbler	*Oreothlypis ruficapilla*	Open mixed woods, edges, bogs	X		
Osprey	*Pandion haliaetus*	Shoreline, artificial structures	X	X	
Red-winged blackbird	*Agelaius phoeniceus*	Riparian, wetlands	X	X	
Rock wren	*Salpinctes obsoletus*	Cliffs, rocks, riparian, steppe near rivers		X	
Spotted sandpiper	*Actitis macularius*	Pebbly shores, ponds, marshes	X	X	
Spotted towhee	*Pipilo maculatus*	Developed, riparian, wetlands	X		
Swainson's thrush	*Catharus ustulatus*	riparian woodlands	X		
Turkey vulture	*Cathartes aura*	Rock outcroppings, open dry forest		X	
Western meadowlark	*Sturnella neglecta*	Grassland, steppe, Ponderosa pine, ag	X	X	X
Western tanager	*Piranga ludoviciana*	Ponderosa pine, hardwood forest	X		
Wilson's warbler	*Cardellina pusilla*	Thickets and trees along streams	X	X	

Species Common Name	Scientific Name	Habitat type	Irrigated	Riparian	Shrub-Steppe
Yellow breasted chat	*Icteria virens*	Riparian, wetland, forest/steppe transition	X	X	X
Yellow warbler	*Dendroica petechia*	Riparian	X	X	

2.5.3.2 Mammals

TERRESTRIAL

Shrub-steppe habitat serves the year-round food, cover, mating, and nesting needs of dozens of wildlife species. The WDFW has identified habitat dominated by forbs and bunchgrasses (eastside steppe) and habitat dominated by bunchgrasses and well-spaced shrubs (shrub-steppe) as a priority habitat. Common species that utilize shrub-steppe include yellow-bellied marmot (*Marmota flaviventris*), and mule deer. Secondary consumers such as badger (*Taxidea taxus*) and coyote (*Canis latrans*) rely on shrub-steppe habitat for prey as well as cover and nesting/denning.

Ponderosa pine savannah exists in the midst of shrub-steppe and is extremely valuable to wildlife. The taller trees and shrubs offer protective cover and shade including areas for mule deer (*Odocoileus hemionus*) fawning. Riparian habitat offers wildlife thermal and protective cover, food, and mild microclimate. The Washington Department of Fish and Wildlife (WDFW) has identified riverine forested and shrub-scrub wetlands as a priority habitat. Forests, such as the ponderosa pine or the riverine forested wetlands also meets many of the year-round food, cover, and reproductive needs of several species, such as mule deer, bobcats (*Lynx rufus*), or even potentially mountain lion (*Puma concolor*).

AQUATIC

Mammals that utilize the river and reservoir waterways include river otter (*Lontra canadensis*) and beaver (*Castor canadensis*).

2.5.3.3 Reptiles and Amphibians

Western Rattlesnake (*Crotalus oreganus*), gopher snake (*Pituophis catenifer catenifer*), common garter snake (*Thamnophis sirtalis*), western terrestrial garter snake *Thamnophis elegans*), yellow bellied racer (*Coluber constrictor mormon*) are all found in eastern Washington, and could utilize the varied habitat at CJD (Bentler 2014). Western fence lizard (*Sceloporus occidentalis*) and common side-botched lizard (*Uta stansburiana*) are also known to be present (Bentler 2014).

2.5.3.4 Invertebrates

Lorquin's admiral butterfly, mourning cloak butterfly, Milbert's tortoiseshell butterfly, two-tailed swallowtail, Western tiger swallowtail, ornate tiger moth, Riding's forester moth, white-lined sphinx moth, are known to occur in the study area (Bentler 2014).

Exotic leafrollers, which are pests of fruit trees and ornamentals, damage trees by rolling and eating leaves, conifer needles, and shrubs, are common throughout eastern Washington. Zebra and Quagga mussels are not here yet, but could easily be introduced from other nearby lakes (WISE 2011).

2.6 DWORSHAK DAM AND LOWER CLEARWATER RIVER

2.6.1 Study Area

The study area used to describe the existing conditions and assess the range off potential impacts for wildlife and habitat features begins at the northeastern-most extent of the reservoir on the North Fork Clearater River and Little North Fork Clearwater River and the lower portion of their tributaries (Figure 2-6). The study area extends from here downstream below Dworshak dam to the confluence of the Snake River at the Washington-Idaho boarder (between the towns of Clarkston and Lewiston). Lands surrounding Dworshak Reservoir are generally steep, therefore, the lateral extent of the study area is relatively small and close to the shoreline of the reservoir. The southwestern-most portion of the reservoir extending downstream to just north of the town of Lewiston is located on the Nez Perce Reservation. The Dworshak and Clearwater fish hatcheries are in the study area. Land cover, vegetation, and habitat types in the study area are summarized in Table 1-1.

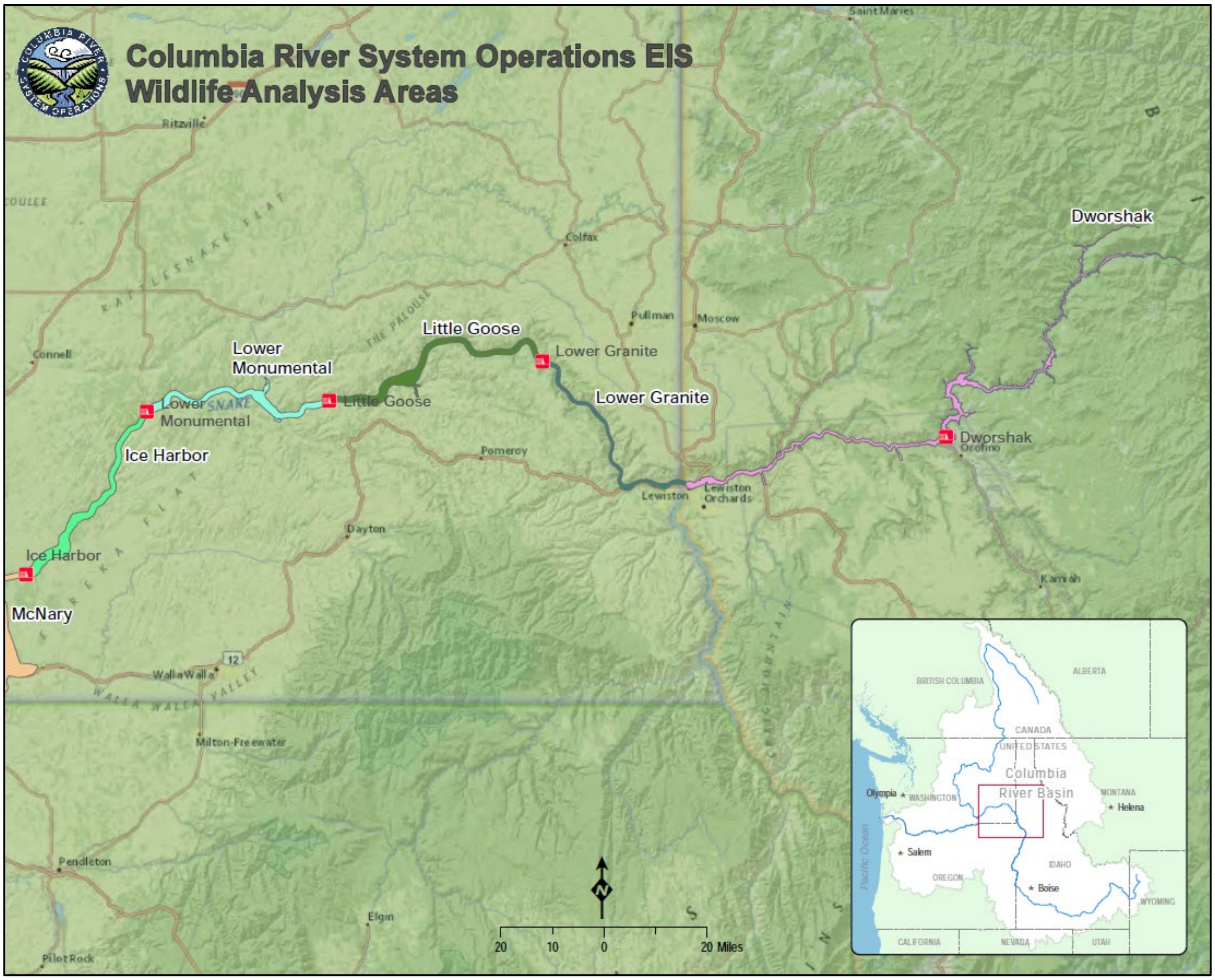

Figure 2-6. Deworshak Dam, Dworshak Reservoir, and Lower Clearwater River Study Area.

2.6.2 Land Cover

2.6.2.1 Uplands

Vegetation surrounding Dworshak Reservoir is primarily dense to open coniferous forest. The lower end of the reservoir is dominated by Douglas-fir (*Pseudotsuga menziesii)* and ponderosa pine (*Pinus ponderosa*) forests. Bunchgrass steppe vegetation extends into the lower reaches of the canyon on the warmer south-facing slopes. Elements of Palouse prairie flora, including several regional endemic species, merge with the moister western red cedar (*Thuja plicata*) forests of the Clearwater Mountains. Major forest cover types include ponderosa pine *(Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), and western red cedar.

The upper end of the reservoir is dominated by Douglas-fir, western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*) forests. North facing slopes contain denser forests than south facing slopes, which contain open ponderosa pine stands, brush fields, and meadows. Dominant shrubs include mallow ninebark (*Physocarpus malvaceus*), oceanspray (*Holodiscus discolor*), mock orange (*Philadelphus lewisii*), common snowberry (*Symphoricarpos albus*), serviceberry (*Amelanchier alnifolia*), and thimbleberry (*Rubus parviflorus*). Grasses include bluebunch wheatgrass (*Pseudoroegneria spicata*), cheatgrass brome (*Bromus tectorum*), Kentucky bluegrass (*Poa pratensis*), orchardgrass (*Dactylis glomerata*), and timothy (*Phleum pretense*). Bracken fern (*Pteridium aquilinum*) is a dominant and aggressive colonizer that occurs throughout the area, typically invading areas that have been disturbed sites.

The Corps conducts vegetation treatments in the study area to create brushfields for increasing winter forage for elk. USACE has an ongoing obligation under the Fish and Wildlife Coordination Act to mitigate for loss of Rocky Mountain elk winter range caused by the creation of Dworshak reservoir. The brushfields are part of the mitigation approach agreed to by Corps, U.S. Fish and Wildlife Service, and Idaho Department of Fish and Game, as presented in USACE' 1977 Design Memorandum No. 15, *Plan for Development of Rocky Mountain Elk Habitat* (DM 15) (USACE 1977).

The forests along the Dworshak reservoir also support many sensitive plant species. These include broad-fruit mariposa (*Calochortus nitdus*), pine broom rape (*Orobanche pinorum*) and western starflower (*Trientalis latifolia*). In addition, Palouse thistle (*Cirsium brevifolium*) and Jessica's aster (*Aster jessicae*) are sensitive species found in dry forests or forest openings. More mesic forests at Dworshak support clustered lady's slipper (*Cypripedium fasciculatum*), inactive tube lichen (*Hypogymnia inactive*), Herre's ragged lichen (*Platismata herrei*). Bank monkeyflower (*Mimulus clivicola*) can be found on rock outcrops within the forests. These species are not dependent on the reservoir water levels.

The lower Clearwater River flows through a canyon that runs primarily east-west, resulting in predominantly trees and shrubs on the north facing slopes and grassland on the south facing slopes. Segments of the river are bounded by either U.S. Highway 12, a local road or a railroad. In many places there is only rock riprap between these transportation corridors and the river. Other segments support woody and herbaceous vegetation, agricultural land, or urban development.

Ponderosa pine and bluebunch wheatgrass has been seriously depleted throughout the lower river by livestock grazing. Only small areas remain on very steep upland slopes or in other areas protected from livestock use. This vegetation type has largely been replaced by Ponderosa pine/cheatgrass association. The community is an open Ponderosa pine forest of sapling to large trees up to 40 feet tall. Understory consists of bluebunch wheatgrass (*Agropyron spicatum*), red three-awn (*Aristida longiseta*,) Idaho fescue (*Festuca Idahoensis*), and sand dropseed (*Sporobolus croptandrus*). This community includes large grass openings with some areas dominated by cheatgrass (*Bromus tectorum*) and large colonies of weeds including bouncingbet (*Saponaria officinalis*), spotted knapweed (*Centaurea maculosa*), yellow starthistle (*C. Solstitialis*), and butter-and-eggs (*Linaria vulgaris*).

Notable invasive plants throughout the study area are cheatgrass brome, Kentucky bluegrass, orchardgrass, timothy, bracken fern, tree-of-heaven, and black locust (*Robinia pseudoacacia*). Black locust is a species that does very well in the canyons and is expected to spread.

2.6.2.2 Barren Zone (Drawdown Zone)

Barren rocky slopes devoid of soil and vegetation are characteristic of Dworshak Reservoir below high pool. Where tributaries enter the reservoir some deltas form and are intermittently colonized by herbaceous wetland plants when conditions permit, but are otherwise bare.

The lower Clearwater River fluctuates about seven feet as measured at the Spalding gauge about 29 miles downstream of Dworshak Dam at the confluence of Lapwai Creek and Clearwater River. The lowest flows are observed in August when Dworshak is still maintained for recreation.

Water level fluctuations along the lower Clearwater River are regulated by outflow from Dworshak Dam. The North Fork of the Clearwater drains roughly 30% of the Clearwater basin. Because most of the flow within the basin is uncontrolled, “normal” spring flooding still occurs to some degree on the lower Clearwater River (Lichthardt 1992). Peak flows occur in May with the spring freshet.

2.6.2.3 Wetlands – Forested and Scrub-Shrub

Aproximately 70 acres of Forested and Scrub-Shrub wetlands surround the reservoir and line the tributaries and springs in the study area. These deciduous forests are dominated by red alder (*Alnus rubra*). The understory is typically an herbaceous layers that may be comprised of the following sensitive species: naked rhizomnium moss (*Tripterocladium leucocladulum*), deerfirn (Blechnum spicant), Herre’s ragged lichen (*Platismatia herrei*), Henderson’s sedge (*Carex hendersonii*), Constance’s bittercress (*Cardmine constancei*), Case’s cordalis (*Corydalis caseana ssp. hastata*), and white shooting star (*Dodecatheon dentatum*).

Along the lower Clearwater River below Dworshak Dam, forests are comprised of mature deciduous trees, frequently black cottonwood (*Populus trichocara*), with an understory of native Idaho fescue (*Festuca idahoensis*) and the introduced invasive spotted knapweed (Centraurea maculosa). Trees occur in small, widely scattered groups or in narrow bands along rivers and creeks. In some areas, notably where tributaries enter Clearwater, grazing has influenced the vegetation, which may be dominated by shrubs with a weedy forb layer. Bare cobble is exposed in some spots. Much of the soil surface is covered by a well developed cryptogamic crust.

2.6.2.4 Wetlands – Emergent Herbaceous

A variety of emergent herbaceous wetlands are present in the study both in the vicinity of the reservoir and downstream of the Dworshak Dam. Idaho Partners In Flight (IPIF) has designated non-riverine wetlands as high priority habitat. IPIF has a goal to achieve a net increase in the number of wetland acres in Idaho. A large number of small isolated wetlands are present in the study area. Beaver, waterfowl, frogs and toads, and many land bird species are dependent on wetland communities.

At Dworshak Reservoir low lying, flat tributary deltas support emergent herbaceous wetland vegetation during the spring months, but experience die off for most of the remaining year as the reservoir level drops. Along the shorelines of the reservoir, herbaceous wetlands are interspersed among the forested wetlands. Sensitive species found within these emergent herbaceous wetland habitats include deerfern (*Blechnum spicant*), Henderson's sedge (*Carex hendersonii*), Constance's bittercress (*Cardamine constancei*), Case's corydalis (*Corydalis caseana ssp. hastata),* and white shooting star (*Dodecatheon dentatum*).

Common wetland species throughout the study area include black cottonwood *(Populus trichocarpa*), red-osier dogwood (*Cornus stolonifera*), tree-of-heaven (*Ailanthus altissima*), box elder (*Acer negundo*), black raspberry (*Rubus* sp.), poison ivy (*Rhus radicans*), sourweed (*Rumex acetosella*), rush (*Juncus* sp.) rough hairgrass (*Agrostis scabra*), morning glory (*Convolvulus arvensis*), annual sunflower (*Helianthus annuus*), smooth mullein (*Verbascum blattaria*), goldenrod (*Solidago* sp.), and common purslane (*Portulaca oleracea*).

Downstream of Dworshak Dam on the lower Clearwater River, wetlands are present on some of the islands in the study area. These wetlands are discussed in the "Islands" section.

2.6.2.5 Water

There are approximately 15,200 acres of open water in the Dworshak Dam study area. During the winter, ice can form on the reservoir. If the reservoir is drawn down after ice has formed, the reservoir water no longer supports the ice. This can lead to sheets of ice dropping onto the shoreline within the barren zone. Deer and elk have broken through the ice sheets that cover the lake during the winter migration and subsequently drowned.

There are no submerged aquatic beds within the Dworshak Reservoir or in the study area below the dam on the lower Clearwater River.

2.6.2.6 Islands

In Dworshak Reservoir one 0.57-acre island forms when the water is high. During normal drawdown, a landbridge connects this island to the mainland.

Twenty five islands totaling 265 acres are present in the lower Clearwater River. These islands are covered by a mix of forested and scrub-shrub wetlands and emergent herbaceous wetlands. Many types of wildlife use these islands. Waterfowl nest/breed here. Deer, aquatic mammals, raptors, songbirds, and other wildlife capable of swimming to the islands are known to use them.

Lichthardt (1992) describes vegetation and habitat conditions on the lower and Middle Cottonwood Islands. Her work provides the foundation for this section. Within the study area below Dworshak Dam BLM and Idaho Department of Fish and Game manage several islands in the lower Clearwater River for ecological values and waterfowl production as part of their Habitat Management Plan. These islands have been designated a Research Natural Area and Area of Critical Environmental Concern by the Bureau of Land Management because of their suitability as ecological reference areas and their value for educational and research uses. A high density of Canada geese nesting boxes is maintained on these islands. The islands are only accessible by water (Lichthardt 1992).

Lichthardt (1992) notes that these islands taper gradually to river level on their upstream ends and drop abruptly at their downstream ends, forming steep rock banks. Cobble bars, which are typically covered by water during spring runoff, are found at the upstream ends of each island. Sand may be present in spaces between the cobbles or may cover the rocks to a depth sufficient to support plants. At the highest elevations, sandy soils of variable depth covers layers of cobble, gravel, sand.

At their lowest extent these bars are characterized by a willow thicket community. Willows are the single dominant species within this zone, forming a dense to open shrub layer 4 to 6 feet tall. The willow community is flooded intermittently throughout the summer due to fluctuations caused by Dworshak dam. Debris caught in branches of the willows indicates they are totally submerged at times.

The BLM has identified five plant communities, which reflect the elevation gradient and its associated flooding frequency and duration. From wettest to driest (lowest to highest elevation) these are: coyote willow (*Salix exigua*), hairy goldaster (*Chrysopsis villosa*), Louisiana sagewort (*Artemisia ludiviciana*), black cottonwood/Idaho fescue (*Populus trichocarpa/Festuca idahoensis*), and Ponderosa pine/bluebunch wheatgrass (*Pinus ponderosa*/*Agropyron spicatum*).

Because rivers are natural corridors for plant dissemination it is not surprising to find a high percentage of weeds and several exotic shrubs and trees on islands in the Clearwater River. Presently, the most serious weed problem on the river is the abundance of spotted knapweed. Spotted knapweed usually invades where there is soil disturbance, and is commonly found on sand bars and it may have invaded the island grasslands after a fire or a flooding event. It is able to spread rapidly. Annual flooding of cobble bar communities keeps them virtually free of noxious weeds.

2.6.3 Wildlife

2.6.3.1 Birds

RAPTORS

IDFG surveys (Bowers and Nadeau 2002) documented 16 species of raptor in the Dworshak Reservoir study area. These include eagles, hawks, ospreys, falcons, and owls. Four species are listed by the state: bald eagle, Swainson's hawk, merlin, and flammulated owl. A large population of bald eagles winter along the reservoir, but only five nests have been documented. Over 150 osprey nests have been observed (USACE 2015). Bald eagles primarily feed on fish, but also use ducks and carrion when available. Osprey feed exclusively on kokanee (*Oncorhynchus nerka*), trout, and other available fish species. Bald eagles winter along the entire reach feeding on fish, waterfowl, and carrion. The highest concentration of bald eagles in the study area is downstream of Dworshak Dam, where they feed largely on kokanee that pass through the turbines. Good perch sites are furnished by mature trees, and releases from Dworshak keep the lower Clearwater ice-free throughout the winter.

WATERBIRDS, SHOREBIRDS AND WATERFOWL

A total of 42 waterfowl and shorebird species were observed on Dworshak Reservoir during terrestrial resource surveys conducted by the IDFG (Bowers and Nadeau 2002). Fourteen species of these waterfowl and shorebirds are currently listed as “Species of Greatest Conservation Need” (IDFG 2015 updated 2017).

Wood duck (*Aix sponsa*), mallard (*Anas platyrhynchos*), common merganser (*Mergus merganser*), Canada goose (*Branta canadesnsis*), and green-winged teal (*Anas crecca*) nest along the reservoir, particularly near the tributaries at the upper end. Most brooding likely occurs within the lower reach under reservoir influence on a combination of managed and naturally vegetated sites. USACE maintains and irrigates two pastures in this and other agricultural areas. The reservoir is primarily used as a stop-over during spring and fall migration, with peak waterfowl occurrence in the late fall, winter, and spring. Some feeding by geese and puddle ducks occurs along the exposed shoreline during the winter drawdown. However, the extreme fluctuations in pool level limit the growth of aquatic vegetation along the shoreline, reducing the amount of food available for waterfowl.

Most shorebird use is confined to the tributaries and upper end of the reservoir. Shorebirds observed along Dworshak Reservoir include the Common snipe (*Gallinago gallinago*), marbled godwit (*Limosa fedoa*), solitary sandpiper (*Tringa solitaria*), American avocet (*Recurvirostra americana*), great blue heron (*Ardea Herodias*), and killdeer (*Charadrius vociferous*). Spotted sandpiper (*Actitus macularia*) and killdeer are known to nest at reservoir (USACE 2015).

Below Dworshak Dam, waterfowl commonly nest on islands of the lower Clearwater River. The number of nesting geese on these islands has tripled since 1981. As many as 82 nesting structures have been erected in recent years to protect geese from high flows and predation and approximately 50 percent of the structures are used. Some geese may winter along the reservoir-influenced portion of the river. Hundreds of wintering ducks are also found in the portion of the study area below the dam. Some common merganser nesting occurs on the islands.

Shorebirds forage along the Clearwater River below the day. Great blue herons frequent the shallow water shorelines, but there are no known great blue heron rookeries along this reach. Some spotted sandpiper (*Himantopus mexicanus*) nest along limited beach areas and islands.

The seven foot annual water level fluctuation provides suitable shoreline foraging habitat for these birds.

PASSERINES

Downy woodpeckers (*Picoides pubescens*) and black-capped chickadees (*Poecile atricapillus*) nest and feed in the forested wetlands around the Dworshak Reservoir. These and other species are dependent on creation of snags to provide suitable nest sites. Some downy woodpecker (*Picoides pubescens*) nesting cavity sites are available in snags found amongst clumps of mature cottonwood (*Populus trichocarpa*) and willow stands along the river and tributaries. Regeneration of this habitat type is limited due to attenuation of periodic flood flows. Downy woodpeckers and other gleaner species feed primarily in these habitats because they provide the highest habitat diversity within a primarily arid ecotype. Most bird species found in this region are dependent on cottonwood/willow habitats for at least a part of their life cycle.

Below the dam, yellow warblers (*Setophaga petechia*) nest and feed in the shrub-scrub wetlands, primarily areas with willows. This habitat is present in small patches along the river. Many of these patches are too small to be mapped but still have significant food and cover value for warblers and other species.

GALLINACEOUS BIRDS

Six gullinaceous birds were documented during IDFG surveys: mourning dove (*Zenaida macroura*), California quail (*Callipepla californica*), ruffed grouse (*Bonasa umbellus*), blue grouse (*Dendragapus obscurus*), spruce grouse (*Dendragapus Canadensis*), and wildl turkey (*Meleagris gallopavo*). One male mountain quail was observed at Magnus Bay in September 1977. Mountain quail were also reported near Reeds Creek in 1990 and 1993. Of these species, only the mountain quail is classified as a special status species in Idaho. Wild turkesy are not native to Dworshak in 1985, howebver, 16 wild turkeys were released by IDFG in the Canyon Creek drainage. In 1993, additional releases of wild turkeys were made near Orofino Creek (26 birds) and Whiskey Creek (22 birds) to supplement the population. Wild turkey populations are now thriving (USACE 2015).

Wild turkeys have been intentially introduced and are managed as a game species in the study area.

2.6.3.2 Mammals

TERRESTRIAL

Surveys conducted by IDFG documented 39 species of mammals in the study area. Two of these are on Idaho's "Species of Greatest Conservation Need" list (IDFG 2015 updated 2017): Townsend's big-eared bat (*Corynorhinus townsendii*) and gray wolf (*Canis lupus*). Sightings of fisher (*Mares pennant*) and wolverine (*Gulo gulo*) have also been reported to Dworshak staff (USACE 2015). Canada lynx (*Lynx canadensis*) is also recognized as a species of concern.

Over 1,000 Rocky Mountain elk (*Cervus elaphus nelsoni*) have been observed wintering in the study area on project lands around Dworshak Reservoir. Mitigation actions have been taken to assure sufficient browse is available to sustain the elk populations. The elk are not dependent on the reservoir or habitat immediately adjacent to the reservoir. The reservoir can create a hazard to elk in winter due to formation of ice. It is not unusual to observe animals having broken through the ice and drowned (USACE 2015).

Whitetailed deer (*Odocoileus virginianus*) also winter along the reservoir. Ice poses a hazard to white-tailed deer as well, because coyotes (*Canis latrans*) have been known to chase then onto the ice. White-tailed deer are more prevalent in this area than mule deer (*Odocoileus hemionus*). Most deer occurrence along the lower Clearwater River is in side canyons with minimal evidence of occurrence in either the riverine corridor or on islands (Asherin and Orme 1978). This may be due to the abundance of water in the side canyons coupled with very minimal security cover afforded by narrow bands of trees and shrubs along the river (Asherin and Orme 1978).

In addition to Townsend's big-eared bat, several other bat species may be present in the study area. These include pallid bats (*Antrozous pallidus*), fringed myotis (*Myotis thysanodes*), California Bat (*Macrotus californicus*), silver-haired bat (*Lasionycteris noctivagans*), and Yuma myotis (*Myotis yumanensis*). These bats forage on stream insects such as midges, caddisflies, and mayflies and can roost up to two miles from the river and reservoier in moist forests.

AQUATIC

In the reservoir, river otter (*Lontra canadensis*) and related species are confined to the upper reservoir and tributaries. Below the dam, river otters are present in and adjacent to dense forest and shrub habitats located near the river and tributaries. Otter feed in shallow water and den in previously excavated sites near the water, or within boulder piles, rock outcrops, or dense logjam-type litter.

North American beaver (*Castor canadensis*), mink (*Neovison vison*), and muskrat (*Ondatra zibethicus*) are present in the study area below Dworshak Dam. No beaver lodges have been observed and bank denning is exclusively used. Den sites are usually associated with well-developed forest and shrub habitat along the river. Beaver feed on abundant scrub-shrub willow and the bark of saplings.

2.6.3.3 Reptiles and Amphibians

Several reptile and amphibian species occur near the reservoir in association with shallow water areas, pools, shallow lake edges, or upstream tributaries. Reptiles present at or near Dworshak Reservoir include rubber boa (*Charina bottae*), racer (*Coluber constrictor*), common garter snake, (*Thamnophis sirtalis*), western terrestrial garter snake (*Thamnophis elegans*), gopher snake (*Pituophis catenifer catenifer*), western rattlesnake (*Crotalus viridis*), northern alligator lizard (*Elgaria coerulea*), and western skink (*Plestiodon skiltonianus*).

Amphibians known to the area include bull frog (*Lithobates catesbeianus*), Pacific tree frog (*Pseudacris regilla*), and Columbia spotted frog (*Rana luteiventris*). These species occur in association with submerged aquatic vegetation or seasonal emergent herbaceous wetlands and ponds. Long-toed salamander (*Ambystoma macrodactylum*) and western toad (*Anaxyrus boreas*) occur in seasonal wetlands or scrub shrub wetlands. At higher elevations, tailed frogs (*Ascaphus truei*) occur in riffles and pools of tributary streams. The Coeur d' Alene salamander (*Plethodon idahoensis*) is a state species of special concern and occurs in the upper reaches of the Dworshak reservoir (S. Stephens, ICDC, pers. comm.).

Below the dam, Western garter snake and ring-necked snake (*Diadophis punctatus*) are reptile species expected to be present in the study area, including along the river and tributaries (Asherin and Orme 1978 and S. Stephens, ICDC, pers. comm.).

Western toad is expected to be present in or near permanent ponds, herbaceous emergent wetlands, lakes, and still-water off-channel riverine habitats, as well as river edges. Long-toed salamanders are also found in these habitats. Bullfrog, pacific tree frog, and Columbia spotted frog may be present in or near seasonal emergent herbaceous wetlands and ponds.

Bullfrogs are a notable introduced invasive species.

2.6.3.4 Invertebrates

Information about invertebrate species in the study area is not readily available. Dworshak reservoir is likely devoid of benthic fauna due to the magnitude of annual drawdown. Any benthic populations would be associated with the tributaries enter the reservoir. High water velocities, sharp temperature changes, and flow fluctuations resulting from operation of Dworshak Dam likely affect the resident insect populations (Fleck et al. 1978). Hydroelectric peak-induced flow fluctuations could destabilize benthic community structure to marked by fewer species, changes in dominance, relationships among species, and in the available energy for higher trophic levels (MacPhee and Brusven 1973).

2.7 LOWER SNAKE RIVER PROJECTS: LOWER GRANITE LOCK AND DAM, LITTLE GOOSE LOCK AND DAM, LOWER MONUMENTAL LOCK AND DAM, ICE HARBOR LOCK AND DAM

2.7.1 Study Area

The study area used to describe the existing conditions and assess the range of potential impacts for wildlife and habitat features includes the lands associated with the lower Snake River beginning at Ice Harbor Dam (RM 9.7) upstream until the confluence of the Snake River and the Clearwater River at RM 140 near the City of Lewiston, Idaho (Figure 2-7).

The study area includes Lower Granite Lock and Dam and Lower Granite Lake, Little Goose Lock and Dam and Lake Bryan, Lower Monumental Lock and Dam and Lake Herbert G. West and Ice

Harbor Lock and Dam and Lake Sacajawea. There are three significant tributaries of the Lower Snake within the study area including the Palouse River (RM 59.5), Tucannon River (RM 62), and Deadman Slough (RM 83). The Clearwater River (RM 140) while a major tributary of the lower Snake is included in the Dworshak Dam study area (Section 2.6 Dworshak Dam and the Lower Clearwater River).

The lower Snake River is within the Columbia Plateau Ecoregion characterized by sagebrush steppe and grasslands. The semi-arid climate supports native shrub-steppe vegetation and drought-tolerant plant communities. More than half of the shrub-steppe has been converted to agriculture (WHCWG 2010).

Within the Lower Snake River Projects (LSRP) study area, there are Habitat Management Units (HMUs) that provide habitat for wildlife species (Table 2-5). There are 62 HMUs scattered along the Snake River from Ice Harbor Dam to the upper extent of the Lower Granite pool. Of those, ten are intensively managed and irrigated (USACE 2002). Some HMU lands were acquired under a compensation plan authority to address losses to wildlife resources incurred during the construction and operation of the lower Snake River dams (USACE 2011). These lands were compensated for in the Lower Snake River Fish and Wildlife Compensation Plan of 1975, of which 23,620 acres of land were designated for HMUs (USACE 2014).

Table 2-5. Habitat Management Units (HMUs) on the Lower Snake River

HMUs	River Mile	HMUs	River Mile
Charbonneau	11	Ridpath	76
Big Flat	15	New York Bar	81
Fishhook	18	Lower Deadman	83
Lost Island	19	Central Ferry	83.5
Hollebeke	25	Willow Bar	88
Snake River Junction	26	Penawawa	91.5
Walker	30	Rice Bar	93
Skookum	48	Swift Bar	97
55 Miles	55	Illia	102
Lyons Ferry	59.5	Kelly Bar	119
Tucannon	62.5	Nisqually John	123
John Henley	68	Chief Timothy	132.5

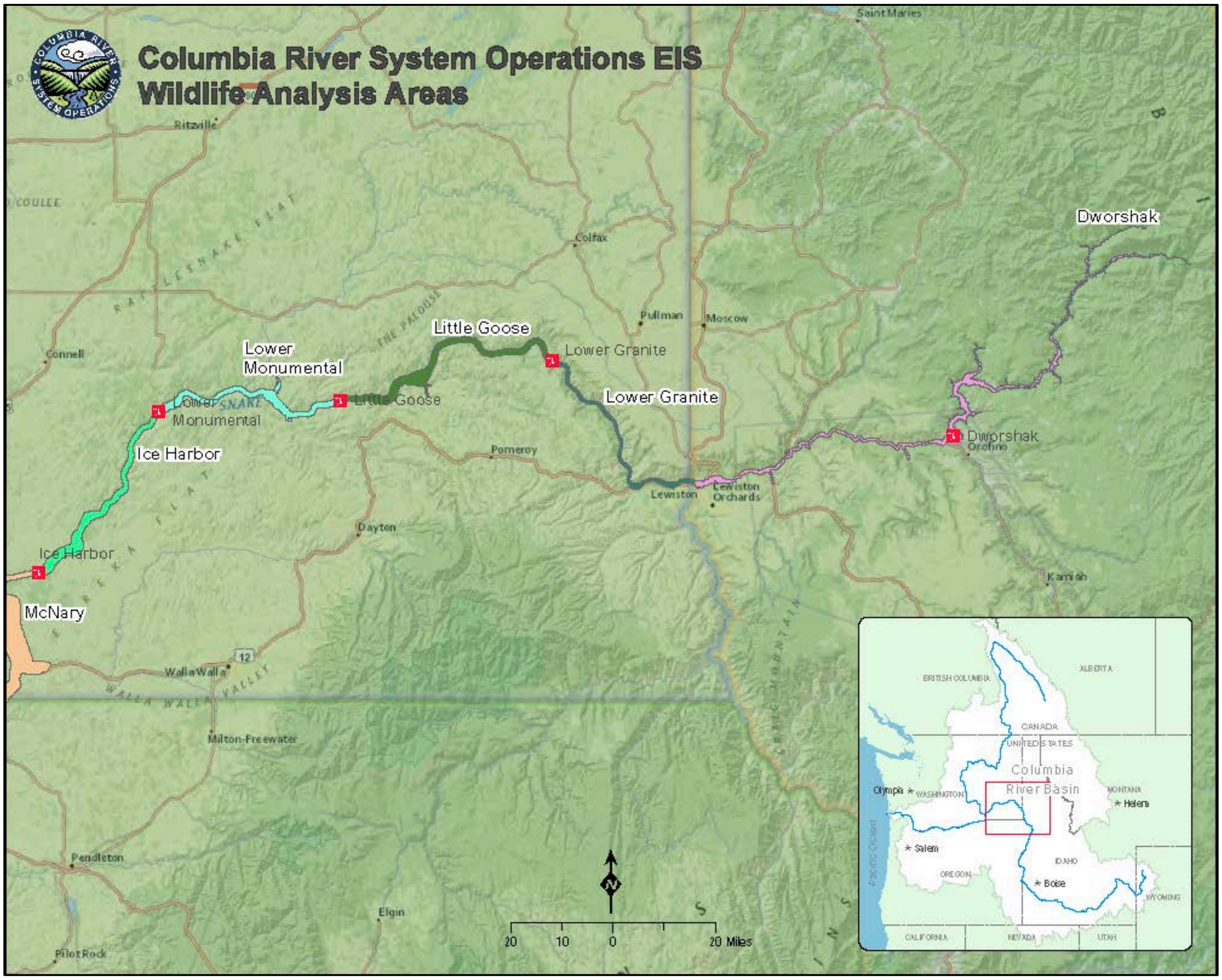

Figure 2-7. Lower Snake River Projects: Lower Granite Lock and Dam, Little Goose Lock and Dam, Lower Monumental Lock and Dam, Ice Harbor Lock and Dam Study Area.

2.7.2 Land Cover

Table 1-2 above shows the acres of the different habitat types within the Lower Snake River study area.

2.7.2.1 Uplands

The primary upland habitat types in the lower Snake River project area includes steppe and shrub-steppe vegetative communities (Franklin and Dryrness 1973). Steppe communities are dominated by bunchgrasses such as bluebunch wheatgrass (*Pseudoroegneria spicata*). Shrub-steppe habitats consist of one or more layers of perennial grass with a discontinuous overstory of shrubs. These communities are co-dominated by sagebrush such as big sagebrush (*Artemisia tridentata*). While the dominating upland habitat in the LSRP study area is shrub-steppe, small remnants of ponderosa pine (*Pinus ponderosa*) and white oak (*Quercus alba*) forest and woodlands exist in the project area. There are 31,000 acres of upland habitat in the LSRP study area.

The WDFW Wildlife Management Program conducted a three-year survey recording bird species on 55 transects throughout Washington's shrub-steppe community to correlate habitat suitability with species present. Concurrent vegetation surveys determined the percent vegetative cover of shrubs, trees, grasses and forbs. Surveys were completed in Franklin, Walla Walla, and Benton counties. The LSRP study area intersects the shrub-steppe habitat that was sampled (WDFW 1996). Data collected by the WDFW survey accurately depicts the current plant species growing in the isolated and fragmented shrub-steppe upland habitat.

Commonly occurring shrubs and trees in eastern Washington's shrub-steppe include serviceberry (*Amelanchier alnifolia*), black sagebrush (*Artemisia arbuscula*), scabland sagebrush (*A. rigida*), common sagebrush (*A. tridentata*), threetip sagebrush (*A. tripartita*), creeping Oregon grape (*Berberis repens*), rubber rabbitbrush (*Ericameria nauseosus*), yellow rabbitbrush (*E. viscidiflorus*), oceanspray (*Holodiscus discolor*), granite prickly phlox (*Linanthus pungens*), cottonwood (*Populus* spp.), cherry (*Prunus* spp.), antelope bush (*Purshia tridentata*), golden currant (*Ribes aureum*), Nooktka rose (*Rosa nutkana*), greasewood (*Sarcobatus vermiculatus*), common snowberry (*Symphoricarpos albus*), and gray horsebrush(*Tetradymia canescens*) (WDFW 1996).

Grasslands are primarily composed of bluebunch wheatgrass, great basin wild rye (*Elymus cinereus*), Idaho fescue (*Festuca idahoensis*), Sandberg's bluegrass (*Poa secunda* ssp. *secunda*), squirrel tail grass (*Elymus elymoides*), needle and thread grass (*Stipa comata*), and western needlegrass (*Stipa occidentalis*). Perennial forbs that occurred in at least 20 percent of the plots sampled and occurring in the LSRP study area include: *Phlox* sp., *Lomatium* sp., yarrow (*Achillea millefolium*), lupine (*Lupinus* sp.), *Erigeron* sp., buckwheat (*Eriogonum* sp.), vetch (*Astragalus* sp.), threadleaf sedge (*Carex filifolia*), paintbrush (*Orthocarpus* sp.) (WDFW 1996).

Upland native plant communities are adapted to the arid climate; most plants become dormant through summer and winter. Some larger shrubs can tap into deep subsurface water and actively grow throughout the hot, dry summers. A critical component of native grassland and shrub-steppe plant communities is the cryptogamic or microbiotic crust. Cryptogams are plants that reproduce by spores and/or those that are non-photosynthetic. This combination of mosses, lichens, liverworts, algae, and bacteria stabilize the soil against wind and water erosion, and enrich the soil by providing carbon and nitrogen, limiting essential nutrients (Kane 2002, USFWS 2013).

The upland areas surrounding the projects are typical of the semi-arid intermountain ecotype found in the Columbia Basin Province, which is dominated by rabbitbrush, cheatgrass and remnant bunchgrasses and forbs. Drastic increases in dry-land agriculture and irrigation has reduced the once expansive native grasslands and shrub-steppe habitats. Some non-irrigated crops grown in the Deadman Creek watershed are winter wheat and barley, spring grain, peas and bluegrass seed. Domestic livestock are pastured on upland areas not suitable for cropland.

Within the Columbia subbasin, ponderosa pine habitat currently covers a wide range of seral conditions. Ponderosa pines occur on warm, dry sites at elevations ranging from sea level to 6,000 feet. Bark beetle infestation has contributed to massive mortality rates of large pines in the basin (NPCC 2004). The shaded, moist microclimates of the canyon draws, in the upper reaches of Little Goose and Lower Granite Dam may support small stands of conifers, including ponderosa pine and white oak woodlands. Under a contract for operation and maintenance of the HMUs, occasionally ponderosa pines with a red (*Alnus rubra*) or white alder (*A. rhombifolia*) understory are planted. Pine survival is dependent upon seasonal conditions and water availability (USACE 2018).

The encroachment of noxious weeds like cheatgrass have degraded the quality of native plant communities within the uplands of the lower Snake River subbasin. Cheatgrass outcompetes native plants for water and space, as they produce copious quantizes of seeds and produce nearly four times the biomass as native grasses (Kane 2002). Cheatgrass disrupts the natural fire regime because it is the first to germinate on disturbed soil, is highly flammable and provides a thick, continuous fuel load, as well as dries out early in the season. Increased periodicity in the fire cycle lessen the chances of native plant communities from recolonizing these areas (USFWS 2013). St. John's wort (*Hypericum perforatum*), yellow starthistle (*Centaurea solstitialis*) and knapweeds (*Centaurea* sp.) are also invading the native bunchgrass grasslands in the lower Snake River project area. Scotch thistle (*Onopordum acanthium*) invades disturbed upland habitat including roadsides and campgrounds that are within the LSRP study area.

2.7.2.2 Barren Zone/Drawdown Area

The lower Snake River projects operate as run-of-river dams which results in virtually non-existent drawdown areas. There is a small band of barren zone that is periodically and irregularly inundated, primarily within the upper two feet of the operating range. The vast majority of this river stretch exhibits relatively steep topography with very few expanses of mud flats. There are only three areas of significant mudflat development at the mouths of tributaries: the Palouse River (RM 59.5), Tucannon River (RM 62), and Deadman Slough (RM 83). The Clearwater River (RM 140) contributes a significant sediment load, however flows are high in this area and deposition is far enough downstream as to not form mudflats.

Hillslopes within the reservoirs with large toe slopes will likely be enriched by silt and clay depositions (USACE 2014). Deposition on toe slopes could result in high unstable terraces once the reservoirs are drained (Randle et al. 2015). Erosion and sloughing occur primarily along lower lying benches, and deposition of silts occurs at the mouths of the tributaries. Small changes in the maximum operating pool (MOP) allows native scrub-shrubs to invade the exposed band of rich sediment deposited on the barren zone. Scrub-shrubs can endure inundation from November through March.

2.7.2.3 Wetlands – Forested and Scrub-Shrub

The lower Snake River project area contains linear strips of wetlands along the interface between aquatic and terrestrial ecosystems, closely following perennial rivers and streams. Forested and scrub-shrub wetlands are composed of a mosaic of shrublands, woodlands, and forest communities and characteristically have either a deciduous, coniferous, or mixed canopy cover. Scrub-shrub and palustrine forested wetlands are dominated by a canopy of willows and cottonwoods. There are approximately 760 acres of forested and scrub-shrub wetlands in the LSRP study area.

Due to the hot, dry climate in the Snake River subbasin, the extent of riparian vegetation and species present along this reach is entirely dependent on water availability. Soil saturation is typically present during flood events. Precipitation increases with the downstream to upstream elevational gradient, ranging from approximately 9 to 15 inches annually (USACE 1995). Greater precipitation in the upstream reaches facilitates a richer band of wetland vegetation in the side draws and shallow pockets across the canyon slopes. Side drainages with woody vegetation above reservoir levels begin at Central Ferry, Washington and continue upstream (USACE 1975). This change in vegetation frequency becomes evident around RM 85 within the Lower Granite Pool. North facing slopes retain more moisture and often have more diverse and extensive woody vegetation. A total of 345 different species of plants have been documented along the lower Snake River riparian zone (USACE 1976).

Currently the two significant native, wetland plant communities include black cottonwood and coyote willow/false indigo. On irrigated lands adjacent to the Snake River, such as HMUs, Russian olive is the most prevalent tree species and Himalayan blackberry (Rubus armeniacus) is the dominating shrub (USACE 2014). Black cottonwood, white alder (*Alnus rhombifolia*), and netleaf hackberry (*Celtis reticulata*) frequently occur in adjacent wetlands. Mesic shrubland occurs in side draws and near seasonal springs and seeps. Species typical of these areas included black hawthorn, chokecherry (*Prunus virginiana*), and willows, with a forb understory consisting of rushes, sedges, bluebunch wheatgrass, and shrub steppe communities of rabbitbrush, sagebrush, or antelope bitterbrush (*Purshia tridentata*). Wetland vegetation occurs in discontinuous bands along the main river at the bottom of the canyon, at the mouths of tributaries, and in the side canyons associated with seeps and springs. Generally in these wetland fragments, trees grow in small groves or even singly.

Grazing cattle and livestock suppressed woody vegetation in wetland areas. Willows become the principal source of cattle browse when springtime palatable understory sedges and forbs desiccate and their protein content decreases. Willow seedlings are especially at risk from grazing and trampling. Cattle often break willow shrub branches while seeking shade during hot summer months. Because the movement of cattle is sporadic, the distribution of forested and scrub-shrub wetland varies from year to year (Kovalchik and Elmore, 1991).

The expansion of exotic, invasive species such as western false indigo (*Amorpha* fruticosa) and Russian olive (*Elaeagnus angustifolia*) has fragmented the once continuous scrub-shrub and forested wetland habitat that existed along the Snake River and tributaries. Western false indigo escapes planted areas and forms dense thickets along streams and rivers, outcompeting native wetland species. Species composition has changed reflecting intrusion of invasive species such as Canada thistle (*Cirsium arvense*), black locust (Robinia pseudoacacia), curly dock (*Rumex crispus*), poison hemlock (*Conium maculatum*), and teasel *(Dipsacus fullonum*). Invasive understory plants grow faster than woody vegetation, preventing sunlight from reaching young tree saplings, like cottonwoods. Butterfly bush (*Buddleia davidii*) is an escaped ornamental that forms dense, shrub thickets that displace native vegetation in forested wetlands, often dominanting willow habitat. Tamarisk (*Tamarix ramosissima*) is an aggressive shrub or small tree that grows in wetlands, choking streambeds and causing flooding downstream. There are large infestations reported in eastern Washington (WISC 2009).

2.7.2.4 Wetlands – Emergent Herbaceous

Emergent wetlands generally occur where groundwater saturates the surface soil layer during the growing season. Water availability must be sufficient and frequent to induce the characteristic vegetative, physical, and chemical conditions of emergent wetland communities (USACE 2002). Numerous small pockets of emergent wetland vegetation, less than a half-acre in size, exist in small impoundments and embayments behind roads and railroads. The size of herbaceous wetlands change seasonally, mostly increasing during the growing season. These wetlands are highly dependent upon water availability; water infiltration along the root zone dictates the amount of growth or desiccation.

Emergent wetlands are dominated by cattail (*Typha sp.*) and bulrush (*Scirpus sp*.) with some rushes (*Juncus sp*.), purple loosestrife (*Lythrum salicaria*), western false indigo, sedges (*Carex sp*.), and common reed (*Phragmites australis*). Palustrine emergent wetlands consists of cattail, sedges, and tule (*Schoenoplectus acutus*). There has been an increase in emergent wetland communities since the construction of the LRSP; this is likely due to several factors: 1) abundant slack water which causes sediments carried into reservoirs to accumulate and create good conditions for wetland vegetation development, especially at the mouths of tributaries; 2) several embayments and backwaters which also allow wetland development; 3) drawdowns which allowed wetland vegetation to establish; and 4) runoff and seeps from nearby irrigated HMU's (USACE 2002). There are approximately 160 acres of emergent wetland habitat in the LRSP study area.

There are several Washington Wetlands of High Conservation Value within the LSRP study area. There are at least 20 small wetlands in the Lower Granite pool with known rare plants and nonvascular species with high state conservation value. All of these wetlands contain rare or state-listed herbaceous plants and/or grass associates. These plants may include blue mountain onion (*Allium diction*), Cusick's milkvetch (A*stralagalus cusickii* var. *cusickii*), Piper's milkvetch (*Astralagus riparius*), Texas bergia (*Bergia texana*), Oregon bolandra (*Bolandra oregana*), sagebrush mariposa lily (*Calochortus macrocarpus* var. *maculosus*), Snake river daisy (*Erigeron disparipilus*), yellow wildrye (*Leymus favescens*), awned halfchaff sedge (*Lipocarpha aristulata*), snake canyon desert-parsely (*Lomatium sandbergii*), Blue Mountain penstemon (*Penstemon pennellianus*), yeti phlox (*Phlox solivaga*), mountain buttercup (*Ranunculus populago*), lowland toothcup (*Rotala ramosior*), and prarie cordgrass (*Spartina pectinata*) (WNHP 2018).

Invasive species such as common reed, reed canarygrass (*Phalaris arundinacea*), Japanese knotweed (*Fallopia japonica*), and western false indigo become a dominant species in some areas. Knotweeds are found throughout Washington State, invading streambeds and riverine systems, dominating all available space, blocking sunlight and devouring all nutrients in wetland habitats. Reed canarygrass forms monotypic stands in stream channels and floodplains throughout the study area. Reed canarygrass is a noxious weed in Washington that continues to displace much of the historic native herbaceous wetland understory. Reed canarygrass's creeping rhizomes form a thick sod layer and stems can grow up to 2 meters tall, blocking sunlight from reaching smaller native plants (TNC 2004). This invasive has outcompeted historically dominant native plants such as small camas (*Camassia quamash*), Nebraska sedge (*Carex nebrascensis*), and blister sedge (*Carex vesicaria*). Flowering rush (*Butomus umbellatus*) is an aquatic, rhizomatous, sedge-like invasive that is capable of colonization drawdown zones where water recedes to expose soil.

2.7.2.5 Water

Open water exists primarily in the four reservoirs: 1) Lake Sacajawea; 2) Lake Bryan; 3) Lake Herbert G. West; and 4) Lower Granite Lake. Open water habitats are found in numerous ponds and embayments, and the tributary confluences with the Palouse and Tucannon River. Aquatic habitats provide essential cover and resources for wildlife species in the LSRP study area. Embayments are formed by the construction of railroads and highways causeways that cut off the surface water of the mainstem Snake River. Hydrologic connectivity is maintained via culverts, small channels, irrigation or groundwater exchange.

Shallow waters in these habitats support productive submergent, emergent and aquatic vegetation communities. Extent of this vegetation type has never been quantified for this reach but is assumed to be limited, correlated with the amount of shallow water present. There are narrow bands of aquatic vegetation along the Snake River in the absence of roads. The upper reaches of the study area have increasingly steep terrain with canyon draws leading to small embayments which support riparian vegetation. These slack waters generally have lower species diversity and high abundance of introduced and invasive aquatic species.

The Ice Harbor pool does support populations of rooted aquatic vegetation such as bulrush (*Scirpus* sp.), spike-rush (*Eleocharis* sp.), false pimpernel (*Lindernia dubia*), longleaf pondweed (*Potamogeton nodosus*) and sago pondweed (*Stuckenia pectinata*) (WSDOE 1996). In the shallows and coves of Lake Bryan, the Little Goose Dam pool, northern mudwort (Limosella aquatica) and common elodea (*Elodea canadensis*) grow near the town of Central Ferry and Deadman Creek (WSDOE 1997). A diversity of aquatic and submerged vegetation grows near the rocky shoreline of Lower Monumental Dam, including common hornwort (Ceratophyllum demersum), longleaf and sago pondweed, and common elodea. Aquatic plants in the Order Alismatales including pondweeds and arrowleafs grow densely in the shallow littoral zone of the Palouse River. Surveys at Lower Granite Lake found few rooted aquatic plants near Chief Timothy island including several fragments of sago pondweed, northern mudwort, and horned pondweed (*Zannichellia* sp.) (WSDOE 1997) in the shallow portions of the lake. Extent of this vegetation type has never been quantified for this reach but is assumed to be limited, correlated with the amount of shallow water present. There are approximately 33,200 acres of water habitat in the LSRP study area.

Invasive plant species found in the shallow waters of Lake Sacajawea and Lake Herbert G. West include curly-leafed pondweed (*Potamogeton crispus*), Eurasian water-milfoil (*Myriophyllum spciatum*), Brazilian elodea (*Egeria densa*), African elodea (*Lagarosiphon major*), slender-leaved naiad (*Najas minor*), and purple loosestrife (*Lythrum salicaria*) (WSDOE 1996-1997).

2.7.2.6 Islands

There are currently two islands of significant size in the LSRP study area. Silcott Island in Lower Granite Lake is 123 acres and connected to the mainland by a causeway. Chief Timothy State Park on Silcott Island is located off U.S. Highway 12 and contains just over 100 campsites on the southern shore. The campground is irrigated, with shaded uplands and wetland vegetation, which may be considered low quality habitat due to the presence of people. The island is located within the Chief Timothy HMU (USACE 2011).

New York Island in Lake Bryan is approximately 50 acres, isolated and accessible only by boat. The eastern shore of New York Island has forested and herbaceous wetland vegetation habitat. The uplands are scrub-shrub and annual grassland. There are about 20 unnamed islands, some as small as 0.1 acres are present in the slackwaters. Island acreages may fluctuate depending upon dam operations. At least four islands have been created from dredged material disposal (USACE 1995).

Little Goose Lock and Dam was constructed on the former Little Goose land. The island was approximately 1,200 feet below the surrounding Columbia River Plateau surface elevation (The Spokeman-Review 1963).

2.7.3 Wildlife

2.7.3.1 Birds

RAPTORS

Raptor diversity in the LSRP study area is relatively high. Documented species include northern harrier (*Circus cyaneus*), Swainson's hawk (*Buteo swainsoni*), red-tailed hawk (*Buteo jamaicensis*), ferruginous hawk (*Buteo regalis*), American kestrel (*Falco sparverius*), prairie falcon (*Falco mexicanus*), bald eagle (*Haliaeetus leucocephalus*), and golden eagle (Aquila chrysaetos). Several of these species, including prairie falcon, golden eagle, American kestrel, and Swainson's hawk nest on cliffs and rocky crevices. Ferruginous hawks nest and forage in the open grasslands and shrubby draws (USACE 2002).

Rocklage and Ratti (1998) documented 17 species of raptors in the Lower Granite Pool, including 209 individuals of 12 species during the breeding season. Of these 209 individuals, over 80 percent were one of three species: red-tailed hawk (45 percent), American kestrel (21 percent), and northern harrier (14 percent). Great horned owls (*Bubo virginianus*) and burrowing owls (*Athene cunicularia*) have been reported near the lower Snake River and Lower Granite Lock and Dam (Lewke and Buss 1977), and are likely occasional visitors.

Ferruginous hawks inhabit and breed in the Lower Columbia Basin and surrounding arid lands of southeast Washington. They are a state-listed species that are obligate grassland or desert-shrub nesters that occupy shrub-steppe in the channeled scablands of the Snake River. Ferruginous hawks are sensitive to disturbance and forage on small-medium size mammals beyond the wheat and croplands of the plateau. The largest overwintering populations of prairie falcons in Washington occur in the central Columbia Basin which overlaps with the study area. Prairie falcons nest on the basalt cliffs of the Snake River Gorge and hunt in shrub-steppe habitat that supports abundant prey, including ground squirrels, western meadowlarks (*Sturnella neglecta*), and horned larks (*Eremphila alpestris*). These falcons are specially adapted arid environment of eastern Washington and habituate the upland habitats in the LSRP study area (WDFW 2004).

There are several WDFW designated golden eagle breeding areas along the Snake River (WDFW 2018). These breeding areas increase in frequency towards Lower Granite Dam. The species is uncommon in the transitional phase between montane and shrub-steppe habitats but scattered nest sites can be located on cliffs and in coniferous trees. Grassland and shrub-steppe vegetative communities provide habitat for small to medium mammals such as hares (*Lepus* spp.), ground squirrels, marmots (*Marmota* spp.), mountain beaver (*Aplodontia rufa*), and birds (e.g. pheasant and grouse) that are important prey for the golden eagle (Kochert et al. 2002).

There are several bald eagle territories in southeastern Washington near the Snake River; however, bald eagles are nearly scarce in higher elevations in the Columbia Basin and Palouse Region due to the lack of available nesting habitat. Bald eagles construct nests up to 2 meters in diameter typically in the largest trees in the region. In the arid shrub-steppe habitats in the study area, mature large trees cannot be supported with the limited availability of precipitation (WDFW 2016). No bald eagle nests were documented along the lower Snake River reservoirs. Currently the nearest known nest and winter concentration sites are on the Columbia River bordering the Hanford Reservation. However, wintering bald eagles are commonly seen in the LSRP study area between November and March. The middle and upper Snake River are frequented due to large pockets of old growth coniferous forests. Communal winter roost sites consist of concentrations of eagles within one mile of a large marine or freshwater river or water body (Anthony et al. 1982). Wintering bald eagles are primarily associated with open water near concentrated food sources. Eagles that overwinter in Washington are particularly dependent upon chum salmon (Oncorhynchus keta) in the fall and early winter, and reliant upon carrion and waterfowl in mid-late winter (WDFW 2016). The lack of mature cottonwood and black locust trees along the reservoir margins, likely limits the ability of bald eagles to successfully perch, nest and forage along the lower Snake River.

WATERBIRDS, SHOREBIRDS AND WATERFOWL

Waterbirds in the LSRP study area include gulls, Caspian terns (*Hydroprogne caspia*), double crested cormorants (*Phalacrocorax auritus*), great blue herons (*Ardea herodias*), black-crowned night herons (*Nycticorax nycticorax*), and white pelicans (*Pelecanus erythrorhynchos*).
No known rookeries for any of these species occur on the lower Snake River, with the exception

of several locations listed as “possible” breeding sites in the Breeding Bird Atlas of Washington State (Smith et al 1997).

Several waterbird species breed on the large islands at the mouth of the Snake River, near McNary Wildlife Refuge, but the lack of islands or mature forested wetland has prevented these species from breeding along the reservoirs in the LSRP study area. Between 1980 and 2000 the North American population of white pelicans has doubled; however, they are still considered state-listed endangered species in Washington State and habitat along the Columbia River provides the only known nesting sites of white pelicans in the State. White pelicans are occasionally seen in the shallow water areas of the study area, most often on the western edge near Ice Harbor Dam. American white pelicans are now becoming common on Lower Granite Lake up to City of Clarkston.

Common waterbirds seen at the Palouse River include ring-billed gull (*Larus delawarensis*), herring gull (*Larus argentatus*), double-crested cormornant, California gull (*Larus californicus*), caspian tern (*Hydroprogne caspia*), and Forster’s tern (*Sterna forsteri*) (eBird, Lyon’s Ferry Park). Waterbirds are often seen by visitors at the dams. Mew gull (*Larus canus*), ring-billed gull, glaucous winged gull (*Larus glaucescens*), double-crested cormorant, California gull and herring gull can be seen foraging at Lower Monumental Dam (eBird, 2017). American white pelicans, Caspian terns, double-crested cormorants, mew gull, brown pelican (*Pelecanus occidentalis*), Franklin’s gull (*Leucophaeus pipixcan*), Sabine’s gull (*Xema sabini*) and Iceland gull (*Larus glaucoides*) frequent Ice Harbor Dam. In 2017, Pacific loon (*Gavia pacifica*) and common loon (*Gavia immer*) were seen on the water surface swimming near the Franklin and Walla Walla county line (eBird, Ice Harbor Dam).

Shorebirds are relatively uncommon breeders along the lower Snake River most likely due to the small amount of sandbars and mudflats available (USFWS 1991, Smith et al. 1997). In 1998, killdeer (*Charadrius vociferus*), spotted sandpiper (*Actitis macularius*), and Wilson’s snipe (*Gallinago delicata*) were recorded the area during the breeding season, lesser yellowlegs (*Tringa flavipes*) and greater yellowlegs (*Tringa melanoleuca*) in the fall, and killdeer and long-billed curlew (*Numenius americanus*) in the spring. Fifty-eight individual killdeer were counted during the spring making them the most abundant shorebird species observed (Rocklage and Ratti 1998).

Since 2015, great blue heron, greater yellowlegs, long-billed dowitcher (*Limnodromus scolopaceus*), lesser yellowlegs, spotted sandpiper and black-necked stilt (*Himantopus mexicanus*) have been reported in Central Ferry, Washington on the banks of Deadman Creek (eBird, Central Ferry). Killdeer, great blue heron, least sandpiper, greater yellowlegs, and great egret (*Ardea alba*) have been spotted at the confluence of the Palouse River. Occasionally sandhill cranes can be seen flying over the lower Snake River (eBird, Lyon’s Ferry Park).

Over 30 species of waterfowl have been documented to occur on the lower Snake River (Asherin and Claar, 1976, Lewke and Buss 1977, and Rocklage and Ratti 1998). Ice Harbor usually has the most waterfowl due to is protection as a waterfowl preserve. The most common species of waterfowl observed along the lower Snake River were Canada geese (*Branta* *canadensis*), mallards (*Anas platyrhynchos*), common goldeneye (*Bucephala clangula*), and American widgeon (*Anas americana*) and although impoundment of the river has not significantly changed waterfowl species composition it has affected the abundance and occurrence. An increase in the abundance of cereal grain fields in both HMUs along the river and in the adjacent uplands has provided a consistent source of food for waterfowl, particularly mallards and Canada geese.

Tributaries of the lower Snake are hotspots for waterfowl and shorebirds. Waterfowl commonly seen since 2016 in the Deadman Creek slough include pied-billed grebe (*Podilymbus podiceps*), western grebe (*Aechmophorus occidentalis*), common goldeneye, Clark's grebe (*Aechmophorus clarkii*), ring-necked duck (*Aythya collaris*), lesser scaup (*Aythya affinis*), American coot (*Fulica americana*), American wigeon (*Mareca americana*), northern pintails (*Anas acuta*), bufflehead (*Bucephala albeola*), wood ducks (*Aix sponsa*) and green-winged teal (*Anas crecca*) (eBird, Central Ferry). Waterfowl commonly seen near the Palouse River include: Canada goose, mallard, common merganser, pied-billed grebe, American coot, American widgeon, hooded merganser, cackling goose (*Branta hutchinsii*), ring-necked duck, blue-winged (*Spatula discors*) and green-winged teal (eBird, Lyon's Ferry Park)

The Canada goose, a species once the focus of mitigation and repopulation in eastern Washington, is now common year-round along the Snake River (USACE 2018). The site of the Chief Timothy HMU was selected for the sufficient land adjacent to water sources and pasture for Canada geese. Trees and shrubs, meadows, pasture, fields, annual fuel plots, water guzzler complexes, and nest structures were incorporated into the habitat components for the species when populations were declining. Swallows Park in Clarkston, WA, is several miles upstream of the study area boundaries. Once a high density recreational swimming hole, Swallows Park has since been closed to the public due to poor water quality. Canada geese populations in the area caused coliform bacteria levels in the Snake River to exceed safe levels (USACE 2018). The bacteria dilutes downstream at the confluence with the Clearwater River and does not pose a hazard in the study area. The success of recolonizing Canada geese in Clarkston is spreading throughout the Snake River HMUs.

Total Canada goose nesting along the lower Snake River is currently about 200 nests per year. New York Island averaged 70 to 80 nests, with declining numbers in recent years. In the early 2000s, New York Island produced an average of 64 successful nests each year. Other smaller islands along the Snake River produce an average of 0.3 - 2.4 nests annually (USACE 2002). Cliff nesting appears to be an increasing trend in response to the loss of predator-free island nesting sites. Artificial nest structures along most of the HMUs have regular annual use. USACE maintains 75 goose nesting tubs located in various shallow water areas in association with HMU's. Goose tubs (large nest boxes elevated above river level on poles) have produced 45 nests on the lower Snake River. An abundance of natural and artificially managed Canada geese brooding pastures are present along the lower Snake River. Current dam operations provides greater emergent wetland habitat and ideal foraging resources (USACE 2002).

Very little mallard nesting has been observed along the lower Snake River most likely due to very limited occurrence of suitable dense nesting cover. What little mallard brooding that may occur is associated with the shallow backwaters and embayments. Significant numbers of mallards, winter on the reservoirs.

PASSERINES

The variety of habitats in the LSRP study area, including natural and managed lands, support a diversity of passerines, the perching birds. Forested, scrub-shrub and emergent herbaceous wetlands on the lower Snake River offer critical stop-over habitat for migrating birds. In the semi-arid Columbia Plateau Ecoregion these wetland habitats are crucial during fall migration.

In 1997-1998 an avian survey was conducted investigating species diversity on 25 sites from Ice Harbor Dam upriver to the confluence of the Snake and Clearwater Rivers. Ninety-two species were detected during the breeding season on the lower Snake River. The most frequently detected species were passerines including the bank swallow (*Riparia riparia*), cliff swallow (*Hirundo pyrrhonota*), red-winged blackbird (*Agelaius phoeniceus*), western meadowlark (*Sturnella neglecta*), and Bullock's oriole (*Icterus bullockii*). In addition, the red-winged blackbird, Bullock's oriole, American goldfinch (*Carduelis tristis*), brown-headed cowbird (*Molothrus ater*), and American robin (*Turdus migratorius*) had the highest densities per area surveyed. The following species were also detected frequently: white-crowned sparrow (*Zonotrichia leucophrys*) and European starling (*Sturnus vulgaris*) (Rocklage and Ratti 2000). Since the survey has been conducted, habitat quality likely remains similar or improved with HMU management. Species present in the study area appear to remain similar.

At RM 30 in the Ice Harbor pool at Walker HMU the following passerines were observed since 2015: western wood-pewee (*Contopus sordidulus*), Say's phoebe (*Sayornis saya*), warbling vireo (*Vireo gilvus*), house wren (*Troglodytes aedon*), Bewick's wren (*Thryomanes bewickii*), golden-crowned kinglet (*Regulus satrapa*), ruby-crowned kinglet (*Regulus calendula*), cedar waxwing (*Bombycilla cedrorum*), American goldfinch, lark sparrow (*Chondestes grammacus*), white-crowned sparrow (*Zonotrichia leucophrys*), song sparrow (*Melospiza melodia*), Lincoln's sparrow (*Melospiza lincolnii*), spotted towhee (*Pipilo maculatus*), orange-crowned warbler (*Oreothlypis celata*), Nashville warbler (*Oreothlypis ruficapilla*), yellow-rumped warbler (*Setophaga coronata*), and Wilson's warbler (*Cardellina pusilla*) (eBird 2015).

Lyon's Ferry State Park at the confluence of the Palouse River with the Snake River hosts a variety of bird species. In 2018 the following birds were identified at the Palouse River: western wood-pewee, barn swallow, American robin, lesser goldfinch (*Spinus psaltria*), cliff swallow, house finch (*Haemorhous mexicanus*), American goldfinch, red-winged blackbird, brown-headed cowbird, yellow warbler (*Setophaga petechia*), violet-green swallow (*Tachycineta thalassina*), downy woodpecker (*Picoides pubescens*), western kingbird (*Tyrannus verticalis*), common raven (*Corvus corax*), and European starling (*Sturnus vulgaris*). Less frequently seen visitors include yellow-breasted chat (*Icteria virens*), lazuli bunting (*Passerina amoena*), northern rough-winged swallow (*Stelgidopteryx serripennis*), dusky flycatcher (*Empidonax* *oberholseri*), gray catbird (*Dumetella carolinensis*) and western tanager (*Piranga ludoviciana*) (eBird 2018).

Significant colonies of cliff and bank swallows occur at a number of locations along the river. Bank swallows are usually present wherever there are exposed cutbanks suitable for nesting that are consistently above water level. Cliff swallows nest both on steep rock faces and in the dam structures themselves. Nesting cavities associated with snags and decaying riparian hardwoods are extremely limited along the lower Snake River. Browse of young saplings by deer and elk, and habitat use by beaver can greatly reduce the reestablishment rate of wetland and riparian tree species, such as cottonwood.

Horned larks (*Eremophila alpestris*) and western meadowlarks are the most abundant breeding birds in the sagebrush/bunchgrass habitat. Loggerhead shrikes (*Lanius ludovicianus*), sage thrashers (Oreoscoptes montanus), and sage sparrows (Artemisiospiza nevadensis) are sagebrush obligates and are found in the upland habitat in the LSRP study area. Avian diversity is higher in the forested and scrub-shrub wetland habitats. Red-winged and yellow headed blackbirds are most commonly found chirping in the emergent vegetative communities of the Palouse River. Red-winged blackbirds can be found occupying almost all wetland areas supporting cattail throughout the reach. Other riparian species include kinglets (*Regulus* sp.), warbling vireos, yellow-rumped warblers, and Wilson’s warblers. Wintering species in wetland habitats include dark-eyed junco (*Junco hyemalis*), white-crowned sparrow, American robin and Townsend’s solitaire (*Myadestes townsendi*) (USFWS 2013).

Loggerhead shrike is a summer resident of eastern Washington. The species is a candidate for state listing. Loggerhead shrikes breed in open country, primarily shrub-steppe and grasslands where there are scattered tall shrubs, fence posts, utility wire, or lookout posts. Shrikes generally nest in dense, thorny trees or shrubs. Loggerhead shrikes avoid riparian zones or within 500 meters of water, possibly to avoid nest predation by magpies (*Pica hudsonia*) and ravens. Common prey includes lizards, small mammals, small birds and insects which are impaled on thorns or fences and retrieved for later consumption (WDFW 2015).

The sage thrasher is a sagebrush obligate and mostly builds nest in big sagebrush or three-tip sagebrush shrub-steppe communities. A short-distance migrant, sage thrashers arrive in eastern Washington by late March. A candidate for Washington state listing, the sage thrasher is currently a species of concern due to cheatgrass invasion and intensive livestock grazing in the Columbia Plateau ecoregion (WDFW 2015). Sagebrush sparrows prefer sagebrush/bunchgrass shrub-steppe landscapes of the Columbia Basin and is a summer resident in eastern Washington. Sagebrush sparrows forage on the ground for insects, spiders, small fruits and seeds.

GALLINACEOUS BIRDS

Commonly occurring gallinaceous birds in the LSRP study area include ring-necked pheasant, California quail, and chukar. Mourning doves are native to the lower Snake River and reside in upland habitats. Wild turkeys can be seen in the mornings near the Palouse River (eBird 2018).

Chukars use a wide variety of habitats including riversides, shrublands, talus areas and uplands. Douglas hackberry, smooth sumac (*Rhus glabra*), and poison ivy (*Toxicodendron radicans*) stands along the Snake River provide cover and access to the biggest limiting factor in the ecoregion, water. Foraging habitats include cheatgrass invaded grasslands and agricultural fields.

Ring-necked pheasants and quail often habituate the irrigated HMUs, like Swift Bar at RM 97. HMU management includes the planting of food plots of sunflower, grains, and corn which attracts gallinaceous birds. The HMU also has a permanent water sources or guzzlers which can sustain populations over the average carrying capacity of the study area. Pheasants also depend on permanent shrub and tall herbaceous cover grown in the regularly irrigated land. There are 960 acres of food plots, meadows, and woody vegetation plots under irrigation in the 10 intensively managed HMUs in the LSRP study area (USACE 2002). Ring-necked pheasant, quail and chukar populations are maintained for hunting in the HMUs.

Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbiansu*) is listed as a threatened species in Washington State and a federal species of concern. Columbian sharp-tailed grouse habitat consists of a mix of perennial bunchgrasses, forbs, and a few shrubs. Shortages of nesting, brood rearing, and wintering habitats are important limiting factors to Columbian sharp-tailed grouse population recovery. Columbian sharp-tailed grouse use riparian areas with deciduous trees and shrubs for cover and food (berries, seeds, buds, and catkins) in the winter when snow covers the ground. The most important riparian trees and shrubs for Columbian sharp-tailed grouse include water birch (*Betula nigra*), serviceberry (*Amelanchier* sp.), chokecherry, rose (*Rosa* sp.), black hawthorn, snowberry (*Symphoricarpos albus*), cottonwood, and aspen (*Populus tremuloides*).

2.7.3.2 Mammals

TERRESTRIAL

Whitetail (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus*), mountain lion (*Puma concolor*), Rocky mountain elk (*Cervus canadensis*), striped skunk (*Mephitis mephitis*), black-tailed jackrabbit (*Lepus californicus*), coyotes (Canis latrans), ground squirrels, and porcupines (*Erethizon dorsatum*) are commonly found in the LSRP study area (USACE 2018). Mammals occupying upland habitat near the lower Snake River occasionally include bobcat (*Lynx rufus*), red fox (*Vulpes vulpes*), and mink. Irrigated HMUs in the LSRP study area are hotspots for terrestrial mammals, especially whitetail and mule deer which are attracted to dense patches of shrubs and planted food plots (USACE 2002).

American badgers (Taxidea taxus) distribution includes portions of eastern Washington from the eastern Cascade foothills to the Idaho border. Badgers are found in grassland, shrub-steppe and a variety of human-impacted land cover types like parkland and agriculture. Coyotes, bears and mountain lions prey upon the badgers (WDFW 2015). Their population size and status in Washington is unknown but there is suitable habitat for the fossorial mammal in the LSRP study area. There are several 'Rocky Mountain' bighorn sheep populations in south-eastern

Washington but pneumonia outbreaks continue to cause low lamb recruitment and mortality. Bighorn sheep can occur is xeric shrub-steppe and desert grassland habitats. Habitat must include escape terrain such as cliffs and talus slopes (WDFW 2015. While bighorn sheep primarily are found in upland habitats, they may use tributaries of the Snake River during summertime droughts.

White-tailed Jackrabbit (*Lepus townsendii*) and black-tailed jackrabbit have both declined in the project area due to habitat loss, degradation, fragmentation, competition, and overhunting. White-tailed jackrabbits occur in areas of bunchgrass habitats with sparse shrub cover while black-tailed jackrabbits occur primarily in sagebrush habitats (WDFW 2015). Jackrabbits are considered an ecologically important species because of their role as prey for a wide variety of raptors and mammalian predators.

Eleven small mammal species have been observed in the project area: deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), Great Basin pocket mouse (*Perognathus parvus*), house mouse (*Mus musculus*), long-tailed vole (*Microtus longicaudus*), montane vole (*Microtus montanus*), northern pocket gopher (*Thomomys talpoides*), vagrant shrew (*Sorex vagrans*), Merriam's shrew (*Sorex merriami*), bushy-tailed woodrat (*Neotoma cinerea*), and Ord's kangaroot rat (*Dipodomys ordii*) (USACE 2002). Evidence suggests small mammals prefer native riparian habitat to other habitat. Asherin and Claar (1976) found the highest small mammal species diversity in the native cattail and shrub willow habitat types. Deer mice made up 74 percent of total captures in a study conducted by Rocklage and Ratti (1998). Townsends' ground squirrel (*Urocitellus townsendii*) and Washington ground squirrel (*Spermophilus washingtoni*) are candidates for state listing and occur in south-central to southeastern Washington. They inhabit native shrub-steppe, grasslands, and large sagebrush patches at forest edges. Ground squirrels are a burrowing species that may occur in small to large colonies. American badgers, raptors and snakes are their primary predators (WDFW 2015).

Deer populations are surveyed extensively in the LSRP study area because they are managed for hunting in Washington, especially in the HMUs. Mule and whitetail deer are the two most commonly hunted species occupying lands in the lower Snake River. Irrigated HMUs near Ice Harbor and Lower Monumental Dam provide dense shrub cover used for fawning habitat. Planted food plots of cereal grains may be used for foraging. New York Island in Lake Bryan may also provide suitable fawning habitat in years with high precipitation (USACE 2002). Mule deer and white-tailed deer populations in eastern Washington are stable to increasing, at their carrying capacity. Mule deer populations are closely tied to severe winter events and drought. Both species are influenced by the liberal harvest of alfalfa and cereal grains, such as oats, wheat, and barley, which provide forage during lean times. Both species in the study area are susceptible to chronic wasting disease (CWD), epizootic hermorrhagic disease (EHD), and hair loss syndrome (WDFW 2015).

Deer use a wide variety of habitats in the project area, including vegetated draws and pockets of wetland vegetation for cover and fawning, and grasslands for foraging. Greater precipitation near the Lower Granite and Little Goose Dams provides a higher variety of habitats than the drier lands surrounding Lower Monumental and Ice Harbor (USACE 1990). Whitetail deer are most strongly associated with the dense shrub and tree cover provided around Lower Granite reservoir. Aerial winter deer counts conducted by the USACE and WDFW between 1978 and 1988 along the four reservoirs found an average of 3,547 deer per year. Mule deer made up approximately 80 percent of the surveyed population. HMUs are thought to have aided in the deer population recovery by providing browse and excluding livestock from much of the USACE managed lands (USACE 1990).

Documented species of bat in the project area include the Yuma myotis (*Myotis yumanensis*), long-legged myotis (*Myotis volans*), long-eared myotis (*Myotis evotis*), small-footed myotis (*Myotis leibii*), fringed myotis, canyon bat (*Parastrellus hesperus*), and Townsend's big-eared bat (USACE 2002). Townsends's big-eared bat is a Washington state candidate species of concern (WDFW 2017). Other bat species thought to occur based on habitat suitability, their range, and their occurrence in the vicinity include the hoary bat (*Lasiurus cinereus*), little brown bat (*Myotis lucifugus*), pallid bat, California bat (*Macrotus californicus*), and big brown bat (*Eptesicus fuscus*) (USACE 2002).

The majority of bat species can use a variety of roosting sites, including caves, mines, trees, buildings, bridges, dams, and rock crevice. Some bat species may roost two miles from the Snake River. The bat species will forage in a wide variety of habitats including arid grassland, scrub-shrub, ponderosa pine and white oak forests, and rocky areas. Many of the bat species forage on stream insects such as midges, caddisflies, and mayflies.

Townsend's big-eared bat is thought to be dependent on caves or mines for both winter and summer roosting. Townsend's big-eared bats prey primarily on moths and seems to require still lakes, ponds, or pools to obtain water, as it flies low and laps water with its tongue. The canyon bat, is closely associated with steep canyon walls and rock crevices in the project area and utilizes these habitats for roosting (Johnson and Cassidy 1997). Yuma myotis are closely associated with water and tends to forage close to the surface of the water (USACE 2002).

White-nose syndrome (*Pseudogymnoascus destructans*) is a fungus that infects bats in winter during hibernation. The fungus disrupts their thermoregulation, causing frequent interruptions during hibernation. Frequent awakening burns critical stored fat reserves, and when food is seasonally unavailable the bats starve. Mortality rate for some species has been recorded at 90-100% of populations. White-nose syndrome has been documented in Washington affecting Yumo myotis and little brown bat, and may be affecting bats in the LSRP study area (WISC 2004).

AQUATIC

Aquatic mammal abundance has been reported low along the lower Snake River due to the lack of forested wetlands (USACE 2002). Beaver, river otter, and muskrat are the most commonly seen in the study area. McNary Wildlife Refuge and Brownlee Reservoir support a diversity of aquatic mammal populations due to large tracts of intact wetland habitat (USACE 2002).

The two major tributaries of the lower Snake River, the Palouse and Tucannon Rivers, have small groves of black cottonwood, with willows, alders, and dogwoods with dense emergent herbaceous cover. These tributaries are likely the only in the study area to support aquatic mammal survival. Several large vegetated embayments along the river may also provide habitat.

Beaver are dependent on woody riparian growth as a food source. Beaver lodges are rare along the lower Snake River with most denning occurring in banks and in association with at least sapling size trees. Otter denning requirements are not as stringent as the beaver's. Otter use dens previously excavated by other species in close proximity to water. Otters depend are mostly dependent on relatively dense bank cover that can be supplied by vegetation, woody debris, and/or rocks. Heavy riparian vegetation cover provides the best environment for both the cover and feeding.

2.7.3.3 Reptiles and Amphibians

At least sixteen species of amphibians and reptiles have been documented along the Snake River. Five amphibian and eight reptile species during surveys in the study area during a two-year study (Loper and Lohman 1998). Pacific tree frog, bullfrog, western yellow-bellied racer, Great Basin spadefoot (*Spea intermontana*), long-toed salamander, Great Basin gopher snake, night snake (*Hypsiglena torquata*), and painted turtle (*Chrysemys picta*) were the most frequently occurring species (USACE 2002).

Additional species that may occur within the LSRP study area include: tiger salamander (*Ambystoma tigrinum*), northern leopard frog (*Lithobates pipiens*), Woodhouse's toad (*Anaxyrus woodhousii*), short-horned lizard (*Phrynosoma hernandesi*), sagebrush lizard (*Sceloporus graciosus*), rubber boa, and ring-necked snake (USACE 2002). Overall reptile occurrence throughout the project site is limited, although some snake species are dependent on a well-developed riparian zones for availability of prey, cover, and over-wintering.

Both amphibian and reptile species abundance and richness are relatively low at both riparian and uplands sites; however, vegetation types most closely associated with water had the greatest abundance of amphibians. The relative young age of the recovering riparian fringe beside the reservoirs, the isolation of suitable riparian habitat along the river, and fluctuating water levels may prevent the consistent occurrence of litter, debris, pools, and vegetation that these species could use for breeding, resting, and forage (USACE 2002).

Most amphibians are closely associated with permanent ponds without fish, usually within forested wetland vegetation adjacent to rivers. Tree frog and Columbia spotted frog occur in association with submerged aquatic vegetation of seasonal emergent wetlands and ponds. The Northern leopard frog, a Washington State endangered listed species, requires permanent deep water for overwintering, in proximity to seasonal ponds and wetlands for breeding (WDFW 2017). Northern Leopard frogs are negatively associated with the presence of bullfrogs, carp (*Cyprinus carpio*), and other non-native predatory fish. Large expansion of cattails, bulrush, common reed, reed canarygrass, and purple loosestrife can render breeding habitats unsuitable.

2.7.3.4 Invertebrates

Several species of mollusks have been identified inhabiting the lower Snake River, of which only six are native (Frest and Johannes 1992). The most abundant species observed were the introduced Asian clam (*Corbicula fluminea*) and native Rocky Mountain ridged mussel (*Gonidea angulata*). The California floater (*Anodonta californiensis*), western floater (*Anodonta kennerlyi*), shortface lanx (*Fisherola nuttallii*), and the Columbia pebble snail (*Fluminicola Columbiana*) have been identified by the U.S. Fish and Wildlife Service (USFWS) as species of concern.

Benthic production is usually minimal in shallow-water areas if the water levels fluctuate and expose the organisms. The 1992 Drawdown Test found the presence of freshwater clams and crayfish (*Pacifasticus leniusculus*) were the most noticeable aquatic organisms, other than fish, impacted by the drawdown (USACE 1992). Freshwater clams were found in a variety of substrates including mud and mixed cobble/gravel areas. Densities were observed as much as 36 clams/100 feet of beach. Clam tracks indicated that the clams were moving downslope to the water in response to lowered water. Their ability to move toward the water is dependent on substrate, texture, bank slope, and drawdown rate.

The Northern crayfish (*Orconectes virilis*) is a non-native crustacean that can alter open water habitats, and even impact fish populations. Densities of crayfish in the lower Snake reservoirs have not been quantified, except for limited evaluations in Lower Granite reservoir. Bennett et al. (1983) found the highest densities of crayfish at upstream sites in Lower Granite main channel. Crayfish tend to congregate near the shaded, vegetated shoreline with ample rock crevices for evading predators. Crayfish are an important component to the diet of smallmouth bass (*Micropterus dolomieu*), northern pikeminnow (*Ptychocheilus oregonensis*), and channel catfish (*Ictalurus punctatus*) in the Lower Granite and Little Goose reservoirs (USACE 2002).

Additional non-native species that are outcompeting native invertebrates and negatively impacting the quality of open water habitat include New Zealand mud snails (*Potamopyrgus antipodarum*) and copeods (*Oithona davisae* and *Pseudodiaptomus forbesi*) . Mud snails dominante river and lakebed habitat by outcompeting native snails and insects and were found in the lower Columbia River in 2002. Invasive copepods have been found in the Columbia River, and likely have invaded the Snake. Both known species replace native copepod species, and potentially can alter entire food webs in the study area. Zebra (*Dreissena polymorpha*) and quagga mussels (*Dreissena rostriformis*) have not yet been reported in Washington (WISC 2009).

2.8 MCNARY DAM AND LAKE WALLULA

2.8.1 Study Area

The study area used to describe the existing conditions and assess the range of potential impacts for wildlife and habitat features includes the entire Lake Wallula, which begins just below the U.S. Department of Energy's Hanford Site at Priest Lake Rapids Dam on the Columbia River and extends 64 miles downstream to McNary Dam (see Figure 2-8). The lake also extends 10 miles up the Snake River to Ice Harbor Lock and Dam. The lake also includes a small portion of the Yakima River. Lake Wallula has a water surface area of 38,800 acres with more than 200 miles of shoreline (USACE 2012). The north side of the dam is in Benton County, WA and the south side is in Umatilla County, OR. Surrounding the lake are 16,908 acres of project (Federal) lands that are used for recreational, wildlife habitat, wildlife mitigation, and water-connected industrial development. In 2005, about 2,400 acres were licensed to either State or local park agencies, and the U.S. Fish and Widllie Service leases about 3,500 acres as part of the McNary National Wildlife Refuge. Port districts own about 1,500 acres for industrial development.

McNary Dam and Lake Wallula are located in the Columbia Plateau Ecoregion. See Section 1.2.2 for a description of characteristic features of this ecoregion. Lake Wallula is located in the Tri-Cities (Kennewick, Pasco, and Richland) area at the confluence of the Yakima, Snake, and Columbia Rivers in the Columbia aisn of Eastern Washington. Lands adjacent to the lake vary from heavily urbanized in the middle portions, to towering vertical basalt cliffs at the downstream end, and long gently sloping shelves in the upper reaches (USACE 2012).

McNary National Wildlife Refuge covers over 15,000 acres along the west bank of Lake Wallula from the confluence of the Snake River to the mouth of the Walla Walla River, and downstream into Oregon. The refuge includes sloughs, ponds, streams, an islands, forested and herbaceous wetlands, and upland shrub-steppe and cliff-tallus habitats. It serves as an anchor for biodiversity in the mid-Columbia Basin (USFWS 2018). McNary NWR is managed as part of the Mid-Columbial River National Wildlife Regute Complex. Table 1-1 identifies the land cover, vegetation, and habitat of the study area. Land cover and vegetation on federal lands immediately adjacent to Lake Wallula are described in the McNary Shoreline Management Plan (USACE 2012).

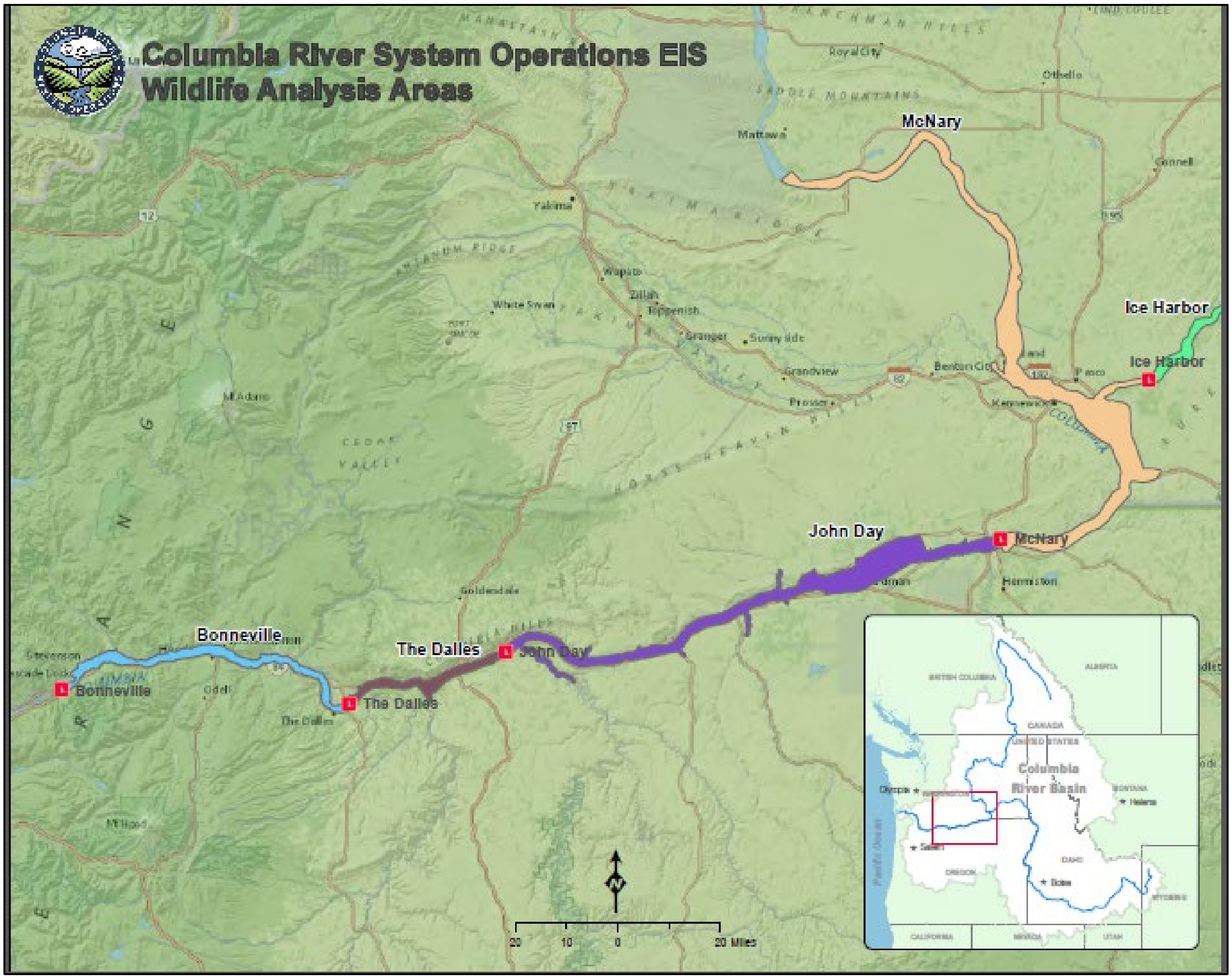

Figure 2-8. McNary Dam and Lake Wallula Study Area.

2.8.2 Land Cover

Table 1-2 above shows the acres of the different habitat types within the McNary Dam study area.

2.8.2.1 Uplands

There are approximately 50,000 acres of uplands within the study area. Shrub-steppe communities dominate the uplands surrounding the McNary project. Gray rabbitbrush and green rabbitbrush (*Chrysothamnus viscidiflorus*) are the dominate species. Some big sagebrush species are present. Limited associations of sagebrush and bitterbrush are present, usually on flat benches. Introduced Cheatgrass (*Bromus tectorum*) has replaced most of the native bunch grasses.

Introduced plants are common in disturbed areas and in areas historically dominated by native grasses. Other common introduced plants include blackgrass, squirreltail, reed canarygrass, mustard, dock, and pigweed. The introduced invasive Russian olive (*Elaeagnus angustifolia*) has colonized the Yakima River delta.

2.8.2.2 Barren Zone (Drawdown Zone)

Much of the lower half of Lake Wallula is bordered by steep topography and riprap protecting a road on the east side and railroad on the west side. The shorelines bordering the upper half of the reservoir are relatively flat, especially on the east side between the mouths of the Snake and Walla Walla Rivers. This provides for the creation of extensive mudflats when the pool is operated at or near its minimum. Erosion and landslide potential is minimal throughout the reservoir.

2.8.2.3 Wetlands – Forested and Scrub-Shrub

Forested and scrub-shrub wetlands are found along the Lake Wallula shoreline, backwaters, sloughs and tributaries. Approximately 4,000 acres of Forested and Scrub-Shrub wetlands are found within the McNary study area. Most wetlands occur just below the mouth of the Snake River, in Burbank Slough. Typical wetland taxa include black cottonwoods and willows.
The most extensive stand of cottonwood in the project area is located at the mouth of the Walla Walla River. Other common tree species include white alder, red alder, hackberry, and black locust. This vegetation provides critical cover and food for most of the wildlife species found in the study area.

Scrub-shrub wetlands are usually found adjacent to the high water line along protected backwater areas and is dominated by willow species and western false indigo. Moister shrub-scrub communities are dominated by black hawthorn, chokecherry, golden currant (*Ribes aureum*), and red-osier dogwood (*Cornus sericea*). Wood's rose (*Rosa woodsii*) can dominate drier areas.

2.8.2.4 Wetlands – Emergent Herbaceous

Approximately 1,600 acres of emergent wetlands within the McNary study area. Most wetlands occur just below the mouth of the Snake River and Burbank Slough Slough and is found mostly on sandbars, mudflats, and subirrigated areas adjacent to the reservoir. Typical wetland taxa for the region include cattail, bulrush, and sedges. Representative grasses include blackgrass (*Alopecurus myosuroides*), squirreltail (*Elymus elymoides*), and reed canarygrass (*Phalaris arundinacea*). Forbs include mustards, docks, pigweeds, composites, and thistles.

2.8.2.5 Water

In the study area, the most extensive aquatic vegetation beds likely occur in ponds. Common aquatic plants are flowering rush (*Butomus umbellatus*) and Eurasian milfoil (*Myriophyllum spicatum*).

2.8.2.6 Islands

Thirteen named islands are located within Lake Wallula: Badger Island, Casey Island, Clover Island, Crescent Island, Foundation Island, Indian Island, Peavin Island, Strawberry Island, Tanglefoot Island, Two Rivers Islands, Van Skinner Island, Island 19 (Richland Island), and Island 20 (Fencepost Island). Badger Island and Crescent Island, located upstream of McNary Dam near the town of Wallula, are owned and managed by the U.S. Fish and Wildlife Service as part of McNary National Wildlife Refuge. Crescent Island is an artificial island created from dredged materials in 1985 as mitigation for waterfowl nesting habitat lost during construction of the Wallula pulp mill. Today Crescent Island consists of 7.5 acres with a mix of dense upland shrub habitat and bare ground.

Foundation Island also located upstream of McNary Dam near the Town of Burbank, WA is the site of the largest double-crested cormorant colony on the mid-Columbia River. The earliest nesting record on Foundation Island was in 1998 when 100 breeding pairs were counted in the trees at the southern end of the island. By 2004 there were 300 breeding pairs, which grew to 360 pairs in 2006, and then declined to 310 pairs in 2010 (Adkins et al. 2014). All the cormorants in this colony nest in trees along with black-crowned night-herons and great blue herons.

Island 20 (also called Fencepost Island) is on the Columbia River upstream of McNary Dam near the city of Richland is owned and managed by the USACE. Island 20 is colonized by well over 15,000 breeding pairs of California gulls (*Larus californicus*). Once Island 19 had supported a very large mixed colony of ring-billed gulls (*Larus delawarensis*) and California gulls consisting of over 10,000 breeding pairs in the 1990’s, but gulls no longer next on this island. On the Columbia Plateau gull declines are associated with declines in suitable colony sites free from human disturbance and predators (Adkins et al. 2014).

2.8.3 Wildlife

2.8.3.1 Birds

RAPTORS

A few bald eagles winter along Lake Wallula feeding primarily on waterfowl and to a lesser extent upland avian species, salmonid carcasses, and other wildlife.

Burrowing owls are a candidate species of concern in the State of Washington. Burrowing owls inhabit open grassland and shrub-steppe habitats in eastern Washington. There are breeding records from most of the non-forested low elevation areas of eastern Washington, but historical information suggests that their range in Washington has undergone a significant contraction in recent decades. Burrowing owls have become uncommon to rare outside of Benton, Franklin, Grant, and western Adams counties.

WATERBIRDS, SHOREBIRDS AND WATERFOWL

Approximately 20 breeding pairs of white pelicans began nesting on nearby Badger Island, which is part of the McNary National Wildlife Refuge, in 1997. By 2016, over 1,600 breeding pairs were documented on this island. This accounts for almost 9 percent of the population of these birds in the western United States (Stinson 2016). An average of 3,118 individuals were counted from aerial photos in May of 2016. Badger Island is currently the only known location of American White pelicans in the State of Washington. Badger Island is closed to both the public and researchers in order to avoid human disturbance to nesting birds that might cause abandonment of the colony. Pelicans nest on the ground in at least three distinct areas of the island: the upstream tip, halfway down the island on the eastern shore, and the interior of the island. Much of the pelican colony is concealed from view from the water and from the air by dense shrub vegetation so the size of the colony is estimated by counts of adults from aerial photos taken of the island. In 1994, a breeding colony established on Crescent Island, which is also part of the McNary NWR. The pelicans stopped nesting there in 1998. In 2010 about 50 pelicans attempted to nest on Crescent Island but all nests failed (Adkins et al. 2014).

A substantial great blue heron rookery is located on Foundation Island. This rookery also contains black-crowned night herons. Great blue herons are commonly observed foraging along shallow shorelines, backwaters, and embayments. Doublecrested cormorants are also present.

Caspian terns have nested on Crescent Island. Adkins, et al. (2014) reported that from 2004 to 2010, the number of breeding paris has varied, ranging from a high of 530 breeding pairs in 2004 to a low of 349 pairs in 2009.

Shorebirds found along the shores of Lake Wallula include the American coot (*Fulica americana*), black- bellied plover (*Pluvialis squatarola*), lesser golden plover (*Pluvialis dominica*), snowy plover (*Charadrius nivosus*), semipalmated plover (*Charadrius semipalmatus*), western sandpiper (*Calidris mauri*), spotted sandpiper, least sandpiper (*Calidris minutilla*), Baird's sandpiper (*Calidris bairdii*), stilt sandpiper (*Calidris himantopus*), pectoral sandpiper (*Calidris melanotos*), killdeer, black-necked stilt (*Himantopus mexicanus*), American avocet, greater and lesser yellowlegs, whimbrel (*Numenius phaeopus*), long-billed curlew (*Numenius americanus*), marbled godwit, sanderling (*Calidris alba*), dunlin (Calidris alpine), short-billed dowitcher (Limnodromus griseus), long-billed dowithcer (*Limnodromus scolopaceus*), common snipe, Wilson's phalarope (Phalaropus tricolor), red-necked phalarope (*Phalaropus lobatus*), and Virginia rail (*Rallus limicola*).

Lake Wallula supports a large population of nesting Canada geese. Number of wintering Canada geese on McNary NWR have been known to peak at about 50,000 with as many as 20,000 additional geese utilizing other areas of the reservoir. Wintering geese use the abundant corn and wheat fields provided on the refuge and surrounding agricultural lands. Most goose nesting occurs on seven islands with a combined average of 130 successful nests. The highest number of successful goose nests (around 73) occur on Badger Island. Some ground nesting has also been observed within the NWR but nests are very susceptible to both avian and ground predators. The U.S. Fish and Wildlife Service erected 30 nesting baskets on the Strawberry

Islands and 19 nesting platforms in McNary NWR to help eliminate predation. The baskets receive about 20 percent use. Adequate habitat for brooding pastures is thought to exist along naturally occurring habitat along Lake Wallula.

In addition to Canada geese, common waterfowl along Lake Wallula include the mallard, gadwall, northern shoveler (*Anas clypeata*), cinnamon teal (*Anas cyanoptera*), blue-winged teal (*Anas discors*), green-wing teal, redhead (*Aythya americana*), canvasback (Aythya valisineria), lesser scaup (*Aythya affinis*), ruddy duck (*Oxyura jamaicensis*), ring-necked duck (*Aythya collaris*), bufflehead (*Bucephala albeola*), and common goldeneye (*Bucephala clangula*), wood duck, pied-billed grebe (*Podilymbus podiceps*), red-necked grebe (*Podiceps grisegena*), and western grebe (*Aechmophorus occidentalis*). Nine boxes have been added to goose structures for mallard use as well as 12 plastic nesting tubs. Some additional duck nesting likely occurs on the more heavily vegetated islands within the reservoir. Very limited brooding may also occur associated with the islands or along shallow backwaters along the reservoir. An attractive brooding area consisting of a complex of backwater ponds and wetlands occurs immediately below the mouth of the Snake River.

PASSERINES

All red-winged blackbird nesting and most of the feeding occurs within wetlands dominated by cattails. Small pockets of cattail occur throughout backwaters along the reservoir.

Yellow Warblers exclusively occupy scrub-shrub habitat provided by willow growth. Many pockets of this habitat type occur along backwaters, embayments, and tributary deltas.

Mature cottonwoods are present near the mouth of the Walla Walla River and pockets along the shoreline make suitable downy woodpecker nesting habitat. Cottonwood regeneration around Lake Wallula is a concern because it normally requires a hydrologic regime characterized by periodic flooding. A stretch of forested riparian areas dominated by Russian olive along the western shoreline up to the mouth of the Yakima River also makes suitable woodpecker nesting habitat.

GALLINACEOUS BIRDS

No native gallinaceous birds noted. Introduced species found in this study area include ring-neck pheasant.

2.8.3.2 Mammals

TERRESTRIAL

The federally listed gray wolf (*Canis lupus*) is known to exist around Lake Wallula. As of December 2016, there were six established wolf packs and one estimated wolf use area totaling around 45 individual wolfs in lands surrounding the project. One of the six wolf packs was newly discovered in 2016, the other five all showed growth since first being discovered between 2009 and 2014. Four of the six wolf packs had breeding pairs; a breeding pair is a male and a female that have produced at least two pups surviving to Dec 31 (ODFW 2018).

Gray wolves have two main life requisite requirements; 1) an abundance of prey species and 2) isolation from human disturbance. Wolves will take a variety of prey species, but the bulk of their prey is composed of ungulates, mainly deer, elk, and moose (USFWS 1987). Gray wolves are sensitive to human disturbance, particularly near their denning and rendezvous sites. Factors such as road density have been shown to be important indices of levels of disturbance that wolves can tolerate (Mladenoff et al. 1995).

Mule deer are present throughout the project area. Fawning is associated with heavy cover available in palustrine and riverine forested and scrub-shrub wetlands. Islands are used to some extent. Mule deer are only partially dependent on lands near Lake Wallula for food, with increased dependence during winter for sources of browse.

Raccoon foraging and denning requirements are largely dependent on prey found in forest and scrub-shrub wetlands and adjacent shallow water areas.

AQUATIC

Beaver and river otters are present in the studay area. Beaver are found in association with the forested and scrub-shrub wetlands, especially where there is a high proportion of young trees and suitable banks for denning. River otters use dens excavated by other species or riprap where they are located close to water are of suitable size. River otters depend on prey found in shallow waters and are also dependent on relatively dense bank cover of plants, woody debris, and large rocks.

2.8.3.3 Reptiles and Amphibians

Amphibian occurrence in habitats along the reservoir is very low. Vegetated areas along the reservoir are used to some extent by garter and gopher snakes. These areas provide sources of prey, cover, and over-wintering habitat.

2.8.3.4 Invertebrates

Invertebrates found in the study are are those common to the overall CRSO study area.

2.9 JOHN DAY DAM AND LAKE UMATILLA

2.9.1 Study Area

The study area used to describe the existing conditions and assess the range of potential impacts for wildlife and habitat features includes lands associated with John Day, Lake Umatilla, and the mouths of its primary tributaries: Umatilla River, Willow Creek, and John Day River (Figure 2-9). The study area is entirely contained within the Columbia Plateau ecoregion, characterized as a nearly level Pleistocene lake plain that was created by flood waters from glacial Lake Missoula. Similar to the mid-Columbia River reaches, the river reach between McNary and John Day are the driest and warmest portions of the Columbia River Basin consisting of sagebrush steppe and grasslands. Winds can exceed 20 miles per hour and temperatures can exceed 100° at the height of the summer in the Columbia River Gorge. The John Day and Lake Umatilla reach typically receives less than 12 inches of annual precipitation, the vast majority of which falls between October and February (NPCC 2005).

Between McNary and John Day, the Yakama Indian Nation has Trust lands along the Washington shore and the Confederated Tribes of the Warm Springs have Trust lands along the Oregon shore. In addition to mixed agricultural lands, the Umatilla Ordinance Depot and Boardman Bombing Range are located approximately 3 to 4 four miles from the Oregon shoreline of the Columbia River in this reach. The USFWS Umatilla National Wildlife Refuge (Umatilla NWR) and the Oregon Department of Fish and Wildlife (ODFW) Irrigon Wildlife Area provides significant wildlife habitat along both shorelines of Lake Umatilla, where the refuge is comprised of a multitude of different habitat types supporting a wide diversity of wildlife.

Figure 2-9. John Day Dam and Lake Umatilla Study Area

2.9.2 Land Cover

Table 1-2 above shows the acres of the different habitat types within the John Day Dam study area.

2.9.2.1 Uplands

Uplands adjacent to John Day and Lake Umatilla largely consist of shrub-steppe vegetation and agricultural areas farmed for dryland wheat, alfalfa and barley. Shrub-steppe habitat is often associated with hotter and drier climates, alluvial and sandy soils. Where shrub-steppe habitat occurs in this reach, it is patchy and often intermixed with uplands converted to agriculture and livestock pasture and areas of human development (Johnson and O'Neil 2000). Native vegetation is dominated by characteristic shrub species, consisting of sagebrush (*Artemisia* sp.), bitterbrush, rabbitbrush (*Ericameria* sp.) and short-spine horsebrush (*Tetradymia spinosa*). Native fescues, wheatgrass, bottlebrush squirreltail, needlegrass, sedges, bluegrasses and rye compose mid- and understory bunchgrasses (WDFW and NWHI, 2001) (NHI&NPCC Columbia River Basin Wildlife Habitat Classification). Depending on the relative level of current and historical disturbance, sites can have little forb cover or contain many species. As described in vegetation communities for upriver reaches of the Columbia River, common forbs include arrowleaf balsamroot, yarrow, buckwheat, blanket flower, parsley, and lupine species.

Trees are relatively uncommon in shrub-steppe habitats and where trees do occur they might be isolated individuals or woodland clusters. Ponderosa pine and Oregon white oak (*Quercus garryana*) woodlands occur sporadically in the Lake Umatilla reach of the Columbia River, notably in the vicinity of Plymouth Park, as well as the Umatilla National Wildlife Refuge where native vegetation is largely intact. Similar to other woodland habitats in the Columbia Plateau, the tree canopy is more open (10 to 60 percent) than the dense coniferous forests found in the Rocky Mountains to the east and Cascade Mountains west (Johnson and O'Neil 2000). Understory species in woodland patches consist largely of sagebrush, bitterbrush, and rabbitbrush, in addition to various bunchgrasses, sedges and forbs. There are approximately 100 acres of ponderosa pine and white oak woodlands in upland habitats along Lake Umatilla

Like many upstream reaches on the Columbia Plateau, cheatgrass is widespread across the study area and difficult to eradicate. Other widespread invasive species common in upland include Russian olive, black locust, Himalayan blackberry, Russian knapweed, diffuse knapweed (*Centaurea diffusa*), thistles, toadflaxes, reed canary grass (ODFW 2008 and 2016). In recent years, ODFW has conducted management efforts at the Irrigon Wildlife Area to remove Russian olive and restoring native bunchgrasses to support preservation of shrub-steppe habitat which is listed as a *strategy habitat* under the Oregon Conservation Strategy (ODFW 2016).

2.9.2.2 Barren Zone (Drawdown Zone)

Barren or drawdown zones between McNary andJohn Day are virtually non-existent, as John Day is managed as a run-of-river project. On average, water surface elevations in Lake Umatilla fluctuate less than a foot per day. As a result, there are few areas along the shoreline where habitat is exposed for prolonged periods of time. However, there are areas where the shoreline is predominantly basalt bedrock or gravel and sand, with limited or no vegetation. Northern wormwood (*Artemisia campestris* var. *wormskioldii*), however, is an example of a perennial plant in the aster family that occupies exposed basalt terraces and sand habitat along the banks of the Columbia River and rocky islands (ODFW 2016, from USFWS 2016).

Where upland shrub-steppe habitats transition abruptly to the river's edge and no forested or scrub-shrub wetlands exists, the shorelines are largely formed by a band of basalt bedrock from prehistoric lava flows with unstable sandy shorelines (Camp et al. 2017 and ODFW 2008). Landslides and erosions are from current reservoir operations and irrigation are uncommon due to the bedrock foundation dominating both the Oregon and Washington shorelines.

2.9.2.3 Wetlands – Forested and Scrub-Shrub

There are approximately 1,000 acres of Forested and Shrub-Scrub wetlands adjacent to the Columbia River. With the exception of the Willow Creek Wildlife Area, the majority of this habitat occurs upstream of RM 262 and is within the boundaries of the Umatilla NWR and the Irrigon Wildlife Area. Downstream of RM 262 on the mainstem Columbia River, the side slopes and channel banks are steep and rocky, precluding soil development to support and sustain vegetation and wildlife habitat. The Willow Creek Wildlife Area provides a mosaic of forested and shrub-scrub wetlands, emergent herbaceous wetlands, and open water slough habitats in an otherwise arid and isolated portion of the river (Figure 2-10).

Within the John Day and Lake Umatilla study area, there are several significant state and federally managed wildlife areas containing vast tracts of intact forested and scrub-shrub wetlands. The Umatilla NWR, spanning the shorelines from RM 261 to 283, was established in 1969 as mitigation for forested and scrub-shrub wetlands and emergent herbaceous wetlands that were lost following construction of John Day. The refuge is spread across 23,555 acres and contains 22 miles of shoreline along Oregon and Washington shores. The refuge is approximately 45 miles upstream from John Day and 9 miles downstream from McNary.
The Irrigon Wildlife Area contains 979 acres of forested and scrub-shrub wetlands and emergent herbaceous wetlands spanning 7 miles of riverfront shoreline of the Columbia River between the cities of Irrigon and Umatilla at RM 252. The Willow Creek Wildlife Area contains 646 acres of comprised of land and open water where Willow Creek flows into the Columbia River at RM 252. The Irrigon and Willow Creek Wildlife Areas are managed by ODFW as part of the Columbia River Wildlife Areas, a composition of four sites in the Columbia Plateau region which are managed for wildlife. These managed lands provide important habitat for the conservation of fish and wildlife within this reach of the Columbia River (ODFW 2008).

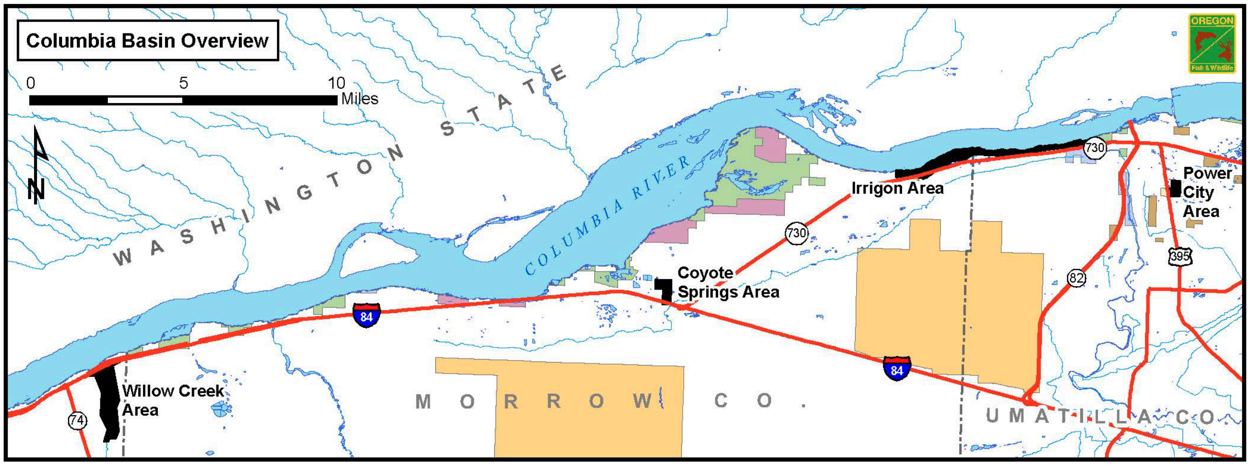

Figure 2-10. The Irrigon and Willow Creek Wildlife Areas as a part of the greater Columbia Basin Wildlife Areas on the Columbia Plateau (ODFW 2008).

Forested and scrub-shrub wetlands occur adjacent to Lake Umatilla in areas along the shoreline with permanent or seasonal inundation or in areas with impounded water and along lakes and ponds. Habitats along Lake Umatilla consists of narrow bands of trees, shrubs, and herbaceous vegetation. In addition, due to the presence of dryland farming in the uplands and irrigation of streamsides and toe-slopes, more water is available in some areas than would occur without agricultural practices, providing an important hydrologic element necessary for maintenance of riparian habitats in arid lands. Successional development is frequently controlled by flooding and fires, and disturbances could occur every 25 to 50 years (Johnson and O'Neil 2000).

Predominant vegetation in the forested and scrub-shrub wetlands of Lake Umatilla consists of a multi-layered mosaic of trees, shrubs and forbs. Trees include conifers and broadleaf deciduous species, including Ponderosa pine, Douglas fir, black cottonwood, quaking aspen, willows (*Salix*, sp.), alders (*Alnus*, sp.) and birch (*Betula* sp.). Riparian areas include a wide variety of shrubs, both shade and sun tolerant, including red-osier dogwood, mountain alder, chockcherry, roses, snowberry, serviceberry, black hawthorne, willows, current (*Ribes* sp.), elderberry and spirea (*Spirea douglasii*). Shrubs can form dense thickets, dominating the understory canopy.
The herbaceous layer is highly variable and consists of an assortment of graminoids (grasses) and broadleaf forbs. Common plants include asters, horsetail (*Equisetum* sp.), parsley and parsnip, skunk cabbage, nettles, speedwell (*Veronica* sp.) and violets.

Widespread invasive plant species common in riparian habitats include Russian olive, poison hemlock, black locust, Himalayan blackberry, Japanese knotweed (*Fallopia japonic*), leafy spurge (*Euphorbia esula*), tansy ragwort, crested wheatgrass (*Agropyron cristatum*), and climbing nightshade (*Solanum dulcamara*) (ODFW 2008 and 2016).

2.9.2.4 Wetlands – Emergent Herbaceous

There are approximately 700 acres of emergent wetlands in the John Day study area. Similar to forested and scrub-shrub wetlands in Lake Umatilla, emergent herbaceous wetlands along Lake Umatilla primarily occurs upstream of RM 262 and is found predominantly within the Umatilla

NWR and Irrigon Wildlife Area, as well as isolated pockets along the Columbia River. In this portion of the river, herbaceous wetland habitats are a result of altered landscapes associated with modern agricultural practices and irrigation, in addition to operation of John Day (ODFW 2008). Emergent wetlands, as well as forested and scrub-shrub wetlands, usually occupy sites where seepage from upslope or sub-irrigation maintains hydric soils necessary to support the establishment and growth of wetland plants (FGDC 2013; BPA 1990). Additionally, slackwater areas also support the development of wetland plant communities, examples of which include Patterson and McCormack Sloughs in the Umatilla NWR and the Willow Creek Wildlife Area at RM 252.

Common plants present in freshwater wetlands in Lake Umatilla include cattails (*Typha* sp.), horsetail, bulrush, and a variety of sedges and rushes, in addition to many of the herbaceous species also found within forested and scrub-shrub wetlands (discussed above). In addition, burreed, mannagrass and tufted hairgrass are important wetland grasses supporting wildlife. Trees and shrubs are not typically present in great numbers of density;willows and other woody shrubs may occur in patches along wetland margins. Although aquatic plants are considered important wetland features, they are discussed in greater detail in the following section *Water*.

2.9.2.5 Water

Open water, ponded areas and other embayments, and tributary confluences provide important habitat for fish and wildlife. Embayments are open water areas which are cut off from surface water of the mainstem Columbia River by the construction of highway or railroad causeways. Hydrologic connectivity occurs via culverts, small channels, irrigation or groundwater exchange. Shallow-water areas in these habitats support productive submergent, emergent and aquatic vegetation communities which are important to fish and wildlife.
A narrow band of aquatic vegetation is evident in aerial photography in some locations of the Lake Umatilla shoreline, however the spatial extent and species composition of this vegetation has not been formally documented. In addition to embayments, tributaries and ponds reflect slack water conditions immediately adjacent to the river, increasing overall habitat for aquatic plant communities. There are approximately 45,000 acres of open water habitat in the John Day study area.

Slack water sites in Lake Umatilla comprise substantially more acreage than comparable areas in downstream reaches, notably The Dalles Dam reach. There are over a dozen ponded embayments in Lake Umatilla covering thousands of acres. Paterson Slough is the largest embayment (1,043 acres) on the Washington Shore of the Umatilla NWR; McCormack Slough is the largest embayment (494 acres) on the Oregon shore of the Umatilla NWR and the Willow Creek Wildlife Area (200 acres). Open water and off-channel habitat behind Whitcomb Island and Crow Butte Island provide approximately 1,500 acres of open water and wetland habitat supporting submerged aquatic vegetation.

Aquatic plant species in this reach of the river typically include yellow pond lily (*Nuphar lutea*), pondweeds (*Potamogeton* spp.), duckweed (*Lemna* spp.), smartweed (*Polygonum* spp.), wild millet (*Panicum miliaceum*), goosefoot (*Chenopodium* spp.), and swamp timothy (*Crypsis* *schoenoides*). Eurasian water-milfoil is common submerged aquatic invasive species. Purple loosestrife is a common invasive plant in wetland and riparian habitats. The Oregon Department of Agriculture (ODA) considers purple loosestrife a Class A weed, wherein the plant occurs in small-enough infestations to make eradication feasible (ODA 2017). Other aquatic invasive plants include purple loosestrife, yellow flag iris (*Iris pseudacorus*), and watercress (*Nasturtium* sp.).

2.9.2.6 Islands

Depending of water surface elevations in Lake Umatilla, there are numerous islands within the Umatilla NWR boundaries, as well as several large islands downstream of the refuge. Island habitats consist of a basalt foundation with varying habitat types depending on soil condition, elevation and frequency of inundation. Island habitats mimic surrounding upland, riparian and wetland habitats with regards to species composition, diversity and assemblage. Higher elevation islands mimic upland, riparian and/or wetland habitat found on the adjacent Washington and Oregon shorelines. Lower elevation islands which may be inundated frequently during the growing season are frequently bare of vegetation and mimic the barren, rocky shorelines.

There are 13 notable island complexes in the John Day reach of Lake Umatilla. Plymouth Island is approximately 180 acres and is located downstream from McNary Dam at RM 288 to 290 in Lake Umatilla. Plymouth Park Campground is located near the small town of Plymouth and features a boat launch and day use area on the island. Blalock Islands, part of the Umatilla NWR, span RM 273 to 277 and consist of several islands: Big Blalock, Little Blalock, Rock Island, Telegraph Island, Monument Island, Sand Island, West Sand Island, Long Walk Island, Upper Long Walk Island, and Cooks Island. All islands and associated beaches on Umatilla NWR are closed to public access to protect cultural resources and wildlife, and are home to many colonial nesting birds. Whitcomb Island is approximately 1,400 acres of islands within the Umatilla NWR where it is located along the Washington shore between RM 266 and 296. USFWS manages the island for cereal crop production, mostly corn, to provide forage for migrating and wintering waterfowl (USFWS 2008). The island's periphery contains woody and herbaceous wetland habitats where an oxbow provides open water and backwater habitats. Downstream from Whitcomb Island is Crow Butte Island, the upstream portion of which is also part of the Umatilla NWR. Crow Butte Island is also located on the Washington shoreline between RM 261 and 264 and the island is approximately 1,300 acres. The downstream portion of the island is managed by the Port of Benton as a recreational park where the majority of the island's shrub-steppe habitat remains intact. The recreational campground is maintained with cottonwood trees and non-native turf grass.

2.9.3 Wildlife

2.9.3.1 Birds

The John Day and Lake Umatilla study area provide significant habitats for a wide diversity of birds. In 2002, the Audubon Society of Portland, in cooperation with the National Audubon

Society, identified the Umatilla NWR as a state-level Important Bird Area (IBA) for its exceptional concentration of waterfowl, wading birds and shorebirds (Audubon 2002).

RAPTORS

The regionally significant wetland and riparian habitats in Lake Umatilla, and particularly within the Umatilla NWR and Irrigon Wildlife Area, provides crucial breeding and wintering habitat habitat raptors. Turkey vultures are common visitors to the study area, breeding and wintering throughout the reach. Both golden and bald eagles are present in the area, with high numbers (upwards of 30) bald eagles overwintering at the Umatilla NWR (Audubon 2018). While golden eagles are present, they are not known to nest within the Study Area; habitat use for golden eagles would occur largely in shrub-steppe and other upland habitats adjacent to the river. Osprey occur in the study area during the breeding season, where nests are often visible on platforms constructed near the shoreline or at the end of pile dikes.

The concentration of riparian habitat near the Umatilla NWR and Irrigon Wildlife Area support breeding and nesting hawks, including red-tailed and Swainson's hawks. Northern harriers, or marsh hawks, are present throughout the year and commonly observed in wetland and marsh habitats. Summer observations are likely fewer because the majority of breeding and nesting activity likely occurs outside of the study area. Accipiters are less common, with only occasional observations of sharp-shinned and Cooper's hawks occurring in the study area. Rough-legged hawks are present during the winter months, where they forage in agricultural habitats adjacent to the Study Area.

Great horned owls are commonly found within this reach. Occasional observations of barn, burrowing, long-eared and short-eared owls occur largely in upland portions of the study area, hunting in adjacent agricultural fields during spring and fall migrations and throughout the winter months.

American kestrals are present year-round at Umatilla NWR, while merlins, peregrines and prairie falcons are observed primarily during spring and fall migrations.

WATERBIRDS, SHOREBIRDS AND WATERFOWL

Tens of thousands of migrating and over-wintering waterfowl use the wetland and open water habitats in Lake Umatilla. The USFWS Pacific Flyway Data Book informs the following discussion (2017). The locally-rare and regionally significant wetland habitats at Umatilla NWR and the Irrigon Wildlife Area provide crucial high quality forage and cover for over-wintering waterfowl. Lake Umatilla supports one of the most significant wintering concentrations of waterfowl in Oregon and Washington, particularly Canada geese and mallards. Other geese overwintering in Lake Umatilla include snow, Ross's, greater white-fronted, and cackling geese, as well tundra swans. In addition to mallards, numerous duck species commonly overwinter in the refuge waters, including Northern shovelers, gadwalls, American widgeon, Northern pintail, green-winged teal, ring-necked duck, redhead, canvasback, bufflehead, common goldeneye, and common merganser. Western and pied-billed grebes frequently overwinter in Lake Umatilla, while horned and eared grebes are less common during the winter. Other waterbird species overwintering in the study area include Bonaparte's, mew and herring gulls.

In addition to over-wintering habitat, island and shoreline habitats in the refuge boundaries of Lake Umatilla provide protected nesting habitat for nesting colonial waterbirds, such as Caspian and Forster's terns, glaucous-winged, ring-billed and California gulls, and Canada geese, as well as great blue heron and black-crown night heron rookeries. Other common nesting waterbird species include American white pelican, double-crested cormorant, great egret, and American bittern, Viriginia rail and sora (rail). Other common nesting duck species include wood ducks, cinnamon and blue-winged teals, gadwalls, pied-billed grebes and occasionally Western grebes. American coots are year-round residents (breeding and over-wintering) of Lake Umatilla.

Shorebird activity is largely limited to the breeding season, when killdeer, black-necked slilt, American avocet, and spotted sandpiper are common breeders at Umatilla NWR and surrounding areas. Additional species are commonly observed during the spring and fall migration, but which do not over winter in Lake Umatilla, include sandhill cranes, long-billed dowitcher, semipalmated plover, least plover, Western plover, solitary sandpiper, Wilson's snipe, Wilson's and red-naped phalarope, and greater yellowlegs.

PASSERINES

Passerines which are commonly observed nesting at Umatilla NWR include the Western wood pewee, Western and Eastern kingbirds, Northern rough-winged, tree, violet-green, bank, barn, and cliff swallows. Other breeding species include black-capped chickadee, red- and white-breasted nuthatches breed in the Lake Umatilla study area, as well as house, Bewick's and marsh wrens. Yellow warblers are common during the summer breeding season in riparian areas, while yellow-rumped warblers are commonly observed during the spring and fall migratory seasons, as well as over-winter. American crow, common raven and black-billed magpie are year-round resident corvids, and Stellar's and California scrub jays are frequently observed throughout the river reach between John Day and McNary. Other year-round resident passerines include American robin and American goldfinch, as well as song sparrows, yellow-headed, red-winged and Brewer's black birds, Western meadowlark.

Bullock's oriole, brown-headed cowbirds, black-headed grosbeaks, Western tanager, lazuli buntings are common breeding birds observed in Lake Umatilla reach of the Columbia River where suitable habitat conditions exist in riparian and upland areas. Dark-eyed junco, white- and golden-crowned sparrows, savannah sparrow and spotted towhee are frequently observed during the winter and migratory seasons. Mixed upland grasslands are important for long-billed curlew (*Numenius americanus*) and sage sparrow (*Amphispiza belli*), both of which are state-listed sensitive species for Oregon.

GALLINACEOUS BIRDS

Similar to other species present along John Day pool, upland gamebirds are also more abundant in the upper reaches of the pool, particularly in the Umatilla NWR. This is a reflection of suitable habitat occurrence. Quail and pheasants are frequently seen in the summertime, along with mourning doves feeding on the wheat harvests surrounding the Umatilla NWR. Mountain quail have been observed along the tributaries of the John Day River. California quail have been seen in Irrigon and Willow Creek wildlife areas. Chukar are ground-loving, harvested upland game-birds. Chukar's are common permanent residents of eastern Oregon along the steppe habitats along the Columbia River. Ring-necked pheasants were introduced as an exotic game birds and inhabits grasslands and agricultural fields in the study area (ODFW 2016).

Mourning doves and rock pigeons are frequently observed in multiple habitat types throughout the study area. Belted kingfishers and downy woodpeckers are common breeders at Umatilla NWR, and Northern flickers are commonly observed year-round. Lewis' and hairy woodpecker occur at Mary Hill State Park, as well as common nighthawks. Anna's and rufous hummingbirds also occur within the Lake Umatilla study area.

2.9.3.2 Mammals

TERRESTRIAL

Lake Umatilla provides year-round habitat for food, cover, mating and nesting or denning for a wide variety of mammalian species. In the Columbia Basin Wildlife Area Management Plan, ODFW describes 32 species of mammals using shrub-steppe, forested and scrub-shrub wetlands and emergent herbaceous wetland habitats in the John Day and Lake Umatilla region, including small mammals to large ungulates (ODFW 2008). Predators common in shrub-steppe and forested and scrub-shrub wetland habitats include raccoon (*Procyon lotor*), coyote, striped skunk (*Mephitus mephitus*) and badgers (*Taxidea taxus*). Comprehensive surveys of small rodent distribution, abundance and diversity are lacking, but known species include deer mice, pocket mice, shrews, northern pocket gopher (*Thomomys talpoides*), montane voles, long-tailed voles, and sagebrush voles (ODFW 2008).

Large ungulate populations near John Day and Lake Umatilla are dominated by mule deer, and smaller upland mammals include blacktailed jackrabbit and mountain cottontail (*Sylvilagus nuttallii*). Shrub-steppe habitat is the most important habitat for mule deer in the Lake Umatilla area, although woody and herbaceous wetland habitats provide important habitat resources for deer. Additional, island habitats, particularly those on Umatilla NWR, provide important fawning areas for mule deer due to the lack of predators (Tubor 1976).

The most abundant upland terrestrial invasive animal is the feral swine (*Sus scrofa*). John Day is located within Sherman County, OR, of which feral swine have been reported there and in neighboring counties (ODFW 2013). Swine have destructive rooting activities which damage agricultural crops and sensitive fish and wildlife habitat. House Bill 2221 passed in 2009 requires landowners to notify ODFW if swine are roaming their property (OISC 2007).

Limited data for bat populations exists on the Umatilla NWR or ODFW-managed wildlife areas. However, suitable roost habitat and prey availability exists on Umatilla NWR and the Willow Creek and Irrigon Wildlife Areas to suggest several species of bats, such as Townsend's big-eared bat (*Corynorinus townsendii*), long-eared myotis (*Myotis evotis*), long-legged myotis (*M. volans*), pallid bat (*Antrozous pallidus*), silver-haired bat (*Lasionycteris noctivagans*), small-footed myotis (*M. ciliolabrum*), and Yuma myotis (*M. yumanensis*) could be present (USFWS 2008 and ODFW 2016). ODFW notes that spring and summer invertebrate populations and suitable roosting habitats are available in forested and scrub-shrub wetland areas, but inventories and surveys are needed to confirm presence and identify potential bat species that may be present in the study area (ODFW 2008).

AQUATIC

Aquatic mammals are more prevalent upstream of RM 252 where woody and herbaceous wetlands are more common. Between RM 252 and John Day (at RM 216), there are fewer wetland habitats, which are important in supporting aquatic mammals, including many small rodents. Beaver (*Castor canadensis*) and river otters (*Lutra canadensis*) are also common in wetland habitats, and muskrats are often associated with cattail-bulrush wetlands in the John Day study area (Tubor 1976).

Nutria (*Myocastor coypus*) are semi-aquatic rodents found in lakes, wetlands, sloughs, drainage ditches, and irrigation canals along the Columbia River. Nutria burrows and tunnels can damage the integrity of flood control levees, man-made canals, and stream banks resulting in erosion and instability. These giant rodents primarily feed upon succulent plant stalks and roots transforming contiguous wetlands into open water habitat. The nutria is considered an invasive species and classified as a Prohibited Species which can be trapped year round (USFWS 2013).

2.9.3.3 Reptiles and Amphibians

Most amphibian and reptile species that typically inhabit arid habitats in the John Day and Lake Umatilla study area are confined to shrub-steppe habitats and the adjacent fringe of forested and scrub-shrub wetlands and emergent herbaceous wetlands. The abundance of woody and herbaceous wetland habitat in the Umatilla NWR, Willow Creek and Irrigon Wildlife Areas provide essential habitat for all life stages of aquatic-dependent species. Terrestrial and aquatic invertebrate populations associated with shrub-steppe and wetland habitats provide an ample prey base for foraging, and the soils, vegetation and habitat structure (logs or other large wood structures) provide opportunity for nesting, egg laying, basking, escape from predators and refugia. ODFW notes that 13 species of amphibians and reptiles are known to occur across the Columbia Basin Wildlife Area habitats, 10 of which are commonly occurring species (ODFW 2008).

Amphibian species include tree frog (*Hyla regilla*), northern leopard frog (*Rana pipiens*), and Oregon spotted frog (*Rana pretiosa*) (ODFW 2008). The Great Basin spadefoot toad (*Spea intermontana*), Western toad (*Anaxyrus boreas*) and Woodhouse's toad (*A. woodhousii*) are also associated with shrub-steppe and wetland habitats in the John Day study area (Tubor 1976).

Reptile species in the John Day and Lake Umatilla study area include northern sagebrush lizard (*Sceloporus graciosus graciosus*) and short-horned lizard (*Phrynosoma douglasii*). Western painted turtles (*Chrysemys picta belli*), an Oregon Conservation Strategy species is common at Willow Creek and Irrigon Wildlife Areas, where populations are thought to be stable or increasing (ODFW 2008). ODFW has observed six species of snake at the Willow Creek and Irrigon Wildlife areas, including common and Western terrestrial garter snakes (*Thamnophis sirtalis* and *T. elegans*), gopher snake (*Pituophis catenifer*), Western rattlesnake (*Crotalus oreganus*), racer (*Coluber constrictor*) and rubber boa (*Charina bottae*) (ODFW 2008). Species status is unclear, although observations indicate individuals are widespread throughout the study area.

A common widespread invasive that thrives in wetlands and open waters, including the warm waters of ponds, lakes, marshes, sloughs, irrigation ditches and streams, is the bullfrog (Lithobates catesbeianus). Bullfrogs eat fish, reptiles, small mammals, birds, amphibians and insects, so vigorously as to adversely affect native populations. They also aid in the spread of Ranavirosis, as well as the chytrid fungus which are major contributors of the global population decline of native frogs (OSU 2018). Two invasive turtle species are known in Oregon and Washington: the red-eared slider (*Trachemy scripta elegans*) and common snapping turtle (*Chelydra serpentina*). These species outcompete western painted turtles for food resources and basking sites.

2.9.3.4 Invertebrates

Historically, the Columbia River may have supported a rich benthoinvertebrate fauna consisting of caddisfly and chironomid larvae; however, today the river is considered to have low species diversity. A baseline sampling survey due to a scheduled drawdown was conducted in 1994-1995. Invertebrates and zooplankton were collected and processed. Cladoceran, branchiopod crustacean) and rotifer (wheel animals) species were found in the upper reservoir of Lake Umatilla. Most taxa both occurred at low densities and occurred infrequently (PSU 2007).

Aquatic invasive species (AIS) common to lakes and reservoirs of Oregon include the Chinese mystery snails (*Cipangopaludina chinensis malleata*), Chinese mitten crab (*Eriocheir sinensis*), Louisiana red swamp crayfish (*Procambrus clarkia*), New Zealand mud snail, zebra (*Dreissena polymorpha*) and quagga mussels (*D. bugensis*) (USFWS 2013). These species outcompete their native counterparts for resources, like food, nesting and cover habitat, often spreading disease and parasites and degrading water quality. AIS threaten the diversity and abundance of native species, the stability and water quality of infested waters, and the commercial and recreational activities dependent on the waters. Species continue to invade primarily by transoceanic shipping, but also through aquaculture, aquarium trade, the bait industry, research, and even environmental restoration projects (CDFG 2008).

Most research on invertebrates has been on the invasive species in the reservoirs and open water habitat. Aquatic invasives common in the waterways of Oregon and Washington include Asian clams, New Zealand mud snails, zebra and quagga mussels, and red-swamp crayfish. There are indications of large beds of *Corbicula fluminea* based on shorelines with dense layers of shells on the beach and observations of diving duck concentrations. Threatened and endangered invertebrates are discussed in Section 3.

2.10 THE DALLES DAM AND LAKE CELILO

2.10.1 Study Area

The study area used to described the existing conditions and assess the range of potential impacts to wildlife and habitat features includes land associated with The Dalles, Lake Celilo, and the mouths of its primary tributaries, Deschutes River and Fifteenmile Creek (Figure 2-11).

Similar to John Day and Lake Umatilla study area, the upland habitats in the The Dalles Dam and Lake Celilo stuay area are entirely within the Columbia Plateau ecoregion. The river reach between John Day and The Dalles are one of the driest and warmest portions of the Columbia River Basin where winds can exceed 20 miles per hour and temperatures can exceed 100° at the height of the summer.

The Deschutes River and Fifteenmile Creek are the primary tributaries that persistently flow into Lake Celilo from Oregon. No tributaries flow persistently into Lake Celilo from Washington. Between John Day and The Dalles, the Yakama Indian Nation has Trust lands along the Washington shore and the Confederated Tribes of the Warm Springs have Trust lands along the Oregon shore. In addition to grain producing agricultural lands in the uplands, there are numerous wineries and vineyards in this river reach.

Unlike the river reaches upstream of John Day, there are no USFWS-administered wildlife lands in the vicinity of Lake Celilo. ODFW manages 8,526 acres of wildlife habitat along the Deschutes River along the Oregon shoreline, the Lower Deschutes Wildlife Area, where the Deschutes River empties into the Columbia at RM 204. The wildlife area was initially established to provide access to the water for anglers, and acreage was subsequently enhanced to support fish and wildlife habitat (ODFW 2009). Table 1-2 identifies the land cover, vegetation, and habitat of the study area.

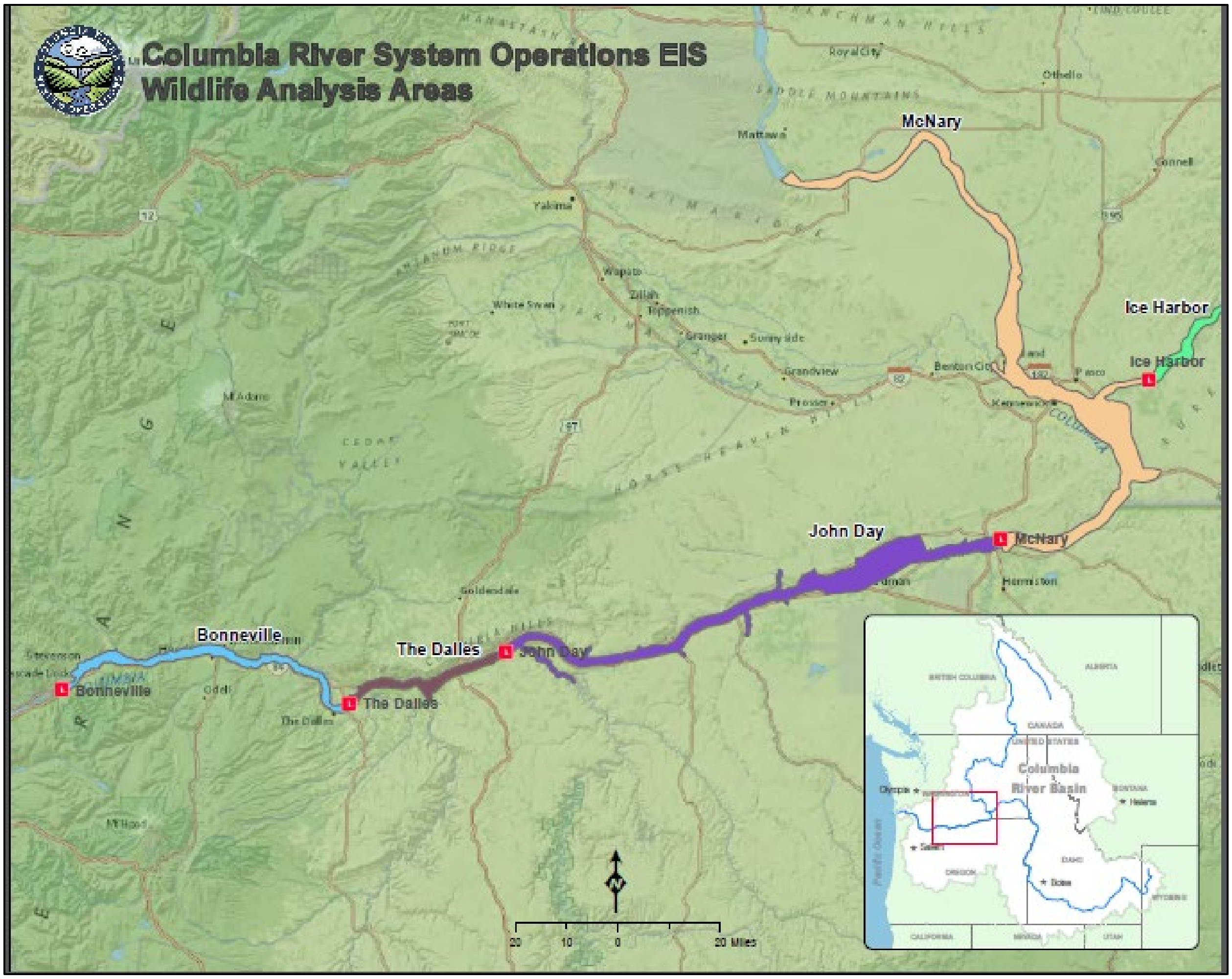

Figure 2-11. The Dalles Dam and Lake Celilo Study Area

2.10.2 Land Cover

2.10.2.1 Uplands

Much of the upland habitat adjacent to The Dalles and Lake Celilo study area is similar to other reaches in the Columbia Plateau ecoregion, which consists largely of shrub-steppe vegetation, mixed grasslands, agricultural areas and vineyards. Conifers, where present, consist mostly of Western juniper (*Juniperus occidentalis*) and ponderosa pine. Sagebrush is the dominant native shrub, with bitterbrush present in isolated pockets (ODFW 2009). Grasslands surrounding the Deschutes River confluence consist of bluebunch wheatgrass, sheep fescue (*Festuca ovina*), Sherman big bluegrass (*Poa ampla*), small burnet (*Sanguisorba minor*), and alfalfa (*Medicago sativa*) (ODFW 2009).

Trees are relatively uncommon in shrub-steppe habitats and may occur as isolated individuals, in irrigated park settings, or in woodland clusters. There are a few, relatively isolated pockets of irrigated park settings and upland habitats with cottonwood trees, including Columbia Hills State Park, which includes Horsethief and Little Spearfish Lakes, and Maryhill State Park in

Washington state at RM 194 and 209, respectively. Avery Park is located further downstream on the Washington shoreline near RM 198 and also provides some irrigated forested habitat along the shoreline. Additionally, the Rufus Landing Recreation Area and Giles French Park are administered by the Corps on the Oregon shore immediately downstream from John Day Dam at RM 214 and 215, respectively, and provide trees with limited irrigated upland grasses. Some tree habitat also occurs at the Deschutes River State Recreation Area on the Oregon shore where the Deschutes River flows into Lake Celilo.

Tree profiles in upland habitats consist of Oregon white oak and ponderosa pines. Similar to the John Day study area, understory species in upland habitats along Lake Celilo consist of sagebrush, bitterbrush, and both green and gray rabbitbrush, in addition to various grasses, sedges and forbs, including sunflowers, buckwheat and asters. Upland grasslands consist of a combination of native and non-native species. Native species include bluebunch wheatgrass, sheep fescue (*Festuca ovina*), Sherman big bluegrass (*Poa ampla*), small burnet (*Sanguisorba minor*), and alfalfa (*Medicago sativa*) (ODFW 2009). Non-native, invasive species include medusahead (*Taeniatherum caput-medusae*) and cheatgrass brome (*Bromus tectorum*) (ODFW 2009).

2.10.2.2 Barren Zone (Drawdown Zone)

There are no drawdown areas in the study area between John Day and The Dalles because The Dalles Dam is managed as a run-of-river project. Water elevations in Lake Celilo fluctuate less than five feet in elevation over a normal water year (Corps 2004). Consequently, there are few areas along the shoreline where habitat is exposed for prolonged periods of time. Similar to the John Day study area, typical substrates along the Oregon and Washington shorelines of Lake Celilo are comprised predominantly of basalt bedrock, sand, gravel and silts with limited or no vegetation (Camp et al. 2017 and ODFW 2008). Sand and silt deposits along the shoreline are most evident in backwaters, inlets, and embayments or at the mouths of rivers like the Deschutes River.

Where upland shrub-steppe habitats transition abruptly to the river's edge and no riparian habitat exists, the shorelines are largely formed by a continuous band of basalt bedrock extending from prehistoric lava flows in upstream portions of the river. Similar to the John Day study area, landslides and erosions in the The Dalles study area are uncommon due to the bedrock foundation dominating both the Oregon and Washington shorelines along Lake Celilo. Some plants inhabit the rocky, cliff habitat adjacent to the river including Columbia goldenweed (*Ericameria resinosa*).

2.10.2.3 Wetlands – Forested and Scrub-Shrub

There are 972 acres of Forested and Scrub-Shrub wetlands in The Dalles study area. Forested and scrub-shrub wetlands growth and development is limited between The Dalles and John Day study areas due to the immediate juxtaposition of highways and railroads to the river's shorelines. However, forested and scrub-shrub wetland plant communities occur where tributaries empty into the Columbia River and consists of narrow bands of trees, shrubs, and herbaceous vegetation, similar to Lake Umatilla upstream of John Day Dam. In addition, due to the presence of dryland farming and vinticulture in the uplands, there are areas where irrigation supports a hydrologic regime and the development of wetland habitats that would otherwise be arid without the presence of irrigation and runoff from farming or agriculture.

Where state and federal parks occur, they are comprised largely of non-native grasses irrigated for recreation. For example, Mary Hill and Columbia Hills State Parks provides a mixture of native and non-native wetland plant communities in the immediate vicinity of the shoreline. Forested habitat consists of native hardwood trees, such as big leaf maples, Oregon ash, black cottonwood and red alders, while the shrubby undergrowth often consists of Pacific willow, common snowberry, golden and red-flowering current, serviceberry, oceanspray and pioneer roses, Douglas spirea, and Oregon grape. Additional scrub-shrub wetland plant species common to the The Dalles study area include sedges, grasses and forbs, including bulrush, blue-bunch wheatgrass and broad-leafed lupine.

There are few forested and scrub-shrub wetland habitats in the Lake Celilo study area that are federally managed or maintained by the states of Oregon or Washington specifically for terrestrial wildlife. ODFW manages the Lower Deschutes Wildlife Area, immediately upstream from the Deschutes River State Recreation Area at on the Columbia River, to improve and maintain habitats for native fish and wildlife species. Mary Hill State Park provides a narrow band of forested wetland vegetation along approximately two miles of shoreline which is adjoining a similarly narrow band of riparian vegetation adjacent to the Waving Tree Winery and Vineyard from RM 210 to 211.

Other forested and scrub-shrub wetland habitats occur in small pockets along both the Oregon and Washington shorelines.

Near the ODFW-managed Lower Deschutes Wildlife Area wetland plant communities are comprised mainly of red alder, cottonwood, spirea, common chokecherry (*Prunus viginiana*), and Lewis' mock orange (*Spiraea* spp.).

2.10.2.4 Wetland – Emergent Herbaceous

There are approximately 700 acres of Emergent Herbaceous wetland habitats in and adjacent to Lake Celilo occurs in isolated pockets along the length of the Oregon and Washington shorelines. Similar to upriver reaches, herbaceous wetlands are a result of altered landscapes associated with modern agricultural and irrigation practices, in addition to operation of The Dalles Dam (ODFW 2009). Emergent wetlands, both forested/scrub and herbaceous, occupy sites where seepage from irrigation or natural waterways maintains the hydric soils necessary to support the establishment and growth of wetland plants. Unlike the John Day study area, there are few slackwater areas which support the development of wetland plant communities.

There are no formal wetland delineations of the The Dalles study area, but summary estimates of USFWS NWI herbaceous wetland classifications are provided in Table 1-2. Similar to the John Day study area, common plants present in freshwater wetlands in Lake Celilo include cattails and other rushes, a variety of sedges and many of the herbareous species found in forested and scrub-shrub wetland areas discussed above. Trees and shrubs are present in low densities, where they occur in patches along margins. Although aquatic plants are considered important wetland features, they are discussed in greater detail in the following section: *Water*.

2.10.2.5 Water

Open and slack water sites in Lake Celilo are present along both the Oregon and Washington shorelines, as well as around island and lake habitats. As noted above, the location of highways and railroad embankments immediately adjacent to the river channel impounds water in low areas between upland habitats and the river channel throughout the study area. These areas provide 6,776 acres of valuable habitat for birds and wildlife, even though direct connectivity to the Columbia River channel may be limited or non-existent. Slack water is present near Rufus, OR at RM 211 to 2013 where low elevation islands along the Oregon shoreline reduce water velocities. Open water habitat around Miller and Browns Islands provide open water and wetland habitat supporting submerged aquatic vegetation. An additional of open water and backwater channels are present near Bob’s Point at RM 207. Horsethief Lake and Spearfish Lake provide larger areas of open water, aquatic habitat sheltered from the main Columbia River channel at RM 193 and 195, respectively.

The location, extent, and nature of aquatic plant beds in Lake Celilo is unknown, however there are few areas of shallow-water, low velocity areas which would support aquatic plant communities important to fish and wildlife. Similar to Lake Umatilla and the John Day study area, there is a narrow band of aquatic vegetation evident in aerial photography in some locations of The Dalles study area, but the species and distribution of aquatic vegetation has been been formally documented.

Similar to the John Day study area, Lake Celilo supports a wide diversity of aquatic plant species, including yellow pond lily, pondweed, duckweed, smartweed, wild millet, goosefoot, and swamp timothy (Corps 2004). Eurasian water-milfoil, purple loosestrife and curley-leaf pondweed, are common aquatic invasive plants in Lake Celilo (USGS 2018b).

2.10.2.6 Islands

There are few notable island habitats in The Dalles study area and the acreage of the islands varies substantially. Immediately downstream from John Day Dam on the Oregon shore across from Mary Hill State Park at RM 212 near Rufus, there are several small low elevation, bedrock islands that are exposed during the late summer months. These islands support scrub-shrub wetlands in ponded embayments and grassy upland habitats.

Miller Island, at RM 203 to 207, is a large island near the confluence of the Deschutes River. The island is owned by the U.S. Forest Service and the main navigation channel for the Columbia River is south of the island. Much of the upland area is other exposed basalt rock with some cliff habitat or open shrub-steppe habitat. The island’s periphery is mostly a narrow band of shrubs, low stature vegetation or barren rock. There are some rocky outcrops immediately upriver of the island which have a subsurface connection to Miller Island but which are isolated from the main portion of the island during normal water years. These rocky outcrops provide nesting habitat for approximately 20 pairs of colonial nesting birds, including Caspian terns and numberous gull species, which forage at The Dalles and John Day Dams, as well as throughout the Columbia River Basin.

Browns Island is a smaller basalt island of upland dry scrub-shrub and forested scrub-shrub wetland habitat at RM 196. There are some trees and scattered wetland shrubs on Browns Island where seasonal hydrology supports the establishment and growth of wetland habitat. Other portions of the island are bare, open ground with some grass and shrub habitat.

2.10.3 Wildlife

2.10.3.1 Birds

RAPTORS

Raptors common in The Dalles study area year-round include bald and golden eagles, osprey, red-tailed hawks and American kestrals. Peregrine falcons are common visitors to the upland cliff habitats adjacent to The Dalles study area and Deschutes River corridor, while prairie falcons are less common visitors to upland habitats. Turkey vultures are commonly found throughout The Dalles study area in the spring and summer months.

The Corps annually hosts an Eagle Watch at The Dalles Dam Visitor Center for visitors to learn about bald eagles and watch the birds congregate along the Columbia River to feed during the winter and roost overnight. In 2017, upwards of 50 bald eagles were present in the vicinity of The Dalles Dam during the winter months (Tilton and Cordie, 2019, pers. communication).

WATERBIRDS, SHOREBIRDS AND WATERFOWL

Many of the water and shorebirds occurring in The Dalles study area are migratory and occur primarily during the spring and fall migration periods. However, there are several colonies of nesting seabirds, including Caspian terns, ring-billed and California gulls which breed in Lake Celilo on low elevation rocky outcrops upriver from Miller Island. Double-crested cormorants, great blue herons, Canada geese, mallards and common mergansers (*Mergus merganser*) are common breeders in The Dalles study area. Migrating waterfowl that are commonly observed in Lake Celilo include American widgeon, ring-necked duck, redhead, and bufflehead, and lesser scaup. Common shorebirds include killdeer and spotted sandpipers, both of which breed in wetland habitats found throughout Lake Celilo (www.ebird.org).

Waterfowl use in Lake Celilo is primarily associated with open and slack water habitats adjacent ot the highways and wetland habitats adjacent to the shorelines. There is limited suitable habitat to support nesting ducks and geese, however some nest habitat occurs on Browns Island at RM 198 and in the Rufus Ponds at RM 211. The presence of shallow water habitat near

Rufus Ponds, as well as gravel bars and low elevation islands, provides protection from high velocities and winds for overwintering habitat and breeding habitat in the summer months.

PASSERINES

Common nighthawk, belted kingfisher, Northern flicker, Western kingbird, Common corvids include black-billed magpie, common raven, and Amercian crow. Smaller passerines which commonly occur in the study area include horned lark, swallows, black-capped chickadee and bushtits. Several wrens are common breeders in The Dalles study area, including, Bewick's, house and canyon wrens. Canyon wrens are associated with canyon habitats within The Dalles study area where cliff habitats occur in closer proximity to wetland and shoreline habitats. Other common birds include American robins and introduced European starlings, yellow and yellow-rumped warblers, spotted towhee, house and song sparrows, dark eyed juncos, Bullock's oriole, Western meadowlark, house and American goldfinches, and several blackbirds, including Brewer's, red-winged and brown headed cowbirds.

GALLINACEOUS BIRDS

According to ODFW, several non-native upland game bird species occur in upland grassy habitats of the Lower Deschutes Wildlife Area, including chukar partridge (*Alectoris chukar*), Hungarian (gray) partridge (*Perdix perdix*) ring-necked pheasant (*Phasianus colchicus*), and California quail (*Callipepla californica*). It is reasonable to assume that these species occur through The Dalles study area, in addition to wild turkeys, and native mourning doves (*Zenaida macroura*).

2.10.3.2 Mammals

TERRESTRIAL

ODFW has documented numerous mammalian species in The Dalles study area, the most abundant of which include mule deer (*Odocoileus hemionus hemionus*), California bighorn sheep (*Ovis canadensis californicus*) and Rocky Mountain elk (*Cervus elaphus nelsoni*) (ODFW 2009). California bighorn sheep can be found in upland canyon habitats in the Deschutes River basin, a portion of which is found within the study area. Other common species include mountain lion and bobcat, coyote, raccoon, striped skunks, squirrels and white-tailed jackrabbit (*Lepus townsendii*) and mountain conttontail (*Sylvilagus nuttallii*). Badgers, long-tailed weasel (*Mustela frenata*) and mink are also known to occur in The Dalles study area.

There has been no systematic survey for smaller mammals or bats within The Dalles study area. However, many species are noted to occur in the Lower Deschutes Wildlife Area and it is reasonable to assume many, if not all, of these species occur elsewhere in The Dalles study area due to proximity and similarity of habitat types adjacent to the Columbia River. ODFW has documented the following bat species at the Lower Deschutes Wildlife Area: little brown myotis *(Myotis lucifugus),* Townsend's big-eared bat *(Plecotus townsendii)*, and pallid bat *(Antrozous pallidus).* Other small mammals documented in the Lower Deschutes Wildlife Area include

California ground squirrel *(Spermophilus beecheyi),* Northern pocket gopher *(Thomomys talpoides)*, vagrant Shrew *(Sorex vagrans)*, Great Basin pocket mouse *(Perognathus parvus)*, deer mouse *(Peromyscus maniculatus)*, house mouse *(Mus musculus)*, bushy-tailed woodrat *(Neotoma cinerea)*, montane vole *(Microtus montanus)*, long-tailed vole *(Microtus longicaudus),* sagebrush vole *(Lagurus curtatus)* and muskrat *(Ondatra zibethicus)* (ODFW 2009).

AQUATIC

River otters and beaver are present where suitable habitat occurs, primarily near island habitats and where wetlands occur along the shorelines.

2.10.3.3 Reptiles and Amphibians

Amphibian and reptiles occur where suitable habitat exists, which differs substantial throughout The Dalles study area. Snakes and lizards common in the dry, upland shrub-steppe habitats include gopher snakes (*Pituophis catenifer*), common garter snake (*Thamnophis sirtalis*), Western rattlesnake (*Crotalus viridis*), northern sagebrush lizard (*Sceloporus graciosus*), and Western fence lizard (*Sceloporus occidentails*). Conversely, common amphibians occur in forested, scrub-shrub and emergent herbaceous wetland habitats include rough-skinned newt (*Taricha granulosa*), Western toad (*Bufo boreas*), and Pacific treefrog (*Pseudacris regilla*).

2.11 BONNEVILLE DAM AND LAKE TO THE COLUMBIA RIVER ESTUARY

2.11.1 Study Area

The study area used to described the existing conditions and assess the range of potential impacts to wildlife and habitat features includes land associated with Bonneville Dam, Bonneville Lake, and the Columbia River to the estuary (River Mile 0 to River Mile 145) (Figure 2-12). The area below Bonneville dam is a free-flowing river influenced by tidal fluctuations, which intensifies closer to the mouth of the Columbia.

Riverine habitat include sloughs, backwaters, islands, shorelines, mudflats and riparian zones. Railroads and highways parallel the river through much of this reach on both sides and prevents riparian expansion here. Human development is also prevalent in the study area. Agricultural areas encompass a substantial amount of the floodplain.

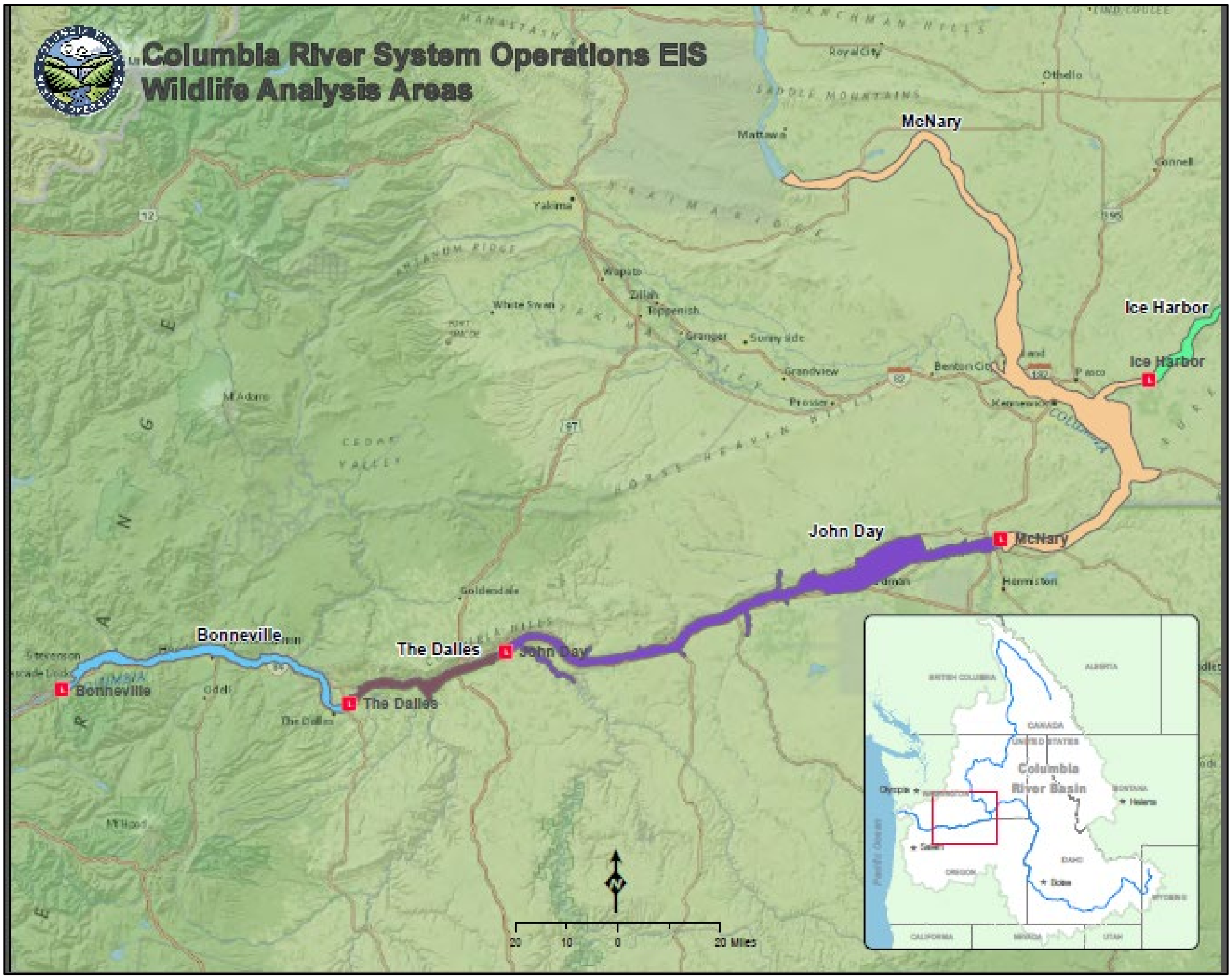

Figure 2-12. Bonneville Dam and Lake Study Area

2.11.2 Land Cover

2.11.2.1 Uplands

There are approximately 165,800 acres of upland habitat, mostly Westside Lowland Conifer-Hardwood Forest, in the study area. There are also approximately 76,000 acres of agricultural lands. Upland areas exhibit a considerable variation in plant communities from west to east. This is attributable to a graduation from a mild, wet marine west coast climate to a dry, cold winter-hot summer continental climate. Pool levels typically only influence a very narrow region immediately abutting the reservoir and river. This zone of influence includes riparian habitat but does not extend into the upland habitats. Thus, the upland zone is not considered an area subject to impacts from implementation of various operational strategies.

2.11.2.2 Barren Zone (Drawdown Zone)

There are no drawdown areas in the study area because Bonneville is operated as a run-of-river project. There are few areas along the shoreline where habitat is exposed for prolonged periods of time. A substantial delta formed from silts exists at the mouth of the Klickitat River in Bonneville pool. Sand/silt deposits are also evident just downstream of the Deschutes River mouth. Sand and silt deposits along the shoreline are most evident in backwaters, inlets, and embayments or at the mouths of rivers like the Deschutes River.

Where upland shrub-steppe habitats transition abruptly to the river's edge and no riparian habitat exists, the shorelines are largely formed by a continuous band of basalt bedrock extending from prehistoric lava flows in upstream portions of the river.

2.11.2.3 Wetlands – Forested and Scrub-Shrub

There are approximately 76,100 acres of Forested and Scrub-Shrub wetlands in the Bonneville study area. Forested and scrub-shrub wetlands growth and development is limited through much of the area by the immediate juxtaposition of highways and railroads to the river's shorelines. However, forested and scrub-shrub wetland plant communities occur where tributaries empty into the Columbia River and consists of narrow bands of trees, shrubs, and herbaceous vegetation.

Black cottonwood and various species of willows are the dominant tree species for riparian areas in this reach of the Columbia River. Mature black cottonwoods are the dominant tree species in terms of height. Willows range in size from invasive stands on sand bars and beaches to mature stands comprising a major component of the overstory vegetation. Tree species comprising lesser components of the riparian zone include Oregon ash and black hawthorn.

Shrub willows, red osier dogwood, young cottonwoods and Himalayan blackberry are predominant shrub components. A dense shrub layer is often present. Reed canarygrass, nightshade, trailing blackberry, and stinging nettles are common groundcover components of the vegetation. Reed canary grass can dominate ground cover in many locations.

Mature riparian forests provide perch and nesting habitat for bald eagles and osprey in this reach. Many species of passerines, including yellow warblers and Swainson's thrushes, use the riparian forest and shrub habitat for foraging and nesting. Decadent trees, either a result of maturity or from wind/ice snappage provide opportunities for cavity nesters such as downy woodpeckers. Great blue herons also use the riparian stands for nesting. Canada geese will nest within the riparian forest, generally along the edge, on islands. Beaver use shrub willow and cottonwood stands for foraging; denning occurs in the bankline.

Invasive species include Russian olive, rush-skeleton weed, reed canary grass, pepperweed, and purple loosestrife.

2.11.2.4 Wetland – Emergent Herbaceous

There are approximately 42,400 acres of Emergent Herbaceous wetland habitats in the Bonneville study area along the length of the Oregon and Washington shorelines. Similar to upriver reaches, herbaceous wetlands are a result of altered landscapes associated with modern agricultural and irrigation practices. Emergent wetlands, both forested/scrub and herbaceous, occupy sites where seepage from irrigation or natural waterways maintains the hydric soils necessary to support the establishment and growth of wetland plants.

Emergent wetlands below Bonneville Dam are primarily limited to backwater sloughs and ponded areas away from the main Columbia River. Franz Lake at Franz NWR contains an extensive stand of wapato. Old slough channels, embayments and ponded areas on Government Island, Sandy River Delta, Steigerwald Lake, Ainsworth State Park (RM 138 to 139) and other riverine areas support emergent wetlands. Often, these areas are dominated by reed canarygrass.

These habitats provide forage, loafing, and night roost locations for waterfowl. The extensive wapato stand at Franz Lake supports a substantial (1,000 plus) population of wintering tundra swan in addition to other waterfowl species. These sites also provide foraging areas for various species of waterfowl, great blue herons, rails, passerines such as re-winged blackbirds, swallows, and marsh wrens, and other species of birds, mammals and amphibians.

2.11.2.5 Water

The study area has approximately 181,700 acres of open and slack water. Shallow water habitat occurs along the shoreline of the Columbia River and around islands within the various pools. Typically the substrate for Bonneville is comprised of rock, gravel, sand, and silt with rocky shorelines predominating in many locations. Shallow water areas can be very productive of submergent, emergent and aquatic vegetation in addition to benthic invertebrate populations. However, this productivity is somewhat tempered in Bonneville by fluctuating pool levels. Still, aquatic plant beds are evident in some locations; their areal extent and species composition have not been formally documented, however. Neither has areas of importance for benthic invertebrates nor detailed work on their density and species composition been determinedAquatic plant beds are present in the pool and are expected to be most prevalent below 73.5 msl. Location, extent and nature of these aquatic plant beds is unknown.

Embayments, adjacent ponds, and associated tributaries provide an important habitat feature for fish and wildlife resources on these projects. These embayments are relatively unique to the three projects and provide special wildlife values. They provide protected loafing and roosting areas for waterfowl and other waterbirds, in addition to food resources. Embayments are considered bodies of water cut off from the main river by highway or railroad causeways, or other features and are typically connected to the Columbia River via culverts or small channels. Associated tributaries reflect slack water conditions that extend up tributaries. Adjacent ponds encompass bodies of water adjacent to the river; the source of the water in these sites may arise from subirrigation and/or drainage from adjoining lands.

2.11.2.6 Islands

This reach of the Columbia River is dominated by a number of large islands. Hayden Island occurs just upstream of the mouth of the Willamette River. This island is heavily developed on its upstream end while the lower half contains riparian forest and grass/forb uplands. Interstate 5 and the railroad bisect Hayden Island. Lemon, Sand, McGuire and Government Islands form a large island complex at RM 112 to 117. Government Island is bisected by Interstate 205. These islands contain grass-forb uplands, riparian forest, sloughs, and small lake habitats. Gary and Flagg Islands are riparian forest dominated islands off the Sandy River delta. Reed Island at RM 124 to 127 is comprised of riparian forest and grass-forb upland. Another Sand Island occurs at RM 131 to 132. Riparian forest and a large, erosive sand bluff on the northeast shoreline dominate this island.

Other notable islands in the study area include Puget, Whites and Tenasillahe islands. These islands 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 federally threatened Columbian white-tailed deer. Other islands support large breeding colonies of waterbirds, including Miller Sands Island and East Sand Island in the estuary 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 cormorants, and ring-billed gulls. Several hundred American white pelicans nest at Miller Sands Island and Rice Island in the lower river.

2.11.3 Wildlife

2.11.3.1 Birds

RAPTORS

Red-tailed hawks and osprey are probably the most abundant nesting raptors in this reach. Osprey are very dependent on the river for foraging and associated riparian and coniferous forest habitats for nest sites. Two bald eagle nests and two peregrine eyries are associated with the area below Bonneville Dam. Wintering bald eagles are also present.

WATERBIRDS, SHOREBIRDS AND WATERFOWL

Wintering waterfowl account for the majority of waterfowl use in this reach. Steigeiwald and Franz National Wildlife Refuges along with the Government Island area represent the major wintering waterfowl sites. The dense stand of wapato at Franz NWR supports 1,000-plus tundra swans at peak periods during the winter.

Nesting by Canada geese along this reach is not as significant as for Bonneville pool or for the Columbia River downstream of Portland. Production of ducks is minor and generally associated with sloughs, ponds and backwater areas.

PASSERINES

The riparian forest supports numerous passerine species including Swainson's thrushes, song sparrows, western wood peewees and robins. Barn, tree, violet-green and cliff swallows are abundant in this reach.

GALLINACEOUS BIRDS

Gallinaceous and Columbine birds, or ground feeding birds, in the 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. Agricultural lands near the rivers support ring-necked pheasants and mourning doves. Gallinaceous birds eat a variety of seeds, agricultural grasses (i.e wheat, oats, and corn) and insects. The pheasant and quail are found most commonly near agricultural lands. Chukars use a wide variety of habitats including riversides, shrublands, talus areas and uplands.

2.11.3.2 Mammals

TERRESTRIAL

The array of mammals present along this reach of the Columbia River is typical for western Oregon and Washington, including mule deer, mountain lion, coyote, racoon, striped skunks, squirrels, and fox are abundant. Tabor (1976) recorded 16 species of small mammals along this reach of the Columbia River. He noted that riparian habitat - specifically ash/cottonwood/ willow - had the highest diversity of small mammals. Deer mice, vagrant shrew, and Townsend's vole are the most abundant small mammal in his study for this reach.

AQUATIC

River otters and beaver are present where suitable habitat occurs, primarily near island habitats and where wetlands occur along the shorelines. Muskrat would be expected to occur in backwaters, sloughs and ponded areas which support emergent marsh habitat.

2.11.3.3 Reptiles and Amphibians

Amphibian and reptiles occur where suitable habitat exists, which differs substantial throughout Bonneville study area. Western painted turtles occur in Columbia Slough, a former attached side channel of the Columbia River in the Portland area of this reach.

2.11.3.4 Invertebrates

Invertebrates found in the study are are those common to the overall CRSO study area.

CHAPTER 3 - SPECIAL STATUS SPECIES

The following list of threatened, endangered, and sensitive species are species that are listed or candidates for listing under the Endangered Species Act (ESA) of 1973, as amended, and/or protected under the Marine Mammal Protection Act (MMPA) of 1972, as amended and includes species that may occur within the study area or be impacted by any of the alternatives (Table 3-1). The USFWS ECOS database and USFWS Field Office website's were accessed to determine if species should be considered given their range and habitat where they are known to occur.

Table 3-1. Candidate (C), Endangered (E), and Threatened (T) Species located within the Vicinity of the Study Area.

Species, Critical Habitat, and Status				State			
Species	**ESA Status**	**Critical Habitat**	**MMPA**	**ID**	**MT**	**OR**	**WA**
Mammals							
Canada lynx	T	Y	N	X	X	X	X
Gray wolf	E	N	N				X
Grizzly Bear	T	N	N	X	X		X
Pygmy rabbit	E	N	N				X
Columbia White Tailed Deer	T	N	N			X	X
Red Tree Vole	C	N/A	N			X	
Northern Idaho Ground Squirrel							
Selkirk Mountain Woodland carabou							
Birds							
Marbled murrelet	T	Y	N			X	X
Northern spotted owl	T	Y	N			X	X
Short-tailed albatross	E	N	N			X	X
Streaked-horned lark	T	N	N			X	X
Western snowy plover	T	Y	N			X	X
Western Yellow-billed cuckoo	T	N	N	X	X	X	X
Amphibians							
Oregon spotted frog	T	Y	N			X	
Plants							
Ute ladies' tresses	T	N	N	X	X		X
Water howelia	T	N	N	X		X	X
Nelson's checker-mallow	T	N	N			X	X
Spalding's Catchfly	T	N	N	X	X	X	X
Macfarlane's four o'clock							
White bluffs bladderpod	T	Y	N				X

Species, Critical Habitat, and Status				State			
Species	**ESA Status**	**Critical Habitat**	**MMPA**	**ID**	**MT**	**OR**	**WA**
Marine Mammals							
Southern resident killer whales DPS	E	Y	Y			X	X
California sea lion	N	N	Y			X	X
Stellar sea lion	N	N	Y			X	X

C: Candidate

E: Endangered

T: Threatened

3.1 CANADA LYNX

The lynx is a medium-sized cat with long legs, large, well-furred paws, long tufts on the ears, and a short, black-tipped tail. The Canada lynx has long legs and large feet make it highly adapted for hunting in deep snow. The distribution of lynx in North America is closely associated with the distribution of North American boreal forest. Critical habitat for the contiguous United States DPS of the Canada lynx was revised on September 12, 2014 (79 FR 54781). Critical habitat surrounds the western and eastern shores of Lake Koocanusa and extends south from the U.S. – Canada border to the Kootenai River near the town of Troy, Montana. Critical habitat encompasses the Hungry Horse project area including the Hungry Horse Reservoir, the North and South Fork of the Flathead River, and Flathead Lake.

The distribution and population cycles of lynx are strongly associated with their primary prey, the snowshoe hare. Landscapes with high prey densities consist of moist, cool boreal spruce-fir forests. Hares are most abundant in young regenerating or mature multi-storied forests with dense understory vegetation that provides food and cover from predators. In the contiguous U.S., boreal forest habitat is patchy and fragmented. Lynx incorporate these small fragments into their home ranges and use them for traveling between expansive northern forests in Canada with dense snowshoe hare populations. Lynx are highly mobile and disperse in times of low prey availability, often over 60 miles within their home ranges which have been reported as large as 83 square miles (USFWS 2014a). Lynx populations generally occur where continuous snow cover lasts four months or longer. This dynamic habitat is present in higher elevations forests within the Northern Rockies Ecoregion.

3.2 GRAY WOLF

Wolves are listed as endangered in parts of western Oregon and western Washington (https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=A00D, accessed on November 12, 2018), but have been recovered and delisted in Idaho, Montana, and some counties in eastern Oregon and eastern Washington. A keystone predator and habitat generalist, gray wolves utilize a broad spectrum of habitats with three key components: 1) sufficient, year-round prey base of ungulates and secondary prey; 2) suitable and secluded denning sites; and 3) sufficient space with minimal exposure to humans. Wolf den and rendezvous sites can be characterized by having adjacent forested cover and distant from human activity (USFWS 1987).

On May 5, 2011, the Northern Rocky Mountain (NRM) DPS gray wolf population was delisted from ESA protection and management reverted to the state plans (76 FR 25590). The NRM DPS gray wolf population met its biological recovery goals first in 2002, when wolves began dispersing freely between Wyoming, Montana, and Idaho into Canada and Alaska (MFWP 2018, IDFG 2017)). Wolves in Montana and Idaho are not federally listed or protected by federal ESA. The eastern side of Washington and Oregon in within the range for the NRM DPS population, while the western and central parts of the state contain wolves that are fully protected by ESA (43 FR 9607).

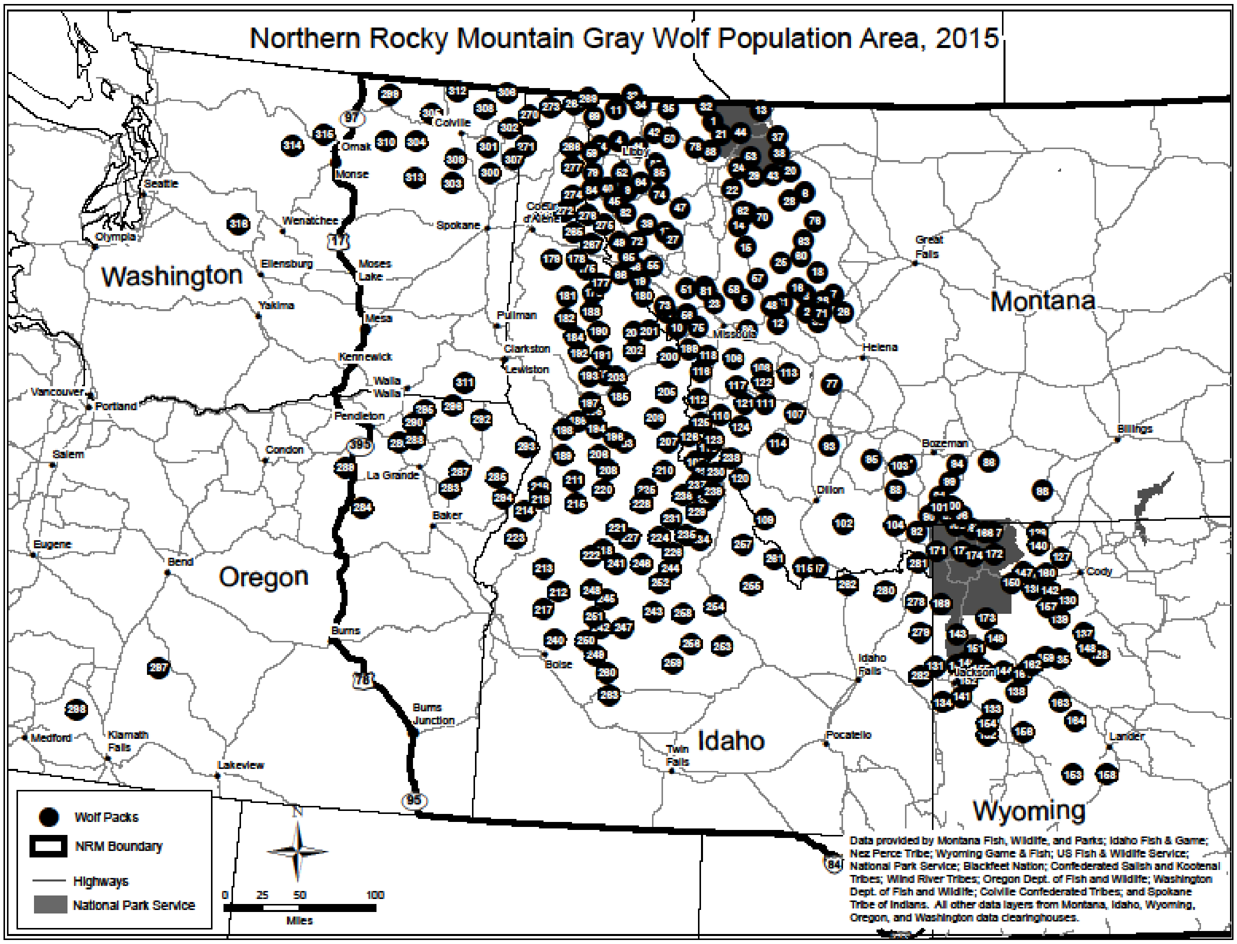

Figure 3-1. Northern Rocky Mountain Gray Wolf Population in Washington, Oregon, Montana, Idaho and Wyoming.

Despite the vast majority of wolves occurring in the delisted zones of Washington and Oregon, a handful of wolf pack and groups are living in the endangered zone near the Columbia and Snake Rivers (Figure 3-1). In 2017 in Washington alone it was recorded that wolf 48f of the Dirty Shirt Pack dispersed 300 miles in eight days. A wolf of the Smackout pack, 65m, traveled a minimum of 1,700 miles from December 2016 and spring of 2017 entering into Yellowstone National Park. A female wolf, 71f, of the Loup Loup pack (near Chief Joseph Dam) dispersed 542 miles from April to July 2017 (WDFW 2018). The wide range of habitats in which wolves can thrive reflects their adaptability as a species and in the study area includes temperate forests, mountains, and sage-brush steppe. Gray wolves have been known to follow ungulate herds (like deer and elk) from their lowland wintering grounds to their high summer pastures.

3.3 GRIZZLY BEAR

The grizzly bear is listed as threatened throughout the conterminous States, except where listed as an experimental population or delisted. The Bitterroot Ecosystem Recovery Zone Population is an experimental population (65 FR 69624) and the Greater Yellowstone Ecosystem DPS has been delisted due to recovery (40 FR 31734). However, there are several other ecosystems that the grizzly bear occupies in Washington, Idaho and Montana. The current range for grizzly bears overlaps with areas in the Columbia River study area in Montana near Libby and Hungry Horse reservoirs, in Idaho near Orofino and Dworshak Dam (the experimental population), and in Washington near Wenatchee. Habitat use within the Columbia River Basin is varied 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 is the most at-risk population in the U.S. today. The recovery zone encompasses 9,800 square miles and includes all of the North Cascades National Park, and most of the Mount Baker-Snoqualmie, Wenatchee and Okanogan National Forests (USFWS 1997). Despite the NCE being the largest ecosystem also encompassing an additional 3,800 square miles across the international border and providing rugged, remote habitat, the 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 20 and nearly reaches Chief Joseph Dam.

The Northern Continental Divide Ecosystem (NCDE) in northwestern Montana includes Glacier National Park and adjacent areas in Canada, and the Bob Marshall Wilderness Complex, including the Flathead, Kootenai, Helena-Lewis and Clark, and Lolo National Forests contained within 8,900 square miles. This population has 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 with an estimated 50 grizzly bears. The CYE is bisected by the Kootenai River, with the Cabinet Mountains to the south and the Yaak River area to the north. Most of the 2,600 square miles are within the Kootenai and Panhandle National Forests (USFWS 2017).

3.4 COLUMBIA BASIN PYGMY RABBIT

Columbia Basin pygmy rabbits occur in the Columbia Plateau Ecoregion consistent with semiarid shrub steppe habitat and adjacent intermountain regions of the west. Pygmy rabbits are highly dependent upon tall, dense stands of sagebrush (*Artemisia* spp.) for food and shelter. As one of only two native rabbit species in North America that digs its own burrows, pygmy rabbits are generally found in areas of deep, loose soils associated with sagebrush.

Historically, dense vegetation along permanent and intermittent stream channels, alluvial fans, and sagebrush plains provided travel corridors and dispersal habitats for the rabbits. Farming practices on the shrub steppe have provided man-made areas of dense vegetation including fence rows and abandoned fields which may also provide dispersal habitat between local populations. The majority of pygmy rabbit habitats is considered the big sagebrush (*Artemisia tridentate*) – bluebunch wheatgrass (*Agropyron spicatum*) zonal habitat type. The less dominant habitat types includes the threetip sagebrush (*Artemisia tripartite*) – Idaho fescue (*Festruca idahoensis*) zone (USFWS 2012).

Columbia Basin pygmy rabbit may occupy sagebrush dominated land due south of Grand Coulee and Chief Joseph Dam towards the confluence of the Snake River into the Columbia River. Federal lands which contain suitable habitat include the Hanford Reach National Monument and Saddle Mountain National Wildlife Refuge near Mattawa, WA, both of which are adjacent to the Columbia River. They are known to occur, or may occur, in Adams, Benton, Douglas, Franklin, Grant and Lincoln counties in Washington.

3.5 COLUMBIA WHITE-TAILED DEER

The Columbia River DPS Columbia white-tailed deer (CWTD) has maintained its threatened status since listing in March 11, 1967 (32 FR 4001). The Columbia River population occurs along the lower Columbia River in Oregon and Washington from Wallace Island RM 50 downstream to Karlson Island RM 32. There are four main subpopulations (Washington mainland, Tenasillahe Island, Puget Island, Wallace Island-Westport) of CWTD 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 estuary, was established by USFWS for the recovery and maintenance of the CWTD.

These islands and bottomlands within an 18-mile stretch of the lower Columbia contain most of the CWTD range. The white-tailed deer are restricted to the flatlands which have an elevation of about 3 meters above sea level. Vegetation cover preferred by CWTD includes forested communities with plant heights reaching at least two feet. Studies completed in the seventies identified the primary plant communities used by CWTD as park-forest, open canopy forest, sparse rush, and dense thistle (Suring 1974), and some subpopulations used “tidal spruce” communities (Davison 1979).

While degradation of riparian habitat from logging and brush removal remains the largest threat to CWTD, flooding of the lowlands also poses a threat to their survival. Some islands in the lower Columbia River remain undiked and high water restricts woody vegetation survival, therefore decreasing available white-tailed deer habitat. High water can also lead to disease and rot killing the open canopy trees and reducing cover and forage available (USFWS 1976).

3.6 RED TREE VOLE

The red tree vole is a candidate for listing under the ESA. It is a small, endemic vole native to the humid coniferous forests in western Oregon. The red tree vole occurs in western Oregon from the Cascade crest to the Pacific coast, with a geographic range covering approximately 16.3 million acres across multiple land ownerships (https://ecos.fws.gov/ecp0/profile/species Profile?spcode=A0J3, accessed on November 13, 2018).

3.7 NORTHERN IDAHO GROUND SQUIRREL

Northern Idaho ground squirrel was listed in April 2000 under the Endangered Species Act as a threatened species. They occuy dry mountain meadoes, such as open areas of grasses and forbs surrounded by ponderosa pine (Pinus ponderosa) or Douglas-fir (Pseuduotsuga menziesii) forest. Unitl 2005, all known Northern Idaho ground squirrel sites were within the elevation range of 3,400 to 5,000 feet. Since then, Northern Idaho ground squirrels have been discovered at higher elevations, including Lick Creek Lookout and Smith Moutnain Lookout at 7,500 feet (Evans Mack 2006).

Populations of this subspecies can only be found in Adams and Valleu Counties of western Idaho. It is estimate that the population has declined by 80% from initial surveys conducted in 1985. Important travel corridor has been fragmented, leaving the gound squirrels to survive in isolated islands of non-connected habitat. As of 2011, recovery status remained unclear, through range wide monitoring shows the opuopulations are stable to slightly increing ove time. Biologists have recorded several new puplation sites, and the animal seems to be responding positively to habitat restoration at certain locations, especially on the Payette National forest (IDFG 2008)

3.8 SELKIRK MOUNTAIN WOODLAND CARIBOU

Selkirk Mountains Wood Caribou were listed under the Endangered Species Act as endangered in 1983 and are proposed to be delisted. The population is generally found aboce approximately 4,000 feet elevation in the Selkirk Mountains. Habitat consists of Englemann spruce/subalpine fir and western red cedar/western hemlock forest types. The population is threatened by habitat fragmentation and loss, predation, and disease.

Historically, the population consisted of approximately 100 animals. However, by the early 1980s this population had dwindled to 25 to 30 individuals whos distribution centered around Stagleap Provincial park, Britsh Columbia. Recovery area for caribou in the Selkirk Mountains is comprised of approximately 5,700 km2 in northern Idaho, notrteaster Washingt, and southern B.C.

3.9 MARBLED MURRELET

The marbled murrelet is a small chubby seabird that has a very short neck that inhabits western Oregon and Washington. It was listed as threatened in 1992 and critical habitat extends from the western slopes of the Cascade Mountains in northwest Washington to the Puget Sound and the Pacific Ocean and from the coast range west to the Pacific Ocean in western Oregon.. Marbled murrelets use forests that primarily include typical old-growth forests (characterized by large trees, a multistoried stand, and moderate to high canopy closure), but also use mature forests with an old-growth component (USFWS 1997b) Because marbled murrelets feed primarily on fish and invertebrates in nearshore marine waters, they require nearshore marine habitats with sufficient prey resources (USFWS 1997b).

3.10 NORTHERN SPOTTED OWL

The northern spotted owl is a medium-sized, dark brown owl with a barred tail, white spots on the head and breast, and dark brown eyes surrounded by prominent facial disks. Scientific research and monitoring indicate spotted owls generally rely on mature and old-growth forests because these habitats contain the structures and characteristics required for nesting, roosting, and foraging (USFWS 2011). Although spotted owls can disperse through highly fragmented forested areas, the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated or described (USFWS 2011).

3.11 SHORT-TAILED ALBATROSS

Short-tailed albatross are pelagic seabirds that was federally listed as endangered throughout its range, including the United States, on July 31, 2000 (65 FR 147:46643-46654). In 2014, USFWS estimated the total population of short-tailed albatross to approximate 4,350 individuals, of which approximately 1,900 breeding-age birds nest on remote islands in the western Pacific near Japan and Taiwan (USFWS 2014b). Like all albatross species, short-tailed albatross forage at sea where they are frequent visitors to territorial waters of U.S. and productive foraging areas in the Gulf of Alaska, the Aleutian Islands and the Bering Sea, as well as marine waters around Hawaii. Within the Columbia River study area, both Clatsop County in Oregon and Pacific County in Washington are considered part of the species' marine range, but it is unknown to what extent the birds use open ocean areas of the North Pacific Ocean near northern California, Oregon, and Washington. There have been few confirmed sightings of short-tailed albatross off the Oregon Coast. The closest sighting to the study area occurred 20 miles southwest of the Mouth of the Columbia River (Marshall et al., 2003).

3.12 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 16−20 centimeters (6−8 inches) in length. The combination of small size, dark brown back, and yellow on the underparts distinguishes this subspecies from all adjacent forms. The current range of the streaked horned lark can be divided in to 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 (https://www.fws.gov/oregonfwo/articles.cfm?id=149489450, accessed on November 12, 2018).

Horned larks are birds of wide open spaces with no trees and few or no shrubs. They nest in the ground in sparsely vegetated sites. They utilize prairies, coastal dunes, sandy beaches, and grasslands. The habitat adjacent to the Columbia River from Corbet, Oregon west is designated critical habitat.

3.13 WESTERN SNOWY PLOVER

The western snowy plover was listed as threatened in March 1993. It is a small shorebird (about 6 inches long) that nest adjacent to tidal waters along the Pacific Coast from Washington to Mexico (https://www.fws.gov/arcata/es/birds/wsp/plover.html, accessed on November 12, 2018). The western snowy plover winters mainly in coastal areas from southern Washington to Central America.

The Pacific coast population of the western snowy plover breeds primarily above the high tide line on coastal beaches, sand spits, dune-backed beaches, sparsely-vegetated dunes, beaches at creek and river mouths, and salt pans at lagoons and estuaries (USFWS 2007). Less common nesting habitats include bluff-backed beaches, dredged material disposal sites, salt pond levees, dry salt ponds, and river bars (USFWS 2007). In winter, western snowy plovers are found on many of the beaches used for nesting as well as on beaches where they do not nest, in man-made salt ponds, and on estuarine sand and mud flats (USFWS 2007). Within the Columbia River study area, the Pacific Coast population of Western snowy plovers are known to occur on coastal beaches near the mouth of the Columbia River. While Western snowy plovers historically nested in the vicinity of Clatsop Spit in Clatsop County, Oregon, no nests were detected in 2012 even though two individuals were observed near Clatsop Spit (Lauten et al. 2016). A small population of Western snowy plovers occurs on beaches at Leadbetter Point, in Pacific County, Washington, which is outside of the study area; in Oregon, Western snowy plovers nest at Bayocean Spit in Tillamook County, which is also outside of the study area. Although snowy plovers are not currently nesting in the study area, the Oregon Parks and Recreation Department (OPRD) has identified Clatsop Spit in its 2010 Habitat Conservation Plan for the species, which is the western-most portion of the study area (ICF 2010).

3.14 WESTERN YELLOW BILLED CUCKOO

Yellow Billed Cuckoo was listed as threatened in November 2014. While critical habitat has been proposed by the USFWS, no portion of the study area was identified for designation. However, suitable habitat for yellow-billed cuckoos occurs throughout the Columbia River Basin where large remnant stands of forested wetland habitat occurs near Flathead Lake and along the Columbia and Snake Rivers in Washington state. Yellow-billed Cuckoos breed throughout much of the eastern and central U.S., winter almost entirely in South America east of the Andes, and migrate through Central America (https://ecos.fws.gov/ecp0/profile/species Profile?spcode=B06R#lifeHistory, accessed on November 12, 2018). *Western yellow-billed cuckoos require large contiguous stands of riparian vegetation with optimal home ranges of 200+ acres, of widths of 2000 feet (USFWS 2013).*

Yellow-billed Cuckoos use 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 cuckoos nests are often placed in willows along streams and rivers, with nearby cottonwoods serving as foraging sites (https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=B06R#lifeHistory, accessed on November 12, 2018).

3.15 OREGON SPOTTED FROG

Oregon spotted frog was listed as threatened in September 2014. Critical habitat has been designated in Washington and Oregon but the study area does not overlap with critical habitat. Spotted frogs may occur near the confluence of the Washougal and Columbia rivers near Camas, Washington. This species is the most aquatic native frog in the Pacific Northwest. It is almost always found in or near a perennial body of water that includes zones of shallow water and abundant emergent or floating aquatic plants (https://www.fws.gov/oregonfwo/articles.cfm?id=149489458, accessed on November 12, 2018). Large concentrations of Oregon spotted frogs have been found in areas with the following characteristics: (1) the presence of good breeding and overwintering sites connected by year-round water; (2) reliable water levels that maintain depth throughout the period between oviposition and metamorphosis; and (3) the absence of introduced predators, especially warm-water game fish and bullfrogs (https://www.fws.gov/oregonfwo/articles.cfm?id=149489458, accessed on November 12, 2018).

In Oregon, this frog species is only known to occur in Wasco, Deschutes, Klamath, Jackson and Lane counties, although historically they were also found in Multnomah, Clackamas, Marion, Linn, and Benton, counties. In Washington, the frogs currently occur in Whatcom, Skagit, Thurston, Skamania and Klickitat counties.

3.16 UTE LADIES'-TRESSES

A proposal to list Ute ladies'-tresses as threatened was filed with USFWS in November 1990 (55 FR 47347), and the species was listed as threatened in January 1992 (57 FR 2048). No critical habitat is designated for the species and although a revocery plan was prepared, it was never finalized (USFWS 1995). The species usually occurs in small scattered groups and occupies relatively small areas iwhtin the riparian systems. Early to mid-seral riparian habitats created and maintained by stream activity within the floodplain appear to be essential to the orchid. Flowering is generally from mid-July through August; however, based on location it might flower slightly earlier or later.

The primary threats to Ute ladies'-tresses are competition from exotic weeds, vegetation succession, habitat loss through development and modification, mowing during flowering, grazing by livetock, over collection, and vulnerability to stochastic events due to a slow reproductive rate and scattered distribution of populations (57 FR 2048). Additional threats include loss of pollinators, natural herbivory, and changes in hydrology and conflicting management iwht other rare species (Fertig et al. 2005).

Potentially suitable habitat occurs on stabilized gravel bars and/or shoreline areas along the Columbia Rivers that are mosit thorugout the growing season and inundated early in the growing season. While the species has a wide range across the western United States; within the action area, the plant is currently documented in Washington State, occurring along the Rocky Reach Reservior on gravel bars adjacent ot 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's ladies' tresses throughout their range, including along the Columbia River (Fertig et al. 2005). While discharge from Chief Joseph Dam obviously inflences downstream flows, the water surface elevation in Rocky Reach reseriovr is primarily controlled by the operation of Rocky Reach Dam, which is owned and managed by Chelan County Public Utility District.

3.17 WATER HOWELLIA

Water howellia was listed as threatened in July 1994. It is a winter annual aquatic plants that grows 4 to 24 inches high. The plant grows in areas that were once associated with glacial potholes and former river oxbows that flood in the spring, but usually at least partially dry in late summer (https://www.fws.gov/mountain-prairie/es/uteLadiestress.php, accessed on November 13, 2018). It is associated with deciduous trees such as black cottonwood and aspen. The range that overlaps with the study area includes portions of Clark County in Washington and Columbia and Multnomah counties in Oregon.

3.18 NELSON'S CHECKER-MALLOW

Nelson's checker-mallow was listed as threatened in 1993. Critical habitat has not been designated. The range includes counties that overlap with the study area including Clatsop, Columbia, and Multnomah counties in Oregon, and Cowlitz County in Washington. Nelson's checker-mallow is a perennial herb in the mallow family (Malvaceae). It has tall, lavender to deep pink flowers. The plant can reproduce vegetatively, by rhizomes, and by seeds, which drop near the parent plant (https://www.fws.gov/oregonfwo/Species/Data/NelsonsCheckerMallow/, accessed on November 13, 2018).

The majority of sites where the species occurs is in the Willamette Valley of Oregon; the plant is also found at several sites in the Coast Range of Oregon and at two sites in the Puget Trough of southwestern Washington (https://www.fws.gov/oregonfwo/Species/Data/Nelsons CheckerMallow/, accessed on November 13, 2018). Thus, the range of the plant extends from southern Benton County, Oregon, north to Cowlitz County, Washington, and from central Linn County, Oregon, west to the crest of the Coast Range (https://www.fws.gov/oregonfwo/ Species/Data/NelsonsCheckerMallow/, accessed on November 13, 2018). The species is known to occur in 62 patches within 5 relict population centers in Oregon, and at 2 sites in Washington (https://www.fws.gov/oregonfwo/Species/Data/NelsonsCheckerMallow/, accessed on November 13, 2018).

3.19 SPALDING'S CATCHFLY

Spalding's Catchfly was listed as threatened in October 2001. Critical habitat has not been designated. It is found in Idaho, Montana, Oregon and Washington, primarily in grasslands, but may also be found in sagebrush step and coniferous forests. Its flowers, which bloom July-September, are light green, and lance-shaped. Its leaves and flowers are very sticky. The plant height ranges from 8-24 inches but can grow to three feet. (www.fws.gov/pacific/news/2006/Silene_drft.pdf, accessed on November 30, 2018).

3.20 MACFARLANE'S FOUR-O'CLOCK

Macfarlane's four o'clock was listed as endangered on November 29, 1979. At that time only three pouplations were known, with a total of 20 to 25 individual plants. Ti was downlisted to threatened on March 15, 1996 (61 FR 52) when additional populations were discovered in the Hell's Canyon Recreational Area. USFWS completed the recovery plan in 2000. No critical habitat has been designated.

Macfarlane's four o'clock is only found in northeast Oregon and Northern Idaho. Populations have been found downstream of the Hells Canyon dam and a few sites in the Imnah River and Salmon River Bbasins (61 FR 52). Its habitat is steep river canyon grassland habitats composed of gravelly to loamy and sandy substrates that are characterized by regionally warm and dry conditions. It prefers steep, sunny slope ranging form 1,000 to 3,000 feet in elevation and will grow on rockslides, canyon walls, and sandy to gravelly talus slopes.

Actions that are known to affect this species include instream flow regulation, conversion of native plant communities to agricultural, ranching, or residential use, trespass grazing, and construction, maintiennace, and traffic on roads and trails.

3.21 WHITE BLUFFS BLADDERPOD

White bluffs bladderpod was listed as threatened in May 2013. White Bluffs bladderpod occurs in a single population in a 33 foot wide, 10.6 mile long band along the top of the White Bluffs of the Columbia River, and appears to be restricted to the weathered alkaline paeosols and mixed soils overlying the Ringold Formation. The species habitat is along the top of the bluffs and does not interact with or toerhwise exposed to water management activities associated with the management of the CRS. Southern Resident Killer Whale DPS

The Southern Resident killer whale (SRKW) DPS is a single population totaling 75 individuals as of July 2018 (https://www.whaleresearch.com/orca-population, accessed on November 12, 2018). The population ranges from central California to Southeast Alaska. During the period from July to September, the DPS inhabit 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 (NMFS 2014). There is no critical habitat designated within the Columbia River study area; however, National Marine Fisheries Service (NMFS) is presently working through the process of determining whether or not including Pacific Ocean marine water along the West Coast is appropriate for the southern resident DPS.

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. NMFS' analysis showed that Puget Sound Chinook salmon stocks are one of the most important salmon stocks for Southern Resident killer whales since, the whales have access to them for a greater part of the year than fish from the Columbia, Snake, and Fraser rivers. In the Columbia River basin, different stocks vary in overall importance for the diet of SRKW. For example, Snake River spring-summer Chinook salmon are mainly available to SRKW when the fish gather off the mouth of the Columbia, 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 and WDFW 2018; NMFS 2014; NMFS 2018).At times or locations of low Chinook abundance, whales also select other species such as chum salmon, smaller salmonids, or other non-salmonid prey (herring or rockfish).

3.22 STELLER SEA LION

The Eastern Distinct Population Segment (DPS) of the Steller sea lion occurs along the West Coast between Washington and California. Steller sea lions are 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 (NOAA 2014). The Steller sea lions was previously listed under the ESA and the eastern DPS was delisted in 2014 because it had met its recovery goals (NOAA 2013). In 2010, 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 144º west longitude) is still listed as endangered under the ESA (NOAA 2013). The eastern DPS is still protected under the MMPA in all areas where individuals occur.

In the Columbia River, Steller sea lions 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; Steller sea lions have 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 coast of southern Oregon at Rogue Reef. Use of the South Jetty by Steller sea lions occurs year round, but is heaviest from April through October when as many as 200-300 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 as 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 2017).

3.23 CALIFORNIA SEA LION

Like Steller sea lions, California sea lions are "eared seals" native to the West Coast of North America where they live in coastal waters and on beaches, docks, buoys, and jetties. California sea lions are distributed from the southern tip of Baja California to southeast Alaska, where they are protected under the Marine Mammal Protection Act in all areas. California sea lions breed 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 estimate for California sea lions was estimated to include approximately 150,000 individuals and the population has experienced a positive growth rate since the 1970s (NOAA 2015b). The primary diet of California sea lions consists of 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 lions can be found on the South Jetty, piers and docks in Astoria, Oregon. Since the mid-1980s, increasing numbers of California sea lions 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 10-30% 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 2017).

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Appendix G
Air Quality and Greenhouse Gases

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The following appendix contains four sections related to the evaluation of air quality and Greenhouse Gas (GHG) for the Columbia River Systems Operations (CRSO) EIS. Chapter 1 provides information regarding pollutant emissions management in the Pacific Northwest. Chapter 2 provides a detailed evaluation of methane emissions related to hydroelectric project reservoirs. Chapter 3 describes society's willingness to pay to avoid climate-related impacts associated with an additional unit of a GHG in the atmosphere, also known as the Social Cost of Carbon (SCC). Chapter 4 describes regional haze, Class I Areas and wind speed trends. Chapter 5 evaluates the Columbia River Basin as a source of emissions of methane to the atmosphere.

CHAPTER 1 - AIR QUALITY STANDARDS AND GREENHOUSE GAS TARGETS

Table 1-1 characterizes the human health and environmental concerns related to each of the six criteria pollutants.

Table 1-1. Criteria Air Pollutants: Adverse Health and Environmental Effects

Pollutant	Description and Sources	Health and Environmental Effects
Carbon Monoxide (CO)	CO is formed by the incomplete combustion of fossil fuels and by atmospheric photochemical reactions. CO emissions primarily come from incomplete combustion in mobile sources.	CO exposure reduces blood's ability to carry oxygen to body tissues (hypoxia). Reduced oxygen availability can cause cardiovascular events; exposure is especially dangerous for people with impaired cardiovascular systems. CO exposure may adversely affect other key body functions.
Lead (Pb)	Lead is primarily emitted from industrial processes such as iron and steel processing and from combustion of leaded aviation gasoline.	Lead exposure has neurotoxic effects, especially in young children. Multiple studies show an inverse relationship between blood lead levels and children's IQ even at low blood lead levels. Lead contaminates surface soils and harms plants and other organisms.
Nitrogen Dioxide (NO_2)	NO_2 is primarily emitted from combustion processes such as electric utility fuel combustion and industrial fuel combustion as well as from highway and off-highway vehicles.	NO_2 exposure can cause respiratory symptoms including airway inflammation and decreased lung function. Ecologically, NO_2 deposition results in acidification, excess nutrient enrichment, low dissolved oxygen, harmful algal blooms, and loss of aquatic vegetation. NO_2 also degrades visibility.
Ozone (O_3)	Ground-level ozone is formed through reactions of volatile organic compounds (VOCs) with pollutants such as nitrogen oxides (NO_x) and CO in the presence of sunlight.	Ozone exposure is associated with respiratory symptoms such as asthma exacerbation. Ozone is also harmful to plants, causing cellular damage and plant death. Ozone directly contributes to global climate change.
Particle Pollution $PM_{2.5}$-PM_{10}/[1]	Primary PM is directly emitted from sources, such as vehicles and construction sites. Secondary PM is formed from chemical reactions with gases (e.g. organic carbon, sulfates) emitted from power plants, industrial facilities, and vehicles.	Exposure to $PM_{2.5}$ can cause respiratory symptoms such as asthma exacerbation, as well as cardiovascular events. Environmental effects include visibility impairment and deposition of particulate matter which can result in toxic pollutants accumulating in organisms and ecosystems via vegetation, soils, and surface water.
Sulfur Dioxide (SO_2)	SO_2 is primarily emitted from fossil fuel combustion at electric utilities and other industrial facilities. Other sources of emissions include large ships, non-road diesel equipment that burns sulfur-containing fuels, and wildfires in the Pacific Northwest.	SO_2 exposure causes adverse respiratory effects such as bronchoconstriction and decreased lung function. Asthmatics in particular are sensitive to SO_2 exposure. SO_2 deposition on ecosystems results in acidification, excess nutrient enrichment, and increased mercury methylation and ultimate mercury contamination. SO_2 also degrades visibility.

Note: 1PM2.5 includes particles with an aerodynamic diameter less than or equal to 2.5 microns, and PM10 includes particles with an aerodynamic diameter less than or equal to 10 microns.

Sources: CO: USEPA 2010a Pb: USEPA 2006; USEPA 2008 NO2: USEPA 2010b O3: USEPA 2015 PM: USEPA 2012 SO2: USEPA 2010c

Table 1-2 provides the current National Ambient Air Quality Standards (NAAQS) and state-level ambient air quality standards (AAQS).

Table 1-2. National and State Ambient Air Quality Standards

Pollutant	Primary[1] / Secondary[2]	Averaging Period	NAAQS	OR AAQS	WA AAQS	ID AAQS	MT AAQS	Notes
Carbon Monoxide (CO)	Primary	1 hour	35 ppm	35 ppm	35 ppm	35 ppm	23 ppm	3
		8 hours	9 ppm	9 ppm	9 ppm	9 ppm	9 ppm	3
Lead (Pb)	Both	Rolling 3-mo. avg.	0.15 μg/m³	0.15 μg/m³	0.15 μg/m³	0.15 μg/m³	0.15 μg/m³	5
	--	Quarterly	1.5 μg/m³	1.5 μg/m³	--	--	1.5 μg/m³	6
Nitrogen Dioxide (NO_2)	Primary	1 hour	100 ppb	100 ppb	100 ppb	100 ppb	0.30 ppm	7
	Both	1 year	53 ppb	53 ppb	53 ppb	53 ppb	0.05 ppm	8
Ozone (O_3)	--	1 hour	--	--	--	--	0.10 ppm	4
	Both	8 hours	0.070 ppm	0.075 ppm	0.070 ppm	0.070 ppm	--	9
Particle Pollution $PM_{2.5}$	Primary	1 year	12.0 μg/m³	12.0 μg/m³	12.0 μg/m³	12.0 μg/m³	--	10
	Secondary	1 year	15.0 μg/m³	15.0 μg/m³	--	15.0 μg/m³	--	10
	Both	24 hours	35 μg/m³	35 μg/m³	35 μg/m³	35 μg/m³	--	11
Particle Pollution PM_{10}	Both	24 hours	150 μg/m³	150 μg/m³	150 μg/m³	150 μg/m³	150 μg/m³	12
	Both	Annual	--	--	--	--	50 μg/m³	13
Sulfur Dioxide (SO_2)	Primary	1 hour	75 ppb	75 ppb	75 ppb	75 ppb	0.50 ppm	14
	Secondary	3 hours	0.5 ppm	0.5 ppm	0.5 ppm	0.5 ppm	--	3
	Primary	24 hours	0.14 ppm	0.10 ppm	0.14 ppm	0.14 ppm	0.10 ppm	3, 15
	Primary	Annual	0.030 ppm	0.020 ppm	0.020 ppm	0.030 ppm	0.02 ppm	15

Notes:

1- Primary Standards: provide public health protection, including sensitive populations such as asthmatics, children, and the elderly

2-Secondary Standards: provide public welfare protection, including protecting against decreased visibility and damage to animals, crops, vegetation, and buildings

3- Not to be exceeded more than once per year

4- State violation when exceeded more than once over any 12-month period

5- Not to be exceeded

6- Non-attainment areas subject to previous standards

7- 98th percentile of 1-hour daily maximum concentration, averaged over 3 years

8- Annual average

9- Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years

10- Annual mean, averaged over 3 years

11- 98th percentile, averaged over 3 years

12- Not to be exceeded more than once per year on average over 3 years

13- State violation when 3-year average exceeded

14- 99th percentile of 1-hour daily maximum concentration, averaged over 3 years

15- Previous SO2 standards in effect for certain areas; no longer applicable for areas in attainment status for 1 year

16- State violation when average over four consecutive quarters exceeds standard

Sources: USEPA 2016; USEPA 2018 (SIPS); MT DEQ 2007.

Table 1-3 lists GHG emissions reductions targets for identified counties and municipalities that have plans either announced or passed in the Pacific Northwest. The Affected Environment presents the state specific targets.

Table 1-3. Emissions Reduction Targets for Pacific Northwest Municipalities

County/ Municipality	Targets?	Plan?	Rule & Rule Year	Method[a]	Targeted Industries	Type	Base-line Year	Targets	Source
WASHINGTON									
Bellingham, WA	Yes	Yes	City Council approved the Climate Protection Action Plan, 2007	production	Municipal; Residential; Commercial; Industrial; Transportation; Waste	GHG	2002	7% by 2012 28% by 2020 85% by 2050	Climate Protection Action Plan, 2018
King County, WA	Yes	Yes	Ordinance 17270, Council Motion 14349, May, 2015	consumption & production	Transportation; Industrial; Residential; Commercial; Electric Power & Gas; Agriculture; Waste	MT CO2e	2007	25% by 2020 50% by 2030 80% by 2050	King County Strategic Climate Action Plan, 2015
Seattle, WA	Yes	Yes	Resolution 31312, October 3, 2011 and Resolution 31447, June 17, 2013	production	Building Energy; Land Use; Waste	GHG	n/a	0 net GHG by 2050	Seattle Climate Action Plan, 2013
Olympia, WA	No	Yes	City council votes to create the Climate Action Plan, May 10, 1990	production	Buildings; Vehicle Fleet; Street Lighting; Water/ Sewer; Waste	CO2e	2005		City of Olympia Greenhouse Gas Emissions Inventory, 2008
OREGON									
Beaverton, OR	Yes	Yes	Sustainable Beaverton Strategy (SBS) developed in 2014	consumption & production	Fleet; Natural Gas; Electricity; Commute; Supply Chain; Water	CO2e	2008	75% by 2050	Sustainable Beaverton Strategy, 2014
City of Portland and Multnomah County, OR	Yes	Yes	2009 Climate Action Plan updated in 2015	production	Residential; Commercial; Industrial; Transportation; Waste	GHG	1990	14% by 2013 40% by 2030 80% by 2050	Climate Action Plan Progress Report, 2017

County/ Municipality	Targets?	Plan?	Rule & Rule Year	Method[a]	Targeted Industries	Type	Base-line Year	Targets	Source
Corvallis, OR	Yes	Yes	Climate Action Plan adopted by the Corvallis City Council, December 2016	production	Supply Chain; Commute; Watershed; Waste; Fleet; Electricity; Natural Gas	GHG	1990	75% by 2050	Climate Action Plan Goals, 2015
Eugene, OR	Yes	Yes	Counsel Ordinance 20567 Bill 151, July27, 2016	production	Energy; Agriculture; Land Use; Waste; Health; Urban; Natural Resources	GHG	1990	10% by 2020	Strategic Climate Action Plan, 2015
Lake Oswego, OR	No	No	City Council Voted to Draft Climate Action Plan, 2017	production	Materials; Energy; Transportation	CO2e	2008	60% by 2040	Sustainability Action Plan for City Operations, 2014
Milwaukie, OR	No	No	Draft of Climate Action Plan Committee Charter, February 7, 2018	no inventory	--	--	--	--	Climate Action Plan Committee Charter, 2018
West Linn, OR	Yes	Yes	Sustainable West Linn Strategic Plan – Update 2015	production	City Facilities City Fleet	CO2	2008	80% by 2040[b]	Sustainable West Linn, 2015
MONTANA									
Bozeman, MT	Yes	Yes	Bozeman City Commission in adopted the Community Climate Action Plan in 2011	production	Residential; Commercial; Transportation	CO2e	2008	10% by 2025	Bozeman Climate Action Report, 2010
Missoula, MT	Yes	Yes	Resolution 8174, June 26, 2017	production	Municipal	CO2e	2008	30% by 2017 50% by 2020 100% by 2025	No Report Missoula Greenhouse Emissions Inventory, 2010

County/ Municipality	Targets?	Plan?	Rule & Rule Year	Method[a]	Targeted Industries	Type	Base-line Year	Targets	Source
Whitefish, MT	Yes	Yes	Climate Action Plan approved following a public hearing, April 16, 2018	production	Municipal	GHG	2005	26% by 2025	City of Whitefish Climate Action Plan, 2018
IDAHO									
Boise, ID	No	Yes	Resolution #21500, Blueprint Boise Comprehensive Plan, November 29, 2011.	no inventory	--	--	--	--	Boise's Comprehensive Plan, 2018
Ketchum, ID	Yes	No	Resolution 15-012, March 12, 2015	production	No inventory	GHG	2007	75% by 2030	National Mayors Group Committed to Protecting Climate, 2017

Notes:

[a]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.

[b]Target is only to reduce West Linn City operations emissions, not city-wide emissions.

CHAPTER 2 - ENERGY SECTOR GHG EMISSIONS MODELLING

AURORA is the primary model used in the CRSO GHG emissions analysis. AURORA is a power production cost model, described in Appendix J, *Hydropower*. The quantitative emissions analysis focuses specifically on carbon dioxide (CO_2) emissions. CO_2 is the primary source of GHG emissions from power generation, accounting for over 80 percent of energy-related carbon emissions (EIA 2018). Additionally, the AURORA model emissions reporting is limited to CO_2. This analysis notes that quantifying only the CO_2 emissions may understate total GHG emissions and this point is considered in assessing the intensity of the GHG emissions effects of the action alternatives.

Table 2-1 presents the regional nodes or zones used in the AURORA model. Each of these zones contains a set of power resources from which power is "dispatched" to meet demand for electricity. This analysis focused on emissions from power generation from zones in the Pacific Northwest and across the broader Western Interconnection (as defined in Section 3.7.2), excluding sources in Northern Mexico and Canada.

Table 2-2 presents the detailed emissions outputs of AURORA for each action alternative by month and by region in million metric tons (MMT) CO_2. The analysis relies on 3,200 iterations of the AURORA model (drawn from 80 water years and 40 climate scenarios) to estimate the average dispatch of power resources and thus emissions for the regional power system. The values in the table reflect averages across all 3,200 iterations and represent emissions expected in 2022. The AURORA outputs take into consideration the change in modelled hydropower generation and the resource replacement portfolios of either zero-carbon or conventional least-cost resources. Even under a "zero-carbon" portfolio there is the potential for emissions to increase as other coal or natural gas power plant generation increases to meet load under MO3 and MO4.

Note that the emissions estimates from AURORA in Table 2-2 are for the base case scenario (described below) and that the Pacific Northwest totals presented in this table do not include Jim Bridger and North Valmy power plants, which are included in the "Other Western US" region in the AURORA model instead.

The AURORA CO_2 emissions output is the basis for forecasting emissions from 2022 to 2041. This analysis considers a base case scenario for the mix of resources generating power in the Pacific Northwest over time, as well as two additional scenarios that assess the sensitivity of emissions estimates to alternative assumptions regarding potential future coal plant retirements that have been announced and are described in the NW Council 7th Power Plan Midterm Assessment (2019). The sensitivity analysis scenarios developed by Bonneville for power system reliability analysis (and described in Section 3.7) are as follows:

- The "limited coal retirement" scenario assumes an additional reduction of 2,505 MW of coal power capacity compared to the No Action base case by 2022 (see Table 2-3). This scenario includes potential future coal plant retirements and only limited coal capacity remaining (including Colstrip unit 4 and Jim Bridger units 3 and 4).

- The "no coal" scenario assumes the retirement of all coal plants operating in the Northwest or serving Northwest loads by 2022.

Table 2-3 compares emissions forecasts for 2022 across the base case under the zero-carbon resource replacement portfolios (as described in Section 3.8).

Table 2-4 displays the full 2022 to 2041 emissions projections for the base case, including both the conventional least-cost and zero-carbon resource replacement portfolios.

The emissions projections for 2022 for the base case analysis rely on the CO_2 emissions from power generation reported by the AURORA model runs with the addition of emissions from Jim Bridger and North Valmy power plants (estimated as the average annual emissions from 2012, 2014, and 2016) as these coal plants are not within the AURORA Pacific Northwest estimate.[1] Emissions projections between 2023 and 2035 rely on average annual decreases in coal generation and increases in natural gas generation observed in dispatch forecasts from the NW Council over the same timeframe based on the NW Council's Regional Portfolio Model (RPM) for the Existing Policy scenario of the 7th Power Plan (NW Council 2016b). The NW Council dispatch data do not extend beyond 2035, therefore emissions between 2036 and 2041 are held constant at 2035 levels (NW Council 2016b).

Table 2-1. AURORA Zones and Regions

AURORA Zone	Region
Avista	Pacific Northwest
Bonneville, ID and MT	Pacific Northwest
Bonneville, OR	Pacific Northwest
Bonneville, WA	Pacific Northwest
Chelan County PUD	Pacific Northwest
Douglas County PUD	Pacific Northwest
Grant County PUD	Pacific Northwest
Idaho Power FE	Pacific Northwest
Idaho Power MV	Pacific Northwest
Idaho Power TV	Pacific Northwest
Northwestern, MT	Pacific Northwest
Olympia	Pacific Northwest
Pacificorp East ID	Pacific Northwest

[1] A considerable fraction of the emissions are associated with generation from two coal plants, Jim Bridger in Wyoming and half of the generation of North Valmy in Nevada. Both lie outside the Pacific Northwest region; however, the NW Council considers them regional resources (NW Council 2016; 2019). All generation from Jim Bridger serves Pacific Northwest customers as does half of 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 2016b; 2019). Over the last three years of available data, the EPA estimated Jim Bridger emitted an average of 14.2 MMT CO2, and 900,000 tons of CO2 for half of North Valmy. However, the analysis considers that by 2022 North Valmy 1 will retire and therefore includes only 474,000 tons of CO2. (USEPA 2018; NW Council 2019).

AURORA Zone	Region
PACW South	Pacific Northwest
Portland General	Pacific Northwest
Puget Sound Central	Pacific Northwest
Puget Sound North	Pacific Northwest
Seattle CL	Pacific Northwest
Tacoma Power	Pacific Northwest
Balancing Authority of Northern California	California
Imperial Irrigation District	California
Los Angeles Water & Power	California
PG&E Bay Area	California
PG&E North	California
PG&E ZP26	California
Southern California Edison	California
San Diego Gas and Electric	California
Turlock Irrigation District	California
Arizona Public Service	Other Western United States
El Paso Electric	Other Western United States
Nevada North	Other Western United States
Nevada South	Other Western United States
Pacificorp East, UT	Other Western United States
Pacificorp East, WY	Other Western United States
Public Service, CO	Other Western United States
Public Service, NM	Other Western United States
Salt River Project	Other Western United States
Tucson Electric	Other Western United States
Valley Electric Association	Other Western United States
Western Area Power Administration (WAPA), CO	Other Western United States
WAPA, Lower CO	Other Western United States
WAPA, Upper MO	Other Western United States
WAPA, WY	Other Western United States

Table 2-2. Emissions by Region and Month for each CRSO Scenario in Million Metric Tons CO2, Base Case

AURORA Average Monthly Emissions by Region, Month and Scenario, MMT CO_2												
Scenario and Region	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
NAA												
Pacific Northwest	2.2	1.9	1.8	1.4	0.95	0.81	1.6	2.1	2.3	2.2	2.2	2.6
California	3.9	3.2	2.8	2.5	2.5	2.9	4.2	4.5	4.2	4.1	4.0	4.4
Other Western US	8.5	7.4	7.1	6.2	6.5	7.0	10	10	8.9	7.7	7.9	9.4
MO1 Conventional Least-Cost (Difference from No Action)												
Pacific Northwest	-0.024	-0.0047	0.018	0.071	0.087	0.041	0.018	0.051	0.0024	0.016	0.012	0.048
California	-0.015	-0.00082	0.0046	0.023	0.034	0.0051	0.016	0.036	-0.012	0.0012	-0.0035	0.0081
Other Western US	-0.036	-0.006	0.0088	0.041	0.044	0.0093	0.052	0.11	-0.021	0.0051	-0.0046	0.021
MO1 Zero-Carbon (Difference from No Action)												
Pacific Northwest	-0.064	-0.06	-0.034	0.0098	0.025	-0.0051	-0.1	-0.1	-0.11	-0.021	-0.019	0.00033
California	-0.014	-0.0012	-0.002	0.015	0.035	0.016	0.014	0.044	-0.008	-0.025	-0.015	0.0071
Other Western US	-0.03	0.0093	0.018	0.057	0.093	0.051	0.09	0.15	-0.021	-0.06	-0.024	0.025
MO2 (Difference from No Action)												
Pacific Northwest	-0.11	-0.088	0.038	-0.0083	-0.13	-0.068	-0.17	-0.30	-0.11	-0.027	-0.046	-0.085
California	-0.025	-0.016	0.025	-0.013	-0.097	-0.051	-0.048	-0.069	0.02	0.00062	-0.017	-0.024
Other Western US	-0.054	-0.037	0.048	-0.028	-0.12	0.0097	-0.019	-0.16	0.035	0.037	-0.0016	-0.044
MO3 Conventional Least-Cost (Difference from No Action)												
Pacific Northwest	0.27	0.30	0.32	0.41	0.43	0.28	0.37	0.12	0.23	0.21	0.13	0.15
California	0.022	0.020	0.019	0.065	0.14	0.11	-0.007	-0.15	-0.038	-0.017	-0.027	-0.021
Other Western US	0.012	0.036	0.045	0.13	0.19	0.088	-0.13	-0.39	-0.093	-0.09	-0.13	-0.12
MO3 Zero-Carbon (Difference from No Action)												
Pacific Northwest	0.15	0.16	0.17	0.23	0.27	0.16	0.11	-0.12	0.015	0.072	0.024	0.024
California	0.065	0.064	0.060	0.093	0.15	0.11	0.036	-0.091	0.012	-0.0050	-0.0031	0.018
Other Western US	0.12	0.13	0.13	0.22	0.31	0.19	0.032	-0.26	0.015	-0.059	-0.047	0.0021
MO4 Conventional Least-Cost (Difference from No Action)												
Pacific Northwest	-0.00065	0.028	0.58	0.53	0.40	0.28	0.35	0.39	0.18	0.14	0.081	0.12
California	-0.018	-0.0053	0.18	0.12	0.17	0.16	0.07	0.0013	-0.053	0.0037	-0.0064	0.011
Other Western US	-0.070	-0.022	0.35	0.19	0.24	0.19	0.0053	-0.0018	-0.096	-0.034	-0.072	-0.018

AURORA Average Monthly Emissions by Region, Month and Scenario, MMT CO_2												
Scenario and Region	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
MO4 Zero-Carbon (Difference from No Action)												
Pacific Northwest	-0.14	-0.16	0.34	0.24	0.15	0.12	0.045	0.020	-0.12	-0.09	-0.075	-0.036
California	-0.027	-0.014	0.16	0.088	0.11	0.095	0.0094	-0.008	-0.045	-0.052	-0.032	0.0042
Other Western US	-0.10	-0.044	0.35	0.21	0.29	0.19	-0.048	-0.084	-0.21	-0.18	-0.11	-0.033
Preferred Alternative (Difference from No Action)												
Pacific Northwest	-0.039	-0.038	0.017	0.15	0.22	0.11	0.098	0.026	0.00063	-0.023	0.015	0.010
California	-0.013	-0.011	0.0083	0.063	0.11	0.061	-0.015	-0.045	-0.021	-0.0073	0.0060	0.00036
Other Western US	-0.046	-0.026	0.016	0.10	0.14	0.017	-0.12	-0.16	-0.067	-0.060	-0.017	-0.022

Note: Emissions associated with Jim Bridger and North Valmy generation are associated to the "Other Western US" region in the AURORA. Model. All values for MOs reflect the difference relative to the No Action Alternative in MMT CO_2 and are rounded to two significant figures.
Source: AURORA model outputs

Table 2-3. Emissions Forecast for 2022, Base Case

Alternative (Resource Replacement Portfolio)	Base Case without additional coal retirements	
	2022 Emissions (MMT CO_2)	**Change in Emissions Relative to Base Case NAA**
NAA	36.7	--
MO1 (Zero-Carbon)	36.2	-1.3%
MO2	35.6	-3.0%
MO3 (Zero-Carbon)	37.9	3.5%
MO4 (Zero-Carbon)	37.0	0.83%
PA	37.2	1.5%

Table 2-4. Total Annual Emissions from 2022 to 2041, Base Case

Total Annual Emissions Estimates for Each Alternative, MMT CO_2									
Year	**No Action**	**MO1 (Conventional Least-Cost Replacement)**	**MO1 (Zero-Carbon Replacement)**	**MO2**	**MO3 (Conventional Least-Cost Replacement)**	**MO3 (Zero-Carbon Replacement)**	**MO4 (Conventional Least-Cost Replacement)**	**MO4 (Zero-Carbon Replacement)**	**PA**
2022	36.7	37.0	36.2	35.6	39.9	37.9	39.8	37.0	37.2
2023	36.5	36.9	35.9	35.3	40.5	37.9	39.9	36.8	37.1
2024	36.5	36.8	35.9	35.2	40.5	37.9	39.9	36.7	37.1
2025	36.4	36.8	35.9	35.2	40.5	37.9	39.9	36.7	37.1
2026	36.4	36.8	35.8	35.2	40.5	37.8	39.8	36.6	37.1
2027	36.4	36.8	35.8	35.1	40.5	37.8	39.8	36.6	37.0
2028	36.4	36.7	35.8	35.1	40.5	37.8	39.8	36.6	37.0
2029	36.3	36.7	35.7	35.1	40.5	37.8	39.8	36.5	37.0
2030	36.3	36.7	35.7	35.0	40.5	37.7	39.8	36.5	37.0
2031	36.3	36.7	35.7	35.0	40.5	37.7	39.8	36.5	36.9
2032	36.3	36.6	35.7	35.0	40.5	37.7	39.8	36.4	36.9
2033	36.2	36.6	35.6	35.0	40.5	37.7	39.8	36.4	36.9
2034	36.2	36.6	35.6	34.9	40.5	37.7	39.8	36.4	36.9
2035	36.2	36.6	35.6	34.9	40.6	37.7	39.8	36.4	36.9
2036	36.2	36.6	35.6	34.9	40.6	37.7	39.8	36.4	36.9
2037	36.2	36.6	35.6	34.9	40.6	37.7	39.8	36.4	36.9
2038	36.2	36.6	35.6	34.9	40.6	37.7	39.8	36.4	36.9
2039	36.2	36.6	35.6	34.9	40.6	37.7	39.8	36.4	36.9
2040	36.2	36.6	35.6	34.9	40.6	37.7	39.8	36.4	36.9
2041	36.2	36.6	35.6	34.9	40.6	37.7	39.8	36.4	36.9

CHAPTER 3 - 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. 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 CO2 emissions.

The academic literature and Federal agency guidance on these measures is actively evolving. A Federal Interagency Working Group (IWG) 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 2016). The Interagency guidance provided a SCC dollar value based on the average of three integrated assessment models (IAMs). 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.

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/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 due to 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.

Table 3-1 presents the full schedule of SCC estimates for the years 2010 to 2050 from the August 2016 IWG update. The table lists estimates for three discount rates: 5 percent, 3 percent and 2.5 percent as well as an estimate of low-probability high impact outcomes at the 3 percent discount rate. As per best practices the 3 percent discount rate is considered the central estimate. The schedule comes from the August 2016 update to the Social Cost of Carbon. Dollars values are in 2019 US dollars adjusted using the BEA Implicit Price Deflator. The totals are the discounted present values as well as annualized values, each in an independent table.

Table 3-2 presents the total present value estimates of the SCC for each action alternative under the varying discount rate assumptions by multiplying the SCC value estimate from Table 3-1 by the emissions estimate for that specific year. The present values reflect the value of the changes in GHG emissions under each alternative relative to the No Action Alternative in the base case (i.e., these values do not reflect the limited coal or no coal retirement scenarios described above). Table 3-3 annualizes these estimates. All values are presented in millions of 2019 US dollars, rounded to two significant digits.

Table 3-1. Social Cost of Carbon Estimates per Metric Ton CO_2 in 2019 US dollars

Discount Rate Year	Annual Social Cost per Metric Ton CO_2 Emissions, 2019 Dollars			
	5% Average	3% Average	2.5% Average	3% High Impact (95^{th})
2010	$12.04	$37.31	$60.18	$103.52
2011	$13.24	$38.52	$61.39	$108.33
2012	$13.24	$39.72	$63.80	$111.94
2013	$13.24	$40.93	$65.00	$116.76
2014	$13.24	$42.13	$66.20	$121.57
2015	$13.24	$43.33	$67.41	$126.39
2016	$13.24	$45.74	$68.61	$130.00
2017	$13.24	$46.94	$71.02	$134.81
2018	$14.44	$48.15	$72.22	$139.63
2019	$14.44	$49.35	$73.43	$144.44
2020	$14.44	$50.56	$74.63	$148.05
2021	$14.44	$50.56	$75.83	$151.67
2022	$15.65	$51.76	$77.04	$155.28
2023	$15.65	$52.96	$78.24	$158.89
2024	$15.65	$54.17	$79.44	$162.50
2025	$16.85	$55.37	$81.85	$166.11
2026	$16.85	$56.57	$83.06	$169.72
2027	$18.06	$57.78	$84.26	$172.13
2028	$18.06	$58.98	$85.46	$175.74
2029	$18.06	$58.98	$86.67	$179.35
2030	$19.26	$60.18	$87.87	$182.96
2031	$19.26	$61.39	$89.07	$186.57
2032	$20.46	$62.59	$90.28	$190.18
2033	$20.46	$63.80	$91.48	$193.80
2034	$21.67	$65.00	$92.68	$197.41
2035	$21.67	$66.20	$93.89	$202.22
2036	$22.87	$67.41	$95.09	$205.83
2037	$22.87	$68.61	$97.50	$209.44
2038	$24.07	$69.81	$98.70	$213.05
2039	$24.07	$71.02	$99.91	$216.67
2040	$25.28	$72.22	$101.11	$220.28
2041	$25.28	$73.43	$102.31	$223.89
2042	$26.48	$73.43	$103.52	$227.50
2043	$26.48	$74.63	$104.72	$231.11
2044	$27.69	$75.83	$105.93	$233.52
2045	$27.69	$77.04	$107.13	$237.13
2046	$28.89	$78.24	$108.33	$240.74

Discount Rate Year	Annual Social Cost per Metric Ton CO_2 Emissions, 2019 Dollars			
	5% Average	3% Average	2.5% Average	3% High Impact (95th)
2047	$28.89	$79.44	$110.74	$244.35
2048	$30.09	$80.65	$111.94	$247.96
2049	$30.09	$81.85	$113.15	$251.57
2050	$31.30	$83.06	$114.35	$255.18

Table 3-2. Total Discounted SCC Estimates (Present Value) for Each Alternative and Discount Rate, Millions of 2019 US Dollars (2022-2041)

Alternative (Resource Replacement Scenario)	Total Discounted SCC Estimates (PV), Million 2019 US Dollars			
	Present Value 5% Average	Present Value 3% Average	Present Value 2.5% Average	Present Value 3% 95th
No Action	$7,900	$31,000	$48,000	$95,000
Difference from No Action				
MO1 (Conventional Least-Cost)	$82	$320	$500	$980
MO1 (Zero-Carbon)	-$130	-$510	-$780	-$1,500
MO2	-$270	-$1,100	-$1,700	-$3,300
MO3 (Conventional Least-Cost)	$900	$3,600	$5,500	$11,000
MO3 (Zero-Carbon)	$310	$1,200	$1,900	$3,700
MO4 (Conventional Least-Cost)	$750	$3,000	$4,600	$9,000
MO4 (Zero-Carbon)	$43	$170	$250	$500
Preferred Alternative	$140	$550	$850	$1,700

Note: Values for all action alternatives are relative to No Action, they represent the difference in the total discounted SCC estimates in 2019 USD. The values are rounded to two significant digits.

Table 3-3. Annualized SCC Estimates for Each Alternative and Discount Rate, Millions of 2019 US Dollars (2022-2041)

Alternative (Resource Replacement Scenario)	Total Annualized SCC Estimate, Million 2019 US Dollars			
	Present Value 5% Average	Present Value 3% Average	Present Value 2.5% Average	Present Value 3% 95th
No Action	$600	$2,000	$3,000	$6,200
Difference from No Action				
MO1 (Conventional Least-Cost)	$6.2	$21	$31	$64
MO1 (Zero-Carbon)	-$9.8	-$33	-$49	-$100
MO2	-$21	-$71	-$100	-$210
MO3 (Conventional Least-Cost)	$69	$230	$340	$710
MO3 (Zero-Carbon)	$24	$80	$120	$240
MO4 (Conventional Least-Cost)	$58	$190	$290	$590
MO4 (Zero-Carbon)	$3.3	$11	$16	$33
Preferred Alternative	$11	$36	$53	$110

Note: Values for all action alternatives are relative to No Action, they represent the annualized estimates in 2019 USD. The values are rounded to two significant digits.

CHAPTER 4 - REGIONAL HAZE AND WIND SPEED DATA

EIS Section 3.8.2.1 discusses EPA permitting and regulatory requirements related to air quality and criteria air pollutants. The 1999 Regional Haze Rule call for states to establish goals for improving visibility in national parks and wilderness areas and to develop long-term strategies for reducing emissions of air pollutants that cause visibility impairment (EPA 2019a). The rule provides protection to 156 “Class I Areas” across the country (EPA 2019a). These Class I areas are defined as having special natural, scenic, recreational, or historic value in a national or regional context. The management and improvement of visibility conditions is organized by regional planning organizations, with the Western Regional Air Partnership (WRAP) managing the Western United States. In the Pacific Northwest there are 37 Class I Areas. These include large national parks, including Glacier National Park in Montana (covering over 1 million acres) and Mount Rainier. In addition, the Columbia River Gorge Scenic Area is within the Columbia River Basin. The Gorge is not a Class I Area but has protection as a National Scenic Area and, as such, receives protection along with Class I Areas (OR DEQ 2020).

Haze may be formed by natural air pollutants or air pollutant emissions from anthropogenic sources. Fugitive dust and other small airborne particles generate haze as well as a variety of other particles react with sunlight in the atmosphere to form haze and impair visibility and air quality related values (AQVRs). AQRVs include visibility as well as any other resource that could be adversely affected by changes in air quality including but not limited to cultural, biological or physical resources identified by a Federal land manager in a Class 1 Area. Air pollutant emissions from major sources, such as power plants, may contribute to haze even if they are operating within the requirements of their Prevention of Significant Deterioration (PSD) permits. Near a source of air pollutants, such as a city or power plant, haze is typically a mixture of aerosols (a dispersion of microscopic solid or liquid particles in gaseous media such as smoke or fog) and gases, such as sulfur dioxides and nitrogen dioxides from fossil fuel power plants (EPA 1999).

The EPA and other state agencies that regulate these areas examine haze in terms of a “haze-index,” based on the unit of measurement “deciview.” The higher the deciview, the lower the visibility. Generally, visibility at Class I Areas in the Pacific Northwest has improved since 2000, however some monitors have identified increasing index scores (i.e., worsening visibility) in recent years (OR DEQ 2020). As multiple factors contribute to haze, including wildfires, variations may occur year to year.

Table 4-1 presents the number of Class I areas and the number acres they cover by state. Figure 4-1 presents a map of Class I Areas in the Pacific Northwest and the CRSO Regions.

Table 4-1. Class I Areas in the Pacific Northwest by State

State	Number of Class 1 Areas	Total Acres
Idaho	5	1,363,684
Montana	12	3,040,568
Oregon	12	1,111,372
Washington	8	3,019,420
Total[1]	**34**	**8,535,044**

1/ The total number of Class 1 Areas does not sum because some Class 1 Areas cross state borders, for example Yellowstone National Park is Montana, Wyoming and a small part of Idaho. For Class 1 Areas in multiple states, the area is included in the state specific count but not counted multiple times in the total.

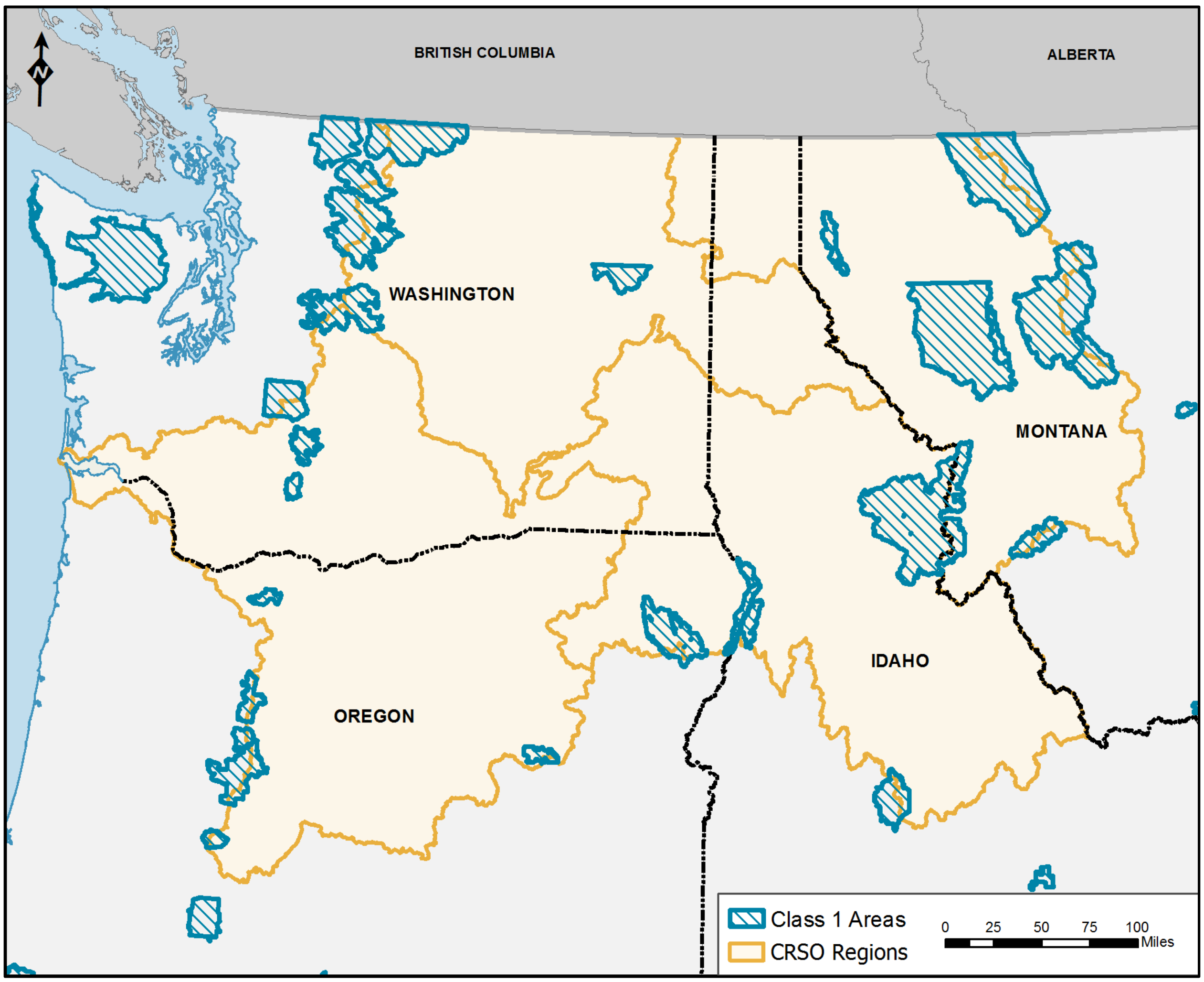


Figure 4-1. Class 1 Areas in the Pacific Northwest and CRSO Regions

The Air Quality analysis also considers regional wind speeds at a variety of meteorological monitors in the Pacific Northwest to evaluate potential windblown fugitive dust effects. This analysis considers the EPA guidance on high-wind events (25 miles per hour) as well as the fugitive dust guidance from the AP-42 emissions factors (potential for wind erosion occurring at 12 miles per hour) to assess the potential for fugitive dust effects due to changes in water elevation as well as other sources of potential dust (e.g., unpaved roads or construction activities).

Table 4-2 presents the list of relevant monitoring stations. Stations were selected based on proximity to CRSO projects and the availability of data. The data on wind speed is from the Midwest Regional climate data portal. The data presented in Tables 4-3 and 4-4 reflect multiple years of wind data from the Midwestern Regional Climate Center cli-MATE program. All records missing either a speed or direction record were excluded. Table 4-3 presents median and mean wind speeds, as well as the 5^{th} and 95^{th} percentiles for the relevant monitoring stations, as well as the percentage of time for "calm" hours (below 1.3 mph), wind speeds above the AP-42 threshold of 12 mph, and wind speeds above the high-wind event threshold of 25 mph.

Table 4-4 presents the monthly breakdown by station. Generally speaking, the results indicate relatively low median and average wind speeds across the region, below both the high-wind event threshold and the lower AP-42 threshold. All the stations do experience occasional speeds above 25 miles per hour; however, occurrences are infrequent, accounting for less than 1 percent of the recorded hourly data analyzed with the exception of at the Dalles. Walla Walla, the Dalles, and Pullman Moscow experience the highest percentage of hours with speeds above 12 miles per hour indicating a higher likelihood for the potential of wind erosion and suspension of sediment at sites near those monitors.

Table 4-2. Meteorological Monitoring Stations Analyzed

Station Name	County and State	Closest CRSO Project(s) and Relative Direction
Dalles	Klickitat, WA	Dalles and John Day
Hermiston	Umatilla, OR	McNary and Ice Harbor
Lewiston	Nez Perce, ID	SE of Lower Granite and W of Dworshak
Kalispell	Flathead, MT	East of Libby and West of Hungry Horse
Pasco Tri-Cities	Franklin, WA	NW of Ice Harbor and N of McNary
Pullman Moscow	Whitman, WA	NE Lower Granite and NW of Dworshak
Lowell/Three Rivers	Idaho, ID	SE of Dworshak
Walla Walla	Walla Walla, WA	Lower Snake

Table 4-3. Mean, Median, 5^{th} and 9^{th} Percentile Wind Speeds for Regional Monitors, Miles per Hour

Percentile	Monitoring Station Location							
	Walla Walla	Dalles	Hermist on	Lewisto n	Tri-Cities	Pullman Mosco w	Lowell/ Three Rivers	Kalispell
5^{th}	0	0	0	0	0	0	0	0
Median	7	6	6	5	6	7	0	5
95^{th}	17	21	18	15	17	18	6	15

Percentile	**Monitoring Station Location**							
	Walla Walla	**Dalles**	**Hermist on**	**Lewisto n**	**Tri-Cities**	**Pullman Mosco w**	**Lowell/ Three Rivers**	**Kalispell**
Calm Periods (% of all records below 1.3 mph)	12%	27%	18%	25%	24%	25%	69%	38%
Above 12 mph	19%	29%	18%	9%	15%	23%	0.16%	12%
Above 25 mph	0.80%	1.6%	0.86%	0.42%	0.92%	0.81%	0%	0.31%
Mean Wind Speed (excluding calm periods)	9.0	10.9	8.8	7.3	8.5	10.0	4.4	8.1
Maximum Wind Speed	48	40	41	47	47	49	23	44

Table 4-4. Monthly Median, 5th and 9th Percentile Wind Speeds for Regional Monitors, Miles per Hour

Station	Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Walla Walla	5th	0	0	0	0	0	0	0	0	0	0	0	0
Walla Walla	Median	6	7	8	8	8	8	8	8	7	7	6	6
Walla Walla	95th	19	18	20	18	16	16	15	15	15	16	20	21
Dalles	5th	0	0	0	0	0	0	0	0	0	0	0	0
Dalles	Median	3	3	6	9	10	13	14	11	7	5	3	3
Dalles	95th	14	17	21	22	23	24	23	23	21	18	15	14
Hermiston	5th	0	0	0	0	0	0	0	0	0	0	0	0
Hermiston	Median	5	5	7	8	8	8	8	7	6	5	5	5
Hermiston	95th	16	18	21	21	19	20	18	17	16	16	17	16
Lewiston	5th	0	0	0	0	0	0	0	0	0	0	0	0
Lewiston	Median	5	5	6	6	6	6	5	5	5	5	5	5
Lewiston	95th	17	15	16	15	14	14	14	13	13	13	16	16
Tri-Cities	5th	3	3	3	3	3	3	3	3	3	3	3	3
Tri-Cities	Median	6	7	8	8	8	8	7	7	6	6	6	6
Tri-Cities	95th	21	21	22	21	18	18	16	16	16	18	20	18
Pullman Moscow	5th	0	0	0	0	0	0	0	0	0	0	0	0
Pullman Moscow	Median	9	8	9	8	7	6	5	5	6	7	9	9
Pullman Moscow	95th	21	20	20.85	20	17	16	15	15	16	17	20	20
Lowell/Three Rivers	5th	0	0	0	0	0	0	0	0	0	0	0	0
Lowell/ Three Rivers	Median	0	0	0	0	0	0	0	0	0	0	0	0
Lowell/ Three Rivers	95th	6	6	6	6	7	7	6	5	5	5	6	6
Kalispell	5th	0	0	0	0	0	0	0	0	0	0	0	0
Kalispell	Median	0	3	6	7	6	6	5	5	3	3	3	0
Kalispell	95th	15	15	16	17	16	14	15	15	14	14	15	15

CHAPTER 5 - METHANE EVALUATION COLUMBIA RIVER BASIN

5.1 METHANE EVALUATION COLUMBIA RIVER BASIN

5.1.1 Introduction

The greenhouse gas (GHG) methane (CH_4) produced from anthropogenic activities accounts for roughly 40% of global climate forcing (Stocker et al. 2013). An estimate of global methane sources shows that roughly 71% of methane emissions stem from anthropogenic activities, namely the burning of fossil fuels (Figure 5-1). Inland water bodies, including freshwater lakes and manmade reservoirs, can be net emitters of CH_4 and the less potent GHG carbon dioxide (CO_2), particularly in tropical and mid-latitude locations (Demarty and Bastien 2011). Hydroelectric dams can prevent the downstream transport of organic and inorganic carbon (C) as the riverine system conditions are converted into lacustrine systems (Wetzel 2001). It has recently been suggested that the drawdown of reservoirs behind dams is perhaps an important anthropogenic source of GHG emissions to the atmosphere, and thus should be included in global budget estimates (Deemer et al. 2016). A recent synopsis of GHG research studies has concluded that worldwide CH_4 emissions are responsible for 80% of the radiative forcing from reservoir surfaces over a 100-year span and 90% over a 20-year span (Deemer et al. 2016). CH_4 is 25 times more potent than CO_2 at trapping heat per 100 years (Stocker et al. 2013). This report will therefore focus on CH_4 emissions because it is a much more potent GHG than CO_2, however it is important to not discount the production of CO_2 via oxidation, described below.

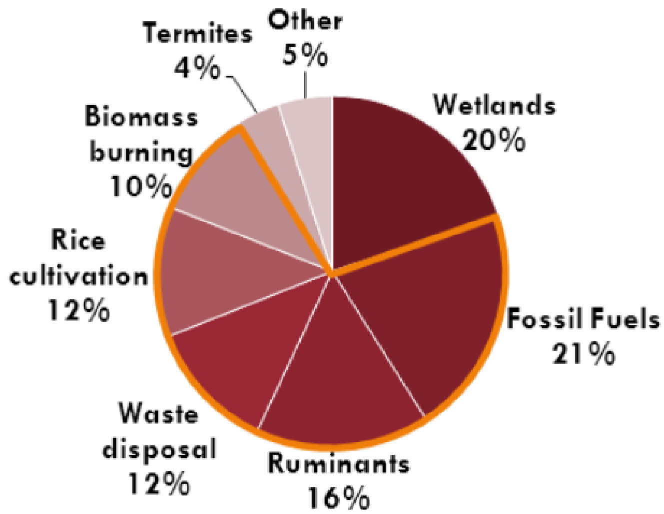


Figure 5-1. Estimates of global sources of methane with anthropogenic sources outlined in orange (Wuebbles and Hayhoe 2002).

To more fully comprehend the environmental conditions that affect CH_4 production, it is helpful to have a fundamental understanding of the underlying chemistry, namely reduction-oxidation (redox) potential and the ensuing reactions. Oxidation involves the loss of electrons from a species and reduction involves the gain of electrons. Oxidation always occurs in conjunction with reduction because the net exchange of electrons must balance - the number of electrons lost by one species must equal the number gained by the other, therefore, in any redox reaction one species is always oxidized and another is reduced.

A general redox reaction is as follows:

Oxidized species + e^- + H^+ $\leftrightarrow$ reduced species

Redox potential is the tendency of an environment to receive or supply electrons. A solution with a higher (more positive) reduction potential than the new species will have a tendency to gain electrons from the new species (i.e., to be reduced by oxidizing the new species) and a solution with a lower (more negative) reduction potential will have a tendency to lose electrons to the new species (i.e., to be oxidized by reducing the new species). Figure 5-2 shows standard reduction potentials.

An oxic environment has high redox potential because O_2 is available as an electron acceptor. For example, Fe (iron) oxidizes to rust in the presence of O_2 because the iron shares its electrons with the O_2:

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3$$

By contrast, an anoxic environment has low redox potential because of the relative absence of O_2.

The net reaction for aerobic oxidation of organic matter (OM) is:

$$CH_2O + O_2 \rightarrow CO_2 + H_2O$$

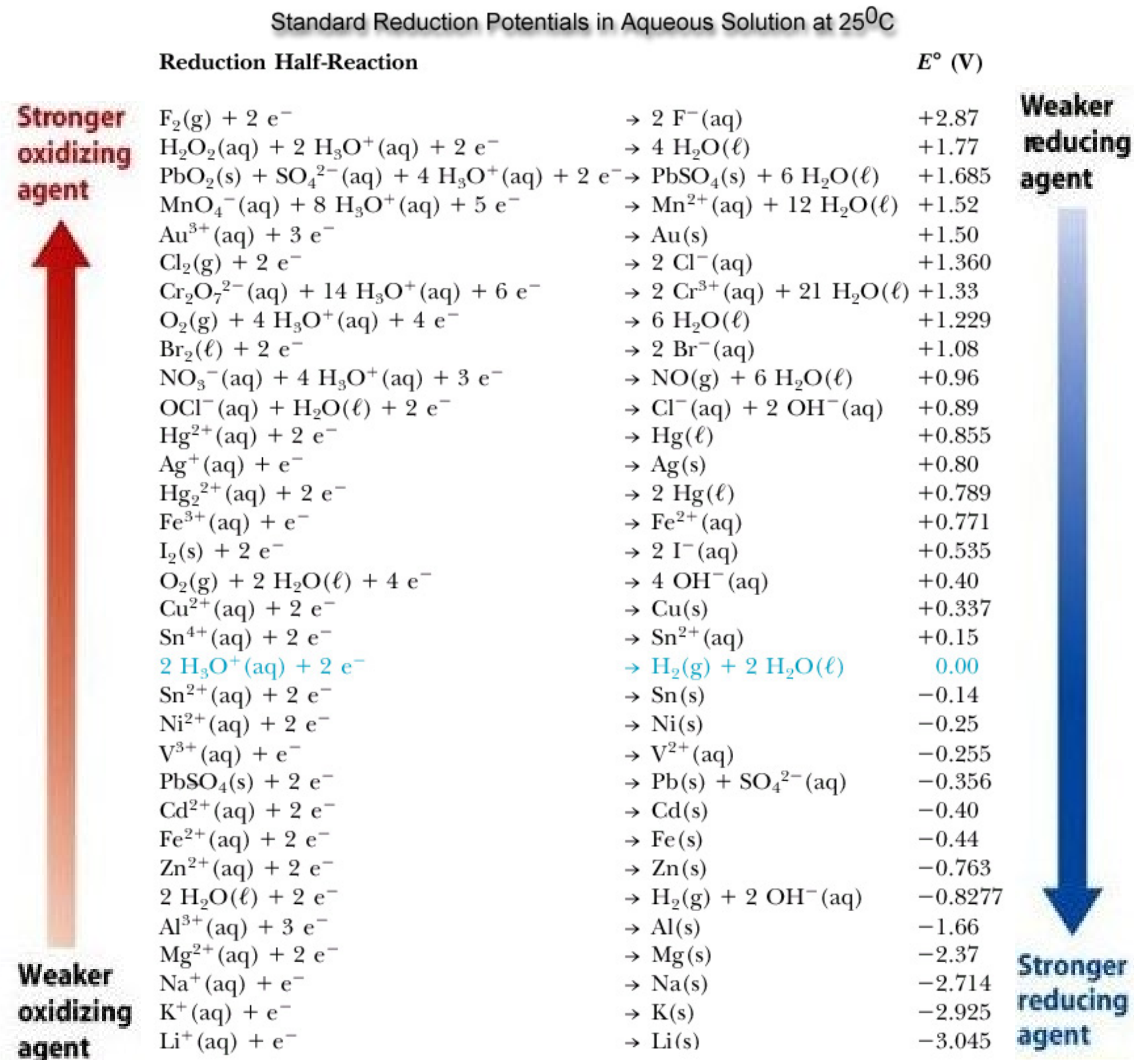
In this case, oxygen is the electron acceptor; the reduction half-reaction is:

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

CH_4 is produced primarily under anoxic conditions from the degradation of organic matter (OM) by microbes within lake or reservoir sediments. This process, called methanogenesis, is a form of anaerobic respiration and uses C in the form of CO_2 or acetic acid instead of oxygen, as demonstrated in the following reactions:

$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$$

$$CH_3COOH \rightarrow CH_4 + CO_2$$



Standard Reduction Potentials in Aqueous Solution at 25⁰C

Reduction Half-Reaction		$E°$ (V)
$F_2(g) + 2\ e^-$	$\rightarrow 2\ F^-(aq)$	+2.87
$H_2O_2(aq) + 2\ H_3O^+(aq) + 2\ e^-$	$\rightarrow 4\ H_2O(\ell)$	+1.77
$PbO_2(s) + SO_4^{2-}(aq) + 4\ H_3O^+(aq) + 2\ e^-$	$\rightarrow PbSO_4(s) + 6\ H_2O(\ell)$	+1.685
$MnO_4^-(aq) + 8\ H_3O^+(aq) + 5\ e^-$	$\rightarrow Mn^{2+}(aq) + 12\ H_2O(\ell)$	+1.52
$Au^{3+}(aq) + 3\ e^-$	$\rightarrow Au(s)$	+1.50
$Cl_2(g) + 2\ e^-$	$\rightarrow 2\ Cl^-(aq)$	+1.360
$Cr_2O_7^{2-}(aq) + 14\ H_3O^+(aq) + 6\ e^-$	$\rightarrow 2\ Cr^{3+}(aq) + 21\ H_2O(\ell)$	+1.33
$O_2(g) + 4\ H_3O^+(aq) + 4\ e^-$	$\rightarrow 6\ H_2O(\ell)$	+1.229
$Br_2(\ell) + 2\ e^-$	$\rightarrow 2\ Br^-(aq)$	+1.08
$NO_3^-(aq) + 4\ H_3O^+(aq) + 3\ e^-$	$\rightarrow NO(g) + 6\ H_2O(\ell)$	+0.96
$OCl^-(aq) + H_2O(\ell) + 2\ e^-$	$\rightarrow Cl^-(aq) + 2\ OH^-(aq)$	+0.89
$Hg^{2+}(aq) + 2\ e^-$	$\rightarrow Hg(\ell)$	+0.855
$Ag^+(aq) + e^-$	$\rightarrow Ag(s)$	+0.80
$Hg_2^{2+}(aq) + 2\ e^-$	$\rightarrow 2\ Hg(\ell)$	+0.789
$Fe^{3+}(aq) + e^-$	$\rightarrow Fe^{2+}(aq)$	+0.771
$I_2(s) + 2\ e^-$	$\rightarrow 2\ I^-(aq)$	+0.535
$O_2(g) + 2\ H_2O(\ell) + 4\ e^-$	$\rightarrow 4\ OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2\ e^-$	$\rightarrow Cu(s)$	+0.337
$Sn^{4+}(aq) + 2\ e^-$	$\rightarrow Sn^{2+}(aq)$	+0.15
$2\ H_3O^+(aq) + 2\ e^-$	$\rightarrow H_2(g) + 2\ H_2O(\ell)$	0.00
$Sn^{2+}(aq) + 2\ e^-$	$\rightarrow Sn(s)$	−0.14
$Ni^{2+}(aq) + 2\ e^-$	$\rightarrow Ni(s)$	−0.25
$V^{3+}(aq) + e^-$	$\rightarrow V^{2+}(aq)$	−0.255
$PbSO_4(s) + 2\ e^-$	$\rightarrow Pb(s) + SO_4^{2-}(aq)$	−0.356
$Cd^{2+}(aq) + 2\ e^-$	$\rightarrow Cd(s)$	−0.40
$Fe^{2+}(aq) + 2\ e^-$	$\rightarrow Fe(s)$	−0.44
$Zn^{2+}(aq) + 2\ e^-$	$\rightarrow Zn(s)$	−0.763
$2\ H_2O(\ell) + 2\ e^-$	$\rightarrow H_2(g) + 2\ OH^-(aq)$	−0.8277
$Al^{3+}(aq) + 3\ e^-$	$\rightarrow Al(s)$	−1.66
$Mg^{2+}(aq) + 2\ e^-$	$\rightarrow Mg(s)$	−2.37
$Na^+(aq) + e^-$	$\rightarrow Na(s)$	−2.714
$K^+(aq) + e^-$	$\rightarrow K(s)$	−2.925
$Li^+(aq) + e^-$	$\rightarrow Li(s)$	−3.045

Figure 5-2. Standard reduction potentials at 25°C, where E° (v) = electrode potential at standard state: solutes concentration = 1 mol/L; gases pressure = 1 atm (Wilbraham et al. 2008).

However, a sequence of redox reactions must occur before methanogenesis is possible. Each of these half-reactions involves oxidants, or electron acceptors, which exhibit low redox potentials. In aquatic environments, OM is oxidized as follows, and as summarized in Table 5-1 below, which also denotes the standard reduction potentials of each half-reaction (Schlesinger and Bernhardt 2013):

1) O_2 reduction (aerobic oxidation): availability of O_2 in water is limited by the amount of organic matter present any by how much circulation there is in the water column.
2) NO_3 reduction (denitrification): NO_3 availability typically quickly runs out.
3) Mn reduction and Fe reduction: dependent on soil composition.

4) SO_4 reduction: usually minor in fresh water and more important in marine environments
5) CO_2 reduction (methanogenesis): usually highly available and thus very important in freshwater systems, particularly those rich in OM.

Table 5-1. Sequence of Organic Matter Oxidation Preceding Methanogenesis in Aquatic Environments.

Organic Matter Oxidation Reactions (Reducing Half-Reactions)		
Sequence	**Reaction**	**E° (v)**
1. Reduction of O_2	$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	+0.812
2. Reduction of NO_3	$2NO_3^- + 6H^+ + 6e^- \rightarrow N_2 + 3H_2O$	+0.747
3. Reduction of Mn^{4+}	$MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$	+0.526
4. Reduction of Fe^{3+}	$Fe(OH)_3 + 3H^+ + e^- \rightarrow Fe^{2+} + 3H_2O$	-0.047
5. Reduction of SO_4^{2-}	$SO_4^{2-} + 10H^+ + 8e^- \rightarrow H_2S + 4H_2O$	-0.221
6. Reduction of CO_2	$CO_2 + 8H^+ + 8e^- \rightarrow CH_4 + 2H_2O$ -or- $CH_3COOH \rightarrow CH_4 + CO_2$	-0.244

CH_4 produced by microbial anaerobic respiration in benthic substrates can be converted to CO_2 in the overlying water column, as represented by the following reaction:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

CH_4 can undergo reverse methanogenesis within anoxic freshwater or low salinity estuarine sediments, whereby it is anaerobically oxidized via coupling to nitrate and nitrite reduction, thus reducing the emission of CH_4 (Tremblay et al. 2005). This results in a CH_4 sink instead of source, although CO_2 is still produced. However, as stated previously CH_4 is the more potent GHG as it is 25 times better at trapping heat than CO_2.

Anaerobic oxidation occurs via the following reactions:

$$CH_4 + 4NO_3^- \rightarrow CO_2 + 4NO_2^- + 2H_2O$$

$$3CH_4 + 8NO_2^- + 8H^+ \rightarrow 3CO_2 + 4N_2 + 10H_2O$$

The decomposition of organic C by microbes in reservoirs can be a significant source of CH_4 to the atmosphere, but can range substantially depending on water temperature, reservoir age, sediment deposition rates, redox conditions, and the quantity and quality of C delivered to the sediments (Barros et al. 2011; Nguyen et al. 2010; Sobek et al. 2012; West et al. 2012; Falter 2017). Generally, systems that are more nutrient-enriched exhibit higher rates of CH_4 emission, and autochthonous C has been correlated to higher rates of methanogenesis than allochthonous C (Bastviken et al. 2008; West et al. 2012). A key characteristic of reservoirs that emit high levels of CH_4 is the presence of large amounts of flooded OM, particularly under anoxic conditions, and CH_4 production is further increased from continued high inputs of OM and the nutrients nitrogen and phosphorus (Nguyen et al. 2010; Sobek et al. 2012; Harrison et al. 2016).

As mentioned previously, methanogenesis depends on the availability of OM, in the form of either particulate organic matter (POM) and/or dissolved organic matter (DOM), 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 OM 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). These conditions, particular to each reservoir, result in extensive variability in CH_4 production both between and even within reservoirs. In run-of-river reservoirs, as on the mid-Columbia River, a littoral aquatic macrophyte (AM) bed may have CH_4 production rates per unit area 3 or 4 orders of magnitude greater than in the adjacent deep-water column (Falter 2017). The following table shows principal controllers of CH_4 emissions for reservoirs in general, demonstrating the extensive variables that drive CH_4 emissions (Table 5-2).

Table 5-2. Controllers of CH_4 Emissions to Atmosphere from Reservoirs (Falter 2017).

Controllers of CH_4 Production and Release[1/]	Relationship to CH_4 Production and Release
Reservoir age	CH_4 production sharply drops after 3 years; release of soluble OM and nutrients from flooded terrestrial vegetation tails out to near zero after 30-50 years
Reservoir surface area[b] (size)	CH_4 production (mg CH_4 m^{-2} day^{-1}) higher in small lakes/reservoirs; Dramatically increased in water bodies less than 1 – 2 km^2 (0.3 – 0.7 mi^2).
Lake length	Greater length provides greater shoreline length and potential for littoral development.
Shoreline development (SDL): compares shoreline length to a same area circle	Higher SDL related to potentially higher littoral thus potential sites of CH_4 production and release
Lake orientation	Wind fetch strongly correlated to mixing, thus sediment entrainment and gas diffusion at S/W and A/W interfaces
Hydraulic Retention Time (HRT)	CH_4 production directly correlated w/ HRT; Low HRT water bodies have very low CH_4 emission rates in pelagic waters.
Lake level fluctuation – Load following	CH_4 release from shallow sediments positively correlated with fluctuation frequency magnitude, and rapidity of water surface change.
Year-round top-to-bottom water circulation	Precludes development of anoxia, hence CH_4 production in water column and surficial sediments year-round; anaerobic conditions with accompanying methanogenesis may occur in deeper sediments. Thicker sediment deposits may store more CH_4, subject to release at S/W interface with sufficient currents.

[b] Per Holgerson and Raymond (2016): Small lakes have a high perimeter-to-surface-area ratio and accumulate a higher relative amount of terrestrial carbon. Small lakes also tend to be shallow, which means their terrestrial carbon loads are highly concentrated compared to larger lakes. Lastly, gases produced at the bottom of these lakes are able to surface more so than in larger lakes, due to greater water mixing and shallower waters.

Controllers of CH_4 Production and Release[1/]	Relationship to CH_4 Production and Release
Winter ice cover	Winter ice cover in a water body can provide a months-long seal of the A/W interface leading to lower under-ice oxygen levels and increased CH_4 accumulation both in the water column and sediments due to anoxic conditions. Large volumes of CH_4 releases can then occur at Spring overturn.
Vertical water stratification	Stratification permits vertical layering and isolation from atmosphere of deeper areas of water column and sediments. Anoxia is enhanced with subsequent CH_4 production.
Near-bottom velocity	CH_4 production in, and release from sediments at S/W interface negatively correlated with near-bottom velocity.
Fine sediment accumulation	CH_4 production is inversely correlated with sediment particle size, i.e., finer sediments can have higher rates of methanogenesis.
Littoral fine, organic-rich sediment	Strongly correlated with near-shore band of OM accumulation, potential CH_4 production, and AM, then release via either: 1) direct diffusion to water [least important], ebullition; or 2) the AM pathway to water. Relative areal coverage determines total CH_4 release of the total reservoir.
Organic content of watershed soils	Aquatic CH_4 production is positively correlated with allochthonous (loading from terrestrial sources) OM inputs to reservoir.
Organic content and nutrients of lake sediments	High CH_4 production is correlated with OM and nutrients of sediments. Drowned timber and terrestrial vegetation extremely important drivers of methanogenesis in early life of reservoir.
Littoral sediment development	Littoral fine sediments tend to be rich in OM and nutrients, correlating with methanogenesis and CH_4 release to water via diffusion, ebullition, or AM piping, yielding the highest rates of CH_4 production in a reservoir per unit area.
Nutrient loading from watershed to reservoirs	CH_4 production increases with non-point watershed nutrient supply (irrigated agriculture, forest practices, and urban runoff).
Nutrient loading to reservoirs	Higher nutrient loading usually leads to higher lake productivity, organic sediments, and CH_4 production.
In-Reservoir (autochthonous) production	Higher autotrophic production provides more OM to sediments for anaerobic decomposition in sediment, thus higher CH_4 production. Autotrophic OM production from within the water body is more efficient at CH_4 production.
Water temperature	Higher water temperatures correlate very strongly with higher CH_4 production
Water transparency	Clearer waters indicate lower plankton but higher potential littoral AM production; balance of resulting OM accrual is dependent on physical characteristics, e.g., steep shorelines limit littoral area, greatly reducing CH_4 production rates.
Rooted aquatic macrophyte (AM) development	Shore bands of AM reduce water velocity which forms, traps, and builds OM- and nutrient-rich benthic sediments. By reducing velocity in thick beds, deeper anoxic sediments conducive to methanogenesis develop.
CH_4 Ebullition to surface	Generally a large factor in CH_4 release to atmosphere in littoral waters < 3 m for several reasons: 1) drawdown-enhanced release of CH_4 from sediments occurs mostly in the drawdown band; 2) OM deposits form there from settling in quiescent water along with high OM production from ABA and AM; 3) AM release bubbles in the shallow littoral ensuring that more CH_4 reaches the surface; and 4) AM piping of gaseous CH_4 to the A/W. In deeper water columns, most of CH_4 bubbles are absorbed and/or oxidized to CO_2 before reaching the A/W interface.
ABA = attached benthic algae	AM = aquatic macrophytes

Controllers of CH_4 Production and Release[1/]	**Relationship to CH_4 Production and Release**
S/W = sediment/water interface	A/W = air/water interface
OM = organic matter	WS = Watershed of reservoir

1/ Bold type = major forcing factor

CH_4 can be released into the water column via diffusion, bubbling (ebullition), or by plant-mediated transport in the presence of emergent vegetation (Bastviken et al. 2004; Harrison et al. 2016). CH_4 can also be emitted from reservoirs during drawdown periods via degassing at turbines and spillways (Deemer et al. 2016). The graphic below depicts CO_2 and CH_4 pathways in a freshwater reservoir with an anoxic stratum (Figure 5-3):

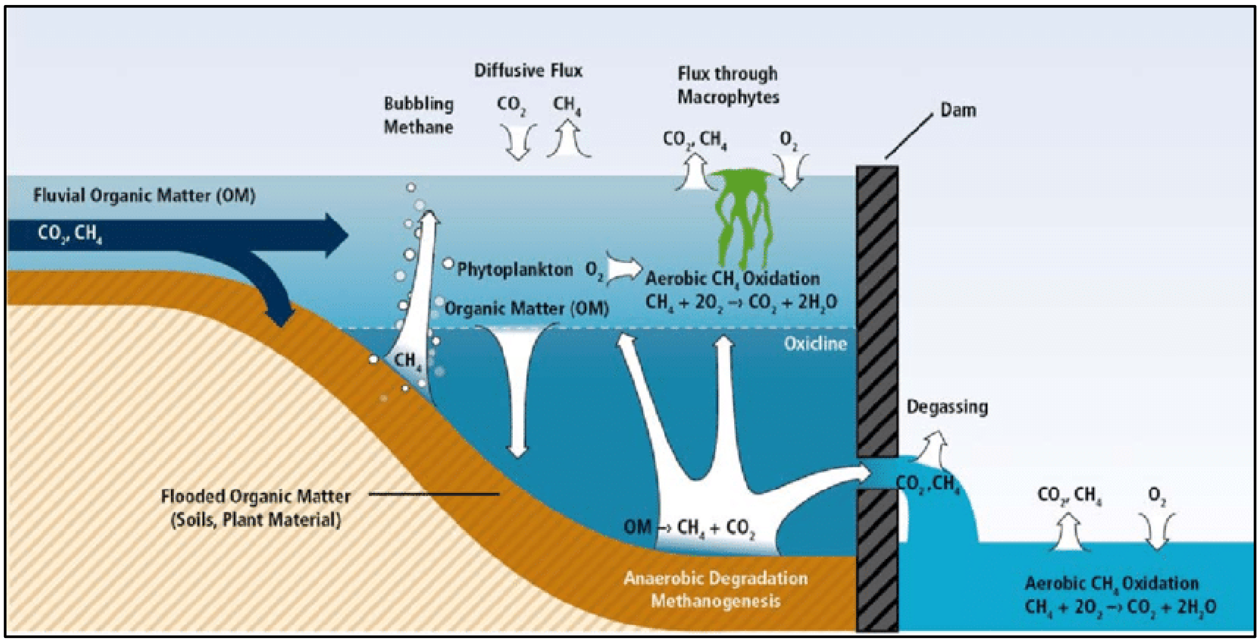


Figure 5-3. Pathways of CO_2 and CH_4 in a freshwater reservoir with an anoxic stratum (Kumar et al. 2012).

Ebullition occurs when CH_4 gas is formed when the partial pressure of all dissolved gases in the pore-water exceeds the ambient pressure and surface tension of the overlying water (Boudreau et al. 2005; Boudreau 2012). Bubbles then develop and enlarge under continued production of CH_4, causing fissures or spaces to form inside the sediment (Boudreau 2012; Johnson et al. 2002). As CH_4 production within the sediment continues, the gas bubbles can grow, combine with other bubbles, and travel upwards through the sediment until they are released into the water column and ultimately into the atmosphere. Figure 5-4 depicts the general pathway of CH_4 production in lakes and reservoirs in forming CH_4 bubbles. Reservoir drawdowns decrease the hydrostatic pressure upon the sediment, which can enable bubbles to move more easily and quickly upward through the sediment, allowing CH_4 ebullition rates to temporarily increase (Maeck et al. 2014). Conversely, in areas where the water is deeper and less disturbed, less CH_4

ebullition occurs because most of CH_4 bubbles are absorbed and/or oxidized to CO_2 before reaching the air. (Beaulieu et al. 2016, Falter 2017).

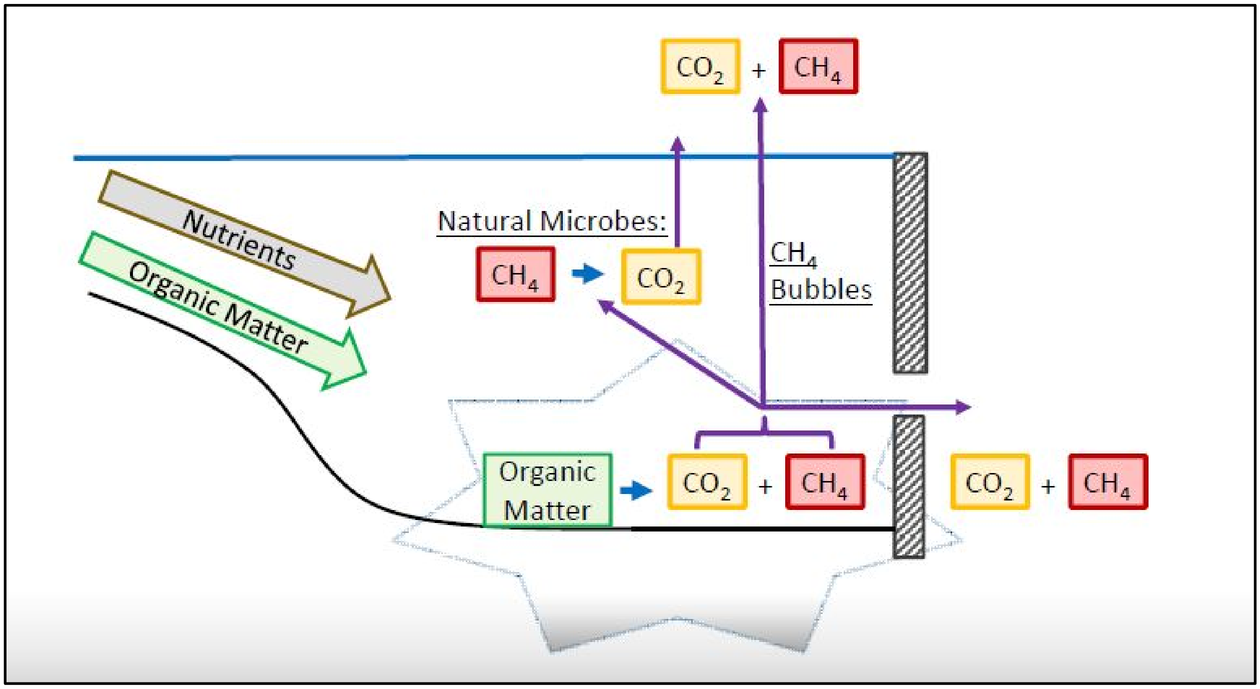


Figure 5-4. Diagram of anaerobic GHG production in lake sediments and resulting formation of CH_4 bubbles within the water column (Northwest Power and Conservation Council 2017).

5.1.2 Methane (CH_4) Emissions Evaluation Framework

The purpose of this report is to provide a preliminary assessment of the potential impacts affecting CH_4 emissions from hydroelectric dam operations within the Columbia River basin. While little research currently exists for this particular geographical area, this is a burgeoning topic of interest and ongoing research initiatives are hoping to capture more information regarding CH_4 emissions from hydroelectric projects in the Pacific Northwest to better inform regional decision makers and dam owner/operators on potential impacts resulting from hydropower operations. In light of the limited data available and time and resource constraints, this report relies on a collection of representative and/or relevant research findings within the field of GHG emission analyses, and as mentioned previously will focus primarily on CH_4 emissions as this is the more potent GHG compared to CO_2.

5.2 LEVEL 1 EVALUATION

5.2.1 River Basin Description

This assessment of GHG emissions encompasses the entire Columbia River basin located south of the U.S.-Canada border, including the mainstem Columbia River and its tributaries, such as the Kootenai and Snake Rivers, located within the Pacific Northwest region (parts of Montana, Idaho, Washington and Oregon). The headwaters of the Columbia and Kootenai Rivers are excluded as these reside in Canada. Figure 2-1 shows the basin and major hydropower projects.

The Columbia River is the fourth largest river in North America as measured by average annual flow and the single largest freshwater source on the west coast. It originates in British Columbia and flows 1,954 km (1,214 mi) through Canada and the United States to the Pacific Ocean. Although only 15 percent of the river's basin lies in Canada, 38 percent of the average annual flow volume originates in Canada. In addition, up to 50 percent of the peak flood waters in the lower Columbia River between Oregon and Washington originate from snowmelt in the Canadian portion of the Columbia River basin. Seasonal unregulated discharge ranges widely from 36,000 cfs to 1,240,000 cfs with an annual mean of 275,000 cfs. The estuarine portion of this immense river, as defined by salt intrusion, ranges from 20 km to 50 km (12 mi to 31 mi) long and the river is tidally influenced all the way upstream to the first hydroelectric project, Bonneville Dam, located 235 km (146 mi) from the estuary mouth (Figure 5-5). Average water depth is 7 m (23 ft), with narrow channels that are dredged to 20–30 m (65–98 ft) deep (Pfeiffer-Herbert et al. 2015).

Within the basin over 60 large hydroelectric projects and their reservoirs are owned and operated by many different entities for multiple purposes (Figure 5-5). The hydroelectric projects located in Eastern Washington, the mid-Columbia mainstem reach, on the Kootenai and Flathead Rivers in Montana, and on the Snake River in Idaho are all within xeric terrain. Many of these reservoirs, along with those located in hydric Western Oregon, have agricultural inputs and are generally not nutrient-limited (Arntzen et al. 2013). However, compared to other U.S. regions, most Pacific Northwest rivers are colder, swifter, and more oxygenated, and thus generally have better water quality with modest levels of nutrient inflow impacts (Arntzen et al. 2013; Falter 2017). Nonetheless, some parts of the basin have substantial drainage areas with significant nutrient loading from agricultural uses, urban/suburban runoff, and treated wastewater, boosting productivity particularly in the mid- and lower-Columbia segments. Conversely, some sections of the basin host ultra-oligotrophic reservoirs (Falter 2017). Overall, most of the reservoirs in the basin are generally oxic although some are known to be anoxic seasonally, such as the Brownlee complex on the Snake River (Arntzen et al. 2013; Nürnberg 2004); anoxic conditions are required for CH_4 production, as noted earlier.

Many Pacific Northwest hydropower complexes employ spring spill operations to aid migratory juvenile fish in accordance with the operative biological opinions and the Clean Water Act. Fish spill operations are conducted at the four lower Snake River and four lower Columbia River dams for the benefit of juvenile fish passage. Fish passage spill is also conducted at Dworshak Dam to provide additional water for flow augmentation and to moderate temperature in the lower Snake River. Such spill operations have the potential to enhance CH_4 outgassing in the tailrace.

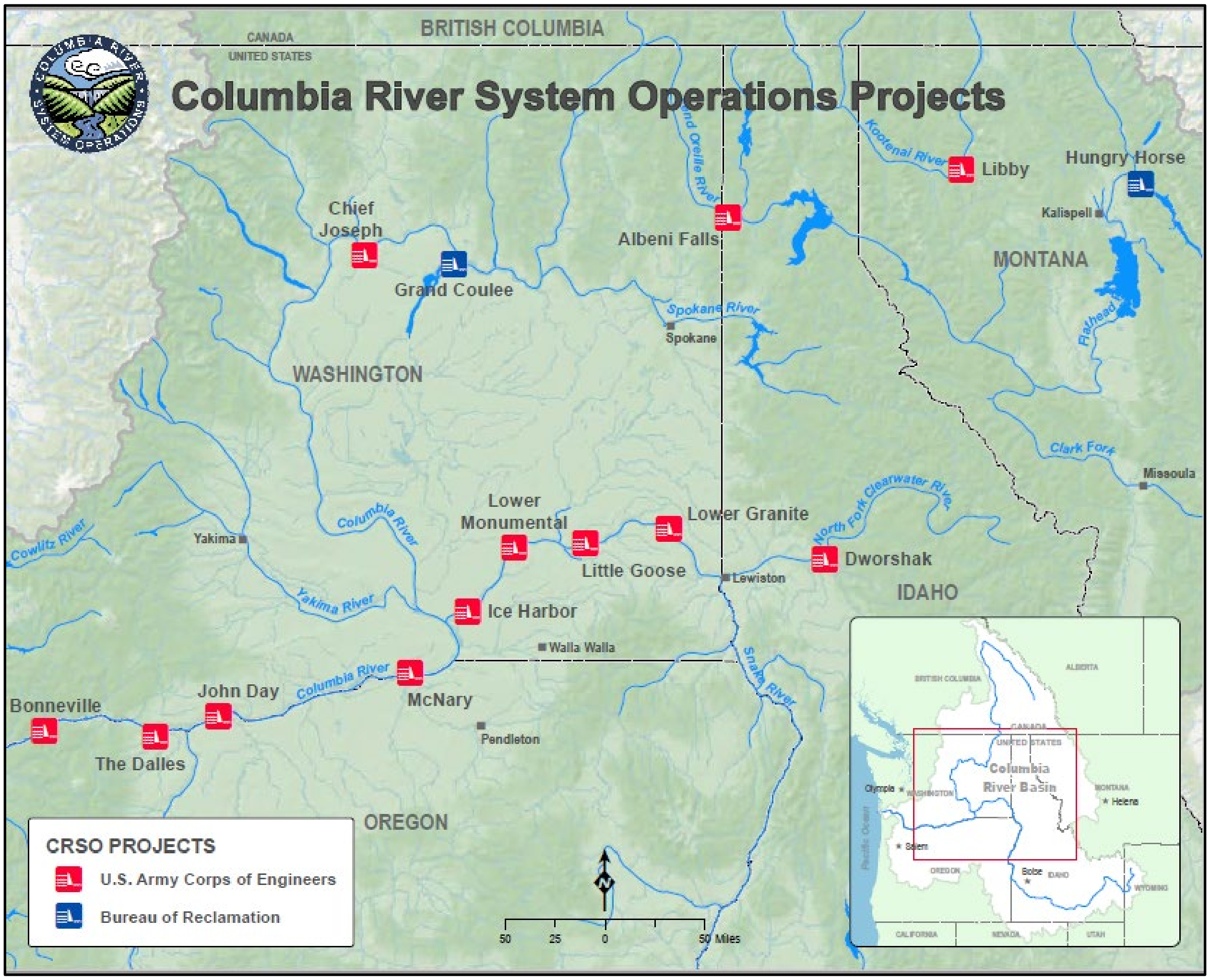


Figure 5-5. Columbia River basin showing major federal hydroelectric projects.

Specifically, high CH_4 emission rates may occur if gas levels increase within slow moving river reaches and then is rapidly released downstream at turbulent sites (Lilley et al. 1996; Nürnberg 2004). Drafting reservoirs can also lead to ebullition of CH_4 because the hydrostatic pressure on littoral sediments becomes reduced, enabling CH_4 bubbling directly into the water column instead of undergoing oxidation (Falter 2017). Fluctuating reservoir levels can also contribute to releases of CH_4 from the littoral zone, although most of the drawdown zone typically encompasses the surface waters which do not contain adequate OM and fine sediments necessary for CH_4 production (Falter 2017). This is especially true for projects located in Eastern Washington and Western Idaho (i.e. the Snake River Complex and Dworshak dam).

5.2.2 Summary of Existing Data

While very little data is available for Columbia River hydropower project reservoirs, recent findings show that CH_4 emissions from hydroelectric reservoirs in the basin are relatively low compared to other hydroelectric reservoirs, likely because of the well-oxygenated conditions typically found in the basin, particularly in the mainstem of the river (Kumar et al. 2012; Falter

2017). Soumis et al. (2004) found a range of emissions between 3.2 – 9.0 mg CH_4 m^{-2} day^{-1} for F.D. Roosevelt Lake, behind Grand Coulee Dam in the upper portion of the basin. Priest Rapids Reservoir, located on the mid-Columbia reach, was found to have very low surface estimates of CH_4: Falter (2017) reported a mean of 0.004 mg CH_4 m^{-2} day^{-1} from the pelagic zone and Arntzen et al. (2013) reported a mean close to zero. The Lower Monumental Reservoir on the Snake River was also found to have comparable mean flux rates (Arntzen et al. 2013; Falter 2017). By comparison, the free-flowing Hanford reach of the Columbia was found to have a mean surface flux of 0.08 mg CH_4 m^{-2} day^{-1} during the fall (Arntzen et al. 2013). These amounts are quite low compared to a global synthesis, whereby Deemer et al. (2016) calculated a mean range of CH_4 emissions from hydroelectric reservoirs worldwide of 24 – 112 mg CH_4 m^{-2} day^{-1} and a mean of 120 mg CH_4 m^{-2} day^{-1} for all reservoirs worldwide.

Conversely, CH_4 production in the littoral zone of the Priest Rapids Reservoir was found to be much higher, with a mean of 362 mg CH_4 m^{-2} day^{-1} (Falter 2017). This large difference between the two reservoir zones is likely due to underestimating CH_4 flux by current gas diffusion methodologies as it is difficult to accurately quantify and thus extrapolate. The high potential for CH_4 production in littoral zones of a water body that is only moderately productive, like Priest Rapids reservoir, is another factor influencing this measurement (Falter 2017). It is important to note that the high ratio of pelagic:littoral area resulted in relatively low overall reservoir-wide mean CH_4 emissions compared to general estimates for reservoirs on a national scale (Falter 2017).

Given evidence from Falter (2017), littoral areas in the Columbia River Basin are expected to be confined to the mid-Columbia River area, an area in which the CRS project reservoirs do not experience considerable changes in under any of the MOs or the Preferred Alternative. While MO3 would result in breaching the four lower Snake River projects, which would result in the loss of the reservoirs behind these projects, the information provide in Falter (2017) indicates that littoral areas are less likely at these sites.

Chapter 3 of the EIS details some of the characteristics of regions through the CRSO study area, including the mid-Columbia region (Region B) where littoral zones are abundant. For example, Table 5-2 profiles the hydrology of reaches in the region, noting that many of these areas are characterized by flat pools at particular times of year, while Section 3.3 describes sediment supply and transport in the same region. More information about the aquatic vegetation and shoreline development that that contributes to CH_4 production in the littoral zones abundant in the mid-Columbia River, is described in detail in Section 3.6 of the EIS.

The Priest Rapids reservoir has very comparable limnology to the Rock Island and Rocky Reach reservoirs directly upstream (Falter 2017). The data for Priest Rapids can be applied toward these reservoirs, thus it is expected that there are very low CH_4 emissions from pelagic waters and sporadic distribution of moderately high CH_4 emission pockets within the littoral sediment accumulation zones and along aquatic macrophyte beds (Falter 2017). By applying the controllers of CH_4 production and emission described previously in Table 1-2 and within other global research results, pelagic methanogenesis is believed to be very low in the Rock Island

and Rocky Reach reservoirs and exceptionally low in oligotrophic water bodies such as nearby Lake Chelan, whose river flows into the Columbia (Deemer et al. 2016; Falter 2017). Given this, there are likely also amplified areas of CH_4 production near sediment deposition zones (i.e., stream deltas, backwater embayment areas, and nearshore deposition areas of organic sediment deposition) and areas with highly productive aquatic macrophyte beds and attached benthic algae populations. These amplified areas likely have high rates of local methanogenesis and may produce greater emissions of CH_4 within the water column and into the atmosphere (Falter 2017). As noted above, both reservoirs' morphometry and hydrology indicate that these potentially high CH_4 emission rates that are expected to occur within the littoral zones are a small portion of the overall reservoir area, suggesting that the CH_4 emissions per reservoir are likely to be low on the regional scale and extremely low on the national and worldwide scales of CH_4 emissions from hydropower project reservoirs (Falter 2017).

For the lower river section, studies have found higher CH_4 oxidation in the lower Columbia River estuary compared to the mainstem and tributaries because of the prevailing saltwater conditions, which results in a net uptake of riverine CH_4 by the estuarine sediment, creating a CH_4 sink (Lilley et al. 1996; Tremblay et al. 2005). Pfeiffer-Herbert et al. (2015) found that nearly a quarter of the riverine CH_4 supply was consumed by methantrophic bacteria within the Columbia River estuary, greatly reducing the potential for CH_4 emissions. Additionally, the estuary experiences rapid flushing due to the sheer volume of discharge from the Columbia River and also tidal action, which both minimize CH_4 production (Pfeiffer-Herbert et al. 2015).

Degassing of CH_4 at hydroelectric projects' forebays and tailraces from water passing through the turbines or spillways is highly variable between each project and appears to also be dependent on the season (Arntzen et al. 2013). Overall, system concentrations of CH_4 in March across Columbia River hydroelectric projects were lower in the tailrace than in the forebay, indicating that the system was a source, with a mean degassing flux of 3.1×10^{-6} t CH_4 d^{-1} (Arntzen et al. 2013). During September, the system was a sink for CH_4, with a mean degassing flux of -5.6×10^{-4} t CH_4 d^{-1} (Arntzen et al. 2013). This also supports Falter's (2017) findings that Lower Monumental and Priest Rapids were sinks for CH_4 at the hydropower projects' outflows.

Ebullition as measured in littoral embayment zones for the mid-Columbia and Snake River hydropower complexes were high in September (mean concentrations of CH_4 were over 7,000 mg L^{-1}) and were roughly an order of magnitude lower in March (Arntzen et al. 2013). These results are to be expected, as higher CH_4 flux coincides with increased temperatures in the summer (DelSontro et al. 2010). Increased summer temperatures also moderately affect hyporheic flux of CH_4 within sediment pore-water in littoral embayments – the system had mean fluxes of 4.2 mg m^{-2} day^{-1} in March and 8.1 mg m^{-2} day^{-1} in September (Arntzen et al. 2013). CH_4 efflux from ebullition was more pronounced in embayment areas within reservoirs than embayments located in the free-flowing Hanford reach segment of the River, as was CH_4 pore-water flux, although the differences in the sediment pore-water values were minor and remained relatively constant seasonally (Arntzen et al. 2013).

There can be wide variation between projects' estimated CH_4 emissions from ebullition: the mean flux for the embayments of the Lower Monumental reservoir on the Snake River ranged from roughly 10.5 – 533 mg CH_4 m^{-2} day^{-1}, and Priest Rapids reservoir embayments had a range of about 176 – 1039 mg CH_4 m^{-2} day^{-1} (Arntzen et al. 2013). Again, it is difficult to accurately estimate and extrapolate CH_4 ebullition flux for a given area using current gas diffusion methodologies and given the extensive range of small-scale site-specific variables that control CH_4 emissions (Falter 2017).

5.3 RECOMMENDATIONS AND CONCLUSIONS

5.3.1 Methane (CH_4) Emissions Summary

The available data presented in this report on surface fluxes of CH_4 emissions from diffusion for the Columbia River hydroelectric project reservoirs, particularly those located on the mainstem or in more arid terrain, demonstrate that the basin's overall contributions to global CH_4 emissions are very small compared to other studies of comparable systems (Table 5-3), although they can be quite high locally. The Columbia basin reservoirs produce CH_4 in the range of one or two orders of magnitude less than current global estimates of surface emissions from reservoirs, even when only including hydroelectric reservoirs (Table 3-1). As discussed previously, relatively cold water temperatures and OM input coupled with well-oxygenated conditions and low water residence times prevalent throughout the basin contribute to low levels of CH_4 emissions in the region (St. Louis et al. 2000; Barros et al. 2011; Kumar et al. 2012; Arntzen et al. 2013; Falter 2017). The emission values seen thus far for the Columbia River system are quite low; indeed, during the fall the system tends to act as a CH_4 sink (Arntzen et al. 2013; Falter 2017). Slightly higher rates of CH_4 emissions from diffusion have been identified at other reservoir settings in the United States, including both run-of-river projects and lakes **(**Beaulieu et al. 2016, 2018; Bevelhimer et al. 2016).

Table 5-3. Compiled synopsis of CH_4 emissions from diffusion from recent literature.

Literature Synopsis of CH_4 Emissions from Diffusion		
Surface flux amount	**Sample Site Information**	**Source Cited**
120 mg CH_4 m^{-2} d^{-1}	Global reservoirs (all)	Deemer et al. 2016
1.0×10^{11} g CH_4 y^{-1}	Global temperate reservoirs	Barros et al. 2011
24 – 112 mg CH_4 m^{-2} d^{-1}	Global hydroelectric reservoirs	Deemer et al. 2016
1.5 – 12.0 mg CH_4 m^{-2} d^{-1}	Temperate run-of-river reservoir, Switzerland	DelSontro et al. 2010
3.0 – 11.0 mg CH_4 m^{-2} d^{-1}	Wisconsin recreational reservoirs (flooded peatlands)	St. Louis et al. 2000
3.2 – 9.0 mg CH_4 m^{-2} d^{-1}	F.D. Roosevelt Lake, Columbia River (behind Grand Coulee Dam)	Soumis et al. 2004
4×10^{-3} mg CH_4 m^{-2} d^{-1}	Priest Rapids Reservoir	Falter 2017
0 mg CH_4 m^{-2} d^{-1} (350 g CH_4 y^{-1})	Priest Rapids complex	Arntzen et al. 2013
0 mg CH_4 m^{-2} d^{-1} (-0.5 g CH_4 y^{-1})	Lower Monumental complex, Snake River	Arntzen et al. 2013
0.08 mg CH_4 m^{-2} d^{-1}	Hanford Reach, Columbia River (September)	Arntzen et al. 2013

Literature Synopsis of CH_4 Emissions from Diffusion		
Surface flux amount	**Sample Site Information**	**Source Cited**
0.07–6.18 mg CH_4 m^{-2} h^{-1} in tributary areas 0.03–2.18 mg CH_4 m^{-2} h^{-1} in in open water areas	Harsha Lake, Ohio	Beaulieu et al. 2016
2.0 mg CH_4 m^{-2} h^{-1}	Harsha Lake, Ohio	Beaulieu et al. 2018
251-5151 kg CH_4 day^{-1}	Six hydropower reservoirs in the southeastern United States	Bevelhimer et al. 2016

For contributions of CH_4 emissions to the atmosphere via degassing at hydroelectric projects, Arntzen et al. (2013) found that the tailrace acted as a sink seasonally in the fall with an overall net flux of -4.2×10^{-4} t CH_4 d^{-1}, which supports Falter's (2017) finding that the tailraces of hydroelectric complexes along the mainstem were sinks for CH_4. Soumis et al. (2004) also found low emissions of CH_4 emissions via degassing, with values ranging from 0.003 – 0.815 t CH_4 d^{-1} for hydropower project reservoirs in the upper basin (F. D. Roosevelt) and on the Clearwater River (Dworshak), a tributary to the Snake River.

Table 5-4 describes the flux of CH4 emissions from ebullition recorded across recent studies, again comparing other sites to estimates from select CRSO sites. As previously described, ebullition can account for the most significant source of CH_4 emissions from reservoirs. Arntzen et al. (2013) recorded high and extremely variable efflux of CH_4 via ebullition within littoral embayments, ranging from 10.5 to 533 mg CH_4 m^{-2} d^{-1} within Lower Monumental Dam reservoir embayments (mean flux of 324 mg CH_4 m^{-2} d^{-1}) and ranging from 176 to 1039 mg CH_4 $m^{-2}d^{-1}$ within Priest Rapids Dam reservoir (mean flux of 482 mg CH_4 m^{-2} d^{-1}). Arntzen et al. (2013) were careful to note that their study was not designed to estimate reservoir-wide ebullition emissions; as mentioned previously it is very difficult to accurately estimate and extrapolate CH_4 ebullition flux for an entire reservoir, let alone a complete river system, especially one the size of the Columbia River basin. These areas are characterized by water velocity near zero, abundance of aquatic macrophytes, oxic conditions, and high nutrient inputs, which all contribute to CH_4 production. Related research in the CRSO context by Miller et al. (2017) found that ebullition comprises more than 97 percent of emissions from these two hydropower reservoirs. Combined, these estimates from CRS projects suggest considerable variability across sites.

Unlike the diffusion citations, these CRS projects can produce methane from ebullition at levels more consistent with other temperate reservoirs recently studied. Beaulieu et al. (2016) identify ranges of 0 to 136.1 mg CH4 m^2 h^{-1} in the open-water areas and 0 to 186.1 mg CH_4 m^2 h^{-1} in the tributary-areas of Harsha Lake in Ohio. In a more recent study at the same site, Beaulieu et al. (2018) report rates they characterize as among the highest ever reported at a reservoir (mean of 32.3 mg CH4 m^{-2} h^{-1}), however this site (a lake) is very dissimilar to the reservoirs within the CRSO system. At six hydropower reservoirs in the southeastern United States, ebullition rates ranged considerably from 0 to 3834 kg day^{-1}. In similarly temperate European settings, DelSontro et al. (2010) found ebullition values for a Swiss reservoir to be substantially higher at roughly 1,000 mg CH_4 m^{-2} day^{-1}. For reservoirs in France and Germany, Decloux et al.

(2017) extrapolate their findings to estimate total annual ebullition flux of 2.7±2.3 $MgCH^4$ while Maeck et al. (2013) identify emissions ranges of 0 to 4235 mg m^{-2} d^{-1} across ten sites, respectively. Across studies that measure both types of emissions, CH_4 emissions from ebullition are more significant contributors to total emissions than diffusion.

Table 5-4. Compiled synopsis of CH_4 emissions from ebullition from recent literature.

Literature Synopsis of CH_4 Emissions from Ebullition		
Surface flux amount	**Sample Site Information**	**Source Cited**
324 mg CH_4 m^{-2} d^{-1}	Lower Monumental Dam, Snake River, Washington	Arntzen et al. 2013
482 mg CH_4 m^{-2} d^{-1}	Priest Rapids Dam reservoir, Columbia River, Washington	Arntzen et al. 2013
0–136.1 mg CH_4 m^2 h^{-1} in the open-water areas 0–186.1 mg CH_4 m^2 h^{-1} in the tributary-areas	Harsha Lake, Ohio	Beaulieu et al. 2016
32.3 mg CH_4 $m^{-2}h^{-1}$	Harsha Lake, Ohio	Beaulieu et al. 2018
0-3834 kg CH_4 day^{-1}	Six hydropower reservoirs in the southeastern United States	Bevelhimer et al. 2016
1,000 mg CH_4 m^{-2} day^{-1}	Swiss reservoir	Del Sontro et al. 2010
2.7±2.3 mg CH_4 annually	French reservoir	Descloux et al. 2017
0-4235 mg CH_4 m^{-2} d^{-1}	Ten German reservoirs	Maeck et al. 2013

Reservoir drawdown can influence rates of CH_4 ebullition due to a reduction in the hydrostatic pressure on littoral sediments. The magnitude of effects of fluctuating reservoir levels on CH_4 emissions from the littoral zone and riverine areas depends on specific localized site characteristics (Falter 2017); the projects that are typically drafted more deeply during seasonal operations are located in more arid regions of the basin (i.e. the Snake River Complex and Dworshak dam), and thus are less likely to experience large increases in CH_4 emissions during drawdown periods. For these reservoirs that undergo a wider operating range, the fluctuation of the reservoir levels and the age of the projects prevent sufficient amounts of impounded OM needed for increased CH_4 production. These hydroelectric projects are all at least 40 years old, and several studies have found that GHG production is severely reduced or mirrors emissions from natural lakes after ten years (St. Louis et al 2000; Tremblay et al 2004; IPCC 2006; Barros et al 2011). Arntzen et al. (2013) found hyporheic flux of CH_4 within sediment pore-water in littoral embayments to range from approximately 4 – 8 mg m^{-2} day^{-1}, while DelSontro et al. (2010) found peak flux from sediments to be about 40 mg m^{-2} day^{-1} for a temperate hydropower project reservoir in Switzerland. Despite this seemingly high value, DelSontro et al. (2010) estimated the system-wide sediment flux to be only about 15 mg m^{-2} day^{-1}.

5.3.2 Recommendations

Ideally, more data is required to fully assess and verify contributions of CH_4 emissions via the various pathways from hydroelectric reservoirs within the Columbia River basin. Unfortunately, due to time and resource constraints, a full suite of scientific data collection and analyses is simply not feasible at this time. Data and knowledge gaps imperative to quantifying CH_4

emissions from hydroelectric reservoirs in the Columbia River basin and determining their contribution to the global carbon budget are detailed below.

It is critical to incorporate both short and long-term temporal and spatial variability in research efforts, which can be quite difficult to capture due to resource constraints and logistical feasibility. As discussed previously, the amount of CH_4 emitted varies widely among reservoirs (depending on basin-specific characteristics, reservoir morphology, latitude, and climate), within reservoirs (nearshore vs. water column, sample site proximity to dam and location within the water column), and over time (land use changes, reservoir aging, seasonal and daily biological and physical changes such as precipitation, photosynthesis, methanogenesis, and temperature). In addition, individual dam operation should also be considered; operations vary, depending on energy demand, reservoir level, and runoff/precipitation amounts. Average CH_4 diffusive emission values can vary by an order of magnitude in temperate regions, highlighting the need for comprehensive assessments (IPCC 2006).

Despite the difficulties of such an endeavor, quantifying CH_4 emissions from reservoirs is essential because reservoirs can be of substantial size, e.g., Franklin D. Roosevelt Lake, behind Grand Coulee Dam, is considerable at 125 mi^2 (324 km^2). Furthermore, the extensive total surface area of all reservoirs regionally and globally necessitates studying these systems at larger spatial and temporal scales to capture all of the variability in order to establish realistic estimates of CH_4 contributions to the regional and global carbon budgets.

Arguably the most important aspect towards broadening the knowledge base of mechanisms contributing to CH_4 emissions is to conduct comprehensive assessments of site-specific characteristics for each reservoir, notably climate (wind, precipitation, temperature) and drainage basin characteristics (residence time, OM inputs). Climate affects OM inputs and CH_4 production and oxidation (Nguyen et al. 2010; Barros et al. 2011; Sobek et al. 2012; West et al. 2012; Falter 2017); wind, precipitation and temperature likely affect gas exchange rates at the water-atmosphere interface (Bastviken et al. 2008), and it has also been thoroughly demonstrated that warmer temperatures are associated with greater CH_4 emissions (Barros et al. 2011; Demarty and Bastien 2011; Deemer et al. 2016).

Additionally, since increased GHG emissions is positively correlated with warmer temperatures, there will be an ongoing need to study the impacts of climate change on CH_4 processes within temperate hydroelectric reservoirs (IPCC 2006). The IPCC notes that temperature is the main driver affecting reservoirs as a result of climate change, which impacts oxygenation levels, redox potentials, lake stratification mixing rates, growth of biota, and methanogenesis rates (IPCC 2006). Warming trends are likely to prolong and intensify summer thermal stratification which leads to anoxic conditions aiding increased methanogenesis, leading to increased CH_4 production (IPCC 2006; Barros et al. 2011; Demarty and Bastien 2011; Deemer et al. 2016).

Run-of-river hydroelectric projects are regularly used in densely populated areas with poor water quality to improve oxygen conditions or selectively draft cooler water from deeper within the reservoir (Kumar et al. 2012). This strategy could be useful in mitigating against the effects of increased GHG emissions from global climate change impacts. Building new structures that promote degassing, such as stilling basins or aeration weirs, may also help prevent GHG supersaturation at project tailraces (Kumar et al. 2012). The IPCC (2006) recommends proactive risk management as an adaptive measure to address extreme climate events; as precipitation events become more unpredictable, reservoir operations may become more limited in range, particularly for run-of-river projects. Climate change is imperative to consider when assessing GHG production and future mitigation measures.

Wind stress can create turbulence and waves, affect vertical circulation (and contribute to down- or up-welling), and influence transport of OM or dissolved compounds involved in methanogenesis or oxidation, all of which is also dependent on the specific characteristics of the body of water (shape, depth, size) and its surrounding terrain (Bastviken et al. 2004; Falter 2017). Wind direction is particularly important in influencing downwelling or upwelling, which can directly affect CH_4 production. Downwelling favors CH_4 oxidation, as CH_4 is converted into CO_2 due to the heightened availability of oxygen coupled with a decreased supply of OM within the water column, thus reducing CH_4 emissions (Capelle and Tortell 2016). Conversely, upwelling can lead to increased CH_4 emissions as CH_4 from the deeper oxic regions is shuttled to the reservoir surface (Capelle and Tortell 2016). Indeed, coastal upwelling and downwelling were found to be the dominant transport mechanism for CH_4 across the continental shelf of southern British Columbia (Capelle and Tortell 2016). CH_4 measurements at varying water depths, under different weather conditions and in multiple seasons are necessary to determine the role upwelling and downwelling may play for any particular reservoir. These measurements can be difficult to obtain as the data collection must encompass broad spatial and temporal scales in order to capture upwelling or downwelling events, as evidenced by the extremely limited number of studies addressing the role of upwelling and downwelling in CH_4 production.

Land use, type and amount of vegetation cover, along with intensity and frequency of precipitation events can alter OM loading and water residence time, thus affecting CH_4 production and emissions (Bastviken et al. 2004). Reservoirs often have shorter residence times than natural lakes and have more complex in-situ variability because they typically have one or more major inlets compared to naturally occurring lakes (Falter 2017). The reservoir inlets also play into the dynamics of how OM is incorporated into the reservoir, e.g. if it is quickly carried to the deeper anoxic layers, the OM will more readily undergo methanogenesis (Capelle and Tortell 2016). These examples illustrate a need for measuring site-specific residence time and variability around OM inputs.

Another crucial element in understanding and quantifying CH_4 emissions is the adoption of standardized methods. There is a remarkable lack of consistent, standardized methods or protocol for measuring CH_4 emissions. Granted, this is a relatively new field of research - the first IPCC Assessment Report considering GHG contributions to global climate change was published in 1990. Yet after nearly 30 years there is still no standard methodology for measuring CH_4 emissions from reservoirs, particularly ebullition (Lilley et al. 1996; St. Louis et al. 2000; Johnson et al. 2002; Boudreau 2012; Harrison et al. 2016). The suite of environmental variables that contribute to ebullition is not fully understood, and as discussed earlier, emphasis should be placed on comprehensive assessments of site-specific characteristics to capture all variables influencing CH_4 emissions. For instance, in deep reservoirs, CH_4 bubbles typically dissolve in the water column before reaching the surface, unlike in shallow reservoirs (Delsontro et al. 2010). This highlights the idea that estimating CH_4 diffusive emissions should be done on a case-by-case basis until additional knowledge on the dynamics of CH_4 emissions is available.

However significant and promising advancements in monitoring techniques that could be employed to generate emissions estimates have been made in recent years (e.g., Beaulieu et al. 2016). A recent study by Miller et al. (2017) provides an overview of the methods used to measure methane flux at temperate hydropower reservoirs, including the bubble trap, optical detector, echosounder, inverted tunnel, and automated bubble trap.

It is also important to understand the effects of stratification. Methanogenesis is prevalent in persistently stratified tropical reservoirs (Demarty and Bastien 2011), but because of oxidation by methantrophic bacteria in the oxygenated layer of the water column, most of the CH_4 produced in a tropical reservoir is instead emitted to the atmosphere as the less potent GHG CO_2 (Guerin and Abril 2007). While not strictly acting as a CH_4 sink, oxidation does ultimately reduce CH_4 emissions, although GHG is still being produced. Deep tropical reservoirs also allow greater methanotrophic activity in the water column compared to shallow reservoirs, resulting more efficient oxidation of CH_4 and less emission directly to the atmosphere (Lima 2005). Again, measurements should be conducted long- and short-term and across multiple depths and locations to capture temporal and spatial variability.

Turning to the role of hydroelectric projects themselves, more information is needed to fully understand and measure degassing from turbines. CH_4 degassing can occur at the project from turbulence as water passes through the turbines or can occur further downstream. When passing through the turbines, CH_4 gas is exposed to low pressure and high temperature conditions which enables rapid degassing in tropical reservoirs (Kemenes et al. 2007). However, high amounts of CH_4 can remain in the outflow after passing through the turbines; GHG has been measured up to 25 mi (40 km) downstream of a tropical dam (Guerin et al. 2006). These findings point to the need to better understand and quantify degassing that occurs at the turbines and downstream of hydroelectric dams, particularly in temperate regions for which such data is still lacking.

Another consideration that should be included in CH_4 emissions estimates is the concept that age matters: reservoirs produce more GHG in the first ten to twenty years after impoundment (IPCC 2006; Barros et al 2011). Studies of Canadian systems demonstrated that CO_2 emissions from reservoirs over ten years old were on par with emissions from natural lakes and rivers (Tremblay et al 2004). Temperate reservoirs had a significant negative relationship between age and GHG emissions, meaning with increasing age GHG diminished over time (St. Louis et al 2000). Therefore, it is important to incorporate the age of the reservoir in calculations of GHG emissions.

To more accurately estimate CH_4 contributions to the global carbon budget, future research efforts should continue to focus on tropical reservoirs due to the relationship between temperature and high OM with CH_4 emissions and because this is the region with the most potential for future hydroelectric development. It would be very informative and beneficial to the scientific community at large to assess whether reservoirs are net CH_4 sinks or sources by evaluating pre- and post-impoundment values to compare carbon burial in the reservoir versus under pre-impoundment conditions (i.e., carbon burial in the ocean). However, as hydroelectric power is already very highly developed in temperate regions, many hydroelectric dams are nearing the end of their lifespans; consequently, the effects of dam decommissioning on the global carbon budget will be important to study. The major knowledge gaps listed above need to be filled by future research to better understand CH_4 production overall and to better estimate regional and global carbon budgets.

5.3.3 Conclusions

Primary contributing controllers of CH_4 emissions from hydroelectric project reservoirs are geographically and sample site-specific, and include availability of OM, condition of reservoir sediments, reservoir trophic status (dependent upon nutrient inputs, primary productivity, and water temperature), presence of rooted aquatic macrophyte and algal populations, and factors that affect CH_4 ebullition to the reservoir surface, including hydrostatic pressure changes and benthic sediment conditions (Falter 2017). Strong correlations have been identified between reservoir CH_4 emissions and OM and nutrient accumulation in nearshore sediments, nutrient loading in reservoirs (eutrophic conditions), increased water temperatures, and presence of aquatic macrophytes (Bastviken et al. 2004; Demarty and Bastien 2011; West et al. 2012; Arntzen et al. 2013; Deemer et al. 2016; Falter 2017). The available data and comparisons presented in this report support the likelihood that CH_4 emissions are very low from pelagic waters within Columbia River basin hydroelectric project reservoirs. The sporadic distribution of moderately high CH_4 emissions for some reservoirs results from 'hot spots' of littoral sediment accumulation and robust aquatic macrophyte beds. The high ratios of pelagic:littoral area, particularly for Eastern Washington reservoirs, in all probability means overall reservoir-wide CH_4 emissions are low in comparison to reservoirs on a regional or national scale.

Even though the surface flux measurements of Columbia River hydroelectric project reservoirs presented in this report indicate that CH_4 emissions are lower compared to other studies conducted in temperate regions, it's been shown that CH_4 ebullition and pore-water flux in littoral embayments can potentially produce substantial emissions, particularly in the summer. The values reported here may be high relative to surface flux values, but are on par with ebullition and pore-water flux results from recent comparable studies of temperate reservoirs and are much lower than global estimates (DelSontro et al. 2010; Arntzen et al. 2013; Deemer et al. 2016). The implication of these results is that temperate hydroelectric project reservoirs provide a modest source of CH_4 to the atmosphere. Indeed, several studies have found that, in particular, temperate estuarine and river contributions of CH_4 to the global budget are likely minor because of their small footprint (De Angelis and Lilley 1987; Middelburg et al. 2002; Borges and Abril 2012; Pfeiffer-Herbert et al. 2015). This realization coupled with the knowledge that the primary controllers affecting CH_4 emissions are inconsistently present within Columbia River basin reservoirs supports the conclusion that GHG emissions from hydroelectric projects in the Columbia River basin play a relatively minor role in contributing to the global CH_4 and overall GHG emissions budgets.

Indeed, CH_4 emissions from reservoirs compared to total global sources are quite small. In mean estimates of data from the 2000s, global reservoirs, including tropical locations, contributed about 4–5% of CH_4 from anthropogenic sources, and of these, hydroelectric reservoirs contributed about 3–6% of CH_4 emissions (Deemer et al. 2016). However, non-tropical reservoirs have been shown to emit far less CH_4 due to local regional features such as geology, climate, type of flooded soils and vegetation, and hydrologic regime (Figure 5-6; St. Louis et al. 2000); CH_4 emissions from hydroelectric reservoirs in the western United States were reported to be the lowest of those on the continent, compared to eastern Canada and Central/South America (Soumis et al. 2004).

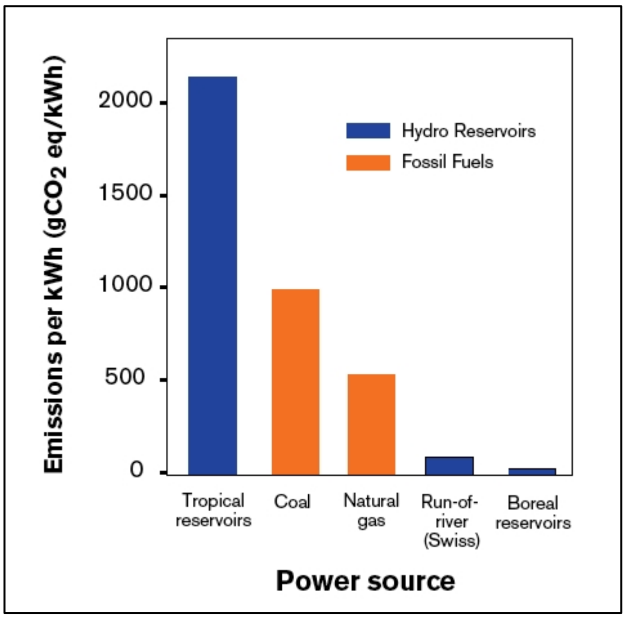


Figure 5-6 Comparison of CO_2 and CH_4 emissions per kilowatt-hour for various power sources

Note: based on one year of data; tropical reservoirs bar represents net average emissions from three Brazilian reservoirs, boreal reservoirs bar represents gross average emissions from five Canadian reservoirs, run-of-river bar represents gross emissions (without degassing) from the Wohlensee reservoir in Switzerland (International Rivers, 2008).

In the United States, ruminant digestion is the largest anthropogenic source of CH_4 (Figure 5-7; EPA 2018). Within the category of electric power production, hydroelectric dams account for a very small portion, second only to petroleum-based generation (gasoline or diesel generators, for example); the value is so small that hydroelectric GHG emissions are not accounted for separately in the EPA's 1990–2016 Draft Inventory of US Greenhouse Gas Emissions and Sinks, but are included with renewable-based generation (Figure 5-8; EPA 2018). Again, CH_4 emissions are specific to the local characteristics of the reservoir and its operation, and those in the western United States, particularly the Columbia River basin, have been shown to be a minor player in contributing to the global budgets of GHG and especially CH_4 emissions compared to worldwide or even solely U.S. sources (Lilley et al. 1996; Soumis et al. 2004; Arntzen et al. 2013; Falter 2017).

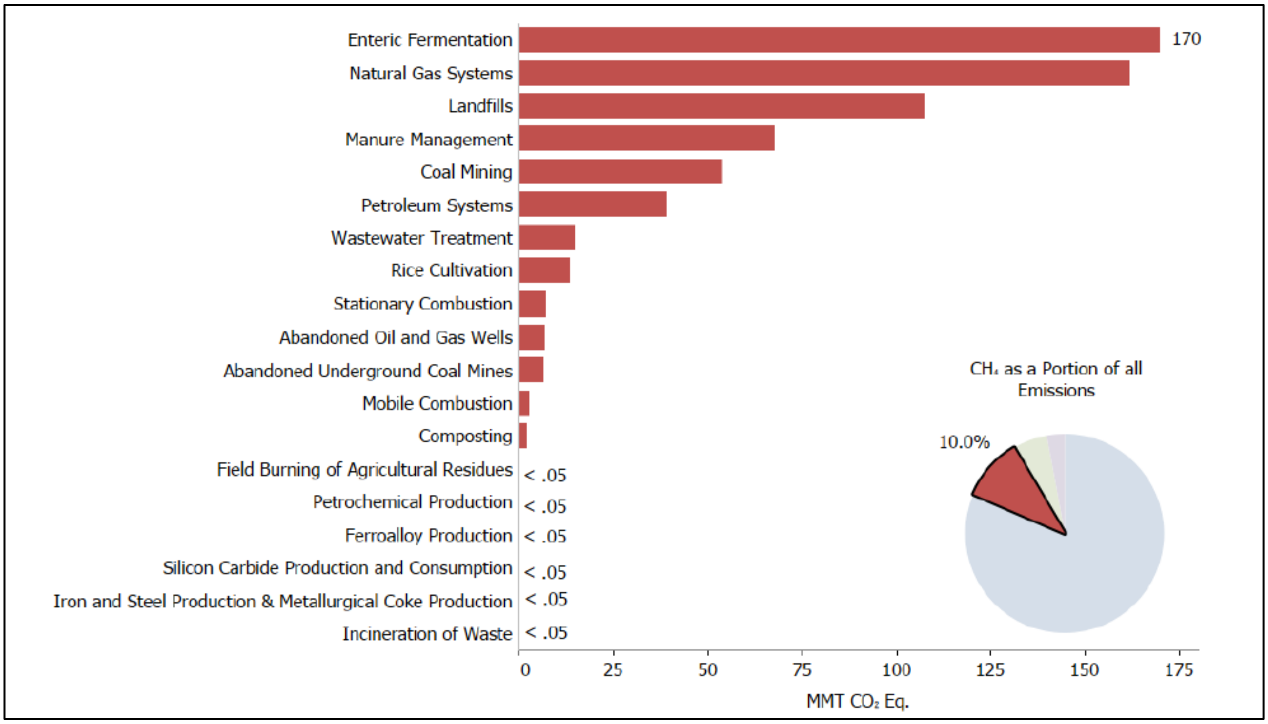


Figure 5-7. Anthropogenic sources of CH_4 emissions (million metric tons of CO2 equivalent) in 2016 (EPA 2018).

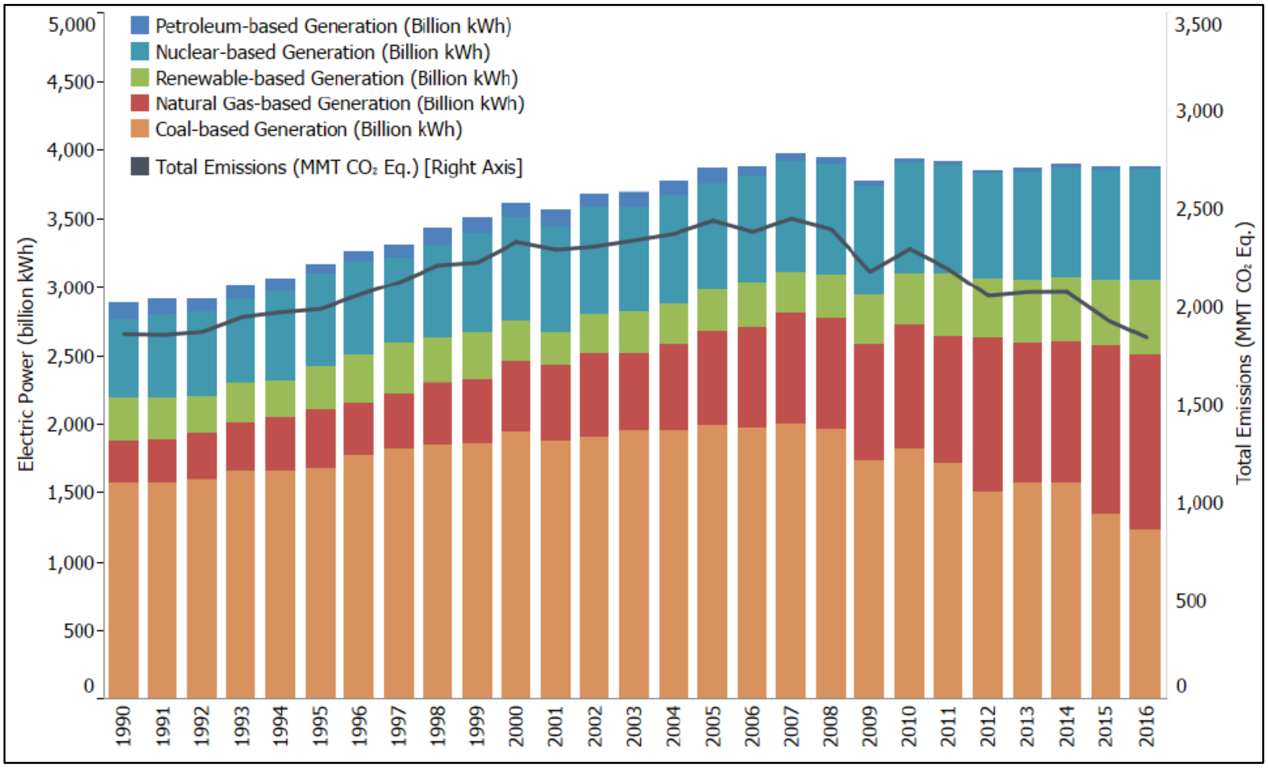


Figure 5-8. Emissions (million metric tons of CO_2 equivalent) from electric power generation; hydroelectric power is included in renewable-based generation, colored green (EPA 2018).

CHAPTER 6 - REFERENCES

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Columbia River System Operations
Final Environmental Impact Statement

Appendix H
Power and Transmission

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Meaning
ADS	Anchor dataset
aMW	Average Megawatts
Bonneville	Bonneville Power Administration
BP-20	Bonneville FY 2020-2021 rate proceeding
BP-22	Bonneville FY 2022-2023 rate proceeding
BP-28	Bonneville FY 2028-2029 rate proceeding
COI	California-Oregon Intertie
Corps	U.S. Army Corps of Engineers
CRS	Columbia River System
CRSO	Columbia River System Operations
DOE	U.S. Department of Energy
EIA	Energy Information Administration
EIS	Environmental Impact Statement
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FY	Fiscal year
GENESYS	NW Council’s GENeration Evaluation SYStem Model
GIS	Geographic Information System
GW	Gigawatt
GWh	Gigawatt-hour
HYDSIM	Hydrologic Simulator Model
ID	Idaho
IMPLAN	IMPact Analysis for PLANning Model
IOU	Investor-owned Utility
IRP	Integrated Resource Plan
LOLP	Loss-of-Load Probability
LSR	Lower Snake River
kW	Kilowatt
kWh	Kilowatt-hour
Mid-C	Mid-Columbia market hub
MMBTU	Million British Thermal Units
MOs	Multiple Objective Alternatives
MO1	Multiple Objective Alternative 1
MO2	Multiple Objective Alternative 2

Acronym/Abbreviation	Meaning
MO3	Multiple Objective Alternative 3
MO4	Multiple Objective Alternative 4
MT	Montana
MW	Megawatt
MWh	Megawatt-hour
NAA	No Action Alternative
NAICS	North American Industry Classification System
NED	National Economic Development
NEPA	National Environmental Policy Act
NREL	National Renewable Energy Laboratory
NW Council	Northwest Power and Conservation Council
NWEC	Northwest Energy Coalition
O&M	Operation and Maintenance
OR	Oregon
PA	Preferred Alternative
PDCI	Pacific DC Intertie
PF	Priority Firm
PUD	Public Utility District
RAM2020	Rates Analysis Model
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RUC	Rural-Urban Continuum
Tri-Cities	Region consisting of three neighboring cities (Kennewick, Pasco and Richland)
TRM	Tiered Rate Methodology
U.S.C.	United States Code
WA	Washington
WECC	Western Electricity Coordination Council
WTP	Willingness-to-pay

CHAPTER 1 - INTRODUCTION

1.1 FRAMEWORK FOR THE ANALYSIS

This appendix details the analysis of the effects of the CRSO alternatives on power and transmission, including the models, methods, and data sources employed, and a stepwise presentation of the results for each alternative. Figure 1-1presents the framework for the analysis.

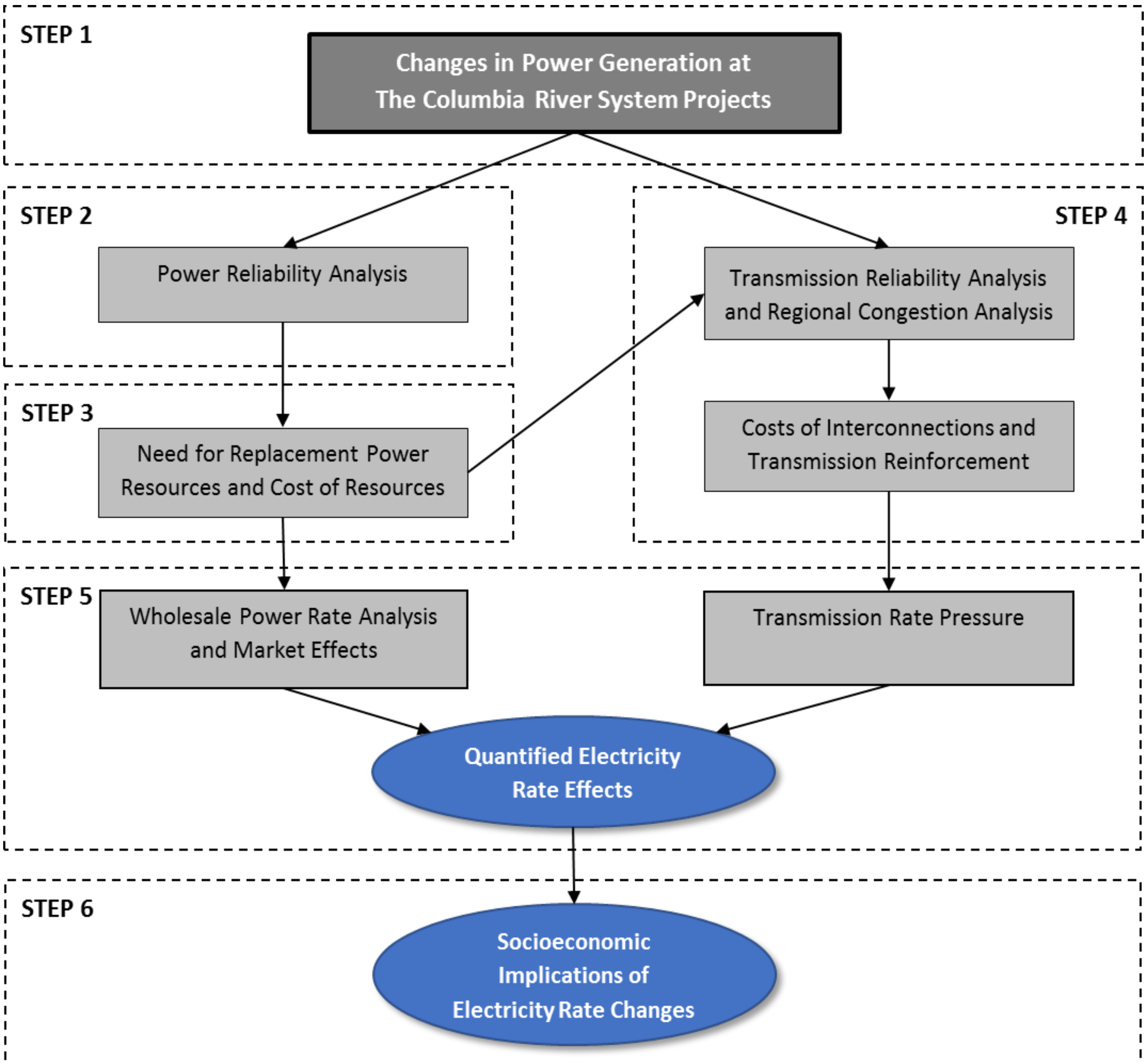

Figure 1-1 Analytical Approach for Evaluating Power and Transmission Effects of the CRSO Action Alternatives

Note: Additional power and transmission analysis occurs within each of the step boxes depicted.

The analysis first assesses the effects of the CRSO alternatives on power generation based on average historical water conditions and for critical water conditions.[1] The amount of power generated by the system under each of the alternatives determines whether additional changes to or investments in the system may be required to maintain Bonneville's ability to supply adequate and reliable power (both energy and capacity) to its firm power customers under 20-year contracts. The analysis then evaluates the extent to which the alternatives would result in the need for Bonneville or other regional entities to acquire power from other resources (e.g., new generating plants) and construct new transmission infrastructure to replace the lost capability at Federal hydropower projects. To the extent this analysis identifies a potential need to acquire resources or transmission infrastructure, and if Bonneville proposes to take such action in the future, Bonneville would do so consistent with the Northwest Power Act and would complete additional site-specific planning, analysis, and compliance with environmental laws, including the National Environmental Policy Act (NEPA).

Based on the need for additional investments under each alternative, the analysis considers the rate pressure resulting from the increased costs of providing power. The wholesale rate pressure analysis considers potential effects of alternatives on the price Bonneville charges to its power customers. The retail rate pressure analysis considers how wholesale rate pressure may affect the cost of living and doing business for electricity end-users (households, businesses, and industry) across the Pacific Northwest.

The areas of analysis for the power and transmission resources differ as a function of Bonneville's products and services. Both the power and transmission analyses focus on Bonneville's service area (Figure 1-2)**.** The Bonneville 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, and Wyoming within the Columbia River drainage basin. However, because Bonneville regularly markets its surplus power both within and outside the Pacific Northwest, the power analysis additionally considers potential effects on power markets within the larger Western Interconnection (Figure 1-3). Similarly, because the power system of the Western Interconnection reacts to changes in Pacific Northwest generation (e.g., changes in generation from the CRS projects), the social welfare effects analysis considers changes in generation and costs for the entire Western Interconnection.

1 The "critical water year" or "critical water conditions" represent the historic water year when the capability of the hydro system produces the least amount of dependable generation while considering power and non-power operating constraints.

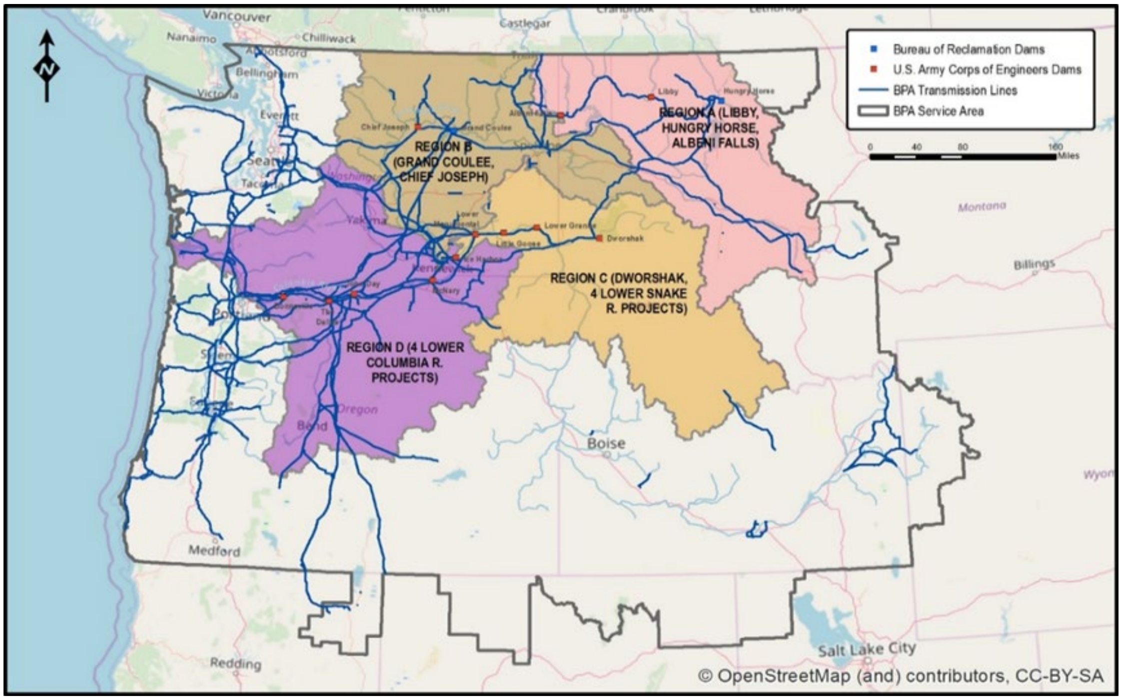

Figure 1-2. Transmission Area of Analysis – the Bonneville Service Area and Transmission Lines

Note: The dark blue lines are Bonneville transmission lines

Source: Bonneville 2018

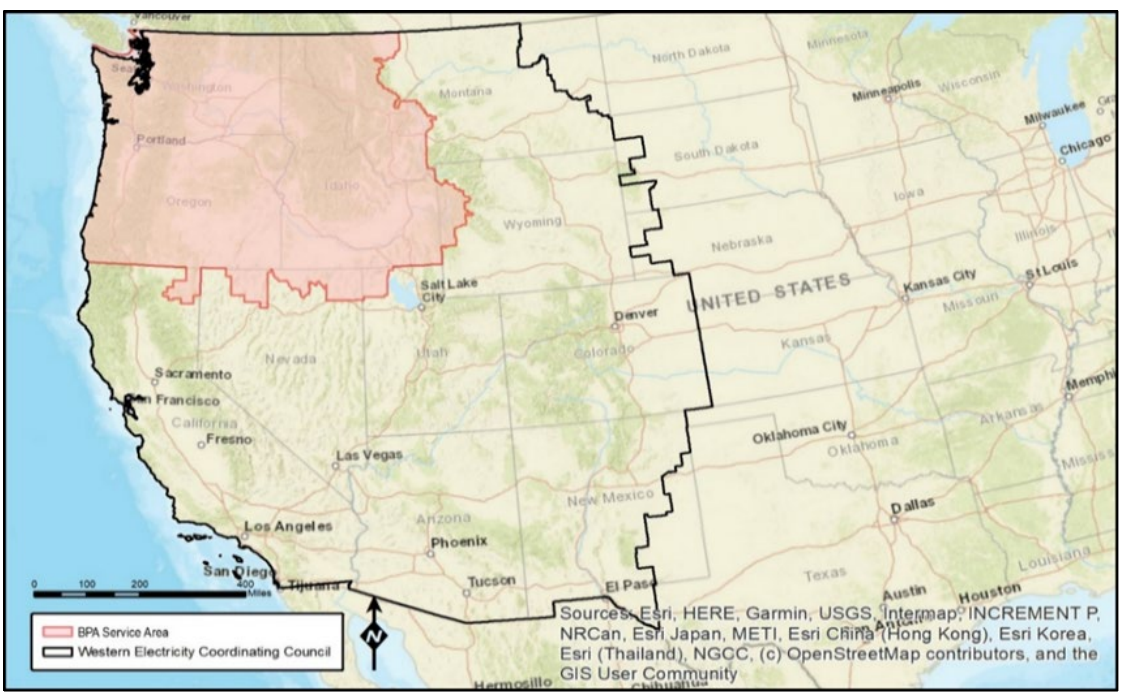

Figure 1-3. Power Area of Analysis – the U.S. Portion of the Western Interconnection and the Bonneville Service Area

Source: WECC 2018, Bonneville 2018

The power and transmission analysis considers the effects of the alternatives 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 analysis timeframe. The retail rate pressure analysis evaluates potential changes in the cost of electricity for residential, commercial, and industrial ratepayers over a 20-year timeframe (2022-2041), based on the best available information.[2] Quantifying effects beyond 20 years introduces uncertainty regarding how the electricity sector will evolve in response to policy and technological developments.

1.2 ORGANIZATION OF THE APPENDIX

A detailed discussion of Step 1 of this analysis—evaluating effects of the Multiple Objective Alternatives (MOs) on power generation at the 14 CRS projects—appears in Appendix J, *Hydropower*.[3] The remainder of this appendix is organized as follows:

- **Chapter 2 - Power Supply and Replacement Resources:** Chapter 2 focuses on Steps 2 and 3 (Figure 1-1), describing the approach to modeling changes in power generation at the CRS projects, impacts on power supply (expressed in terms of loss of load probability [LOLP]), and costs associated with maintaining an adequate and reliable supply of electricity.[4] This chapter also considers how the uncertainty regarding potential future coal plant retirements could influence the results of this analysis.
- **Chapter 3 - Transmission System Reliability and Congestion:** Chapter 3 describes Step 4 (Figure 1-1), linking changes in how and where power is generated to effects on the transmission system reliability and congestion.
- **Chapter 4 - Wholesale Power and Transmission Rates:** Chapter 4 describes Step 5 (Figure 1-1), evaluating how changes in the cost of power generation and transmission affect Bonneville's wholesale power and transmission rate pressure.
- **Chapter 5 - Social and Economic Effects of Changes in Power and Transmission:** Chapter 5 details Step 6 (Figure 1-1), describing effects of the alternatives on residential, commercial, and industrial ratepayers across the Pacific Northwest. Specifically, this chapter evaluates

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[2] The power analysis model generation for a single year (2022) using 80 historical water years under the operations, maintenance and configuration regime for the CRS projects defined by the alternatives. The transmission power-flow analysis relies on the 2023 and 2028 Western Electricity Coordinating Council (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 (FY 2028 – 2029). The socioeconomic analysis then relies on the rate forecast from the NW Council to project the rate pressure effects over the 20-year timeframe.

[3] The 14 CRS projects are Libby, Hungry Horse, Albeni Falls, Grand Coulee, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville.

[4] Loss of Load Probability under the No Action Alternative is 6.6%. The NW Council target for LOLP is 5%. *See NW* Council Document Number 2011-14, Page 4, available at: https://www.nwcouncil.org/sites/default/files/2011_14_1.pdf.

how the changes in the costs of generating and delivering power affect the cost of living and doing business in the region.

- **Chapter 6 - References**

1.3 SUMMARY OF RESULTS OF THE POWER AND TRANSMISSION ANALYSIS

Table 1-1 presents the summary of results for all alternatives. The following paragraphs describe results by topic for the MOs relative to the No Action Alternative.

1.3.1 Regional Hydropower Generation

Under MO1, the 80 year average hydropower generation from the CRS projects would decrease by 130 average megawatts (aMW) (roughly the amount of power used by 100,000 Northwest homes or a city about the size of Everett, Washington consumes) relative to the No Action Alternative.[5] Under MO3 and MO4, the generation from the CRS projects would decrease by 1,100 and 1,300 aMW (more than the amount of power used by the city of Seattle and about two cities the size of Portland), respectively. Under MO2, however, generation would increase by 450 aMW (about half the amount of power used by the city of Seattle). Under the Preferred Alternative hydropower generation would decrease by 210 aMW (roughly the amount of power used by 150,000 Northwest homes).

Under MO1, the Federal Columbia River Power System (FCRPS) would lose 300 aMW of firm power,[6] which is used to serve Bonneville's long-term, firm power sales to preference customers. Firm power would decrease by 750 aMW under MO3 and 890 aMW under MO4. Firm power would increase by 380 aMW under MO2. Firm power would decrease by 330 aMW under the Preferred Alternative. As part of ongoing ESA consultation with NMFS, a measure to use surface weir spill for adult steelhead and bull trout was modified in the Preferred Alternative. This measure would reduce annual average generation by less than 4 aMW, which would not affect the generation results or power rates (*i.e.,* it is within rounding).

1.3.2 Regional Power Supply – Loss of Load Probability (LOLP)[7]

Under the No Action Alternative, regional LOLP is currently 6.6 percent. Without replacement resources, regional LOLP would increase under MO1 (+4.6 percentage points), MO3 (+7.3 percentage points) and MO4 (+23 percentage points). LOLP would decrease under MO2 (-1.6

[5] An average megawatt is one million watts delivered continuously 24 hours a day for one year.
[6] Firm power is the amount of power that can be reliably produced by the FRCPS assuming the most adverse water year on record (critical water).
[7] LOLP is expressed as a percentage that reflects the probability that the system will not be able to meet the demand for electricity in a particular year. Higher LOLPs reflect the increased likelihood that the power system would be unable to meet demand, and therefore, will result in power shortages or blackouts. A high LOLP is an indication of a less reliable power system. A low LOLP reflects a low likelihood that the power system will experience a power shortage. The LOLP is a measure of the frequency of outages but not a measure of their duration or magnitude.

percentage points) and the Preferred Alternative (-0.2 percentage points but this is not significant within the accuracy of the LOLP metric) relative to the No Action Alternative. If Bonneville and/or its power customers did not acquire additional resources to replace the reduction in hydropower generation under MO1, M03, and MO4, then there would be an increased risk of power shortages. Replacement resources would be required not only to replace the energy lost but also to replace some peaking capability of the hydropower system. Replacing lost peaking capability would result in a need for replacement resources (e.g. 560 MW natural gas generation or 1,800 MW of new zero-carbon resources under MO1) that would exceed the average power lost (-130 aMW) and would increase transmission rate pressure and wholesale power costs. Under MO3, 1,120 MW of natural gas or 3,540 MW of zero-carbon resources would be required. Under MO4, 3,240 MW of natural gas or 5,600 MW of zero-carbon resources would be required. MO2 and the Preferred Alternative reduce LOLP and therefore do not require additional replacement resources.

1.3.3 Wholesale Power and Transmission Rate Pressure

Under the No Action Alternative, the average cost of Bonneville's firm power for regional public customers is $34.56 per megawatt hour (MWh). Reductions in the generating capability of the CRS projects would require replacement resources to meet Bonneville's current firm power load obligation. The cost to Bonneville of replacing these resources is affected by (1) the type of resource replacing the lost generation (zero-carbon or conventional least-cost); and (2) whether Bonneville acquires the replacement resources or other regional utilities acquire the resources. Bonneville's cost of power would go up under MO1, MO3, and MO4, and decrease slightly under MO2.

- Under MO1, Bonneville wholesale power rates experience upward rate pressure ranging from 4.5% (potentially leading to wholesale rates of $36.14/MWh) to 8.6% (potentially leading to wholesale rates of $37.53/MWh) under the conventional least-cost portfolio financed by entities other than Bonneville and the zero-carbon portfolio financed by Bonneville, respectively.
- Under MO2, Bonneville wholesale power rates experience downward rate pressure of 0.8% (potentially leading to wholesale rates of $34.28/MWh).
- Under MO3, Bonneville wholesale power rates experience upward rate pressure ranging from 8.2% (potentially leading to wholesale rates of $37.41/MWh) to 20.6% (potentially leading to wholesale rates of $41.67/MWh) under the conventional least-cost portfolio financed by entities other than Bonneville and the zero-carbon portfolio financed by Bonneville, respectively.
- Under MO4, Bonneville wholesale power rates experience upward rate pressure ranging from 15.3% (potentially leading to wholesale rates of $39.87/MWh) to 25.3% (potentially leading to wholesale rates of $43.32/MWh) under the conventional least-cost portfolio financed by entities other than Bonneville and the zero-carbon portfolio financed by Bonneville, respectively.

- Under the Preferred Alternative, Bonneville wholesale power rates experience upward rate pressure of 2.7% (potentially leading to wholesale rates of $35.50/MWh).

All of the alternatives would result in some degree of upward transmission rate pressure for the 2020 to 2028 analysis period relative to the No Action Alternative.

- Under MO1: The upward transmission rate pressure would be 0.7 percent annualized (6.1 percent over an 8-year period [BP-22 to BP-28]) relative to the No Action Alternative under the conventional least-cost replacement portfolio, and 0.6 percent annualized increase (5.1 percent over an 8-year period) under the zero-carbon replacement portfolio.
- Under MO2: The upward transmission rate pressure would be 0.1 percent annualized (0.9 percent over an 8-year period [BP-22 to BP-28]) relative to the No Action Alternative.
- Under MO3: The upward transmission rate pressure would be 1.3 percent annualized (11.3 percent over an 8-year period [BP-22 to BP-28]) for the conventional least-cost portfolio and 1.6 percent annually (13.5 percent over an 8-year period) under the zero-carbon portfolio, relative to the No Action Alternative.
- Under MO4: The upward transmission rate pressure would be 1.6 percent annualized (13.5 percent over an 8-year period [BP-22 to BP-28]) for the conventional least-cost portfolio, and 1.9 percent (16.5 percent over an 8-year period) under the zero-carbon portfolio, relative to the No Action Alternative.
- Under the Preferred Alternative: The upward transmission rate pressure would be 0.09 percent annualized (0.7 percent over an 8-year period [BP-22 to BP-28]) relative to the No Action Alternative.

1.3.4 Socioeconomic Effects

Socioeconomic effects measure the impact of the MOs on regional retail ratepayers. Overall, the MOs have differing effects on regional ratepayers. Regional utilities that purchase most or all of their power supply from Bonneville would experience larger effects than entities that do not currently purchase firm power from Bonneville, such as the region's Investor-owned Utilities (IOUs) and certain public utility districts (PUDs). A summary of the potential regional retail rate pressure impacts of the MOs is provided below:

- Under MO1, depending on the types of power resources and transmission infrastructure acquired or built to replace the services of the reduced hydropower generation, households in the region could experience an increased cost of electricity of 0.65 percent to 0.79 percent. However, this increase is not evenly distributed; customers of utilities that receive power from Bonneville would generally experience larger increases, up to 7.6 percent for some households. The increased cost of electricity may change household and business spending patterns on other regional goods and services, resulting in a reduction in annual regional economic output (i.e., reductions in sales from businesses across the region) of $130 million to $150 million and cost 820 to 980 jobs.

- Under MO2, households in the region could experience a decreased cost of electricity of 0.48 percent. Customers of utilities that receive power from Bonneville would generally experience larger decreases, up to 1.5 percent. This potential decrease in the cost of power could result in an increase in regional economic output of $97 million and 660 jobs.
- Under MO3, depending on the types of power resources and transmission infrastructure acquired or built to replace the services of the reduced hydropower capacity and generation, households in the region could experience an increased cost of electricity of 1.7 to 2.8 percent. However, this increase is not evenly distributed; customers of utilities that receive power from Bonneville would generally experience larger rate increases, up to 14 percent for some households, compared to customers of utilities who do not receive power from Bonneville. The increased cost of electricity may change household and business spending patterns on other regional goods and services, resulting in a reduction in annual regional economic output (i.e., sales) of $320 million to $540 million and cost 2,100 to 3,500 jobs.
- Under MO4, depending on the types of power resources and transmission infrastructure acquired or built to replace the services of the reduced hydropower generation under MO4, households across the region could experience an increased cost of electricity of 2.9 to 3.3 percent on average. However, this increase is not evenly distributed; customers of utilities that receive power from Bonneville would generally experience larger increases, up to 18 percent for some households, compared to customers of utilities who do not receive power from Bonneville. The increased cost of electricity may result in a reduction in annual regional economic output (i.e., sales) of $580 million to $650 million and cost 3,800 to 4,300 jobs.
- Under the Preferred Alternative, households in the region could experience an increased cost of electricity of 0.44 percent. Customers of utilities that receive power from Bonneville would generally experience larger increases, up to 1.2 percent, compared to customers of utilities who do not receive power from Bonneville. This potential increase in the cost of power may result in a reduction in regional economic output (i.e., sales) of $89 million and cost 590 jobs.

1.3.5 Additional Power Rate Sensitivity Analysis

The analysis of replacement resources and associated costs for each alternative relies on assumptions, for example about the future resources that would be available to serve the region under the No Action Alternative baseline. Accordingly, the quantitative results of the analysis are sensitive to these assumptions. The base case power rate analysis described in this appendix 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. Chapter 3.7 of the main body of the EIS *Power Generation and Transmission*, Section 3.7.3.1 *Methodology,* describes these effects and provides estimates where practicable.

The specific rate sensitivities addressed include the following:

- Fish and Wildlife Costs
- Integration Services
- 8th Power Plan Updates
- Forward Cost Curves
- Other Resource Cost Uncertainties (Contingencies)
- Ramping and Flexibility
- Resource Financing Assumptions
- Demand Response
- Oversupply

The results are included in the summary table, Table 1-1, and described in detail in the EIS in Section 3.7.3.1.

1.3.6 Other Regional Cost Pressure Analysis including Availability of Coal Resources

In addition to the base case analysis and the nine 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) "Regional Cost of Carbon Compliance" and (2) accelerated "coal retirement" (capital costs and other costs).

Energy economics and state and local de-carbonization policies are changing the generation scenario in the region and across the Western Interconnection into the 2020s and beyond. The analysis used for the results summarized above reflects assumptions about the future of the power system as of 2017. These assumptions include the retirement of only a few coal-fired power plants serving Northwest loads. Since this analysis was performed, regional utilities have announced additional coal-plant retirements and have accelerated the plans for retiring other coal plants. The loss of generation from these coal resources would affect the reliability of the regional power system. As a result, this analysis considered how a range of potential coal-plant retirements could affect the LOLP and the amount of replacement resources needed to restore the LOLPs to the No Action Alternative levels. In general terms, the results of the coal retirement sensitivity analyses suggest that the impacts to MO2 would likely be a reduction in rate pressure, MO3 would see a further upward rate pressure, and MO1, MO4, and the Preferred Alternative would show a similar or slightly smaller upward rate pressure compared to the base case without the additional coal-plant retirements. When considering all cost pressure sensitivities (i.e., not only coal retirements but other regional cost pressures, such as replacement resource financing assumptions or renewable integration services mentioned above), the analysis generally finds that potential upward rate pressure effects are understated.

Table 1-1. Summary of Power and Transmission Effects for All Alternatives

Effect[1/]	No Action Alternative[2/]	MO1 Relative to No Action[1/]	MO2 Relative to No Action	MO3 Relative to No Action[1/]	MO4 Relative to No Action[1/]	Preferred Alterative Relative to No Action
CRS Hydropower Generation (aMW) 80 year average	8,300	-130	+450	-1,100	-1,300	-210
Firm power of FCRPS (aMW)	6,600	-300	+380	-750	-890	-330
LOLP	6.6%	+4.6 LOLP %	-1.6 LOLP %	+7.3 LOLP %	+23 LOLP %	-0.2 LOLP %
Replacement Resources to return LOLP to No Action Alternative level	——[2/]	560 MW of Gas or 1,200 MW Solar plus 600 MW demand response	Avoided build of 440 MW of Gas or 250 MW solar, 660 MW MT wind, and 600 MW demand response[4/]	1,120 MW natural gas or 1,960 MW solar, 980 MW of battery storage and 600 MW demand response	3,240 MW natural gas or 5,000 MW solar and 600 MW demand response	------[7/]
Replacement Resource Cost to return LOLP to No Action Alternative level (annual cost)	——[2/]	+$34 million to +$160 million	-$19 million to -$140 million[4/]	+$234 million to +$405 million	+$198 million to +$575 million	$0
Transmission Infrastructure to return LOLP and/or transmission system reliability to No Action Alternative level (annualized reinforcement and/or interconnection cost)	——[2/]	$3.8 million to $3.9 million	——[4/]	$9.1 million to $13 million	$12 million to $19 million	——[7/]
Average Bonneville Wholesale Priority Firm (PF) Power Rate pressure (base analysis)		+4.5% to +8.6%	-0.8%[/3]	+8.2% to +20.6%	+15.3% to +25.3%	+2.7%
Potential Range of Bonneville wholesale power rate ($/MWh)	$34.56	$36.14/MWh to $37.53/MWh	$34.28/MWh	$37.41/MWh to $41.67/MWh	$39.87/MWh to $43.32/MW	$35.50
Potential Range of Bonneville wholesale power rate pressure including rate sensitivities[10/]		+5.9%[10/] to +14.3%	-3.2% to +1.3%	+4.0% to +50.2%	+18.6%[10/] to +40.2%	+0.8% to +2.7%

Effect[1/]	No Action Alternative[2/]	MO1 Relative to No Action[1/]	MO2 Relative to No Action	MO3 Relative to No Action[1/]	MO4 Relative to No Action[1/]	Preferred Alterative Relative to No Action
Annualized Transmission Rate Pressure relative to No Action Alternative (%)	——[2/]	+0.6% to +0.7%[5/]	+0.1%	+1.3% to +1.6%	+1.6% to +1.9%	+0.1%
Average Annual Social Welfare Effects ($): Market Price Method Estimate	——[2/]	-$25 million	+$75 million[4/]	-$150 million	-$180 million	-$12 million
Average Annual Social Welfare Effects ($): Production Cost Method Estimate	——[6/]	-$64 million to -$170 million	+$82 (up to +$170 million) million[4/]	-$270 million to -$540 million	-$380 million to -$650 million	-$17 million
Residential Rate, regional weighted average and range across all scenarios (cents/kWh for the No Action Alternative and % change from the No Action Alternative)[8,9/]	10.21	+0.65% to +0.79% (-0.49% to +7.6%)	-0.48% (-1.5% to +0.21%)	+1.7% to +2.8% (+0.21% to 14%)	+2.9% to +3.3% (+0.041% to 18%)	+0.44% (less than +0.1% to +1.2%)
Commercial Rate, regional weighted average and range across all scenarios (cents/kWh for the No Action Alternative and % change from the No Action Alternative)[/9]	8.89	+0.69% to +0.83% (-0.66% to +8.1%)	-0.56% (-2.1% to +0.23%)	+1.8% to +3.0% (+0.21% to 15%)	+3.2% to +3.5% (+0.042% to +18%)	+0.49% (less than +0.1% to +1.4%
Industrial Rate, regional weighted average and range across all scenarios (cents/kWh for the No Action Alternative[/9] and % change from the No Action Alternative)	7.25	+0.90% +1.1% (-1.1% to +12%)	-0.67% (-2.5% to +0.33%)	+2.3% to +3.9% (+0.21% to 28%)	+4.2% to +4.7% (+0.051% to +36%)	+0.62% (less than +0.1% to +2.0%)
Regional Economic Productivity Effects: Change in Output	——[2/]	-130 million to -$150 million	+$97 million	-320 million to -$540 million	-580 million to -$650 million	-$89 million
Regional Economic Productivity Effects: Change in Employment	——[2/]	-820 jobs to -980 jobs	+660 jobs	-2,100 jobs to -3,500 jobs	-3,800 jobs to -4,300 jobs	-590 jobs

Effect[1/]	No Action Alternative[2/]	MO1 Relative to No Action[1/]	MO2 Relative to No Action	MO3 Relative to No Action[1/]	MO4 Relative to No Action[1/]	Preferred Alterative Relative to No Action
Share of households experiencing >5% upward rate pressure to NAA, highest across portfolios	——[2/]	1.2%	0%	14%	+28%	0%
Share of businesses with >5% upward rate pressure relative to NAA, highest across portfolios	——[2/]	2.1%	0%	25%	27%	0%
Regional Cost of Carbon Compliance	——[2/]	-$71 to +$46 million/year	-$30 to -$155 million/year[/4]	+$34 to +$497 million/year	+$8 to +$448 million/year	+$15 to +$77 million/year

Notes: The estimated LOLP effect, and resulting social welfare and rate impacts, 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 2.3 discusses how these results could change if the expected coal-plant closure assumptions change.

1/ The ranges in some entries on this table represent different scenarios, such as whether Bonneville acquires replacement resources or other entities acquire the resource and whether the conventional least-cost or zero-carbon resources are built.

2/ 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 through 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).

3/ This value would be -4% without the new fish collection structure at McNary Dam. That is, without the structure, wholesale rates under MO2 would be 4% lower than under the No Action Alternative.

4/ 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.

5/ Under MO1, transmission rate pressure is lower under the zero-carbon portfolio (0.6 percent) than under the conventional least-cost portfolio (0.7 percent). For the other alternatives the low end of the transmission rate pressure range is the conventional least-cost portfolio.

6/ 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.

7/ The LOLP of the Preferred Alternative is essentially the same as the No Action Alternative, so no resources are needed to return power system reliability to the same level as the No Action Alternative. Conversely, the Preferred Alternative does not materially contribute to avoiding building new resources.

8/ The retail rate effects presented are a regional weighted average. 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.

9/ These values reflect the base case; the rate sensitivities could lower or raise these ranges.

10/ These ranges apply to the Bonneville Finances Scenario for which the rate sensitivity was calculated.

CHAPTER 2 - POWER SUPPLY AND REPLACEMENT RESOURCES

The operation, configuration, and maintenance changes described in the CRSO MOs would affect the magnitude of power generated from the 14 CRS projects, as detailed in the Appendix J, *Hydropower*. The CRS projects are a subset of the FCRPS (31 Federal dams), and the associated transmission infrastructure. The FCRPS and other resources acquired by Bonneville to meet its firm power supply obligations constitute what is known as the Federal Base System. Fluctuations in power generation at the CRS projects would therefore trigger adjustments in not only the Federal Base System but also the larger regional system of aggregated resources (e.g., incorporating additional generating capacity) to ensure the system is capable of supplying the demand for power, which fluctuates over the course of minutes, hours, days, months, and years.

This chapter first describes the methods employed to identify how changes in generation at the CRS projects under the MOs would affect the adequacy and reliability of Bonneville's power supply absent any adjustments (i.e., the ability of the system to meet the demand for power). It then describes the approach used to identify and quantify the costs of "replacement resources," which are investments that would be needed to add capacity to maintain power system reliability at a level consistent with the No Action Alternative.

This stage of the analysis is scenario based. It evaluates the sensitivity of the results to assumptions regarding how the system would respond to changes stemming from the CRSO MOs (changes in generation at the CRS projects) in conjunction with other potential changes in regional power generation (e.g., coal plant retirements).

2.1 REGIONAL POWER SYSTEM RELIABILITY ANALYSIS

This analysis relies on the power system reliability metric referred to as Loss of Load Probability (LOLP). LOLP is expressed as a percentage that reflects the probability that the CRS and the larger regional power supply is adequate to meet the region's expected load demand for electricity in a year. Higher LOLPs reflect the increased likelihood that the power system would be unable to meet demand and lower LOLPs reflect a decreased likelihood that the power system would be unable to meet demand. The LOLP is a measure of the frequency of outages but not a measure of their duration or magnitude. While LOLP reflects the adequacy of the aggregated regional power supply, individual utilities within the Pacific Northwest, such as Bonneville, face a wide range of future resource needs that are unique to them which trigger actions and/or decisions to develop, add, or acquire resources to meet their obligations.

Achieving a higher level of power system reliability (a lower LOLP) requires the development of resources to meet either load growth or as replacement for losses in existing resources. Resources are developed by either individual utilities to meet their load serving obligations or by commercial/independent power producers that assume the risk of building resources to meet forecasted supply needs.

In 2011, the NW Council set a regional standard for LOLP to be no higher than 5 percent (NW Council 2011). That is, in roughly one of every 20 years, the region would experience one or more energy shortages (potentially blackouts). The NW Council uses this metric as a warning to the region when the LOLP is above 5 percent. Because this is not an enforceable standard, the EIS refers to this as a "target."

The analysis applies the NW Council's GENeration Evaluation SYStem (GENESYS) model to determine LOLP for the No Action Alternative and each MO. The GENESYS model relies on datasets containing plant-specific parameters and constraints for hydropower resources, thermal generation plants, and wind and solar power plants. Additional inputs to the model include power demand (i.e., "loads") produced by the NW Council and assumptions regarding the availability of independent power producers and imports from outside the region.[8]

The GENESYS model relies on Monte Carlo simulations of the system to estimate LOLP based on weather-related load uncertainty, in addition to uncertainties in streamflows, wind, solar, and forced outages for thermal generation.[9] The model performs a detailed dispatch of the regulated hydropower projects in the watershed of the Columbia River, Pacific Northwest regional thermal plants, wind, solar, along with other renewable energy resources, and power imports to meet the load (demand) of the Pacific Northwest. In situations where the aggregate resources fail to meet the load results in power shortages. The full results of hydropower generation effects are included in Chapter 3 of Appendix J, *Hydropower*.

Table 2-1 presents the LOLP results for each MO and the Preferred Alternative. Based on the modeled changes in power generation, existing load forecasts, and coal plant retirements anticipated as of 2017, the No Action Alternative would result in an LOLP of 6.6 percent in 2022. This would exceed the current NW Council target of 5 percent.[10] However, because the NW Council's target is useful regional guidance, and 6.6 percent is within the range of LOLP in recent years, this analysis considers the 6.6 percent LOLP a reasonable benchmark level during the timeframe of this analysis.

Changes in power generation anticipated from structural and operational changes specified by the MOs and the Preferred Alternative would affect the LOLP of the regional power system. As identified in Table 2-1, MO1, MO3, and MO4 are anticipated to increase LOLP. That is, these alternatives would increase the risk that regional power supplies will not be able to meet regional demands for energy, resulting in blackouts or periods of power shortage because of the loss of power supplied by the CRS. These alternatives would reduce power supply adequacy and system reliability, for example, by increasing spill levels or directly removing hydropower

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[8] Details for load descriptions are provided in NW Council's Pacific Northwest Power Supply Adequacy Assessment for 2022, Document 2017-5 (July 11, 2017), available at https://www.nwcouncil.org/sites/default/files/2017-5.pdf.
[9] In general, Monte Carlo simulation is a statistical technique that uses random events, or probability analysis, to simulate an outcome. Bonneville uses it to forecast potential regional load growth.
[10] 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. Nonetheless, it is a useful metric of overall system reliability and stability (NW Council 2011).

from the system due to dam breach. MO2 would increase anticipated hydropower from the CRS projects and therefore would reduce LOLP relative to the No Action Alternative. That is, the region would experience a reduced risk of blackouts under MO2. The LOLP of the Preferred Alternative (6.4 percent) is considered comparable to that of the No Action Alternative (6.6 percent) to within the resolution of GENESYS LOLP modeling.

Table 2-1. LOLP Results for CRSO Alternative

Alternative	LOLP (%)	Change from No Action	Blackout(s) / Power Shortage(s) Every x Years
No Action	6.6	-	1 year in every 15 years
MO1	11	+4.6	1 year in every 9 years
MO2	5.0	-1.6	1 year in every 20 years
MO3	14	+7.3	1 year in every 7 years
MO4	30	+23	1 year in every 3 years
PA	6.4	-0.2[1/]	1 year in every 15 years

Note: Estimates are rounded to two significant digits and changes from NAA may not match the LOLP % column exactly due to rounding.
1/ A 0.2 percentage point decrease is not significant within the precision of the metric.

2.2 REPLACEMENT RESOURCES TO MAINTAIN REGIONAL POWER SYSTEM RELIABILITY

For each of the alternatives where the LOLP would be higher than the No Action Alternative, the analysis identifies replacement resources that would add sufficient capacity to restore power system reliability (LOLP) to the No Action Alternative level of 6.6 percent. The following data sources informed the assessment of potential replacement resources and associated costs:

- NW Council Resource Adequacy Advisory Committee (2017)
- NW Council 6th and 7th Power Plans (2016b)
- NW Council 7th Power Plan Mid-Term Assessment (2019a)
- Regional Integrated Resource Plans (IRP)

Based on these sources, the analysis assumes that only resources that would be commercially available at large scale would be viable replacement resources as identified in the NW Council's 7th Power Plan (2016b). Specifically, the resources evaluated to replace capacity in the larger regional power system include natural gas fired-resources (simple and combined cycle), solar, wind (in both Montana and the Columbia Gorge), demand response, and energy storage.[11] In addition, the replacement resource analysis includes the NW Council target of 600 MW of demand response for all alternatives that would reduce power system reliability, although

[11] Neither demand response nor batteries are resources as defined in the Northwest Power Act; however, Bonneville considers them actions/tools that could be used (i.e., demand response) or property that could be procured (i.e., batteries).

more capacity from demand-response may be feasible. All cost-effective conservation from the NW Council's 7th Power Plan (2016b) is included in the load forecast.

The NW Council performs Power Plans pursuant to requirements set forth in the Northwest Power Act. The NW Council develops Power Plans roughly every five years. The 7th Power Plan was developed in 2016, with a mid-term update published in 2019. The 8th Power Plan, which the NW Council is calling the "The 2021 Northwest Power Plan," is expected to be published in June 2021. During public meetings in the spring of 2020, the NW Council approved draft resource cost data that will be used in the 2021 Power Plan.

2.2.1 Replacement Resource Portfolio Assumptions

The specific resources that would be developed to maintain a sufficient and reliable supply of power are uncertain. Costs, technical feasibility, and regional greenhouse gas emissions policies and targets, among other factors, all influence resource availability in the future.

To determine the optimal mix of resources under each portfolio, this analysis assesses the cost-effectiveness of specific power resources by dividing the total costs by the LOLP benefit. The most cost-effective resources were then added into the GENESYS model until the resulting LOLP reached the No Action Alternative LOLP (6.6 percent). Given uncertainties regarding what projects would be developed to restore power system reliability under the MOs, the analysis considers two alternative potential resource-replacement portfolios:

- **"Zero-carbon" portfolio:** Under this portfolio, only carbon-free resources (e.g., solar, wind, non-power generating tools such as demand response, or storage technologies for those resources such as batteries) are used. While they are the lowest-cost option among carbon-free resources, the portfolios that reduce the LOLP to the No Action Alternative level may have higher costs than the natural gas resources selected in the "conventional least-cost" portfolios. The EIS assesses the MOs with the zero-carbon replacement resources on the assumption that *new* resources would be carbon-free. However, 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.
- **"Conventional least-cost" portfolio:** Under this portfolio, the potential cost of the replacement resources would drive replacement resource selection, using gas-fired power generation as the lowest cost resource historically.

2.2.2 Selection of Replacement Resource Portfolios for the Base Case Analysis

The following sections describe the methodology and approach taken in the power analysis to determine the most cost-effective replacement resources for each alternative. The broader context of replacement resource selection is also provided. Section 2.2.2.4 provides detailed summary tables of the modeling results for each individual alternative. All modeling results, unless otherwise noted, are developed from the NW Council GENESYS model.

2.2.2.1 Scope of Selection Process

The replacement resource selection approach used in this EIS is not intended to be equivalent to a full-fledged resource selection process nor solve for the preferred resource portfolio for the region. Instead, it is intended to provide the outline of replacement resource options that would be available, and the incremental costs incurred, to replace lost capability and reliability resulting from the various MOs. Optimization and scenario analysis, then, would occur as a separate step, independent of the EIS, and constrained and directed by the criteria and objectives of a particular utility through an Integrated Resource Planning (IRP) or similar process. For this reason, a vendor-supplied optimization program and detailed scenario analysis were not deemed to be necessary for the EIS. The approach used in the EIS establishes the broad contours of the resource portfolios that would likely be in play to replace lost capability caused by the various MOs; the EIS identifies the costs of these bookend portfolios in the power resource replacement analysis. Between these two portfolios, there are many different potential variations. Selecting the right combination of resources – greenhouse gas emitting fossil fuel generation and renewables, dispatchable and non-dispatchable, emerging technology or established technology, etc. – into a “preferred” resource portfolio is not within the scope of the EIS.

If acquisitions are needed in the future, a more specific resource acquisition process would be followed, outside of a federal NEPA process, in which the acquiring utility (or utilities’) resource portfolio decisions are considered. Regional utilities and policy makers have a long history of collaboration and cooperation in resource development, siting, and participation. Bonneville, in particular, would engage in appropriate regional processes – including the NW Council’s planning process to guide resource selection, among others – to acquire the resources it needs to ensure an adequate, efficient, economical and reliable supply of power to meet its obligations. The detailed elements of an IRP or comparable analysis, with computer optimization, scenario analysis, and meeting multiple objectives throughout a 20-year time horizon, would likely occur when deciding the specific resource acquisition plan.

2.2.2.2 Resource Selection and Energy Efficiency

To select the most cost-effective replacement portfolios, the EIS power analysis assesses all resources considered “primary” by the NW Council’s 7th Power Plan.[12] These resources include

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[12] Primary resources are those that are deemed proven, commercially available, and deployable on a large enough scale in the Pacific Northwest. At the time the 7th Power Plan was released, long-term energy storage (i.e. batteries) were not considered a primary resource (NW Council, 7th Power Plan p. 13-5) but now they have become commercially available and will be considered a primary resource in the 8th Power Plan. They are included in this

different types of natural gas technologies, demand response (DR), solar photovoltaic, wind, and energy storage (batteries). Wind was broken into two distinct geographic types: Columbia River Gorge (Gorge) and Montana. These two locations have different generation profiles provided by the NW Council. Other technologies are not considered in the base case analysis, but some are considered in a rate sensitivity analysis discussed in EIS Section 3.7.3.1.

All cost-effective conservation identified in the NW Council's 7th Power Plan was embedded in the load forecast and therefore was not considered as a replacement resource. Under Washington and Oregon law, all cost effective conservation must be acquired regardless of the status of the FCRPS. Therefore, conservation is not considered a resource replacement option in this EIS because it would be duplicative of cost-effective conservation already expected to be acquired in the region. This is not only true of the conservation action plan of the 7th Power Plan which is included in this EIS, but also of the conservation that will be developed in the 8th Power Plan, as it is the least-cost resource to the region. Additional conservation from individual choices resulting from higher utility rates and electricity substitution to natural gas, propane, and solar would lower the demand. These effects are described in Chapter 5 -of this Appendix (Socioeconomic Effects). The EIS considered whether additional energy efficiency should be assumed in the EIS, beyond what is achieved in the NW Council's Power Plan, if the price of power increases. However, this assumption was not adopted due to the uncertainty around whether current conservation efforts will achieve targeted decreases in energy demand. For instance, the NW Council's recent "State of the Columbia River System, Fiscal Year 2019 Annual Report,"[13] notes:

> While the region currently is on track to meet Seventh Plan goals, there are some areas to watch including forecasts of declining savings from efficiency programs. And whether the region will identify new savings opportunities to replace those of residential lighting. Utilities' achievements in energy efficiency have been on an annual decline since 2016. Forecasts from utilities show that this trend is expected to continue, despite relatively stable funding levels. Given this trend, there is some uncertainty as to whether there will be enough savings from other mechanisms to reach the 1,400 average megawatt goal by the end of Fiscal Year 2021.

The EIS assumes that the trends identified by the NW Council would continue, making it unlikely that conservation goals beyond those identified in the NW Council's Plan would be achieved. The EIS, thus, assumes all cost effective conservation identified by NW Council in the

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study as a potential resource candidate. Small nuclear reactors are not considered a primary resource due to the lack of commercial availability. Pumped storage is considered a secondary resource in the 8th Power Plan, because it is commercial technology but is limited to a few sites in the region. Note that for the full lower Snake River replacement sensitivity analysis under MO3 the power analysis did assess small modular reactors and pumped storage.

[13] NW Council 2020, p. 11 (https://www.nwcouncil.org/sites/default/files/2020-3.pdf)

Plan would be achieved, but does not assume that substantial amounts of additional energy efficiency would be available or achievable as power prices increase, such as in MO3 or MO4.

2.2.2.3 EIS Resource Scenario Methodology

The power replacement analysis identifies the least-cost, most effective resource group for returning regional reliability to the NAA levels. To do this, the power replacement analysis uses the seven primary resource groups from the NW Council's Plan and assembles them into individual 500 MW resource classes (*i.e.,* 500 MW natural gas, 500 MW Demand Response, etc.). These resource groupings represent a range of resource classes that would be available to regional utilities, planners, and policymakers when considering replacement portfolios to maintain regional reliability.

The analysis separately adds each of these groups to a GENESYS study that includes the respective MO CRS operations (except for MO2 and the Preferred Alternative) to evaluate the resource class's effectiveness at reducing LOLP.[14] Each GENESYS study includes the alternative-specific hydro regulation for each MO, including the generation capability of the FCRPS and non-Federal hydroelectric projects downstream of CRS dams. The analysis then integrates load forecasts, all other regional resources, and import capability identified by the NW Council in their 2022 Resource Adequacy Assessment into the reliability analysis to establish a base case for each action alternative.

The analysis then runs a model which simulates the operations of the MO with one of the seven replacement resources groups, using average conditions under 6,160 simulations from GENESYS, and compares this output to the base case MO without replacement resources. This establishes a percent reduction in LOLP per MW associated with each primary resource class. The resource classes with the greatest reduction in LOLP relative to costs are selected as the least-cost, most effective resource groups for use with the respective MO. The results of this comparison are presented below under each MO in a table. For reference, see Table 2-3 below for MO1's cost per MW of associated reliability benefit for each resource class. A more detailed description of each step of this process is provided below.

2.2.2.3.1 COST IMPACT OF REPLACEMENT RESOURCES

The EIS uses resource costs from the NW Council's 7th Power Plan and Mid-Term Update – with the exception of batteries, which used newer sources, namely 2018 and 2019 IRPs from Northwestern Energy (2018) and Puget Sound Energy (2018) for this resource selection process. Updated costs for the NW Council's draft 8th Power Plan became available after the EIS base-

[14] Given the increase in reliability under MO2 compared to the No Action Alternative it was a special study case explained further below and in Section 2.2.2.4 Replacement Resources for MO2 of this appendix and in Section 3.7.3.4 of the EIS.

case analysis was complete, but are reflected in the rate sensitivity analysis in the EIS, and the battery cost was included in MO3's base case.

Costs were aggregated for each primary resource class to establish a dollar-per-capacity resource cost metric. The costs considered in the analysis include the fixed costs of new resources and the variable costs associated with the new resources, as well as changes in operation of existing resources included in the initial GENSYS runs described above, using the average deviations in variable costs between the base case and the runs containing the test resource.

The analysis evaluates five different categories of these variable costs associated with existing and added test resources:

- Wind variable costs
- Natural gas fuel and variable costs (or savings)
- Coal fuel and variable costs (or savings)
- Changes in costs of purchasing power from the regional independent power producers (IPP) and regional power imports
- Changes in the sales of regional power exports[15]

Fixed costs of replacement resources are then added into the mix, including the annual amortization expenses of the capital and fixed O&M expenses. Adding the fixed and variable cost components produces the incremental change in regional power system costs above those in the base run for each MO before primary resources are added.

In this way, the cost analysis develops a full picture of the alternative-specific incremental costs associated with each test resource. This is particularly important because, for example, renewable resources displace natural gas and coal generation and therefore lower power-system fuel costs, reducing the need to purchase power from IPPs or the market, and increase export sales. These benefits are accounted for in the power system as a variable cost savings detailed in the tables presented in Section 2.2.2.4 below.

2.2.2.3.2 RELIABILITY IMPACT

While the replacement resources increase the costs of the regional power system, the benefit is that they lower the LOLP (i.e. increasing regional power system reliability). The magnitude of the decrease in LOLP depends on the resource type.

The results of the analysis showed that the most effective resource type of the seven resources tested is dispatchable natural gas fired resources. These resources can respond quickly to changes in load and are not energy-limited – i.e., they can continuously generate. In the zero-

[15] While there are no export markets in GENESYS, surplus energy in GENESYS stemming from renewables and other must-run resources that exceed the load are given export revenue credit for the full amount.

carbon scenarios, while both DR and battery storage are dispatchable resources, both have limitations that reduce their overall system value. DR resources are severely energy-limited; according to the NW Council's modeling in the 7th Power Plan these DR resources are limited to 50 hours per year of dispatch. Battery storage provides short-term capacity, but batteries are net consumers of energy which lowers their value.

In terms of renewable resources which are subject to the variabilities of sun and wind, GENESYS modelling found that solar reduces the LOLP by the greatest incremental amount followed by Montana wind. Wind in the Columbia River Gorge was less effective. *See e.g.,* Table 2-3.

2.2.2.3.3 ASSESSING COST EFFECTIVENESS

To determine the most cost-effective replacement resources, the analysis divides the incremental costs of the seven resource classes by the reliability benefit of such class to find the resource that was most cost-effective at reducing the LOLP. For each MO, two options were selected: a least-cost overall resource class and a least-cost "zero-carbon" class. Although natural gas fired resources did not have the lowest incremental costs of the seven resources, it provided the largest LOLP benefit and was the most cost-effective per unit of LOLP reduction. *See e.g,.* Table 2-3 (showing natural gas costing $5,287,000 for each 1 percent drop in LOLP, compared to battery costing $139,428,000 for each 1 percent drop in LOLP). The natural gas portfolio was therefore deemed the "conventional least-cost" portfolio. The other six resources did not include any carbon-emitting replacement resources and were designed to determine the least-cost zero-carbon portfolio. Except for the MO2 avoided build portfolio, the least-cost zero-carbon resource was solar. *See, e.g.,* Table 2-3. For MO3, the solar power zero-carbon portfolio included coupled battery storage (2:1 ratio of solar:battery) to address lost flexibility from breaching of the four LSR dams, as described below.

The costs of the potential replacement portfolios (and the avoided cost in the case of MO2) are based on the best available resource information from the NW Council's 7th Power Plan, Midterm Assessment, and consultation between Bonneville and staff experts at the NW Council (NW Council 2016b, 2019a). To reflect recent information about potential reductions in resource costs from publicly released information available as of the final EIS, prices for solar and battery storage were updated with draft developments from the 8th Power Plan, along with new projections showing de-escalating cost curves for these resources prepared by National Renewable Energy Lab (NREL). These reductions in resource costs are reflected as a sensitivity in the rate sensitivity analysis discussed in Section 3.7.3 of the EIS.

Table 2-2 provides the per unit capital costs ($/kW) of the replacement resources identified for each alternative and portfolio. The analysis uses the midpoint of the costs for the resource replacement selection. The NW Council's 2022 load forecast that is used for the LOLP reliability modeling includes all cost-effective conservation. According to the 7th Power Plan, by 2022 1,871 aMW of conservation is available to the region for $80/MWh or less. This conservation is assumed to have been achieved in the load forecast used in the analysis. There is an additional 148 aMW of conservation available for more than $80/MWh, with half of it available for over

$140/MWh. This conservation has a higher cost than the other resources that were developed for the MOs, and therefore is not included in the analysis.

Table 2-2. Capital Costs of Replacement Resources (2019$)

Resource Type	Cost ($/kW)
Solar	$1,350 to $1,500
Wind	$1,500 to $1,700
Combined Cycle Gas	$1,100 to $1,300
Simple Cycle Gas	$500 to $650
Battery[1/]	$1,927

Source: Cost based on the NW Council Midterm Assessment, 2018; energy storage costs sourced from three recent IRPs

Note: The costs have not been scaled up or down for changes in costs for resources that are ten or more times larger than projects contemplated in the Midterm Assessment.

1/PacifiCorp 2018, Northwestern Power 2018, Puget Sound Energy 2018.

2.2.2.3.4 ASSESSING THE QUANTITY OF RESOURCES NEEDED

After identifying the most cost-effective resources in terms of cost per LOLP percentage point improvement, additional analysis identified the necessary amount of these resources to be added for each of the MOs that needed replacement resources. Natural gas (conventional least-cost), solar (zero-carbon for MO1 and MO4), or solar plus battery (2:1 for MO3) replacement resource capacity was added until the LOLP of those portfolios achieved the No Action Alternative LOLP (6.6 percent). The 7th Power Plan found that a minimum of 600 MW of demand response (DR) would be cost-effective to develop under all future conditions tested across all scenarios.[16] While this amount of DR is the minimum from the NW Council 7th Power Plan, the installations of DR are uncertain and the NW Council's Midterm Assessment determined that the region was unlikely to meet this target.[17]

2.2.2.4 Cost Effective Resource Results

The following tables provide the results of the cost effective resource analysis for each MO. The Preferred Alternative had roughly the same reliability as the No Action Alternative and did not require replacement resources and is thus not included.

Each table summarizes the change in variable and fixed costs as well as the calculated cost-to-reliability benefit as described in the methodology above.

2.2.2.4.1 REPLACEMENT RESOURCES FOR MO1

Table 2-3 below summarizes the variable costs, or savings, and the annualized capital costs for each test resource examined under MO1. The table also presents the reduction in LOLP and the

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[16] NW Council 7th Power Plan (p.4-2)

[17] To address this concern, the sensitivity analysis provides a range around potential demand response costs.

cost-to-reliability benefit ratio for each resource (cost for each one percentage point decrease in LOLP).

Natural gas had the lowest cost-to-reliability ratio due to the largest (4.2 percent) drop in LOLP. The fixed costs of roughly $22 million and variable costs of $554,000 result in roughly $5 million per percentage point drop in LOLP. Demand response was the lowest cost resource; however it also had a relatively low effect on LOLP (0.8 percentage points) with a cost-to-reliability ratio above $17 million and was thus not as cost-effective as an independent resource. Thus, natural gas was selected as the conventional least-cost resource under MO1. To reach the LOLP of the No Action Alternative, 560 MW of simple cycle natural gas became the conventional least-cost portfolio for MO1.

For the zero-carbon portfolio, the analysis identified solar as the most-cost effective resource. The effects of solar resources and wind resources in Montana on LOLP were comparable (1.8 and 1.6 percentage point drop) but the fixed costs of solar were lower than wind resulting in the lower cost-reliability ratio of roughly $16 million. As described above, demand response was also a relatively low-cost resource and when added to the solar portfolio reduced the overall system cost. Thus, the MO1 zero-carbon portfolio included 1,200 MW solar with 600 MW of demand response.

Table 2-3. Cost Effective Resource Summary under Multiple Objective 1

Annual Cost Portfolio: (2019$)	500 MW Gas	500 MW DR	500 MW Solar	500 MW MT Wind	500 MW Gorge Wind	250 MW Solar and 250 MW MT wind	500 MW Battery
Variable Costs (Thousands)[/1]							
Wind Variable O&M	$0	$0	$0	$3,640	$2,870	$1,809	$0
Fuel and O&M (Natural Gas)	$2,132	-$24	-$11,128	-$16,646	-$10,702	-$13,838	$1,156
Fuel and O&M (Coal)	$59	$0	-$4,255	-$6,374	-$5,527	-$5,332	-$9
IPP & Import	-$1,833	-$9	-$3,601	-$6,964	-$3,844	-$5,251	-$1,060
Increase Export Sales	$197	-$34	-$5,487	-$7,848	-$8,117	-$6,592	-$67
Total Variable Costs (Annual)	**$554**	**-$66**	**-$24,471**	**-$34,192**	**-$25,320**	**-$29,203**	**$20**
Fixed Costs (Thousands)							
DR	$0	$13,997	$0	$0	$0	$0	$0
Gas	$21,650	$0	$0	$0	$0	$0	$0
Batteries	$0	$0	$0	$0	$0	$0	$97,580
Wind	$0	$0	$0	$74,208	$74,208	$37,104	$0
Solar	$0	$0	$53,253	$0	$0	$26,626	$0
Total System Costs (Annual)	$21,650	$13,997	$53,253	$74,208	$74,208	$63,730	$97,580
Total Increase in Costs[/2]	**$22,204**	**$13,931**	**$28,782**	**$40,016**	**$48,888**	**$34,527**	**$97,600**
LOLP With the 500 MW Resources Added							
Loss of Load Probability[/3] (LOLP)	7.0%	10.4%	9.4%	9.6%	10.9%	9.2%	10.5%
Drop in LOLP Points	**4.2**	**0.8**	**1.8**	**1.6**	**0.3**	**2.0**	**0.7**
Cost / Reliability Benefit[/4]	**$5,287**	**$17,414**	**$15,990**	**$25,010**	**$162,960**	**$17,264**	**$139,428**

Notes: /1 Negative variable cost values represent regional power system savings compared to the base system MO without replacement resources.
/2 Total increase in costs is the sum of the change in variable costs (row Total Variable Costs) combined with the change in fixed costs (row Total System Costs).
/3 The base system LOLP under MO1 without replacement resources is 11.2 percent.
/4 The cost-to-reliability benefit is the cost in thousands of dollars for each one percentage point decrease in LOLP. The lower the ratio the more cost-effective the resource portfolio.

2.2.2.4.2 REPLACEMENT RESOURCES FOR MO2

In the case of MO2, no new resources are needed to meet the LOLP of the No Action Alternative, because MO2 provides a reliability benefit relative to the No Action Alternative (5 percent vs. 6.6 percent). To assess the value of the added reliability of MO2, resources were added to the No Action Alternative until its LOLP was equal to that of MO2 (5 percent). This amount of resources represents the amount of resource acquisitions MO2 avoids (and associated avoided costs) compared to NAA should the region decide that new resources are needed with the CRS operating under the NAA. The analysis identifies avoided build of new resources using the GENESYS model in the same manner as described previously to identify replacement resources needed for the other MOs.

These resource additions amounted to 440 MW of simple-cycle natural gas-fired generation for the conventional least-cost portfolio, and 250 MW of solar, 660 MW of Montana wind, and 600 MW of DR in the zero-carbon portfolio. This set of test resources had the lowest savings from variable costs but also the lowest fixed costs, resulting in a cost-to-reliability ratio of roughly $53 million per percentage point of LOLP. This was slightly lower than the test resource portfolio of only solar and Montana wind without demand response. Without Montana wind, substantial amounts of solar (2,250 MW solar or the combination of 1,700 MW solar with 600 MW DR) would be needed to drop LOLP 1.6 percentage points. These solar test resources reduced variable costs by up to $100 million but had higher fixed costs resulting in higher cost-to-reliability ratios.

Table 2-4 presents the cost-effective resources for the assessment of MO2 avoided-builds.

Table 2-4. Cost Effective Resource Summary under Multiple Objective 2

Annual Cost Portfolio: (2019$)	440 MW Gas Simple Cycle	2,250 MW Solar	660 MT Wind; Solar 250; 600 MW DR	1,700 MW Solar and 600 MW DR	660 MT Wind and 550 MW Solar
Variable Costs (Thousands)/1					
Wind Variable O&M	$0	$0	$4,812	$0	$4,812
Fuel and O&M (Natural Gas)	$1,270	-$45,647	-$26,485	-$34,823	-$32,543
Fuel and O&M (Coal)	$58	-$21,045	-$11,037	-$15,689	-$13,801
IPP & Import	-$1,320	-$14,137	-$10,445	-$10,812	-$12,306
Increase Export Sales	-$81	-$27,899	-$13,783	-$20,889	-$17,569
Total Variable Costs (Annual)	**-$73**	**-$108,727**	**-$56,938**	**-$82,213**	**-$71,407**
Fixed Costs (Thousands)					
DR	$0	$0	$16,797	$16,797	$0
Gas	$19,052	$0	$0	$0	$0
Batteries	$0	$0	$0	$0	$0
Wind	$0	$0	$97,955	$0	$97,955
Solar	$0	$239,637	$26,626	$181,059	$58,578
Total System Costs (Annual)	$19,052	$239,637	$141,378	$197,856	$156,533
Total Increase in Costs/2	**$18,979**	**$130,910**	**$84,439**	**$115,643**	**$85,125**

Annual Cost Portfolio: (2019$)	440 MW Gas Simple Cycle	2,250 MW Solar	660 MT Wind; Solar 250; 600 MW DR	1,700 MW Solar and 600 MW DR	660 MT Wind and 550 MW Solar
LOLP with the Resources Added					
Loss of Load Probability/3 (LOLP)	5.0%	5.0%	5.0%	5.0%	5.0%
Drop in LOLP Points	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**
Cost / Reliability Benefit/4	**$11,862**	**$81,819**	**$52,774**	**$72,277**	**$53,203**

Notes: /1 Negative variable cost values represent regional power system savings compared to the base system MO without replacement resources.
/2 Total increase in costs is the sum of the change in variable costs (row Total Variable Costs) combined with the change in fixed costs (row Total System Costs).
/3 The base system LOLP under the No Action Alternative without additional resources is 6.6 percent. LOLP under MO2 is 5 percent.
/4 The cost-to-reliability benefit is the cost in thousands of dollars for each one percentage point decrease in LOLP. The lower the ratio the more cost-effective the resource portfolio.

2.2.2.4.3 REPLACEMENT RESOURCES FOR MO3

To maintain power system reliability in the Northwest with MO3, additional generation resources would be needed. Table 2-5 below summarizes the variable costs, or savings, and the annualized capital costs for each test resource examined under MO3. The table also presents the reduction in LOLP and the cost-to-reliability benefit ratio for each resource (cost for each one percentage point decrease in LOLP).

As presented in Table 2-5, the analysis identifies natural gas as the least-cost resource. For the natural gas resource test, variable costs of the system increase by less than $1 million annually. The fixed costs are $20.3 million per year. Natural gas had the largest percentage point drop in LOLP (four percent) of the test resources. The cost-reliability ratio is $5.5 million for every 1 percentage point decrease in LOLP for the natural gas test resource. For MO3, combined cycle gas plants were ultimately selected. Simple cycle units have lower capital costs than combined cycle units, but they are less efficient. The incremental amount of gas required for MO3 to maintain reliability was more cost-effective in a combined cycle unit than a simple cycle unit even though it had higher capital costs.

Extending this analysis to the zero-carbon test resources, the solar resource had the lowest cost-to-reliability benefit ratio of any of the renewable resources. This resource test reduced variable costs of the power system by about $25 million, mostly stemming from natural gas fuels savings. These savings are offset by about $50 million in fixed costs resulting in a cost-to-reliability ratio of roughly $12 million per 1 percentage point reduction in LOLP, or nearly twice that of the natural gas resources but still more cost-effective than the other zero-carbon test resources. The other zero-carbon resources had ratios ranging from $16 million up to roughly $120 million per percentage point drop in LOLP.

The 500 MW of demand response has the lowest annual costs but only reduces the LOLP by only 0.7 percentage points, thus it has a higher cost-to-reliability ratio than the solar resources. However, after the solar resources satisfied the requirement to reduce the LOLP to 6.6 percent, adding 600 MW total potential of DR lowered the overall amount of solar capacity required and thus the cost of that portfolio. Therefore, the zero-carbon portfolios include 600 MW of DR.

For MO3, 2,550 MW solar and 600 MW demand response reflects the least-cost renewable resources group for reducing LOLP. However, the GENESYS model run for MO3 with solar and demand response showed that other resources in the region would increase generation to produce an overall LOLP of 6.6 percent. Therefore, for MO3, batteries were added to solar and constrained to a 2:1 ratio of solar:battery in order to return some of the lost sustained peaking and ramping capability and to reduce leaning on other regional resources to make up for these generation characteristics. The amount of replacement resources (solar and batteries) were scaled until the LOLP of MO3 matched the LOLP of the No Action Alternative. This produced the base case portfolio of 1,960 MW solar, 980 MW batteries, and 600 MW of demand response. This portfolio nonetheless still results in increased generation from other resources in the region.

In the future condition with additional coal-plant retirements, this option would not be sufficient to return the LOLP to the No Action level, because without coal, more of the capability or replacement capability of the lower Snake River (LSR) projects would be needed for power system reliability. Consequently, the EIS also developed a portfolio of replacement resources that replaces all of the generation capabilities currently supplied by the LSR projects. In the short-term, this portfolio may replace some of the generation capability that may be considered surplus (though it does contribute to reducing fossil-fuel-based generation and GHG emissions). However, as more coal plants retire, replacing the full capability of the LSR projects becomes more essential to maintain the reliability of the power system. For example, the ability of the projects to ramp generation up and down quickly is very valuable to integrating new renewable generation.

These portfolios are not intended to be the sole portfolios that utilities, policy makers, or federal agencies would choose to develop. Between these two resource portfolios are many combinations which could be optimized with other resources to achieve the specific objectives the utility seeks.

Table 2-5. Cost-Effective Resource Summary for Multiple Objective 3

Annual Cost Portfolio: (2019$)	500 MW Gas	500 MW DR	500 MW Solar	500 MW MT Wind	500 MW Gorge Wind	250 MW Solar and 250 MW MT wind	500 MW Battery
Variable Costs (Thousands)[1]							
Wind Variable O&M	$0	$0	$0	$3,640	$2,870	$1,809	$0
Fuel and O&M (Natural Gas)	$3,194	-$28	-$12,277	-$18,484	-$12,076	-$15,309	$1,572
Fuel and O&M (Coal)	$71	$0	-$5,043	-$6,815	-$5,938	-$5,966	-$12
IPP & Import	-$2,889	-$9	-$4,317	-$8,278	-$4,556	-$6,296	-$1,450
Increase Export Sales	$181	-$35	-$4,491	-$6,322	-$7,645	-$5,296	-$131
Total Variable Costs (Annual)	**$556**	**-$72**	**-$26,127**	**-$36,259**	**-$27,345**	**-$31,058**	**-$21**
Fixed Costs (Thousands)							
DR	$0	$13,997	$0	$0	$0	$0	$0
Gas	$21,650	$0	$0	$0	$0	$0	$0
Batteries	$0	$0	$0	$0	$0	$0	$97,580
Wind	$0	$0	$0	$74,208	$74,208	$37,104	$0
Solar	$0	$0	$53,253	$0	$0	$26,626	$0
Total System Costs (Annual)	$21,650	$13,997	$53,253	$74,208	$74,208	$63,730	$97,580
Total Increase in Costs[2]	**$22,207**	**$13,925**	**$27,125**	**$37,949**	**$46,863**	**$32,672**	**$97,559**
LOLP with the 500 MW Resources Added							
Loss of Load Probability[3] (LOLP)	9.9%	13.2%	11.6%	12.4%	13.5%	11.8%	12.7%
Drop in LOLP Points	**4.0**	**0.7**	**2.3**	**1.5**	**0.4**	**2.1**	**1.2**
Cost / Reliability Benefit[4]	**$5,552**	**$19,894**	**$11,794**	**$25,299**	**$117,158**	**$15,558**	**$81,299**

Notes: /1 Negative variable cost values represent regional power system savings compared to the base system MO without replacement resources.
/2 Total increase in costs is the sum of the change in variable costs (row Total Variable Costs) combined with the change in fixed costs (row Total System Costs).
/3 The base system LOLP under MO3 without replacement resources is 13.9 percent.
/4 The cost-to-reliability benefit is the cost in thousands of dollars for each one percentage point decrease in LOLP. The lower the ratio the more cost-effective the resource portfolio.

2.2.2.4.4 REPLACEMENT RESOURCES FOR MO4

Due to the elevated LOLP under MO4 (29.6 percent), the MO4 cost-effective resource analysis required larger test resource capacities. In addition, the amount of Montana wind was limited to the sum of the amount of currently available transmission wind capacity from Montana identified in the Montana Renewable Energy Report plus the Washington shares of the Colstrip 1 & 2 units located in eastern Montana which were closed in 2019. Gorge wind resources were still available and included as a test resource of 1,500 MW.

Similar to the result for other MOs, natural gas is the least-cost resource. The variable costs increase by nearly $3 million and the fixed costs would be $68 million. The natural gas test resource does have a large effect on LOLP, reducing it by 13.3 percent, resulting in a cost-reliability ratio of roughly $5 million. To match the LOLP of the No Action Alternative, the conventional least-cost portfolio consists of 3,240 MW simple-cycle natural gas.

For the other resources being assessed, the most cost-effective zero-carbon resource was solar. The solar test resource reduced variable costs by roughly $80 million with fixed cost increases of $160 million. After natural gas, solar had the largest effect on LOLP, decreasing it by 9 percent. This results in a cost-reliability ratio of roughly $9 million per percentage point drop in LOLP. Consistent with the other zero-carbon portfolios, demand response reduced the total cost of the portfolio and thus, 600 MW were included in the zero-carbon portfolio. Table 2-6 below presents the cost-effectiveness results for MO4. The zero-carbon portfolio for MO4 to match the LOLP of No Action consists of 5,000 MW solar and 600 MW of demand response.

Table 2-6. Cost Effective Resource Summary for Multiple Objective 4

Annual Cost Portfolio: (2019$)	1,500 MW Gas Simple Cycle	1,500 MW DR	1,500 MW Solar	1,500 MW Gorge Wind	840 MW Solar and 660 MW MT wind	1,500 MW Battery
Variable Costs (Thousands)/1						
Wind Variable O&M	$0	$0	$0	$8,610	$4,812	$0
Fuel and O&M (Natural Gas)	$8,252	-$108	-$34,745	-$34,978	-$43,170	$2,381
Fuel and O&M (Coal)	$159	-$2	-$15,691	-$19,743	-$18,470	-$26
IPP & Import	-$7,128	-$64	-$13,323	-$13,918	-$18,128	-$1,636
Increase Export Sales	$1,475	-$178	-$15,522	-$22,591	-$17,598	-$795
Total Variable Costs (Annual)	$2,757	-$351	-$79,280	-$82,620	-$92,553	-$75
Fixed Costs (Thousands)						
DR	$0	$41,991	$0	$0	$0	$0
Gas	$64,950	$0	$0	$0	$0	$0
Batteries	$0	$0	$0	$0	$0	$292,740
Wind	$0	$0	$0	$222,625	$97,955	$0
Solar	$0	$0	$159,758	$0	$89,464	$0
Total System Costs (Annual)	$64,950	$41,991	$159,758	$222,625	$187,419	$292,740
Total Increase in Costs/2	**$67,707**	**$41,640**	**$80,478**	**$140,005**	**$94,866**	**$292,664**
LOLP with the 500 MW Resources Added						
Loss of Load Probability/3 (LOLP)	16.3%	26.8%	20.6%	28.0%	22.3%	26.9%
Drop in LOLP Points	**13.3**	**2.8**	**9.0**	**1.6**	**7.3**	**2.7**
Cost / Reliability Benefit/4	**$5,091**	**$14,871**	**$8,942**	**$87,503**	**$12,995**	**$108,394**

Notes: /1 Negative variable cost values represent regional power system savings compared to the base system MO without replacement resources.
/2 Total increase in costs is the sum of the change in variable costs (row Total Variable Costs) combined with the change in fixed costs (row Total System Costs).
/3 The base system LOLP under MO4 without replacement resources is 29.6 percent.
/4 The cost-to-reliability benefit is the cost in thousands of dollars for each one percentage point decrease in LOLP. The lower the ratio the more cost-effective the resource portfolio.

2.2.2.4.5 SUMMARY OF REPLACEMENT RESOURCES

This analysis considers the zero-carbon and conventional least-cost replacement resource portfolio analysis for MO1, MO3, and MO4. Table 2-7 describes resources prioritized for each replacement resource portfolio. The conventional least-cost portfolio consists of natural gas resources whereas the zero-carbon portfolio reflects a mixture of demand response and solar power. To provide a sense of scale, the region currently has about 900 MW of utility scale solar (roughly 55,500 acres or 8.5 square miles of land).

The PA has an LOLP of 6.4 percent, which is roughly the same as that of the No Action Alternative. Therefore, the PA would neither require additional resources nor avoid the need to build new resources to match the power system reliability under the No Action Alternative.

Table 2-7. Potential Replacement Resource Portfolios by Scenario

Resource Portfolio	MO1	MO2[1/]	MO3	MO4
Zero-Carbon	600 MW demand-response and 1,200 MW solar	Avoided build of 250 MW solar, 660 MW MT wind, and 600 MW demand response[1/]	600 MW demand-response, 1,960 MW solar, and 980 MW of battery storage	600 MW demand-response and 5,000 MW solar
Conventional Least-Cost	560 MW simple cycle natural gas	Avoided build of 440 MW of simple cycle natural gas[1/]	1,120 MW combined cycle natural gas	3,240 MW simple cycle natural gas

1/ MO2 would improve power system reliability relative to the No Action Alternative; therefore, the analysis identifies potential "avoided builds" of replacement resources.

Before acquiring such resources, Bonneville and the Northwest Power and Conservation Council, through a regional public process, would develop a resource plan to identify the least cost resource portfolio to assure Bonneville and its customers an adequate, economical power supply consistent with regional reliability and environmental policy criteria.

2.2.3 Cost Assumptions for Replacement Resources: Bonneville Finances vs. Region Finances

The EIS uses resource costs from the NW Council's 7th Power Plan and Mid-Term Update – with the exception of batteries. Updated costs for the NW Council's draft 8th Power Plan became available after the EIS base-case analysis was complete, but are reflected in the rate sensitivity analysis.[18] Battery prices for MO3's base case used prices from the Council's 8th Power Plan that became available late fall 2019.

Uncertainty related to how replacement resources would be acquired, and the cost associated with replacement portfolios has implications for the relative effect of alternatives on ratepayers across the Pacific Northwest. To account for this uncertainty, the analysis considers two scenarios for financing the development of new resources with different implications on ownership or rights to capacity. One scenario ("Bonneville Finances Scenario") assumes

[18] The cost analysis assumes that Production Tax Credit and Investment Tax Credit would not be renewed.

Bonneville would acquire output from the replacement resources (costs recovered from Bonneville's customers and their retail ratepayers). The second scenario assumes regional public utilities would finance the construction of resources, and their costs would be recovered directly from the retail ratepayers of those utilities ("Region Finances Scenario").

While this analysis requires some simplification to evaluate potential outcomes for financing replacement resources, it highlights the need to address the practical and technical ramifications of developing additional resources. For example, Bonneville does not have statutory authority to own or construct replacement resources; thus Bonneville's role would be limited to contracting for the output of replacement resources acquired or developed by another entity.[19] In addition, developing new resources, whether purchased by Bonneville or regional entities, can require long lead times for the planning, permitting, land acquisition, and physical construction.

To quantify the full cost of a replacement resource under each portfolio and alternative, the analysis undertakes the following:

- amortizes the capital cost of the resources over their expected life span at the tax-exempt financing rate from the FY 2019 Common Agency Assumptions;
- estimates variable costs of the resources (e.g., fuel costs) using the AURORA dispatch under each alternative; and
- estimates variable costs of other changes in the power system (e.g., adding solar into the power system reduced the need to burn gas and coal, and all portfolios create changes in power purchases and export sales).

Table 2-8 presents the estimated costs for replacement resources under each financing scenario and resource replacement portfolio. In the zero-carbon replacement scenarios, demand response costs include the Portland General Electric portion of acquisitions for the region finances scenarios, and the Bonneville finances scenarios show just Bonneville's portion. In the conventional least-cost scenarios, variable costs for gas-fired generation are higher in the Bonneville finances scenarios where variable costs assume dispatch under 1937 water conditions, while in the Region finances scenarios variable costs assume dispatch under average water conditions.

[19] The term "acquire" and "acquisition" as used in the Northwest Power Act expressly excludes authorization for the Bonneville Administrator to construct or have ownership of any electric generating facility. *See* 16 U.S.C. §389a(1).

Table 2-8. Annual Replacement Resource Costs by Financing Scenario and Replacement Portfolio (thousands, 2019$)

Financing Scenario	Resource Portfolio	Average Annual Costs	MO1	MO2	MO3	MO4	PA
Region	Conventional Least-Cost	Capital Costs	$27,000	Avoided build of 440 MW of Gas or 250 MW solar, 660 MW MT wind, and 600 MW demand response[/2]	$138,000	$156,000	Neither replace-ment resourc es nor avoided build
		Variable Costs[1/]	$7,000		$96,000	$42,000	
	Zero-Carbon	Capital Costs Demand Response	$131,000 $30,000		$374,000 $30,000	$547,000 $30,000	
Bonneville	Conventional Least-Cost	Capital Costs	$27,000		$138,000	$156,000	
		Variable Costs[1/ and 3/]	$16,000		$112,000	$91,000	
	Zero-Carbon	Capital Costs Demand Response	$131,000 $20,000		$374,000 $20,000	$547,000 $20,000	

Notes: Estimates are rounded to two significant digits. These estimates are the post-processing results from the rates analysis which including financing assumptions, and, as such, do not represent the direct GENESYS results from the LOLP modelling. The costs do not include transmission costs discussed in Chapter 3 -. Demand response costs under Bonneville finances scenario exclude assumed Demand Response program in Portland area ($10 million, which is included in the Region finance).

1/ The variable costs are the fuel costs and operations and maintenances associated with the replacement resources (including fuel transmission in MO3 or storage tank backups in MO1 and MO4); other costs such as import and export effects and changes to operations at other power plants (e.g., increased generation from existing regional natural gas resources) are not included in this total. Chapter 5 -describes the system-wide variable cost effects.

2/ The analysis of avoided builds for MO2 was not implemented in the rates analysis and therefore no costs were estimated.

3/ Due to Bonneville ratemaking procedures, these estimates of the Bonneville variable costs reflect critical water year replacement resource generation (i.e., more gas-fired generation). The region-replace scenario is for an average water year.

2.2.4 Process and Timeline for Acquiring Replacement Resources

The hydropower analysis uses a single study year to enable a comparison of before-and-after effects for each alternative, utilizing the most recently available, and vetted, models and data up and through 2022. This single study year ensured that the effects of the MOs could be compared fairly with each other and the NAA without the co-lead agencies speculating on when resources would be removed or when resources would be constructed and online. Thus, if an alternative requires replacement resources, the analysis identifies those resources needed to restore the reliability of the regional power system.

However, while many of the operational measures in an alternative might be implemented soon after the completion of the CRSO NEPA process, resource additions would not happen instantly. There are a number of steps and processes that would likely have to occur before replacement resources could be selected, sited, and constructed. Below is an overview of the likely steps that would need to be completed for replacement resources. These steps are presented roughly in sequential order, though some steps may occur in parallel or simultaneously, while others may be iterative.

Authorization from Congress

MO1 and MO4 involve operational changes to the existing CRS system and thus, may be completed within the co-lead agencies' existing statutory authority. MO3 (with dam breaching) is not. Thus, for MO3 to be implemented, one of the first steps that would need to occur is the passage of legislation authorizing the US Army Corps of Engineers through a Water Resources Development Act to breach the four lower Snake River dams. The timing needed to pass such legislation is unknown. Considering the complexity of the regional issues involved, and multiplicity of stakeholder interests, including tribal, state, shipping, navigation, irrigation, environmental, utility, and many others, it is reasonable to surmise that it would take several years of regional negotiations to develop and pass legislation authorizing the US Army Corps of Engineers to take the necessary steps to remove the four lower Snake River dams.

Customer Elections

After legislation is passed (for MO3) or in the case of MO1 or MO4, immediately after selection of these alternatives, additional time would be needed to determine *who* would replace the lost capability caused by the changes in CRS operations. Although the output of the CRS is included in the supply of resources Bonneville sells to meet its customers firm power loads under long-term contracts, Bonneville is not automatically obligated to replace lost CRS capability. If CRS firm capability is reduced because of a MO, the firm power Bonneville sells to its customers under its current long-term contracts (which go through fiscal year 2028) would similarly decline. In this instance, additional firm resources may be needed to meet the firm power loads of Bonneville's customers. Bonneville's customers would then face a choice: request Bonneville to acquire resources to meet their firm power loads *or* purchase the firm resources themselves through non-Federal acquisitions. This election option occurs periodically, with the next election opportunity scheduled for the 2025 through 2028 period (the end of the current long-term contracts).

Bonneville Statutory Processes for Selecting Replacement Resources

If customers elect Bonneville to meet their firm power loads, Bonneville would have to engage in the appropriate statutory process to contract for the output of a resource to replenish its supply to meet its obligations. This would likely include a regional consultation process conducted under section 6(c) of the Northwest Power Act to acquire a major resource. Bonneville rarely acquires major resources, so initiating a section 6(c) process would likely require at least a year to complete. The size and type of the selected resource(s) would be determined in the section 6(c) process, which would involve the input of regional stakeholders. Thereafter, assuming the resource(s) were not already operating, the resource development and construction would occur by the project owner.

Customer Processes for Selecting Replacement Resources

If customers elect to meet their own firm power loads, then Bonneville would not be obligated to acquire any additional resources, and individual or groups of utility customers would be responsible for determining the size, type, and timing of additional resource acquisitions.

The EIS does not attempt to decide whether Bonneville or other regional utilities would acquire the replacement resources needed to maintain regional reliability at the NAA levels. Rather, the EIS leaves this question open and presents a range of potential replacement portfolios that may be selected by regional utilities and planners to meet future power needs. Additional analysis would likely be performed by regional planners (Bonneville or Customers) to determine the optimal mixture of replacement resources with the most current cost information and technological advances. This step would likely involve additional time developing and issuing requests for proposals (RFPs). Acquiring new generation might include a combination of purchasing power from existing generation, from projects under development such as by independent power producers many of whom are currently developing new renewable generation, and acquiring generation from new projects. (Bonneville would not own the projects, but could contract for generation from a project as it does with the Columbia Generating Station owned by Energy Northwest.)

Transmission Request Process

Unless the resource is existing, or under construction, the project associated with that resource would have to go through a generator interconnection process with the Transmission Service Provider (TSP) where the resource project would interconnect. Each TSP would follow its own tariff process. Most TSPs use the Federal Energy Regulatory Commission (FERC) Large Generator Interconnection (LGI) process or Small Generator Interconnection (SGI) process. Bonneville uses a similar process under its open access transmission tariff. The process follows a prescribed timeline to complete required studies including Feasibility Evaluation (FES), System Impact Study (ISIS), and Facilities Assessment (FAS). The study process may take a year or more to complete. Following the study process, a transmission Construction Agreement between the TSP and requestor would be completed before the project would proceed to construction of required transmission facilities. Energization of the required facilities would be subject to the work schedule of the TSP. For Bonneville, the typical work schedule for transmission-related facilities is a minimum of three years from the time a Construction Agreement is signed.

Environmental Review Processes

Additional site-specific environmental review, including NEPA and permitting processes, would need to be completed by the appropriate parties for transmission interconnection and/or resource acquisition or construction. If Bonneville were to propose to take actions in the future, in addition to required studies including Feasibility Evaluation (FES), System Impact Study (ISIS), and Facilities Assessment (FAS) and the 6(c) process, Bonneville would complete the additional site-specific planning, analysis, and environmental compliance before entering into an LGI or SGI Construction Agreement or contract for resource acquisition. Additional effects analysis for natural and cultural resources, which may include land-use, vegetation, birds, wildlife habitat, archeological resources, and traditional cultural properties may be warranted. Large battery, solar, or wind projects may have implications for metal and mineral use as well as concerns about disposal and/or recycling at the end of a project's useful life.

State Permitting Processes

In the states of Washington and Oregon, State Energy Facility Siting Council (EFSEC)[20] large utility-scale solar, wind, and natural gas projects undergo a multi-step permitting process. For utility-scale solar projects built in Oregon and Washington in the past two decades, the state permitting process has taken ½ to 1 year for projects under 100 MW. Larger projects, including some projects initiated in 2018, have not been constructed in Oregon and Washington. Wind projects have ranged from 1 year to over 4 years to permit. Natural gas plants have taken 6 months to 2.5 years though the last natural gas plant permitted was in 2015.

Construction of Replacement Resources

Finally, the construction itself for new resource projects of this scale can vary in time. The NW Council's reference simple cycle natural gas plants take 1 year to construct and the combined cycle take 2 years. The NW Council also estimates a 1 year construction period for wind and solar plants in the 100 to 216 MW size range. Based on information from the NW Council's 7th Power plan, demand response may take up to about 5 years to scale up.

The development of these projects would be happening concurrently with the development of projects to replace the generation from retiring coal-fired power plants in the region. This may or may not influence the timeline for acquiring resources to replace any lost hydropower generation.

2.3 SENSITIVITY OF LOLP TO ASSUMPTIONS ABOUT COAL CAPACITY

The No Action Alternative assumes 1,675 MW of coal capacity would be retired and 4,246 MW of coal capacity would continue to exist in the Pacific Northwest. However, energy economics in addition to state and local de-carbonization policies are changing the generation portfolio in the region and across the Western Interconnection into the 2020s and beyond. For example, regional IOUs have recently announced additional and accelerated coal-plant retirements.[21] In light of this, a sensitivity analysis considers how a range of potential coal-plant retirements under the No Action Alternative could affect the LOLP. This sensitivity analysis additionally

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[20] Permitting and construction timing was determined based on project-specific application, permitting, and construction dates posted on the Washington and Oregon EFSEC websites https://www.efsec.wa.gov/energy-facilities and https://www.oregon.gov/energy/facilities-safety/facilities/Pages/Facilities-Under-EFSC.aspx

21 Both the Oregon Coal to Clean Energy Act (2016) and the Washington Clean Energy Transformation Act (2019) mandate the elimination of coal-fired resources in retail rates by 2025 (WA) and 2030 (OR). In 2017, the CRSO power analysis selected the NW Council's Resource Adequacy dataset for 2022 as the basis to prepare LOLP analysis for the CRSO EIS. The NW Council's 2022 data set was prepared in 2017, and included 407 MW of utility solar (updated to 550 MW for the CRSO) in the region, and 4,246 MW of coal, dedicated to serving regional IOU load. This plan, which is utilized for the No Action Alternative, does not incorporate TransAlta's plan to close their last unit at Centralia in 2025, nor Washington State's New Energy Transition Act which would render nearly all coal uneconomical by 2025.

assumes that no new natural gas power plants would be constructed to serve northwest loads; therefore, the sensitivity analysis applies only to the zero-carbon replacement options. Specifically, the sensitivity analysis focuses on the following scenarios:

- **Limited Coal Retirement Scenario**. This scenario assumes that an additional 2,505 MW of coal generation would be retired compared to the No Action Alternative baseline. Under this scenario, Colstrip Unit 4 and Jim Bridger Units 1 and 2 would continue operating. Under this scenario, 1,741 MW of coal capacity would continue to operate in the Pacific Northwest.
- **No Coal Scenario**. This scenario assumes that all coal plants operating in the Pacific Northwest or serving Pacific Northwest loads would be retired. As such, no coal capacity would exist under this scenario.

Table 2-9 presents assumptions about the capacity of coal generation that would serve Northwest loads under the No Action Alternative (base case) and the study of coal generation scenarios.[22]

Table 2-9. Coal Power Plants Retirement Assumptions

Coal Plant	No Action Alternative (Base Case) (MW)	Limited Coal Retirement Scenario (MW)	No Coal Scenario (MW)
Centralia 2 (WA)	670	0	0
Colstrip 3 (MT)	518	0	0
Colstrip 4 (MT)	681	681	0
Hardin (MT)	119	0	0
Jim Bridger 1 (WY)	530	0	0
Jim Bridger 2 (WY)	530	0	0
Jim Bridger 3 (WY)	530	530	0
Jim Bridger 4 (WY)	530	530	0
Montana 1 (MT)	4	0	0
North Valmy 2 (NV)	134	0	0
Total	**4,246**	**1,741**	**0**

Table 2-10 and Figure 2-1 present the LOLP associated with No Action Alternative, and alternative coal plant closure scenarios. As shown, the alternative scenarios where additional coal is assumed to retire would substantially increase LOLP. For context, a 50 percent LOLP indicates blackouts or emergency measures in about every other year. The LOLP for the No Action Alternative where all coal is retired would be 63 percent. To reduce this LOLP to the base-case LOLP (6.6 percent) under the zero-carbon portfolio, the analysis assumes that 600 MW of demand response (the NW Council target) and 1,696 MW of Montana wind (the effective transmission transfer capability following the Colstrip closure 1-4). The addition of these resources would lower the LOLP to 53

[22] These analyses focus on the LOLP and the impacts to the fixed costs of the Pacific Northwest power system that would result; therefore, a full analysis was not prepared.

percent and are represented by the first blue diamond in Figure 2-2. [23] Subsequently, the analysis added 22,000 MW of solar and 4,000 MW of storage to lower the LOLP to the No Action Alternative level of 6.6 percent.

[23] Figure 2-2 does include 1,696 MW of Montana wind (the amount of currently available transfer capability with Washington's state share of freed up Colstrip 3&4 Transmission) and 600 MW of demand response.

Table 2-10. Coal Capacity Assumptions Zero-Carbon Replacement Resources

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 as Impacted by Additional Coal Retirement (MW)	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Incremental Resource Build 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%	3,540	+3,540	43%	13,000	+660	79%	35,000	+3,460
MO4	30%	5,600	+5,600	55%	12,000	0	81%	30,000	0
PA	6.4%	0	0	24%	8,600	0	59%	27,000	0

Notes: The replacement resources for No Action include demand-response, wind, and solar; for MO1 and MO3, the analysis additionally includes storage (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.

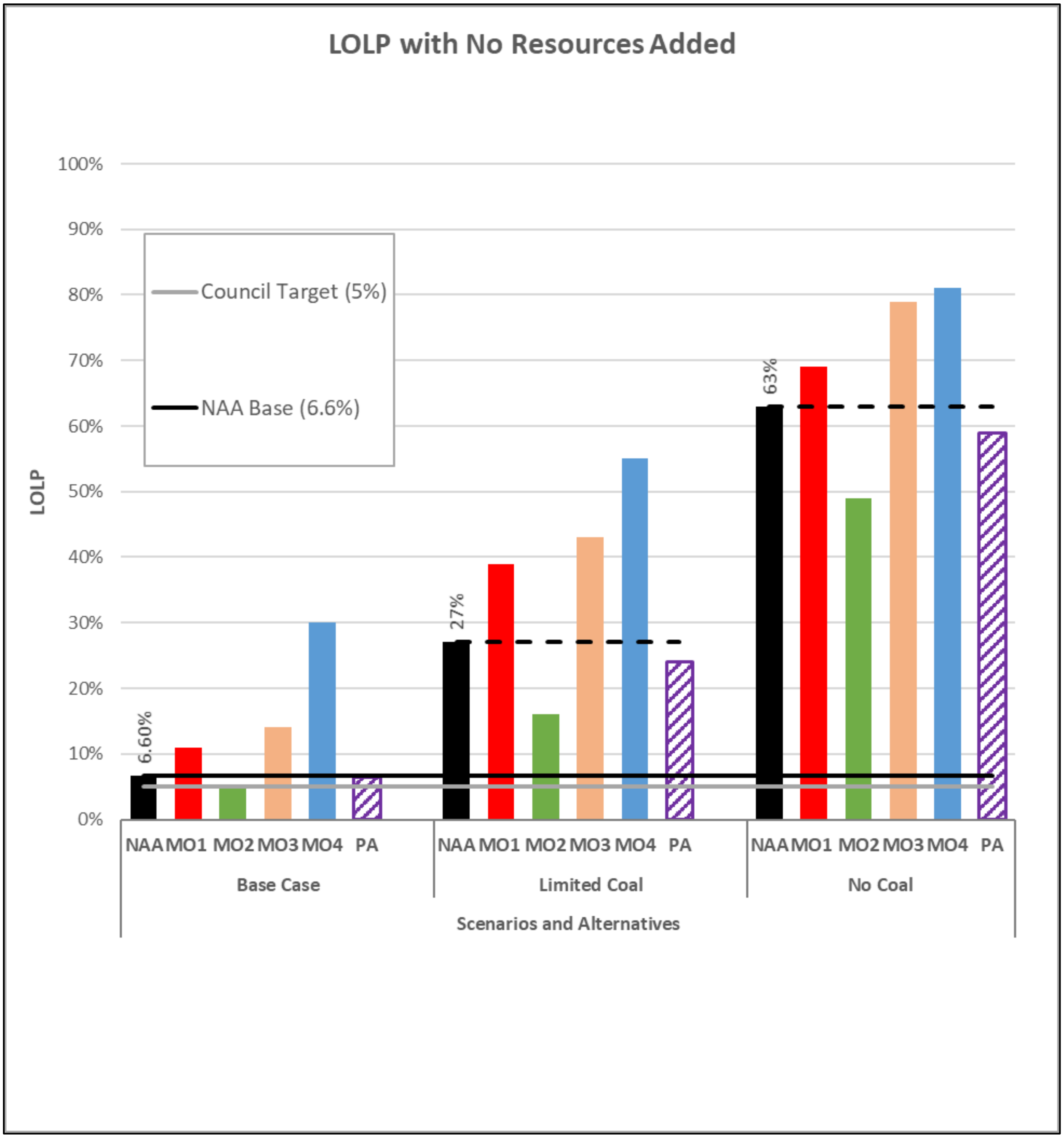

Figure 2-1. LOLP for Coal Capacity Scenarios Before Potential Replacement Resources Are Evaluated

Under the zero-carbon portfolio, MOs are assumed to utilize up to 5,000 MW of solar replacement power, which would be the most cost-effective way to serve load. However, the effectiveness of solar to serve load rapidly becomes less effective in reducing LOLP for requirements that exceed 5,000 MW. As shown in Figure 2-2, the first 5,000 MW of solar to replace the coal plants is relatively effective in reducing anticipated LOLP, but the curve flattens out at this point and additional solar becomes less effective in reducing LOLP.[24] Because of the declining effectiveness of solar as a regional replacement for coal plant closures, energy storage is assumed to be utilized in MOs to lower the costs of the replacement portfolios (the red squares in Figure 2-2 include 4 gigawatts (GW) of energy storage, which is almost twice the amount of utility-scale battery-storage capacity that the EIA (2019b) projects for the United States nationwide for 2023).

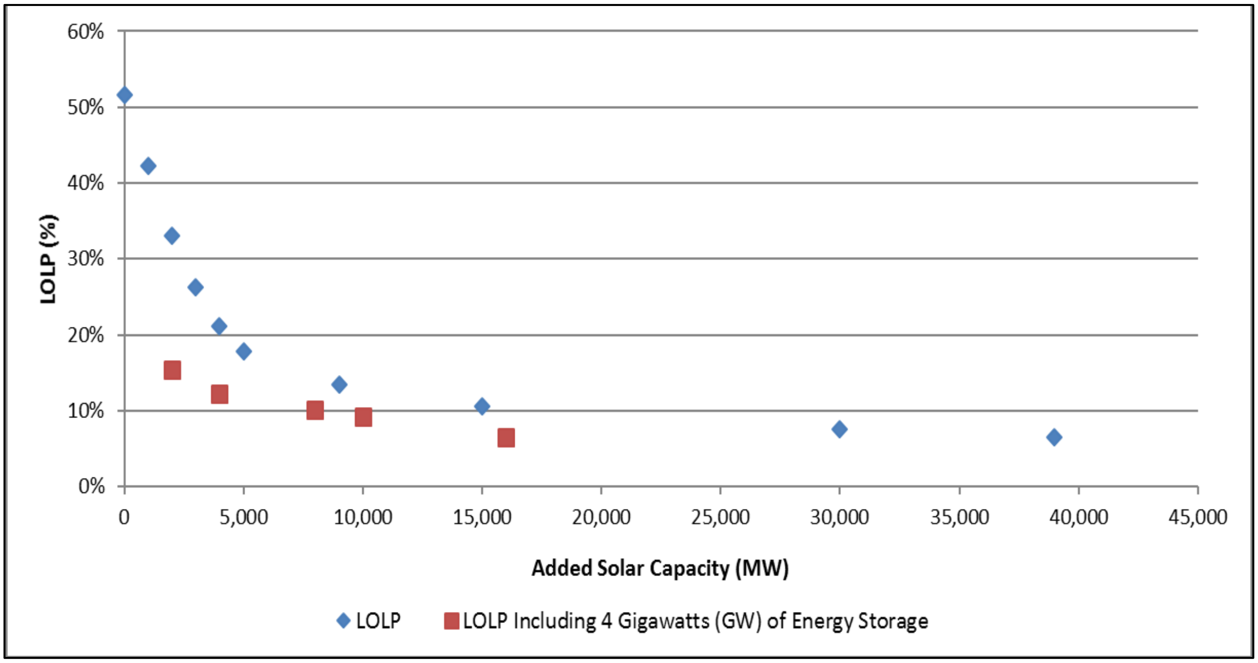

Figure 2-2. Effectiveness of Solar at Reducing LOLP under the No Coal Scenario, Including 600 MW of Demand Response and 1,696 MW of Montana Wind

All of the LOLP studies include 4,905 MW of existing wind generating facilities located near the Columbia River Gorge dedicated to serve Pacific Northwest loads. For the CRSO analysis, additional wind in the Gorge was not selected as a zero-carbon replacement resource primarily due to the fact that additional Gorge wind provides very little incremental benefit in reducing the LOLP. Figure 2-3 presents the No Action Alternative (no coal scenario) case where the LOLP is 63 percent with no resource additions. Even after the addition of 25,000 MW of new gorge wind the LOLP remains at 37.1 percent, a reduction of approximately 26 percent. In contrast, the addition of 25,000 MW of solar capacity would reduce LOLP to below 10 percent (a reduction of approximately 40 percent).

[24] The base assumption is that the No Action Alternative includes 550 MW of solar, so this represents an additive amount of solar in addition to that base amount.

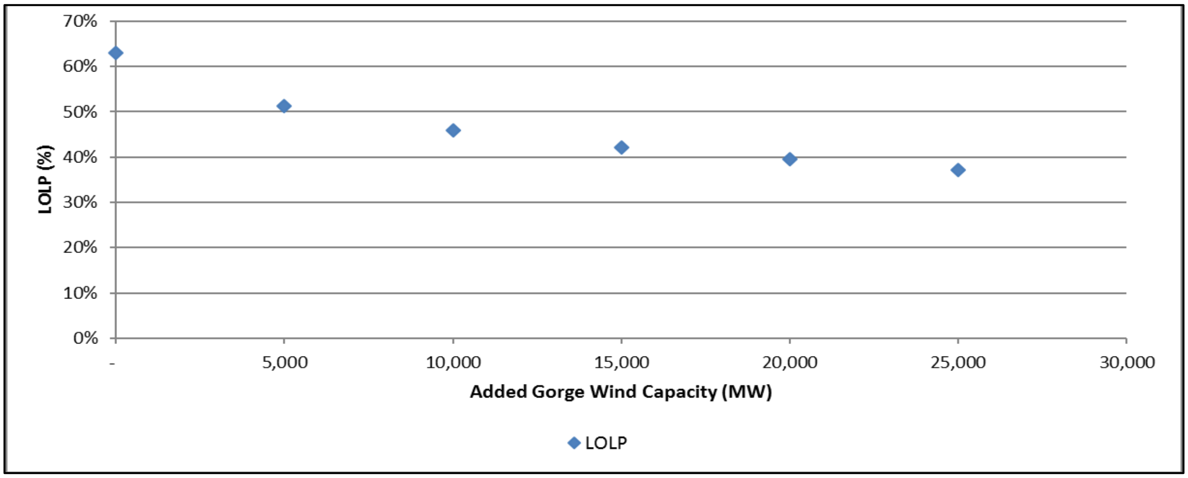

Figure 2-3. Summary of LOLP under the No Action Alternative in the No Coal Scenario with Additional MWs of Gorge Wind

2.3.1 Other Potential Solutions to Replace Coal and Hydropower

Without coal and with less hydropower, the capital investment costs of the zero-carbon portfolio to maintain regional power system reliability would be in the tens of billions of dollars. Facing a replacement portfolio cost of this magnitude could prompt other actions to replace lost generation such as further development of demand-response programs, pursuit of geothermal energy, or Montana and coastal wind that have generation profiles more closely aligned with Pacific Northwest area loads (see Figure 2-4) as well as new technologies not yet available at utility scale.

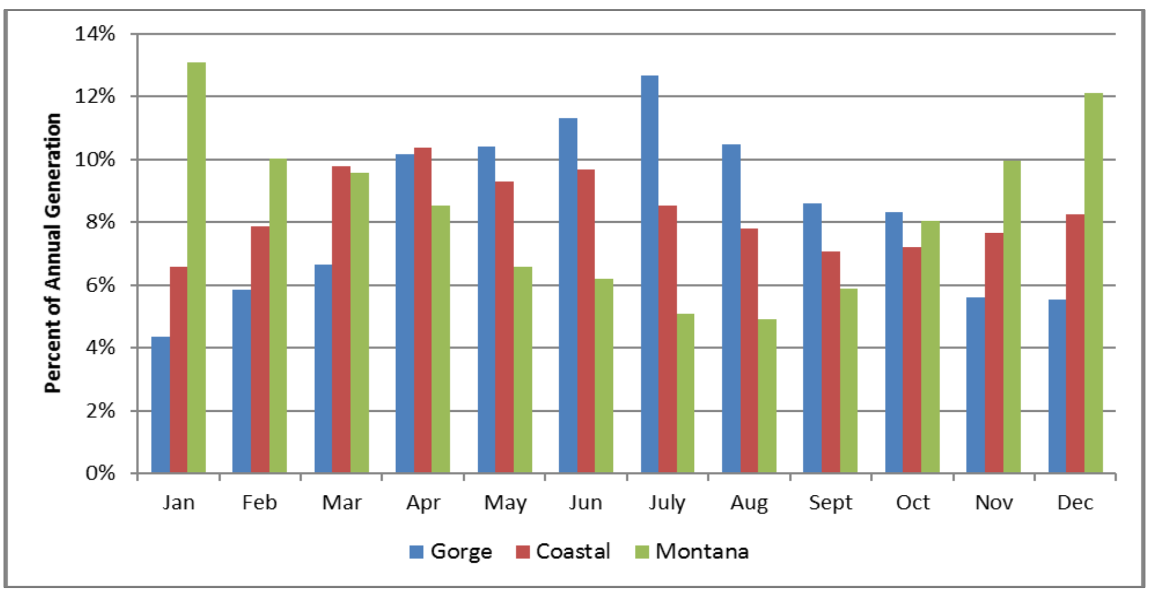

Figure 2-4. Wind Energy Distribution by Region

Note: Monthly generation profiles are the average monthly generation since 2011. Gorge is the Milner Dam Wind Park in Idaho; Coastal is the Coastal Energy project in Washington; and Montana is the Judith Gap Wind Energy Center.

Source: EIA 2019a

2.3.2 Summary Results: Meeting Load

In summary, the amount of zero-carbon replacement resources required to return the region to the No Action Alternative target of 6.6 percent LOLP are substantial under a limited coal or no coal scenario. To meet that level, MO3 would require between 4,000 MW and 7,000 MW of zero-carbon replacement resources over the No Action Alternative alone (requiring around 60,000 to 110,000 acres). Table 2-11 below shows the replacement resources that would be required (in MW of capacity) for each alternative to meet the No Action Alternative LOLP.

This analysis does not include the additional amount of generation reserves needed to integrate new renewable resources under a zero-carbon replacement resource portfolio. Generation reserves allow grid operators to increase or decrease generation in response to changes in load and generation. In this analysis, the generation 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. Currently, generation 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. MO3 and MO4 reduce the flexibility of the hydropower system to supply these generation reserves.

Table 2-11. Potential Renewable Resources Required to Meet 6.6 Percent LOLP, Total and Difference from No Action (MW)

Alternative	Demand Response (MW)	Montana Wind (MW)	Solar (MW)	Energy Storage (MW)[/4]
Base Case				
No Action	0	0	0	0
MO1	0 + 600	0+0	0 +1,200	0+0
MO2[1/]	0 + 0[1/]	0+0[1/]	0+0[1/]	0+0
MO3	0 + 600	0+0	0 +1,960	0+980
MO4	0 + 600	0+0	0 +5,000	0+0
PA	0 + 0[2/]	0 + 0[2/]	0 + 0[2/]	0 + 0[2/]
Limited Coal[3/]				
No Action	600	1,696	4,000	2,500
MO1	600 + 0	1,696 + 0	4,000 + 500	2,500 + 0
MO2	600 + 0	1,696 + 0	4,000 - 2,900	2,500 + 0
MO3[5/]	600 + 0	1,696 + 0	4,000 + 3,200	2,500 + 1,000
MO4	600 + 0	1,696 + 0	4,000 + 3,200	2,500 + 0
PA	600 + 0	1696 + 0	4,000 – 200	2,500 + 0
No Coal[3/]				
No Action	600	1,696	22,000	4,000
MO1	600 + 0	1,696 + 0	22,000 - 1,000	4,000 + 0
MO2	600 + 0	1,696 + 0	22,000 - 6,100	4,000 + 0
MO3	600 + 0	1,696 + 0	22,000 + 6,000	4,000 + 1,000
MO4	600 + 0	1,696 + 0	22,000 + 1,400	4,000 + 0
PA	600 + 0	1,696 + 0	22,000 - 1,000	4,000 + 0

Note: In each cell, the first number refers to the amount of renewable energy capacity needed to replace the retired coal plants and the second number is the additional capacity needed to replace lost hydropower generation from the MOs. In a few cases, the MOs reduce the amount of new resources needed compared to the No Action Alternative in the scenarios with limited or no coal.

1/ MO2 under all coal scenarios would create a reliability benefit. Therefore, the amount of resources relative to the No Action Alternative is negative representing a potential avoided build of replacement resources. The avoided build in the base case would be 600 MW of demand response, 660MW of Montana wind and 250 MW of solar.

2/ The PA, under the base analysis, results in approximately the same LOLP as the No Action Alternative and would not require the addition of new resources.

3/ The limited coal scenario includes 1,741 MW of remaining coal capacity and the no coal scenario has 0 remaining coal capacity.

4/ Some scenarios more than double the EIA projected U.S. battery storage capacity projected for 2023.

5/ Returning MO3 to a LOLP of 6.6% does not replace the LSR sustained ramping or reserve capabilities.

Figure 2-5 depicts the marginal resource build required under the MOs relative to the No Action Alternative considering the limited or no coal scenario to restore the LOLP. With less coal in the Pacific Northwest, MO3 replacement resources would require more additional renewable resources because solar is less effective at replacing the winter loss of power from the LSR dams than the summer power losses. For MO3 it may be cost-effective to add battery storage for peak demand.

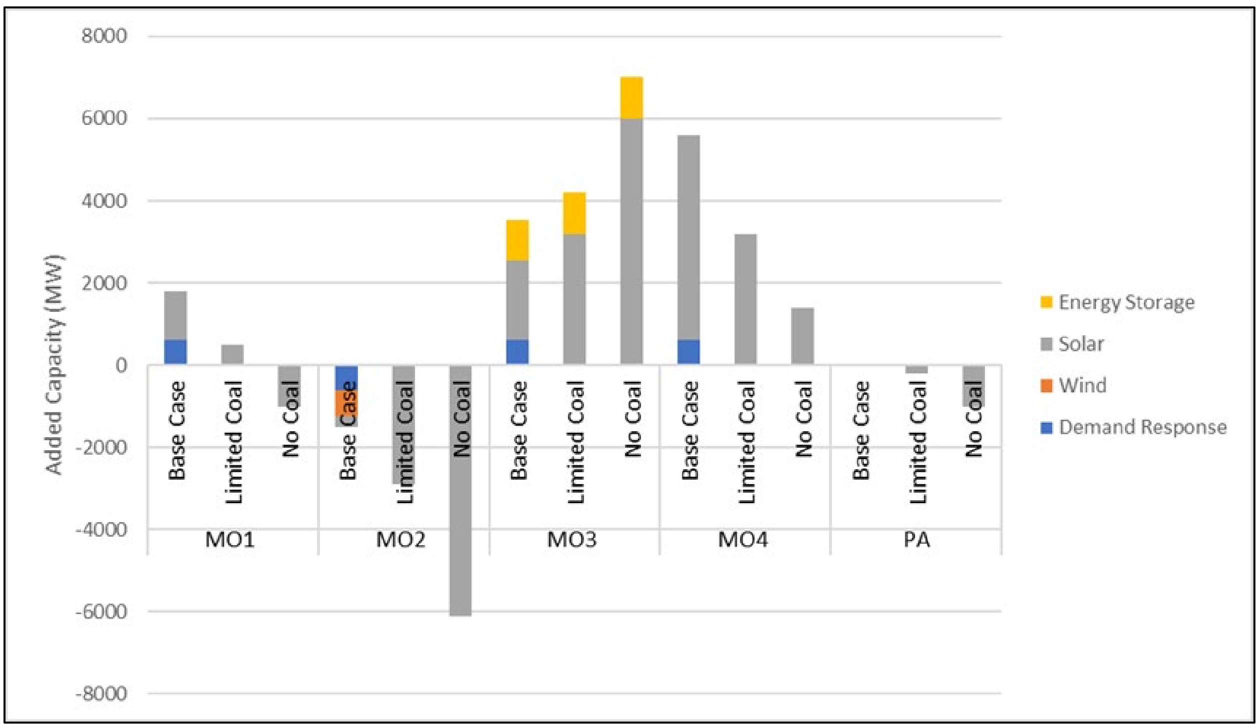

Figure 2-5. Marginal Resource Build above No Action for the Base Case, Limited Coal and No Coal in MW

Note: For the no coal scenario, the total solar is -1,000 MW for MO1 and the PA, -6,100 MW for MO2, 6,000 for MO3 and +1,400 MW for MO4. See Table 2-11 for the full coal scenario resource results.

2.4 COMPARISON OF THE NWEC STUDY WITH THE MO3 ALL-GAS ALTERNATIVE

In March 2018, the NW Energy Coalition (NWEC) released a report prepared by Energy Strategies Inc. that evaluated the effects of replacing the four lower Snake River 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 (NW Energy Coalition 2018). 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 NWEC study uses older load data and natural gas price forecasts, has lower estimates for transmission-related costs, and therefore underestimates impacts to Bonneville ratepayers. The EIS analysis for MO3 includes not only dam breaching, but other measures as well. Dam breaching accounts for roughly 90 percent of the average generation lost in MO3 and perhaps a larger fraction of the reliability impact due to when the various measures impact generation.

2.4.1 Scenarios

The MO3 replacement resource portfolios were designed to include enough new generating resources so that power system reliability was equal to that of the No Action Alternative (i.e., LOLP would equal 6.6 percent). The Northwest Energy Coalition (NWEC) study, by contrast, does not target a specific LOLP nor does it include enough information to extrapolate the cost of its all-gas alternative with an LOLP equal to that of the reference scenario (i.e., the NWEC equivalent of the No Action Alternative). However, every portfolio considered in the NWEC study has an LOLP below the 5 percent LOLP standard after including replacement resources. In total, NWEC examined nine portfolios including combinations of demand response, energy efficiency, renewables and non-generating resources, and natural gas. This comparison focuses on the natural gas scenarios.

2.4.2 Natural Gas Replacement Resource Portfolio

Examining the NWEC all-gas alternative and the MO3 conventional least-cost portfolio, the two portfolios are similar in their conclusions about the amount of replacement resource capacity that would be required. However, there is a difference in the type of natural gas replacement resources, as the NWEC studies use some level of reciprocating engines instead of combined cycle natural gas turbines. Table 2-12 below compares the portfolios.

Table 2-12. Comparison of NWEC and MO3 Portfolios (Installed MW)

Resource	NWEC All Gas	MO3 Conventional Least-Cost
Combined Cycle	500	1,120
Reciprocating Engines	450	--
Total	950	1,120

2.4.3 Variable Costs

The following tables outline the differences in total variable costs between the NWEC and MO3 portfolios. The difference is substantial, amounting to approximately a factor of three. Variable costs in the CRSO are derived from the changes in fuel consumption and other variable costs using the AURORA model. The NWEC study used GENESYS to estimate the total production costs as changes in fuel consumption and regional imports and exports. NWEC concludes that annual production costs would be $335 million (Table 2-13). That amount consists of $253 million in fuel-related costs and $82 million from loss of exports.

Table 2-13. Comparison of Variable Costs

Costs	NWEC All Gas	MO3 Conventional Least-Cost	NWEC All Gas (Low Cost)
Variable Costs	$335 million	$112 million	$198 million

The large difference in fuel-related costs between the two studies results from a difference in gas price forecasts. For the NWEC study, the average gas price at all hubs is $4.97 per million British thermal units (MMBTU), while the MO3 uses a figure of $2.20/MMBTU at Stanfield. For the M03 study, even the highest 5 percent of simulations had a lower gas price ($4.13/MMBTU) than the NWEC study. The differences in gas prices make up 90 percent of the fuel costs differences that drive the $253 million discrepancy in production costs. Table 2-14 below presents the gas prices and the estimate of MO3 fuel costs using the 5th and 95th percentile fuel costs.

Table 2-14. Fuel Prices and Total Production Costs

Measure	Gas Prices/Costs		
	Lowest 5%	**Average**	**Highest 5%**
Fuel Prices ($/MMBTU)			
MO3 Average Fuel Price	1.13	2.20	4.13
NWEC Hub Fuel Price (Average Only)	4.97	4.97	4.97
Production Costs			
MO3 Production Costs	$73 million	$137 million	$227 million
NWEC Production Costs (Average Only)	$253 million	$253 million	$253 million
MO3 as a Percentage of NWEC Costs	28.9%	54.2%	89.7%

To calculate regional energy imports and exports, the NWEC study only examined the Pacific Northwest, where M03 looks WECC-wide. The NWEC methodology concludes that the all-gas scenario would result in a lowering of net exports out of the region by $82 million The MO3 methodology, by contrast, is not set up to account for such a loss. A more precise analysis under MO3 would be required in order to estimate any potential loss of revenue from power exports. AURORA does estimate changes in total production costs for California and the rest of the Western United States. These are not directly comparable to changes in regional imports and exports, but they do provide an estimate of changes in regional power generation.

2.4.4 Fixed Costs

Under the NWEC study, the fixed costs are approximately 42 percent higher than the fixed gas costs of M03. One of the major drivers of this difference is the drop in estimated fixed gas transmission costs between the 7th Power Plan and the latest estimates from the 8th Power

Plan. These cost estimates are partially dependent on the fuel efficiency of the gas plant, but in general these fixed costs have dropped from $62.60/kW in the 7th Power Plan to $41.40/kW for the 8th Power Plan. Table 2-15presents the annualized replacement resource fixed costs.

Table 2-15. Total Fixed Costs

Costs	NWEC All Gas	MO3 Conventional Least-Cost	NWEC All Gas (Low Cost)
Fixed Costs	$200 million	$138 million	$60 million

Note: The fixed costs include the annualized capital costs, transmission and gas pipeline costs.

2.4.5 Summary

The differences in overall results between NWEC and MO3 conventional least-cost is largely explained by the differences in fuel price forecasts. The higher price per MMBTU in the NWEC study generates a total variable cost nearly three times higher than that of the MO3 conventional least-cost portfolio. The fixed costs are comparable between the two studies, with discrepancies coming from the use of more recent data in MO3.

In December 2019, Northwest RiverPartners released a report prepared by EnergyGPS Consulting, LLC (EGPSC) (2019), reviewing the above NWEC study. The review points out that the NWEC study relied on load and resource forecasts that are now over three years old and now out-of-date, in large part due to changing regional energy and climate policies (EnergyGPS 2019). Many more coal-plants are slated for retirement since the NWEC study, and the authors expect that all cost-effective demand response and energy efficiency resources will be used to replace the lost coal generation. 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 review paper 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 (EnergyGPS 2019). This portfolio would cost about $860 million per year or $96/MWh.

CHAPTER 3 - TRANSMISSION SYSTEM RELIABILITY AND CONGESTION

The following sections present the results of analyses for regional congestion and the reliability of the Bonneville transmission system. These analyses build on the power generation results as discussed in Appendix J, *Hydropower* and the power system reliability results discussed in Chapter 2, *Power Supply and Replacement Resources*, of this appendix. The regional transmission congestion forecasting was a standalone result of the transmission modeling while the Bonneville transmission system reliability analysis was an input to the Bonneville transmission rate pressure analysis (as described in Chapter 4, *Wholesale Power and Transmission Rates*, of this appendix). The following sections describe the methodology, data, and results of the regional congestion forecasting and Bonneville transmission system reliability analyses that supports the transmission discussion in Chapter 3, Section 3.7*, Power Generation and Transmission* of the main body of the EIS.

Based on the power system reliability analysis described in Chapter 2 of this appendix, the resource mix and general geographic location of replacement resources for each alternative and for each base case resource replacement portfolio were identified to maintain the LOLP under each of the alternatives (see Chapter 2). The resource mix and general locations were then considered with past Bonneville interconnection requests and existing infrastructure to identify reasonable locations for siting replacement resources as shown in Table 3-1 through Table 3-3below.

Table 3-1. Conventional Least-Cost Replacement Resources and Assumed Locations

Alternative	Total Amount (MW) and Assumed Location
MO1	560 MW, gas-fired simple-cycle combustion turbines in north central Oregon near McNary Substation.
MO2	N/A (LOLP under this alternative is lower than under No Action Alternative).
MO3	1,120 MW of gas-fired combined-cycle turbines in north central Oregon near McNary Substation.
MO4	3,240 MW of gas-fired simple-cycle combustion turbines in north central Oregon and southeast Washington.
PA	N/A (LOLP under this alternative is lower than under No Action Alternative).

Table 3-2. Zero-Carbon Replacement Resources and Assumed Locations

Alternative	Location
MO1	1,200 MW of solar generation in south central Oregon, and 600 MW of demand response in Spokane, Portland, and Seattle.
MO2	N/A (LOLP under this alternative is lower than under No Action Alternative).
MO3	1,960 MW of solar generation in eastern Oregon[1/]; 600 MW of demand response in Spokane, Portland, and Seattle.
MO4	5,000 MW of solar generation in south central Oregon, north central Oregon, central Washington, south central Idaho, and 600 MW of demand response in Spokane, Portland, and Seattle.
PA	N/A (LOLP under this alternative is lower than under No Action Alternative).

Note: [1/] 980MW of battery storage capacity was also added in eastern Oregon for the congestion analysis.

Table 3-3. Detailed Zero-Carbon Replacement Resources and Assumed Locations

Approximate Replacement Resource Location	Replacement Resource Amount				
	MO1	MO2	MO3	MO4	PA
Demand Response					
Spokane	300 MW	--	300 MW	300 MW	--
Portland	200 MW	--	200 MW	200 MW	--
Seattle	100 MW	--	100 MW	100 MW	--
Solar					
Captain Jack Substation	--	--	999 MW[1/, 2/]	1,250 MW	--
Grizzly Substation	1,200 MW	--	961 MW[1/, 2/]	1,250 MW	--
Slatt Substation	--	--	--	1,250 MW	--
Wautoma Substation	--	--	--	625 MW	--
Midpoint Substation	--	--	--	625 MW	--

Note: The substations listed are the assumed interconnection points and do not represent the location of the replacement resource itself.

1/Battery storage capacity was assumed to be added near Bonneville's Grizzly Substation (480 MW) and Captain Jack Substation (500MW) for the congestion analysis.

2/ See Section 3.7.3.5 of the EIS, *Effects on Transmission Flows, Congestion, and the Need for Infrastructure*, Section 3.2.1 of Appendix H for a discussion of the effects associated with including batteries on transmission system reliability in the base case Zero-Carbon Replacement Resource.

3.1 REGIONAL CONGESTION FORECASTING

The regional transmission congestion analysis relies on a production cost modeling analysis to evaluate how changes in the operation of the CRS projects and the replacement resources under each alternative would alter the utilization of the transmission system in the Pacific Northwest. This section provides an overview of the production cost modeling analyses for the MOs.

Production cost modeling allocates the available generating resources to the required load in a way that minimizes the overall cost of operation. The allocation of available generating units conforms to the operating constraints of the generators and the transmission system. The regional transmission congestion analysis used the GridView modeling package (which is developed by ABB, Inc.) for the production cost modeling. GridView simulates the conventional least-cost (i.e. most economic) operation of a power system in hourly intervals for periods ranging from one day to many years. For the CRSO EIS congestion analysis, a one-year window with an hourly time step was used to produce a forecast of the utilization of generating resources and power flow patterns across the transmission system.[25] Gridview incorporates

[25] All values produced using GridView are averages over hourly intervals. Values cited as maximums and minimums are calculated from these hourly averages. Maximums and minimums based on values averaged over shorter time intervals or on values taken instantaneously (e.g. SCADA) may be higher and lower respectively. Any references to instantaneous engineering units (e.g. MW) used in all tables and charts are implicitly suffixed with "averaged over the hour."

detailed hourly generation and load modeling, and a nodal transmission system representation of the Western Interconnection derived from powerflow modeling.

WECC's 2028 Anchor Data Set (ADS) case (Version 2.2 released 1/25/2019) provides the basis for development of the base case used in the congestion forecast studies. This ADS case is the best publicly available utility-provided modeling information forecasted for 2028 for generating resources, customer loads, and transmission expansion plans for the Western Interconnection.

As discussed in Appendix J, *Hydropower,* the operating restrictions and limitations for each hydropower project along with its historical water run-off data produces forecasted monthly values for average energy production at each project. Monthly maximum and minimum generation limits were also provided for several Federal hydropower projects in the Pacific Northwest. The congestion analysis uses the monthly values as inputs to determine the individual project's hourly generation for each month. To assess the operation of the hydropower system over the range of future water run-off scenarios, the congestion analysis uses the hydropower generation results for historical run-off for three years representing median (1960), high (1997), and low (1931) flows. A description of the hydropower generation results that serve as inputs to the transmission analysis are available in Appendix J, *Hydropower*.

GridView was run for the two base case resource replacement scenarios (conventional least-cost and zero-carbon), for each CRSO alternative.[26] Resource replacement portfolios were not run for the No Action Alternative, MO2, or the Preferred Alternative because neither alternative would result in changes in power system operations and generation that would require resource replacement. A total of 36 GridView case runs are included in the transmission congestion analysis.

The structural and operational measures with the studied alternatives and their resource replacement portfolios would result in shifts in generation across the Pacific Northwest and the entire Western Interconnection. Shifts in the pattern of generation can alter the ranges of power flows expected across transmission interfaces.[27] Power flow changes that approach transmission interface limits indicate the risk that changes to generation dispatch may be needed. In certain cases, this may also indicate increased reliability risk to the regional transmission system.[28] This analysis assumes that implementation of the studied alternatives and their resource replacement portfolios would not require changes in any transmission

[26] GridView was also run for a no resource replacement scenario. These results are not used in this analysis.
[27] A transmission interface in this context refers to a collection of one or more transmission facilities for which the aggregate power flow is monitored in GridView. Transmission interface definitions generally correspond to the flow on one or more WECC-rated paths, Bonneville internal flowgates, or other similar sets of related transmission facilities.
[28] The modeled limit in GridView for an interface could represent a system operating limit, total transfer capability, or WECC Path Rating.

interface definitions or limits.[29] The assumed system 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 GridView studies that were performed. Transmission interface limits are assumed to reflect "all lines in service" conditions throughout the entire year, so the potential impact of planned maintenance or forced outages on congestion is excluded. A map of regional transmission lines and flowgates that generally correspond to the transmission interfaces used in the GridView analysis is provided in Figure 3-1.

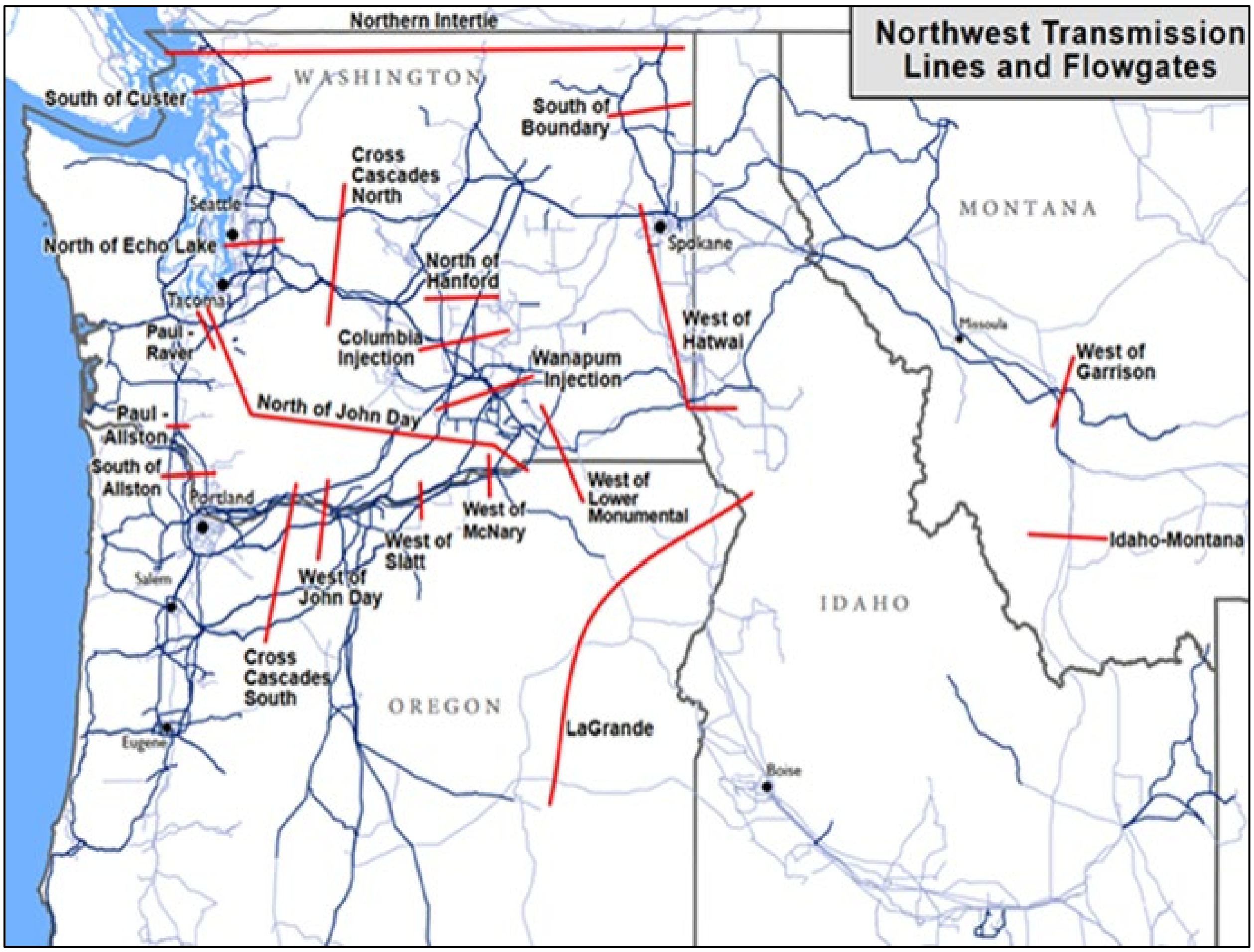

Figure 3-1. Northwest Transmission Lines and Flowgates

In this analysis, transmission interfaces experiencing flows within 0.1 percent of its current transfer limit are said to be "congested." The change in the number of congested hours is one

[29] The transmission path transfer capabilities are established based on what is the most limiting element (the amount power that transmission equipment or line(s) can accommodate). Removing generation from one location and replacing it in another location can change the limiting element. In some cases, even the path limits need to be changed. The 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 impacts to congestion would be greater than those identified in the congestion analysis.

measure of the impact that the alternatives and their resource replacement portfolios have on the regional transmission system. Transmission interfaces that are congested can, therefore, restrict the dispatch of lower cost generating plants and instead require the dispatch of higher cost generating plants, which increases the overall cost of serving customer loads.

While the WECC ADS is the primary dataset used in the GridView analysis, transmission interface limits were updated with Bonneville's most current information at the time of the study. For transmission interfaces in which limit information was only available in one direction, the limit for the opposite direction was assumed to be of equal magnitude. Table 3-4 shows the transmission interface limits based on the WECC ADS on the regional transmission system and also on certain key interfaces in Canada, Montana and Idaho. Table 3-5 shows the updates to the transmission interface limits based on Bonneville's current information.

Table 3-4. Pacific Northwest Transmission Interfaces and Limits

Interface Name	Direction 1 Limit (MW and Direction)		Direction 2 Limit (MW and Direction)	
P01 ALBERTA-BRITISH COLUMBIA	1,000	East-to-West	1,200	West-to-East
P03 NORTHWEST-BRITISH COLUMBIA	3,000	South-to-North	3,150	North-to-South
P03EAST SIDE NW-BC	400	South-to-North	400	North-to-South
P03WEST SIDE NW-BC	2,750	South-to-North	2,850	North-to-South
P04 WEST OF CASCADES-NORTH	10,250	East-to-West	10,250	West-to-East
P05 WEST OF CASCADES-SOUTH	7,500	East-to-West	7,500	West-to-East
P06 WEST OF HATWAI	4,277	East-to-West	4,250	West-to-East
P08 MONTANA TO NORTHWEST	2,200	East-to-West	1,350	West-to-East
P14 IDAHO TO NORTHWEST	2,400	East-to-West	1,200	West-to-East
P16 IDAHO-SIERRA	500	North-to-South	360	South-to-North
P17 BORAH WEST	4,450	East-to-West	4,450	West-to-East
P18 MONTANA-IDAHO	383	North-to-South	256	South-to-North
P19 BRIDGER WEST	4,100	East-to-West	2,300	West-to-East
P20 PATH C	2,250	West-to-East	2,250	East-to-West
P25 PACIFICORP/PG&E 115 KV INTER	100	North-to-South	45	South-to-North
P65 PACIFIC DC INTERTIE (PDCI)	3,220	North-to-South	3,100	South-to-North
P66 COI	4,800	North-to-South	3,675	South-to-North
P71 SOUTH OF ALLSTON	3,100	North-to-South	1,480	South-to-North
P73 NORTH OF JOHN DAY	8,800	North-to-South	8,800	South-to-North
P75 HEMINGWAY-SUMMER LAKE	1,500	East-to-West	550	West-to-East
P80 MONTANA SOUTHEAST	600	East-to-West	600	West-to-East
P83 MONTANA ALBERTA TIE LINE	325	South-to-North	300	North-to-South
BPA 01 TRICITIES	1,050	Import	--	Export
COLUMBIA INJECTION	1,300	Import	--	Export
NORTH OF ECHO LAKE	2,800	South-to-North	--	North-to-South
NORTH OF HANFORD	4,450	North-to-South	4,450	South-to-North
PAUL-ALLSTON	2,400	North-to-South	2,400	South-to-North
RAVER-PAUL	1,450	North-to-South	1,450	South-to-North
SOUTH OF BOUNDARY	1,400	North-to-South	--	South-to-North
SOUTH OF CUSTER	1,850	North-to-South	--	South-to-North
WEST OF JOHN DAY	4,530	East-to-West	4,530	West-to-East

Interface Name	Direction 1 Limit (MW and Direction)		Direction 2 Limit (MW and Direction)	
WEST OF LOWER MONUMENTAL	4,200	East-to-West	4,200	West-to-East
WEST OF MCNARY	5,230	East-to-West	5,230	West-to-East
WEST OF SLATT	4,670	East-to-West	4,670	West-to-East

Table 3-5. Bonneville Transmission Interface Limit Changes

Interface Name	Direction	Limit in ADS Case (MW)	New Bonneville Limit (MW)
TRICITIES AREA IMPORT	Import	--	1,050
P04 WEST OF CASCADES-NORTH	East-to-West	10,700	10,250
P05 WEST OF CASCADES-SOUTH	East-to-West	7,605	7,500
P14 IDAHO TO NORTHWEST	East-to-West	3,400	2,400
P14 IDAHO TO NORTHWEST	West-to-East	2,250	1,200
P73 NORTH OF JOHN DAY	North-to-South	8,000	8,800
NORTH OF ECHO LAKE	North-to-South	2,636	2,800
NORTH OF HANFORD	North-to-South	5,100	4,450
RAVER-PAUL	North-to-South	1,800	1,450
SOUTH OF CUSTER	North-to-South	2,832	1,850
WEST OF JOHN DAY	East-to-West	3,750	4,530
WEST OF MCNARY	East-to-West	5,000	5,230
WEST OF SLATT	East-to-West	4,200	4,670
Z CG PDCI SOUTH	North-to-South	2,800	Removed

Note: The interface Z CG PDCI South was duplicative of the PDCI Interface and was removed from the ADS case.

3.1.1 Transmission Interface Utilization Results

Given the hydropower generation levels under each CRSO alternative, the gas-fueled replacement generation resources added for the conventional least-cost resource replacement portfolio were regularly called on as part of GridView's hourly least-cost generating dispatch process.[30]

When the zero-carbon resource replacements were added with the hydropower generation levels under each alternative, additional solar generation was assumed to be non-dispatchable with a fixed hourly output and zero variable cost. It had an approximately 23 percent capacity factor. About 274 aMW, 583 aMW, and 1,152 aMW of the solar resource replacements for MO1, MO3, and MO4 respectively were called upon. Dispatch of the added battery storage in the zero-carbon resource replacement base case portfolio for MO3 was managed by GridView as part of its hourly least-cost generating dispatch process. Battery storage was dispatched when the differences between hourly locational marginal prices (LMPs) were enough to make the value of the energy discharged during hours of high LMPs greater than the cost of the energy needed to charge the batteries during hours of low LMPs. In these GridView cases, systemwide solar generation produced a daily pattern in LMP pricing that drove the dispatch of the battery storage. Although Demand Response would be necessary to meet power resource adequacy standards

[30] Conventional least-cost use was predicted on gas hub price forecasts, as described above in Chapter 2, *Power Supply and Replacement Resources.*

under both resource replacement portfolios, because it was assumed to be a high variable cost dispatch resource, it was never called upon in the transmission congestion modeling.

Figure 3-2 identifies the regional transmission interfaces that became congested for at least one hour during the GridView simulations for any of the studied alternatives. The middle (darker) dot is the number of congested hours for median run-off cases (without portfolios) for each alternative. The outer (lighter) dots are the maximum and minimum number of hours for all cases run for that alternative (i.e. three runs for No Action Alternative, MO2, and the Preferred Alternative; nine runs for MO1, MO3, and MO4).

The changes in the patterns of generation under the MO alternatives and their resource replacement portfolios and the Preferred Alternative would have measurable impacts on loading and congestion for many regional transmission interfaces. The changes in the numbers of congested hours on most transmission interfaces, however, are small in comparison to the changes related to variations in hydropower generation related to different run-off conditions.

Congested transmission interfaces can restrict the use of lower cost generating plants in the region and in the WECC and end up requiring the dispatch of higher cost generating plants. Using the higher cost generating plants increases the overall cost of serving customer loads. Congestion constraints on the transmission system as a result of hydropower generation or resource replacement portfolios under the alternatives can also lead to the restriction or curtailment of renewable resource generation, such as wind and solar, as part of the conventional least-cost (i.e. economic) dispatch. This shift in the use of generating resources may result in the use of resources that produce higher levels of greenhouse gases (see Chapter 3.8 of the main body of the EIS, *Air Quality and Greenhouse Gases* for more discussion).

The GridView simulation assumes that if available zero variable cost generation in a given hour exceeds the amount that can be delivered to load due to transmission interface limits, then the excess generation must be "curtailed." Under normal conditions, generation from the hydropower projects would be reduced to allow for the excess generation and water would be spilled or stored for later use rather than run through the generating turbines. However, during times of increased hydropower run-off, additional spill or storage is no longer practicable, and the curtailment of both solar and wind generation is necessary.

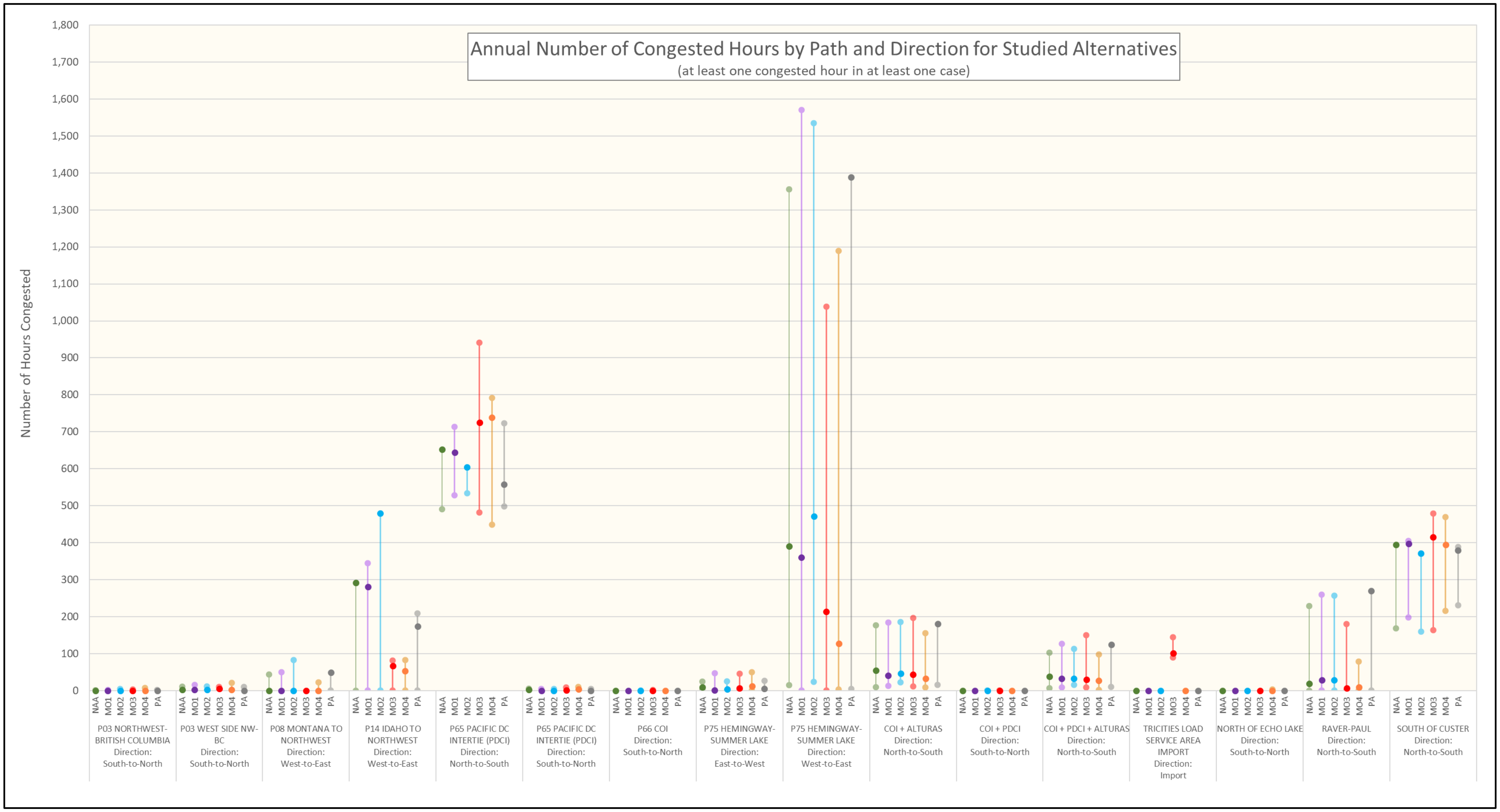

Figure 3-2 Number of Congested Hours by Interface and Direction for Studied Alternatives without Additional Coal Retirements

Under MO1, the solar generation added for the zero-carbon resource replacement portfolio increases combined system-wide solar and wind curtailment by 461 gigawatt hours (GWh) in a heavy run-off years, which is 18.4 percent of the 2,504 GWh produced by the added solar generation. Under MO2, increased hydropower generation increases combined solar and wind curtailment by 721 GWh in a heavy run-off year, which is 15 percent of the 4,811 GWh of higher hydropower generation under MO2. Under MO3, the solar generation added for the zero-carbon portfolio increases combined system-wide solar and curtailment by 58 GWh in a heavy run-off year, which is 1.9 percent of the 3,937 GWh produced by the added solar generation. However, operation of the battery storage capacity would come at the expense of an additional 167 GWh of added system load in a heavy run-off year, which is another 4.2 percent of the 3,937 GWh produced by the added solar generation. Under MO4, solar generation added for the zero-carbon portfolio increases combined system wide solar and wind curtailment by 1,371 GWh in a heavy run-off year, which is 14.2 percent of the 9,659 GWh produced by the added solar generation. Finally, under the Preferred Alternative, changes to hydropower generation change combined system-wide solar and wind curtailment by between 4 GWh and -324 GWh depending on the level of water run-off, which is 0.5% to -17% of the system-wide combined curtailment. These shifts in renewable resource generation and curtailments are modeled at the regional and Western Interconnection-wide scale and allocated based on the security-constrained economic dispatch. These results do not estimate curtailments based on specific Bonneville or other utility oversupply policies.

There can be instances when the generating resources are located within the load service area where transmission congestion could prevent load from being fully served by other generating resources without reinforcing the transmission system to increase capacity. The regional congestion analysis suggested that this may occur under MO3 in the Tri-Cities area due to the location of Ice Harbor Dam within the load service area.

The Tri-Cities transmission interface consists of transmission lines and transformers used to provide service to serve Kennewick, Pasco, and Richland. The Ice Harbor project is also located inside this area, and its output reduces the need for bringing in (importing) power from outside the load area and the need for power to flow across the Tri-Cities transmission interface. When needed imports across the Tri-Cities transmission interface approach 1,050 MW to meet load, there is potential to require reductions to customer loads. The risk increases further when imports exceed 1,160 MW.

Under MO3, flows across the Tri-Cities transmission interface increase substantially compared to any other MOs and the Preferred Alternative due to its removal of all Ice Harbor generation. Table 3-6 shows that there are hours where flows across the Tri-Cities transmission interface would exceed the 1,050 MW and 1,160 MW levels for each hydropower run-off scenario and resource replacement portfolio.

The simulation results indicate that new transmission reinforcements or net load reductions in the Tri-Cities area would likely be needed under MO3 to allow for uninterrupted load service to end users because there are very limited options for managing congestion across the Tri-Cities transmission interface.[31] For transmission interfaces other than the Tri-Cities, any increased congestion identified for the CRSO EIS alternatives would restrict the dispatch of lower cost generating plants. Therefore, the overall cost of serving customer loads increases, but would not prevent customer loads from being served.

Table 3-6. Tri-Cities Import Limit Violations under MO3 without Additional Coal Retirements

Run-Off	Import Limit: 1,050 MW			Import Limit: 1,160 MW		
	MO3	MO3 Conventional Least-Cost	MO3 Zero-Carbon	MO3	MO3 Conventional Least-Cost	MO3 Zero-Carbon
Low Water Run-Off						
Hours Above Limit	124	142	134	16	21	16
Maximum Amount about Limit (MW)	202	213	204	92	103	95
Total of Energy above Limit (MWh)	7,203	8,370	7,277	611	776	656
Median Water Run-Off						
Hours Above Limit	99	109	100	12	15	13
Maximum Amount about Limit (MW)	194	199	197	84	89	87
Total of Energy above Limit (MWh)	5,644	6,330	5,641	474	535	465
High Water Run-Off						
Hours Above Limit	87	98	88	12	16	12
Maximum Amount about Limit (MW)	195	208	193	85	98	83
Total of Energy above Limit (MWh)	5,101	5,792	5,147	410	560	411

These findings are consistent with the Bonneville system reliability assessment as described in Section 3.2 Bonneville Transmission System Reliability and Network Interconnections. Section 3.2 contains additional powerflow results and identifies any needed reinforcements as a result of changes in hydropower generation under the CRSO alternatives.

3.1.2 GridView Congestion Results by Transmission Interface

The following sections detail the congestion results by transmission interface for only those interfaces experiencing congestion as presented in Figure 3-2 above. These transmission interfaces include Bonneville Network flowgates, WECC-rated paths, load service areas, and combinations of flows on multiple parallel interfaces. Some transmission lines are therefore part of more than one congested transmission interface grouping that was modeled. Although many interfaces are bidirectional many interfaces only show congestion occurring for flows in one direction.

[31] For this reason, flows across the Tri-Cities transmission interface were monitored but not used to constrain the economic dispatch

Table 3-7 through Table 3-14 present the total annual congested hours estimated by GridView for low, median and high run-off years for those interfaces and directions that show at least one hour of congestion over one of the scenarios.

3.1.2.1 P03 West Side Northwest to British Columbia

The limit on this interface is 2,750 MW and it is a bidirectional interface that experiences congestion in the south to north direction. Annual congestion is highest in low run-off years with minimal to no congestion occurring during high run-off across all resource replacement portfolios. The largest increases relative to the No Action Alternative occur under MO4 during low-run off conditions under the conventional least-cost resource replacement portfolio.

Table 3-7. Annual Congested Hours for Low, Medium, and High Runoff Years, West Side Northwest to British Columbia, under the No Action and Relative to No Action for all MOs without Additional Coal Plant Retirements (GridView Output)

Interface	Run Off	No Action	MO1 Conv. Least-Cost	MO1 Zero-Carbon	MO2	MO3 Conv. Least-Cost	MO3 Zero-Carbon	MO4 Conv. Least-Cost	MO4 Zero-Carbon	PA
P03 WEST SIDE NW-BC	Low	11	-1	-3	+1	-1	-6	+10	-2	-1
	Median	3	-2	2	-1	+7	+2	-1	-1	+1
	High	0	0	0	+1	0	+1	0	0	0

3.1.2.2 P08 Montana to Northwest

This bidirectional interface has a limit of -1,350 MW and experiences congestion in the west to east direction only. This interface shows changes congestion under high run-off conditions in alternatives with lower hydropower generation relative to the No Action Alternative (specifically with decreases in congestion hours under MO3 and MO4). Relative to the No Action Alternative, the changes in congestion hours are highest under MO2, MO3, and MO4 during high-runoff years.

Table 3-8. Annual Congested Hours for Low, Medium, and High Runoff Years, P08 Montana to Northwest, under the No Action and Relative to No Action for all MOs without Additional Coal Plant Retirements (GridView Output)

Interface	Run Off	No Action	MO1 Conv. Least-Cost	MO1 Zero-Carbon	MO2	MO3 Conv. Least-Cost	MO3 Zero-Carbon	MO4 Conv. Least-Cost	MO4 Zero-Carbon	PA
P08 MONTANA TO NORTHWEST	Low	0	0	0	0	0	0	0	0	0
	Median	0	0	0	0	0	0	0	0	0
	High	44	+6	-2	+39	-44	-44	-35	-21	+5

3.1.2.3 P14 Idaho to Northwest

The Idaho to Northwest bidirectional interface has a limit of -1,200 MW and experiences congestion in the west to east direction only. This interface contains multiple transmission lines, including the Hemingway – Summer Lake transmission line, which is both a part of the Idaho to Northwest Interface and is its own interface with one transmission line (see the description for P75 below). It should be noted that Bonneville neither operates nor manages the Idaho to Northwest or Summer Lake-Hemingway transmission paths.

If the Hemingway – Summer Lake Interface flows reach its limit, then GridView limits flows on the Northwest to Idaho Interface even though it may not appear as an Idaho to Northwest Interface congestion hour in Table 3-9. For the Idaho to Northwest Interface, transmission congestion changes would occur under all alternatives in median and high run-off scenarios. Congestion decreases are greatest in median run-off scenarios for MO3 and MO4 when there would be less hydropower generation available to send in an easterly direction under those alternatives, while the greatest increases are under MO2.

Table 3-9. Annual Congested Hours for Low, Medium, and High Runoff Years, West Side Idaho to Northwest, under the No Action and Relative to No Action for all MOs without Additional Coal Plant Retirements (GridView Output)

Interface	Run Off	No Action	MO1 Conv. Least-Cost	MO1 Zero-Carbon	MO2	MO3 Conv. Least-Cost	MO3 Zero-Carbon	MO4 Conv. Least-Cost	MO4 Zero-Carbon	PA
P14 IDAHO TO NORTHWEST	Low	0	0	0	0	+1	0	0	0	0
	Median	292	+53	-8	+187	-211	-249	-209	-234	-83
	High	150	+3	-44	+90	-125	-113	-85	-105	+24

3.1.2.4 P65 Pacific DC Intertie (PDCI)

This PDCI intertie interface has a limit 3,220 MW for the north to south direction and 3,100 MW for the south to north direction. Congestion primarily occurs on the north to south direction under all CRSO alternatives. Increases in congestion would occur relative to the No Action Alternative under all CRSO alternatives and all run-off scenarios. The increases in congestion relative to the No Action Alternative would be highest for MO3 with the conventional least-cost resource replacement portfolio where both the north to south and south to north directions experience increases in the number of congested hours. MO4 with the conventional least-cost resource replacement portfolio would also experience increases in the number of congested hours under both scenarios.

Table 3-10. Annual Congested Hours for Low, Medium, and High Runoff Years, P65 Pacific DC Intertie, under the No Action and Relative to No Action for all MOs without Additional Coal Plant Retirements (GridView Output)

Interface	Run Off	No Action	MO1 Conv. Least-Cost	MO1 Zero-Carbon	MO2	MO3 Conv. Least-Cost	MO3 Zero-Carbon	MO4 Conv. Least-Cost	MO4 Zero-Carbon	PA
PDCI North-to-South	Low	490	+47	+71	+44	+100	-5	+20	-41	+8
	Median	652	+21	+62	-47	+180	+88	+110	+37	+71
	High	576	+21	+58	+11	+365	+283	+215	+32	-18
PDCI South-to-North	Low	5	0	-2	0	+3	+2	+5	+1	0
	Median	2	-2	-2	-2	0	+1	+2	+1	-2
	High	0	0	0	0	0	0	0	0	0

3.1.2.5 P75 Hemingway-Summer Lake

The Hemingway-Summer Lake interface has a limit of 1,500 MW in the east to west direction and limit of 550 MW in the west to east direction. Congested hours are highest in the west to east direction under all of the alternatives. Relative to the No Action Alternative, the number of congestion hours in the west to east direction decrease under MO4 and MO3 for median and high run-off when there would be less hydropower generation available to send in an easterly direction under those alternatives. It should be noted that Bonneville does not operate or manage the Hemingway-Summer Lake transmission path.

Table 3-11. Annual Congested Hours for Low, Medium, and High Runoff Years, P75 Hemingway-Summer Lake, under the No Action and Relative to No Action for all MOs without Additional Coal Plant Retirements (GridView Output)

Interface	Run Off	No Action	MO1 Conv. Least-Cost	MO1 Zero-Carbon	MO2	MO3 Conv. Least-Cost	MO3 Zero-Carbon	MO4 Conv. Least-Cost	MO4 Zero-Carbon	PA
HEMINGWAY-SUMMER LAKE West-to-East	Low	15	-15	-7	+9	-11	-6	-11	+38	-11
	Median	390	+2	+83	+81	-159	-80	-238	-70	-72
	High	1,356	+82	+214	+179	-498	-318	-526	-167	+30
HEMINGWAY-SUMMER LAKE East-to-West	Low	24	-11	+23	+1	-13	+22	-17	+23	+3
	Median	9	-5	-5	-5	-4	-3	-8	-3	-2
	High	4	-3	+1	-3	-4	-2	-4	-4	+1

3.1.2.6 Raver-Paul

The Raver-Paul interface has a limit of 1,450 MW and has congested hours in the north to south direction. Congestion occurs primarily under the median and high run-off scenarios for MO1, MO2, and the Preferred Alternative. Congestion would be decrease under these run-off scenarios under MO3 and MO4, particularly under high run off conditions.

Table 3-12. Annual Congested Hours for Low, Medium, and High Runoff Years, Raver-Paul, under the No Action and Relative to No Action for all MOs without Additional Coal Plant Retirements (GridView Output)

Interface	Run Off	No Action	MO1 Conv. Least-Cost	MO1 Zero-Carbon	MO2	MO3 Conv. Least-Cost	MO3 Zero-Carbon	MO4 Conv. Least-Cost	MO4 Zero-Carbon	PA
RAVER-PAUL	Low	0	0	0	0	0	0	0	0	0
	Median	19	+6	-1	+10	-10	-1	-10	-17	+5
	High	229	+19	+29	+28	-57	-49	-158	-157	+41

3.1.2.7 South of Custer

The South of Custer interface has a limit of 1,850 MW and had congestion hours in the north to south direction. Congestion occurs under the No Action Alternative for all run-off scenarios. Congestion increases on the South of Custer interface most notably under MO3 and MO4 under high run-off conditions.

Table 3-13. Annual Congested Hours for Low, Medium, and High Runoff Years, West Side South of Custer, under the No Action and Relative to No Action for all MOs without Additional Coal Plant Retirements (GridView Output)

Interface	Run Off	No Action	MO1 Conv. Least-Cost	MO1 Zero-Carbon	MO2	MO3 Conv. Least-Cost	MO3 Zero-Carbon	MO4 Conv. Least-Cost	MO4 Zero-Carbon	PA
SOUTH OF CUSTER	Low	168	+68	+30	-8	-4	-4	+2	+48	+63
	Median	395	+10	+4	-23	-17	+2	-6	-1	-7
	High	378	+15	+3	-18	+87	+101	+71	+33	+2

3.1.2.8 North of Echo Lake

North of Echo Lake has a limit of 2,800 MW and had three congested hours on the south to north interface under the MO4 zero-carbon resource replacement portfolio. North of Echo Lake and South of Custer make up a complimentary pair of unidirectional interfaces.

3.1.2.9 California Oregon Intertie and Alturas and PDCI (COI + Alturas, COI+PDCI+Alturas)

The interties connecting the Pacific Northwest to systems in the south include multiple lines and interties that experience congestion. The limit for COI and Alturas is 4,800 MW and the limit including the PDCI is 8,020 MW. The north to south interface experiences congested hours. For the three run-off scenarios, all lines in this interface would experience the greatest number of congested hours under MO3 in higher run-off conditions.

Table 3-14. Annual Congested Hours for Low, Medium, and High Runoff Years, California-Oregon Intertie and Alturas and PDCI, under the No Action and Relative to No Action for all MOs without Additional Coal Plant Retirements (GridView Output)

Interface	Run Off	No Action	MO1 Conv. Least-Cost	MO1 Zero-Carbon	MO2	MO3 Conv. Least-Cost	MO3 Zero-Carbon	MO4 Conv. Least-Cost	MO4 Zero-Carbon	PA
C0I + ALTURAS	Low	9	+4	+7	+13	+12	+15	+5	0	+7
	Median	55	-17	-14	-9	-3	-10	-7	+9	-8
	High	177	-20	+7	+8	+19	-10	-26	-21	+4
C0I + PDCI + ALTURAS	Low	6	+3	+7	-10	+4	+7	+5	-4	+4
	Median	38	-5	-5	-6	0	-9	+1	+8	-3
	High	103	-6	+23	+10	+47	+21	-5	-21	+22

3.2 BONNEVILLE TRANSMISSION SYSTEM RELIABILITY AND NETWORK INTERCONNECTIONS

The purpose of the transmission system reliability powerflow analysis was to evaluate transmission system reliability and interconnection requirements that may be necessary under each of the MOs. The hydropower generation (as discussed in Appendix J, *Hydropower*) and the location of replacement resources without additional coal retirements (as discussed in Section 2.2of Chapter 2), were used in the powerflow analysis to assess the impacts of the MOs and the Preferred Alternative to the transmission system. The analysis does not include the additional generation reserves needed to integrate renewable resources because there is not enough certainty about the possible replacement resources to have confidence that changing reserve assumptions would increase the accuracy of the simulation. The resource replacement mix and general locations for each of the conventional least-cost and zero-carbon base case resource replacement portfolios are shown in Table 3-1 through Table 3-3 above.

A summer 2023 WECC-derived base case for power demand and loads along with the associated power flow was used to evaluate the CRSO alternatives. As transmission system reliability impacts are largely dictated by the extremes in loading, the most informative scenarios involved seasonal consideration of peak loads within the region. The base case assumed that load demand would be met by the minimum hydropower generation levels for the Lower Snake and Lower Columbia projects, with a corresponding increase in hydropower generation in Upper Columbia (Chief Joseph and Grand Coulee) projects. Next, to reflect full transmission system usage by serving regional loads and providing for export on the Southern Interties, the analysis included generation output from existing wind resources in the Pacific Northwest. This formed the No Action Alternative that was used as the basis for comparison with MOs.

The powerflow analysis focused on the lower CRS hydropower generation variation by alternative. The powerflow analysis focused on the lower CRS generation dispatch due to the following:

- The transmission system generally evolved with high generation output from the various Columbia River System resources. Operation of the transmission system with reduced generation at the CRS projects generally results in reduced stress to the transmission system.
- Since reduced peak output from the CRS resources was central to all of the MO alternatives (MO2 had increased average output, but, did not result in increased peak output from the CRS resources), the result would be a system that has less capacity or ability to reliably serve the peak loads typical in July and August when there is a reduced availability of hydropower generation.
- The third consideration was the location of the replacement resources. For the conventional least-cost and zero-carbon portfolios, it was important to see how the reduced output from the CRS hydropower projects would interact with the addition of the replacement resources. Again, it is the times when the CRS resources are at their lowest output that are critical to determining whether the transmission system, in concert with the replacement resources, will still be able to reliably serve load within the Region. While the CRS resources would be at a reduced output, the replacement resources would be at or near their expected full output to serve the required load.

For each of the MOs and the Preferred Alternative, the No Action Alternative was adjusted by modifying the generation at the Lower Snake and Lower Columbia River projects to the minimum levels specified in each of the alternatives. The replacement resources were then added to preserve service to loads within the region and to support exports on the Southern Interties.

3.2.1 Powerflow Results

Given seasonal demand for power in the Pacific Northwest and seasonal differences in transmission system capacity, winter and spring/fall demand scenarios were determined not to produce conditions that were limiting. During the summer, however, many areas experience substantial peak loads at the same time that the capability of the transmission system is reduced. The capability of the transmission system is reduced in the summer because higher ambient temperatures limit the ability of the system to transmit energy. Additionally, due to low streamflow conditions and spill requirements, generation and flexibility allowed under the various alternatives for the Columbia and Lower Snake hydropower projects is at the lowest levels, which results in a higher reliance on the replacement resources. The reduction in allowed generation also limits the flexibility of the CRS projects during the limiting summer season. For these reasons, a summer 2023 base case was used in the powerflow analysis to assess the impact to the transmission system from replacement resources operating in conjunction with output from the Columbia River projects under each of the CRSO alternatives.

Table 3-15 provides the generation levels in MW modeled in the powerflow cases for the significant generating resources in the region, including the CRS projects. For the No Action Alternative and each of the MO alternatives, there is a column labeled “Powerflow Starting

Case" that includes the generation levels prior to the addition of the assumed replacement resources. The generation at the various CRS projects is taken from the HYDSIM output for that alternative (see Appendix J, *Hydropower*). Generation from the replacement resources is listed at the bottom of the table. Table 3-16 provides the corresponding transmission interface flows from the powerflow cases for the major transmission interfaces in the region.

Table 3-15 and Table 3-16 reflect a zero-carbon replacement portfolio of 2,550 MW of solar generation under MO3. A decrease of about 590 MW of solar generation and the addition of batteries in the MO3 zero-carbon resource replacement portfolio reflected in the final EIS would have a slight change in powerflows (see Section 2.2.2.4, *Replacement Resources for MO3* of Appendix H). The updated resources assume that the batteries would allow for shaping output of the replacement resources, but, would not add to the peak output of those replacement resources. In order to assess the reliability impact to the transmission system from the replacement resources, the powerflow analysis relied on the peak output from the replacement resources. Since the replacement resources for MO3 considered a reduced peak output from the replacement resources, the results from the powerflow analysis for 2,550 MW of solar generation also apply to the results for 1,960 MW of solar generation and additional batteries comprising the zero-carbon resource replacement portfolio under MO3 in the final EIS.

For the Preferred Alternative analysis, the minimum and maximum hydropower generation levels (see Appendix J, *Hydropower*), were analyzed and were found to fall within the range of dispatches previously analyzed through the powerflow modeling for the various MOs and the No Action Alternative. Because the Preferred Alternative analysis found that the generation levels were similar to those previously modeled and found to not require transmission reinforcements, no additional powerflow simulations were completed.

For the Preferred Alternative analysis, the expected monthly maximum and minimum generation outputs from the CRS projects on the Columbia and LSR for the Preferred Alternative and the No Action Alternative were compared. Table 3-17 through Table 3-19 below, list the expected monthly maximum generation for the CRS projects under the No Action Alternative, Preferred Alternative, as well as the difference (Preferred Alternative minus the No Action Alternative), respectively. Similarly, Table 3-20 through Table 3-22 below, list the expected monthly minimum generation for the CRS projects under the No Action Alternative, Preferred Alternative, as well as the difference (PA minus the No Action Alternative), respectively.

For the LSR Projects (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor), the difference tables (Table 3-19 for the maximum generation and Table 3-22 for the minimum generation) show modest shifts (increase for some CRS projects, decrease for others) in expected generation across all the months of the year. The minimum generation levels, in particular show no change for the LSR projects.

For the projects of the Lower Columbia (McNary, John Day, The Dalles, and Bonneville), the difference table for the maximum generation (Table 3-19) does show more substantial increases for the April through September timeframe. The increases in generation could provide for additional units to be on-line and available to support the electrical stability of the larger network.

Table 3-15. Generation Levels from the Powerflow Cases without Additional Coal Plant Retirements (MW)

Plant	NAA	MO1			MO2			MO3			MO4		
	Starting Powerflow Case	Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar
Bonneville	136	131	131	131	163	163	163	132	132	132	113	113	113
Dalles, The	310	307	307	307	322	322	322	301	301	301	280	280	280
John Day	443	385	385	385	397	397	397	388	388	388	372	372	372
McNary	272	258	258	258	276	276	276	252	252	252	246	246	246
FCRPS Lower Columbia	1,161	1,081	1,081	1,081	1,158	1,158	1,158	1,073	1,073	1,073	1,011	1,011	1,011
Ice Harbor	65	55	55	55	68	68	68	0	0	0	62	62	62
Lower Monumental	84	84	84	84	87	87	87	0	0	0	83	83	83
Little Goose	80	80	80	80	86	86	86	0	0	0	81	81	81
Lower Granite	80	80	80	80	84	84	84	0	0	0	81	81	81
FCRPS Lower Snake	309	299	299	299	325	325	325	0	0	0	307	307	307
Grand Coulee	4,777	4,777	4,777	4,777	4,777	4,777	4,777	4,777	4,777	4,777	4,777	4,778	4,777
Chief Joe	2,038	2,038	2,038	2,038	2,038	2,038	2,038	2,038	2,038	2,038	2,038	2,038	2,038
FCRPS Upper Columbia	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,815	6,816	6,815
CGS	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,152	1,151
Libby	90	90	90	90	90	90	90	90	90	90	90	90	90
Priest Rapids	790	790	790	790	790	790	790	790	790	790	790	790	790
Rock Island	437	437	437	437	437	437	437	437	437	437	437	437	437
Rocky Reach	1,112	1,112	1,112	1,112	1,112	1,112	1,112	1,112	1,112	1,112	1,112	1,113	1,112
Wanapum	853	853	853	853	853	853	853	853	853	853	853	854	853
Wells	800	800	800	800	800	800	800	800	800	800	800	801	800
Mid Columbia (Total)	3,992	3,992	3,992	3,992	3,992	3,992	3,992	3,992	3,992	3,992	3,992	3,995	3,992
NW Thermal Gen	6,374	6,374	6,374	6,374	6,374	6,374	6,374	6,374	6,374	6,374	6,374	6,308	6,374
Wind Power – NW	5,580	5,661	5,071	4,357	5,569	5,110	5,300	6,000	4,823	3,166	5,727	2,384	1,056

Plant	NAA	MO1			MO2			MO3			MO4		
	Starting Powerflow Case	Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar
Replacement Resources													
MO Gas Central Ferry	--	--	--	--	--	--	--	--	--	--	--	1,060	--
MO Gas McNary	--	--	560	--	--	440	--	--	1,120	--	--	1,120	--
MO Gas Slatt	--	--	--	--	--	--	--	--	--	--	--	1,060	--
MO Solar Captain Jack	--	--	--	--	--	--	--	--	--	999	--	--	1,250
MO Solar Grizzly	--	--	--	1,200	--	--	250	--	--	961	--	--	1,250
MO Solar Midpoint	--	--	--	--	--	--	--	--	--	--	--	--	625
MO Solar Slatt	--	--	--	--	--	--	--	--	--	--	--	--	1,250
MO Solar Wautoma	--	--	--	--	--	--	--	--	--	--	--	--	625

Table 3-16. Interface Flows from the Powerflow Cases without Additional Coal Plant Retirements (MW)

Path	NAA	MO1			MO2			MO3			MO4		
	Starting Powerflow Case	Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar[1]/	Starting Powerflow Case	Gas	Solar
Alston - Keeler	1,245	1,246	1,244	1,214	1,245	1,243	1,239	1,240	1,236	1,161	1,248	1,263	1,176
California-Oregon Intertie (COI)	3,716	3,704	3,706	3,727	3,717	3,721	3,725	3,716	3,720	3,801	3,702	3,690	3,775
Hemingway-Summer Lake	-155	-157	-157	-109	-155	-155	-146	-153	-153	-50	-157	-166	-98
IDAHO - NORTHWEST	-50	-48	-49	-43	-50	-52	-49	-52	-54	-15	-48	-25	-49
Keeler - Pearl	406	406	406	372	409	409	403	401	400	313	405	418	323
MONTANA - NORTHWEST	-46	-46	-46	-64	-45	-46	-48	-49	-50	-96	-45	-40	-104
North of Dixonville	-781	-779	-779	-682	-784	-785	-763	-779	-780	-430	-777	-774	-417

Path	NAA Starting Powerflow Case	MO1			MO2			MO3			MO4		
		Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar[1]/	Starting Powerflow Case	Gas	Solar
North of Echo Lake	-941	-942	-940	-938	-942	-941	-941	-941	-938	-933	-942	-947	-919
North of Grizzly	4,039	4,028	4,029	3,032	4,037	4,040	3,832	4,046	4,048	2,092	4,027	4,014	2,037
North of Grizzly/Marion	6,173	6,159	6,165	5,089	6,172	6,180	5,951	6,172	6,186	3,939	6,158	6,192	3,919
North of Hanford (NOH)	3,910	3,913	3,881	3,838	3,915	3,890	3,896	3,923	3,860	3,785	3,914	3,695	3,513
NORTH OF JOHN DAY	6,141	6,147	6,272	5,958	6,147	6,246	6,102	6,092	6,345	5,696	6,156	6,449	5,874
North of Malin/Captain Jack	3,553	3,546	3,547	3,755	3,551	3,553	3,597	3,559	3,561	3,079	3,548	3,544	3,077
Northwest-British Columbia	-3,139	-3,139	-3,139	-3,139	-3,139	-3,139	-3,139	-3,138	-3,138	-3,139	-3,139	-3,161	-3,138
Northwest-British Columbia (East)	-299	-299	-300	-299	-298	-299	-299	-299	-299	-299	-299	-299	-299
Northwest-British Columbia (West)	-2,840	-2,840	-2,839	-2,840	-2,841	-2,840	-2,840	-2,839	-2,839	-2,840	-2,840	-2,861	-2,839
NWACI	3,716	3,704	3,706	3,727	3,717	3,721	3,725	3,716	3,720	3,801	3,702	3,690	3,775
PACIFIC DC INTERTIE (PDCI)	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940
Paul - Allston (PA)	2,074	2,076	2,072	2,040	2,072	2,069	2,066	2,070	2,061	1,981	2,081	2,098	2,003
Raver - Paul (RP)	1,590	1,592	1,588	1,563	1,588	1,585	1,583	1,586	1,579	1,514	1,596	1,609	1,534
Redmond Area Import	-530	-530	-530	-530	-530	-530	-530	-530	-530	-529	-530	-530	-529
SORE Southern Oregon Import	-456	-456	-456	-455	-456	-456	-456	-456	-456	-440	-456	-455	-440
SOUTH OF ALLSTON	2,248	2,250	2,244	2,207	2,245	2,240	2,237	2,242	2,231	2,137	2,256	2,276	2,163

Path	NAA Starting Powerflow Case	MO1			MO2			MO3			MO4		
		Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar	Starting Powerflow Case	Gas	Solar[1] /	Starting Powerflow Case	Gas	Solar
South of Boundary SOB	1,001	1,001	1,001	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,001	1,001
South of Custer SOC	2,753	2,753	2,752	2,753	2,754	2,753	2,753	2,753	2,752	2,753	2,753	2,774	2,752
South of Grizzly	4,007	3,995	3,997	4,214	4,004	4,008	4,053	4,013	4,016	3,334	3,995	3,985	3,280
South of Summer Lake	3,743	3,734	3,735	3,854	3,742	3,745	3,770	3,746	3,749	2,932	3,733	3,726	2,918
West of Cascades - North (WOCN)	3,821	3,823	3,818	3,777	3,817	3,813	3,810	3,815	3,803	3,703	3,829	3,827	3,731
West of Cascades - South (WOCS)	5,266	5,266	5,272	5,203	5,244	5,249	5,229	5,273	5,285	5,006	5,277	5,251	4,985
WEST OF HATWAI	813	815	809	837	811	807	816	826	813	898	814	756	849
West of John Day	3,407	3,402	3,400	3,458	3,379	3,377	3,391	3,435	3,431	3,481	3,424	3,383	3,423
West of Lower Monumental (WOLM)	1,659	1,669	1,592	1,531	1,669	1,609	1,640	1,504	1,348	1,220	1,677	2,154	1,153
West of McNary (Scheduling)	2,700	2,701	3,006	2,465	2,708	2,947	2,661	2,666	3,274	2,167	2,708	3,109	1,831
West of Slatt	3,650	3,661	3,721	3,290	3,656	3,704	3,581	3,654	3,774	2,933	3,673	4,328	3,453

Note: The numbers in the solar column reflect a portfolio of 2,550 MW. A decrease of about 590 MW to 1960 MW would have a slight change in powerflows, but would not be at a level that would result in any additional reinforcement needs.

Considering the modest shifts in generation under the PA as compared to the No Action Alternative, no additional transmission reinforcements are expected to be needed under the PA. Also, under the PA, there would be an increase in the operational outputs of the plants of the Lower Columbia. The transmission system would realize some operational benefits from having additional generating units on-line in order to support the electrical stability of the larger network.

Where there are modest increases in expected plant output at some of the CRS projects, those outputs would not be expected to exceed the existing transmission capacity or otherwise trigger a need for system reinforcement.

Table 3-17. No Action Alternative, Monthly Maximum Generation by Plant

Plant	October	November	December	January	February	March	April 1	April 2	May	June	July	August 1	August 2	September
Grand Coulee	3,795	3,810	3,817	3,820	4,172	4,087	4,050	3,978	4,092	4,422	4,660	4,580	4,541	4,113
Chief Joseph	1,990	1,984	1,982	2,006	2,214	2,143	2,152	2,153	2,216	2,340	2,444	2,414	2,418	2,163
Lower Granite	503	651	783	721	783	783	691	673	673	673	610	512	512	498
Little Goose	572	769	733	800	790	785	685	663	653	653	590	561	561	565
Lower Monumental	598	736	837	847	842	820	810	800	794	713	694	643	643	583
Ice Harbor	554	571	637	553	647	622	656	643	640	646	490	539	540	591
McNary	593	773	826	860	862	855	729	744	742	685	750	744	746	640
John Day	1,899	2,115	2,105	2,091	2,089	2,097	1,901	1,880	1,910	2,008	1,874	1,962	1,965	2,077
The Dalles	1,387	1,751	1,807	1,922	1,776	1,744	1,389	1,390	1,428	1,393	1,389	1,365	1,368	1,543
Bonneville	819	905	950	971	991	925	788	795	769	719	767	812	823	869

Table 3-18. Preferred Alternative, Monthly Maximum Generation by Plant

Plant	October	November	December	January	February	March	April 1	April 2	May	June	July	August 1	August 2	September
Grand Coulee	3,661	3,668	3,689	3,704	4,048	3,958	4,127	4,062	4,148	4,461	4,717	4,631	4,594	3,996
Chief Joseph	1,989	1,983	1,983	2,006	2,211	2,145	2,264	2,265	2,323	2,437	2,516	2,491	2,497	2,145
Lower Granite	634	651	783	721	783	788	776	756	756	771	688	571	571	624
Little Goose	707	769	733	800	790	785	755	731	721	736	658	619	619	700
Lower Monumental	667	736	837	847	847	820	820	810	804	729	704	653	653	651
Ice Harbor	593	571	637	553	647	622	624	611	608	630	463	518	518	635
McNary	767	773	832	860	861	855	937	950	933	871	957	945	949	808
John Day	2,259	2,236	2,231	2,232	2,234	2,244	2,187	2,172	2,171	2,159	2,156	2,149	2,153	2,226
The Dalles	1,688	1,752	1,808	1,922	1,774	1,744	1,713	1,714	1,755	1,717	1,705	1,681	1,686	1,877

Plant	October	November	December	January	February	March	April 1	April 2	May	June	July	August 1	August 2	September
Bonneville	954	905	950	972	986	926	915	921	891	846	890	938	955	1,002

Table 3-19. Difference (Preferred Alternative – No Action Alternative), Monthly Maximum Generation by Plant

Plant	October	November	December	January	February	March	April 1	April 2	May	June	July	August 1	August 2	September
Grand Coulee	-133	-142	-128	-116	-123	-129	78	84	56	40	57	51	53	-117
Chief Joseph	-1	-1	1	0	-2	2	111	111	107	97	72	77	79	-17
Lower Granite	132	0	0	0	0	5	85	83	83	98	78	59	59	127
Little Goose	135	0	0	0	0	0	70	68	68	82	68	58	58	135
Lower Monumental	69	0	0	0	5	0	10	10	10	15	10	10	10	68
Ice Harbor	39	0	0	0	0	0	-33	-32	-32	-16	-27	-22	-22	44
McNary	174	0	6	0	-1	0	208	205	190	186	208	201	203	168
John Day	360	121	126	141	145	147	286	293	260	151	281	187	188	150
The Dalles	301	1	1	0	-2	0	324	324	327	324	316	316	318	334
Bonneville	135	0	0	1	-5	0	126	126	122	126	124	126	132	134

Table 3-20. No Action Alternative, Monthly Minimum Generation by Plant

Plant	October	November	December	January	February	March	April 1	April 2	May	June	July	August 1	August 2	September
Grand Coulee	366	362	359	347	335	322	303	378	280	324	359	451	389	362
Chief Joseph	196	441	435	431	427	193	192	252	189	181	190	241	210	197
Lower Granite	80	82	0	0	0	83	81	78	78	77	80	80	80	80
Little Goose	86	86	0	0	0	86	82	80	80	80	80	80	80	82
Lower Monumental	87	87	0	0	0	83	82	79	79	77	83	84	84	85
Ice Harbor	68	68	0	0	0	63	62	60	60	59	63	66	66	67
McNary	279	272	264	262	260	257	268	240	252	236	263	260	259	284
John Day	482	486	477	474	472	467	469	357	444	419	456	401	448	477
The Dalles	380	378	362	357	353	344	359	262	327	279	350	316	353	382
Bonneville	130	127	113	108	105	103	109	96	97	87	106	120	119	133

Table 3-21. Preferred Alternative, Monthly Minimum Generation by Plant

Plant	October	November	December	January	February	March	April 1	April 2	May	June	July	August 1	August 2	September
Grand Coulee	363	360	354	347	331	320	404	378	374	404	365	369	364	360
Chief Joseph	196	442	435	431	426	192	257	252	252	225	194	197	197	197
Lower Granite	80	82	0	0	0	83	81	78	78	77	80	80	80	80
Little Goose	86	86	0	0	0	86	82	80	80	80	80	80	80	82
Lower Monumental	87	87	0	0	0	84	82	79	79	77	83	84	84	85
Ice Harbor	68	68	0	0	0	63	62	60	60	59	63	66	66	67
McNary	273	272	264	262	260	258	251	239	238	223	250	260	259	280
John Day	508	508	498	495	493	490	395	377	376	376	479	491	490	505
The Dalles	379	378	362	357	352	347	288	262	261	238	352	371	370	383
Bonneville	128	127	113	108	105	104	110	96	97	87	106	119	119	133

Table 3-22. Difference (Preferred Alternative – No Action Alternative), Monthly Minimum Generation by Plant

Plant	October	November	December	January	February	March	April 1	April 2	May	June	July	August 1	August 2	September
Grand Coulee	-2	-3	-6	0	-4	-3	101	0	94	79	7	-82	-25	-2
Chief Joseph	0	0	0	0	-1	0	65	0	63	44	4	-43	-13	0
Lower Granite	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Goose	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower Monumental	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ice Harbor	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McNary	-6	0	0	0	0	1	-16	-1	-15	-14	-13	0	0	-4
John Day	26	22	21	21	21	23	-74	20	-68	-42	22	90	43	28
The Dalles	-1	0	0	0	0	3	-71	0	-66	-41	2	55	17	0
Bonneville	-1	0	0	0	0	1	1	0	0	0	0	0	0	0

3.2.2 Bonneville Network Reinforcement Needs

Though the quantity of generation added via the resource replacement portfolios is considerable for some of the alternatives, the addition of these resources would not require network reinforcements in most cases. This is because the displacement of the CRS hydropower generation would tend to relieve congestion on existing monitored interfaces on the transmission system while the replacement resource tend to be located on the unconstrained side of most monitored interfaces.

MO3, which includes the breach of LSR dams, would be the only alternative where the studies indicated a need for transmission system reinforcement. As also discussed in Section *3.1 Regional Congestion Forecasting*, generation at Ice Harbor provides load service to the Tri-Cities during peak summer load conditions and during emergencies (e.g., loss of the main grid connection at Sacajawea). An outage of one of the transmission lines connecting the Tri-Cities area to the main transmission grid limits the amount of power that can be delivered to the Tri-Cities load. During such outages, having generation from the Ice Harbor project supports reliable service to the Tri-Cities load. The generation at Ice Harbor also provides support for transmission operations and maintenance in the Tri-Cities area. In MO3, 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 result in loss of load within the Tri-Cities area.

Prior to evaluating the impacts of potential breach of Ice Harbor Dam, 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 operations and maintenance. 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.

Under MO3, the loss of hydropower generation at Ice Harbor would require that the reinforcement project be in place prior to breaching of the dam, which may be sooner than would be required under the No Action Alternative. 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 be approximately $94 million in capital costs (direct, unloaded costs) to construct. It should be noted that these types of transmission system reinforcements typically takes many years to plan, permit, and construct.

3.2.3 Bonneville Transmission Interconnections

The developer of the individual generation resources under the base case resource replacement portfolios would have to develop additional transmission infrastructure, such as lines, that 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 to complete the interconnection of the new resource to the larger transmission network. The Bonneville interconnection would require equipment such as bulk transformers, circuit breakers, and other substation equipment, which may require the expansion of multiple existing substations. Added 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.

The expected capital costs (direct, unloaded costs) associated with the interconnection of the resource replacement portfolios under the CRSO alternatives are depicted in Table 3-23 and Table 3-24. Interconnection costs would range from $70 to $357 million, depending on the alternative and resource replacement portfolio. Under MO2, while there is the potential for future avoided costs of individual generation, as discussed above in Chapter 2 -, the avoided costs are not likely to result in an overall cost reduction because this is not an avoided capital costs for transmission facilities that would otherwise be required to reliably serve load. Similarly, under the Preferred Alternative, there would not likely be any replacement resources and no associated interconnection costs.

Table 3-23. Interconnection Costs for the Conventional Least-Cost Resource Replacement Scenario

	MO1		MO2		MO3		MO4		PA	
Location	**Capacity (MW)**	**Cost**	**Capacity (MW)**	**Cost**	**Capacity (MW)**	**Cost**	**Capacity (MW)**	**Cost**	**Capacity (MW)**	**Cost**
McNary	560	$70 million	-	-	1,120	$72 million	1,120	$72 million	-	-
Central Ferry	-	-	-	-	-	-	1,060	$72 million	-	-
Slatt	-	-	-	-	-	-	1,060	$72 million	-	-
Total	560	$70 million	-	-	1,120	$72 million	3,240	$220 million	-	-

Note: Cost estimates are rounded to two significant digits and may not sum to the totals reported due to rounding. This table does not present the costs associated with the potential avoided transmission interconnections required under MO2. The substation expansion needed for interconnection of resources from the No Action Alternative to MO2 levels would cost about $70 million.

Table 3-24. Interconnection Costs for the Zero-Carbon Resource Replacement Scenario

	MO1		MO2[1]		MO3[2]		MO4		PA	
Location	**Capacity (MW)**	**Cost**	**Capacity (MW)**	**Cost**	**Capacity (MW)**	**Cost**	**Capacity (MW)**	**Cost**	**Capacity (MW)**	**Cost**
Captain Jack	-	-	-	-	999	$72 million	1,250	$72 million	-	-
Grizzly	1,200	$72 million	-	-	961	$72 million	1,250	$72 million	-	-
Slatt	-	-	-	-	-	-	1,250	$72 million	-	-
Wautoma	-	-	-	-	-		625	$70 million	-	-
Midpoint (Idaho)	-	-	-	-	-	-	625	$70 million	-	-
Broadview (Montana)	-	-	-	-	-	-	-	-	-	-
Total	1,200	$72 million	-	-	1,960	$145 million	5,000	$360 million	-	-

Note: Cost estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

1/This table does not present the costs associated with the potential avoided transmission interconnections required under MO2. The substation expansions needed for interconnection of resources from the No Action Alternative to MO2 levels would interconnect an additional 250MW of resource capacity at Grizzly, at a cost of

about $70 million, and an additional 660MW of resource capacity at Broadview (Montana) at a cost of about $72 million.
2/ No additional interconnection costs for batteries under MO3 is included in this cost. See Section 3.7.3.5 of the EIS, *Effects on Transmission Flows, Congestion, and the Need for Infrastructure*, Section 3.2.1 of Appendix H for a discussion of the effects associated with including batteries on transmission system in the base case Zero-Carbon Replacement Resource.

3.2.4 Bonneville Operational Considerations

Alternatives MO1, MO3, and MO4 all would result in reduced hydropower generation from the Lower Columbia projects (MO3 does have some allowance for increased output from the Lower Columbia CRS projects during August). Though no immediate transmission system reliability issues were identified during the powerflow analysis discussed in Sections 3.2.1 through 3.2.3, in the future, lost hydropower generation under MO1, MO3, and MO4 may affect voltage and dynamic stability on the transmission system (i.e., the ability of the transmission to get back to a stable configuration following a significant disturbance in the transmission system) due to a reduction of generators that are online during certain times of the year.[32] Without sufficient voltage support, inertia, and frequency response capability, the power system will not be stable. This, in turn, can lead to equipment damage and potentially wide-spread uncontrolled loss of load. Additionally, if too few generation units are on-line, the transmission system may need to operate at a lower transfer level, which could result in congestion and require re-deployment of resources throughout the Western Interconnection to meet the required demands at that time.

The conventional least-cost replacement portfolios assume the location of replacement resources would be in close proximity to the CRS projects where hydropower generation is being displaced and would provide similar voltage and dynamic support for the transmission system. Under the zero-carbon resource replacement portfolio, the replacement resources would be spread in multiple locations in Oregon, Washington, and Idaho. The dispersed location of these replacement resources would benefit voltage support. The analysis does not include adding resources for the generating reserves needed to integrate the increased amount of renewable resources because there is not enough certainty about the possible replacement resources to have confidence that changing reserve assumptions would increase accuracy of the simulation.

Depending on the timing for installation of the solar resources, they may not provide adequate dynamic response to a disturbance in the transmission system (such as a line or equipment outage) compared to what would have been expected from the lost hydropower generation.[33]

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[32] "Online" generators need to be running within an acceptable operating range based on turbine generator efficiencies and mechanical capabilities.
[33] Gas generators (such as those under the conventional least-cost replacement resource portfolio) provide a similar rotating momentum as hydropower generators and would maintain a proper voltage profile that would support transmission system operation and be responsive to disturbances such as equipment outages or changes in load.

Unlike hydropower (or other rotating generators), solar resources do not have rotating mass and may not have specialized voltage control capability to assist the transmission system to respond to disturbances. Technology under development may allow solar resources to assist with transmission disturbances in the future. Until such technology is developed, additional transmission system requirements may be needed under a zero-carbon resource portfolio.[34]

Under the Preferred Alternative, for the projects of the Lower Columbia (McNary, John Day, The Dalles, and Bonneville), the difference between the Preferred Alternative and the No Action Alternative for the maximum generation does show substantial increases in generation for the April through September timeframe. The increases in generation could provide for additional units to be on-line and available to support the electrical stability of and operational benefits for the larger transmission network.

3.2.5 Summary of Transmission Infrastructure Costs

The total costs associated with the MO alternatives (MO1, MO3, and MO4) would range from $70.1 million to $357.5 million (Table 3-23 and Table 3-24). The system study identified the need for network reinforcement sooner than currently planned to maintain reliable load service to the Tri-Cities area under MO3. The cost associated with implementing this project on an accelerated timeline would be about $94.5 million under both the conventional least-cost and the zero-carbon resource replacement portfolios. The system study did not identify additional network reinforcements under any of the MO alternatives based on the assumed replacement resource portfolios.

MO1 would result in the lowest replacement costs under both the conventional least-cost and zero-carbon resource replacement portfolios (about $70.1 million and $72.4 million, respectively). The distinction in cost impacts between the two replacement portfolios would become more pronounced under other MOs. Under MO3, replacement costs under the conventional least-cost resource replacement scenario would be about $72.4 million, and under the zero-carbon resource replacement portfolio would be about $144.8 million. MO4 would result in the highest replacement costs for both resource replacement portfolios (about $217.3 million for conventional least-cost and about $357.5 million for zero-carbon). Since MO2 would result in a reduction in LOLP (5 percent as compared to 6.6 percent for No Action Alternative), the comparison costs for MO2 would represent costs that might be avoided if that alternative were selected. The avoided costs are not likely to produce a reduction in cost because this is not an avoided capital cost of transmission facilities that would otherwise be required to reliably serve load. Under the Preferred Alternative, no replacement resources

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[34] 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 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 projects to be online in order to provide voltage and dynamic support for requirements of the transmission system.

would likely be needed; therefore, there would be no interconnection costs under this alternative.

A qualitative discussion of operational impacts from the various MOs (MO1, MO3, and MO4, primarily) highlighted that since alternatives MO1, MO3, and MO4 would all result in reduced generation from the Lower Columbia River projects, the reduced generation would likely also result in fewer generating resources at the CRS projects being on-line to support (e.g. voltage and dynamic support) the transmission system. Under the Preferred Alternative, there could be some additional flexibility that could provide operational benefits for the transmission system.

CHAPTER 4 - WHOLESALE POWER AND TRANSMISSION RATES

Bonneville's wholesale power and transmission rate setting process (or "rate case") is a public administrative process that is implemented pursuant to requirements established under Section 7(i) of the Pacific Northwest Power Planning and Conservation Act ("Northwest Power Act"). Pursuant to the Northwest Power Act, wholesale power and transmission rates are set to recover the costs associated with the acquisition, conservation and transmission of electric power, including the amortization of the Federal investment in the FCRPS over a reasonable number of years. As described in the previous chapters, the CRSO EIS alternatives would affect the revenue requirements of both power and transmission rates, by affecting the costs to replace resources in addition to the costs to connect those replacement resources to the transmission grid.

This chapter describes how the power and transmission costs described in Chapter 2 and Chapter 3 of this appendix affect the rates that power and transmission customers pay for delivered power (i.e., "wholesale power and transmission rates"). Chapter 5 of this appendix, describes how these changes would affect end-users (i.e., "retail rates").

4.1 POWER RATE PRESSURE ANALYSIS

4.1.1 Power Rates Methodology and Assumptions

This analysis relies on the Rates Analysis Model (RAM2020) used to set rates for the FY 2020-2021 period (BP-20 rate proceeding or BP-20) to evaluate the effects of the CRSO EIS alternatives on Bonneville wholesale priority firm (PF) power rates. The Power Rate, Market Price, and Power and Transmission Risk studies from BP-20 detail the ratemaking methodology used, including statutory directives governing cost recovery through rates and assumptions relevant to rate design (Bonneville 2019).[35] The governing methodology for the rate design is the Bonneville Tiered Rate Methodology (TRM) (Bonneville 2011).[36]

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35 See the Power Rates Study (BP-20-FS-BPA-01) and associated Power Rates Study Documentation (BP-20-FS-BPA-01A), the Market Price Study and Documentation (BP-20-FS-BPA-04), and the Power and Transmission Risk Study (BP-20-FS-BPA-05) and associated Power and Transmission Risk Study Documentation (BP-20-FS-BPA-05A) from the BP-20 rate case, located externally at https://www.bpa.gov/Finance/RateCases/BP-20/Pages/Final%20Proposal.aspx

36 The TRM, as described in the Chapter 3.7.2, *Power Generation and Transmission, Affected Environment*, established the rate design methodology used to tier the PF power rate that is charged for firm power requirements service.

RAM2020 is then updated for the multiple factors that affect wholesale electricity rates for a given customer for each scenario in the power rates analysis.[37] The key assumptions affecting rate pressure are included in the following sections: current power sales under long term Regional Dialogue power sales contracts and application of Bonneville's TRM; generation and contract resource forecasts; costs in the revenue requirement (including the Colville Settlement payment, fish and wildlife expenses, and capital costs); transmission expenses for power deliveries; new revenue requirement additions for replacement resource costs; market price forecasts for electricity and gas; and revenue credits (including the revenues associated with the sale of surplus power and the Treasury payment under 4(h)(10)(C) of the Northwest Power Act). Results are then applied customer by customer based on specific product choice of customers and the associated rate design under the TRM. This analysis assumes that Bonneville's customer base and customer product selections would remain constant over the timeframe of this analysis.

As addressed in Section 2.3 resulting rate pressures and socioeconomic effects did not consider the potential for additional coal retirements beyond those anticipated in the NW Council's 7th Power Plan and the Mid-Term update to the 7th Power Plan (published in 2016 and 2019, respectively). Subsequent announcement of earlier and additional retirements of coal-fired power plants than those assumed in this study, and described in Section 2.3 could have material impacts on the results of this analysis. However, the potential rate pressure effects of the Limited or No Coal scenarios are not reflected in the base case analysis that assumes 4,246 MW of coal are dedicated to serving regional load. Information about additional power rate sensitivity analyses and financial analysis are included in detail in Section 3.7.3 of the EIS, *Environmental Consequences,* and are not repeated herein.

4.1.1.1 Tier 1 Purchases and Load

Customer load forecasts are updated for the BP-22 rate period (2022/2023). Forecasts of each customer's Total Retail Loads and their dedicated non-federal power supply requirements from BP-20 provide the starting point for determining assumed load supplied by Bonneville. The forecasted amount of generation from the Tier 1 System resources affects the amount of firm power Bonneville's customers can purchase at Tier 1 rates; as the amount of firm power the FCRPS can generate changes, the amount of Tier 1 power a customer is entitled to purchase at Tier 1 rates changes. (If the amount of Tier 1 power decreases, customers may need to purchase Tier 2 power from Bonneville or acquire power elsewhere, depending on the customer election for Above Rate Period High Water Mark load). Bonneville's anticipated load is also affected by changes to both:

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37 Bonneville currently sells and transmits firm power from the CRS projects under long term contracts to regional customers (municipalities, PUDs, cooperatives, Federal agencies, and direct service industries) across the Pacific Northwest. Regional IOUs also have the right to request and buy firm power but currently do not. Bonneville also operates and maintains three-fourths of the high-voltage transmission system within the Pacific Northwest (Bonneville 2018a). This system interconnects and integrates electric power that flows through the regional transmission system throughout the western United States and parts of Canada and Mexico.

- hydropower operations, and
- the amount and dispatch of any required replacement resource.

Therefore, for CRSO EIS alternatives, customer loads on Bonneville are calculated after updating the forecasted Tier 1 resource generation changes under each alternative. This accounts for the changes in critical water assumptions from the HYDSIM analysis, any applicable changes to Bonneville system obligations (such as Canadian Entitlement or Reclamation Irrigation loads), and any replacement power resources. Table 4-1 shows annual average loads for Bonneville's firm power customers and the computed Tier 1 System resources available to meet these loads. If the amount of firm generation available from the Federal Columbia River Power System decreases, then the amount of Tier 1 power that customers can purchase from Bonneville decreases. Customers then have the choice of either purchasing Tier 2 power from Bonneville or acquiring power elsewhere. Thus, the level of loads presented in the table are driven by the changes in hydropower generation and generation from replacement resources.[38]

Table 4-1. Net Public Customer Loads and Tier 1 System Loads by Replacement Resource Scenario, by Alternative (aMW)

Scenario	NAA	MO1	MO2	MO3	MO4	PA
Public Utility Customer Loads (aMW)1/						
Bonneville Finances Zero-Carbon	6,891	6,880	7,002	6,817	6,977	6,801
Region Finances Zero-Carbon	6,891	6,783	7,002	6,544	6,456	6,801
Bonneville Finances Conventional Least-Cost	6,891	6,812	7,002	6,895	6,651	6,801
Region Finances Conventional Least-Cost	6,891	6,787	7,002	6,548	6,461	6,801
Tier 1 System Resources (aMW)2/						
Bonneville Finances Zero-Carbon	7,141	7,111	7,509	6,877	7,561	6,821
Region Finances Zero-Carbon	7,141	6,787	7,509	6,348	6,211	6,821
Bonneville Finances Conventional Least-Cost	7,141	6,847	7,509	7,152	6,537	6,821
Region Finances Conventional Least-Cost	7,141	6,787	7,509	6,348	6,211	6,821

1/ Includes Tier 2 Load Service.

2/ Represents the net Federal system available for load service to public utilities after other Federal Base System obligations have been met.

4.1.1.2 Resource Assumptions

Federal hydropower generation is adjusted for encroachment under each CRSO EIS alternative. Table 4-2 presents the adjusted forecast hydropower generation from the Federal system assuming an average of historical water conditions across 80 water years and critical water conditions (1937 water).

[38] Bonneville sells firm power to its preference customers, Federal agencies and Direct Service Industry (DSI) customers. Because DSI load is invariant to the size of the Tier 1 System, it is assumed to be constant across all scenarios at BP-20 Proposal levels.

Generation that serves Bonneville load other than the 14 CRS projects—including contracted wind and solar, and thermal resources (which are all unaffected by hydropower operations on the Columbia and Snake River systems)—do not vary across alternatives. This analysis assumes BP-20 forecasts for these resources.

Table 4-2. CRS Hydropower Generation for 80-year-Average Water and Critical Water (1937), by Alternative (aMW)[39]

	NAA	MO1	MO2	MO3	MO4	PA
CRS Hydropower Generation – 1937 (Critical Water)	6,285	5,987	6,663	5,537	5,396	5,956
CRS Hydropower Generation – Average of 80 Water Years	8,387	8,255	8,832	7,282	7,084	8,624

4.1.1.3 Revenue Requirement

Bonneville's proposed spending levels from BP-20 for FY2020-2021 are extrapolated into the CRSO study period accounting for inflation. In addition, several revenue requirement line items vary in response to different hydropower operations under CRSO EIS alternatives. These include:

- Colville Settlement payment;
- Bonneville Fish and Wildlife Program expenses and capital costs;
- Transmission expenses for Power; and
- Replacement resource costs.

The following sections describe these items in more detail.

4.1.1.3.1 COLVILLE AND THE SPOKANE TRIBE OF INDIANS SETTLEMENT PAYMENTS

The annual Colville and the Spokane (likely starting in 2021) settlement payments are a function of Bonneville's revenue from power sales and generation at Grand Coulee. As such, these payments are anticipated to vary across CRSO alternatives when Bonneville's revenue would be affected. The anticipated change in the payments under each CRSO EIS alternative is estimated based on forecast power sales revenues, power sales price, and Grand Coulee generation. Table 4-3 presents the estimated percent change in the Colville and Spokane settlement payments under each CRSO EIS alternative compared to the No Action Alternative.

[39] These values include encroachment, a reduction in generation caused by a rise in tail water elevation from a downstream project, which varies slightly by alternative.

Table 4-3. Percent Change of the Colville and Spokane Settlement Payment by Alternative Relative to the No Action Alternative

Alternative	Change in Payment
MO1	-0.5 to 0.3%
MO2	-2%
MO3	1 to 6%
MO4	5 to 8%
PA	+1%

4.1.1.3.2 BONNEVILLE FISH AND WILDLIFE PROGRAM EXPENSE AND CAPITAL COSTS

This analysis assumes that capital expense levels developed for BP-20 provide the best available starting point to forecast the capital costs across all alternatives.[40] However, Bonneville Fish and Wildlife Program expenses and associated costs (both capital and expense) may vary across the CRSO EIS alternatives. Rates were adjusted based on anticipated changes to Bonneville Fish and Wildlife Program expenses under CRSO EIS alternatives. Bonneville Fish and Wildlife Program costs are assumed to be $299 million for MO1, MO2, and MO4. For MO3, $267 million is assumed to be spent, which accounts for removal of the Lower Snake River Compensation Plan expenses from the revenue requirement, given that the LSR dams would no longer be operating to produce power. For each alternative, the change in annualized costs from the No Action Alternative is directly incorporated into rate calculations across power customers (consistent with TRM methodology). Table 4-4 shows the change in structural costs for each alternative.

Table 4-4. Change in Structural Capital Costs for Power Relative to the No Action Alternative by Alternative (thousands, 2019$)

Capital Costs from Structural Measures	NAA	MO1	MO2[1/]	MO3	MO4	PA
Annualized Costs	--	21,000	57,000	17,000	47,000	9,000

Note: Estimates are rounded to two significant digits. Assumes a 50-year useful life and a Bonneville financing rate of 4.22%.

1/ MO2 includes a costly fish collection structure at McNary and MO3 includes reductions in O&M costs from the LSR Dams. If MO2 were implemented, fish collection at McNary could be achieved by a less costly option.

[40] Initially, program expense levels for the No Action Alternative were set to FY 2016 levels to reflect the applicable FY when the Notice of Intent to Prepare the EIS was released. Bonneville evaluated the difference in capital costs in FY 2016 from the repayment study run for the BP-20 rate proceeding, and determined that FY 2016 and BP-20 fish and wildlife capital costs were nearly identical. Because many other capital costs (such as investment in generating assets, systems, etc.) and debt management programs (such as Regional Cooperation Debt) affect the level of amortization and debt repayment in any given year, it was deemed the BP-20 repayment run (incorporating a number of debt management decisions since the BP-16 rate period) provides a superior forecast for capital costs going forward, and therefore capital expense levels from BP-20 were assumed across all alternatives.

Table 4-5 presents the total power sales by alternative, the wholesale power rate prior to structural costs, and the portion of the total upward wholesale rate pressure that is derived from the changes in structural capital costs in dollars per MWh ($/MWh).

Table 4-5. Effect of Structural Costs on Wholesale Power Rates by Alternative and Scenario (2019$)

Alternative	Scenario	Wholesale Power Rate (without structural costs) ($/MWh)	Tier 1 Power Sales (1,000 MWh)	Cost per Megawatt Hour of Structural Cost Change ($/MWh)
NAA	N/A	$34.56	59,770	N/A
MO1	Bonneville Finances Zero-Carbon	$37.19	59,643	$0.35
	Region Finances Zero-Carbon	$36.48	58,215	$0.36
	Bonneville Finances Conventional Least-Cost	$36.29	58,585	$0.35
	Region Finances Conventional Least-Cost	$35.78	58,250	$0.36
MO2[1/]	N/A	$33.35	60,716	$0.94
MO3	Bonneville Finances Zero-Carbon	$41.39	60,243	$0.28
	Region Finances Zero-Carbon	$37.65	55,608	$0.31
	Bonneville Finances Conventional Least-Cost	$37.59	59,804	$0.29
	Region Finances Conventional Least-Cost	$37.10	55,050	$0.31
MO4	Bonneville Finances Zero-Carbon	$42.56	60,789	$0.77
	Region Finances Zero-Carbon	$40.02	53,873	$0.87
	Bonneville Finances Conventional Least-Cost	$41.87	56,537	$0.82
	Region Finances Conventional Least-Cost	$39.00	53,909	$0.87
PA	N/A	$35.35	59,752	$0.15

1/ MO2 includes a costly fish passage at McNary. If MO2 were implemented, fish collection could be achieved by a less costly option. MO3 includes reductions in O&M costs and ongoing capital spend for the LSR Dams.

4.1.1.3.3 TRANSMISSION EXPENSES FOR POWER

After meeting Bonneville's firm requirements power sales obligations, Bonneville is authorized to sell the power that is surplus both in and out of the Pacific Northwest region. Because these surplus (or secondary) sales are delivered across Bonneville's transmission system, the Bonneville power revenue requirement includes transmission expenses to deliver such sales. In addition, there are other obligations for which Bonneville's power business line incurs a transmission cost, such as delivering the Canadian Entitlement or delivering power to Reclamation loads, which are recovered in power rates.

The transmission rates are anticipated to be materially different across the MOs. Consequently, these expenses were adjusted for each alternative. For each alternative, the incremental deviation in annualized cost from the No Action Alternative was directly assigned to rate calculations across power customers (consistent with TRM). Table 4-6 shows the end-result transmission expense for power assumptions for each CRSO EIS alternative without additional coal retirements.

Table 4-6. Expenses Incurred by Power for Use of Transmission Services (thousands, 2019$)

Portfolio	NAA	MO1	MO2	MO3	MO4	PA
Discretionary Expenses						
Bonneville Finances Zero-Carbon	72,421	74,582	78,640	62,681	69,444	70,550
Region Finances Zero-Carbon	72,421	71,915	78,640	60,851	59,552	70,550
Bonneville Finances Conventional Least-Cost	72,421	71,723	78,640	61,800	56,039	70,550
Region Finances Conventional Least-Cost	72,421	72,089	78,640	60,651	59,288	70,550
Non-Discretionary Expenses						
All scenarios	30,711	31,036	30,769	31,552	31,726	30,942

4.1.1.3.4 REPLACEMENT RESOURCE COSTS

This analysis relies on the overarching assumption that increased constraints on the Federal hydropower system and removal of Federal resources affect LOLP. Consequently, if the LOLP for a particular MO is greater than that for the No Action Alternative, replacement power resources are required to return the region to the No Action Alternative level of LOLP (see Section 2.2. Two different replacement resource portfolios are considered in this analysis: (1) “zero-carbon,” and (2) “conventional least-cost.” Each of these portfolios is described in detail in Chapter 2 of this appendix, *Power Supply and Replacement Resources* and inform the selection of replacement power generation scenarios. Additionally, the power rates analysis considers whether the replacement resources are purchased and financed by Bonneville (Bonneville finances) or by a consortium of public utilities (Region finances). Therefore, for all MOs that would require resource replacement (MO1, MO3, and MO4), four sets of rates are computed across all of Bonneville’s customer base:

- Bonneville finances zero-carbon
- Region finances zero-carbon
- Bonneville finances conventional least-cost
- Region finances conventional least-cost

To compute the capital costs that would be required for resource replacement, the analysis uses the same methodology that is used to compute the marginal capacity resource cost for the power demand rate under the TRM, including the NW Council’s assumptions (7th Power Plan and the Mid-Term update to the 7th Power Plan) (See Chapter 2, *Power Supply and Replacement* Resources of this appendix). The production cost model, AURORA, provides variable costs (e.g., O&M and fuel, where applicable) using the modeled dispatch under the applicable scenario (Section 3.3 of Appendix I, *Hydroregulation* and Section 2.3.3 of Appendix J, *Hydropower* provides additional detail on AURORA modeling). Bonneville's FY 2019 Common Agency Assumptions for Bonneville Treasury Financing Rates and Public Financing Rates documents provide financing assumptions for the "Bonneville finance" and "Region finance" options respectively. These rates are used to amortize the total investment costs for any gas-fired generation or solar generation replacements under the CRSO EIS alternatives, then included in the revenue requirement.[41]

In Bonneville finance scenarios, Bonneville's loads and resources assumptions include power generation associated with these replacement resources from AURORA. In the Region finance scenarios, Bonneville's loads and resources are not adjusted, nor are the costs associated with any replacement resources included in the revenue requirement.

However, resource replacement in the zero-carbon scenarios includes demand response. For these scenarios, the analysis assumes that 600 MW of demand response would be achievable, split across Portland, Seattle, and the rest of Washington. Additionally, the analysis assumes that Bonneville would be the entity acquiring demand response in Seattle and the rest of Washington, regardless of whether the scenario was Bonneville finances or the Region finance, and that a local IOU would acquire demand response in Portland. Just like thermal and solar replacements, AURORA directly provides the dispatch of demand response.

Demand-response costs are sourced from the NW Council's 7th Power Plan and the Mid-Term update to the 7th Power Plan. To avoid double counting, the demand-response costs taken from the plan *do not account for transmission and distribution offsets*, because the Transmission Rate Analysis accounts for those effects. Table 4-7 presents resource replacement cost assumptions for the No Action Alternative and each MO without additional coal retirements.

Table 4-7. Annual Resource Replacement Costs by Alternative and Scenario (thousands, 2019$)

Scenario	NAA	MO1	MO2	MO3	MO4	PA
Bonneville Finances Zero-Carbon	-	151,665	-	394,566	565,223	-
Region Finances Zero-Carbon	-	160,042	-	404,642	574,532	-
Bonneville Finances Conventional Least-Cost	-	42,780	-	249,957	240,346	-
Region Finances Conventional Least-Cost	-	34,118	-	233,764	197,820	-

Note: Given the reliability benefit of MO2, there are avoided resource replacement costs because MO2 has a lower LOLP than the baseline LOLP for No Action Alternative. As an estimate, the value of these avoided resource replacements could range from $20 million to $140 million annually, depending on the least-cost or zero-carbon portfolio. This is incremental value is not accounted for in resulting rates or socioeconomic effects in this analysis. These costs include Demand Response costs in the zero-carbon scenarios ($20 million for Bonneville finances and $30 million for region finances). In the Bonneville finance zero-carbon scenario the other $10 million of demand response costs are paid by a regional IOU.

[41] See Appendix J, Hydropower, and Section 2.2, *Replacement Resources to Maintain Regional Power System Reliability,* for a discussion of replacement resource selection.

4.1.2 Market Prices

The production cost model, AURORA, is used to forecast market prices. Specifically, the BP-20 version of AURORA was updated to account for hydropower operations and replacement resources applicable under each CRSO EIS alternative. Table 4-8 presents monthly-diurnal market prices for the No Action Alternative, Preferred Alternative and MOs under average water conditions, and are adjusted to 2019 dollars using inflation.

Table 4-8. AURORA Average Market Price by Scenario and Alternative (Mid-C $/MWh, 2019$)

Scenario	NAA	MO1	MO2	MO3	MO4	PA
Zero-Carbon	$19.42	$19.18	$18.77	$19.94	$19.34	$19.54
Conventional Least-Cost	$19.42	$19.63	$18.77	$19.87	$20.82	$19.54

4.1.3 Revenue Credits

For the most part, revenues from sources other than long-term firm power sales are assumed to remain flat at the same levels forecast in BP-20. This includes revenues associated with assigning certain power costs from Federal generating resources that provide capacity or energy for ancillary and control area services provided by Bonneville Transmission, revenues associated with downstream benefits, and any market-sales revenues extending into the FY2022 period. No additional resources above the amount needed for the base analysis were added regardless if additional reserves would be needed to integrate added intermittent renewable generation. Two revenue credits, however, would be affected by different hydropower operations under CRSO EIS alternatives: the secondary energy revenue credit and the revenue credit under section 4(h)(10)(C) of the Northwest Power Act. These credits are described below.

4.1.3.1 Secondary Energy Revenue Credit

This credit accounts for the expectation that Bonneville will have surplus power in an average water year, compared to critical water (1937 water conditions). To forecast the amount of this credit Bonneville relied on the BP-20 methodology for valuing the sale of surplus power. Bonneville's load-resource balance is computed based on expected loads, adding system obligations, less the expected Federal system output with 1937 water conditions.[42] If loads exceed resources, the deficit is made up by System Augmentation—a flat purchase of power assumed in the resource mix. If, on the other hand, resources exceed load, a flat Firm Surplus

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[42] 1937 was a relatively dry year with a very early runoff of winter snowpack. This year is used to compute what is considered "firm" generation. Average water years produce more—and a better shape of—generation, such that if loads are met with 1937 water conditions, in expectation more generation will be available to sell. This excess is then sold into the market producing secondary revenue credits, which are credited to the PF rate, reducing the net revenue requirement collected from Bonneville's long-term firm power customers. In some periods under certain weather or water conditions, Bonneville makes balancing purchases to meet load; these are netted from total secondary sales before the secondary credit is applied against the cost base collected in rates.

sale is assumed on the load side so that total loads equal total resources (with 1937 water conditions). Generation in excess of the amount of energy available with 1937 water conditions (i.e., the additional energy expected on average across all 80 water years) is then assumed to be sold into the wholesale power market. Bonneville also assumes purchases of power to cover short term supply needs in a particular monthly-diurnal period. This is known as balancing purchases and is netted against expected surplus sales. The expected value of these *net* secondary revenues is credited against the total revenue requirement to produce a net revenue requirement to be collected from power rates charged to Bonneville's firm power customers.

Under each replacement resource scenario, AURORA is used to calculate: (1) the amount of generation from the replacement resources meeting load with 1937 water conditions to achieve initial load-resource balance, and (2) the average dispatch of the resources under all water conditions. Because the dispatch of gas-fired resources will be higher with low water conditions, and lower with average water conditions, the net effect is to reduce the secondary energy credit slightly for the difference in dispatch. Table 4-9 shows the quantity and value of secondary energy revenue credits anticipated for each CRSO EIS alternative and the replacement resources.

Table 4-9. Secondary Energy Revenue Credit by Alternative and Scenario (aMW and thousands, 2019$)

Scenario	NAA	MO1	MO2	MO3	MO4	PA
Quantity (aMW)						
Bonneville Finances Zero-Carbon	2,310	2,440	2,403	1,962	1,971	2,352
Region Finances Zero-Carbon	2,310	2,406	2,403	1,909	1,831	2,352
Bonneville Finances Conventional Least-Cost	2,310	2,381	2,403	1,807	1,706	2,352
Region Finances Conventional Least-Cost	2,310	2,408	2,403	1,911	1,834	2,352
Value thousands, 2019$)						
Bonneville Finances Zero-Carbon	325,894	328,847	374,083	271,419	360,986	324,713
Region Finances Zero-Carbon	325,894	290,170	374,083	246,243	235,893	324,713
Bonneville Finances Conventional Least-Cost	325,894	310,305	374,083	299,258	243,748	324,713
Region Finances Conventional Least-Cost	325,894	309,921	374,083	254,962	266,294	324,713

4.1.3.2 4(h)(10)(C) Credits

The Northwest Power Act requires Bonneville to make expenditures to mitigate fish and wildlife and their habitats in the Columbia River Basin affected by the development and operation of the Columbia River System.[43] Bonneville fulfills this mandate by making expenditures for: (1) direct fish and wildlife program operations and maintenance; (2) direct fish and wildlife program capital projects; and (3) power purchases made to replace the Federal system's firm generating capability lost due to fish mitigation measures. While Bonneville incurs these costs

[43] Section 4(h)(10)(A), 16 U.S.C. § 839b(h)(10)(A).

as part of its section 4(h)(10)(A) mitigation duty, the actions funded also offset the impacts of the Columbia River System's non-power purposes such as navigation, irrigation, or flood risk management. Bonneville is responsible for the power share of mitigation costs only, and must therefore recover the non-power share of its fish and wildlife mitigation expenditures in some other way. Section 4(h)(10)(C) provides that vehicle. It requires the Administrator to allocate the expenditures incurred mitigating fish and wildlife and to recoup the non-power share of those expenditures from the U.S. Treasury. The system-wide weighted average of the non-power cost allocation is 22.3%. Bonneville thus takes a 22.3% credit annually against its obligations to the U.S. Treasury for the non-power share of mitigation it funds.

The annual amount of section 4(h)(10)(C) credit is expected to vary across CRSO EIS alternatives because the hydropower operations undertaken and mitigation expenditures that Bonneville would make to protect fish and wildlife under these alternatives would vary, and, in turn, affect the amount of credit received. The value of the credit was modeled for the MOs using the standard rate case procedure (see Appendix J, *Hydropower*). Table 4-10 below shows the estimated revenue from the 4(h)(10)(C) Treasury credit under each alternative and scenario.

Table 4-10. 4(h)(10)(C) Treasury Credit by Scenario (thousands, 2019$)

Scenario	NAA	MO1	MO2	MO3	MO4	PA
Bonneville Finances Zero-Carbon	$93,336	$94,018	$90,096	$111,162	$110,743	$95,090
Region Finances Zero-Carbon	$93,336	$94,018	$90,096	$111,162	$110,743	$95,090
Bonneville Finances Conventional Least-Cost	$93,336	$94,060	$90,096	$110,951	$112,526	$95,090
Region Finances Conventional Least-Cost	$93,336	$94,060	$90,096	$110,951	$112,526	$95,090

4.1.4 Summary of Wholesale Power Rate Pressure by Alternative

This analysis describes how the changes in the cost of power generation and transmission place upward (or downward) pressure on wholesale electricity rates. The term "upward rate pressure" indicates the potential for increases in rates resulting from the added costs of and/or reduced revenue from 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 generation variables and the total cost adjustments described in the previous sections provide the inputs to the final wholesale power rate pressure calculation. The total costs, including all applicable discounts, divided by total system output defines the rate pressure effect for each MO and replacement resource and financing scenario. Rates may vary by utility depending on utility specific variables such as demand charges and discounts.

Table 4-11 summarizes the potential Tier 1 Average Net Cost by Scenario. The information in Table 4-11 identifies how wholesale rates would be affected if Bonneville or other regional utilities are not able to balance out the increased costs of generating and transmitting power for MO1, MO3, MO4, and the Preferred Alternative. For alternatives with relatively limited added rate pressure (e.g., the Preferred Alternative), if Bonneville is able to balance out the increased costs, wholesale power customers may not experience the increase in wholesale power rates described in Table 4-11.

This analysis did not include the effects of additional coal-plant retirements that were announced regionally after the analysis was initiated. Factoring in the effect of additional coal-plant retirements would likely increase the upward rate pressure further relative to the No Action Alternative for MO3, and lower the rates further for MO2. For MO1 and MO4, it would likely reduce the upward rate pressure relative to the No Action Alternative. When considering all cost pressure sensitivities (i.e., not only coal retirements but other regional cost pressures, such as replacement resource financing assumptions or renewable integration services), the analysis generally finds that potential upward rate pressure effects are understated. Section 3.7, especially Section 3.7.3.2 in the EIS discusses the interplay between coal-plant closures and changes in the CRS on power reliability and rates.

Table 4-11. Forecast Average Bonneville Wholesale PF Power Rate by Alternative and Scenario ($/MWh, 2019$)

Scenario	NAA	MO1	MO2[1/]	MO3	MO4	PA
Bonneville Finances Zero-Carbon	$34.56	$37.53	$34.28	$41.67	$43.32	$35.50
Region Finances Zero-Carbon		$36.83		$37.96	$40.88	
Bonneville Finances Conventional Least-Cost		$36.64		$37.88	$42.70	
Region Finances Conventional Least-Cost		$36.14		$37.41	$39.87	

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, wholesale PF rates under MO2 would be 4% lower than under the No Action Alternative as opposed to the less than one percent decrease when including the structure.

Detailed cost pressures are presented in Table 4-12 below. Key cost drivers in O&M, Fish and Wildlife programmatic spending, replacement resource costs, structural measure costs, and changes to revenue credit streams such as secondary sales on the trading floor, as well as the 4(h)10(C) credit from the US Treasury assumed in base-rate calculations are summarized by alternative. The table also shows the range of cost pressure under each alternative from the sensitivity analyses. To augment the information contained therein, Table 4-13 through Table 4-17 detail cost and revenue data going into the base case rate analysis. These tables show both the cost/revenue impacts, and decompose the overall rate impact, in percentage terms, among each of the cost/revenue drivers of the rate change relative to the No Action Alternative.

The tables are divided into four sections. The first section (rows 1-8) show the impacts to expenses assumed under each alternative relative to the No Action Alternative. For replacement resource costs, this would include demand response costs accruing to Bonneville, as well as variable O&M costs associated with replacement resources in the least-cost scenarios.[44] The second section (rows 9 and 10) show capital related costs; these reflect

[44] Line 7 also includes deviations from the No Action Alternative in tribal settlement payments, which are generally less than $1 million (average deviation is $348,000).

annualized spending on structural measures (row 9) and amortization of construction and fixed costs associated with replacement resources (row 10). In MO3, row 9 also includes changes to the replacement of federal debt due to LSR dam breach and removal of ongoing capital expenses at those dams from the repayment study.

The third section (rows 11 through 20) show deviations from the No Action Alternative under each alternative related to rate-making costs and revenue credits which are not set by budget levels. These include costs associated with the Low Density Discount, the Irrigation Rate Discount, Residential Exchange Program costs, transmission costs necessary to deliver federal power to Canada under the Canadian Entitlement, as well as transmission expenses associated with the delivery of secondary sales sold on the trading floor, Planned Net Revenues for Risk (if any), modelled secondary revenues from surplus sales associated, 4(h)10(C) revenues from the US Treasury, revenues associated with ancillary services provided to Transmission for renewable integration and balancing reserves ("Generation Inputs"), revenues accruing from the sale to Industrial customers at the Industrial Priority Firm rate, and other miscellaneous credits. The final section (row 22) shows the impact of a load change on the rate level under each alternative relative to the No Action Alternative. When loads decrease, there are fewer MWhs over which to spread Bonneville's fixed costs (and vice versa in the case of a load increase). Therefore, this rate impact is shown in percentage terms only.

Table 4-12. Summary of Cost Pressures in Rate Pressure Analysis (millions, 2019$)

Annual cost pressure deltas from NAA Bonneville Finances in millions 2019$	MO1 Zero-Carbon	MO1 Least-Cost	MO2	MO3 Zero-Carbon	MO3 Least-Cost	MO4 Zero-Carbon	MO4 Least-Cost	PA
Corps of Engineers O&M	$0	$0	$0	-$47	-$47	$0	$0	$0
Fish and Wildlife	$0	$0	$0	-$34	-$34	$0	$0	$0
Replacement Resource[/2]	$152	$43	$0	$395	$250	$568	$242	$0
Other Structural Capital Costs[/3]	$21	$21	$57	$9	$9	$47	$47	$9
Other Costs & Credits[/4]	$0	$17	-$40	$55	$20	-$47	$59	-$1
Base Case Cost Pressure	**$172**	**$80**	**$16**	**$379**	**$199**	**$568**	**$347**	**$9**
Sensitivity Analysis Cost Pressure	-$15 to $114	-$1 to $11	-$50 to $45	-$182 to $599	-$117 to $12	-$105 to $314	-$95 to $56	-$38 to $0
Base Case + Sensitivity Analysis	**$158 to $287**	**$79 to $91**	**-$34 to $61**	**$197 to $978**	**$82 to $211**	**$463 to $882**	**$252 to $403**	**-$29 to $9**

1/ Does not include rate pressure caused by decreased sales, i.e. the load effect.
2/ MO1 zero-carbon, MO2 zero-carbon, and MO3 zero-carbon do not include $10 million in demand response costs assumed to be recovered in non-Bonneville rates.
3/ Includes reduction in amortization expenses due to dam breach under MO3.
4/ Generation Inputs, net power purchases & sales, 4(h)(10)(C), etc.

Table 4-13. MO1 Detailed Rates Table: Individual cost and revenue components of rate pressure analysis (millions, 2019$)

		Zero-Carbon Portfolio – BPA Replaces		Zero-Carbon Portfolio – Region Replaces		Conventional Least-Cost Portfolio – BPA Replaces		Conventional Least-Cost Portfolio – Region Replaces	
		Change from NAA	Change in PF Tier 1 Rate	Change from NAA	Change in PF Tier 1 Rate	Change from NAA	Change in PF Tier 1 Rate	Change from NAA	Change in PF Tier 1 Rate
1	Columbia Generating Station	-	0.0%	-	0.0%	-	0.0%	-	0.0%
2	Bureau of Reclamation	-	0.0%	-	0.0%	-	0.0%	-	0.0%
3	Corps of Engineers	-	0.0%	-	0.0%	-	0.0%	-	0.0%
4	Fish and Wildlife	-	0.0%	-	0.0%	-	0.0%	-	0.0%
5	Energy Efficiency	-	0.0%	-	0.0%	-	0.0%	-	0.0%
6	Internal Operations	-	0.0%	-	0.0%	-	0.0%	-	0.0%
7	Replacement Resources (variable and demand response)	20	1.0%	20	1.0%	16	0.8%	0	0.0%
8	**Total**	**20**	**1.0%**	**20**	**1.0%**	**16**	**0.8%**	**0**	**0.0%**
	Capital								
9	Capital Related Costs	21	1.0%	21	1.0%	21	1.0%	21	1.0%
10	Replacement Resource Capital Cost	131	6.4%	-	0.0%	27	1.3%	-	0.0%
	Rate Case Cost and Credits								
11	Rate Discounts	5	0.2%	5	0.2%	5	0.2%	4	0.2%
12	Residential Exchange	(3)	-0.2%	(3)	-0.1%	(2)	-0.1%	(2)	-0.1%
13	Transmission and Ancillary Services	2	0.1%	(0)	0.0%	0	0.0%	0	0.0%
14	Planned Net Revenues for Risk	-	0.0%	-	0.0%	-	0.0%	-	0.0%
15	Net Power Purchase and Sales	(3)	-0.1%	36	1.8%	16	0.8%	16	0.8%
16	4(h)10(C)	(1)	0.0%	(1)	0.0%	(1)	0.0%	(1)	0.0%
17	Generation Inputs	-	0.0%	-	0.0%	-	0.0%	-	0.0%
18	DSI Sales	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%
19	Other Credits	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%
20	**Total**	**0**	**0.0%**	**37**	**1.8%**	**17**	**0.8%**	**17**	**0.9%**
21	**Total Net Revenue Requirement**	**172**	**8.4%**	**78**	**3.9%**	**80**	**4.0%**	**38**	**1.9%**
22	**Load Effect**		**0.2%**		**2.7%**		**2.0%**		**2.7%**
23	**Total Effect**		**8.6%**		**6.6%**		**6.0%**		**4.5%**

Table 4-14. MO2 Detailed Rates Table: Individual cost and revenue components of rate pressure analysis (millions, 2019$)

		Change from NAA	Change in PF Tier 1 Rate
1	Columbia Generating Station	-	0.0%
2	Bureau of Reclamation	-	0.0%
3	Corps of Engineers	-	0.0%
4	Fish and Wildlife	-	0.0%
5	Energy Efficiency	-	0.0%
6	Internal Operations	-	0.0%
7	Replacement Resources (variable and demand response)	(0)	0.0%
8	**Total**	**(0)**	**0.0%**
	Capital		
9	Capital Related Costs	57	2.7%
10	Replacement Resource Capital Cost	-	0.0%
	Rate Case Cost and Credits		
11	Rate Discounts	(2)	-0.1%
12	Residential Exchange	0	0.0%
13	Transmission and Ancillary Services	6	0.3%
14	Planned Net Revenues for Risk	-	0.0%
15	Net Power Purchase and Sales	(48)	-2.3%
16	4(h)10(C)	3	0.2%
17	Generation Inputs	-	0.0%
18	DSI Sales	0	0.0%
19	Other Credits	-	0.0%
20	**Total**	**(40)**	**-1.9%**
21	**Total Net Revenue Requirement**	**16**	**0.8%**
22	**Load Effect**		**-1.6%**
23	**Total Effect**		**-0.8%**

Table 4-15. MO3 Detailed Rates Table: Individual cost and revenue components of rate pressure analysis (millions, 2019$)

		Zero-Carbon Portfolio – BPA Replaces		Zero-Carbon Portfolio – Region Replaces		Conventional Least-Cost Portfolio – BPA Replaces		Conventional Least-Cost Portfolio – Region Replaces	
		Change from NAA	Change in PF Tier 1 Rate	Change from NAA	Change in PF Tier 1 Rate	Change from NAA	Change in PF Tier 1 Rate	Change from NAA	Change in PF Tier 1 Rate
1	Columbia Generating Station	-	0.0%	-	0.0%	-	0.0%	-	0.0%
2	Bureau of Reclamation	-	0.0%	-	0.0%	-	0.0%	-	0.0%
3	Corps of Engineers	(47)	-2.3%	(47)	-2.5%	(47)	-2.3%	(47)	-2.5%
4	Fish and Wildlife	(34)	-1.7%	(34)	-1.8%	(34)	-1.7%	(34)	-1.8%
5	Energy Efficiency	-	0.0%	-	0.0%	-	0.0%	-	0.0%
6	Internal Operations	-	0.0%	-	0.0%	-	0.0%	-	0.0%
7	Replacement Resources (variable and demand response)	20	1.0%	21	1.1%	113	5.5%	0	0.0%
8	**Total**	**(61)**	**-3.0%**	**(60)**	**-3.2%**	**32**	**1.5%**	**(81)**	**-4.2%**
	Capital								
9	Capital Related Costs	9	0.5%	9	0.5%	9	0.5%	9	0.5%
10	Replacement Resource Capital Cost	375	18.5%	-	0.0%	138	6.7%	-	0.0%
	Rate Case Cost and Credits								
11	Rate Discounts	12	0.6%	7	0.4%	5	0.2%	6	0.3%
12	Residential Exchange	(3)	-0.2%	(3)	-0.2%	(3)	-0.2%	(3)	-0.2%
13	Transmission and Ancillary Services	(9)	-0.4%	(11)	-0.6%	(10)	-0.5%	(11)	-0.6%
14	Planned Net Revenues for Risk	-	0.0%	-	0.0%	-	0.0%	-	0.0%
15	Net Power Purchase and Sales	54	2.7%	80	4.2%	27	1.3%	71	3.7%
16	4(h)10(C)	(18)	-0.9%	(18)	-1.0%	(18)	-0.9%	(18)	-0.9%
17	Generation Inputs	20	1.0%	20	1.0%	20	1.0%	20	1.0%
18	DSI Sales	(1)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%
19	Other Credits	-	0.0%	-	0.0%	-	0.0%	-	0.0%
20	**Total**	**55**	**2.7%**	**74**	**3.9%**	**20**	**1.0%**	**65**	**3.4%**
21	**Total Net Revenue Requirement**	**379**	**18.7%**	**23**	**1.2%**	**199**	**9.6%**	**(7)**	**-0.4%**
22	**Load Effect**		**1.9%**		**8.7%**		**-0.1%**		**8.6%**
23	**Total Effect**		**20.6%**		**9.8%**		**9.6%**		**8.2%**

Table 4-16. MO4 Detailed Rates Table: Individual cost and revenue components of rate pressure analysis (millions, 2019$)

		Zero-Carbon Portfolio – BPA Replaces		Zero-Carbon Portfolio – Region Replaces		Conventional Least-Cost Portfolio – BPA Replaces		Conventional Least-Cost Portfolio – Region Replaces	
		Change from NAA	**Change in PF Tier 1 Rate**	**Change from NAA**	**Change in PF Tier 1 Rate**	**Change from NAA**	**Change in PF Tier 1 Rate**	**Change from NAA**	**Change in PF Tier 1 Rate**
1	Columbia Generating Station	-	0.0%	-	0.0%	-	0.0%	-	0.0%
2	Bureau of Reclamation	-	0.0%	-	0.0%	-	0.0%	-	0.0%
3	Corps of Engineers	-	0.0%	-	0.0%	-	0.0%	-	0.0%
4	Fish and Wildlife	-	0.0%	-	0.0%	-	0.0%	-	0.0%
5	Energy Efficiency	-	0.0%	-	0.0%	-	0.0%	-	0.0%
6	Internal Operations	-	0.0%	-	0.0%	-	0.0%	-	0.0%
7	Replacement Resources (variable and demand response)	21	1.0%	21	1.1%	86	4.4%	1	0.0%
8	**Total**	**21**	**1.0%**	**21**	**1.1%**	**86**	**4.4%**	**1**	**0.0%**
	Capital								
9	Capital Related Costs	47	2.2%	47	2.5%	47	2.4%	47	2.5%
10	Replacement Resource Capital Cost	547	26.0%	-	0.0%	156	8.0%	-	0.0%
	Rate Case Cost and Credits								
11	Rate Discounts	12	0.6%	12	0.6%	15	0.8%	11	0.6%
12	Residential Exchange	(3)	-0.2%	(3)	-0.2%	(3)	-0.2%	(3)	-0.2%
13	Transmission and Ancillary Services	(2)	-0.1%	(12)	-0.6%	(16)	-0.8%	(12)	-0.7%
14	Planned Net Revenues for Risk	-	0.0%	-	0.0%	-	0.0%	-	0.0%
15	Net Power Purchase and Sales	(35)	-1.7%	90	4.8%	82	4.2%	60	3.2%
16	4(h)10(C)	(17)	-0.8%	(17)	-0.9%	(19)	-1.0%	(19)	-1.0%
17	Generation Inputs	-	0.0%	-	0.0%	-	0.0%	-	0.0%
18	DSI Sales	(1)	0.0%	(1)	0.0%	(1)	0.0%	(1)	0.0%
19	Other Credits	(0)	0.0%	(0)	0.0%	(0)	0.0%	(0)	0.0%
20	**Total**	**(47)**	**-2.2%**	**69**	**3.7%**	**59**	**3.0%**	**35**	**1.9%**
21	**Total Net Revenue Requirement**	**568**	**27.0%**	**136**	**7.3%**	**347**	**17.8%**	**83**	**4.4%**
22	**Load Effect**		**-1.7%**		**11.0%**		**5.8%**		**10.9%**
23	**Total Effect**		**25.3%**		**18.3%**		**23.5%**		**15.3%**

Table 4-17. Preferred Alternative Detailed Rates Table: Individual cost and revenue components of rate pressure analysis (millions, 2019$)

		Change from NAA	Change in PF Tier 1 Rate
1	Columbia Generating Station	-	0.0%
2	Bureau of Reclamation	-	0.0%
3	Corps of Engineers	-	0.0%
4	Fish and Wildlife	-	0.0%
5	Energy Efficiency	-	0.0%
6	Internal Operations	-	0.0%
7	Replacement Resources (variable and demand response)	0	0.0%
8	**Total**	**0**	**0.0%**
	Non IRP		
9	Capital Related Costs	9	0.4%
10	Replacement Resource Capital Cost	-	0.0%
	Rate Case Cost and Credits		
11	Rate Discounts	3	0.1%
12	Residential Exchange	(1)	-0.1%
13	Transmission and Ancillary Services	(2)	-0.1%
14	Planned Net Revenues for Risk	-	0.0%
15	Net Power Purchase and Sales	1	0.1%
16	4(h)10(C)	(2)	-0.1%
17	Generation Inputs	-	0.0%
18	DSI Sales	(0)	0.0%
19	Other Credits	(0)	0.0%
20	**Total**	**(1)**	**0.0%**
21	**Total Net Revenue Requirement**	**9**	**0.4%**
22	**Load Effect**		**2.3%**
23	**Total Effect**		**2.7%**

4.2 TRANSMISSION RATE PRESSURE ANALYSIS

4.2.1 CRSO Transmission Rate Pressure Methodology and Assumptions

For the transmission rate pressure analysis, a comparative analysis estimated capital costs, potential sales impacts, and the transmission rate pressure for each MO over time compared to the No Action Alternative. The transmission rate pressure analysis did not consider the potential for additional coal retirements beyond those anticipated in the BP-20 Initial Proposal and "base case" forecast. Additional details about impacts of these retirements are described in the Power Reliability Sensitivity Analyses (see Section 2.2).

4.2.1.1 Revenue Requirement

To evaluate the impacts of the MOs, the analysis calculates the estimated incremental change in revenue requirement due to additional transmission capital investments. The incremental revenue requirement approach takes the loaded capital investment and estimates the capital-related costs over time. The transmission rate pressure analysis incorporates the revenue requirement with the updated capital-related costs as described below.

4.2.1.1.1 CAPITAL ASSUMPTIONS

The transmission investments required to support the conventional least-cost and zero-carbon resource replacement portfolios under each of the MOs were used to identify the incremental capital costs associated with each of the MOs. Chapter 2 of this appendix, *Power Supply and Replacement Resources* describes the resource-replacement portfolios and selection process. Chapter 3.2 describes the process of determining the costs of new transmission infrastructure. This analysis uses typical planning estimates for the direct costs, with overhead cost loadings applied.

The overhead cost forecast is a composite rate used to distribute the non-direct capital project costs. The overhead costs are loaded onto the direct capital cost estimates. The cost components include non-direct transmission costs, supply chain support services and contracting costs, and corporate overhead costs. The FY 2019 composite rate is projected through FY 2025 (year of assumed energization) using a forecast of the GDP price deflator. This analysis assumes that capital spending would have a flat distribution between the construction start in FY 2022 and energization in FY 2025 for all capital investments. Table 4-18 below presents the capital costs added by alternative.

Table 4-18. Total Incremental Capital Costs by Portfolio and Alternative (thousands)

Alternative	Portfolios	Direct Costs	Loaded Costs
NAA	N/A	N/A	N/A
MO1	Zero-Carbon	$72,000	$99,000
	Conventional Least-Cost	$70,000	$96,000
MO2[1/]	N/A	N/A	N/A

Alternative	Portfolios	Direct Costs	Loaded Costs
MO3	Zero-Carbon	$239,000	$327,000
	Conventional Least-Cost	$167,000	$228,000
MO4	Zero-Carbon	$357,000	$489,000
	Conventional Least-Cost	$217,000	$297,000
PA[2/]	N/A	N/A	N/A

1/MO2 does not require additional capital investment. While there is the potential for avoided builds, as described in Chapter 2 -, the avoided builds are not likely to produce a reduction in the capital portfolio compared to the No Action Alternative.
2/The Preferred Alternative does not require additional capital investment.

4.2.1.2 Expense Assumptions

No changes to transmission expenses are assumed to occur under CRSO EIS alternatives. Both transfer costs and demand response expenses are included in the power revenue requirement.

4.2.1.3 Segmentation Assumptions

As described in Chapter 3.7 of the main body of the EIS, *Power Generation and Transmission*, the costs that make up the transmission revenue requirement are spread across various segments of the transmission system (groups of transmission facilities servicing a particular function or providing a specific service) for ratemaking purposes.[45] The transmission rate pressure analysis treats the capital investments under each MO as additions to the network segment. This treatment is consistent with the standard practice when investments in the system could benefit multiple users.

To incorporate this assumption into the analysis, the segmented investment base is adjusted within the revenue requirement based on when the investments are energized. When the network investment base increases, the network segment's percent share of the capital-related cost allocation increases when holding all else equal. This, in turn, reduces the percent share of costs for all other segments except the ancillary services segment. The costs of the ancillary services segment were assumed to remain constant at the level in the No Action Alternative baseline, consistent with the assumption regarding generation reserves described in Section 2.3 as the costs of which interact with ancillary services. Therefore, when incremental capital-related costs for each alternative were spread across the segments, the ancillary services segment was excluded from incremental cost distribution.

4.2.1.4 Financing Assumptions

The transmission rate pressure analysis is based on the following financing assumptions:

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[45] Additional information can be found in Bonneville's Transmission Segmentation Study and Documentation, last published for the BP-18 rate proceeding, and available at: https://www.bpa.gov/Finance/RateCases/BP-18/Pages/BP-18-Final-Proposal.aspx.

- All investments would be fully Treasury financed, consistent with typical long-term financial modeling. While there is a chance that future investments may be eligible to be part of a large generator interconnection agreement or part of the lease purchase program, those options are not modeled;
- Repayment period would be 30 years, which matches the maximum life of a single bond. This is shorter than the allowable repayment period of 35 years;
- Depreciation period would be 51 years, consistent with the weighted average service life of transmission assets; and
- Given uncertainty around time periods for construction, debt was assumed to be issued when new plant investment is put into service; therefore, there was no inclusion of allowance for funds used during construction in this analysis.

4.2.1.5 Repayment Assumptions

The financial modeling approach used in this analysis differs from a rate case approach, as an incremental revenue requirement methodology replaces the repayment model used in a rate case. Traditional repayment modeling evaluates the entire debt portfolio, aiming to minimize the costs, while considering borrowing authority constraints and financial policies. This analysis instead adds the incremental capital-related costs on top of the underlying debt portfolio, without re-running the repayment model or evaluating the potential impacts of financial policies.

The incremental approach is used to isolate the impacts of the capital additions because adding capital investment on top of the underlying debt portfolio could trigger other impacts if the repayment modeling was used. In reality, the impacts that could be triggered in repayment modeling would not only be attributed to these capital investments, but would also reflect the impacts of the full capital forecast and the underlying debt portfolio, thus obscuring the true impact of each discrete investment. Therefore, when running a delta analysis, the incremental approach used in this analysis better isolates the capital-related cost impacts of investments. However, this approach has some limitations. For example, the capital-related cost pressures could trigger a borrowing authority or financial policy effect that could increase rate pressures. Additionally, adding investments to the capital portfolio could trigger re-evaluation of the full portfolio, which may cause trade-offs in investments.

4.2.1.6 Rate Pressure Analysis

To analyze each of the CRSO EIS alternatives against the No Action Alternative, the transmission rate pressure analysis used the transmission long-term rates model. The rate levels used for the No Action Alternative were based on an existing long-term model with FY 2020-2021 (BP-20) rates applied and certain long-term financial planning assumptions. The No Action Alternative transmission analysis did not make changes to the segmented revenue requirement, long-term sales, or short-term sales.

To calculate the rate pressure under each MO, the No Action Alternative model was updated based on changes to the segmented revenue requirement, long-term sales, and short-term sales for each alternative. Once the modeling assumptions were updated for each MO, review of the modeling occurred to identify adjustments needed for cost recovery.

4.2.1.7 Short-Term Sales Assumptions

For each CRSO EIS alternative and resource replacement portfolio, the analysis relies on hydropower and market price forecasts to calculate short-term sales. Where changes occur to the hydropower and market price forecasts, short-term sales are updated beginning in FY 2022 and held constant over time (see Section 4.1.2, *Market Prices* and 4.1.3, *Revenue Credits* for discussion of market prices and secondary sales).

4.2.1.8 Long-Term Sales Assumptions

The transmission rate pressure analysis assumes that customers would use the rights under existing contractual arrangements for point-to-point service to meet transmission needs prior to purchasing additional long-term service from Bonneville. For the conventional least-cost resource replacement scenario, this assumption results in no change to Bonneville's long-term sales. For the zero-carbon resource replacement portfolio (which include solar power), however, long-term sales increased because the cumulative transmission demand is assumed to exceed the rights under existing contractual arrangements at certain times. This is because a greater amount of additional solar resources is required to meet baseline requirements in these portfolios given that solar generation is dependent on time of day, location, and seasonality.

The analysis assumes 75 percent of installed solar capacity would require firm transmission service, with 5 percent attributable to additional sales. These additional sales would begin in 2025, the year of assumed resource energization. Table 4-19 below presents the long-term sales added to each zero-carbon resource replacement scenario by alternative. No additional sales were assumed for gas-fired resources given that these resources are generally dispatchable upon demand.

Table 4-19. Changes in Long-Term Sales by Zero-Carbon Alternative (MW)

Alternative	Solar Capacity Added	Additional Long-Term Sales
NAA	N/A	N/A
MO1	1,200	45
MO2	0	0
MO3	1,960	74
MO4	5,000	188
PA	0	0

4.2.1.9 Geographic Rate Pressure Inputs

To provide a proxy geographic distribution for the transmission rate pressure, as needed for the geographic analysis described in the socioeconomic analysis, the rate pressure geographic distribution relies on the rate impacts to individual customers in the BP-20 transmission customer impact model. The BP-20 transmission customer impact model was used as a starting point for the proxy geographic distribution due to the absence of information on how customers might change over time or where additional sales might be generated in the future. To generate the geographic rate pressure, each customer's portion of the overall average rate pressure was identified based on each customer's impact from the BP-20 rates.

The geographic rate pressure distribution is based on sales assumptions from the BP-20 rate case. In order to capture the potential impacts on sales of customers converting from the network point-to-point product to network integration service in the future, the analysis assumes that eligible customers would convert their service when their existing reservation term expires. Although it may be possible under Bonneville policy for customers to convert some service earlier than assumed in the analysis, the assumption used in the analysis provides a reasonable proxy for the long-term effects of product conversion. Other than the assumptions about product conversion, the geographic rate pressure distribution relies on the BP-20 transmission customer impact model and makes no other assumptions about changes in the type or amount of service taken, the location of additional sales, or changes in Bonneville transmission customers.

The analysis estimated 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 calculated in the alternatives. 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 to evaluate retail rate implications (see Chapter 5, *Social and Economic Effects of Changes in Power and Transmission,* for a discussion of the retail rate pressure).

For load-serving utilities, transmission usage will likely tie to the geographic region in which the utility resides. Due to the nature of transmission sales and product flexibility, however, geographic impacts may not directly tie to the customer's location of sale. Although the analysis tries to geographically distribute the rate pressures based on the location of the utility, there are limitations to the accuracy of these estimates.

4.2.2 Summary of Transmission Rate Pressure by Alternative

Table 4-20 summarizes the estimated rate pressure by CRSO EIS alternative and resource replacement portfolio as compared to the No Action Alternative through FY 2028.

Table 4-20. Cumulative and Annualized Rate Pressure by Alternative and Portfolio without additional coal plant retirements (%)

Alternative	Resource Replacement Portfolio	Cumulative Rate Pressure	Annualized Rate Pressure
MO1	Zero-Carbon	5.09%	0.62%
	Conventional Least-Cost	6.06%	0.74%
MO2	N/A	0.89%	0.11%
MO3	Zero-Carbon	13.50%	1.60%
	Conventional Least-Cost	11.26%	1.34%
MO4	Zero-Carbon	16.52%	1.93%
	Conventional Least-Cost	13.52%	1.60%
PA	N/A	0.70%	0.09%

Under MO1, capital costs under the zero-carbon resource replacement portfolio would exceed capital costs under the conventional least-cost resource replacement portfolio. However, the rate pressure under the conventional least-cost resource replacement portfolio exceeds the rate pressure under the zero-carbon resource replacement portfolio because the zero-carbon resource replacement portfolio include an additional 45 MW of long-term sales from the additional 1,200 MW of solar generating capacity. Short-term sales are also higher under the zero-carbon resource replacement portfolio, reflecting the changes to hydropower and pricing (see Section 4.1, *Power Rate Pressure Analysis* for discussion of secondary sales). The resulting cumulative upward transmission rate pressures would be 6.06 percent for the least-cost replacement scenario and 5.09 percent for the zero-carbon resource replacement portfolio.

Under MO2, there would be no changes to capital-related costs or long-term sales. Additionally, this alternative does not include separate resource replacement portfolios. The rate pressure under MO2 instead reflects changes in short-term sales compared to the No Action Alternative. Therefore, hydropower and pricing changes drive the rate pressure under this alternative (see Section 4.1.3, *Revenue Credits* for discussion of secondary sales). The resulting cumulative upward transmission rate pressure would be 0.89 percent.

MO3 includes capital investment in both gas and solar replacement resources for reinforcement of the south Tri-Cities in the absence of Ice Harbor Dam generation. These investments account for approximately $94.5 million of the direct costs, or $129 million of the loaded costs in each resource replacement scenario. The remaining capital-related costs under this alternative reflect resource-specific investment needs. This alternative also includes the short-term sales updates and the solar long-term sales updates. The resulting cumulative upward transmission rate pressure would be 11.26 percent and 13.50 percent for the least-cost and zero-carbon scenarios respectively.

This analysis estimates that upward rate pressure would be highest under MO4, reflecting the fact that capital investment additions are highest under this alternative. MO4 also would result in the largest need for additional capacity, with either 3,240 MW of gas or 5,000 MW of solar required, depending on the portfolio (without additional coal retirements). The addition of solar capacity would result in 188 MW of long-term sales increases under the zero-carbon resource portfolio. Additionally, both resource portfolios include updates for hydropower and pricing changes (refer to Section 4.1, *Power Rate Pressure Analysis*, for discussion of changes in power rates). The resulting cumulative upward transmission rate pressure would be 13.52 percent and 16.52 percent for the least-cost and zero-carbon scenarios respectively.

Under the Preferred Alternative, there would be no changes in capital investments or long-term transmission sales. Upward transmission rate pressure would be about 0.09 percent annually (0.7 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.

CHAPTER 5 - SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION

To provide additional perspective on how people may be affected by the changes in how power is produced and delivered across the Pacific Northwest, this analysis evaluates the following categories of social and economic effects:

- **Social welfare effects:** The social welfare effects analysis provides information on the changes in the value of the national output of goods and services. These social welfare effects are sometimes referred to as National Economic Development (NED) effects, which are concerned only with economic efficiency at national societal level (i.e., these effects do not consider economic gains by one group at the expense of another, which are referred to as "transfers" of benefits). Social welfare gains or losses from the national perspective in this analysis are due to the changes in the marginal costs of producing power.
- **Regional economic effects:** Regional economic effects consider a regional or local perspective on changes in spending patterns and economic productivity resulting from the changes in power and transmission. This analysis provides information on how the changes in the cost of providing power affects the cost of living and doing business across Pacific Northwest residents, and commercial and industrial enterprises. In addition, this analysis employs IMPLAN to assess the effects of changing in spending on the wider regional economy through "multiplier" effects.
- **Other social effects:** The analysis of other social effects considers additional relevant dimensions of how the changes in power and transmission affect people's well-being, outside of the changes in economic value and financial cost implications. Other social effects in this analysis focus on potential health and safety outcomes of the alternatives.

The following sections provide additional detail on the methods, data, and results of these analyses, as described in Section 3.7.3 of the main body of the EIS, *Power Generation and Transmission, Environmental Consequences*. The analysis relies on the "base-case" assumptions for coal retirements described in Section 2.3 which assumes 4,246 MW of coal dedicated to serving regional load.

5.1 SOCIAL WELFARE EFFECTS ANALYSIS

From an economic perspective, the conceptual basis for measuring economic value is society's "willingness-to-pay" (WTP) for a good or service.[46] Absent data to directly measure WTP, it is common to use available information on market prices and other estimates of the marginal costs of production to quantify social welfare values of changes in power generation and transmission. This analysis applies two separate methods to estimate social welfare values of the changes in power generation and transmission: the market price method and the

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[46] WTP 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.

production cost method. These methods are both consistent with the Corps' guidance for valuing social welfare effects of changes in power, and are presented as changes relative to the No Action Alternative.[47]

These two methods are distinct approaches for estimating the social welfare effects of the alternatives. 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, which are covered in the regional economic effects analysis.

The "**market price method**" 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 alternative relative to the No Action Alternative. At market equilibrium, the market price of a good (i.e., power) exactly equals the marginal value to the buyers and the marginal cost to the sellers. Thus, the market price method is an estimate of the value (i.e., societal WTP) 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, the market prices may not provide a valid measure of the economic value of the change. In this analysis, 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 based on the costs of providing equivalent power output under each alternative.

The 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).[48] The production cost method estimates economic

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[47] These methods for quantifying social welfare effects are consistent with the Corps' guidance for valuing national economic development effects of changes in power, which 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.

[48] 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 WTP 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.

effects based on changes in the fixed and variable costs of meeting 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 interconnection). The variable costs include the changes in the cost of fuel, variable operations and maintenance, start-up costs and emissions penalties (in California) for the various generating resources under each alternative relative to the No Action Alternative. The production cost method provides a range of results based on the alternative replacement resource portfolios without additional coal retirements (as described in Chapter 2 of this appendix, *Power Supply and Replacement* Resources).

For the power system reliability benefit under MO2 the production cost method also estimates the fixed and variable costs of the resource portfolio required to bring the No Action to the same LOLP as MO2 (5 percent). Chapter 3 -describes the portfolio for the MO2 potential avoided build and this section quantifies the related social welfare effects; the values presented in each table for the production cost method represent the MO2 alternative with this potential avoided build. The social welfare analysis does not estimate potential avoided builds for the PA.

5.1.1 Social Welfare Effects Based on the Market Price Method

To develop welfare estimates, the market price approach multiplies changes in Pacific Northwest hydropower generation from HYDSIM by the average market price reported by AURORA.

5.1.1.1 Monthly Hydropower Generation

The HYDSIM model estimates the level of hydropower generation across the Pacific Northwest for the No Action Alternative and each of the MOs. The generation levels account for the total generation of the Pacific Northwest-United States system, which includes Federal and non-Federal hydropower projects across the Pacific Northwest, as defined in Chapter 1, *Introduction to Columbia River system Operations EIS and Hydropower* of Appendix J, *Hydropower*.[49] As described in Section 3.7 of the main body of the EIS, *Power Generation and Transmission,* the CRSO alternatives have the potential to affect generation at other non-federal hydropower projects. HYDSIM estimates generation levels on a monthly basis, with April and August divided into two periods, creating a fourteen-period year. Additional definitions, methodologies for the hydropower analysis, and detailed hydropower generation results are found in Chapter 3, *Impacts of the Alternatives on Hydropower, of* Appendix J*, Hydropower*.

Table 5-1 presents the monthly generation for the No Action Alternative and each MO in MWh relative to the No Action Alternative. These values are estimates of monthly aMW from HYDSIM modelling converted to MWh assuming equal half month periods for the two April and August periods. Exhibit 9 in Appendix J, *Hydropower,* provides the full operating year values including

[49] The hydropower modelling uses 80 historical water years to estimate monthly and annual hydropower generation levels. The values used in this analysis reflect the average of the 80 water years.

both April and August periods. The negative estimates identify a reduction in generation in the time period whereas positive estimates identify an increase in generation.

Table 5-1. Average Monthly Hydropower Generation under No Action Alternative, and Relative to each MO (MWh)

Month	Generation (MWh) NAA	Change in Generation Relative to No Action (MWh)				
		MO1	MO2	MO3	MO4	PA
January	11,000,000	+170,000	+430,000	-920,000	+180,000	+200,000
February	10,000,000	+11,000	+310,000	-1,000,000	-33,000	+150,000
March	10,000,000	-87,000	-280,000	-1,100,000	-2,600,000	-130,000
April	9,400,000	-320,000	+110,000	-1,600,000	-2,000,000	-790,000
May	12,000,000	-380,000	+820,000	-2,100,000	-2,100,000	-1,200,000
June	13,000,000	-110,000	+260,000	-1,500,000	-1,800,000	-640,000
July	11,000,000	-190,000	+570,000	-860,000	-1,400,000	-31,000
August	8,200,000	-430,000	+1,100,000	+520,000	-1,100,000	+250,000
September	6,600,000	+66,000	+130,000	-580,000	-220,000	+100,000
October	7,000,000	-62,000	+4,500	-480,000	-340,000	+140,000
November	8,800,000	-12,000	+160,000	-170,000	-60,000	-49,000
December	10,000,000	-180,000	+340,000	-280,000	-300,000	+4,400
Average Annual Generation	**120,000,000**	**-1,500,000**	**+4,000,000**	**-10,000,000**	**-12,000,000**	**-2,000,000**

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

5.1.1.2 Monthly Market Prices

The market prices used in this analysis are the average monthly prices from the Mid-Columbia market hub (Mid-C) calculated using the hydropower generation across 80 water conditions. These prices are considered the best indicator of societal WTP for the hydropower for the social welfare analysis because they are reflective of the broader regional power market (not limited to any one producer or customer). These market prices are estimated in AURORA by water condition (for the 80 water conditions modelled) by month and expressed as dollars per MWh, ($/MWh), adjusted to 2019 dollars. The AURORA market price estimates do not include replacement resources to evaluate how the market would respond to the operational and structural measures directly.

Table 5-2 presents the average monthly market price for the No Action Alternative and the annual average, weighted by monthly generation. Market prices in the Pacific Northwest tend to fluctuate with hydropower generation, when hydropower generation is high, particularly in the spring run-off period the average market price tends to drop while in the fall and winter when generation is lower market prices increase.

Table 5-2. Average Monthly Market Prices ($/MWh 2019$)

Month	$/MWh
January	22.32
February	21.35
March	17.78
April	16.50
May	8.71
June	4.96
July	20.18
August	23.98
September	23.33
October	21.60
November	23.35
December	24.89
Weighted Average Price	**18.32**

Note: The weighted average price represents the average monthly market price weighted by the hydropower generation for that month. The social welfare effects analysis is based on the monthly generation change presented in Table 5-1 and the corresponding monthly price presented above.

5.1.1.3 Monthly Market Price Effect

The market price approach estimates the average annual social welfare effect by multiplying the change in generation by the average monthly market price and summing over time. The intent is to approximate the change in the marginal cost of producing power, which theoretically should be reflected in the price. Table 5-3 presents these effects by month relative to the No Action Alternative. Positive values indicate a net economic gain whereas negative values indicate a net economic loss relative to the No Action Alternative.

Table 5-3. Average Monthly Market Effect (2019$)

Month	Total Market Value NAA	Monthly Effect Relative to No Action				
		MO1	MO2	MO3	MO4	PA
January	$250 million	$3.8 million	$9.5 million	-$21 million	$4 million	$4.5 million
February	$220 million	$230,000	$6.7 million	-$21 million	-$710,000	$3.2 million
March	$180 million	-$1.5 million	-$5.0 million	-$19 million	-$47 million	-$2.3 million
April	$160 million	-$5.2 million	$1.8 million	-$26 million	-$33 million	-$13 million
May	$110 million	-$3.3 million	$7.1 million	-$18 million	-$18 million	-$11 million
June	$63 million	-$520,000	$1.3 million	-$7.3 million	-$8.8 million	-$3.2 million
July	$210 million	-$3.9 million	$12 million	-$17 million	-$28 million	-$620,000
August	$200 million	-$10 million	$27 million	$12 million	-$27 million	$6 million
September	$150 million	$1.5 million	$3 million	-$14 million	-$5.2 million	$2.4 million
October	$150 million	-$1.3 million	$98,000	-$10 million	-$7.3 million	$3.1 million
November	$210 million	-$290,000	$3.7 million	-$3.9 million	-$1.4 million	-$1.1 million
December	$250 million	-$4.5 million	$8.3 million	-$7 million	-$7.5 million	$110,000
Total	**$2,100 million**	**-$25 million**	**+$75 million**	**-$150 million**	**-$180 million**	**-$12 million**

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

5.1.1.4 Average Annual Social Welfare Effects based on the Market Price Method

Table 5-4 provides the average annual social welfare effect for each alternative by summing the monthly effects over the year. The average annual social welfare effect based on this market price approach ranges from a net economic cost of $180 million under MO4 to a net economic gain of $75 million under MO2. The changes in generation are valued at the monthly No Action Alternative prices presented in Table 5-2.

Table 5-4. Market Prices Method Average Annual Social Welfare Effects (2019$)

Scenario	Change in Generation (aMW)	Change in Generation (MWh)	Average Annual Social Welfare Effect
MO1	-170	-1.5 million	**-$25 million**
MO2	+450	+4.0 million	**+$75 million**
MO3	-1,100	-10 million	**-$150 million**
MO4	-1,300	-12 million	**-$180 million**
PA	-230	-2.0 million	**-$12 million**

Note: The change in generation and the social welfare effect are rounded to two significant digits and may not sum to the totals reported due to rounding.

5.1.2 Social Welfare Effects Based on the Production Cost Method

As previously described, the market price method most likely underestimates the social welfare effects of the alternatives because it does not fully account for the marginal cost of producing power in the region under each of the alternatives. Where hydropower generation is reduced, there are additional costs associated with adding capacity in order to maintain power system reliability that are not reflected in the AURORA market price outputs for each alternative.

Specifically, the production cost method constitutes a “bottom up” approach to estimating the marginal cost of producing power based on changes in the fixed and variable costs of the system. This method sums three cost components to estimate the economic effects of the CRSO alternatives on the cost of producing and delivering power across the Western Interconnection: 1) the fixed cost of building replacement resources; 2) the fixed costs of building the necessary transmission infrastructure; and 3) the changes in the variable costs of operating the plants (e.g., the cost of fuel and other variable costs associated with fossil fuel resources).

5.1.2.1 Annualized Fixed Costs of Replacement Resources

Chapter 2 of this appendix, *Power Supply and Replacement* Resources*,* describes the methodology for calculating the costs of adding generating capacity to the system to return to the regional level of power system reliability (measured in LOLP) under the No Action Alternative assuming 4,246 MW of coal dedicated to serving regional load.

As described in Chapter 2 -, the analysis uses NW Council 7th Power Plan and Midterm Assessment values for the capital costs of natural gas and solar power. The annualized costs of these resources assume a four percent interest rate and 30-year period for the debt repayment.[50] The battery storage in MO3 assumes a shorter repayment period (15 years) based on the expected lifecycle of the batteries and thus uses a lower interest rate.

Table 5-5 lists the power resource costs by alternative. These costs do not include any fuel costs but they do include insurance, fixed operations and maintenance, and the capital expense as well as demand response costs (roughly $30 million per year) for the zero-carbon replacement resource portfolios. These estimates represent the fixed costs of providing power to maintain power system reliability under each alternative (i.e., returning LOLP to the No Action Alternative level of 6.6 percent).

Table 5-5. Power Resources Annualized Fixed Costs for the Base Case without Rate Sensitivities or Additional Coal-Plant Retirements (2019$)

Alternative	Zero-Carbon	Conventional Least-Cost
MO1	-$160 million	-$27 million
MO2[1/]	+$140 million	+$19 million
MO3	-$400 million	-$140 million
MO4	-$580 million	-$160 million
PA[1/]	--	--

Note: Estimates are rounded to two significant digits. Positive values in the table represent a decrease (net benefit) in the cost of producing power while negative values represent an increase (net cost) in the cost of producing power.
1/MO2 has a reliability benefit relative to the No Action Alternative that results in a net economic benefit of +$140 million or +$19 million for the zero-carbon and conventional least-cost portfolios, respectively. These positive values reflect a benefit in terms of the reduction in new power resources that would be required to meet reliability standards. Without considering these avoided builds there are no fixed costs associated with MO2. The Preferred Alternative also has a slightly reliability benefit, however it is small and no potential builds are quantified.

Because LOLP is five percent under MO2, this alternative is associated with a net economic benefit relative to the No Action Alternative. To estimate the value of this power system reliability benefit, the analysis estimates the capacity and generation of resources required under the No Action Alternative to reach the same LOLP level as MO2 (5 percent). The estimate of the annual avoided power replacement capital costs for MO2 is $140 million for the zero-carbon portfolio and $19 million for the conventional least-cost portfolio for the base case additional rate sensitivities or without coal-plant retirements.

5.1.2.2 Annualized Fixed Costs of Transmission Infrastructure

The transmission analysis described in Chapter 3, *Transmission System Reliability and* Congestion, identified the total infrastructure cost for connecting the replacement power resources to the electric grid. For the social welfare analysis these costs were annualized using financing assumptions consistent with the power resources analysis (interest rate of 4 percent and a 30-year period). Table 5-6 presents the amortized fixed costs by alternative for

[50] Both portfolios use the Bonneville FY 2019 tax-exempt borrowing 30-year rate for financing.

transmission infrastructure. Since MO2 avoids new power resources there are also avoided transmission infrastructure costs, however these costs were not estimated.

Table 5-6. Transmission Fixed Costs (2019$)

Alternative	Zero-Carbon	Conventional Least-Cost
MO1	$3.9 million	$3.8 million
MO2[1/]	--	--
MO3	$13 million	$9.1 million
MO4	$19 million	$12 million
PA[1/]	--	--

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
1/This analysis did not estimate the potential avoided transmission fixed costs under MO2 and the Preferred Alternative; thus the benefits (i.e., avoided costs) of MO2 and Preferred Alternative are likely an underestimate.

5.1.2.3 Average Annual Variable Costs

This analysis relies on AURORA model estimates of the fuel price and total fuel consumed in MMBTU for three regions in the western interconnection: the Pacific Northwest, California, and the rest of the western United States. Variable costs include natural gas and coal, which make up the majority of the fuel-based changes in power generation. Table 5-7 lists the fuel price for coal and natural gas. The fuel prices for each region are dollars per MMBTU.

Table 5-7. Fuel Prices by Region, dollars per million British thermal unit ($/MMBTU, 2019$)

Fuel Price	Pacific Northwest	California	Western U.S.
Coal	1.39	2.20	1.71
Natural Gas	2.08	3.02	2.08

Note: Prices reflect the annual average price from AURORA. Canada was excluded from the analysis but AURORA does generate estimates. Some very minor variation occurs between the prices in each alternative however this variation is not apparent when averaging across regions due to rounding.

AURORA estimates the amount of fuel consumed for coal and natural gas power production in MMBTU by month and water year for each region. AURORA is also able to estimate the total production cost defined as the fuel costs, startup costs, variable operations and maintenance as well as emissions penalties (in California). The fuel consumption is multiplied by the fuel price to produce a monthly fuel cost, which is averaged across water years and summed to produce an average annual total production costs which consist of the fuel cost and additional variable costs.

Table 5-8 presents the average annual fuel consumption for coal by Region and CRSO action alternative and Table 5-9 presents the average annual fuel consumption for natural gas. Because the alternatives add different resources to the regional fuel mix (i.e., natural gas versus renewables), the amount of fuel consumption differs by resource portfolio. For the zero-carbon portfolios, fossil fuel consumption does increase in certain scenarios where the replacement solar power generation is not able to sufficiently meet demand, thus requiring existing fossil fuel plants to increase generation. For example, even when solar power is added under MO1 with a zero-carbon portfolio, coal generation reduces in the Pacific Northwest, however coal generation increases in California and the rest of the Western United States. This is potentially due to the reduction in the timing and volume of hydropower exports relative to the No Action Alternative. The changes in fuel use in California for coal are much smaller than the other regions given the smaller capacity of existing coal power resources compared to the rest of the Western United States.

Table 5-8. Fuel Consumption for Coal Power Generation under the No Action Alternative, and Change from No Action by Alternative (MMBTU)

Alternative	Pacific Northwest	California	Western U.S.
NAA	85 million	3.5 million	510 million
Difference Relative to No Action			
MO1 – Zero-Carbon	-1.4 million	+7,100	+3.2 million
MO1 – Conventional Least-Cost	+580,000	+960	+1.5 million
MO2[1/]	-5.2 million	+4,400	-1.5 million
MO3 – Zero-Carbon	+7.0 million	-2,200	+5.1 million
MO3 – Conventional Least-Cost	+5.6 million	-23,000	-5.4 million
MO4 – Zero-Carbon	+5.2 million	+7,900	+2.3 million
MO4 – Conventional Least-Cost	+9.1 million	-13,000	+2.3 million
PA	+1.5 million	-9,500	-2.9 million

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
1/The MO2 values in this table do not consider avoided builds.

Table 5-9. Fuel Consumption for Natural Gas Generation under the No Action Alternative, and Change from No Action by Alternative (MMBTU)

Alternative	Pacific Northwest	California	Western U.S.
NAA	240 million	720 million	990 million
Difference Relative to the No Action Alternative			
MO1 – Zero-Carbon	-7.1 million	+1.3 million	+1.3 million
MO1 – Conventional Least-Cost	+5.4 million	+1.7 million	+1.6 million
MO2[1/]	-12 million	-5.6 million	-3.5 million
MO3 – Zero-Carbon	+12 million	+9.3 million	+5.8 million
MO3 – Conventional Least-Cost	+52 million	+1.7 million	+470,000
MO4 – Zero-Carbon	-4 million	+5.4 million	+630,000
MO4 – Conventional Least-Cost	+43 million	+11 million	+8.2 million
PA	+8.2 million	+2.3 million	+310,000

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
1/The MO2 values in this table do not consider avoided builds.

Multiplying the annual fuel consumed by the average annual fuel price generates the total variable costs for each alternative. Total variable costs reflect the difference in fuel costs between the No Action and MOs. Table 5-10 presents these total variable costs for all the alternatives relative to the No Action. Note that Table 5-10 does not present the production cost estimate for the potential avoided build of MO2. The avoided fuel cost benefits of the MO2 avoided resource build would be $22 million for a zero-carbon portfolio or $55 million for a conventional least-cost portfolio.

Table 5-10 presents the total production cost effect for each alternative by region from AURORA. The following table, Table 5-11, summarizes the effect by calculating a total variable cost effect (i.e., adding the three regions together) for each alternative relative to the No Action Alternative.

Table 5-10. AURORA Total Production Cost by Alternative and Region (2019$)

Alternative	Pacific Northwest	California	Western U.S.
NAA	$840 million	$3,600 million	$4,100 million
Difference Relative to the No Action Alternative			
MO1 – Zero-Carbon	-$22 million	+$9.2 million	+$15 million
MO1 – Conventional Least-Cost	+$17 million	+$7.8 million	+$8.1 million
MO2[1/]	-$47 million	-$23 million	-$11 million
MO3 – Zero-Carbon	+$52 million	+$43 million	+$28 million
MO3 – Conventional Least-Cost	+$150 million	+$2.6 million	-$24 million
MO4 – Zero-Carbon	+$8.1 million	+$31 million	+$14 million
MO4 – Conventional Least-Cost	+$140 million	+$45 million	+$19 million
PA	+$23 million	+$7.0 million	-$12 million

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
1/The MO2 values in this table do not consider avoided builds.

Table 5-11. Annual Variable Benefits/Costs Relative to the No Action Alternative by Alternative (2019$)

Alternative	Zero-Carbon	Conventional Least-Cost
MO1	-$2.5 million	-$33 million
MO2[1/]	+$55 million	+$22 million
MO3	-$120 million	-$130 million
MO4	-$53 million	-$210 million
PA[/2]	-$17 million	-$17 million

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding. Positive values in the table represent a decrease (net benefit) in the cost of producing power while negative values represent an increase (net cost) in the cost of producing power.
1/MO2 reduces natural gas and coal fuel use resulting in a net benefit for variable costs. The results presented in this table consider potential fuel costs for avoided new generating resources under MO2. The avoided fuel cost benefits of the MO2 avoided resource build would be $22 million for a zero-carbon portfolio or $55 million for conventional least-cost. This benefit is distinct and not additive to the $82 million benefit of MO2 when not including the potential build.
2/ The Preferred Alternative does not have replacement resource portfolios. The change in variable costs is the system wide change due to changes in fossil fuel generation under the Preferred Alternative.

5.1.2.4 Average Annual Social Welfare Effects based on the Production Cost Method

The marginal cost of producing power based on the production cost method is a sum of the changes in fixed and variable costs. Table 5-12 presents the average annual social welfare effects of each alternative based on the production cost approach.

The effects range from a benefit of $82 million under MO2 to a cost of $650 million under MO4. Table 5-12 does not present the production cost estimate for the potential avoided build of MO2. These estimates would be a benefit of $170 million ($140 million in avoided fixed costs and $22 million in avoided variable costs) for a zero-carbon portfolio and $74 million ($19 million in avoided fixed costs and $55 million in avoided variable costs) for a conventional least-cost portfolio.

Table 5-12. Production Cost Method Average Annual Social Welfare Effects (2019$)/1

Alternative	Zero-Carbon				Conventional Least-Cost			
	Total Fixed Cost	Fixed Transmission Cost/2	Variable Costs	Total Social Welfare Effect	Total Fixed Costs	Fixed Transmission Cost/2	Variable Costs	Total Social Welfare Effect
MO1	-$160 million	-$3.9 million	-$2.5 million	**-$170 million**	-$27 million	-$3.8 million	-$33 million	**$64 million**
MO2/1	+$140 million	--	+$22 million	**+$170 million**	+$19 million	--	+$55 million	**+$74 million**
MO3	-$400 million	-$13 million	-$120 million	**-$540 million**	-$140 million	-$9.1 million	-$130 million	**$270 million**
MO4	-$580 million	-$19 million	-$53 million	**-$650 million**	-$160 million	-$12 million	-$210 million	**$380 million**
PA/1	--	--	-$17 million	**-$17 million**	--	--	-$17 million	**-$17 million**

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding. Positive values in the table represent a decrease (net benefit) while negative values represent an increase (net cost) in the cost of producing power.

/1. This table presents the social welfare effects associated with the potential avoided resources required under MO2. The resource portfolio equivalent to the improvement in reliability from the No Action Alternative to MO2 would have a value ranging up to $170 million annually for a zero-carbon portfolio or a value of $74 million for a conventional least-cost portfolio. The avoided builds associated with the Preferred Alternative were not analyzed given the small changes to regional reliability.

/2 This analysis did not estimate the potential avoided transmission fixed costs under MO2 and the Preferred Alternative; thus, the benefits (i.e., avoided costs) of MO2 and Preferred Alternative are likely an underestimate.

5.1.3 Summary of Social Welfare Effects

Table 5-13 presents the total social welfare effects by alternative. Under the market price approach, the social welfare effects of the CRSO EIS alternatives range from a net economic loss of $180 million per year for MO4 to a net economic gain of $75 million per year under MO2. The production cost method results identify that the social welfare effects range from a net economic loss of $650 million per year under MO4 to a net economic gain of $55 million per year under MO2 (effects for each alternative are presented as a range based on replacement resource portfolio assumption). As previously described, the two approaches are not additive but reflect alternative approaches to estimating the social welfare effects of the alternatives. Note that Table 5-13 presents the production cost estimate for the potential avoided build of MO2. This estimate would be a benefit of up to $170 million per year for the base case without additional coal-plant retirements. With additional coal-plant retirements, the benefit for MO2 would increase, the cost for MO3 would increase, and the cost for MO1 and MO4 would be slightly smaller relative to No Action Alternative. Additionally, the benefit of MO2 would be larger if fish collection at McNary were implemented with a more cost-effective option.

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 influence this value. However, if the average annual effects persist over a 50-year timeframe (2022-2071), the net present value of the social welfare effects would be as follows[51]:

- MO1: 50-year present value cost of $680 million based on the market price method, or $1.7 billion to $4.6 billion based on the production cost method for estimating social welfare effects.
- MO2: 50-year present value benefit of $2.0 billion based on the market price method, or $2.2 billion based on the production cost method for estimating social welfare effects.
- MO3: 50-year present value cost of $4.1 billion based on the market price method, or $7.4 billion to $15 billion based on the production cost method for estimating social welfare effects.
- MO4: 50-year present value cost of $4.8 billion based on the market price method, or $10 billion to $18 billion based on the production cost method for estimating social welfare effects.
- Preferred Alternative: 50-year present value cost of $310 million based on the market price method, or $470 million based on the production cost method of estimating social welfare effects.

Table 5-13. Summary of Average Annual Social Welfare Effects (2019$)

Alternative	Market Price Method	Production Cost Method	
		Zero-Carbon	Conventional Least-Cost
MO1	-$25 million	-$170 million	-$64 million
MO2[1/]	+$75 million	+$170 million	+$74 million
MO3	-$150 million	-$540 million	-$270 million
MO4	-$180 million	-$650 million	-$380 million
PA[1/]	-$12 million	-$17 million	-$17 million

[51] 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.

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding. Positive values in the table represent a decrease (net benefit) while negative values represent an increase (net cost) in the cost of producing power and market price valuation method.
1/ The main numbers in this table presents the social welfare effects associated with the potential avoided resources required under MO2. The resource portfolio equivalent to the improvement in reliability from the No Action Alternative to MO2 would have a value ranging up to $170 million annually for a zero-carbon portfolio or a value of $74 million for a conventional least-cost portfolio. Without considering avoided potential resources the average social welfare value would be a benefit of $82 million annually for the production cost method.

5.2 REGIONAL ECONOMIC EFFECTS ANALYSIS AND METHODOLOGY

The regional economic effects analysis considers how the alternatives affect the costs of living and doing business in the Pacific Northwest. This involves estimating how the rate pressure may affect retail rates (rates paid by the residential, commercial, and industrial sectors) based on the modelled wholesale power rates, market effects, and the transmission rate pressure. The key metric provided in this analysis is average expenditures on electricity for each ratepayer sector. The geographic scale of the regional effects analysis is county-level, accounting for differences in both retail rates and consumption at this level.

The regional economic effects analysis relies on a variety of external data sources including:

- NW Council 7th Power Plan and Midterm Assessment provides a wealth of modelled power and economic data that the socioeconomic analysis used to forecast retail rates and socioeconomic data (e.g., the total number of households).
- EIA data and definitions provide various assumptions to the modeling of rates across end user groups. In addition, EIA survey data provides details on how end users consume electricity and the breakdown of costs that influence retail rates.
- U.S. Census – the CRSO rates analysis sourced demographic, county level data from the U.S. Census for a variety of household and business data. U.S. Census sources also provided geographic data.
- U.S Department of Energy (DOE) and National Renewable Energy Laboratory (NREL) – the U.S. Utility Rate Database supplies historical retail rates for each end-user group by utility where available.

The following sections provide additional detail on methods and data sources employed to estimate the regional economic effects of the alternatives. The detailed results by county can be found in Exhibit 1. Retail Rates by County.

5.2.1 Retail Rate Pressure Estimation

This analysis first estimates retail rate pressure by ratepayer sector based on changes in the Bonneville wholesale power rate pressure and transmission rate pressure described in Sections 4.1, *Power Rate Pressure Analysis* and 4.2,*Transmission Rate Pressure Analysis* . For each action alternative, changes in wholesale power and transmission rate pressure and changes in market-power purchases influence retail rate pressure, which may then lead to changes in retail rates (i.e., rates charged by retail utilities, not Bonneville or other wholesale power sellers).

Bonneville wholesale power rate pressure. Section 4.1, *Power Rate Pressure Analysis,* presents these results and elaborates on the methodology for estimating these rate changes. For Bonneville's power customers, changes in wholesale power rates directly affect utility expenditures for the share 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 based on load and resource data provided by Bonneville for each action alternative. Table 5-14 presents the average Bonneville wholesale rates. This is not the rate charged to all or any specific utility, it is the average across Bonneville customers.

Table 5-14. Average Wholesale Power Rate by Alternative for the Base Case Analysis without Rate Sensitivities or Additional Coal-Plant Retirements ($/MWh)

Resource Replacement Scenario	NAA	MO1	MO2	MO3	MO4	PA
Bonneville Finances Zero-Carbon	$34.56	$37.53	$34.28[1/]	$41.67	$43.32	$35.50
Region Finances Zero-Carbon		$36.83		$37.96	$40.88	
Bonneville Finances Conventional Least-Cost		$36.64		$37.88	$42.70	
Region Finances Conventional Least-Cost		$36.14		$37.41	$39.87	

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection at McNary could be achieved by a less costly option. Without the structure, wholesale PF rates under MO2 would be 4% lower than under the No Action Alternative as opposed to the less than one percent decrease when including the structure.

With additional coal-plant retirements, the rate pressures would likely be higher for MO3, lower for MO2, and not as much higher than the No Action Alternative for MO1 and MO4. When considering all cost pressure sensitivities (i.e., not only coal retirements but other regional cost pressures, such as replacement resource financing assumptions or renewable integration services), the analysis generally finds that potential upward rate pressure effects are understated.

Market purchases. For Bonneville and all utilities in the region (i.e., Bonneville's power customers and non-Bonneville customers), the analysis estimates how changes in market power prices and purchases (from the AURORA model) would affect overall utility expenditures. The analysis then spreads these changes over total load to estimate implications on retail rate pressure. For non-Bonneville customers, public utility disclosure data from the EIA and Washington State fuel disclosures as well as IOU IRPs allocated the estimated market effects. As presented in Section 4.1, *Power Rate Pressure Analysis*, AURORA estimated the average market prices. Table 4-8 presents the average annual market prices. Section 4.1 describes these results in further detail.

With additional coal-plant retirements, the rates would likely be higher for MO3, lower for MO2, and not as much higher than the No Action Alternative for MO1 and MO4. When considering all cost pressure sensitivities (i.e., not only coal retirements but other regional cost pressures, such as replacement resource financing assumptions or renewable integration services), the analysis generally finds that potential upward rate pressure effects are understated.

Bonneville transmission rate pressure. Section 4.2, *Transmission Rate Pressure Analysis,* describes the transmission rate pressure results and methodology and Table 4-20 presents the results by alternative for both the cumulative and annualized transmission rate pressure. The transmission rate pressure for each action alternative is the percentage difference in the transmission rate relative to the No Action Alternative. The analysis did not estimate a specific monetized rate and instead estimated a total cumulative rate pressure and an annualized value running from the BP-20 Proposal through the BP-28 rate period (i.e., 8 years).

To integrate the transmission rate pressure into the retail rate estimates the annualized rate pressures, as described above, the analysis translates into a geographic rate pressure (see 4.2.1.1) and then applies to the assumed transmission rate (13 percent of the 2022 retail rate) to estimate a cents per kWh effect for an individual utility. Historical retail rate data and the fraction of the rate were based on FERC and EIA retail rate information (EIA 2017a, 2017b). To account for the cumulative rate pressure over time the analysis first infers the share of the retail rate that comes from transmission costs for the year 2022. It then increases that share over time based on the annualized transmission rate pressure estimates for each action alternative. The transmission rate pressure analysis assumes rate pressure is 0 following the BP-28 period as this is beyond the current transmission planning horizon and uncertainty exists in forecasting rates.

Changes in Regional Total Production Cost. The changes in hydropower generation under each Alternative cause other regional power generating resources to respond and adjust their own generation. These changes in the power generation mix result in changes in the total production cost across the Western Interconnection under each MO compared to the No Action Alternative. The total production cost includes fuel costs, start-up costs, variable operations and maintenance as well as emissions penalties (in California) for existing coal and natural gas power plants. This analysis uses the AURORA model to estimate changes in the total production cost for three regions (Pacific Northwest, California and the rest of the Western United States) as described in Section 5.1.2, *Social Welfare Effects Based on the Production Cost Method.*

Table 5-10 presents the total production costs by region for the No Action Alternative and the difference for each alternative. The replacement resource variable costs are included in these totals as well. This retail rate estimation analysis only applies the change in production costs for the Pacific Northwest region and excludes the replacement resource variable costs (which are already accounted for in the resource financing scenarios). The AURORA model is not able to directly allocate these costs to utilities as this analysis requires so to allocate these costs to regional IOUs the amount of fossil fuel use for each utility was estimated with recent generation data. The change in production costs was then applied to the retail rates of regional IOUs based on their respective levels of fossil fuel generation.

Retail Rate Calculation. Taking the components described above, the analysis calculates and forecasts retail rates for 2022. The calculation for retail rate effects for utilities that purchase Bonneville wholesale power is:

> Estimated retail rate = weighted wholesale power rate + transmission rate pressure + other non-wholesale power costs

Where the wholesale power rate is a weighted combination of the Bonneville wholesale price, the market price and any replacement resource costs ($/MWh); the transmission rate pressure is a cents per kWh value derived by multiplying the utility specific rate pressure by the assumed transmission portion of the retail rate; and the other non-wholesale power costs includes administrative costs, distribution costs and transmission costs included in end-user retail rates.

The analysis weights the wholesale power rate by the fraction of total retail load purchased directly from Bonneville and then assumes the rest (net of owned existing resources) would be purchased from the market at the average annual market price for that action alternative. The analysis discounts the difference between each action alternative and the No Action Alternative wholesale rate based on the fraction of owned resources used by utility to best reflect the mixture of wholesale power costs utilities pay. For the region-finances scenarios, the wholesale power rate estimate also includes the replacement resource costs assuming 4,246 MW of coal dedicated to serving regional load (see below).For other non-wholesale power costs, the analysis assumes the MOs do not affect these costs and holds the estimated costs constant between MOs. The analysis takes these costs from the forecasted 2022 retail rate, using NW Council rate forecasts and historical retail rate data. Table 5-15 provides an example of this step of the analysis.

For entities that do not buy firm power on a long-term basis, which include some regional public bodies and IOUs, the analysis examines the transmission rate pressure, changes in production costs and the market effect as the effects on their retail rates. These utilities do not purchase firm power from Bonneville and the replacement resource analysis assumes they do not to participate in the “consortium” of utilities that purchase replacement power in the Region-finance scenario, as described below. The estimate of changes in production costs and market effects distributes the difference relative to the No Action Alternative across the entire total utility retail load along with the transmission rate pressure for that action alternative to determine effects on non-Bonneville customer retail rate pressure.

Table 5-15. Example Retail Rate Pressure Calculation, (Illustrative Example)

Utility / Column	Wholesale Rate ($/MWh) / A	Market Price ($/MWh) / B	Portion of Power from Bonneville (%) / C	Weighted Wholesale ($/MWh) / E[1/]	Non-Power Costs ($/MWh) / F	Transmission Rate Delta (cents/kWh) / G	Estimated Retail Rate (cents/kWh) / H[2/]
Utility A	30	22	100	30.0	35	0.01	6.51
Utility B	40	22	90	38.2	50	0.02	8.82
Utility C	50	22	90	47.2	40	0.01	8.73

1/ Weighted Wholesale (column E) = (C*A)+((1-C)*B)

2/Estimated Retail Rate (H) = (E+F)/1000+G

One important analytical step in the retail rate pressure analysis is the differentiation of replacement resource financing between the Bonneville or Region financing scenario. Following the calculation of Bonneville wholesale power rates, this step of the analysis determines the total cost of the replacement resource and the total generation dispatch of the replacement resources. Chapter 2 of this appendix, *Power Supply and Replacement* Resources presents the costs of the replacement resources by scenario and AURORA produced the average generation for the replacement resources for each action alternative assuming 4,246 MW of coal dedicated to serving regional load. Table 5-16 summarizes these results in MWh by alternative and portfolio. The analysis assumes that the generation of these resources does not change based on who finances the resource.

Table 5-16. Generation from Replacement Resources Estimated by AURORA, for the Base Case without Rate Sensitivities or Additional Coal-Plant Retirements (MWh)

Alternative	Zero-Carbon (solar generation)	Conventional Least-Cost (natural gas generation)
MO1	2.8 million	240,000
MO2	N/A	
MO3	6.0 million	6.0 million
MO4	12 million	1.4 million
PA	N/A	

Note: Estimates rounded to two significant digits. MO2 and the Preferred Alternative do not require replacement resources to match the reliability of the No Action Alternative.

The rate estimation allocates costs and the generation of the replacement resources based on the amount of non-federal power acquired by a regional public utility. The rate estimation spread the replacement resource costs across the total retail load of the regional utilities. If a utility does not purchase any of its power supply from Bonneville and thus would not lose power from Bonneville in MO1, MO3, or MO4 then no costs for replacement resources were allocated to that utility. Thus, the region finance scenario reflects a hypothetical group or "consortium" of regional public utilities that are no longer receiving as much power from Bonneville coming together to finance and acquire power from the replacement resources to serve their load and to restore regional reliability to the No Action Alternative level.

For both MO3 and MO4, the total generation estimated from solar power under the zero-carbon portfolio exceeded the total retail load needs of the consortium. To best reflect the total costs, the excess generation from the replacement resources the analysis assumed the consortium utilities would sell this power at the average market price. These analytical steps generated a wholesale power cost for each utility assumed to be a part of the consortium, the retail rate analysis then used this wholesale power cost for all power not coming from Bonneville.

Under each financing scenario, financing assumptions led to small differences in the total cost of replacement portfolios. Chapter 2, *Power Supply and Replacement* Resources and Chapter 4 of this appendix, *Wholesale Power and Transmission* Rates detail these portfolios and the cost assumptions, respectively. In addition, the Bonneville estimate of variable costs (fuel) for the conventional least-cost portfolio relies on critical water year generation, for consistency with typical Bonneville forecasting practice in its ratemaking procedure. This results in higher generation from the gas-fired power plants than in the region-replace scenario. While the analysis did not deviate from Bonneville's ratemaking forecasting practice, regional utilities would not be bound by such practice.

5.2.1.1 Retail Rate Structures and Cost Mechanisms

The retail rate pressure analysis assumes that multiple components of retail rate costs do not change with the CRSO MOs. These components include administrative costs or delivery charges that an individual utility may charge their customers either as a flat service fee or based on usage (such as per kWh consumed). In addition, the basis for these estimates come from the most recent year of retail rate data forecasted out with 2022, without accounting for additional potential changes in rate structures or more complex ratemaking adjustments by individual utilities. These rate changes could have changes in wholesale PF power rates that could affect end user retail rates, but analysis of the exact effects is too speculative at this time. Similarly, the analysis did not make any assumptions about future power plant construction or planned changes beyond the baseline dataset, which could affect the load of certain utilities in the future, instead as noted it follows the "base-case" analysis of no additional coal retirements.

The retail rate pressure analysis also does not estimate the exact cost associated with power generating resources used by public utilities that are also served by Bonneville as determining that cost would be too speculative. Instead the retail rate analysis weighted the increase in Bonneville wholesale power rate pressure by the percentage of the total retail load served by owned and existing resources. For example, if a specific utility would experience a $5/MWh increase in their Bonneville rate under an action alternative but they serve 20 percent of their total retail load with their own resources then the effect on their retail rate would be $4/MWh ($5 multiplied by one minus 20%).

5.2.1.2 Inclusion of Non-Bonneville Wholesale Power Customers

The regional economic effects analysis includes all utilities in the Pacific Northwest. This includes both Bonneville firm power customers and those that do not currently purchase firm requirements power under long-term contracts from Bonneville. IOUs and public utilities that do not purchase firm power from Bonneville are still affected through market purchases and transmission rate pressure; however they would not be impacted by wholesale power changes, the more direct effect of the CRSO EIS alternatives. As such, the end user rate pressures, presented in aggregate and weighted geographically as described above, may not highlight the direct impact to Bonneville's firm power customers. These customers would bear a larger portion of the costs. Therefore, in the geographic presentation of rates the counties with larger effects are generally those served by a firm power customer of Bonneville.

5.2.1.3 End User Groups

The analysis estimates retail rate pressure for three end user groups with unique electricity rate and consumption characteristics: residential, commercial and industrial. As with the whole rates analysis, this analysis estimates the potential change in retail rates assuming that retail rate pressures lead to an increase in the actual retail rates (though this may not always be the case if utilities are able to balance out some of the added costs under the MOs). To distribute the effects of each retail rate aspect above, the DOE and NREL (2018) utility rate database identifies different historical retail rates for each end user group. The EIA (2018d) defines the three end user groups as:

- **Residential**: consumers using electricity for household purposes such as heating, cooking, appliance use or any other residential uses in single and multi-family dwellings, apartments or mobile homes.
- **Commercial**: service-providing businesses as well as the equipment of businesses. The commercial sector includes government facilities as well as institutional living quarters and sewage treatment facilities. Typical electricity uses include using a wide range of equipment, lighting, refrigeration and heating/cooling.
- **Industrial**: all facilities that produce, process or assemble goods. Typical electricity uses include powering machinery, lighting and heating/cooling. Many industrial sector energy consumers generate electricity and use the heat produced from those processes within industrial activity. The North American Industry Classification System (NAICS) codes defined for industrial end users are:
    - NAICS 31-33: Manufacturing
    - NAICS: 11: Agriculture, forestry, fishing and hunting
    - NAICS 21: Mining, including oil and gas extraction
    - NAICS 23: Construction

The analysis uses the number of households as the estimate for residential end users. The commercial end user group includes all commercial establishments, except for those that are in the industrial NAICS codes listed above (i.e., all business establishments minus the industrial businesses). The industrial end user group includes all business entities included in the NAICS codes listed above.

For any utility that did not have historical data available on specific end user retail rates, the analysis adopts the average regional retail rate. The majority of regional utilities have public rate information available with only a small portion of end users being covered by utilities without this information.

5.2.1.3.1 RETAIL RATE RESULT BY END USER GROUP

Table 5-17 presents the average retail rate results by alternative for residential, commercial and industrial end-users. Section 5.2.2, *Regional Economics Results and Geographic Analysis*, describes how the analysis further breaks down these rate effects by county to generate a range of county level rate estimates and categorizes the effects into a range to contextualize the effects. Table 5-21 below presents the rate results showing the number of households and businesses that experience the specific range of average effects.

Table 5-17. Weighted Average Retail Rates by Action Alternative and Scenario (cents per kWh)

End User Group	Scenario	NAA	MO1	MO2[1 and 2/]	MO3	MO4	PA[2/]
Residential	Bonneville Finances Zero-Carbon	10.21	10.28	10.16	10.48	10.50	10.25
	Region Finances Zero-Carbon		10.28		10.44	10.51	
	Bonneville Finances Conventional Least-Cost		10.28		10.37	10.53	
	Region Finances Conventional Least-Cost		10.27		10.37	10.50	
Commercial	Bonneville Finances Zero-Carbon	8.89	8.97	8.84	9.16	9.19	8.94
	Region Finances Zero-Carbon		8.97		9.13	9.19	
	Bonneville Finances Conventional Least-Cost		8.96		9.06	9.22	
	Region Finances Conventional Least-Cost		8.96		9.05	9.18	
Industrial	Bonneville Finances Zero-Carbon	7.25	7.32	7.20	7.51	7.54	7.29
	Region Finances Zero-Carbon		7.32		7.48	7.54	
	Bonneville Finances Conventional Least-Cost		7.32		7.41	7.57	
	Region Finances Conventional Least-Cost		7.31		7.41	7.53	

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection at McNary could be achieved by a less costly option. Without the structure, rates under MO2 would be lower.
2/ MO2 and the Preferred Alternative do not include separate estimates by scenario since they do not require replacement resources.

5.2.1.4 Retail Rate Sensitivities

The retail rate analysis also considered the wholesale power rate sensitivities described in Table 4-13 through Table 4-17 in Section 4.1.4. The retail rate pressure analysis applied the range of sensitivities of the Bonneville wholesale power rate for each Bonneville-finance scenario and estimated the weighted average residential retail rate as well as the number of households that would experience increases greater than five percent for the low and high sensitivity value.

Table 5-18 presents the weighted average retail rate for the Bonneville finance scenario for each of the MOs and the Preferred Alternative under the Base Case analysis as well as the high and low sensitivities. Table 5-19 presents the percentage of households experiencing rate pressure above five percent for the Bonneville finance scenario for each of the MOs and the Preferred Alternative under the Base Case analysis as well as the high and low sensitivities.

Table 5-18. Average Residential Rate Pressure, Low and High Sensitivity and Base Case Analysis

Alternative	Low	Base	High
MO1 Zero-Carbon	0.72%	0.79%	1.4%
MO1 Least-Cost	0.72%	0.73%	0.78%
MO2	-0.72%	-0.48%	-0.25%
MO3 Zero-Carbon	1.7%	2.8%	6.5%
MO3 Least-Cost	1.0%	1.7%	1.7%
MO4 Zero-Carbon	2.4%	3.1%	5.0%
MO4 Least-Cost	2.7%	3.3%	3.6%
PA	0.24%	0.44%	0.44%

Note: These results are specific to the Bonneville finance replacement portfolios. The average rate pressure may be higher or lower for the Base Case Region finance portfolio; however the rate sensitivities do not apply to those portfolios and thus, they are not included.

Table 5-19. Percentage of Households Experiencing Rate Pressure above 5 Percent, Low and High Sensitivity and Base Case Analysis

Alternative	Low	Base	High
MO1 Zero-Carbon	0%	0%	1.8%
MO1 Least-Cost	0%	0%	0%
MO2	0%	0%	0%
MO3 Zero-Carbon	0%	14%	38%
MO3 Least-Cost	0%	0%	0%
MO4 Zero-Carbon	14%	27%	33%
MO4 Least-Cost	10%	23%	28%
PA	0%	0%	0%

Note: These results are specific to the Bonneville finance replacement portfolios. The percentage of households may be higher or lower for the Base Case Region finance portfolio; however the rate sensitivities do not apply to those portfolios and thus, they are not included.

5.2.2 Regional Economics Results and Geographic Analysis

To estimate the effect of CRSO alternatives on specific populations and regions, the analysis combines retail rates for regional Bonneville and non-Bonneville customers into average county retail rates using a geographic weighting process. To determine average county-level retail rates for the socioeconomic analysis, the analysis weights utility rates at the county level based on the estimated portion of households, commercial and industrial entities served by a utility in that county. The regional analysis uses ArcGIS, the industry standard geographic information system (GIS) program developed by Esri to analyze and map the results of the socioeconomic analysis.

The analysis examines county and zip-code level data with utility matching information provided by Bonneville and relies on publicly available GIS data sourced from Bonneville and its Geospatial Portal to confirm the matching of utilities (Bonneville 2018a).[52] The data available includes shapefiles for the Bonneville service area (the area of analysis for the power rates and socioeconomic analysis) and for public utilities across the region. The geographic analysis allowed allocation of retail rate changes to specific counties. An estimate of the households per county and a "centroid method," using geographic information system (GIS) software, utility data and census data, generate an estimate of the percent of each county served by each utility.[53] Some counties are served by multiple utilities while others are served by a single utility. In addition, counties are variably served by Bonneville public utilities customers, public utilities that are not Bonneville customers, IOUs, or some combination of utilities. Section 5.2.3, *Summary of Regional Economic Effects Results*, presents the mapped results of county level rate effects.

Table 5-20 provides an example of the geographic weighting that generated county-level retail rate pressures. County-level data from the U.S. Census determines the number of residential, commercial and industrial end-users in each county (Census 2016, 2017a). In addition, the analysis uses U.S. Census data matched to state and county boundaries primarily using TIGER/Line shapefiles (Census 2018).[54] This data allowed linking the retail rate results by county to the results maps (see Section 5.2.3, *Summary of Regional Economic Effects Results*, and Figure 5-1. Average 2022 Estimated Residential Rate, No Action Alternative (cents per kWh) through Figure 5-6. Preferred Alternative Average Residential Rate Pressure by County (% Change from the No Action Alternative)). For the purpose of estimating rates, the analysis assumes that geographic boundaries across counties do not shift over time (i.e., no utility service territories change over time).

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[52] The Bonneville Geospatial portal provides GIS shapefiles of all utilities that purchase power from Bonneville in the Pacific Northwest as well as regional IOUs and Bonneville transmission infrastructure. This geospatial data is available at: https://bpagis.maps.arcgis.com/home/index.html

[53] The centroid method identifies the center of individual census block groups (the smallest geographic unit of census data) and then matches the corresponding utility based on which utility overlaps the center. This analysis uses utility shapefiles and census American Community Survey data (Census 2017, 2018). This method was not directly applied to utility weighting (i.e., the percent of a county served by a specific utility) but was instead applied to validate the estimated weighting provided by other data sources.

[54] The U.S. Census generates geographic data as Tiger/Line files that provide a standard geographic identifier to link census surveys and data for GIS mapping (Census 2018). These files do not provide demographic data but can be linked to demographic data from the American Community Survey. Tiger/Line data is available at: https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html
American Community Survey data is available at: https://data.census.gov/cedsci/.

Table 5-20. Geographic Weighting Process (Illustrative Example)

County / A	Utility / B	Portion of County Households Served / C	Utility Retail Rate (cents/kWh) / D	Weighted Retail Rate (cents/kWh) / E[1/]	County Retail Rate (cents/kWh) / F[2/]
County X	Utility A	25%	10	2.5	10.5
	Utility B	50%	12	6	
	Utility C	25%	8	2	

1/Weighted retail rate (column E) = C*D
2/ County Retail Rate (column F) = D1+D2+D3

The analysis weights rates by county for each end-user group to estimate residential, commercial and industrial rate pressure.

The rates analysis weights the average rate pressure effect across the region by residential customers (i.e., households) to estimate the average rate pressure effect by county and then categorizes the number of households experience a specific range of rate pressure effects. Table 5-21 presents this categorization and the results by alternative. For context, the average year-to-year upward rate pressure is between 2 and 3 percent. As noted above, certain counties that are not directly affected by wholesale power and transmission changes would largely have no or very little effect. The counties served by utilities that get most or all of their power from Bonneville would experience larger upward rate pressure effects in the base case. Increases or decreases relative to the No Action Alternative are expected to be larger for MO2 (i.e. larger downward rate pressure) and MO3 (larger upward rate pressure) with additional coal-plant closures. As described in Section 3.7.3 of the main body of the EIS, the analysis considers the sensitivity of these results to additional factors as well as coal retirements (such as integration services and financing assumptions) potentially affecting power and transmission rates, generally finding that potential upward rate pressure effects are understated.

Table 5-21. Percent of Households in Northwest that Experience the Range of the Rate Pressures, for the Base Case without Rate Sensitivities or Additional Coal-Plant Closures

Scenario		Percent of Regional Households Experiencing the Range of Rate Pressure					
		Increase Above 10%	Increase above 5%	Increase between 2.5 and 5 %	Increase below 2.5% above 1%	Increase from 0% to 1%	Decrease
MO1	Bonneville Finances Zero-Carbon	0%	0%	6.2%	25%	46%	22%
	Region Finances Zero-Carbon	0%	1.2%	3.0%	27%	46%	22%
	Bonneville Finances Conventional Least-Cost	0%	0%	0%	28%	72%	0%
	Region Finances Conventional Least-Cost	0%	0%	1.2%	18%	81%	0%
MO2	MO2[1/]	0%	0%	0%	0%	2.2%	98%

Scenario		**Percent of Regional Households Experiencing the Range of Rate Pressure**					
		Increase Above 10%	**Increase above 5%**	**Increase between 2.5 and 5 %**	**Increase below 2.5% above 1%**	**Increase from 0% to 1%**	**Decrease**
MO3	Bonneville Finances Zero-Carbon	0%	14%	20%	51%	16%	0%
	Region Finances Zero-Carbon	1.4%	3.8%	29%	46%	20%	0%
	Bonneville Finances Conventional Least-Cost	0%	0%	22%	46%	32%	0%
	Region Finances Conventional Least-Cost	0%	2.0%	14%	52%	32%	0%
MO4	Bonneville Finances Zero-Carbon	0.25%	27%	10%	35%	27%	0%
	Region Finances Zero-Carbon	4.3%	23%	10%	31%	31%	0%
	Bonneville Finances Conventional Least-Cost	0.0%	23%	22%	46%	9.4%	0%
	Region Finances Conventional Least-Cost	0.79%	11%	30%	49%	10%	0%
PA	PA	0%	0%	0%	7.3%	93%	0%

Note: Values are rounded to two significant digits and may not sum to 100 due to rounding.
1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, rates under MO2 would be lower. See the low rate sensitivity results for the potential rate pressures without this structure under MO2.

The regional economic analysis also considers different geographic categorization: CRSO Regions and rural or urban areas. The geographic analysis takes additional county-level data and assigns each county to the CRSO Regions. The analysis of regions follows the standard CRSO regions (A, B, C, D and Other) presented throughout the EIS. Figure 1-2 presents a map of the regions. The rates analysis assigns all counties that did not fall into Regions A through D counties to be in the "Other" Region. Table 5-22 presents the residential retail rate pressures by CRSO Region.

Table 5-22. Average No Action Alternative Residential Retail Rate and Rate Pressure (Percent Change) for Each MO by CRSO Region for the Base Case without Rate Sensitivities or Additional Coal-Plant Closures

Scenario		**Region A**	**Region B**	**Region C**	**Region D**	**Other**
NAA	NAA Rate	**10.13**	**8.32**	**10.04**	**9.43**	**10.49**
MO1	Bonneville Finances Zero-Carbon	1.2%	0.68%	0.64%	1.3%	0.74%
	Region Finances Zero-Carbon	0.96%	1.2%	0.60%	1.7%	0.60%
	Bonneville Finances Conventional Least-Cost	0.87%	0.61%	0.59%	1.0%	0.71%
	Region Finances Conventional Least-Cost	0.71%	0.76%	0.54%	1.1%	0.59%

Scenario		Region A	Region B	Region C	Region D	Other
MO2	MO2[1/]	-0.46%	-0.38%	-0.40%	-0.45%	-0.49%
MO3	Bonneville Finances Zero-Carbon	3.3%	2.4%	2.2%	4.1%	2.7%
	Region Finances Zero-Carbon	1.9%	3.4%	1.9%	4.7%	2.1%
	Bonneville Finances Conventional Least-Cost	1.8%	1.6%	1.3%	2.5%	1.6%
	Region Finances Conventional Least-Cost	1.4%	2.0%	1.3%	2.8%	1.5%
MO4	Bonneville Finances Zero-Carbon	4.2%	3.0%	2.4%	5.2%	2.8%
	Region Finances Zero-Carbon	2.8%	4.1%	2.4%	6.3%	2.7%
	Bonneville Finances Conventional Least-Cost	3.7%	2.9%	2.6%	4.7%	3.2%
	Region Finances Conventional Least-Cost	2.6%	3.4%	2.4%	4.8%	2.7%
PA	PA	0.41%	0.31%	0.35%	0.56%	0.45%

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, rates under MO2 would be lower. See the low rate sensitivity results for the potential rate pressures without this structure under MO2.

For the designation of rural and urban areas, the analysis applies Rural Urban Continuum (RUC) codes. RUC codes use U.S. Census Bureau data to subdivide the Office of Management and Budget's classification of metropolitan and non-metropolitan areas into a more detailed breakdown of nine county distinctions (USDA 2013). These categories distinguish between counties within, adjacent to, or nonadjacent to, a metropolitan area by population levels. Table 5-23 lists these categories and their definitions.

Table 5-23. Rural-Urban Continuum (RUC) Codes and Definitions

RUC Code	Definition
1 – Metro	Counties in metro areas of 1 million population of more
2 – Metro	Counties in metro areas of 250,000 to 1 million population
3 - Metro	Counties in metro areas of fewer than 250,000 population
4 – Non-metro	Urban population of 20,000 or more, adjacent to a metro area
5 – Non-metro	Urban population of 20,000 or more, not adjacent to a metro area
6 – Non-metro	Urban population of 2,500 to 19,999, adjacent to a metro area
7 – Non-metro	Urban population of 2,500 to 19,999, not adjacent to a metro area
8 – Non-metro	Completely rural or less than 2,500 urban population, adjacent to a metro area
9 – Non-metro	Completely rural or less than 2,500 urban population, not adjacent to a metro area

Source: USDA 2013

For the CRSO EIS analysis, the regional economic effects analysis matches each county to the appropriate RUC code and generated a weighted average rate pressure for each categorization. Table 5-24 presents the breakdown of the average rate pressure by scenario by county type. The rate pressure would be larger for customers of public utilities receiving power from Bonneville and lower for others.

Table 5-24. Average No Action Alternative Residential Rate and Rate Pressure Relative to the No Action by RUC Code, for the Base Case without Rate Sensitivities or Additional Coal-Plant Closures

CRSO Alternative and Scenario		Rural-Urban Continuum Code								
		1	2	3	4	5	6	7	8	9
		Metropolitan			Urban				Rural	
NAA	NAA Rate	10.37	10.17	10.02	10.21	10.09	9.67	9.72	10.22	11.64
MO1	Bonneville Finances Zero-Carbon	0.93%	0.63%	0.25%	1.2%	0.81%	1.2%	1.5%	0.69%	0.84%
	Region Finances Zero-Carbon	0.73%	0.73%	0.48%	1.1%	0.64%	1.6%	1.3%	0.74%	0.72%
	Bonneville Finances Conventional Least-Cost	0.81%	0.58%	0.46%	1.0%	0.78%	0.92%	1.1%	0.60%	0.67%
	Region Finances Conventional Least-Cost	0.65%	0.58%	0.52%	0.88%	0.65%	0.99%	0.92%	0.58%	0.58%
MO2	MO2[/1]	-0.47%	-0.40%	-0.56%	-0.49%	-0.61%	-0.38%	-0.44%	-0.36%	-0.39%
MO3	Bonneville Finances Zero-Carbon	3.0%	2.3%	1.8%	3.7%	2.9%	3.4%	4.0%	2.2%	2.5%
	Region Finances Zero-Carbon	2.3%	2.4%	2.2%	3.4%	1.9%	3.4%	2.9%	2.0%	1.9%
	Bonneville Finances Conventional Least-Cost	1.8%	1.5%	1.3%	2.2%	1.6%	1.9%	2.2%	1.4%	1.4%
	Region Finances Conventional Least-Cost	1.7%	1.6%	1.5%	2.2%	1.4%	2.1%	1.9%	1.3%	1.30%
MO4	Bonneville Finances Zero-Carbon	3.3%	2.7%	1.8%	4.3%	3.2%	4.2%	5.1%	2.6%	2.9%
	Region Finances Zero-Carbon	3.2%	3.0%	2.3%	4.7%	2.4%	4.4%	4.2%	2.5%	2.6%
	Bonneville Finances Conventional Least-Cost	3.6%	2.8%	2.5%	4.3%	3.5%	3.8%	4.5%	2.7%	2.8%
	Region Finances Conventional Least-Cost	3.0%	2.7%	2.6%	3.9%	2.7%	3.6%	3.5%	2.4%	2.3%
PA	PA	0.49%	0.35%	0.36%	0.56%	0.46%	0.45%	0.52%	0.34%	0.36%

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, rates under MO2 would be lower. See the low rate sensitivity results for the potential rate pressures without this structure under MO2.

5.2.2.1 Expenditure Effects Analysis

Following the estimation of average retail rates by county, quantified in Step 5, the regional economic effects analysis forecasts the rate effects over time and translates the county-level retail rate effects into changes in spending on electricity and the costs of living and doing business for Pacific Northwest residents and businesses under each alternative compared to the No Action Alternative. The analysis quantifies the effects that alternatives would have on spending levels for residents and businesses for electricity over the 20-year timeframe. This requires forecasting the average county-level retail rate and load over the following 20 years using load and rate forecasts from the NW Council and described below (NW Council 2016b, 2019c). The forecasts for retail rates and loads for residential consumers include low, medium, and high scenarios, which reflect the uncertainty regarding assumptions.

The analysis forecasts retail electricity rates and the loads by end user from 2022 to 2041 to generate a long term rate and expenditures forecast. The analysis presents rate dollar values in 2019 dollars deflated using the Bonneville common agency financing assumptions. For each action alternative the retail rate forecast and load forecasts all derive from NW Council data and are not adjusted between alternatives. To reflect uncertainty, the analysis considers three levels of forecasts: high, medium and low. Table 5-25 below presents the average regional forecast rates.

Table 5-25. Forecast Growth of Regional Electricity Rates, for the Base Case without Rate Sensitivities or Additional Coal-Plant Closures

Scenario	Rate Forecast (real growth rate, adjusted for inflation)	Load Forecast		
		Residential	Commercial	Industrial
High	+0.98%	-1.4%	+0.50%	+1.0%
Medium	-0.68%	-1.6%	+0.22%	+0.71%
Low	-0.98%	-1.9%	-0.21%	+0.29%

The transmission rate pressure estimates an annualized effect that extends out through BP-28. To forecast retail rates beyond 2022, the analysis relies on NW Council data and applies the annualized transmission rate pressure for each year through 2029 (i.e., BP-28). This results in increasing differences between the No Action Alternative and the Multiple-Objective Alternatives (MOs). The transmission rate pressure is the only retail rate variable that fluctuates year over year in the analysis. The power rates analysis (see Section 4.2, *Transmission Rate Pressure Analysis*) estimates wholesale power rates before and after the alternative is implemented, projected, calculated for 2022. Table 5-26**,** Table 5-27 and Table 5-28 below present the average residential retail rate pressure over time for each action alternative relative to the No Action Alternative. All rate pressures (i.e., transmission rate pressure) are held constant after 2030 through 2041.

Table 5-26. Residential Rate Pressures over Time, Medium Scenario, for the Base Case without Rate Sensitivities or Additional Coal-Plant Closures

Scenario		2022	2024	2026	2028	2030
NAA	NAA Rate	10.21	10.07	9.93	9.79	9.66
MO1	Bonneville Finances Zero-Carbon	0.79%	0.95%	1.1%	1.3%	1.4%
	Region Finances Zero-Carbon	0.76%	0.92%	1.1%	1.2%	1.3%
	Bonneville Finances Conventional Least-Cost	0.73%	0.92%	1.1%	1.3%	1.4%
	Region Finances Conventional Least-Cost	0.65%	0.84%	1.03%	1.2%	1.3%
MO2[1/]	MO2[1/]	-0.48%	-0.45%	-0.42%	-0.39%	-0.38%
MO3	Bonneville Finances Zero-Carbon	2.8%	3.2%	3.6%	4.0%	4.2%
	Region Finances Zero-Carbon	2.4%	2.8%	3.2%	3.7%	3.9%
	Bonneville Finances Conventional Least-Cost	1.7%	2.0%	2.4%	2.7%	2.9%
	Region Finances Conventional Least-Cost	1.7%	2.0%	2.3%	2.7%	2.9%
MO4	Bonneville Finances Zero-Carbon	3.1%	3.6%	4.1%	4.6%	4.8%
	Region Finances Zero-Carbon	3.1%	3.6%	4.1%	4.6%	4.9%
	Bonneville Finances Conventional Least-Cost	3.3%	3.7%	4.1%	4.5%	4.7%
	Region Finances Conventional Least-Cost	2.9%	3.4%	3.8%	4.2%	4.4%
PA	PA	0.44%	0.46%	0.49%	0.51%	0.52%

Note: Rate effect is held constant after 2030 through 2041.

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, rates under MO2 would be lower.

Table 5-27. Residential Rate Pressures over Time, High Scenario, for the Base Case without Additional Coal-Plant Closures

Scenario		2022	2024	2026	2028	2030
NAA	NAA Rate	10.21	10.41	10.61	10.82	11.04
MO1	Bonneville Finances Zero-Carbon	0.79%	0.95%	1.1%	1.2%	1.3%
	Region Finances Zero-Carbon	0.76%	0.92%	1.1%	1.2%	1.3%
	Bonneville Finances Conventional Least-Cost	0.73%	0.91%	1.1%	1.3%	1.4%
	Region Finances Conventional Least-Cost	0.65%	0.83%	1.02%	1.2%	1.3%
MO2[/1]	MO2[1/]	-0.48%	-0.45%	-0.42%	-0.39%	-0.38%
MO3	Bonneville Finances Zero-Carbon	2.8%	3.2%	3.6%	3.9%	4.1%
	Region Finances Zero-Carbon	2.4%	2.8%	3.2%	3.6%	3.8%
	Bonneville Finances Conventional Least-Cost	1.7%	2.0%	2.3%	2.7%	2.8%
	Region Finances Conventional Least-Cost	1.7%	2.0%	2.3%	2.6%	2.8%
MO4	Bonneville Finances Zero-Carbon	3.1%	3.5%	4.0%	4.5%	4.7%
	Region Finances Zero-Carbon	3.1%	3.6%	4.1%	4.5%	4.8%
	Bonneville Finances Conventional Least-Cost	3.3%	3.7%	4.1%	4.5%	4.6%
	Region Finances Conventional Least-Cost	2.9%	3.3%	3.7%	4.1%	4.3%
PA	PA	0.44%	0.46%	0.48%	0.50%	0.52%

Note: Rate effect is held constant after 2030 through 2041.

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, rates under MO2 would be lower.

Table 5-28. Residential Rate Pressures over Time, Low Scenario, for the Base Case without Additional Coal-Plant Closures

Scenario		2022	2024	2026	2028	2030
NAA	NAA Rate	10.21	10.01	9.81	9.62	9.43
MO1	Bonneville Finances Zero-Carbon	0.79%	0.95%	1.1%	1.3%	1.3%
	Region Finances Zero-Carbon	0.76%	0.92%	1.1%	1.3%	1.3%
	Bonneville Finances Conventional Least-Cost	0.73%	0.92%	1.1%	1.3%	1.4%
	Region Finances Conventional Least-Cost	0.65%	0.84%	1.0%	1.2%	1.3%
MO2[1/]	MO2[1/]	-0.48%	-0.45%	-0.42%	-0.39%	-0.37%
MO3	Bonneville Finances Zero-Carbon	2.8%	3.2%	3.6%	4.0%	4.2%
	Region Finances Zero-Carbon	2.4%	2.8%	3.3%	3.7%	3.9%
	Bonneville Finances Conventional Least-Cost	1.7%	2.0%	2.4%	2.7%	2.9%
	Region Finances Conventional Least-Cost	1.7%	2.0%	2.3%	2.7%	2.9%
MO4	Bonneville Finances Zero-Carbon	3.1%	3.6%	4.1%	4.6%	4.8%
	Region Finances Zero-Carbon	3.1%	3.6%	4.1%	4.6%	4.9%
	Bonneville Finances Conventional Least-Cost	3.3%	3.7%	4.1%	4.5%	4.8%
	Region Finances Conventional Least-Cost	2.9%	3.4%	3.8%	4.2%	4.4%
PA	PA	0.44%	0.46%	0.49%	0.51%	0.52%

Note: Rate effect is held constant after 2030 through 2041.

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, rates under MO2 would be lower.

Finally, the analysis estimates end-user responses to price changes (i.e., reducing demand due to 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 (EIA 2014). The elasticities section below describes these estimates and the literature review surrounding them. All of the rate and spending estimates are compared back to the No Action Alternative to produce dollar value changes and percentage changes relative to the No Action Alternative.

5.2.2.1.1 END-USER CONSUMPTION

The rates analysis derives end-user electricity consumption for households from NW Council load forecasts and the forecast of the number of households. The estimate of average household electricity consumption equals the total residential load divided by total number of households estimated in 2022.

The NW Council does forecast commercial and industrial load, however it does not forecast the number of commercial or industrial entities in the same manner as households, instead focusing on commercial floor space and industrial production ($ by industry). Thus, the analysis relies on EIA data to provide average consumption information for commercial and industrial end users. The average monthly consumption from the EIA was multiplied to get an annual value then forecasted to 2022 estimated levels based on NW Council load forecasts for commercial and industrial end-users, consistent with the rate estimates (EIA 2017b, NW Council

2016a). The analysis does not consider county or utility level differences between consumption, only state level estimates based on NW Council and EIA data. For the counties outside of the Pacific Northwest, the forecast applies the regional average load growth to 2022.

Table 5-29. 2022 Annual Consumption Estimates, (MWh/year)

State	Residential	Commercial	Industrial
Idaho	10	54	290
Montana	12	42	590
Oregon	9.7	63	610
Washington	10	76	930
California	6.8	64	380
Nevada	11	57	4,100
Wyoming	11	61	1,000

Note: Estimates are rounded to two significant figures.

As described in Section 3.7.3 *Power Generation and Transmission, Environmental Consequences* of the main EIS document, for context and comparison of changes in generation, the analysis assumes that roughly 796 regional households consume 1 aMW per year (NW Council 2019c). This equates to an average across the region of 11 MWh per household per year. For example, the city of Everett, WA consumes roughly 136 aMW per year. This average household consumption is slightly lower than the end user consumption estimates generated from EIA and NW Council data. However, the analysis uses this figure to generate comparisons and provide context for the amount of power generation change in each action alternative not explicitly for the spending and consumption estimates.

Over time, the consumption estimates change based on the forecasted growth rates in Table 5-29**.** The analysis multiplies this average consumption by the average rate in each county to estimate the annual expenditures by end user group and by county. For each action alternative, the regional economic analysis applies elasticity estimates to the level of consumption estimate, based on the percentage rate change and the elasticities described below. Table 5-31 below presents the expenditure results.

5.2.2.1.2 ELASTICITIES AND EXPENDITURE EFFECTS

Consistent with economic theory, price increases typically cause consumers to adjust their consumption based on the price effect. For most goods, when price increases, demand falls. These demand changes based on price changes are the "price elasticity" of a good. The CRSO EIS analysis includes a literature review to determine the most appropriate elasticity estimates for all three end user groups. Economists often identify short-run and long-run elasticities due to the fact that consumers might not be able to adapt consumption immediately, but with a sustained price increase, would adjust over time. Long-run elasticities are thus larger than short-run elasticities. Table 5-30 summarizes the elasticities applied in this analysis.

EIA estimates for the short run are in a similar range with short-run elasticities of -0.12 for year 1 and -0.21 for year 2 (EIA 2014). For industrial end users the EIA uses various data sources to consider ranges for energy-intensive industries and non-energy-intensive industries. EIA estimates ranged from -0.2 to -1.3 depending on the industry and the level of energy-intensiveness (EIA 2018a, 2018b). Estimates for industrial end users often consider all energy and not just electricity with some considering potential fuel changing between fossil fuels and electricity (EIA 2018a, 2018b).

There is little consensus on the exact responsiveness of consumers to price effects; however most literature agrees that consumers do respond to price changes, despite relatively "inelastic" short-run responses (Electric Power Research Institute [EPRI] 2008; NREL 2006; National Economic Research Associates [NERA] 2015). Literature identifies multiple potential estimates for price elasticities for electricity, with most having very close to fully inelastic results in the short term (i.e., close to 0). Epsey and Epsey (2004) in a meta-analysis, identified a residential elasticity of -0.35 while Garcia-Cerruti (2000) found estimates for California of -0.17 with a wide range between different counties. A review of state, sector and temporal data for the U.S. found elasticities similarly inelastic at -0.1 in the short-run increasing to -1 in the long run (Abayasekara and Burke 2017). A review of literature in 2015 identified short-run elasticities ranging from -0.2 to -0.35 for residential end users and 0 to -0.22 for commercial and industrial end users (NERA 2015). These estimates are much higher for the long-run where some literature has identified elasticities over -1 for industrial end users and close to -1 for commercial and residential end users (NERA 2015).

Some literature has identified region and state specific elasticities (NREL 2006). The range for the Pacific Northwest short-run residential elasticity identified by NREL was +0.1 to -0.26. There is also the potential that price elasticity fluctuates with income levels, however the CRSO analysis does not take this potential range of elasticities into consideration (Reiss and White 2001).

For the CRSO EIS, the rates analysis uses EIA estimates for residential and commercial electricity use. These are consistent with other estimates provided in economics literature and are from a Federal source that was also relied upon for other electricity data.

Table 5-30. EIA Elasticity Estimates

End User Group	Year 1	Year 2	Year 3	Year 25
Residential	-0.12	-0.21	-0.24	-0.40
Commercial	-0.12	-0.20	-0.25	-0.82

In addition to the elasticities described above, there is the potential additional individual energy conservation decisions by end-users. Individual residential customers may opt to make additional electricity conservation decisions (i.e., reduce electricity demand) to address any potential increase in household bills that are beyond conservation reactions considered by the load forecast. For example, a household could switch to natural gas or propane instead of heating residences with electricity or opt to obtain residential solar to offset cost increases; however these individual consumption reactions are highly uncertain.

Given the range of activities performed by industrial entities and the various industries that they represent, the analysis applies a conservative estimate for the short-term of -0.2 (the same as commercial entities). There is the potential in the longer term for industrial customers to be far more elastic (reduce consumption more), which would result in larger decreases in load and thus bills. As described above, there is a large range of elasticities for industrial end-users presented in the literature with potentially large variations between industries (EPRI 2008; EIA 2018a, 2018b).

The CRSO electricity expenditures analysis calculates the first-year elasticity effect to determine the amount of consumption that end users reduce based on the retail rate changes relative to the No Action Alternative rates. All expenditure estimates presented in the Power and Transmission Rates analysis factor in these elasticities estimates. Table 5-31 presents the estimated changes in expenditures when considering elasticities for each alternative.

In addition to the rate and load forecast, incomes increased by a real rate of 3.1 percent based on the NW Council 7th Power Plan economic appendices. To estimate the percent of income spent on electricity for residential end users, the analysis divided the total annual expenditures by the estimated 2022 incomes, grown at the NW Council growth rate and deflated to 2019 dollars.

The analysis multiplied the estimated rates by estimates of annual consumption for each end-user group to determine the potential effect on average spending on electricity. The socioeconomic analysis then compared differences between MOs to the No Action Alternative level of expenditures.

Table 5-31. Average Expenditures per Household by Alternative, Total Annual Expenditures under No Action and Percentage Difference by Action Alternative, for the Base Case without Rate Sensitivities or Additional Coal-Plant Retirements

End User Group	Scenario	NAA Expenditures	Difference relative to NAA, %				
			MO1	MO2[1/]	MO3	MO4	PA
Residential	Bonneville Finances Zero-Carbon	$1,100	0.79%	-0.48%	2.8%	3.0%	0.44%
	Region Finances Zero-Carbon		0.76%		2.4%	3.1%	
	Bonneville Finances Conventional Least-Cost		0.73%		1.7%	3.3%	
	Region Finances Conventional Least-Cost		0.65%		1.6%	2.9%	
Commercial	Bonneville Finances Zero-Carbon	$5,900	0.83%	-0.56%	2.9%	3.2%	0.48%
	Region Finances Zero-Carbon		0.79%		2.6%	3.2%	
	Bonneville Finances Conventional Least-Cost		0.77%		1.8%	3.5%	
	Region Finances Conventional Least-Cost		0.69%		1.8%	3.1%	

End User Group	Scenario	NAA Expenditures	Difference relative to NAA, %				
			MO1	MO2[1/]	MO3	MO4	PA
Industrial	Bonneville Finances Zero-Carbon	$58,000	1.1%	-0.67%	3.9%	4.3%	0.62%
	Region Finances Zero-Carbon		1.1%		3.4%	4.4%	
	Bonneville Finances Conventional Least-Cost		1.01%		2.3%	4.6%	
	Region Finances Conventional Least-Cost		0.90%		2.3%	4.1%	

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option and rates would be lower under MO2.

Table 5-32. Average Percent of Household Income Spent on Electricity

Scenario	NAA	MO1	MO2[1/]	MO3	MO4	PA
Bonneville Finances Zero-Carbon	1.69%	1.70%	1.68%	1.74%	1.74%	1.70%
Region Finances Zero-Carbon		1.70%		1.73%	1.74%	
Bonneville Finances Conventional Least-Cost		1.70%		1.72%	1.75%	
Region Finances Conventional Least-Cost		1.70%		1.72%	1.74%	

Note: there is some variation between the financing and resource replacement portfolios, however they are not evident due to rounding.
1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, rates under MO2 would be lower.

5.2.2.1.3 IMPLAN MODELLING

The regional economic analysis consider how changes in the cost of electricity affects 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.[55] 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.

This analysis used IMPLAN to model the effect at the household levels as a change in household income and for commercial and industrial models it in IMPLAN as a change in output. All IMPLAN modelling was done at the state level and then aggregated to the regional level. The region was defined as Oregon, Washington and Idaho as well as the western counties in Montana that fall within the Bonneville service area. The counties in the Bonneville service area

[55] For more information on the IMPLAN® system, visit http://www.implan.com/.

in Nevada, California, Wyoming and Utah were excluded from the IMPLAN analysis since the overall effect in these areas was relatively small.

Before using the IMPLAN model at the state level, the analysis estimates the total change in spending on electricity for each of the three sectors. To estimate this effect for each alternative the total spending change was calculated by summing the effect by county (as described above) multiplied by the estimate of the number of customers, either households or commercial and industrial businesses, in that county. This generated state level changes in spending for each alternative compared to the No Action Alternative. These values were input into IMPLAN where state level multipliers were used.[56]

The IMPLAN model traces expenditures by sector through the regional economy using industry-specific multipliers to estimate the total regional economic effects in terms of jobs, labor income, and sales. However, since IMPLAN does not categorize commercial and industrial electricity end users specifically, this analysis uses NAICS codes and the corresponding IMPLAN sector codes to identify the appropriate sector to examine changes in expenditure specific to commercial and industrial end users. Using the identified sectors in IMPLAN, the percentage of regional electricity spending was assessed in the model and the change in total spending was then assigned to these sectors using the appropriate multipliers.

There are four distinct multiplier effects that IMPLAN the model uses and the power and transmission analysis considers: output (sales), value added, labor income and employment.[57] IMPLAN further breaks down effects into direct, indirect and induced; this analysis presents the total effect across these three categories. Table 5-33, Table 5-34 and Table 5-35 provide the total output, value added, labor income and employments at the residential, commercial and industrial level by alternative.

[56] In order to capture state-specific data on spending on electricity and the multiplier effects, the regional economic impacts of changes in spending on electricity are modeled separately for each state. Because of the interconnectedness of businesses along the supply change across state borders, this results in some “leakage” effects. “Leakage” refers to direct and indirect impacts occurring in businesses outside of the defined region for the impact analysis (in this case, states). As a result, the total regional economic impacts for the power and transmission analysis may underestimate the total indirect and induced impacts.

[57] For more information on IMPLAN multipliers see: https://implanhelp.zendesk.com/hc/en-us/articles/115009505707-Understanding-Multipliers

Table 5-33. Household Income IMPLAN Results, by Alternative

Alternative	Scenario	Output	Value Added	Labor Income	Employment
MO1	Bonneville Finances Zero-Carbon	-$47 million	-$28 million	-$15 million	-300 jobs
	Bonneville Finances Conventional Least-Cost	-$44 million	-$26 million	-$14 million	-280 jobs
	Region Finances Zero-Carbon	-$44 million	-$26 million	-$15 million	-280 jobs
	Region Finances Conventional Least-Cost	-$39 million	-$23 million	-$13 million	-250 jobs
MO2	MO2	+$30 million	+$18 million	+$10 million	+200 jobs
MO3	Bonneville Finances Zero-Carbon	-$170 million	-$99 million	-$55 million	-1100 jobs
	Bonneville Finances Conventional Least-Cost	-$100 million	-$61 million	-$34 million	-660 jobs
	Region Finances Zero-Carbon	-$140 million	-$86 million	-$48 million	-930 jobs
	Region Finances Conventional Least-Cost	-$100 million	-$59 million	-$33 million	-640 jobs
MO4	Bonneville Finances Zero-Carbon	-$180 million	-$110 million	-$60 million	-1,200 jobs
	Bonneville Finances Conventional Least-Cost	-$200 million	-$120 million	-$66 million	-1,300 jobs
	Region Finances Zero-Carbon	-$180 million	-$110 million	-$61 million	-1,200 jobs
	Region Finances Conventional Least-Cost	-$180 million	-$110 million	-$59 million	-1,100 jobs
PA	PA	-$27 million	-$16 million	-$8.9 million	-180 jobs

Table 5-34. Commercial Spending IMPLAN Results, by Alternative

Alternative	Scenario	Output	Value Added	Labor Income	Employment
MO1	Bonneville Finances Zero-Carbon	-$23 million	-$15 million	-$7.4 million	-150 jobs
	Bonneville Finances Conventional Least-Cost	-$22 million	-$14 million	-$7 million	-150 jobs
	Region Finances Zero-Carbon	-$22 million	-$14 million	-$6.9 million	-140 jobs
	Region Finances Conventional Least-Cost	-$19 million	-$12 million	-$6.2 million	-130 jobs
MO2	MO2	+$16 million	+$9.8 million	+$5.1 million	+110 jobs
MO3	Bonneville Finances Zero-Carbon	-$83 million	-$52 million	-$27 million	-560 jobs
	Bonneville Finances Conventional Least-Cost	-$51 million	-$32 million	-$16 million	-340 jobs
	Region Finances Zero-Carbon	-$73 million	-$46 million	-$23 million	-490 jobs
	Region Finances Conventional Least-Cost	-$50 million	-$31 million	-$16 million	-340 jobs
MO4	Bonneville Finances Zero-Carbon	-$89 million	-$56 million	-$29 million	-600 jobs
	Bonneville Finances Conventional Least-Cost	-$99 million	-$62 million	-$32 million	-680 jobs
	Region Finances Zero-Carbon	-$91 million	-$57 million	-$29 million	-610 jobs
	Region Finances Conventional Least-Cost	-$89 million	-$56 million	-$29 million	-610 jobs
PA	PA	-$14 million	-$8.7 million	-$4.5 million	-95 jobs

Table 5-35. Industrial Spending IMPLAN Results, by Alternative

Alternative	Scenario	Output	Value Added	Labor Income	Employment
MO1	Bonneville Finances Zero-Carbon	-$81 million	-$51 million	-$26 million	-530 jobs
	Bonneville Finances Conventional Least-Cost	-$77 million	-$49 million	-$25 million	-500 jobs
	Region Finances Zero-Carbon	-$74 million	-$47 million	-$24 million	-490 jobs
	Region Finances Conventional Least-Cost	-$67 million	-$42 million	-$21 million	-440 jobs
MO2	MO2	+$51 million	+$32 million	+$17 million	+350 jobs
MO3	Bonneville Finances Zero-Carbon	-$290 million	-$180 million	-$93 million	-1,900 jobs
	Bonneville Finances Conventional Least-Cost	-$180 million	-$110 million	-$57 million	-1,200 jobs
	Region Finances Zero-Carbon	-$250 million	-$160 million	-$80 million	-1,600 jobs
	Region Finances Conventional Least-Cost	-$170 million	-$110 million	-$55 million	-1,100 jobs
MO4	Bonneville Finances Zero-Carbon	-$320 million	-$200 million	-$100 million	-2,100 jobs
	Bonneville Finances Conventional Least-Cost	-$350 million	-$220 million	-$110 million	-2,300 jobs
	Region Finances Zero-Carbon	-$320 million	-$210 million	-$100 million	-2,100 jobs
	Region Finances Conventional Least-Cost	-$310 million	-$200 million	-$100 million	-2,000 jobs
PA	PA	-$48 million	-$30 million	-$15 million	-320 jobs

5.2.3 Summary of Regional Economic Effects Results

Table 5-36 presents the average estimated retail rates for each of the three end user groups and the MOs. The results weighted the change in rates by the number of entities (e.g., households) in each county and compared the rates to the No Action Alternative retail rate. Table 5-37 presents these final rate estimates with a weighted average effect in percentage terms as well as the full range (minimum and maximum effect) across the counties of the Pacific Northwest. Figure 5-1 through Figure 5-6 present the residential retail rate pressure results by county in map form for comparison. Exhibit 1. Retail Rates by County contains the residential rate result by county for the entire study area.

This analysis did not include the effects of additional coal-plant retirements that were announced regionally after the analysis was initiated. Factoring in the effect of additional coal-plant retirements would likely raise the rates in MO3, lower them in MO2, and not raise them as much in MO1 and MO4 relative to the No Action Alternative (the overall change in rates from the coal-plant retirement on No Action Alternative was not considered.) When considering all cost pressure sensitivities (i.e., not only coal retirements but other regional cost pressures, such as replacement resource financing assumptions or renewable integration services), the analysis generally finds that potential upward rate pressure effects are understated.

Table 5-36. Weighted Average Retail Rates by Action Alternative and Scenario (cents per kWh), for the Base Case without Rate Sensitivities or Additional Coal-Plant Retirements (Changes Could be Larger for MO2 and MO3, Smaller for MO1 and MO4, with Additional Coal-Plant Retirements)

End User Group	Scenario	NAA Rate	MO1	MO2[1/]	MO3	MO4	PA
Residential	Bonneville Finances Zero-Carbon	10.21	10.28	10.16	10.48	10.51	10.25
	Region Finances Zero-Carbon		10.28		10.44	10.50	
	Bonneville Finances Conventional Least-Cost		10.28		10.37	10.53	
	Region Finances Conventional Least-Cost		10.27		10.37	10.50	
Commercial	Bonneville Finances Zero-Carbon	8.89	8.97	8.84	9.16	9.19	8.94
	Region Finances Zero-Carbon		8.97		9.13	9.19	
	Bonneville Finances Conventional Least-Cost		8.96		9.06	9.22	
	Region Finances Conventional Least-Cost		8.96		9.05	9.18	
Industrial	Bonneville Finances Zero-Carbon	7.25	7.32	7.20	7.51	7.54	7.29
	Region Finances Zero-Carbon		7.32		7.48	7.54	
	Bonneville Finances Conventional Least-Cost		7.32		7.41	7.57	
	Region Finances Conventional Least-Cost		7.31		7.41	7.53	

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, rates under MO2 would be lower.

Table 5-37. Summary of Rate Pressures Relative to the No Action Alternative (cents/kWh and % Difference) for the Base Case without Rate Sensitivities or Additional Coal-Plant Retirements

Scenario		NAA Rate (cents/kWh)	Rate Pressures Relative to NAA, Weighted Average and Range (% change)				
			MO1	MO2/1	MO3	MO4	PA
Residential	Bonneville Finances Zero-Carbon	10.21 (2.97 to 13.42)	0.79% (-0.43% to 3.4%)	-0.48% (-1.5% to 0.21%)	2.8% (0.25% to 8.1%)	3.1% (0.041% to 11%)	0.44% (less than 0.1% to 1.2%)
	Region Finances Zero-Carbon		0.76% (-0.49% to 7.6%)		2.4% (0.25% to 14%)	3.1% (0.041% to 18.3%)	
	Bonneville Finances Conventional Least-Cost		0.73% (0.090% to 2.4%)		1.7% (0.21% to 4.7%)	3.3% (0.25% to 9%)	
	Region Finances Conventional Least-Cost		0.65% (0.090% to 3.4%)		1.7% (0.21% to 7.2%)	2.9% (0.25% to 11%)	
Commercial	Bonneville Finances Zero-Carbon	8.89 (2.91 to 12.01)	0.83% (-0.56% to 3.9%)	-0.56% (-2.1% to 0.23%)	3.0% (0.25% to 9.4%)	3.2% (0.041% to 11%)	0.49% (less than 0.1% to 1.4%)
	Region Finances Zero-Carbon		0.80% (-0.66% to 8.1%)		2.6% (0.25% to 15%)	3.2% (0.041% to 18%)	
	Bonneville Finances Conventional Least-Cost		0.77% (0.093% to 2.7%)		1.8% (0.21% to 5.3%)	3.5% (0.25% to 9%)	
	Region Finances Conventional Least-Cost		0.69% (0.0093% to 3.6%)		1.8% (0.21% to 7.4%)	3.2% (0.25% to 11%)	
Industrial	Bonneville Finances Zero-Carbon	7.25 (2.29 to 17.18)	1.1% (-1.1% to 5.9%)	-0.66% (-2.5% to 0.33%)	3.9% (0.25% to 13%)	4.4% (0.051% to 18%)	0.63% (less than 0.1% to 1.9%)
	Region Finances Zero-Carbon		1.1% (-1.0% to 12%)		3.4% (0.25% to 29%)	4.4% (0.051% to 36%)	
	Bonneville Finances Conventional Least-Cost		1.0% (0.11% to 4.0%)		2.3% (0.21% to 7.6%)	4.7% (0.0.25% to 15%)	
	Region Finances Conventional Least-Cost		0.90% (0.11% to 4.9%)		2.3% (0.21% to 14%)	4.2% (0.0.25% to 22%)	

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, rates under MO2 would be lower.

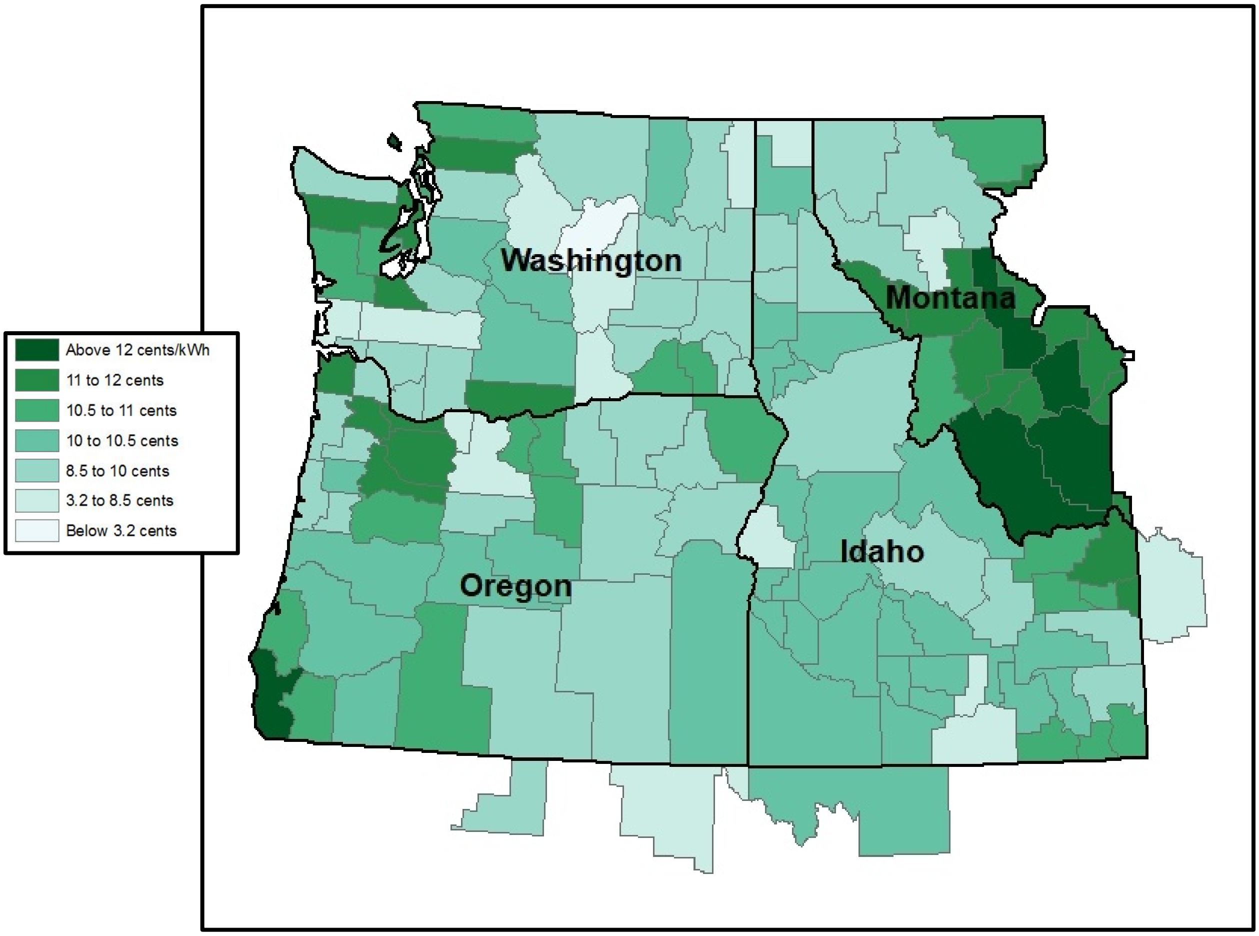

Figure 5-1. Average 2022 Estimated Residential Rate, No Action Alternative (cents per kWh)

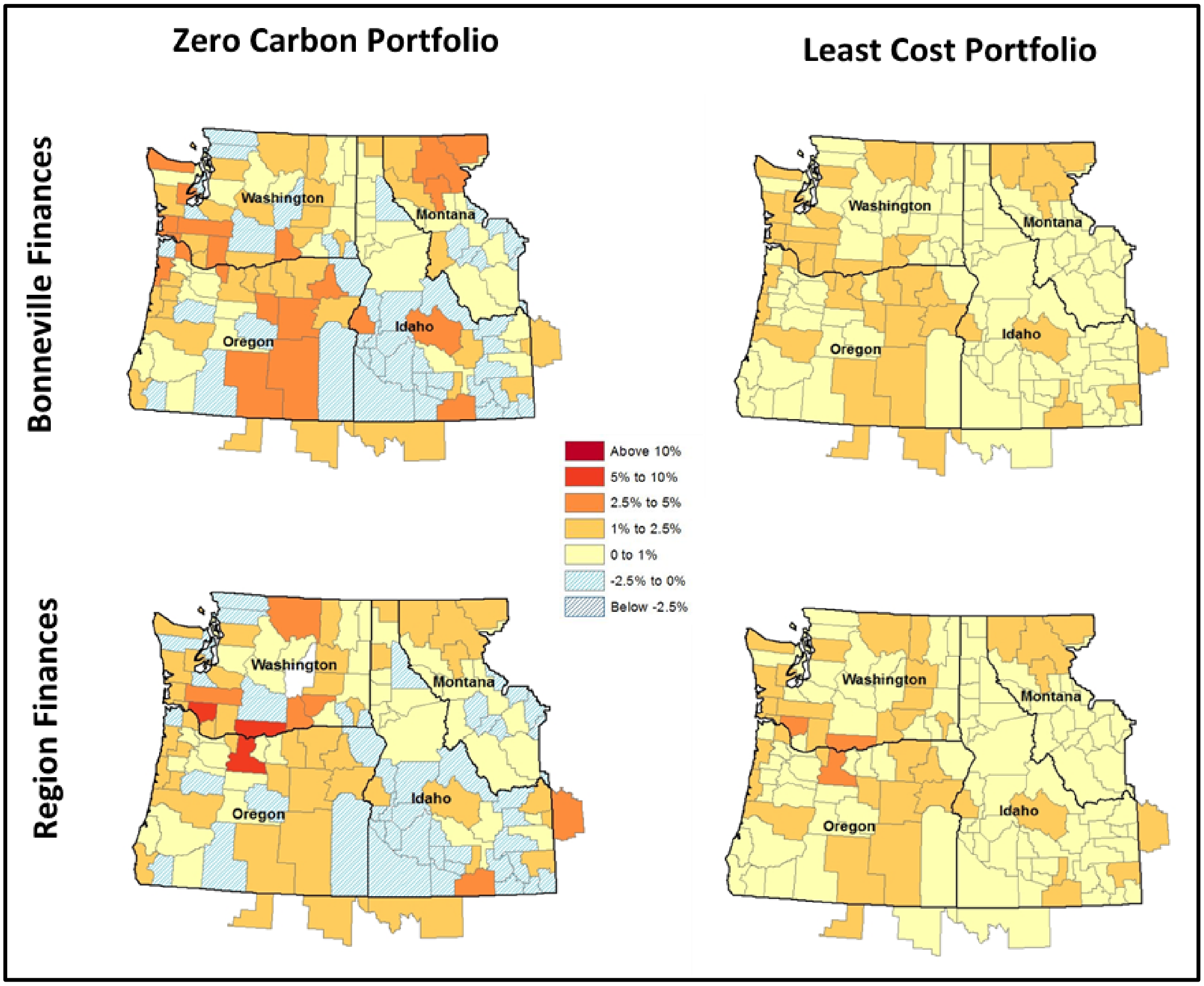

Figure 5-2. MO1 Average Residential Rate Pressure by County (% Change from the No Action Alternative)

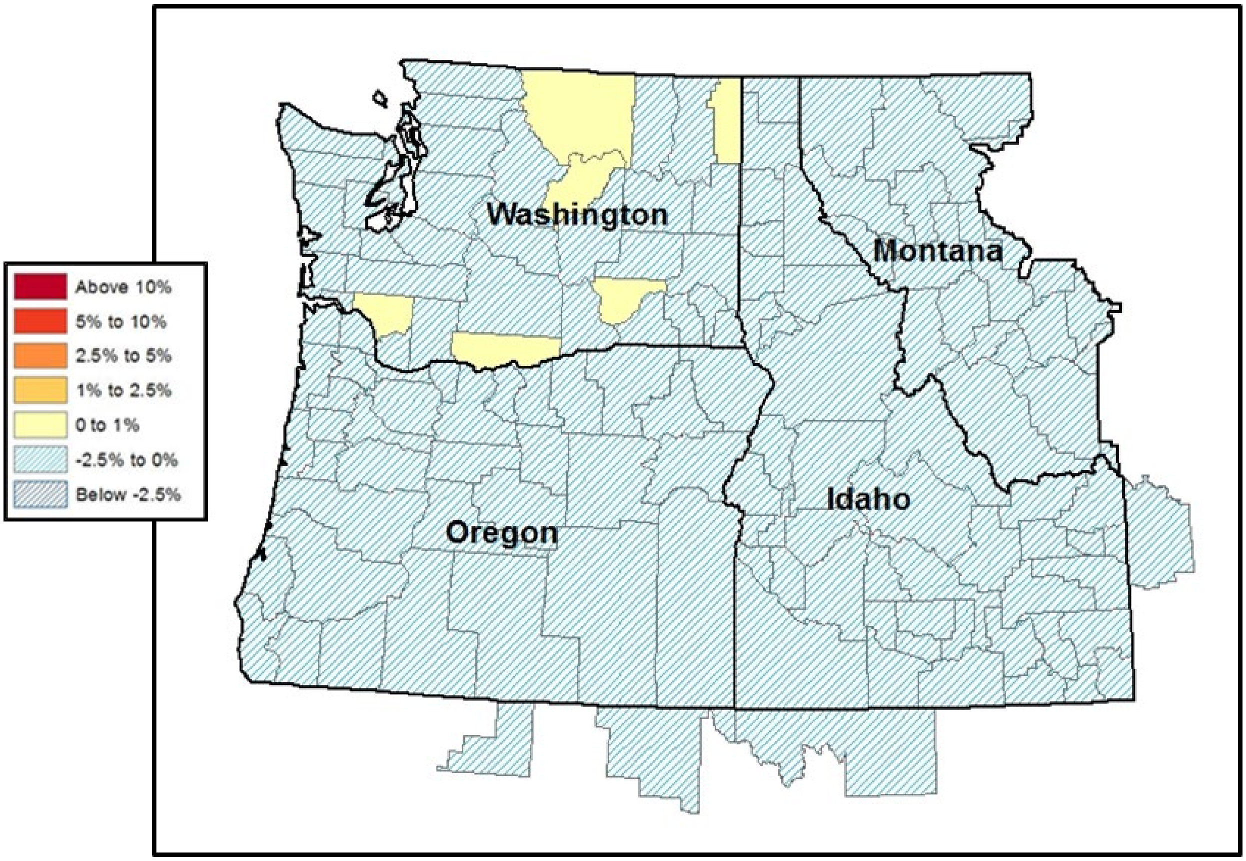

Figure 5-3. MO2 Average Residential Rate Pressure by County (% Change from the No Action Alternative)

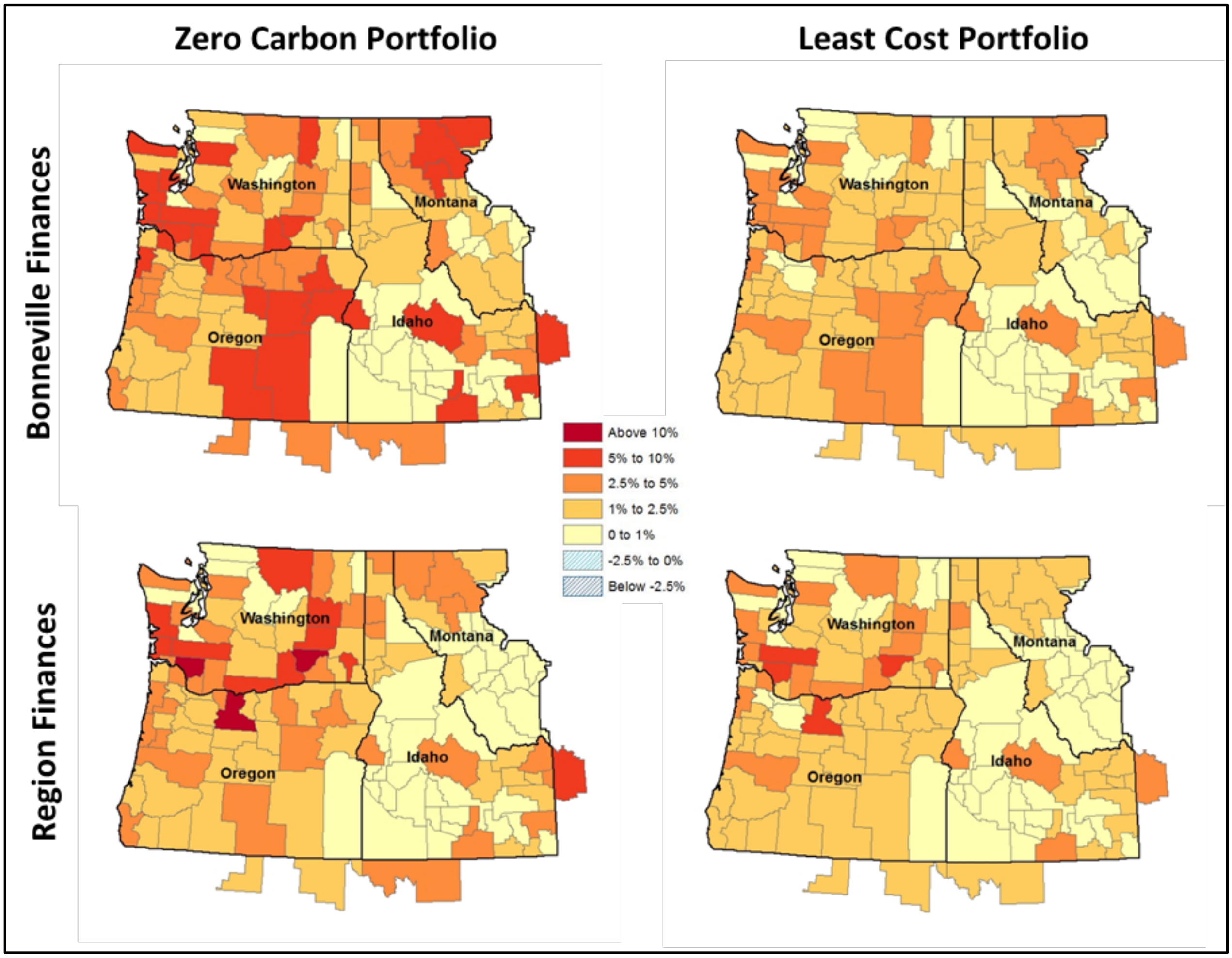

Figure 5-4. MO3 Average Residential Rate Pressure by County (% Change from the No Action Alternative)

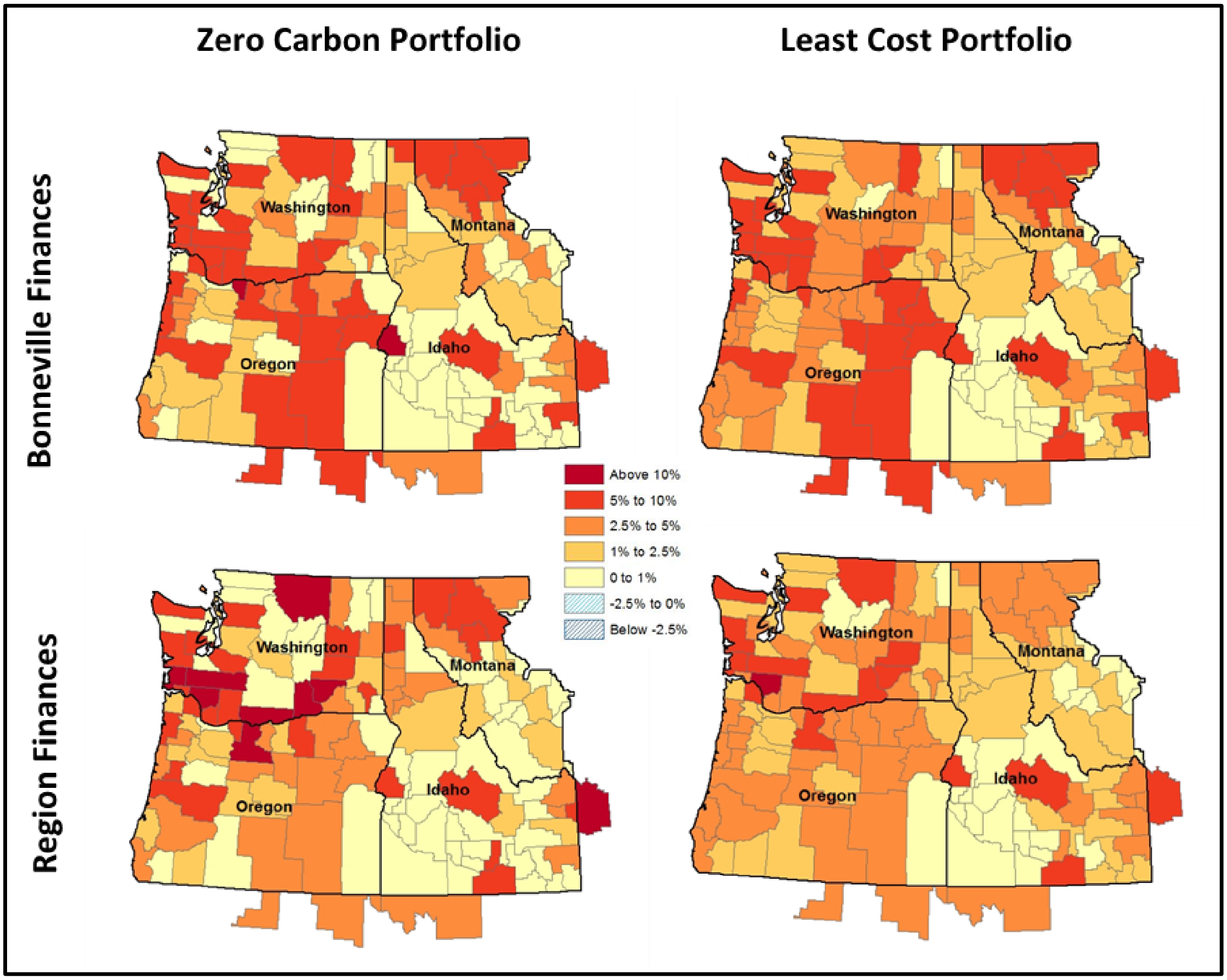

Figure 5-5. MO4 Average Residential Rate Pressure by County (% Change from the No Action Alternative)

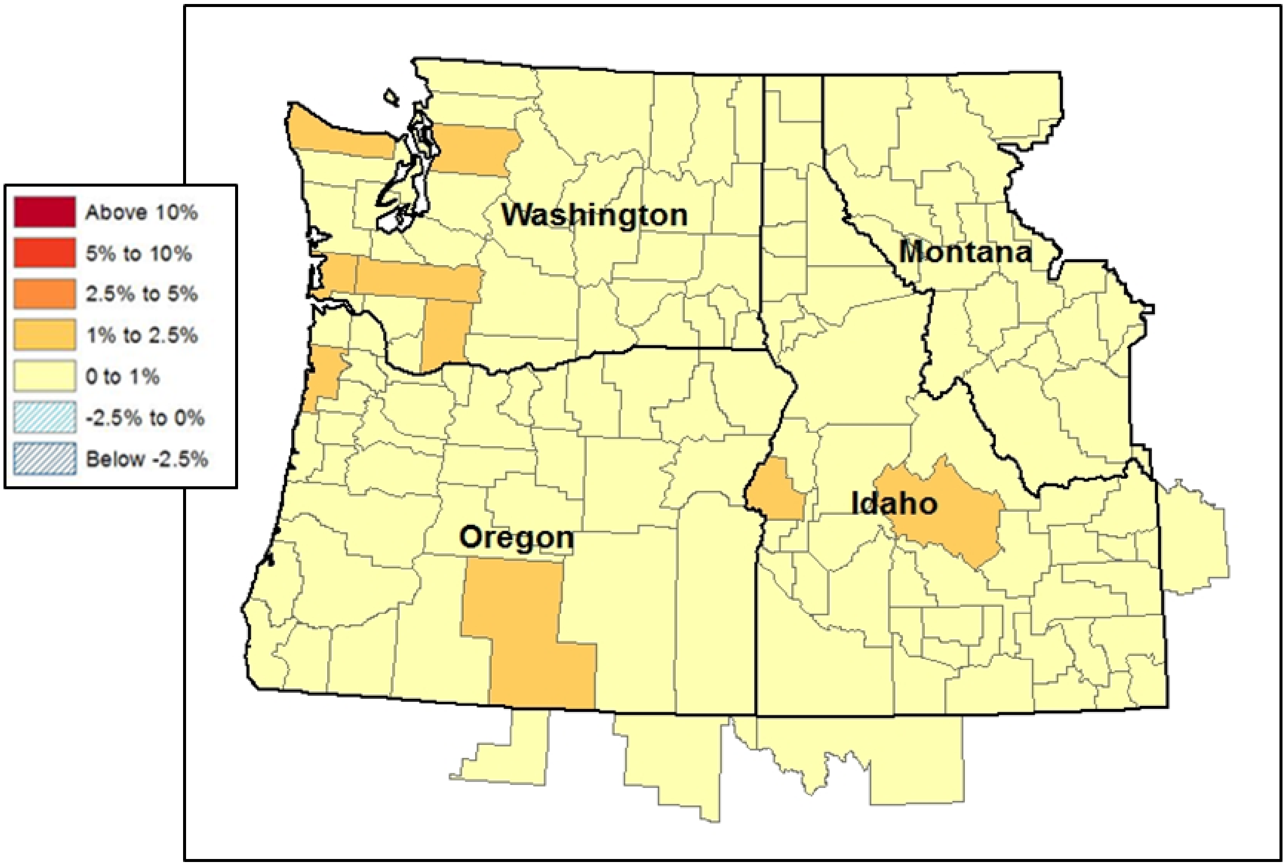

Figure 5-6. Preferred Alternative Average Residential Rate Pressure by County (% Change from the No Action Alternative)

5.3 OTHER SOCIAL EFFECTS

This analysis examines other social effects in the context of historical rate changes as well as specifically for safety and health effects associated with the reliability of the power system. To examine affordability and effects on household wellness, the analysis reviews recent literature and analysis on the affordability of electricity. Large rate pressures could lead to potential energy insecurity if households have to forego other purchases. The Pacific Northwest has historically had relatively low electricity prices compared to the rest of the country; however, lower income households are more vulnerable to electricity price changes and would likely experience retail rate pressures more acutely than higher income households. Given this vulnerability, these households would be more likely to forego purchases and experience energy insecurity due to a higher electricity burden on their household spending. The Environmental Justice analysis (Chapter 3.18, *Environmental Justice*) provides additional context and analysis on the energy burden of low-income households under each alternative.

To qualitatively examine the potential health and safety effects due to changes in reliability, the analysis assumes that replacement resources are added to the region to provide an LOLP at the level of the No Action Alternative. Given the amount of replacement resources that would need to be successfully added to the regional power system, the reliability effects would not be constant across MOs. If these replacement resources are added, then no differences in health and safety effects in the region due to potential loss of power shortages or blackouts would occur; however, if replacement resources are delayed or otherwise not available to address reliability effects, then health and safety effects would occur. Certain populations, such as the elderly, or those who are already in poor health, may experience these effects more acutely because vital services such as heating, cooling and medical equipment often require electricity. MO2 and the Preferred Alternative, with an increase in reliability, would increase reliability and decrease health and safety concerns relative to the No Action Alternative.

5.3.1 Timing and Permitting Considerations

Many of these replacement resource projects for both power and transmission, as noted in the previous sections, require multiple years or planning and permitting as well as potential other analyses followed by construction, as discussed in Section 2.2.4. To the extent this analysis identifies potential needs for replacement resources or transmission infrastructure, and if Bonneville proposes to take such action related to those potential needs 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. If the replacement resources or transmission infrastructure were not acquired as the analysis assumes, there would be a potential increase in power shortages and blackouts, both of which could lead to additional health and safety concerns due to the loss of power.

Given the respective LOLP levels relative to the No Action Alternative described in Chapter 2 - MO4 would have the highest increase in potential health and safety concerns due to decreases in power system reliability. Under MO3, which has a higher LOLP relative to the No Action Alternative, there is also potential that a transmission reinforcement project in the Tri-Cities area would be needed before Ice Harbor dam is breached. The timing of the reinforcement project for MO3 could occur sooner than the reinforcement project would be needed under the No Action Alternative (see Chapter 3, *Transmission System Reliability and Congestion*). If the reinforcement project were not in service before the LSR Dams were breached, there would likely be a decrease system reliability and increase health and safety concerns from the loss of power. The effects would be larger for customers of utilities who receive power from Bonneville, and lower for others.

CHAPTER 6 - REFERENCES

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EXHIBIT 1. RETAIL RATES BY COUNTY

Exhibit 1 below lists the residential retail rate pressures by county, relative to the No Action Alternative.

Exhibit 1. Residential Retail Rate by County for No Action and the Percentage Difference by Alternative, for the Base Case without Rate Sensitivities or Additional Coal-Plant Retirements

		MO1				MO2/1	MO3				MO4				PA
State, County	NAA Rate	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	MO2	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	PA
ID, Ada	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Adams	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Bannock	10.34	-0.10%	0.18%	-0.10%	0.18%	-0.36%	0.6%	0.57%	0.6%	0.57%	0.30%	1.0%	0.30%	1.0%	0.18%
ID, Bear Lake	10.54	-0.23%	0.24%	-0.23%	0.24%	-0.64%	0.9%	0.87%	0.9%	0.87%	0.35%	1.6%	0.35%	1.6%	0.31%
ID, Benewah	9.72	0.96%	0.76%	0.94%	0.69%	-0.37%	2.8%	1.60%	2.50%	1.60%	3.3%	2.9%	3.4%	2.9%	0.40%
ID, Bingham	10.41	-0.14%	0.20%	-0.14%	0.20%	-0.46%	0.7%	0.67%	0.7%	0.67%	0.32%	1.2%	0.32%	1.2%	0.22%
ID, Blaine	10.06	0.11%	0.27%	0.03%	0.23%	-0.34%	1.0%	0.72%	0.7%	0.63%	0.83%	1.1%	0.57%	1.1%	0.19%
ID, Boise	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Bonner	10.15	0.50%	0.46%	0.57%	0.47%	-0.35%	1.80%	1.10%	2.10%	1.30%	2.00%	2.30%	2.60%	2.30%	0.270%
ID, Bonneville	9.35	0.45%	0.73%	0.33%	0.62%	-0.75%	2.9%	2.0%	2.1%	1.8%	2.8%	3.3%	2.3%	3.3%	0.60%
ID, Boundary	7.46	1.8%	0.98%	1.30%	0.69%	-0.78%	4.6%	2.1%	2.60%	1.50%	6.4%	3.4%	4.5%	3.4%	0.080%
ID, Butte	8.99	1.0%	0.86%	0.47%	0.61%	-0.73%	3.4%	2.1%	1.7%	1.5%	3.8%	2.9%	2.1%	2.9%	0.49%
ID, Camas	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Canyon	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Caribou	9.31	1.8%	1.4%	1.3%	1.1%	-0.65%	5.1%	2.8%	2.6%	2.1%	5.9%	3.9%	3.8%	3.9%	0.78%
ID, Cassia	8.05	2.7%	1.9%	2.8%	1.7%	-0.56%	6.6%	3.3%	4.8%	3.1%	8.3%	5.5%	7.1%	5.5%	0.86%
ID, Clark	10.70	-0.33%	0.28%	-0.33%	0.28%	-0.86%	1.1%	1.1%	1.1%	1.1%	0.38%	2.1%	0.38%	2.1%	0.41%
ID, Clearwater	10.35	0.600%	0.50%	0.69%	0.51%	-0.32%	1.90%	1.20%	2.30%	1.40%	2.30%	2.40%	3.00%	2.40%	0.270%
ID, Custer	8.51	3.1%	2.1%	2.2%	1.6%	-0.54%	7.3%	3.6%	3.4%	2.8%	8.9%	5.1%	6.0%	5.1%	1.00%
ID, Elmore	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Franklin	10.65	-0.30%	0.27%	-0.30%	0.27%	-0.79%	1.1%	1.0%	1.1%	1.0%	0.37%	1.9%	0.37%	1.9%	0.38%
ID, Fremont	11.08	0.910%	0.62%	1.00%	0.63%	-0.25%	2.40%	1.40%	2.90%	1.60%	3.00%	2.80%	4.00%	2.80%	0.270%
ID, Gem	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Gooding	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Idaho	9.93	0.31%	0.44%	0.14%	0.35%	-0.45%	1.7%	1.1%	0.99%	0.88%	1.6%	2.3%	2.2%	2.3%	0.32%
ID, Jefferson	10.70	-0.33%	0.28%	-0.33%	0.28%	-0.86%	1.1%	1.1%	1.1%	1.1%	0.38%	2.1%	0.38%	2.1%	0.41%
ID, Jerome	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Kootenai	9.60	0.79%	0.64%	1.9%	1.0%	-0.32%	2.7%	1.7%	5.0%	2.6%	3.6%	4.4%	6.1%	4.4%	0.25%
ID, Latah	10.34	0.590%	0.49%	0.68%	0.50%	-0.32%	1.90%	1.20%	2.30%	1.40%	2.20%	2.40%	2.90%	2.40%	0.270%
ID, Lemhi	10.31	-0.053%	0.19%	-0.06%	0.18%	-0.33%	0.6%	0.55%	0.6%	0.55%	0.37%	0.97%	0.35%	0.97%	0.17%
ID, Lewis	10.34	0.590%	0.49%	0.68%	0.50%	-0.32%	1.90%	1.20%	2.30%	1.40%	2.20%	2.40%	2.90%	2.40%	0.270%
ID, Lincoln	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%

		MO1				MO2[/1]	MO3				MO4				PA
State, County	NAA Rate	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	MO2	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	PA
ID, Madison	10.98	0.49%	0.52%	0.57%	0.52%	-0.48%	2.0%	1.30%	2.4%	1.50%	2.20%	2.7%	2.80%	2.7%	0.33%
ID, Minidoka	7.27	2.4%	1.5%	2.1%	1.3%	-0.90%	6.4%	3.1%	3.6%	2.4%	8.4%	4.8%	5.6%	4.8%	0.56%
ID, Nez Perce	10.34	0.590%	0.49%	0.68%	0.50%	-0.32%	1.90%	1.20%	2.30%	1.40%	2.20%	2.40%	2.90%	2.40%	0.270%
ID, Oneida	10.70	-0.32%	0.28%	-0.32%	0.28%	-0.85%	1.1%	1.1%	1.1%	1.1%	0.38%	2.1%	0.38%	2.1%	0.41%
ID, Owyhee	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Payette	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Power	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Shoshone	9.65	-0.16%	0.21%	-0.16%	0.22%	-0.53%	0.83%	0.77%	0.83%	0.77%	0.37%	1.4%	0.38%	1.4%	0.27%
ID, Teton	11.26	1.3000%	0.74%	1.40%	0.75%	-0.13%	2.90%	1.50%	3.50%	1.80%	3.900%	3.20%	5.200%	3.200%	0.260%
ID, Twin Falls	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Valley	10.32	-0.080%	0.17%	-0.08%	0.17%	-0.33%	0.6%	0.53%	0.6%	0.53%	0.30%	0.93%	0.30%	0.93%	0.160%
ID, Washington	7.12	3.4%	2.3%	2.3%	1.7%	-0.66%	8.1%	4.1%	3.2%	2.6%	10.0%	5.2%	5.9%	5.2%	1.00%
MT, Beaverhead	12.14	0.15%	0.28%	0.03%	0.21%	-0.47%	1.1%	0.72%	0.6%	0.55%	1.1%	1.2%	0.56%	1.2%	0.21%
MT, Broadwater	11.93	-0.089%	0.15%	-0.13%	0.13%	-0.45%	0.7%	0.52%	0.5%	0.46%	0.42%	0.98%	0.22%	0.98%	0.18%
MT, Cascade	11.83	-0.21%	0.09%	-0.21%	0.09%	-0.45%	0.4%	0.41%	0.4%	0.41%	0.041%	0.88%	0.041%	0.88%	0.17%
MT, Chouteau	11.83	-0.21%	0.09%	-0.21%	0.09%	-0.45%	0.4%	0.41%	0.4%	0.41%	0.041%	0.88%	0.041%	0.88%	0.17%
MT, Deer Lodge	11.83	-0.21%	0.09%	-0.21%	0.09%	-0.45%	0.4%	0.42%	0.4%	0.41%	0.052%	0.88%	0.046%	0.88%	0.17%
MT, Flathead	9.26	2.6%	1.6%	2.2%	1.3%	-0.66%	6.3%	3.1%	3.5%	2.4%	8.8%	4.6%	5.6%	4.6%	0.62%
MT, Gallatin	11.85	-0.16%	0.12%	-0.17%	0.11%	-0.45%	0.5%	0.45%	0.5%	0.44%	0.19%	0.94%	0.150%	0.94%	0.17%
MT, Glacier	10.54	2.7%	1.7%	1.7%	1.1%	-0.42%	6.2%	3.2%	2.5%	2.0%	7.9%	3.8%	4.4%	3.8%	0.68%
MT, Granite	11.83	-0.21%	0.09%	-0.21%	0.09%	-0.45%	0.4%	0.41%	0.4%	0.41%	0.041%	0.88%	0.041%	0.88%	0.17%
MT, Jefferson	12.67	0.73%	0.57%	0.42%	0.40%	-0.50%	2.2%	1.2%	0.9%	0.77%	2.9%	1.6%	1.4%	1.6%	0.29%
MT, Lake	6.79	3.1%	2.1%	2.1%	1.5%	-0.44%	7.1%	3.7%	2.8%	2.3%	9.2%	4.3%	5.0%	4.3%	0.90%
MT, Lewis And Clark	11.85	-0.18%	0.11%	-0.19%	0.10%	-0.45%	0.5%	0.44%	0.4%	0.42%	0.14%	0.91%	0.088%	0.91%	0.17%
MT, Lincoln	9.35	2.0%	1.30%	1.8%	1.10%	-0.46%	4.9%	2.5%	3.4%	2.1%	6.5%	4.0%	5.2%	4.0%	0.51%
MT, Madison	12.42	0.46%	0.43%	0.24%	0.32%	-0.49%	1.7%	1.0%	0.8%	0.67%	2.1%	1.4%	1.00%	1.4%	0.25%
MT, Meagher	11.83	-0.21%	0.09%	-0.21%	0.09%	-0.45%	0.4%	0.41%	0.4%	0.41%	0.041%	0.88%	0.041%	0.88%	0.17%
MT, Mineral	11.66	0.15%	0.31%	0.05%	0.25%	-0.42%	1.1%	0.77%	0.7%	0.62%	1.1%	1.3%	0.59%	1.3%	0.26%
MT, Missoula	11.59	0.31%	0.41%	0.17%	0.32%	-0.41%	1.5%	0.92%	0.8%	0.71%	1.5%	1.4%	0.83%	1.4%	0.30%
MT, Park	11.83	-0.21%	0.09%	-0.21%	0.09%	-0.45%	0.4%	0.41%	0.4%	0.41%	0.041%	0.88%	0.041%	0.88%	0.17%
MT, Pondera	11.56	0.34%	0.38%	0.14%	0.29%	-0.44%	1.5%	0.94%	0.8%	0.72%	1.5%	1.4%	0.87%	1.4%	0.27%
MT, Powell	12.36	0.72%	0.59%	0.42%	0.42%	-0.47%	2.2%	1.2%	1.0%	0.81%	2.8%	1.7%	1.4%	1.7%	0.31%
MT, Ravalli	10.74	1.2%	0.89%	0.80%	0.71%	-0.44%	3.3%	1.8%	1.5%	1.2%	4.0%	2.4%	2.2%	2.4%	0.44%
MT, Sanders	10.00	1.10%	0.76%	0.96%	0.66%	-0.31%	2.8%	1.60%	2.3%	1.40%	3.5%	2.6%	3.3%	2.6%	0.35%

State, County	NAA Rate	MO1				MO2[/1]	MO3				MO4				PA
		Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	MO2	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	PA
MT, Silver Bow	11.85	-0.18%	0.11%	-0.19%	0.10%	-0.45%	0.5%	0.44%	0.4%	0.42%	0.13%	0.91%	0.085%	0.91%	0.17%
MT, Teton	11.83	-0.21%	0.09%	-0.21%	0.09%	-0.45%	0.4%	0.41%	0.4%	0.41%	0.041%	0.88%	0.041%	0.88%	0.17%
OR, Baker	9.86	2.3%	1.6%	1.5%	1.2%	-0.44%	5.4%	2.8%	2.2%	1.8%	6.7%	3.5%	3.8%	3.5%	0.75%
OR, Benton	9.95	1.200%	0.75%	1.30%	0.77%	-0.25%	2.90%	1.70%	3.60%	2.00%	3.80%	3.40%	5.10%	3.40%	0.310%
OR, Clackamas	11.26	0.41%	0.31%	0.37%	0.29%	-0.58%	1.6%	0.93%	1.4%	0.87%	1.2%	1.6%	1.0%	1.6%	0.31%
OR, Clatsop	11.83	-0.04%	0.34%	-0.01%	0.34%	-0.66%	1.3%	1.10%	1.5%	1.10%	0.93%	2.1%	1.10%	2.1%	0.35%
OR, Columbia	9.39	2.8%	2.0%	2.4%	1.6%	-0.44%	6.9%	3.5%	4.3%	3.0%	8.5%	5.3%	6.9%	5.3%	0.95%
OR, Coos	10.96	0.410%	0.56%	0.38%	0.52%	-0.61%	2.1%	1.4%	2.1%	1.40%	2.1%	2.6%	2.20%	2.6%	0.41%
OR, Crook	10.48	-0.13%	0.35%	-0.11%	0.35%	-0.79%	1.4%	1.2%	1.5%	1.2%	0.85%	2.3%	1.00%	2.3%	0.41%
OR, Curry	12.32	1.2000%	0.68%	1.30%	0.69%	-0.11%	2.60%	1.40%	3.30%	1.70%	3.500%	3.00%	4.700%	3.000%	0.240%
OR, Deschutes	10.13	0.37%	0.59%	0.26%	0.51%	-0.71%	2.3%	1.5%	1.8%	1.4%	2.2%	2.6%	1.80%	2.6%	0.46%
OR, Douglas	10.47	0.520%	0.57%	0.57%	0.56%	-0.54%	2.2%	1.40%	2.4%	1.60%	2.30%	2.8%	2.90%	2.8%	0.38%
OR, Gilliam	10.70	1.00%	0.84%	0.58%	0.62%	-0.75%	3.3%	1.9%	1.5%	1.3%	4.1%	2.6%	2.1%	2.6%	0.48%
OR, Grant	9.84	2.9%	1.9%	2.0%	1.4%	-0.47%	6.6%	3.4%	2.6%	2.2%	8.4%	4.1%	4.7%	4.1%	0.91%
OR, Harney	9.11	2.5%	1.6%	1.6%	1.2%	-0.64%	5.9%	3.0%	2.2%	1.8%	8.0%	3.7%	4.1%	3.7%	0.71%
OR, Hood River	7.76	3.2%	2.0%	2.1%	1.4%	-0.78%	7.7%	3.8%	3.0%	2.4%	11.0%	4.8%	5.4%	4.8%	0.74%
OR, Jackson	10.41	0.11%	0.55%	0.02%	0.48%	-0.83%	2.0%	1.4%	1.4%	1.3%	1.5%	2.5%	1.1%	2.5%	0.52%
OR, Jefferson	9.98	0.530%	0.60%	0.57%	0.58%	-0.58%	2.3%	1.50%	2.4%	1.60%	2.40%	2.9%	2.80%	2.9%	0.41%
OR, Josephine	10.70	-0.33%	0.28%	-0.33%	0.28%	-0.86%	1.1%	1.1%	1.1%	1.1%	0.38%	2.1%	0.38%	2.1%	0.41%
OR, Klamath	10.54	-0.092%	0.40%	-0.16%	0.36%	-0.83%	1.6%	1.3%	1.3%	1.2%	1.0%	2.2%	0.70%	2.2%	0.44%
OR, Lake	8.64	2.8%	2.0%	2.0%	1.5%	-0.23%	6.5%	3.4%	2.6%	2.1%	8.9%	4.1%	4.6%	4.1%	1.00%
OR, Lane	10.33	1.8%	1.3%	1.7%	1.10%	-0.22%	4.8%	2.7%	4.5%	2.7%	6.1%	4.8%	6.9%	4.8%	0.60%
OR, Lincoln	9.88	1.6%	1.3%	1.3%	1.00%	-0.63%	4.6%	2.5%	3.7%	2.4%	5.1%	4.2%	4.9%	4.2%	0.70%
OR, Linn	10.68	-0.28%	0.30%	-0.27%	0.30%	-0.84%	1.2%	1.1%	1.2%	1.1%	0.50%	2.1%	0.54%	2.1%	0.41%
OR, Malheur	10.30	-0.070%	0.17%	-0.07%	0.17%	-0.33%	0.6%	0.54%	0.6%	0.53%	0.33%	0.94%	0.31%	0.94%	0.160%
OR, Marion	11.13	0.63%	0.48%	0.52%	0.40%	-0.58%	2.1%	1.2%	1.5%	1.0%	1.9%	1.9%	1.4%	1.9%	0.38%
OR, Morrow	9.41	1.80%	1.10%	1.60%	0.92%	-0.38%	4.2%	2.2%	3.40%	2.00%	5.8%	3.7%	5.2%	3.7%	0.42%
OR, Multnomah	11.44	0.26%	0.22%	0.26%	0.22%	-0.59%	1.3%	0.79%	1.3%	0.79%	0.79%	1.5%	0.79%	1.5%	0.28%
OR, Polk	10.14	1.1%	0.87%	0.72%	0.67%	-0.59%	3.3%	1.9%	1.9%	1.5%	3.7%	2.8%	2.2%	2.8%	0.55%
OR, Sherman	10.97	1.2%	1.1%	0.88%	0.89%	-0.61%	3.7%	2.1%	1.9%	1.6%	4.0%	3.0%	2.6%	3.0%	0.69%
OR, Tillamook	9.68	3.1%	2.2%	2.2%	1.6%	-0.47%	7.3%	3.7%	3.0%	2.5%	9.1%	4.6%	5.4%	4.6%	1.1%
OR, Umatilla	9.14	1.5%	1.3%	1.1%	1.1%	-0.71%	4.5%	2.5%	2.4%	2.1%	4.9%	3.8%	3.4%	3.8%	0.80%
OR, Union	9.74	2.9%	1.9%	2.0%	1.4%	-0.48%	6.7%	3.4%	2.6%	2.2%	8.5%	4.2%	4.8%	4.2%	0.91%
OR, Wallowa	10.67	-0.31%	0.27%	-0.31%	0.27%	-0.82%	1.1%	1.1%	1.1%	1.1%	0.38%	2.0%	0.38%	2.0%	0.40%
OR, Wasco	7.27	1.7%	1.3%	7.6%	3.4%	-0.32%	4.4%	2.3%	13%	6.9%	5.8%	9.7%	16%	9.7%	0.63%

State, County	NAA Rate	MO1				MO2[1]	MO3				MO4				PA
		Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	MO2	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	PA
OR, Washington	11.28	0.38%	0.28%	0.37%	0.27%	-0.57%	1.5%	0.89%	1.4%	0.87%	1.1%	1.6%	1.0%	1.6%	0.29%
OR, Wheeler	10.85	2.5%	1.8%	1.9%	1.4%	-0.41%	6.0%	3.0%	2.5%	2.0%	7.3%	3.7%	4.4%	3.7%	0.90%
OR, Yamhill	9.55	1.4%	0.91%	1.3%	0.79%	-0.61%	3.7%	2.0%	2.9%	1.8%	4.1%	3.3%	3.6%	3.3%	0.51%
WA, Adams	8.58	1.2%	0.79%	2.3%	1.1%	-0.19%	3.3%	2.0%	6.1%	3.1%	4.8%	5.2%	7.7%	5.2%	0.30%
WA, Asotin	9.72	-0.07%	0.25%	-0.06%	0.25%	-0.51%	0.96%	0.82%	1.00%	0.84%	0.59%	1.5%	0.69%	1.5%	0.27%
WA, Benton	8.38	2.7%	1.6%	3.3%	1.7%	-0.24%	6.8%	4.0%	7.9%	4.4%	9.8%	7.6%	11%	7.6%	0.53%
WA, Chelan	3.48	0.42%	0.36%	0.33%	0.30%	-0.10%	1.1%	0.65%	0.7%	0.57%	1.3%	0.93%	0.97%	0.93%	0.17%
WA, Clallam	9.39	3.1%	2.1%	2.4%	1.6%	-0.38%	7.3%	3.7%	3.5%	2.8%	9.3%	5.0%	6.0%	5.0%	1.00%
WA, Clark	9.34	1.4%	1.1%	1.1%	0.81%	-0.30%	4.2%	2.4%	3.8%	2.4%	5.0%	4.2%	5.9%	4.2%	0.63%
WA, Columbia	10.70	-0.21%	0.31%	-0.07%	0.37%	-0.81%	1.3%	1.2%	1.6%	1.3%	0.71%	2.4%	1.0%	2.4%	0.40%
WA, Cowlitz	8.52	2.2%	1.1%	6.0%	2.5%	0.17%	6.1%	3.9%	14%	7.2%	9.4%	11%	18%	11%	0.39%
WA, Douglas	2.97	0.10%	0.11%	0.10%	0.11%	0.02%	0.25%	0.21%	0.25%	0.21%	0.30%	0.25%	0.30%	0.25%	0.013%
WA, Ferry	10.18	2.1%	1.6%	1.6%	1.3%	-0.44%	5.3%	2.7%	2.7%	2.3%	6.3%	4.1%	4.6%	4.1%	0.86%
WA, Franklin	9.17	2.4%	1.2%	4.1%	1.8%	0.21%	6.1%	3.9%	11%	5.5%	9.4%	9.0%	15%	9.0%	0.35%
WA, Garfield	9.41	1.2%	0.85%	2.1%	1.2%	-0.33%	3.6%	2.3%	5.2%	3.0%	4.9%	4.9%	6.1%	4.9%	0.40%
WA, Grant	6.04	-0.43%	0.49%	-0.49%	0.45%	-1.5%	1.7%	1.5%	1.4%	1.4%	0.83%	3.0%	0.59%	3.0%	0.49%
WA, Grays Harbor	10.76	2.3%	1.6%	2.0%	1.3%	-0.38%	6.4%	3.9%	6.5%	3.9%	8.1%	6.7%	9.8%	6.7%	0.69%
WA, Island	10.86	0.28%	0.55%	0.17%	0.46%	-0.58%	2.0%	1.4%	1.5%	1.3%	1.9%	2.4%	1.7%	2.4%	0.43%
WA, Jefferson	11.16	0.005%	0.36%	-0.05%	0.32%	-0.60%	1.3%	1.0%	1.0%	0.91%	0.90%	1.7%	0.66%	1.7%	0.34%
WA, King	10.47	0.51%	0.62%	0.39%	0.52%	-0.43%	2.0%	1.3%	1.8%	1.3%	2.1%	2.3%	2.2%	2.3%	0.36%
WA, Kitsap	11.17	-0.22%	0.23%	-0.22%	0.23%	-0.62%	0.9%	0.82%	0.9%	0.82%	0.33%	1.5%	0.33%	1.5%	0.29%
WA, Kittitas	10.06	1.1%	0.94%	0.72%	0.70%	-0.58%	3.5%	1.9%	1.6%	1.4%	4.3%	2.7%	2.3%	2.7%	0.49%
WA, Klickitat	11.09	1.8%	1.2%	5.5%	2.5%	0.11%	4.3%	2.4%	9.4%	4.9%	6.4%	7.2%	11%	7.2%	0.55%
WA, Lewis	8.13	2.6%	1.9%	3.5%	2.0%	-0.31%	7.5%	4.3%	9.4%	5.4%	9.5%	9.1%	14%	9.1%	1.00%
WA, Lincoln	8.84	1.4%	0.88%	2.5%	1.3%	-0.10%	3.7%	2.2%	5.6%	3.0%	5.4%	4.9%	6.8%	4.9%	0.32%
WA, Mason	10.57	2.7%	2.0%	2.2%	1.5%	-0.40%	6.6%	3.2%	3.4%	2.5%	7.9%	4.4%	5.6%	4.4%	0.93%
WA, Okanogan	8.74	1.9%	1.10%	3.9%	1.8%	0.05%	4.4%	2.5%	8.6%	4.3%	6.6%	6.8%	11.0%	6.8%	0.24%
WA, Pacific	8.35	2.7%	2.1%	2.0%	1.5%	-0.52%	8.1%	4.7%	7.3%	4.5%	9.8%	8.1%	11%	8.1%	1.2%
WA, Pend Oreille	7.11	0.12%	0.13%	0.11%	0.12%	0.01%	0.31%	0.22%	0.25%	0.21%	0.37%	0.28%	0.34%	0.28%	0.028%
WA, Pierce	9.29	1.5%	1.3%	1.1%	0.99%	-0.48%	4.6%	2.7%	3.3%	2.4%	5.3%	4.2%	5.1%	4.2%	0.72%
WA, San Juan	13.42	1.1000%	0.63%	1.20%	0.64%	-0.10%	2.40%	1.30%	3.00%	1.60%	3.300%	2.70%	4.400%	2.700%	0.220%
WA, Skagit	11.17	-0.22%	0.23%	-0.22%	0.23%	-0.62%	0.9%	0.82%	0.9%	0.82%	0.33%	1.5%	0.33%	1.5%	0.29%
WA, Skamania	9.10	3.2%	2.4%	2.5%	1.8%	-0.49%	7.8%	3.8%	3.3%	2.7%	9.3%	4.9%	5.7%	4.9%	1.2%

State, County	NAA Rate	MO1				MO2[1]	MO3				MO4				PA
		Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	MO2	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	Bonneville Zero-Carbon	Bonneville Conv. Least-Cost	Region Zero-Carbon	Region Conv. Least-Cost	PA
WA, Snohomish	9.69	2.4%	1.9%	1.8%	1.4%	-0.42%	7.1%	4.1%	4.2%	3.6%	8.5%	6.3%	7.7%	6.3%	1.00%
WA, Spokane	9.15	0.59%	0.56%	0.85%	0.65%	-0.40%	2.2%	1.5%	2.7%	1.7%	2.7%	2.9%	3.0%	2.9%	0.34%
WA, Stevens	9.51	0.066%	0.37%	0.01%	0.33%	-0.54%	1.3%	0.99%	1.00%	0.93%	0.99%	1.7%	0.75%	1.7%	0.34%
WA, Thurston	11.16	-0.21%	0.23%	-0.22%	0.23%	-0.62%	0.9%	0.83%	0.9%	0.83%	0.35%	1.5%	0.35%	1.5%	0.29%
WA, Wahkiakum	9.40	3.1%	2.1%	2.2%	1.5%	-0.45%	7.3%	3.6%	2.8%	2.3%	8.9%	4.3%	5.2%	4.3%	1.00%
WA, Walla Walla	10.68	0.072%	0.38%	0.57%	0.58%	-0.67%	1.6%	1.3%	2.8%	1.8%	1.5%	3.1%	2.7%	3.1%	0.36%
WA, Whatcom	10.97	-0.079%	0.31%	-0.12%	0.29%	-0.61%	1.1%	0.96%	1.0%	0.90%	0.74%	1.7%	0.55%	1.7%	0.33%
WA, Whitman	9.61	0.35%	0.42%	0.60%	0.50%	-0.39%	1.7%	1.20%	2.2%	1.4%	1.9%	2.4%	2.4%	2.4%	0.28%
WA, Yakima	10.39	-0.025%	0.41%	-0.13%	0.35%	-0.86%	1.7%	1.3%	1.2%	1.1%	1.3%	2.2%	0.78%	2.2%	0.41%
CA, Modoc	9.20	1.6%	1.4%	1.2%	1.1%	-0.44%	4.5%	2.5%	2.0%	1.8%	5.6%	3.3%	3.0%	3.3%	0.83%
NV, Humboldt	8.38	1.9%	1.2%	1.1%	0.79%	-0.87%	4.9%	2.4%	1.6%	1.2%	7.2%	3.0%	3.1%	3.0%	0.45%
NV, Elko	10.24	1.40%	0.93%	1.30%	0.77%	-0.19%	3.3%	1.6%	2.9%	1.7%	4.1%	2.9%	4.3%	2.9%	0.42%
WY, Teton	7.76	2.2%	1.5%	4.9%	2.4%	-0.06%	5.6%	3.0%	9%	4.8%	7.9%	7.4%	11%	7.4%	0.76%

1/ MO2 includes the cost of fish passage structures at McNary with a costly feature for fish collection. If MO2 were implemented, fish collection could be achieved by a less costly option. Without the structure, rates under MO2 would be lower.

Columbia River System Operations
Final Environmental Impact Statement

Appendix I
Hydroregulation

Executive Summary

Introduction

This appendix discusses the hydroregulation modeling processes conducted for the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS). The Bonneville Power Administration (Bonneville), U.S. Army Corps of Engineers (Corps), and U.S. Bureau of Reclamation (Reclamation) are co-lead agencies in developing the CRSO EIS, which is required for the agencies' compliance with the National Environmental Policy Act (NEPA). This appendix is part of a larger set of CRSO EIS documents that detail the efforts of the co-lead agencies in evaluating alternatives for the future operation and configuration of 14 major projects of the Federal Columbia River Power System (FCRPS) collectively referred to as the Columbia River System (CRS).

This appendix focuses on the process of executing the hydroregulation studies for the CRSO EIS alternatives. The studies were conducted by Bonneville in close coordination with the Corps and Reclamation. Outputs from the hydroregulation study processes were used in determining changes to hydropower generation, power system reliability, streamflows, lake levels, habitat, water quality, and other purposes. Bonneville also reviewed the potential effects of climate change on the relative effects of the alternatives. The results of these changes are detailed in other appendices, including the *Hydropower Appendix J* and the *Hydrology and Hydraulics Appendix B (H&H Appendix B).*

Columbia River System Projects

The CRS consists of the 14 major projects operated in coordination with each other for several congressionally authorized purposes, including flood risk management (FRM), navigation, hydropower production, irrigation, fish and wildlife conservation, recreation, municipal and industrial water supply, and water quality. They are a subset of the FCRPS, a network of 31 multi-purpose dam and reservoir projects constructed in the Columbia River and its tributaries in the Pacific Northwest and operated by the Corps and Reclamation. The FCRPS also includes the transmission system built and operated by Bonneville to market and deliver electric power.

The CRS projects examined in detail in the CRSO EIS fall into two major categories: storage and run-of-river projects. There are six Federal storage projects in the CRS: Libby, Hungry Horse, Albeni Falls, Grand Coulee, Dworshak and John Day. There are eight Federal run-of-river projects in the CRS: Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, and Bonneville.

Operations at several non-Federal projects in the Columbia River basin are potentially affected by the CRSO EIS alternatives. These projects, being downstream from the 14 CRS projects, may exhibit some differences due to upstream flow changes, but operational goals and procedures remain the same throughout all CRSO EIS alternatives. These include five mid-Columbia River dams downstream of Grand Coulee Dam and Chief Joseph Dam; several non-Federal United States and Canadian dams on the Flathead, Clark Fork, and Pend Oreille Rivers downstream of

Hungry Horse and Albeni Falls Dams; and several Canadian dams on the Kootenay River downstream of Libby Dam. Notable non-Federal dams in the Columbia Basin that are not affected include three Columbia River Treaty (CRT) projects (Mica, Arrow, and Duncan) and Revelstoke Dam in Canada; and the Hells Canyon complex (Brownlee, Oxbow, and Hells Canyon Dams) on the Snake River.

The operation of these dams is coordinated for several purposes. The storage operation of five CRS storage projects, the Hells Canyon complex, and three CRT dams in Canada is coordinated for flood risk management to reduce flooding either locally or for the Columbia River reach below Bonneville Dam. United States and Canadian power production is coordinated per terms of the CRT. All the dams are connected to the Western Interconnection power system and contribute to providing a safe and reliable source of electricity. The 14 CRS projects are also operated to meet several objectives in Biological Opinions intended to reduce and mitigate the effects of the dams.

CRSO EIS Alternatives

In 2016 the co-lead agencies implemented a public scoping process with the public, tribes, local and state governmental agencies, non-government entities, and other stakeholders to identify issues that addressed the general purpose and need of the EIS: to review the management of the CRSO projects. The co-lead agencies used the information to develop measures to address the issues. Then the agencies combined these measures into four multiple objective (MO) alternatives. A no-action alternative (NAA) was also developed for comparing the effects of the alternatives. The following alternatives were modeled:

- NAA – includes operations and structures in place when the Notice of Intent for the EIS was published in September 2016.
- MO1 – includes a number of measures to benefit fish survival, water management, water supply, and hydropower production.
- MO2 – includes measures that emphasize power production, renewable resource integration, and reduction of use of carbon-producing generation resources while also providing for water management and some measures to benefit fish survival.
- MO3 – includes breaching of four lower Snake River dams and adds other measures beneficial to anadromous and resident fish as well as some measures for water management, water supply, and hydropower production.
- MO4 – includes other measures to aid anadromous fish survival without breaching the Snake River dams as well as some measures for resident fish, water management, water supply, and hydropower production.
- PA – combines a number of measures as the preferred alternative to meet the purpose and need, EIS objectives, and avoid, minimize, or mitigate environmental, economic, and sociological impacts. In addition, new information about spill operations from the 2018 and 2019 spring fish spill pilot operations that benefit downstream migration of juvenile anadromous fish became available after the range of alternatives was developed. Using this

new information, the co- lead agencies modified the measure for juvenile fish spill operation for the preferred alternative using the analysis from the range of spill levels evaluated in the MOs.

Modeling Processes

Bonneville conducted the hydroregulation studies in cooperation with the Corps to develop and refine the input data sets. Existing Hydsim, ResSim, and other computer programs and processing tools were used to pre- and post-process the data in the modeling process. Output results of the MO alternatives were then post processed and compared to the NAA model outputs. These results are presented in the EIS and the various appendices.

Conclusion

This document identifies the computer models, software tools, data sets, and sequence of steps used in the hydroregulation modeling process. The MO and PA alternatives' operational and physical changes are discussed, with further details included in Exhibit 4. Results of the modeling processes and assessment of the impacts to the CRS are found in other EIS appendices.

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Abbreviations, Acronyms, and Glossary

aMW	average megawatts
AOP	Assured Operating Plan
BiOp	biological opinion
Bonneville	Bonneville Power Administration
cfs	cubic foot per second
Corps	U.S. Army Corps Of Engineers
CRS	Columbia River System (14 of the 31 FCRPS Projects)
CRSO	Columbia River System Operations
CRT	Columbia River Treaty
DEIS	Draft Environmental Impact Statement
Entity/Entities	Each country that is party to the Columbia River Treaty has a designated Entity; see U.S. Entity and Canadian Entity
ESA	Endangered Species Act
F0	Flood 0
FCRPS	Federal Columbia River Power System
FRM	Flood Risk Management
ft	foot or feet
GENESYS	GENeration Evaluation SYStem
HEC	Hydrologic Engineering Center
HEC-ResSim	Hydrologic Engineering Center reservoir system simulation software
HEC-WAT	Hydrologic Engineering Center watershed analysis tool software
HLH	heavy load hour
HOSS	Hourly Operations Scheduling Simulator
HYDSIM	Bonneville hydropower simulation model
Kcfs	thousand cubic feet per second
LLH	light load hour
LOM	Lack of Market limit
Maf	million acre-feet
MO1	Multiple-Objective Alternative 1
MO2	Multiple-Objective Alternative 2
MO3	Multiple-Objective Alternative 3
MO4	Multiple-Objective Alternative 4
MOP	minimum operating pool
MW	megawatts
NAA	No-Action Alternative
NEPA	National Environmental Policy Act
NGVD29	National Geodetic Vertical Datum of 1929
NMFS	National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	formerly National Marine Fisheries Service
Northwest	States in the Northwest portion of the United States, including Washington, Oregon, Idaho, and Montana
PA	Preferred Alternative
PRMS	Precipitation Runoff Modeling System
RCP	representative concentration pathway
Reclamation	U.S. Bureau of Reclamation
ResSim or HEC-ResSim	Hydrologic Engineering Center reservoir system simulation software program
RMJOC	River Management Joint Operating Committee
SKQ	Sèliš Ksanka Ql̓ispè
Spill	discharge from a dam through its spillway
SRD	storage reservation diagram
TDG	total dissolved gas
Treaty	Columbia River Treaty
TSR	Treaty Storage Regulation
URC	upper rule curve
VarQ	variable discharge Flood Risk Management procedures
VIC	variable infiltration capacity
WAT or HEC-WAT	watershed analysis tool

CHAPTER 1 - INTRODUCTION TO COLUMBIA RIVER SYSTEM OPERATIONS AND HYDROREGULATION

This appendix presents the hydroregulation performed by Bonneville Power Administration (Bonneville) for its hydropower analyses conducted for the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS). The Bonneville, U.S. Army Corps of Engineers (Corps), and U.S. Bureau of Reclamation (Reclamation) are co-lead agencies in developing the CRSO EIS, which is required for National Environmental Policy Act (NEPA) compliance. This appendix is part of a larger set of CRSO EIS documents that detail the efforts of the co-lead agencies in evaluating alternatives for the future operation and configuration of 14 Federal Columbia River Power System (FCRPS) major projects. These 14 FCRPS projects are collectively referred to as the Columbia River System (CRS).

This appendix focuses on hydroregulation models and modeling techniques Bonneville used to assess the effects of the CRSO EIS alternatives on Columbia River hydropower. It is supported by several other CRSO EIS documents that provide additional details on the EIS processes, alternatives, system operation and modeling, and other uses affected by the alternatives. Details about the NEPA process and alternative development are presented in the CRSO EIS. Modeling details for this hydropower assessment are presented in this appendix and the *Hydrology and Hydraulics Appendix B* (*H&H Appendix B*) prepared by the Corps. The hydroregulation results in this appendix contribute to other analyses in the CRSO EIS, including analyses of socioeconomic, air quality, and water quality effects. The results of those other effects are detailed in the main report of the CRSO EIS and appropriate appendices.

1.1 COLUMBIA RIVER SYSTEM PROJECTS

As defined for this study, the CRS consists of the 14 major projects operated in coordination with each other. They are a subset of the FCRPS, a network of 31 multi-purpose Federal dam and reservoir projects constructed in the Columbia River and its tributaries in the Pacific Northwest and operated by the Corps and Reclamation. The FCRPS also includes the Federal transmission system built and operated by Bonneville to market and deliver electric power.

The United States Congress authorized the Corps and Reclamation to construct, operate, and maintain the FCRPS projects to meet multiple specified purposes, including flood risk management (FRM), navigation, hydropower production, irrigation, fish and wildlife conservation, recreation, municipal and industrial water supply, and water quality. Although not every project is authorized for each of these purposes, all 14 FCRPS projects are authorized for hydropower.

1.1.1 FCRPS Projects in the CRS

The 14 FCRPS projects on the Columbia River and its major tributaries are operated as a coordinated system known as Columbia River System (CRS). The CRSO EIS focuses on these 14 FCRPS projects: Libby, Hungry Horse, Albeni Falls, Grand Coulee, Chief Joseph, Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and

Bonneville. Figure 1-1 shows the geographic locations of the 14 projects. Table 1-1 summarizes the general characteristics of the 14 projects.

The CRS projects examined in detail in the CRSO EIS fall into two major categories: storage and run-of-river projects. There are six Federal storage projects in the CRS: Libby, Hungry Horse, Albeni Falls, Grand Coulee, Dworshak and John Day. There are eight Federal run-of-river projects in the CRS: Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, and Bonneville.

Storage is key to operating the CRS for multiple uses. The total water storage available in the reservoirs on the Columbia River and its tributaries is approximately 55 million acre-feet (Maf). About 20 Maf of that storage capacity is in Canada and 17 Maf in the six CRS storage projects. In general, the storage reservoirs capture streamflow during relatively high spring snowmelt flow periods. Refill is managed to reduce downstream flooding and store water for release for multiple objectives in times of relatively low streamflows during late summer and fall months. Computer models operate or regulate storage projects using tools to store and fill, release and draft, or pass inflows.

Run-of-river projects have limited storage capacity. These projects release water at the dam at nearly the same rate it enters the reservoir. The reservoirs behind run-of-river projects often are operated for hydropower resulting in frequent, relatively minor fluctuations in water levels. Reservoir levels behind these projects typically vary only 3 to 5 feet in normal operations. In hydroregulation models, these projects release their inflows and maintain a constant reservoir level. The modeler has several tools to specify the distribution of releases through powerhouse flows, spillway flows, fish passage facility flows, and to compensate for navigation lockages, and/or dam leakage.

1.1.2 Other FCRPS Projects

The remaining 17 FCRPS projects are operated independently of the 14 CRS projects and are located in the upper Snake River basin in southern Idaho, the Yakima River basin in Washington, and the Willamette and Rogue River basins in Oregon. Their operation is replicated in the modeling of each alternative (i.e., their project storage operations, outflows, and generation are the same in each CRSO EIS alternative).

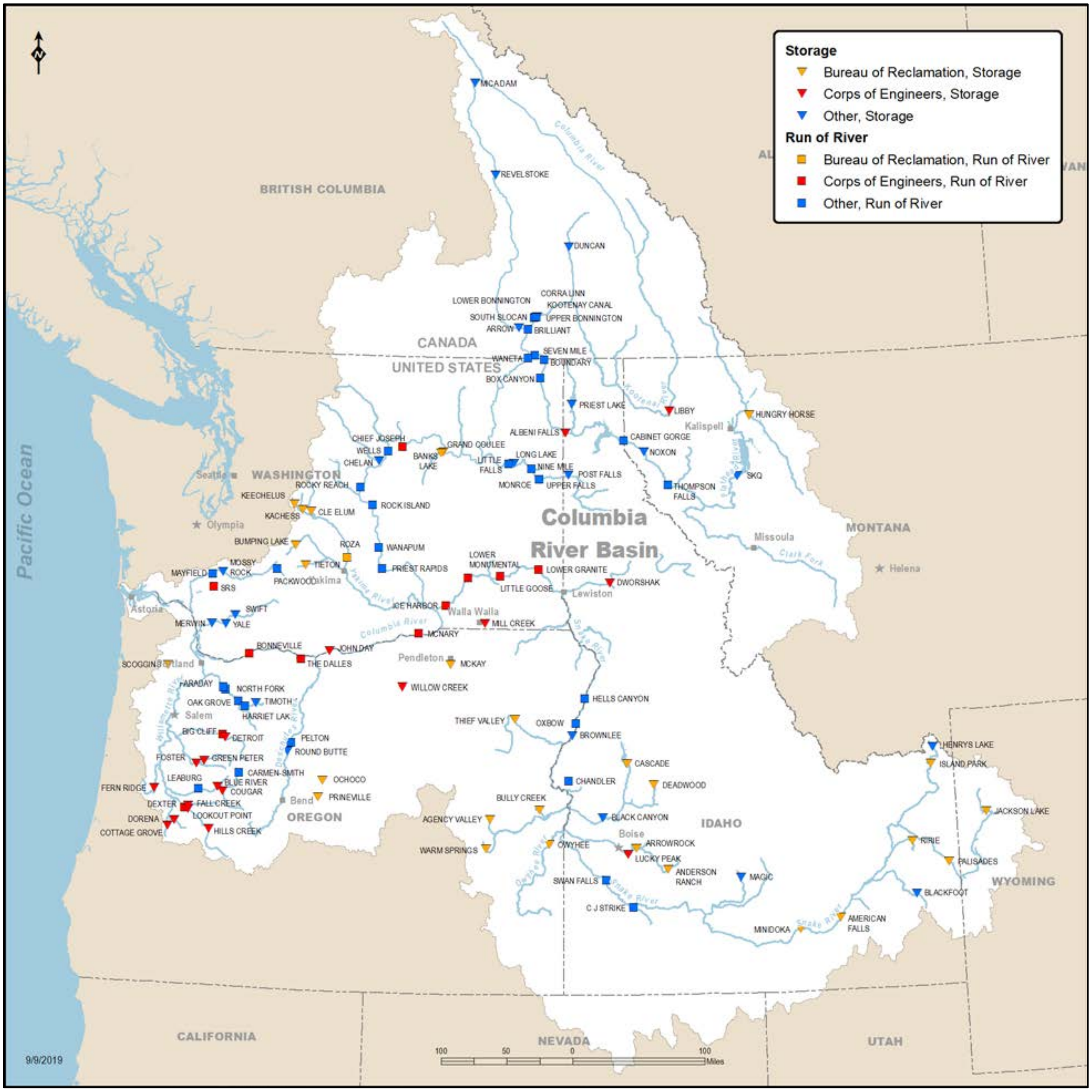

Figure 1-1. Geographic Location for the CRSO Projects

Note: SKQ on the Flathead River in Montana refers to Sèliš Ksanka Qĺispè Dam, formerly known as Kerr Dam.

Table 1-1. General Characteristics of the Columbia River System Projects

Project	Reservoir/ Lake	Project Type	Storage Volume (MAF)	Hydropower (no. of units - capacity)
Libby	Koocanusa	Storage	5.0	5 units – 525 MW
Hungry Horse	Hungry Horse	Storage	3.0	4 units – 428 MW
Albeni Falls	Pend Oreille	Storage	1.2	3 units – 42 MW
Grand Coulee	Roosevelt	Storage	5.4	24 units, 6 pump/generators – 7,015 MW
Chief Joseph	Rufus Woods	Run-of-river	-	27 units – 2,000 Mw

Project	Reservoir/ Lake	Project Type	Storage Volume (MAF)	Hydropower (no. of units - capacity)
Dworshak	Dworshak	Storage	2.0	3 units – 400 MW
Lower Granite	Lower Granite	Run-of-river	-	6 units – 810 MW
Little Goose	Bryan	Run-of-river	-	6 units – 810 MW
Lower Monumental	Herbert G. West	Run-of-river	-	6 units – 810 MW
Ice Harbor	Sacajawea	Run-of-river	-	6 units – 603 MW
McNary	Wallula	Run-of-river	-	14 units – 980 MW
John Day	Umatilla	Storage	0.5	16 units – 2,480 MW
The Dalles	Celilo	Run-of-river	-	22 units – 2,080 MW
Bonneville	Bonneville	Run-of-river	-	18 units – 1,200 MW

Project information from http://www.crso.info/index.html

1.1.3 Non-Federal Dams and Reservoirs

There are numerous other dam and reservoir projects in the Columbia River and its tributaries that are operated by Federal and non-Federal entities in the United States and Canada. These include both storage and run-of-river projects that can affect or be affected by CRS project operations. Exhibit 1 identifies these non-Federal projects, and annotates with an asterisk those projects affected by CRSO EIS alternatives. Locations of major non-Federal projects are shown in Figure 1-1.

1.1.3.1 Canadian Projects

Mica, Arrow, and Duncan (Columbia River Treaty[1] Projects) are major storage projects in Canada with 15.5 Maf of Columbia River Treaty (CRT or Treaty) storage and 5 Maf of non-Treaty storage. The 15.5 Maf of Treaty storage is operated by British Columbia Hydro and Power Authority for FRM and hydropower in accordance with the terms of the Treaty. In addition, there is a non-Treaty storage operation under separate mutual agreements between the United States and Canadian entities to provide resident fish benefits in Canada and anadromous fish benefits in the United States. Operation of these projects is held constant and included in all of the CRSO EIS alternatives being analyzed.

There are several other projects operated by British Columbia Hydro and Power Authority and other entities in Canada on the lower Kootenay and Pend d'Oreille Rivers. Power production at these other Canadian projects is affected by the CRSO EIS alternatives. Canadian projects are listed in Exhibit 1, and are shown in Figure 1-1.

[1] See Bonneville website for information on the Columbia River Treaty at: https://www.bpa.gov/Projects/Initiatives/Pages/Columbia-River-Treaty.aspx

1.1.3.2 Mid-Columbia River Projects

Three Washington State Public Utility Districts (PUDs) operate five run-of-river dams in the mid-Columbia River. These projects are operated under licenses from the FERC:

- Wells, operated by Douglas County PUD
- Rocky Reach and Rock Island, operated by Chelan County PUD
- Wanapum and Priest Rapids, operated by Grant County PUD

These Mid-Columbia Projects are shown in Figure 1-1. They are hydrologically affected by upstream Federal storage project operations which influence flows through the PUD projects particularly from Grand Coulee Dam. Power production at the five PUD dams would be affected by the CRSO EIS alternatives.

1.1.3.3 Middle Snake River Dams

The Idaho Power Company operates three FERC-licensed dams, collectively known as the Hells Canyon Complex, located on the middle Snake River on the Oregon/Idaho border. The Hells Canyon, Oxbow, and Brownlee Projects are hydropower facilities that affect flows on the lower Snake River. Hells Canyon and Oxbow are run-of-river projects downstream of Brownlee Dam. Brownlee Dam is the most significant for CRSO, as this reservoir has a total storage capacity of 1.4 Maf, of which 980,000 acre-feet are used jointly for FRM and power production. Brownlee also is operated for recreation, navigation below Hells Canyon, and provides flow augmentation for the lower Snake and Columbia River juvenile fish migration. Power production at these dams would not be affected by the CRSO EIS alternatives. Operation of these dams is replicated in all the CRSO EIS alternatives.

1.1.3.4 Other Columbia River Non-Federal Dams in the United States

There are other non-Federal dams in the United States located below the CRS storage projects at Hungry Horse and Albeni Falls dams. They include Sèliš Ksanka Ql̓ispè (SKQ) on the Flathead River and Thompson Falls, Noxon Rapids, and Cabinet Gorge on the Clark Fork River below Hungry Horse Dam; and Box Canyon and Boundary dams are located on the Pend Oreille River below Albeni Falls Dam. All are run-of river with the exception of SKQ Dam which regulates the storage at Flathead Lake in Montana. Power production at these dams would be affected by the CRSO EIS alternatives.

There are numerous other dam and reservoir projects in the Columbia River and its tributaries that are operated by non-Federal entities in the United States and Canada. These include both storage and run-of-river projects that can affect or be affected by CRS project operations.
A listing of the Federal and non-Federal dams pertinent to this hydropower analysis is provided in Exhibit 1.

1.2 DESCRIPTIONS OF THE ALTERNATIVES

The CRSO EIS contains four multiple objective alternatives and the No-Action Alternative (NAA). The NAA represents reservoir operations and dam structures in place or scheduled for construction when the Corps filed a Notice of Intent for the EIS in September 2016.

The four multiple objective alternatives contain different combinations of operational and structural measures to address issues identified in the CRSO EIS public scoping meetings. Operational measures include: differing storage operations at the Federal upstream storage projects and differing spill and powerhouse flow levels at the Federal downstream run-of river projects. Structural measures include: differing juvenile and adult fish passage system improvements; installation of more efficient turbines with improved fish passage at select projects; and dam breaches at the four lower Snake River dams.

Summary descriptions and effects of the NAA and four multiple-objective alternatives are provided in the following sections and limited to the measures pertinent to this hydropower assessment. More complete, detailed descriptions of the no-action and multiple-objective alternatives are provided in Chapter 2 of the CRSO EIS. Specific details for how the alternatives were modeled for hydropower assessments are provided in this appendix. Exhibit 2 includes a matrix that lists all the measures in each multiple-objective alternative. Measures that do not affect hydropower production are not listed in the multiple-objective alternative descriptions below.

1.2.1 No-Action Alternative (NAA)

The NAA includes the operation and structures in place or committed for construction when the Notice of Intent for the CRSO EIS was published in the Federal Register in September 2016 and applied to forecast future years. In summary, those pertinent to this hydropower assessment include:

- FRM Operations per Corps current criteria for the five CRS storage projects, three CRT projects in Canada, and United States FERC-licensed projects (Brownlee and SKQ).
- Canadian Treaty project (Mica, Arrow, and Duncan) storage operations for FRM are as defined in the Flood Control Operating Plan[2]; power operations are as defined in the 2022 Assured Operating Plan. Also includes Canadian storage operations for non-power uses as defined in current agreements between the United States and Canadian CRT Entities.
- Project operating criteria as specified in authorizing legislation and water control manuals including minimum and maximum discharge rates of change and minimum and maximum forebay elevations.

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[2] See Columbia River Flood Control Operating Plan prepared by Corps (May 2003) at: http://www.nwd-wc.usace.army.mil/cafe/forecast/FCOP/FCOP2003.pdf

- Flow augmentation objectives consistent with the 2008 BiOp (as amended in 2010 and 2014) issued by NMFS for salmon and steelhead including spring and summer flow targets at Lower Granite and McNary Dams, chum spawning operations below Bonneville Dam, and spawning and rearing operations below Priest Rapids Dam.
- Spill operations for juvenile fish passage consistent with the 2008 BiOp (as amended in 2010 and 2014) issued by NMFS for salmon and steelhead including fish passage spill operations at the eight lower Snake and Columbia River dams.
- Summer drafts at Libby and Hungry Horse dams to meet September 30 targets of 10 feet from full in most years or 20 feet from full in dry years.
- Loads/Resources for hydropower modeling are for 2022 forecasts.
- Turbine-generator unit maintenance/outage schedule for Federal projects is a generic future year based on five-year maintenance averages and includes Grand Coulee turbine-generator overhaul plus forthcoming upgrades to McNary and Ice Harbor turbines.

1.2.2 Multiple-Objective 1 (MO1)

MO1 includes a number of measures to benefit fish and some measures for water management, power production, and water supply. Not all measures in MO1 affect hydropower modeling; MO1 contains the following departures from the NAA that affect the power assessment:

- Fish Passage Spill:
  - The amount of spill in MO1 is more than the NAA, but less than provided by flexible spill operations regional entities agreed to implement in 2020/2021.
  - Block spill: two different spill blocks are provided for spring fish passage — one block is spill to 120/115 percent of the total dissolved gas (TDG) cap level and the other is performance standard spill. Alternative years will have the different spill blocks occurring first or second within the modeling process.
  - NAA summer spill levels are provided, but a fish-count trigger can potentially end summer spill earlier at the lower Snake River projects in August to benefit power when few juvenile fish are migrating.
  - Power contingency reserves can be carried within juvenile fish spill.
- Water Management:
  - Account for local runoff volumes in Libby variable discharge (VarQ)[3] draft and refill operations when the Libby water supply forecast is 6.9 Maf or less.

[3] The VarQ FRM procedure was developed to improve the multi-purpose operation of Libby and Hungry Horse dams while not reducing the level of flood protection in the Columbia River. VarQ details are available in the Water Control Manuals for Libby and Hungry Horse dams. CRSO EIS Flood Risk Management Appendix K.

  - Replace Libby end-of-December variable draft target with single 2,420-foot target elevation.
  - Apply updated Upstream Storage Correction method to determine end of April draft requirement for Grand Coulee.
  - Update Grand Coulee storage reservation diagram (SRD) to account for a reduced planning draft rate limit of 0.8 feet/day and added FRM protection for winter rain-induced flooding below Bonneville Dam.
  - Limit Grand Coulee maximum outflow to account for forecasted increase in outages. Use accelerated maintenance schedule for power plant and spillways instead of NAA five-year average.
- Water Supply
  - Increase water supply diversion from Grand Coulee Dam, below Hungry Horse Dam, and from Chief Joseph Dam.
- Storage
  - Sliding scale summer target elevation at Libby and Hungry Horse dams.
  - Dworshak cool water releases are made earlier (June and July) and later (September) with reduced flow in August.
  - Increase John Day target elevation in April and May by 1 foot to reduce avian predation.
- Run-of-River
  - Increased lower Snake Dam operating range (minimum operating pool [MOP][4] + 1.5 feet).
  - Increased John Day forebay operating range (MOP + 2 feet).
- Structural
  - Construct powerhouse surface passage routes at McNary and Ice Harbor dams; this will affect the powerhouse availability at those projects since fish screens will no longer need to be installed.
  - Construct powerhouse surface passage routes at McNary and Ice Harbor dams; this will affect the powerhouse availability at those projects since fish screens will no longer need to be installed.

1.2.3 Multiple-Objective 2 (MO2)

MO2 represents operations that might be implemented if climate change becomes the primary policy driver in the future. More emphasis is placed on hydropower production and flexibility to integrate other renewable resources to reduce carbon emissions from fossil fuel generating

[4] MOP is the lowest forebay operating limit for a run-of-river project.

resources. Not all measures in MO2 affect hydropower; MO2 contains the following departures from the NAA that affect the power assessment:

- Fish passage spill
    - Fish passage spill amounts are reduced from the NAA, near 110 percent TDG at most projects except when minimum spill levels are higher for powerhouse surface passage routes, for the spillway weirs, and/or for adult attraction to fish ladders.
    - Fish passage spill is curtailed on August 1.
    - Power contingency reserves are carried within fish spill.
- Water Management
    - Libby VarQ draft and refill operations are modified when water supply forecast is 6.9 Maf or less.
    - Libby end-of-December variable draft procedure replaced with a 2,420-foot target elevation.[5]
    - Additional draft below FRM elevation for hydropower allowed at Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak.
    - Updated upstream Storage Corrections Method is applied to the Grand Coulee SRD.
    - Update Grand Coulee SRD to account for a reduced planning draft rate limit of 0.8 feet/day and added FRM protection for winter rain-induced flooding below Bonneville Dam.
    - Limit Grand Coulee maximum outflow to account for forecasted increase in outages. Use accelerated maintenance schedule for power plant and spillways instead of NAA five-year average.
- Water Supply
    - Water supply measures are unchanged from NAA.
- Storage
    - Sliding scale summer target elevation at Libby and Hungry Horse dams.
    - Storage projects are allowed to draft to meet power demand during the most valuable periods of high demand in the fall and winter allowing slightly more generation in the winter and slightly less during the spring.
- Run-of-River
    - Unrestricted forebay operations (i.e., no restrictions to MOP and minimum irrigation pool [MIP]) provide more flexibility for power generation at the lower Snake and

[5] Note that when this measure for an end-of December target of 2,420 feet NGVD29 is combined with the measure that allows deeper drafting for hydropower at storage projects, the resultant modeled end-of December target is 2,400 feet NGVD29.

Columbia River run-of-river projects and benefit integration of more renewables and meeting peak load demand and obligations or prices in energy markets.

- Operate turbines across their full range of capacity year-round.
- Zero generation operations may occur on lower Snake River projects November through February.

- Structural
  - New higher efficiency turbines with improved fish passage survival replaced older turbines at John Day.
  - Added powerhouse surface passage at John Day, McNary, and Ice Harbor Dams, which increases the minimum spill relevant for MO2.

1.2.4 Multiple-Objective 3 (MO3)

MO3 breaches the four lower Snake River dams and adds other measures beneficial to resident and mainstem anadromous fish. For power purposes, a generic future year after the dams are breached is being modeled. Not all measures in MO3 affect hydropower; MO3 contains the following departures from the NAA that affect the power assessment:

- Dam Breach
  - Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams are breached by removing earthen embankments.
- Fish Passage Spill
  - Spring spill for fish passage at the four lower Columbia River dams up to 120 percent TDG.
  - Reduced duration of summer juvenile fish passage spill (curtailed on August 1).
  - Power contingency reserves are carried within fish spill.
- Water Management
  - Libby VarQ draft and refill operations are modified when water supply forecast is 6.9 Maf or less.
  - Libby end-of-December variable draft procedure replaced with a 2,420-foot target elevation with allowance for additional draft of 20 feet below FRM for hydropower (2,400-foot elevation).[6]
  - Updated Upstream Storage Corrections Method is applied to the Grand Coulee SRD.
  - Update Grand Coulee SRD to account for a reduced planning draft rate limit of 0.8 feet/day.

[6] This measure is modeled with an end-of-December elevation of 2,400 feet NGVD29.

  - Limit Grand Coulee maximum outflow to account for forecasted increase in outages. Use accelerated maintenance schedule for power plant and spillways instead of NAA five-year average.
- Water Supply
  - Increased water supply diversion from Grand Coulee Dam; below Hungry Horse Dam, and from Chief Joseph Dam.
- Storage
  - Sliding scale summer target elevation at Libby and Hungry Horse dams.
- Run-of-River
  - John Day allowed to operate up to full pool except as needed for flood risk management.
  - Lower Columbia project turbines operated within and above 1 percent peak efficiency in juvenile fish passage season.
- Structural
  - New higher efficiency turbines with improved fish passage survival replaced older turbines at John Day.
  - Added powerhouse surface passage at McNary Dam.

1.2.5 Multiple-Objective 4 (MO4)

MO4 includes aggressive measures to aid anadromous fish survival without breaching the lower Snake River dams. Not all measures in MO4 affect hydropower; MO4 contains the following departures from the NAA that affect the power assessment:

- Fish Passage Spill
  - Spill through modified spillway weirs at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary and John Day projects during October and November for steelhead overshoots, overwintering steelhead, and kelt.
  - Spill to 125 percent TDG for juvenile anadromous fish passage is provided from March 1 to August 31.
  - Power contingency reserves may be carried during fish spill.
- Water Management
  - Libby VarQ draft and refill operations account for local runoff volumes when that same water supply forecast is 6.9 Maf or less.
  - Replace Libby end-of-December variable draft procedure with a 2,420-foot target elevation.
  - Apply updated upstream Storage Corrections Method to the Grand Coulee SRD.

- Update Grand Coulee SRD to account for a reduced planning draft rate limit of 0.8 feet/day and added FRM protection for winter rain-induced flooding below Bonneville Dam.
- Limit Grand Coulee maximum outflow to account for forecasted increase in outages. Use accelerated maintenance schedule for power plant and spillways instead of NAA five-year average.

- Water Supply
  - Increased water supply diversion from Grand Coulee Dam; below Hungry Horse Dam, and from Chief Joseph Dam.
- Storage
  - Release up to 2 Maf of additional water from upstream Federal storage projects to support 220 kcfs spring and 200 kcfs summer target flows at McNary.
  - Sliding scale summer target elevations at Libby and Hungry Horse dams.
  - Manage Libby outflow November through March to limit Bonners Ferry stage to maximum of 1,753 feet National Geodetic Vertical Datum of 1929 (NGVD29) for riparian habitat protection.
- Run-of-River
  - The eight Lower Snake River and Lower Columbia River projects are operated within MOP+1.5 feet from mid-March to late August.
  - Operate lower Snake and Columbia River dam turbines within or above 1 percent peak efficiency during fish passage season.
- Structural
  - Construct additional powerhouse surface passage routes to meet system-wide PITPH[7] target at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, and/or John Day Dams.

1.2.6 Preferred Alternative (PA)

PA combines a number of measures to benefit fish as well some measures for water management, power production, and water supply. PA contains the following departures from the NAA that affect the power assessment:

- Fish Passage Spill:
  - This measure is a revised juvenile fish passage spill operation based upon results of the spring 2019 Flexible Spill Test Operation and analysis of the four MO Alternatives.

[7] PITPH is a metric that estimates the proportion of juvenile fish passing a dam via the powerhouse. It is based on the relationship between the proportion of juvenile fish that pass via spill and the proportion that pass via the turbines and bypass systems at the dam.

- In a 24-hour period, the Juvenile Fish Passage Spill measure would involve 16 hours of spill operations up to 125% TDG at most projects for juvenile outmigration. For the remaining 8 hours, the projects would spill at a lower level, up to 125% TDG. These spill levels are slightly variable, depending on the project (see Chapter 7 of the EIS). These operations would be implemented during the spring juvenile migration, April 3 – June 21, at the lower Snake River projects, and April 10 – June 16 at 5 the lower Columbia River projects. When Flex Spill ceases, the projects would transition to summer spill operations.
- PA summer spill levels are described in Chapter 7 of the EIS with a late summer transition spill operation from August 15 - 31.
- Power contingency reserves can be carried within juvenile fish passage spill.
- Spill for overwintering steelhead provides for a small volume of spill through the spillway weirs at five projects, for a few hours each week in March, October, and early November. This measure modifies an existing measure in the Preferred Alternative, Study Off-season Surface Spill for Downstream Passage of Adult Steelhead & Bull Trout. A short discussion if its impacts are included in Appendix J.

- Water Management:
  - Account for local runoff volumes in Libby variable discharge (VarQ)[8] draft and refill operations when the Libby water supply forecast is below 6.9 Maf. Revert to NAA operation for years with water supply forecasts above 6.9 Maf.
  - Apply updated Upstream Storage Correction method to determine end of April draft requirement for Grand Coulee.
  - Update Grand Coulee storage reservation diagram (SRD) to account for a reduced planning draft rate limit of 0.8 feet/day.
  - Reduce limit on Grand Coulee maximum outflow to account for forecasted increase in outages. Use accelerated maintenance schedule for power plant and spillways instead of the NAA 5-year average.
- Water Supply
  - Increase water supply diversion from Lake Roosevelt by 45,000 acre-feet of water above the NAA.
- Storage
  - Sliding scale summer target elevation at Libby and Hungry Horse dams.

[8] The VARQ FRM procedure was developed to improve the multi-purpose operation of Libby and Hungry Horse dams while not reducing the level of flood protection in the Columbia River. VarQ details are available in the CRSO EIS FRM Appendix K.

  - Dworshak will be operated with a variable draft elevation target to increase hydropower generation in the winter and reduce non-fish passage spill in the spring, while protecting the refill of the reservoir.
  - Operate John Day pool between 264.5 – 266.5 feet during April 10 – June 15to reduce avian predation.
- Run-of-River
  - Increased lower Snake Dam operating range (MOP[9] + 1.5 feet).
  - Increased John Day forebay operating range (MOP + 2 feet).
  - John Day full pool measure would allow for operation of the reservoir across the full range 262.0 – 266.5 feet elevation outside of fish passage season, except as needed for structural measures
  - Zero generation operations may occur on lower Snake River projects October 15 – February with revised timing of the measure to provide hydropower flexibility to integrate new renewable resources and while minimizing impacts to ESA-listed fish.
- Structural:
  - Use new higher-efficiency turbines with improved fish passage survival in place of older turbines at John Day.

Construct powerhouse surface passage routes at McNary and Ice Harbor dams, which increases the minimum spill relevant for PA and affects turbine availability.

[9] MOP or minimum operating pool is the lowest forebay operating elevation for a run-of-river project.

CHAPTER 2 - MODELING OVERVIEW FOR ALTERNATIVES

2.1 HYDROREGULATION IN THE COLUMBIA RIVER MANAGEMENT AREA

Hydroregulation modeling is performed using one or more computational models that simulate reservoir, powerhouse, and dam operation of the hydropower system over a period of time. Different hydroregulation models are used in a specific sequence to compute outputs to assess the impact on a goal or measure from the operations protocols or physical limitations input into the model.

Hydroregulation models are developed to solve a specific set of mathematical computations, answer a specific set of questions, and satisfy a specific set of needs. Different hydroregulation models cover different timeframes, have different capabilities, and have different strengths and weaknesses. The outputs from one model may be used as inputs to other models to refine the computations or answer different questions, and they output a separate set of results.
The outputs from an existing condition or NAA model run are compared to the outputs from model runs with alternative operations. The differences are quantified to determine the impact to a resource, such as water quality parameters, recreation season reservoir levels, aquatic habitat quantity and suitability, or Heavy Load Hour (HLH) generation (HE 7 am to HE 10 pm, except Sundays and Holidays).

Model inputs are created from a combination of physical components (e.g., reservoir volume curves and powerhouse performance) and operational conditions (i.e., required spill flows or reservoir elevation refill targets). These inputs are created from the objectives or goals of a model run by staff familiar with the hydropower system. Once inputs have been entered and the model run, output results are examined to verify the success of meeting the goals and objectives.

Computer model logic simulates normal reservoir and powerhouse operation, and perhaps even some non-standard operations, but there are numerous instances where operations in real life may differ from model outputs. Examples of the deviations from normal operations include emergency operating requirements, maintenance outages, and differences caused by actual versus forecasted hydrology, and differences in actual versus modeled withdrawals and evaporation. Models also do not cover operations that occur on timeframes shorter than the model's resolution. To meet a specific goal (i.e., a maximum TDG concentration below a dam) modelers input a specific maximum spill constraint. However, in real life, the TDG limit may be achieved at a different spill rate due to temperature, rainfall, reservoir level, wind, and other environmental variables.

2.2 OVERALL MODELING APPROACH

The modeling approach for the CRSO EIS aligned different model approaches and types to provide similar representations of key operations for all impact assessments. Figure 2-1 describes the three primary steps of the modeling approach: input, modeling (or study/task), and output. This section describes the steps applied to achieve outputs for each alternative. Results from the hydroregulation modeling were used in subsequent modeling steps to provide results for different impact assessments.

The results from the Bonneville hydropower simulation model (HYDSIM) portion of the hydroregulation studies were detailed sets of 80-year by 14-period (April and August being split months) project outflows, reservoir elevations, reservoir contents, spillway flows, and power generation data at the 31 projects in the FCRPS and several other electric projects in the Northwest United States and Canada (Exhibit 1). The CRSO EIS focuses on the 14 CRS projects and select non-Federal projects affected by the EIS alternatives.

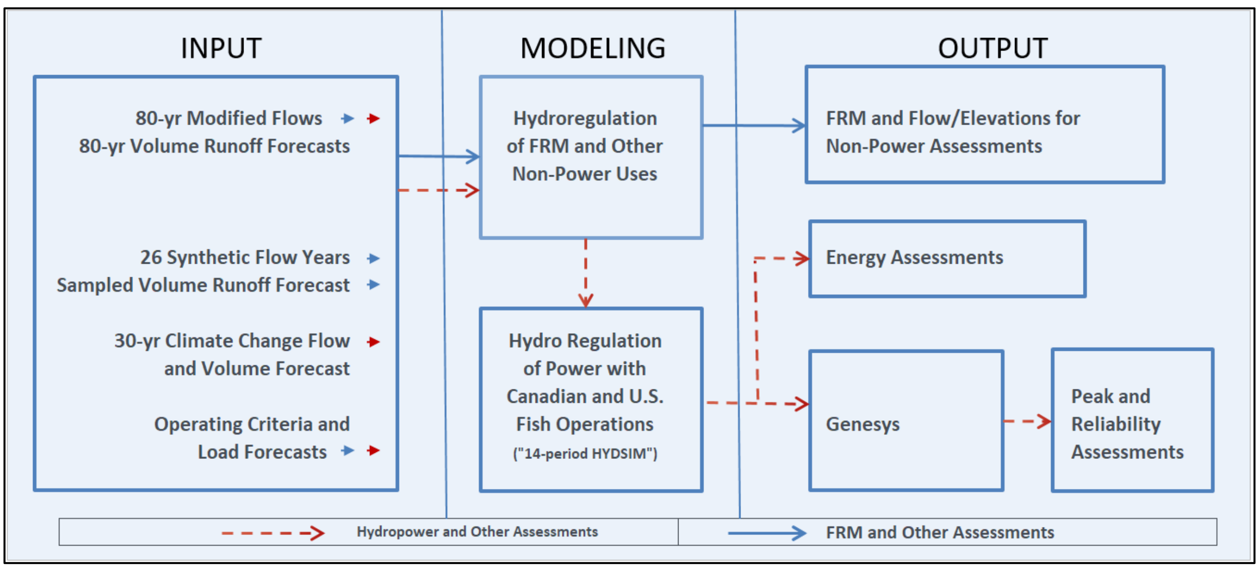

Figure 2-1. Modeling Approach

2.3 HYDROREGULATION MODELS

Models used for hydroregulation for the CRSO EIS primarily include Hydro System Simulator (HYDSIM), Reservoir System Simulation Model (ResSim), and Hourly Operations Scheduling Simulator (HOSS). Other computerized programs are used to develop inputs that influence reservoir storage operations, these inputs include Energy Content Curves (ECC), refill curves, and upper rule curves (URC) that represent FRM requirements. The hydroregulation computations are performed using HYDSIM and ResSim. The ResSim hydroregulation model described here is limited to its role in the overall hydroregulation modeling sequence; further information is in the *H&H Appendix B* (Part 3 – HEC-ResSim/WAT Documentation and Part 1 – H&H Data Analysis).

The general hydroregulation simulation process is for Bonneville staff to develop inputs for HYDSIM from the 80-year Modified Flow dataset, Energy Content Curve inputs, power demand, plant performance inputs from Pacific Northwest Coordination Agreement submissions and other requirements. Input quality control is provided by other modeling staff before the HYDSIM model is run. Outputs are reviewed by multiple modeling staff to ensure the model is implementing the conditions as desired, and no conflicting requirements cause the model to not satisfy a desired operating condition. Further, all the hydroregulation of the CRSO alternatives with the 80-year Modified Flow dataset were run through both the HYDSIM and ResSim models, and the outputs compared by a group of hydro modelers for quality control.

HYDSIM models the system in 14 periods, monthly with two split months, April and August. The outputs are end of period project elevations, period average generation, and period average turbine and spillway outflows. ResSim models are used to model the system on a daily basis, which is better suited to simulate intra-month reservoir elevations, dam outflows, and evaluate potential flooding events.

The HYDSIM output is supplied to the HOSS model. HOSS is used to convert the 14-period generation output into hourly generation. Verification of inputs and outputs are performed by a primary modeler and a modeler who performs quality control checking of the datasets.

Generation outputs from HYDSIM and HOSS are used to evaluate CRSO generation and the ability to meet loads. River flow and reservoir elevation outputs from ResSim are used to evaluate the model run impacts to water quality, fish habitat, navigation, and other affected operating objectives.

CHAPTER 3 - HYDROPOWER MODELING

Bonneville and the Corps modeled the CRSO EIS alternatives, respectively, with HYDSIM producing 14-period output and ResSim producing daily output. These models share common inputs and also rely on output from each other. For example, end of month elevations, flows, and proportional draft points from HYDSIM are used as inputs to ResSim, which develops daily time-step end of day elevations and average flows, ultimately producing upper rule curves (URCs). These URCs then become conditions for the US operation that HYDSIM must meet.

These models interact and are interdependent, and therefore operations in both models need to be similar for each alternative. Bonneville and Corps modelers coordinated extensively throughout the CRSO EIS analyses to assure both models and related outputs are in sync and aligned. For example, regulated project elevations were compared and, if necessary, appropriate adjustments made to the modeling inputs to attain similar results. Bonneville and the Corps also compared 14-period outflow average volumes of both models to assure the operations for the NAA and each MO were similar.

3.1 HYDSIM

The HYDSIM model simulates power production for the month-to-month operation of the Pacific Northwest hydropower system. It is used to determine the hydropower system generation and resulting project outflows, ending storage contents under varying inputs of inflows, power loads, operating procedures and constraints, and physical plant data.

The HYDSIM model is not an optimizer; instead, it is a deterministic model that uses rule curves and flow limits or storage constraints to achieve operating objectives, especially for power, FRM, fish flows and spill, and recreation. HYDSIM uses a 14-period time step. April and August are split into two half-periods because these months tend to have significant natural flow differences between their first and second halves. The model simulates one period at a time, not using any forwarding-looking process.

HYDSIM uses the 2010 Level Modified Flows for water year sequences 1929 through 2008 as input. The model is run in a continuous mode where the same load and resource parameters are applied to all water years and the ending elevations for each historical water year become the starting elevations for the next water year.

For each period, the model reads input files containing unregulated streamflow, power load forecasts, operating rule curves, and operating requirements (more details available in other sections and exhibits). The model follows a priority list of constraints to determine the final operation for each project.

The HYDSIM studies performed for the CRSO EIS simulated hydropower system operation to estimate the hydropower generation produced while meeting the objectives of each of the alternatives. The results provide 80 years of generation averages with each year comprised of 14 periods of generation averages.

3.2 RESSIM

The Reservoir System Simulation (HEC-ResSim) software developed by the U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center is used to model reservoir operations at one or more reservoirs for a variety of operational goals and constraints. The ResSim model for the Columbia River System is used several times in the CRSO EIS modeling sequence. First, the Flood 0 (F0) sequence is used to compute URCs that meet requirements of the operating constraints and FRM. The URCs are then passed to HYDSIM, which operates the reservoirs given these and other inputs. The outputs from this HYDSIM process then go back to the Corps for subsequent modeling, with the final ResSim output coming from the Flood1 model, which produces daily regulation results reflecting the multiple-purpose operation of the system. Detailed information on the ResSim model for the Columbia River System, including a description of model inputs and how HEC-ResSim interfaces with the Watershed Analysis Tool (HEC-WAT), is contained in the several sections of the *H&H Appendix B* (Part 3 – HEC-ResSim/WAT Documentation; Parts 4 and 5 – Hydrologic Data Development and Extended Observed Flows). Output from the HEC-ResSim model is presented in the *H&H Appendix B* (Part 1 – H&H Data Analysis) as well as in the H&H Environmental Consequences section in Chapter 3 of the main CRSO EIS report

3.3 AURORA

AURORA is a production cost model, developed by Energy Exemplar, Ltd Pty., used by hundreds of utilities globally to forecast short- and long-term electricity prices. Given model inputs (resource build, load forecast, fuel cost, etc.), AURORA produces a price forecast by calculating the least cost solution of meeting system-wide load on an hourly basis, subject to a number of operating constraints. The cost of producing and delivering an additional unit of energy to a location in the system is assumed to approximate the price at that location.

Bonneville uses AURORA to create price distributions by using Monte Carlo sampling of projected loads, hydro generation, gas prices, transmission capacity, wind generation, and Columbia Generating Station (CGS) capability. Given 80 years of month-average hydropower energy estimates provided by HYDSIM for each of the CRSO EIS modeling studies, AURORA estimates month-average prices and month-average Lack of Market (LOM) spill MW quantities. LOM spill occurs in AURORA when available hydro generation exceeds transmission capabilities and system load net of lower cost or must-run generation. The AURORA LOM spill estimates are then included as LOM limits in a second pass of HYDSIM.

Energy revenue estimates are developed by applying AURORA prices to the energy differences between each alternative and the reference NAA case.

3.4 GENESYS

The GENeration Evaluation SYStem (GENESYS) is an economic dispatch model that uses Monte Carlo sampling to simulate short-term load uncertainty, and uncertainty in streamflows, wind, solar, and forced outages for thermal generation plants. The model performs a detailed constrained dispatch of the regulated hydropower projects in the watershed of the Columbia

River and a simple dispatch of Pacific Northwest regional thermal plants against an extra-regional import market.

The model was developed by Northwest Power and Conservation Council (NWPCC), Bonneville, and other regional entities, and is used to perform studies requiring detailed hydropower dispatch for planning purposes. More specifically, NWPCC uses GENESYS for annual adequacy assessments, periodic regulated hydropower flow studies and periodic analysis of lost revenue due to hydropower dispatch change. The adequacy of the regional power supply is assessed probabilistically in GENESYS by evaluating any regional shortfall against NWPCC's adequacy standard. This standard was designed to assess whether the region has sufficient resources to meet growing demand for electricity in future years. Regulated hydropower flow studies have been performed for fish passage survival and life-cycle studies, and climate change scenarios.

For the CRSO EIS alternatives, the GENESYS model was run by Bonneville staff. Datasets containing hydropower generation plant parameters and constraints (inputs similar to HYDSIM and ResSim), thermal generation plant parameters and constraints, and other generation sources and constraints (i.e., wind and solar power plants) were input into the model. Power demand loads and both long- and short-term generation commitments also were entered into the model.

3.5 HOSS

HOSS is a hydroregulation model that shapes longer-period average flows and reservoir ending elevations into hourly time steps based on load shape. It is designed to simulate the decision making process of a Bonneville duty scheduler[10]. It uses time-step starting and ending conditions from HYDSIM along with other user entered constraints to simulate hourly operations of the 14 CRS projects (i.e., Libby, Hungry Horse, Albeni Falls, Dworshak, Grand Coulee, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville dams). Libby, Hungry Horse, Albeni Falls, and Dworshak flows are modelled flat every hour of every day with no shaping. At the remaining 10 projects, the model targets HYDSIM month end elevation targets while shaping flows to follow load shape; as a result, generation is shaped more into heavy load hours and less into light load hours.

Inputs consist of HYDSIM flow and elevation targets, residual power load, turbine outages, plant operational constraints (min/max elevation, flow, draft rates, etc.) and non-power constraints such as Banks Lake operations and fish spill operations.

Outputs for inventory purposes are average, HLH, light load hour (LLH), super-peak, and graveyard hydropower generation and inventory. Other output reports include generation by project, plus monthly (28 day), weekly, daily, and hourly operation of the hydropower system by water year.

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[10] Bonneville duty schedulers coordinate the real-time hourly operation of Grand Coulee, Chief Joseph, and the eight Federal lower Snake and lower Columbia River dams.

CHAPTER 4 - HYDROPOWER MODEL INPUTS

This chapter provides a general overview of the inputs Bonneville used to model the system operation under the CRSO EIS alternatives. These inputs also are common to those used by the Corps to model the CRSO EIS alternatives.

The hydrologic datasets contain the Columbia River streamflows and runoff volume forecasts common to all of the alternatives. The project descriptors and operational parameters provide the physical and operational parameters that produce the sideboards or limits on operational flexibility. The climate change streamflows and forecasts are modifications to the hydrologic datasets that reflect potential streamflow changes from potential climate change.

4.1 HYDROLOGIC DATASETS

Hydrologic datasets used in modeling are a time series of data points, where each node or location in a watershed has an inflow value for each time-step (e.g., each day has a daily average inflow value). The base hydrologic dataset for this study is the 80-year Modified Flow dataset.

4.1.1 80-year Modified Flow Dataset

The base source of water inflow time series into reservoirs and stream reaches, used in both HYDSIM and ResSim modeling, is the 80-year Modified Flow dataset (Bonneville 2011). This dataset is computed for the Columbia River hydroelectric system and associated tributaries, and used by the numerous internal and external groups for a variety of studies. Bonneville, Reclamation and the Corps perform hydroregulation studies of the Columbia River basin for analysis of environmental impacts, changes to operation criteria from BiOps, power revenue forecasts, FRM studies, operations planning, downstream benefit calculations, and effects of new projects or plant data. A wide range of other regional organizations, including the NWPCC, Northwest Power Pool, Pacific Northwest Utilities Conference Committee, fishery agencies and organizations, universities, research organizations, contractors, and public interest groups also need a consistent and accepted regional streamflow dataset. Modified flows are defined as the historical streamflows that would have been observed if current irrigation depletions existed in the past and the effects of reservoir regulation were removed (except at the upper Snake, Deschutes, and Yakima basins where current upstream reservoir regulation practices are included). Because irrigation practices and evaporation rates have changed since the historical flows were observed, historical streamflows need to be adjusted to account for current levels of irrigation depletions and evaporative losses. The 2010 modified flow study includes 80 years of flows (1929 to 2008) adjusted to 2010 irrigation depletions and evaporation rates.

4.1.2 Synthetic Events

In addition to the 80-year record described above, a hydrologic dataset with 26 synthetic water years is applied in ResSim modeling. The 26 synthetic water years consist of 17 spring synthetics and 9 winter synthetics. This synthetic event hydrology dataset is described in the *H&H*

Appendix B (Part 4 – Hydrologic Data Development) and is not used in HYDSIM for hydroregulation study analysis for power purposes.

4.1.3 2008 to 2016 Flow for Water Quality Assessment

When modeling the CRS for water quality metrics, an inflow dataset for 2008 to 2016 was used instead of the 80-year Modified Flow dataset because prior to 1995, there is little water temperature or TDG data in the Corps Water Management System[11] database or the U.S. Geological Survey National Water Information System database. The Corps Water Management System provides consistent, basin-wide temperature and TDG data from 2005 to 2016. Unfortunately, the current period of record dataset available for input into the water quality models spans from 1929 to 2008, leaving only three years of overlap between good water quality datasets and flow/weather information. As a result, it was decided to model more recent water years where consistent water quality data exists, which also has a variety of flow and meteorological conditions.

These more recent Extended Observed Flows from 2008 to 2016 were generated by the Corps. The development of this dataset is described in the *H&H Appendix B* (Part 5 – Columbia River System Extended Observed Flows Water Years 2008-2016).

The following three files associated with Bonneville's HYDSIM runs using the 2008 to 2016 Extended Observed Flows were provided to the Corps to assist with their Spill Allocation Process. The Spill Allocation Process is detailed the *H&H Appendix B* (Part 2 – Spill Analysis).

- Hydro availability input specifies the percent of time the hydro generators were available to run at each project.
- LOM spill data resulting from the AURORA run indicates the estimated energy spilled due to a lack of secondary market.
- The specific spill operation at the eight lower Snake and lower Columbia River projects were provided to the Corps.

4.2 RUNOFF VOLUME FORECASTS

Runoff volume forecasts are required inputs for the regulation and simulation of reservoir operations for FRM and hydropower generation. Runoff volume forecasts are an important input as predictors of seasonal reservoir operations of the Columbia River Basin. The operation of certain projects use various periods of runoff volume forecasts. Because reservoirs require months to draft space, they must use runoff volume forecasts to plan ahead to achieve the FRM and BiOp operational goals. Operational guidance for flood storage and power generation can vary depending on water supply volume forecasts during the winter and spring seasons, when storage projects are operating to balance FRM, refill, power generation, and fish

[11]Corps Water Management System is accessible at: https://www.nwd.usace.army.mil/CRWM/Water-Control-Data/

objectives. Information on the development of runoff volume forecasts is provided in the *H&H Appendix B* (Part 4 – Hydrologic Data Development).

4.3 COLUMBIA RIVER SYSTEM AND PROJECT OPERATING PARAMETERS

This section provides a generic description of the types of controls/operations that reservoirs (collectively or individually) can affect with summary (also in tabular format) of the parameters by reservoir and alternative. This section includes the physical and practical operational constraints at the modeled projects.

The 14 CRS projects are operated and modeled to meet several system and project-specific objectives. Flow-related system objectives are managed through the coordinated storage and release of water at Federal storage reservoirs, non-Federal storage reservoirs, and Canadian reservoirs. Generally, project objectives are managed through at-site outflows and upper and lower forebay elevation limits to the reservoirs. CRSO EIS alternative modeling involves meeting alternative objectives to the extent possible while meeting system and project operating parameters.

4.3.1 System Operations

4.3.1.1 System Flood Risk Management

The CRS is authorized to provide FRM in the Columbia Basin. System water managers operate the storage dams and reservoirs in a coordinated manner to balance inflow and outflow with the general objective of minimizing flood consequences throughout the Columbia River Basin. The FRM parameters used by Bonneville for its modeling are the upper rule curves developed and used by the Corps to model the CRSO EIS alternatives. Details for on operations for FRM are provided in the *H&H Appendix B* (Part 3 – HEC-ResSim/WAT Documentation) and in the *Flood Risk Management Appendix K*.

4.3.1.2 Conservation of Fish and Wildlife

The 2008 NOAA Fisheries BiOp, supplemented in 2010 and 2014, and the 2000 USFWS BiOp, supplemented in 2006, provide strategies to prioritize operations with FRM, power, and other objectives. The CRS projects are operated and modeled to the following priorities (in order) for flow management and individual reservoir operations after ensuring adequate FRM is provided:

- Operate storage projects to meet minimum flow and ramp rate criteria for resident fish
- Refill storage projects and provide summer flow augmentation
- Operate Grand Coulee and Hungry Horse to their April 10 elevation objectives to provide spring flow augmentation
- Operate Grand Coulee to balance the needs of chum flow augmentation and spring flow augmentation from the start of chum spawning in November through the end of chum emergence (approximately April)

Flow objectives are provided and prioritized in the 2008, 2010, and 2014 NOAA Fisheries BiOps. The Corps, Reclamation and Bonneville make every effort to follow flow priorities while implementing and modeling operations as they occur chronologically during the year. Objectives include:

- Storage reservoir draft limits in late summer are a higher priority than the summer flow objectives to meet other project uses and provide carry-over storage for the following year.
- Operate the storage reservoirs to achieve the April 10 elevation objectives with a high probability. These levels will vary with the runoff forecast. The April 10 objectives are linear interpolations between the March 31 and April 15 forecasted FRM elevations.
- Refill the storage reservoirs by about June 30 while minimizing spill (except as needed to maintain FRM) to maximize available storage of water for the benefit of summer migrating fish.
- Manage the available storage to augment summer (July and August) flows in the lower Columbia River and lower Snake River in an attempt to meet flow objectives and minimize increases in water temperature.

More detail on the objectives is in the CRSO EIS *Fish, Aquatic Macroinvertebrates, and Aquatic Habitat, Appendix E*.

OPERATIONS FOR WATER QUALITY

Throughout the CRS, elevated levels of TDG are observed where spill occurs at CRS projects. Bonneville modeling helps estimate spill location, amount, and timing due to lack of power markets during periods of relatively high streamflows and for lack-of-turbine when river flows exceed the turbine capacity plus any planned spill for fish passage.

Bonneville modeling reflects the objectives of a TDG management plan included in the annual water management plan. This TDG management plan describes fish passage spill and LOM and lack-of-turbine spill, use of the spill priority list, the process for setting spill caps, TDG management policies, and the TDG monitoring program.

4.3.1.3 Power Generation

One of the authorized purposes of all the 14 CRS projects reviewed in this EIS is electricity generation. Bonneville modeled the CRSO EIS alternatives to identify potential power effects. Bonneville modeling considers several aspects of the CRS projects' hydropower capabilities and parameters in this subsection.

Bonneville is the Federal power-marketing administration within the Department of Energy that markets and transmits power generated at 31 FCRPS dams including the 14 CRS projects listed in Table 4-1. Nameplate capacity is the maximum rated output of the generators and commonly expressed in megawatts (MW). The availability of water and other constraints determine how much power is generated at these projects, up to this capacity limit.

Table 4-1. Total Nameplate Capacity (MW) for the 14 CRS Projects

Project Name	Type	Location	Total Nameplate Capacity (MW)
Lower Granite	Run-of-River	Lower Snake River	810
Little Goose			810
Lower Monumental			810
Ice Harbor			603
McNary		Lower Columbia River	980
John Day[2]			2,480
The Dalles			2,080
Bonneville			1,200
Grand Coulee	Storage	Middle Columbia River	7,015[1]
Chief Joseph	Run-of-River	Middle Columbia River	2,000
Hungry Horse	Storage	South Fork Flathead River	428
Libby		Kootenai River	525
Dworshak		North Fork Clearwater	400
Albeni Falls		Pend Oreille River	42
Total			**20,183**

[1]Capacity includes pump generation.
[2] John Day has 0.5 Maf of storage. It operates like a run-of-river project except during periods of high streamflows when its storage may be used to reduce flows below Bonneville Dam.

For each CRSO EIS alternative, Bonneville modeled the amount of electricity generated at the 31 FCRPS projects as a result of the objectives of each alternative.

Energy supply (including generation, imports, and exports) must equal load (demand for electricity) at all times. When needed, Bonneville participates in the wholesale electricity market to buy and sell electricity to ensure electricity demand and supply on the Federal system remains balanced. Bonneville modeling also simulates the interactions between CRS power production and the wholesale electricity markets.

OPERATING RESERVES

Bonneville modeling also captures operating reserve requirements. Bonneville, as the North American Electric Reliability Corporation registered balancing authority, is responsible for maintaining the balance between generation and load.

Bonneville manages and provides generation operating reserves based on a required reserve obligation using dispatchable energy generation[12] to ensure generation within the Balancing Authority Area matches load at all times. The most common dispatchable power plants for

[12] Dispatchable energy generation refers to sources of electricity that can be dispatched (generation is increased or decreased) at the request of power grid operators or the plant owner to meet fluctuations in demand or supply. Often, baseload power plants such as nuclear or coal cannot be turned on and off in less than several hours. The time it takes a dispatchable generation plant to be turned on or off may vary in seconds, minutes, or hours. Wind and solar power are also not considered dispatchable because they cannot increase generation whenever it would be beneficial for grid operations.

reserve obligations in the Northwest are hydropower[13] and natural gas; therefore, Bonneville sets aside a certain portion of hydropower generation capability to meet its reserves obligation for unexpected increases or decreases in generation or load in the Bonneville Balancing Authority Area.

TRANSMISSION

As a registered North American Electric Reliability Corporation - transmission operator, Bonneville also is responsible for maintaining the safety and reliability of the transmission grid. Certain transmission system needs can affect water management functions at the projects. For example, Bonneville's management of its transmission system in response to a transmission line outage can influence the location and amount of power generation required to maintain system reliability.

MINIMUM GENERATION

Both Snake River and Columbia River projects have minimum generation requirements to support power system reliability, and operate efficiently (which may reduce fish turbine passage mortality by reducing adverse conditions for the fish within the scroll cages). These parameters are incorporated into Bonneville modeling. The Corps has identified minimum generation powerhouse outflow values derived from actual generation records when turbines were operating within ±1 percent of best efficiency. There may be instances where turbine generator units are operated outside of the best efficiency point ±1 percent to generate with the water instead of spilling.

Each of the lower Snake River powerhouses may be required to keep one generating unit online at all times for power system reliability under low river flow conditions resulting in a reduction of spill at that project. Low flow operations at lower Snake and Columbia River projects are triggered when inflow is insufficient to meet both minimum generation requirements and planned Fish Operations Plan spill levels.

4.3.1.4 Irrigation and Water Supply

The total acreage in the United States portion of the Columbia River Basin that is irrigated by Reclamation projects (including Hungry Horse, Columbia Basin Project[14], Chief Joseph, Yakima, Umatilla, The Dalles, Deschutes, and Crooked River) is about 1.4 million acres. Bonneville models the irrigation diversions for the Columbia Basin Project using specific monthly pumping

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[13] Hydropower is dispatchable as long as there is flexibility to increase or decrease generation, which sometimes means having the ability to increase or decrease flows coming from an upstream reservoir. For example, there is less capacity to hold reserves at the Lower Snake River dams when the forebays are maintained within a narrow operating range at MOP. This operating range restriction constrains reservoir storage capability and therefore limits the ability to hold many reserves. EIS Section 3.7.3.5, *Value of Lower Snake River Dam Ramping Capability*, shows historical ramping capability.

[14] The Columbia Basin Project serves east central Washington. The main facilities of the project include Grand Coulee Dam, John W. Keyes III pump/generator plant, Lake Roosevelt, and Banks Lake. From www.usbr.gov/pn/grandcoulee/cbp/ .

volumes from Lake Roosevelt through the John W. Keyes III pump/generating plant. The remaining irrigation diversions, depletions, and return flows are incorporated into the streamflow record used for modeling the CRSO EIS alternatives.

4.3.1.5 Navigation

The Corps maintains a shallow draft navigation channel on the lower Snake and Columbia Rivers to provide commercial barge transport. This depth is generally met in reservoirs and by meeting the minimum flow objectives below Bonneville Dam. It is not a high priority objective in Bonneville modeling; however, it is important enough to draft Lake Roosevelt to support these navigation flows.

4.3.1.6 Recreation

The Corps and Reclamation operate projects to support recreation in various ways including the provision of certain outflows or lake levels during prime recreation seasons. Specific objectives are described in each individual project section.

4.3.2 Reservoir Operating Parameters

Operating and modeling the CRS projects for system objectives considers several on-site operating parameters at each project. Parameters generally include the physical and practical operational constraints that produce the sideboards or limits on operational flexibility. These parameters are generally met in modeling unless an alternative includes measures specifically intended to operate contrary to the parameters.

More detailed information for these parameters can be found in the modelling data sheets in Exhibit 4. Bonneville modelers prepare the data sheets to document the measures included in each HYDSIM study. (Similarly, the Corps modelers' data sheets for ResSim modeling are provided in the *H&H Appendix B* (Part 3 – HEC-ResSim/WAT Documentation). Additional detail is also available in the individual water control manuals for each project. A summary level description of these parameters is provided by project in the following subsections.

4.3.2.1 Libby Project

GENERAL

Libby Dam and Lake Koocanusa are located on the Kootenai River in Northwest Montana and extends into Canada. It is a Corps storage project providing 5.0 Maf of space between its maximum forebay elevation of 2,459 feet NGVD29 and minimum forebay elevation of 2,287 feet NGVD29. It has an installed powerhouse of 5-units, 525-MW, with a maximum total discharge capacity of about 26 kcfs. Its authorized purposes are FRM, fish and wildlife conservation, power, and recreation.

FLOOD RISK MANAGEMENT

Libby Dam operations regulate spring flows in the Kootenai River to provide local FRM as measured at Bonners Ferry, Idaho, and system FRM in the mainstem Columbia River, as measured at The Dalles, Oregon. Currently, Libby Dam is operated consistently with VarQ FRM procedures that influence fall/winter drawdown and spring refill. VarQ procedures also are intended to improve the multiple purpose operation of Libby and Hungry Horse Dams while maintaining the level of local and mainstem FRM in the Columbia River Conservation of Fish and Wildlife

Libby Dam minimum discharges and ramp rates (hourly and daily maximum outflow changes) are intended to benefit downstream resident fish and wildlife by limiting fluctuations in river flow. A tiered volume of water is released from Libby Dam for white sturgeon measures based on the May water supply volume forecasts. The volume in mid- to late May and early June supplements the amount of minimum flow provided for bull trout.

From July through September, Libby discharge is managed to augment flows for the out-migration of juvenile salmon in the Columbia River and resident fish in the Kootenai River. The reservoir is drafted to an elevation of 2,449 feet NGVD29 (10 feet from full) by the end of September, except in the driest 20 percent of years based on The Dalles' May WSF, when the draft will increase to target an elevation of 2,439 feet NGVD29 (20 feet from full).

POWER GENERATION

Five generating units at the Libby project discharge into the Kootenai River. The units have an estimated discharge capacity estimate of up to 5,200 cubic feet per second (cfs) each.

Hourly and daily load shaping may occur primarily from October through February for optimized power production while providing protection for resident fish and maintaining FRM. During October through February, daily load shaping above the minimum 6,000 cfs flow and within the ramping rate constraints provides protection for aquatic biota inhabiting the mainstem river channel.

Transmission limitations in the Flathead Valley can, under certain conditions, require Libby Dam to reduce generation. Bonneville implemented transmission system protection measures to minimize generation modifications at Libby Dam and maintain power system reliability within required standards.

OTHER

Libby Dam also provides temperature control of its powerhouse outflows and Lake Koocanusa has boat ramps, docks, and shoreline recreation sites. These all are important factors to consider in real-time operations, but do not affect Bonneville modeling of Libby operations. Libby Dam does not operate for irrigation, water supply, or navigation purposes.

4.3.2.2 Hungry Horse Project

GENERAL

Hungry Horse Dam and reservoir are located on the South Fork of the Flathead River in Northwest Montana. It is a Reclamation storage project providing about 3 Maf of space between its maximum forebay elevation of 3,560 feet NGVD29 and minimum forebay elevation of 3,336 feet NGVD29. It has a 4-unit, 285-MW powerhouse with a maximum total discharge capacity of about 12 kcfs. Its authorized purposes are FRM, fish and wildlife conservation, power, irrigation, and recreation. The Corps developed a water control manual for Hungry Horse Dam that Reclamation uses as guidance for dam operations to meet FRM needs.

FLOOD RISK MANAGEMENT

Hungry Horse Dam regulates spring flows in the Flathead River to provide local FRM as measured at Columbia Falls, Montana, and system FRM in the mainstem Columbia River, as measured at The Dalles, Oregon. VarQ procedures influence fall/winter drawdown and spring refill and are intended to improve fish and wildlife conditions in the Flathead River.

Reclamation coordinates FRM operations of Hungry Horse with Energy Keepers, Inc., the operators of SKQ Dam on Flathead Lake downstream from Hungry Horse.

CONSERVATION OF FISH AND WILDLIFE

Releases from Hungry Horse Dam are maintained to help benefit resident fish and habitat in the Flathead River. Minimum discharges and ramp rates (hourly and daily maximum outflow changes) are intended to benefit downstream resident fish by limiting fluctuations in river flow and maintaining minimum flows downstream at Columbia Falls, Montana. Hungry Horse Dam provides spring flow augmentation by managing the reservoir to achieve an April 10 objective elevation and follow the VarQ operating procedure. In the summer and early fall, Reclamation drafts Hungry Horse as low as elevation 3,550 feet NGVD29 by the end of September in the wettest 80 percent and 3,540 feet NGVD29 in the driest 20 percent of water years based on The Dalles' May WSF.

POWER GENERATION

Four generating units at Hungry Horse project discharge into the South Fork Flathead River. Each unit has an estimated discharge capacity up to 3,000 cfs. Variations to maximize the value of power generated at the Hungry Horse project are limited to the water available for release, minimum flows, and hourly and daily discharge ramping rates.

Transmission limitations in the Flathead Valley can, under certain conditions, require Hungry Horse Dam to reduce generation. Bonneville implemented transmission system protection measures to minimize generation modifications at Libby and Hungry Horse Dams and maintain power system reliability within required standards.

OTHER

Hungry Horse Dam also provides temperature control of its powerhouse outflows and is operated to avoid spill. The reservoir has boat ramps and shoreline recreation sites. Hungry Horse Dam is authorized for irrigation, but there are currently no water contracts. These are important factors to consider in real-time operations, but do not affect Bonneville modeling of Hungry Horse operations. It does not operate for navigation purposes.

4.3.2.3 Albeni Falls Dam

GENERAL

Albeni Falls project is a Corps project that regulates the level of Lake Pend Oreille providing a useable storage of approximately 1 Maf within the normal operating range from 2,051 to 2,062.5 feet NGVD29, as measured at the gauge located at Hope, Idaho. It has a three unit powerhouse that can generate about 42.6 MW.

FLOOD RISK MANAGEMENT

Albeni Falls project usually begins its fall drawdown of Lake Pend Oreille on September 18 or the third Sunday of September, whichever is later, and drafts to an elevation no lower than 2,060 feet NGVD29 by September 30, followed by further drafts to within half of a foot of 2,051 feet NGVD29 by November 15. Lake Pend Oreille remains near 2,051 feet NGVD29 throughout the winter, subject to flexible winter power operations, and is used for winter FRM. Spring snowmelt runoff in the Pend Oreille Basin generally begins in early April and peaks in May or June. During this period, the lake is refilled and Albeni Falls project occasionally used for FRM.

CONSERVATION OF FISH AND WILDLIFE

Albeni Falls operations for fish and wildlife conservation primarily consist of managing the elevation of Lake Pend Oreille during the fall and winter to support kokanee survival, a critical food source of Endangered Species Act (ESA)-listed bull trout. During the summer, Albeni Falls maintains Lake Pend Oreille between elevation 2,062.0 and 2,062.5 feet NGVD29. The Lake is held above 2,062.0 feet NGVD29 through the third Sunday in September, or September 18, whichever is later.

Starting October 1, Albeni Falls begins drafting to a target elevation of 2,051.0 feet NGVD29 by mid-November, prior to when kokanee are expected to begin spawning. Flows released during the draft also support ESA-listed salmon in the Columbia River, particularly chum salmon downstream of Bonneville Dam.

POWER GENERATION

From the end of kokanee spawning or December 31 whichever is earlier, to the end of March, Albeni Falls may be operated to release or store water for downstream hydropower purposes. The range of fluctuation is between the minimum elevation established for kokanee spawning and elevation 2,056 feet NGVD29 from around December 15 to March 31.

RECREATION

Recreation at Lake Pend Oreille includes fishing, boating, swimming, and camping, and other activities. There are numerous marinas, boat ramps, campgrounds, and shoreline recreation sites around the lake, which depend on managed lake levels in the summer.

OTHER

Albeni Falls is not operated for irrigation or water supply, thus these concerns do not impact modeling.

4.3.2.4 Grand Coulee Dam and Lake Roosevelt

GENERAL

Grand Coulee Dam and Lake Roosevelt is a Reclamation storage project on the mid-Columbia River in central Washington. It provides approximately 5 Maf of useable storage within the normal operating range from 1,290 to 1,208 feet NGVD29. It has 24 generating units in 3 powerhouses. The John W. Keyes III pump/generating station is part of the project and has 6 pumps and 6 pump/generators. The 24 powerhouse generators and 6 pump/generators can produce a total of about 7,015 MW. Water from Lake Roosevelt is pumped into Banks Lake primarily for irrigation of the Columbia Basin project. In addition, when generation is needed for brief periods of unusually high demand, water can be returned to Lake Roosevelt through the pump/generators.

FLOOD RISK MANAGEMENT

From January through April, Lake Roosevelt drafts to prepare for spring runoff. The FRM space requirement is based on the water supply forecast for unregulated runoff at The Dalles, the upstream available storage, and Grand Coulee's FRM SRD. For more information, refer to the *H&H Appendix B* (Part 3 – HEC-ResSim/WAT documentation).

CONSERVATION OF FISH AND WILDLIFE

Outflow from Grand Coulee is provided to maintain a 36,000 cfs minimum discharge below Priest Rapids Dam. Higher flows are provided to meet instream fish flows, serve firm loads, or meet FRM requirements.

From January through April, Grand Coulee's operation maintains an 85 percent probability of reaching the April 10 elevation objective to provide more storage water for spring flow augmentation.

From April 10 through June 30 Grand Coulee is operated to help meet the 135 kcfs spring flow objective at Priest Rapids Dam. During dry years, the initial flow can be as low as 60 kcfs on a weekly basis; however, flow typically begins at 90 kcfs and ramps up incrementally based on water supply forecast and streamflow conditions.

To enhance recreation at Lake Roosevelt, Grand Coulee will typically be operated to fill no higher than elevation 1,287 feet NGVD29 on the Friday prior to July 4. In the week after July 4, operations at Grand Coulee target a refill elevation near 1,290 feet. An amount of refill is foregone to implement the Lake Roosevelt Incremental Storage Release Program to ensure this withdrawal for irrigation does not impact flow during the spring and early summer portion of the juvenile migration period.

After July 4, Grand Coulee is operated during the summer (July and August) to help meet flow objectives for juvenile salmon out-migration. Grand Coulee will draft to support salmon flow objectives during July and August with a variable draft limit of 1,278 to 1,280 feet NGVD29 by August 31 based on the water supply forecast. The amount of refill foregone to implement the Lake Roosevelt Incremental Storage Release Program also is included in the August 31 draft requirement to ensure flow objectives are not impacted by the irrigation withdrawal.

During November and December, Grand Coulee is operated to store or release water to target a tailwater elevation of 11.5 feet at Bonneville Dam for chum salmon spawning and to limit suitable chum spawning habitat in other locations. Release of storage from the Grand Coulee Project to reach an 11.5-foot tailwater elevation to support chum spawning downstream of Bonneville Project is limited to drafting to an elevation of 1,275 feet NGVD29 by the end of November and 1,270 feet NGVD29 by the end of December.

Also, in November and December, Grand Coulee is operated to provide flows to support fall chinook spawning in the Hanford Reach of the Columbia River below Priest Rapids Dam. Similar to the chum operation, a minimum flow is set during the spawning period and must be maintained to avoid dewatering redds.

Grand Coulee is generally operated to refill to elevations between 1,285 and 1,288 feet NGVD29 by the end of October to provide sufficient storage for chum spawning operation and winter power generation. To aid resident fish, Reclamation attempts to operate the Grand Coulee project and Lake Roosevelt to refill to elevation 1,283 feet NGVD29 by September 30. This fall target minimum elevation is met unless streamflow conditions require Grand Coulee to maintain minimum flows at Bonneville Dam instead of achieving the 1,283-foot NGVD29 elevation by September 30. In this instance, the elevation 1,283-foot NGVD29 elevation would be expected by early October instead.

POWER GENERATION

Power generation facilities at Grand Coulee Dam are among the largest in the world with a total generating capacity rated at 7,015 MW. In addition, Lake Roosevelt's large storage capacity provides the ability to capture and store water released from upstream dams. The combination of power production capacity and reservoir storage capacity provides Bonneville the ability to shape Lake Roosevelt outflows to meet real-time power demands with minimal effect on short-term reservoir levels.

IRRIGATION/WATER SUPPLY

The Columbia Basin project diverts up to 3.318 Maf of water from the Columbia River for irrigation most of which is pumped from Lake Roosevelt via the John W. Keyes III pump/generating station. When Lake Roosevelt is below elevation 1,240 feet NGVD29, only six pumps are available to deliver water. If the full demand cannot be met through the pumps then irrigation water is delivered by drafting Banks Lake, then refilling when Lake Roosevelt elevation raises above elevation 1,240 feet NGVD29.

NAVIGATION

Grand Coulee is authorized but not operated for downstream navigation purposes, but two ferries operate on Lake Roosevelt. When reservoir elevations drop below 1,240 feet NGVD29, the Keller Ferry must be moved to a location a short distance upstream on the Sanpoil River. The Inchelium-Gifford Ferry is modeled to be out of service when Lake Roosevelt drafts below elevation 1,229 feet NGVD29. In very low flow years some draft may be provided from Lake Roosevelt to maintain the 70 kcfs flow from Bonneville Dam.

RECREATION

Lake Roosevelt is a National Recreation Area and is operated to expose beaches for recreation; other recreational activities include camping, swimming, motor boating, fishing, and picnicking.

OTHER

The drum gates at Grand Coulee require periodic maintenance for safety and operational integrity. In modeling the 80-year Modified Flow dataset, drum gate operations are applied during February, March, and April if certain criteria are met. Overall, these criteria are based on the February forecast of the April 30 URC, annual frequency requirements, and finally, forced drum gate maintenance years.

There are other important factors such as spill operations that are considered in real-time operation, but do not affect the Bonneville modeling of Grand Coulee operations.

4.3.2.5 Chief Joseph Project

GENERAL

Chief Joseph Dam is a run-of-river Corps project located on the Columbia River downstream of Grand Coulee Dam. Its normal operating range is 950 to 956 feet NGVD29. Its 27-unit powerhouse can produce 2,000 MW.

POWER GENERATION

The Chief Joseph project is a run-of-river dam and passes inflow within the available hydraulic capacity of the powerhouse. An average daily discharge of 35,000 cfs at Chief Joseph is required to meet the mandatory minimum flow of 36,000 cfs below Priest Rapids Dam.

OTHER

There are several important factors that are considered in real-time operation, but do not affect the Bonneville modeling for hydropower. They include TDG management, irrigation/water supply, and recreation.

4.3.2.6 Dworshak Dam and Reservoir

GENERAL

Dworshak Dam and Reservoir is a Corps storage project on the North Fork of the Clearwater River in northern Idaho. It provides useable storage of approximately 2 Maf within the normal operating range from 1,445 to 1,600 feet NGVD29. It has a 3-unit powerhouse that can generate up to 400 MW with two 90-MW units and a 220-MW unit.

FLOOD RISK MANAGEMENT

Dworshak operations for FRM are based on the SRDs for system requirements at The Dalles and local requirements on the Clearwater River at Spalding. URCs are developed for Dworshak based on the forecasted runoff for the April-July period, which establishes FRM draft requirements. The Dworshak system, forecasted runoff volume, and local SRDs help determine the amount of space required to meet system or local FRM objectives. Dworshak also has a unique SRD that accommodates shifting storage space for system FRM to Grand Coulee.

Refill target computations for Dworshak attempt to reduce system flows at The Dalles and provide a 95 percent confidence of refill.

CONSERVATION OF FISH AND WILDLIFE

During the spring snowmelt runoff (April – May or June) Dworshak is operated to maximize the probability of refilling the reservoir for summer flow augmentation while providing flows to meet spring objectives in the lower Snake River during the downstream migration of juvenile salmon and steelhead.

Summer flow augmentation (July – September) is provided from Dworshak to increase survival of ESA-listed adult fish by moderating river temperature and increasing water velocities in the lower Snake River. Dworshak is generally drafted to elevation 1,535 feet NGVD29 by the end of August and 1,520 feet NGVD29 by the end of September.

POWER GENERATION

FRM and fish operations generally limit project flexibility for power generation. During modeling, project releases for FRM and fish flows generally are made through the generating units; however, certain fish flow augmentation and temperature control requirements do require spilling to implement.

OTHER

Dworshak is authorized for navigation for the movement of harvested timber in the reservoir, but the logging industry has abandoned water-based timber movement. Recreation at Dworshak reservoir includes swimming, fishing, boating, hiking, hunting, and camping. There are several marinas, boat ramps, campgrounds, picnic areas, and shoreline recreation sites around the lake; most are designed for water access only. There is no authorization for irrigation/water supply at Dworshak.

4.3.2.7 Lower Snake River Projects

GENERAL

Lower Granite, Little Goose, Lower Monumental, and Ice Harbor are run-of-river Corps projects on the lower Snake River. Their normal operating range is 3 to 5 feet between minimum and maximum forebay levels. All have 6-unit powerhouses. Lower Granite, Little Goose, and Lower Monumental can each produce 810 MW; Ice Harbor can produce 603 MW. All have a navigation lock for passage of commercial and non-commercial river traffic.

LOWER GRANITE FLOOD RISK MANAGEMENT

All four dams do not have authorized flood storage space. However, during periods of high inflow, the operation of Lower Granite is restricted to a reduced maximum forebay elevation to maintain adequate freeboard at the levees near Lewiston, Idaho.

CONSERVATION OF FISH AND WILDLIFE

Turbines at all projects on the lower Snake and lower Columbia Rivers target an operation within ±1 percent of peak turbine efficiency during the juvenile and adult migration seasons, April 1 through October 31. This helps reduce fish injuries and cavitation damage to turbines.

All four lower Snake River projects operate to minimize water travel time for the benefit of juvenile fish migration by operating the forebays in the MOP 1-foot range from April 3 until approximately September 1, though elevations may be adjusted to meet other authorized project purposes (e.g., navigation).

Spring and summer spill for juvenile fish passage is implemented at all four lower Snake River projects from April 3 through August 31, pursuant to the 2016 Fish Operations Plan or other objectives specified by the CRSO EIS alternatives.

The spring flow objective to benefit ESA fish is measured as a target season average outflow at Lower Granite Dam from April 3 through June 20. The target is determined by the final April forecast for Lower Granite project runoff volume over the April through July period. When the forecast is less than 16 Maf, the flow objective is 85 kcfs. If the forecast is between 16 and 20 Maf, the flow objective is linearly interpolated between 85 and 100 kcfs. If the forecast is greater than 20 Maf, the flow objective is 100 kcfs. Spring lower Snake River flows are supplemented by drafting at Dworshak Dam and by flow augmentation water from other projects in the Upper Snake River. The spring flow objective is not always met throughout the entire migration season because there is limited stored water available for flow augmentation.

The summer flow objective to benefit ESA fish is measured as a target season average outflow at Lower Granite Dam from June 21 through August 31. The target is determined by the final June forecast for Lower Granite project runoff volume over the April through July period. When the forecast is less than 16 Maf, the flow objective is 50 kcfs. If the forecast is between 16 and 28 Maf, the flow objective is linearly interpolated between 50 and 55 kcfs. If the forecast is greater than 28 Maf, the flow objective is 55 kcfs. The summer Snake River flows are augmented by the release of water stored upstream of the Lower Granite project. The summer flow objective is not always met throughout the entire migration season because there is limited stored water available for flow augmentation.

POWER GENERATION

All four projects are run-of-river dams and pass inflow within the available hydraulic capacity of their powerhouses. The hourly ramp rate is a maximum tailwater rate of change of 1.5 foot per hour or 70 kcfs per hour at Lower Granite, Little Goose, and Lower Monumental; and 20 kcfs per hour at Ice Harbor. At least one generator must be operated at each dam for most of the year to maintain power system reliability.

OTHER

There are several important factors at these dams that are considered in real-time operation, but do not affect the Bonneville modeling for hydropower. They include the juvenile fish transport program, irrigation/water supply withdrawals around the reservoirs, navigation, recreation, and waterfowl hunting.

4.3.2.8 Lower Columbia River Projects

GENERAL

McNary, John Day, The Dalles, and Bonneville Dams are all run-of-river Corps projects on the lower Columbia River with powerhouses: McNary has 14 generators with a capacity of 980 MW; John Day has 16 generators with a capacity of 2,480 MW; The Dalles has 22 generators with a capacity of 2,080 MW; and Bonneville has 18 generators with a capacity of 1,200 MW. All have a navigation locks for passage of commercial and non-commercial river traffic.

FLOOD RISK MANAGEMENT

Only John Day is operated for FRM. The John Day project is routinely operated as run-of-river, but has approximately 0.5 Maf of flood storage available for system FRM of the lower Columbia River. The reservoir storage is primarily designed for use during winter and spring rain events to help reduce flooding at the Portland Harbor (and the lower Columbia River in general), but can also be used for similar purposes during peak spring freshet flows.

CONSERVATION OF FISH AND WILDLIFE

Turbines at all projects on the lower Snake and lower Columbia Rivers target an operation within ±1 percent of peak turbine efficiency during the juvenile and adult migration seasons, April 1 through October 31. This helps reduce fish injuries and cavitation damage to turbines.

Spring and summer spill operations for juvenile fish passage are implemented at lower Columbia River projects from April through August, pursuant to the 2016 Fish Operations Plan.

The lower Columbia River spring flow objective is measured as the season average outflow at McNary Dam from April 10 through June 30. The objective is determined by the final April forecast for The Dalles project runoff volume over the April through August period. The flow objective is not always met throughout the migration season because there is variability in volume and shape of the natural runoff.

The lower Columbia River summer flow objective is measured as the season average outflow at McNary Dam from July 1 through August 31. The summer flow objective is 200 kcfs. Lower Columbia River summer flow is augmented by the release of water from upstream storage projects. The flow objective is not always met because there is a limited amount of stored water for flow augmentation and the natural shape of the runoff generally produces decreasing streamflows from July through August.

POWER GENERATION

All four lower Columbia River dams normally operate as run-of-river dams and pass inflow within the available hydraulic capacity of the powerhouses. All have maximum hourly rates of outflow change that vary from 1.5 to 3.0 feet per hour change in tailwater elevation. During periods of high runoff, water may be spilled due to lack of load and carrying reserves for power system reliability. Generation from a minimum outflow of 50 kcfs must be maintained at all times at McNary, John Day, and The Dalles for transmission system voltage stability.

IRRIGATION/WATER SUPPLY

All four dams provide minimum lake elevations from which pump stations can withdraw water for irrigation and water supply. From April 10 through September 30, the John Day project is operated to minimize water travel time for downstream-migrating juvenile salmon using the forebay within the minimum irrigation pool (MIP) range of 262.5 to 264.0 feet (the lowest pool elevation that allows irrigation withdrawals).

OTHER

There are several important factors at all four projects that are considered in real-time operation, but do not affect modeling for hydropower. They include navigation, recreation, docking for offloading of U.S. Navy nuclear disposal packages, waterfowl hunting, Tri-City Water Follies hydroplane races, Umatilla Landing Days, tribal treaty fishing, and others.

4.4 POWER SYSTEMS LOADS

When conducting hydropower studies such as those for the CRSO EIS, the generation resulting from an alternative is often compared to a load forecast. These comparisons inform analysts of several factors including the need for additional resources, availability of surpluses, and reliability.

Energy comparisons in the CRSO EIS are made by contrasting HYDSIM output to a regional residual hydropower load (i.e., that portion of regional load intended to be served by HYDSIM generation). Regional residual hydropower load is calculated by subtracting forecasted generation of non-modeled resources from the regional load. Non-modeled resources are comprised of non-hydropower resources (nuclear, fossil-fuel, bio-fuel, wood-waste), renewable resource generation (wind, solar, and geothermal), and other hydropower independent resource generation (independent and small hydro).

Hourly or peak load comparisons for the CRSO EIS are made using HOSS output only for the Federal system. Bonneville prepares a Federal residual hydropower load by adjusting the Federal load forecast for contracts and resources not modeled in HOSS.

Reliability comparisons are made for the CRSO EIS using GENESYS model outputs. Hourly regional (Pacific Northwest) load forecasts[15] for historical weather from 1929 to 2006 were produced by the NWPCC and are adjusted for non-hydropower resource production.

15 Details for load descriptions are provided in NWPCC's Pacific Northwest Power Supply Adequacy Assessment for 2022.

CHAPTER 5 - HYDROREGULATION MODELING STEPS FOR NO-ACTION ALTERNATIVE

5.1 STUDY ASSUMPTIONS AND DESIGN

CRSO modeling is performed through the execution of a specific sequence of steps, as shown on a high level in Figure 5-1. Model inputs for a specific study are developed to implement one or more objectives. The inputs are then run in a model, and output results are analyzed to assess if the objectives were met, and impacts to generation, reservoir levels, flows, and other metrics. Outputs from one model sequence, or step, may be subsequently used as an input into another model or processor to develop finer detail. For example, end of month elevations, flows and proportional draft points from HYDSIM are used as inputs to ResSim, which develops daily time-step end of day elevations and average flows. HYDSIM outputs also are used in HOSS to determine HLH, LLH, 120-Hour (SuperPeak), and other generation metrics.

Inputs for the NAA study are based on the operation and structures in place when the Notice of Intent for the CRSO EIS was published in the Federal Register in September 2016, and those data are applied to current operations and expected future operations and requirements.

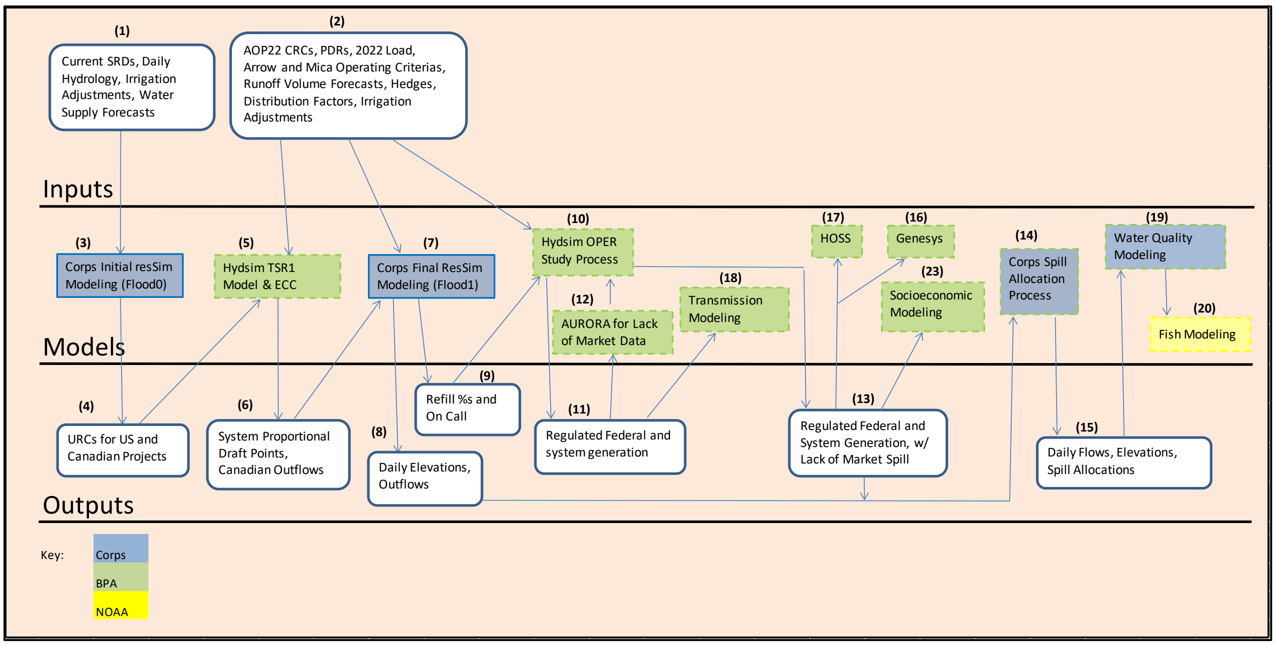

Figure 5-1. CRSO EIS Modeling Schematic

Figure 5-1 shows the steps for a complete study sequence; however, each step may not be needed for alternative MO studies.

5.2 DETERMINISTIC HYDROREGULATION MODELING STEPS

5.2.1 Inputs to Models

Datasets read by the model software include a few different types of data. Paired data, time series data, and operating rule sets are three general categories of inputs. Some of the input data is relatively fixed, not changing over time (i.e., reservoir storage curves), while other datasets can vary depending on other input assumptions (i.e., generation load). For example, residual hydropower load will vary depending upon the assumptions of alternative generation sources, such as wind power and thermal.

Models use paired data to establish a relationship between parameters (i.e., reservoir storage and water surface elevation, or spill flow rates and TDG levels). Generally, paired data allows the model to compute one output metric and have a relationship to another metric available for reference.

Time series data includes datasets such as the Modified Flows Streamflow dataset for each reservoir or measurement point for each time-step. HYDSIM uses monthly average inflows between each dam (incremental flows), in addition to the upstream plant's release, to determine gross inflows into a reservoir.

The model uses the first two data types, time series and paired data, and the model's scheduling logic to operate the plant to stay within the operating rules. Operating rules are generally a time-specific requirement met by the reservoir or powerhouse (i.e., an end of month target elevation or a required spill flow during fish passage season). There may be situations where all operating rules cannot be met simultaneously (i.e., maintaining full reservoirs and keeping spill flows below a certain value). For these situations, operating rules are prioritized to meet the most preferred requirement and the least costly violation first. Thus, the model's logic and inputs could be set to meet the spill flows limitation at the expense of having to draw the reservoir down to contain high runoff events.

5.2.2 Sources of Input

Input data is developed from numerous processes. Reservoir elevation-storage curves are developed using topographic surveys, either before or after the dam is constructed. Once these datasets are developed, they can be adjusted to measure the sedimentation impacts or increase data accuracy from new studies using new measurement and survey technologies. The Modified Flows Streamflow dataset was developed during a multiple-year study process that examined historical observations and computations of current irrigation depletion rates. Because these inputs are used in CRSO modeling and other modeling, the datasets are developed, documented, and shared among the co-lead agencies and other parties for reuse and consistent application of the best available data.

Operating rules may originate from BiOp objectives, such as maximum TDG or temperature limits. Bonneville modelers are provided flow limits that equate to suitable TDG and temperature ranges, which are then entered into the model. Other inputs may be from other studies or steps in the same study sequence, such as the FRM F0 step that determines elevation upper limits required for flood risk management.

5.3 RESSIM F0 – STEP 3

The ResSim F0 model step represents the pre-2024 flood operations without on-call. Both the United States and Canadian reservoirs were operated to URCs that reflect firm energy load carrying capability. Input to the F0 model step included the streamflow dataset and URCs. Details of these system operations are presented in the *H&H Appendix B* (Part 3 – HEC-ResSim/WAT Documentation). The output included URCs that include both draft and refill. These URCs were input to the HYDSIM/Treaty Storage Regulation (TSR) modeling in Step 5.

5.4 HYDSIM TSR1 – STEP 5

An Assured Operating Plan (AOP) is developed annually to determine Canadian storage operation guidelines and other metrics. These plans are prepared annually for the sixth succeeding operating year. AOPs are designed to achieve an optimum power operation in both Canada and the United States. The AOP provides a guaranteed default operation that enables orderly planning of the power systems in Canada and the United States, which are dependent on and coordinated with the operation of treaty storage.

The optimum power operation is created by first determining the monthly residual hydro load shape for the coordinated hydropower system to meet peak load and energy. In this study, the load and resource forecasts for 2022, based on historical metered loads and consultations with Bonneville customers, were obtained from the 2017 White Book (Bonneville 2017). The White Book is a Pacific Northwest loads and resources study to obtain a snapshot of the Federal system and Pacific Northwest regional loads and resources for the upcoming 10-year period. Resource forecasts are determined from NWPCC and Pacific Northwest Utilities Conference Committee submittals, and adjustments are made to the resource forecasts for renewable resources for compliance with state renewable portfolio standards and known closures of coal power plants. The residual hydro load is the net result of Pacific Northwest area loads minus thermal resources, renewables, firm imports and exports, hydro-independent resources, and other non-hydro resources.

The AOP operating criteria consist primarily of a series of rule curves and requirements that guide reservoir operations for FRM and optimum power generation. Typically, Canadian Treaty reservoirs are guided by operating rule curves and requirements that ensure FRM, optimum power, and refill for the coordinated system in average and wetter-than-average water years. During low flow conditions, critical rule curves guide reservoir operations for firm power needs. Procedures for flow and storage content objectives at Mica, together with storage and flow limits at Mica and Arrow, help optimize Canadian power generation within the overall system operation.

TSR1 is a hydro-regulation study that implements the detailed operating plan operating criteria that determines operations for Canadian CRT projects.

The TSR used Energy Content Curves that were developed for the CRSO EIS forecast volumes. The TSR also used the current CRT Flood Control Operating Plan Canadian FRM curves and Libby and Hungry Horse FRM rule curves developed in forecast mode by the F0 ResSim model. During the low flow conditions, proportional draft is triggered when system generation is less than the firm energy load carrying capability determined by the critical period study, which is based on the worst water conditions with expected load and planned non-hydro resources. During proportional draft, the system drafts each reservoir proportionally between its respective critical rule curves. The end draft point for each reservoir resulting from proportional draft is called a proportional draft point. The proportional draft points of various projects are then fed into the ResSim F1 model.

5.5 RESSIM F1 – STEP 7

The ResSim F1 Model uses information from the previous steps to produce the Corps final daily modeling results. The output included daily elevations and outflow, on-call years, and refill statistics. Details of these system operations are presented in the *H&H Appendix B* (Part 3 – HEC-ResSim/WAT Documentation).

5.6 HYDSIM OPER – STEP 10

The HYDSIM OPER Step 10 was performed to further fine-tune Canadian and United States Federal project operations where possible, with the intent of more closely reflecting actual operations. For Federal projects: Libby provided uniform summer drafts, a pulse of water for white sturgeon in the spring, and year-round minimum flows including spring/summer bull trout flows; Hungry Horse provided uniform summer drafts, year-round minimum flows for bull trout and FRM while minimizing spill; Dworshak provided uniform summer drafts, minimum flow, and FRM targets while minimizing spill; Grand Coulee operated to support multiple operations all year that included chum November to April, Vernita Bar October to June, FRM drafts March to April, spring flows in the Mid-Columbia April to June, uniform summer drafts to satisfy BiOp operations, and the Columbia River Water Management Program and refill in September for November kokanee spawning. Output from a first iteration of Step 10 through Steps 11 and 12 determines the LOM spill. This LOM spill data is used in a second iteration through Step 10. LOM spill occurs almost every spring when streamflow and generation are high and require spill according to a spill priority list, similar to that used in actual operations.

5.7 AURORA – STEP 12

Aurora is software used by Bonneville to calculate the variable cost of the marginal resource in a competitively priced electric energy market. This power price curve shows that summer and fall have relatively high market prices. The December to February period has the highest prices, with the maximum average price typically occuring in December.

5.8 CORPS SPILL ALLOCATION PROCESS – STEP 14

Step 14 receives as input the daily elevations and outflows from ResSim and the LOM spill from AURORA, the Hydro availability file, and spill operation at each plant. This process allocates spill between CRS projects based on a priority that directs spill to projects with the least negative effect of increased spill. The resulting outflows and spill allocations are used as inputs to water quality modeling and fish habitat/requirements modeling. Note that because the Corps adds spill (including lack-of-turbine spill) after flows are calculated in ResSim, there is no feedback loop from these two spill steps to the flow calculation. This occasionally results in instances where flows are so high that there is lack-of-turbine spill on some days immediately before or immediately after days when the flow is below the maximum turbine flow. In actual operations, flows would be smoothed between the days to minimize lack-of-turbine spill and to optimize generation (absent other constraints). For more details on the methodology and results from this Spill Allocation Process, refer to the *H&H Appendix B* (Part 2 – Spill Analysis).

5.9 GENESYS MODELING – STEP 16

The GENESYS modeling step receives end-of-period elevations, flows, spill, and system load from the 14 periods per year HYDSIM output. GENESYS dispatches the generation in hourly periods subject to minimum and maximum limits to meet the GENESYS load, taking into account non-dispatchable resources such as wind and solar. This step involves multiple runs with randomly changing inputs (i.e., generation from wind, temperature, load demand, and rainfall). The studies measure the likelihood of meeting load demand, adequacy of regional generation, and costs of implementing various operating rules (i.e., fish spill requirements).

5.10 HOSS – STEP 17

The HOSS modeling step receives end of period elevations and flows from HYDSIM output. The HOSS model develops an hourly schedule of flows, generation, and elevations based on the monthly time-step HYDSIM output. Output includes various metrics (i.e., flexibility of the system [ability to shift generation from LLH to HLH] within a day, and total HLH/LLH hydro generation).

CHAPTER 6 - HYDROREGULATION MODELING FOR MULTIPLE-OBJECTIVE ALTERNATIVES

6.1 MULTIPLE-OBJECTIVE DESCRIPTION/DETAIL/SUMMARY

To visualize potential future states of the CRS, four MO alternatives were developed with different objectives. Objectives were developed and grouped into these MO alternatives to focus on various potential condition improvements (i.e., habitat or fish passage). To meet an objective, specific measures were developed that would cause or contribute to the objective being met. The quantification of the success of meeting the objectives, and the side effects or impacts to other operational metrics, were answered by modeling through the hydroregulation modeling process and other modeling processes.

Measures were divided into two categories: structural measures and operational measures. Structural measures are changes to dams, fishways, fish ladders, spillways, or other hard, physical attributes of a dam, powerhouse, or other structure. Operational measures are changes to operating rules or protocols implemented by system water managers. A crosswalk of these measures is provided in Exhibit 2.

Each measure, whether structural or operational, is described with a specific purpose, measure location, frequency and duration, and intended benefit. These detailed measures and descriptions are found in the CRSO EIS. Sections below provide general description of each MO. Overall, the steps of the hydro modeling process for each MO were identical to the modeling of the NAA, with the following exception: The NAA study determined the Canadian operation for the three Treaty Projects (Mica, Duncan, and Arrow); these operations were 'frozen' and fed into each MO study. Hence, the TSR step was performed for NAA, but not for each MO, and the operation of Mica, Arrow, and Duncan is identical between the NAA and each MO.

Each MO alternative evaluates the CRS's ability to meet all or part of the following objectives:

- Improve ESA-listed anadromous salmonid juvenile fish rearing, passage, and survival within the CRSO project area, through actions including but not limited to project configuration, flow management, spill operations, and water quality management.
- Improve ESA-listed anadromous salmonid adult fish migration within the CRSO project area, through actions including but not limited to project configuration, flow management, spill operations, and water quality management
- Improve ESA-listed resident fish survival and spawning success at CRSO projects through actions including but not limited to project configuration, flow management, improving connectivity, project operations, and water quality management.
- Provide an adequate, efficient, economical, and reliable power supply that supports the integrated CRS power system.
- Minimize greenhouse gas emissions from power production in the Pacific Northwest by generating carbon-free power through a combination of hydropower and integrations of other renewable energy sources.

- Maximize operating flexibility by implementing updated, adaptable water management strategies to be responsive to changing conditions, including hydrology, climate, and environment.
- Meet existing contractual water supply obligations and provide for authorized additional regional water supply.

Additionally, the following secondary objective was considered during development of the alternatives:

- Improve conditions for the lamprey within the CRSO project area through actions potentially including but not limited to project configurations, flow management, spill operations, and water quality management.

One of the objectives at Grand Coulee applicable to MO1, MO2, and MO4, is an updated SRD. Part of the intent of this updated SRD is the inclusion of additional reservoir volume used to protect against rain-induced flooding. This additional storage was omitted in the modeling of these MOs in the month of December, but was applied for other applicable months. At John Day, installation of high-efficiency/capacity turbines was unintentionally omitted from the H/K table (plant change input file) applicable to all four MO alternatives, and should have reflected a 4.5 percent increase in efficiency. The estimated average megawatt effect of these two omissions are presented in the *EIS Hydropower Appendix J*.

6.2 MULTIPLE-OBJECTIVE 1 ALTERNATIVE – MODELING

MO1 includes operational changes to Libby, Hungry Horse, Grand Coulee, Dworshak, and John Day Dams, notably modified operations at Libby and Grand Coulee Dams to maximize operating flexibility and improve overall systems operations including winter FRM; modified operations to meet existing contractual water supply obligations and provide for authorized additional regional water supply including increased or new diversions at Banks Lake, Flathead Lake, and below Chief Joseph Dam; and modified summer draft at Dworshak Dam to control temperatures for ESA-listed adult fish in the lower Snake River.

6.2.1 Hydroregulation Modeling Steps

The hydroregulation modeling process shown in Figure 5-1 was generally followed, with the exception that in Step 3 there was an alternative URC development process. This is because Alternative MO1 contains measures calling for different URCs than the NAA at certain CRSO projects. All URCs were then combined and the remaining overall modeling process was the same.

Changes to the HYDSIM model for MO1 included:

- The flows in powerhouse surface passage routes constructed at McNary and Ice Harbor projects are reflected by an 8 kcfs and 4 kcfs, respectively, increase in other spill at those projects, with the same start and end dates as other fish passage spill at the project.
- Upgrades to adjustable spillway weirs assumed included in the spill totals already present.

- Spring spill designed in a block pattern, with 6 weeks of performance standard plus spill patterns and 6 weeks of spill to gas cap spill in alternating order every year.
- Summer spill in performance standard plus, ending in August at the lower Snake River projects based on the historical average date when counts of passing sub-yearling chinook surpassed 300 for four consecutive days (2010-2017); lower Columbia projects end spill on August 31.
- Contingency reserves may be held within fish passage spill on the lower Snake River and lower Columbia River projects. This reduces the reserve obligation held by other projects in the system, resulting in a higher availability at those projects.
- Changes to FRM are incorporated via Corps-provided URCs and refill tables.
- Changes to the upstream storage correction method incorporated via an updated Grand Coulee URC shift algorithm.
- Updated availability of Grand Coulee generators reflects ongoing maintenance of power plants that is more accelerated than current schedule of outages.
- Water supply measures (increased water pumped from Lake Roosevelt, Chief Joseph diversions, and Flathead River) are incorporated via a negative adjustment to the flows into relevant projects.
- Changes for adult fish: modified timing of lower Snake basin reservoir draft (Section 4.3.2.7).
- Changes for Resident fish: Changes to summer draft at Libby and Hungry Horse (Sections 4.3.2.1 and 4.3.2.2).
- John Day change for Avian Predators (Section 4.3.2.8).

For more details, refer to the Modeling Data Sheets in Exhibit 4.

6.2.2 Differences between Alternative MO1 and No-Action Alternative Results

For details on differences between this MO and the NAA, refer to the *CRSO EIS Hydropower Appendix J* and the *H&H Appendix B*.

6.3 MULTIPLE-OBJECTIVE 2 ALTERNATIVE – MODELING

MO2 includes operational changes to Libby, Hungry Horse, Grand Coulee, Dworshak, and John Day Dams, notably modified operations at Libby and Grand Coulee Dams to maximize operating flexibility and improve overall systems operations including winter FRM; modified operations to meet existing contractual water supply obligations and provide for authorized additional regional water supply including increased or new diversions at Banks Lake, Flathead Lake, and below Chief Joseph Dam; and modified summer draft at Dworshak Dam to control temperatures for ESA-listed adult fish in the lower Snake River.

6.3.1 Hydroregulation Modeling Steps

The hydroregulation modeling process shown in Figure 5-1 was generally followed, with the exception that in Step 3 there was an alternative URC development process. This is because Alternative MO2 contains measures calling for different URCs than the NAA at certain CRSO projects. All URCs were then combined and the remainder of the modeling process was the same.

Changes to the HYDSIM model for MO2 included:

- Increased flows to account for powerhouse surface passage routes constructed at John Day, McNary, and Ice Harbor projects reflected by an increase of 8 kcfs, 8 kcfs and 4 kcfs, respectively, in other spill at those projects, with the same start and end dates as other fish passage spill.
- The powerhouse surface passage routes eliminate the need to install fish screens, resulting in an increase in turbine availability from the NAA for periods where fish screens would have been installed.
- Upgrades to adjustable spillway weirs assume spill of 11 kcfs per weir in spring and 7 kcfs per weir in summer. If spill at the projects needs to be increased over that called for by the NAA to accommodate the new adjustable spillway weirs, it was increased to cover the required spill. The end of spring spill is June 15 in the lower Columbia projects, and June 20 on the lower Snake River projects.
- Fish passage spill is limited to 110 percent TDG, but is marginally higher where additional spill is required for powerhouse surface passage routes, weirs, and/or adult ladder attraction. Spill starts April 3 at lower Snake River projects and April 10 at lower Columbia River projects; fish passage spill ends July 31.
- Flow and pool elevation restrictions are lifted as outlined in individual projects.
- Restrictions to operate turbines within 1 percent of peak efficiency are eliminated, resulting in increased availability during fish passage season.
- Contingency reserves were held within fish passage spill on the lower Snake River and lower Columbia River projects. This reduced the reserve obligation held by other projects in the system, resulting in a higher availability at those projects.
- Changes to FRM were incorporated via the Corps-provided URCs and refill tables.
- The variable end-of-December draft target at Libby was replaced with a single draft target.
- Changes to the upstream storage correction method were incorporated using an updated Grand Coulee URC shift algorithm.
- Grand Coulee turbine availability was modified to reflect ongoing maintenance that is more accelerated than current outages.
- Summer elevation and draft targets were modified at Libby and Hungry Horse (Sections 4.3.2.1 and 4.3.2.2).

- All other assumptions are unchanged from the NAA.

For more details, refer to the Modeling Data Sheets in Exhibit 4.

6.3.2 Differences between MO2 and No-Action Alternative

For details on differences between this MO and the NAA, refer to the *CRSO EIS Hydropower Appendix J* and the *H&H Appendix B*.

6.4 MULTIPLE-OBJECTIVE 3 ALTERNATIVE – MODELING

MO3 includes removal of the four lower Snake River dams; major operational changes to Libby, Hungry Horse, and Grand Coulee; and minor changes to the lower Columbia project operations.

6.4.1 Hydroregulation Modeling Steps

The hydroregulation modeling process shown in Figure 5-1 was generally followed, with the exception that in Step 3 there was an alternative URC development process. This is because Alternative MO3 contains measures calling for different URCs than the NAA at certain CRSO projects. All URCs were then combined and the remainder of the modeling process was the same.

Changes to the HYDSIM model for MO3 included:

- Lower Snake River dams are simulated as removed by designating them as non-generating reservoirs and passing inflow; in HYDSIM all inputs associated with generation, flow requirements, and content targets are removed.
- Increased flows to account for powerhouse surface passage routes to be constructed at McNary project are reflected by an 8 kcfs increase in other spill with the same start and end dates as other fish passage spill at the project.
- The powerhouse surface passage routes eliminate the need to install fish screens, resulting in an increase in turbine availability from the NAA for the duration in those periods where there would have been fish screens installed.
- Upgrades to adjustable spillway weirs assumed included in the spill totals already present.
- Spring fish passage spill is set to levels determined to cap at 120 percent TDG, or as close as possible while maintaining minimum turbine flow requirements. Spring spill starts April 10 at all lower Columbia River projects, and ends June 15.
- Summer spill at the lower Columbia River projects is the same as the NAA, but will end at midnight July 31.
- The State of Washington spill cap waiver is assumed to be 120 percent TDG during both spring and summer spill season (no 115 percent in the downstream forebay requirement) to accommodate the spring spill regime.
- Flow and pool elevation restrictions at John Day are lifted (Section 4.3.2.8).

- Turbine operation within and above 1 percent peak efficiency only increases turbine availability at relevant projects during the fish passage season.
- Summer elevation and draft targets were modified at Libby and Hungry Horse (Sections 4.3.2.1 and 4.3.2.2).
- Contingency reserves may be held within fish passage spill on the lower Columbia River projects. This reduced the reserve obligation held by other projects in the system, resulting in a higher availability at those projects.
- Changes to FRM were incorporated via Corps-provided URCs, SRDs, and refill tables.
- The end-of-December variable draft target at Libby was replaced with a single draft target.
- Changes to the upstream storage correction method incorporated via an updated Grand Coulee URC shift algorithm (Section 4.3.2.4).
- Grand Coulee turbine availability was modified to reflect ongoing maintenance that is more accelerated than current outages.
- Water Supply measures (increased water pumped from Lake Roosevelt, Chief Joseph diversions, and Flathead River) are incorporated via a negative adjustment to the flows into relevant projects.
- All other assumptions are unchanged from the NAA.

For more details, refer to the Modeling Data Sheets in Exhibit 4.

6.4.2 Differences between MO3 and No-Action Alternative

For details on differences between this MO and the NAA, refer to the *CRSO EIS Hydropower Appendix J* and the *H&H Appendix B*.

6.5 MULTIPLE-OBJECTIVE 4 ALTERNATIVE – MODELING

MO4 Alternative includes major operational changes to Libby, Hungry Horse, and Grand Coulee, and minor changes to operations the lower Columbia and Snake River projects.

6.5.1 Hydroregulation Modeling Steps

The hydroregulation modeling process shown in Figure 5-1 was generally followed, with the exception that in Step 3 there was an alternative URC development process. This is because Alternative MO4 contains measures calling for different URCs than the NAA at certain CRSO projects. All URCs were then combined and the remainder of the modeling process was the same.

Changes to the HYDSIM model for MO4 included:

- The flows in powerhouse surface passage routes constructed at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, John Day, and McNary projects are reflected by a 4 kcfs (lower Snake River dams) or 8 kcfs (lower Columbia River dams) increase, in other spill at those projects, with the same start and end dates as other fish passage spill at the project.

- The additional structure for passage means there will be no need for installation of fish screens, resulting in an increase in turbine availability from the NAA for the duration of those periods where there would have been fish screens installed.
- Additional 2 kcfs of spill October 1 – November 30 at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, and John Day dams for steelhead through a structural change in the spillway.
- Fish passage spill is set to 125 percent TDG. Spill starts March 1 and ends August 31 at all projects.
- Allow turbines to operate within or above 1 percent peak efficiency at lower Snake and lower Columbia projects during fish passage season.
- Contingency reserves may be held above the 1% peak efficiency operating limits during fish passage spill on the lower Snake River and lower Columbia River projects. This reduces the reserve obligation held by other projects in the system, resulting in a higher availability at those projects.
- Draft up to an additional 2.0 MAF from Libby, Hungry Horse, Albeni Falls, and Grand Coulee to support spring flow objectives at McNary Dam (Sections 4.3.2.1, 4.3.2.2, 4.3.2.3, and 4.3.2.4).
- Reservoir drawdown to MOP+1.5 feet and associated changes.
- Changes for Resident fish include changes to summer draft at Libby and Hungry Horse (Sections 4.3.2.1 and 4.3.2.2).
- Changes to FRM are incorporated via Corps-provided URCs, SRDs, and refill tables.
- Changes to Libby December draft (Section 4.3.2.1).
- Changes to the upstream storage correction method incorporated via an updated GCL URC shift algorithm (Section 4.3.2.4).
- Updated availability of Grand Coulee turbines reflects ongoing maintenance of power plants that is more accelerated than current outages to represent a broader range of possible hydraulic capacity during maintenance activities.
- Water Supply measures (increased water pumped from Lake Roosevelt, Chief Joseph diversions, and Flathead River) are incorporated via a negative adjustment to the flows into relevant projects.
- All other assumptions are unchanged from the NAA.

For more details, refer to the Modeling Data Sheets in Exhibit 4.

6.5.2 Differences between MO4 and No-Action Alternative

For details on differences between this MO and the NAA, refer to the *CRSO EIS Hydropower Appendix J* and the *H&H Appendix B*.

6.6 PREFERRED ALTERNATIVE – MODELING

PA includes operational changes to Libby, Hungry Horse, Grand Coulee, Dworshak, and John Day Dams, notably modified operations at Libby and Grand Coulee Dams to maximize operating flexibility and improve overall systems operations including winter FRM; modified operations to meet existing contractual water supply obligations and provide for authorized Lake Roosevelt additional water supply.

6.6.1 Hydroregulation Modeling Steps

The hydroregulation modeling process shown in Figure 5-1 was generally followed, with the exception that in Step 3 there was an alternative URC development process. This is because the PA contains measures calling for different URCs than the NAA at certain CRSO projects. All URCs were then combined and the remainder of the modeling process was the same.

Changes to the HYDSIM model for PA included:

- Cease installation of fish screens at Ice Harbor, McNary and John Day projects once IFP turbines are installed if warranted biologically. This measure would result in an increase in turbine availability from the NAA for periods where fish screens would have been installed.
- Fish passage spill is a revised juvenile fish passage spill operation based upon results of the spring 2019 Flexible Spill Test Operation and analysis of the four MO Alternatives. In a 24- hour period, the Juvenile Fish Passage Spill measure would involve 16 hours of spill operations up to 125% TDG at most projects for juvenile outmigration. For the remaining 8 hours, the projects would spill at a lower level, up to 125% TDG. These spill levels are slightly variable, depending on the project (see Chapter 7 of the EIS). These operations would be implemented during the spring juvenile migration, April 3 – June 21, at the lower Snake River projects, and April 10 – June 16 at 5 the lower Columbia River projects. When Flex Spill ceases, the projects would transition to summer spill operations. PA summer spill levels are described in Chapter 7 of the EIS with a late summer transition spill operation from August 15 – 31.
- Contingency reserves were held within fish passage spill on the lower Snake River and lower Columbia River projects. This reduced the reserve obligation held by other projects in the system, resulting in a higher availability at those projects.
- Pool elevation restrictions are lifted as outlined in individual projects.
- Restrictions to operate turbines within and above 1 percent of peak efficiency during fish passage season lower Snake River and lower Columbia River projects.
- Contingency reserves were held within fish passage spill on the lower Snake River and lower Columbia River projects. This reduced the reserve obligation held by other projects in the system, resulting in a higher availability at those projects.
- Changes to FRM were incorporated via the Corps-provided URCs and refill tables.
- Changes to the upstream storage correction method were incorporated using an updated Grand Coulee URC shift algorithm.

- Grand Coulee turbine availability was modified to reflect ongoing maintenance that is more accelerated than current outages.
- Flexibility to shift timing of fill at Grand Coulee as the system sets up for winter chum operations.
- Summer elevation and draft targets were modified at Libby and Hungry Horse (Sections 4.3.2.1 and 4.3.2.2).

For more details, refer to the Modeling Data Sheets in Exhibit 4.

6.6.2 Differences between PA and No-Action Alternative

For details on differences between this PA and the NAA, refer to the *CRSO EIS Hydropower Appendix J* and the *H&H Appendix B*.

CHAPTER 7 - POTENTIAL IMPACTS OF CLIMATE CHANGE

The methodology, analyses, and conclusions in this section do not comply with the policies or technical guidance of the Corps or Reclamation for evaluating the preparedness and resilience of water resource systems using climate change affected hydrology. Bonneville required a quantitative analysis of power generation and revenue to include in this appendix of the CRSO EIS. It was not possible for Bonneville to use an approach that would meet the policies or technical guidance of the Corps or Reclamation under the time frame of the EIS. The technical approach and findings contained in this section are those of the Bonneville and should not be construed as an official Department of the Army or Department of Interior position, policy or decision.

7.1 CLIMATE CHANGE STREAMFLOWS AND FORECASTS

The River Management Joint Operating Committee (RMJOC) of the co-lead agencies is continuously evaluating climate change to identify potential vulnerabilities, risk, and resiliency of the FCRPS. The co-lead agencies used the unregulated (naturalized) streamflow scenarios developed by the University of Washington for Part 1 of the RMJOC 2018[16] study to assess potential climate-related impacts for the CRSO EIS. The 160 unregulated streamflow projections in this study provide a wide range of projected climate change impacts on CRS streamflows, which incorporate not only uncertainties in future climate itself, but also the uncertainties introduced by climate model downscaling and the hydrologic modeling process. The full range of 160 unregulated scenarios is considered in a qualitative sense for the other resources evaluated in the *CRSO EIS Chapter 4*.

Additionally, Bonneville selected four 30-year scenarios from the RMJOC (2018) projections to substitute for the 80-year Modified Flow dataset (1929–2008) that were used in HYDSIM modeling of the NAA and MO alternatives. Each scenario has a 30-year projection (2020–2049, referred to as the 2030s) of flows based on temperature and precipitation assumptions from the selected scenarios.

Hydrologic changes from these projections resulted in changes to the CRS reservoir elevations, streamflows, and hydropower generation. The effects of these changes were assessed quantitatively for potential climate-related impacts on power generation in the CRS. Having a quantifiable understanding of how future climate may impact EIS alternatives was is important to Bonneville's understanding of impacts to generation and revenue in the future. For the other multiple uses, climate change effects are being derived qualitatively from the 160 RMJOC (2018) unregulated streamflow projections. Those qualitative effects are presented in the CRSO EIS.

Bonneville used HYDSIM to produce generation results that can be assessed quantitatively for energy impacts. Bonneville specifically assessed impacts to hydropower under four different climate scenarios selected to roughly represent high, medium, and low annual water conditions, and then assessed the hydropower impacts for the United States, CRS (Federal), and

[16] RMJOC (2010): https://www.bpa.gov/p/Generation/Hydro/hydro/cc/RMJOC-II-Report-Part-I.pdf

Mid-Columbia systems. The net generation impact range for these projects will be used to assess potential resulting impacts to reliability, and revenues are provided in the following sections as well.

In selecting the four scenarios, Bonneville sought to assess hydropower impacts across the broad range of available temperature and precipitation and streamflow projections yet included scenarios that were down-selected for further hydropower evaluation as part of the RMJOC (2018) research effort. Bonneville focused on the carbon emissions pathway (Resource Concentration Pathway 8.5), which is aligned with current observed emissions.

Bonneville also sought to capture at least some of the additional uncertainties resulting from the hydrologic modeling process. Different hydrologic models and model calibrations used in RMJOC (2018) yielded some runoff timing and summer flow differences that were independent from climate change itself. The differences were important to consider relative to the NAA and MOs, particularly with respect to spring and summer natural streamflows.

It is important to note that the four scenarios do not represent the *complete* range of potential climate impacts on the Columbia River – neither from RMJOC (2018) nor from climate change in general. However, they do capture a broad range of expected potential climate impacts on streamflow, which allowed the Action Agencies to compare how NAA and each MO may perform as regional climate changes through the 2030s.

The four climate scenarios selected by Bonneville as representative of a likely and potential spread of annual temperature and precipitation trends by the 2030s (2020-2049), while also leveraging the hydrologic model diversity from the RMJOC (2018) project. The hydrologic diversity includes two hydrologic models, one of which was calibrated with three different methods and historical datasets. While the selection of four scenarios is not as comprehensive as modeling the 19 and 160 scenarios evaluated for the RMJOC (2018) project by Bonneville and the Corps respectively, it provides a range of potential climate scenarios and resulting generation impact.

This approach was developed to provide an assessment of the potential impacts of climate change on impacted resources and alternatives for the CRSO EIS, while providing Bonneville with additional quantifiable information to inform its evaluation of the alternatives.

The four scenarios from RMJOC (2018) used for this analysis included:

- CC1: CanESM2-MACA-PRMS-P1

  CanESM2 was the warmest on all RMJOC (2018) scenarios, with a basin average temperature increase of 5.3°F observed between the historical period (1970-1999) and the 2030s (2020-2049). It was also one of the wetter scenarios on an annual basin-average perspective, with a precipitation increase between the historical period and the 2030s of about 7 percent (warmest/wettest scenario). Although other scenarios in the set of 160 showed even higher future precipitation and annual volume, this scenario was on the high end of projected annual runoff compared to the other 160 scenarios (around 161 Maf by the 2030s, compared to the historical annual runoff of around

132 Maf). It also projected the highest annual average volume runoff into Grand Coulee in the 2030s. The Precipitation Runoff Modeling System (PRMS) hydrologic model results tended to project higher winter flows than the other hydrologic model iterations used for RMJOC (2010), but also lower summer flows.

- CC2: MIROC5-BCSD-VIC-P3

  The MIROC5 climate model projected a little less average annual warming (about 4.4°F) and a little less of a precipitation increase (about 5 percent). This yielded an annual volume of about 155 Maf at The Dalles. One interesting characteristic of this scenario was that the MIROC5 tended to concentrate future precipitation increases above Grand Coulee, with some decrease in precipitation in the Snake River Basin. The Variable Infiltration Capacity (VIC) Macroscale Hydrologic model parameterization used for this scenario (P3) tended to show lower flows in the winter and spring periods, but higher and slightly later spring peak flows compared to the other hydrologic model iterations.

- CC3: HadGEM2-CC-MACA-VIC-P1

  The climate scenario is similar to CC2 in that it projects about 4.5°F of average annual warming by the 2030s, on average, and about a 7 percent precipitation increase. The difference in this scenario, though, is that more of the precipitation and annual volume increases tended to be larger in the Snake Basin compared to the upper Columbia. This VIC hydrologic model parameterization (P1) was the most closely calibrated hydrologic model used in RMJOC (2018), and thus tended to perform best in the historical period, but with a tendency for higher winter flows compared to the other VIC parameterizations.

- CC4: GFDL-ESM2M-BCSD-VIC-P2

  The scenario is one which projects still significant, but less average annual warming across the Columbia Basin, with an average temperature increase around 2.5°F by the 2030s relative to the historical period. However, it is also the driest climate model projection used for RMJOC (2018) for the 2030s, with a slight decrease in annual precipitation (about 2 percent). As a result, it projects the lowest average annual volume for the Columbia Basin at around 138 Maf – similar to what is currently experienced in the Columbia Basin in the historical period. The VIC hydrologic model parameterization (P2) also tended to have lower winter and spring flows compared to the PRMS and VIC-P1 parameterizations, but higher and earlier spring runoffs, with lower summer flows.

Figure 7-1 through Figure 7-3 depict where the four scenarios (shown in yellow) fall in relation to the larger set of the scenarios for the RMJOC (2018) project. The four scenarios are part of the Bonneville-selected 19 scenarios (shown in red) and part of the overall set of 80 RMJOC (2018) Representative Concentration Pathway 8.5 scenarios.

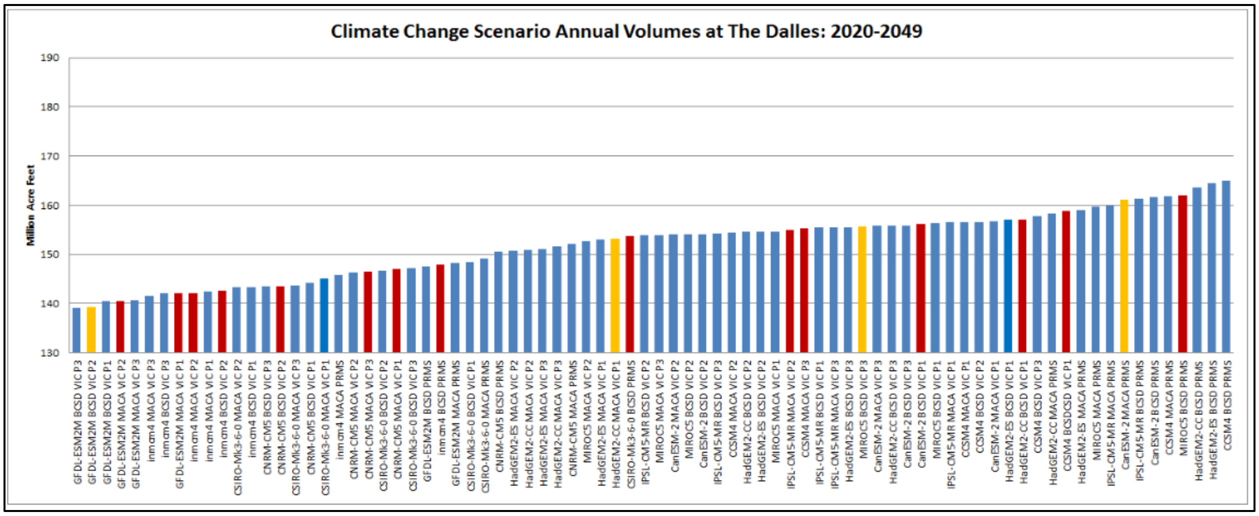

Figure 7-1. Climate Change Scenario Annual Volumes at The Dalles: 2020-2049

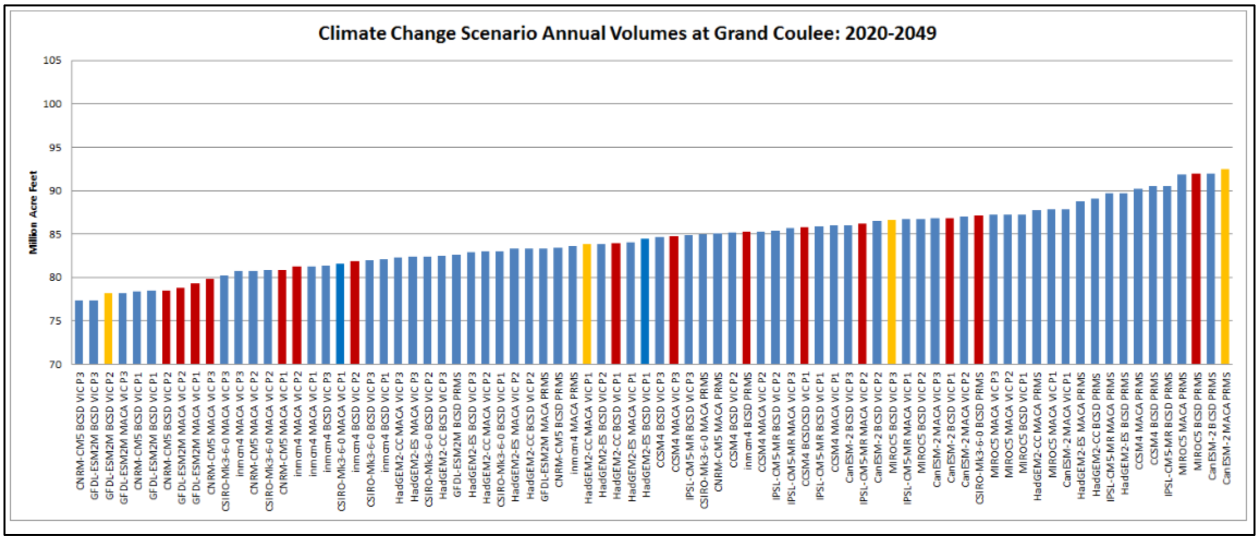

Figure 7-2. Climate Change Scenario Annual Volumes at Grand Coulee: 2020-2049

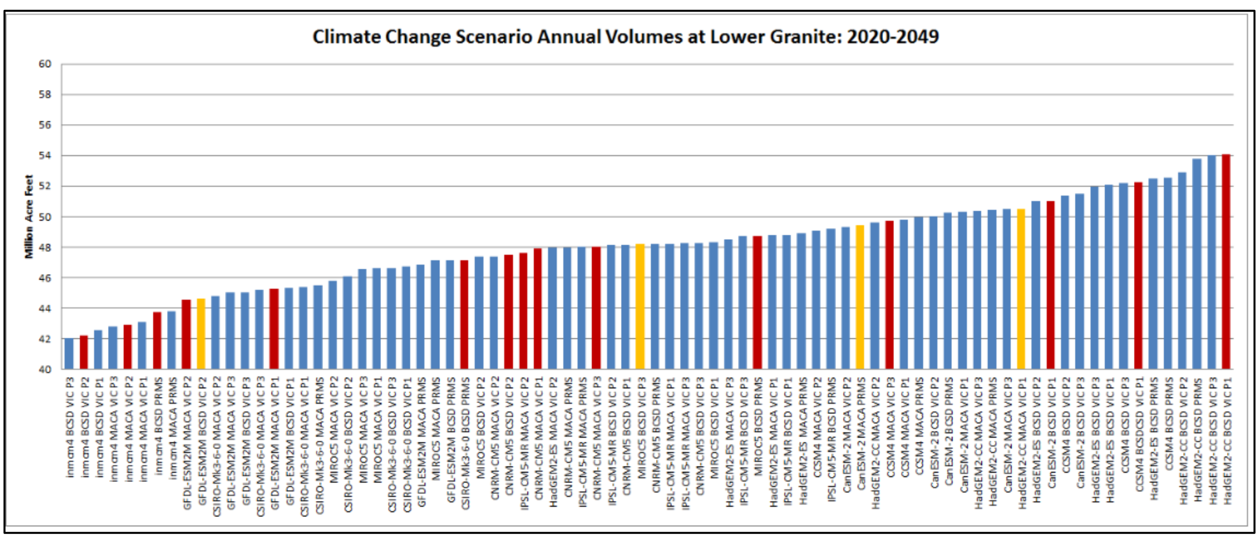

Figure 7-3. Climate Change Scenario Annual Volumes at Lower Granite: 2020-2049

7.2 FLOOD RISK MANAGEMENT INPUTS TO CLIMATE CHANGE MODELING IN HYDSIM

The primary differences in model inputs between the non-climate change scenarios and climate change scenarios are the unregulated (naturalized) streamflow dataset and the associated water supply forecasts. The 80-year Modified Flows dataset and associated forecast flows datasets used as inputs in Figure 5-1 Step 1 are replaced with the climate change inflow dataset and revised water supply forecast dataset. Using these revised inflows and forecasts, the modeling steps determine revised URCs and refill percentage targets to capture runoff to avoid flooding conditions. The URCs define the maximum reservoir elevations for each day to capture forecast runoff and snowmelt and reduce instances of flooding.

7.3 URCS FOR THE NAA ALTERNATIVE WITH CLIMATE CHANGE

For the NAA scenario, the steps outlined in Figure 5-1 were followed, where the results of Step 3, ResSim F0, define the spring snowmelt runoff URCs. The Treaty On-Call FRM operations are performed in the Corps ResSim F1 model, Step 7, along with winter FRM and BiOp operations. The January to April drawdown period of the Treaty On-Call operations modeled in ResSim are used directly in the HYDSIM hydroregulations. The April through July refill values are modeled using HYDSIM. The winter FRM operations from the ResSim F1 model were not used in the Hydsim modeling as they are considered within month real-time operations that are not currently captured in the Hydsim hydroregulation modeling process. The URCs for the NAA modeling of the four climate change scenarios were originally developed for Part II of the RMJOC-II climate change project which is scheduled to be completed in 2020.

7.4 URCS FOR MULTIPLE-OBJECTIVE ALTERNATIVES WITH CLIMATE CHANGE

The URCs for the MO climate change scenarios were developed in the following manner. The URCs for the MO scenarios were assembled from information provided in the NAA climate change URC development, and combined with external calculations of the unique Grand Coulee and Libby winter drawdown requirements defined for each MO. They do not represent comprehensive ResSim modeling output as defined by Figure 5-1since this modeling was not performed. The summary of the URC computation process is described below.

- The URCs for Mica, Arrow, Duncan, Hungry Horse, Brownlee, and Dworshak were taken directly from the climate change NAA ResSim F0 modeling for each of the scenarios. These URCs represent both the December through March winter drawdown that are predicated on the FRM SRD procedures, the climate change water supply forecasts, and the spring April through July refill from the ResSim modeling.
- The URCs for Libby were developed by applying the new FRM SRD procedure defined for the CRSO. Specifically, the winter drawdown at Libby was computed in an Excel spreadsheet using the climate change scenario water supply forecasts and the new CRSO SRD. Spring refill was calculated in the same manner as the NAA modeling using a HYDSIM modeling spreadsheet of the VarQ outflow procedure.
- At Grand Coulee, the winter drawdown was computed using the climate change water supply forecasts and the two new CRSO SRDs representing a new drawdown rate of 0.8 feet

per day and additional space for winter rainfall events along with the new upstream space adjustment procedure. The spring refill was calculated using refill information from the climate change modeling of the NAA for each climate change scenario. The use of the spring refill parameters from the climate change NAA modeling was assumed to be sufficient for the CRSO MO modeling since the new CRSO FRM procedure for Grand Coulee was designed to reach a similar winter evacuation as the current FRM procedure. The calculations were made with the MatLab URC Program and the HYDSIM Excel Grand Coulee upstream space adjustment spreadsheet. The Grand Coulee/Dworshak shift was calculated using the HYDSIM Excel spreadsheet.

Once the URCs, runoff data set, and forecast data sets were identified, each MO alternative was set with their specific operational and physical constraints, then run through Hydsim to obtain the regulation of each project. The model run generation, elevation, and flow outputs were then compared back to NAA outputs. For details on the impacts of climate change variations on the MO alternatives, refer to the *CRSO EIS Hydropower Appendix J*.

CHAPTER 8 - REFERENCES

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Exhibit 1. Project List for United States, CRS, Mid-Columbia, and Canadian Systems

This exhibit provides a listing of projects that are modelled by Bonneville for the CRSO EIS. The projects highlighted with an asterisk (*) are affected by the CRSO EIS alternatives. The remaining projects are not affected by the alternatives, but are part of the Bonneville hydropower models; their operation is replicated in each alternative.

Table E4 - 1. Identification of Hydropower Projects within each Group

	Hydro Project Grouping			
Projects	**US System**	**Canadian System**	**Mid-Columbia**	**Federal System (CRS)**
Cushman 1	✓			
Cushman 2	✓			
Alder	✓			
Lagrand	✓			
Ross	✓			
Diablo	✓			
Gorge	✓			
Upper Baker	✓			
Lower Baker	✓			
Mica		✓		
Revelstoke		✓		
Arrow		✓		
Libby*	✓			✓
Bonners Ferry *	✓			
Duncan				
Corra Linn*		✓		
Canal Plant*		✓		
Upper Bonnington*		✓		
Lower Bonnington*		✓		
South Slocan*		✓		
Brilliant*		✓		
Hungry Horse*	✓			✓
Columbia Falls*	✓			
SKQ*	✓			
Thompson Falls*	✓			
Noxon Rapids*	✓			
Cabinet Gorge*	✓			
Priest Lake				
Albeni Falls*	✓			✓
Box Canyon*	✓			
Boundary*	✓			
Seven Mile*		✓		

	Hydro Project Grouping			
Projects	**US System**	**Canadian System**	**Mid-Columbia**	**Federal System (CRS)**
Waneta*		✓		
Coeur d'Alene Lake				
Post Falls	✓			
Upper Falls	✓			
Monroe Street	✓			
Nine Mile	✓			
Long Lake	✓			
Little Falls	✓			
Grand Coulee*	✓			✓
Chief Joseph*	✓			✓
Wells*	✓		✓	
Chelan	✓			
Rocky Reach*	✓		✓	
Rock Island*	✓		✓	
Wanapum*	✓		✓	
Priest Rapids*	✓		✓	
Brownlee				
Oxbow				
Hells Canyon				
Dworshak*	✓			✓
Lower Granite*	✓			✓
Little Goose*	✓			✓
Lower Monumental*	✓			✓
Ice Harbor*	✓			✓
McNary*	✓			✓
John Day*	✓			✓
Round Butte	✓			
Pelton	✓			
Pelton Rereg	✓			
The Dalles*	✓			✓
Bonneville*	✓			✓
Timothy	✓			
Oak Grove	✓			
North Fork	✓			
Faraday	✓			
River Mill	✓			
Swift 1	✓			
Swift 2	✓			
Yale	✓			
Merwin	✓			

	Hydro Project Grouping			
Projects	**US System**	**Canadian System**	**Mid-Columbia**	**Federal System (CRS)**
Packwood Lake				
Mossyrock	✓			
Mayfield	✓			

* indicates project may be directly affected by CRSO EIS Alternatives

Exhibit 2. CRSO Alternatives Crosswalk

	Measure Category	CRSO Measure Name	Multi-Objective #1 (MO1)	Multi-Objective #2 (MO2)	Multi-Objective #3 (MO3)	Multi-Objective #4 (MO4)	Preferred Alternative (PA)
Structural	Structural	Additional Powerhouse Surface Passage	X	X	X	X	
Structural	Structural	Upgrade to Adjustable Spillway Weirs	X	X	X		
Structural	Structural	Lower Granite Trap Modifications	X			X	X
Structural	Structural	Modify Bonneville Ladder Serpentine Weir	X		X		X
Structural	Structural	Lower Snake Ladder Pumps	X	X		X	
Structural	Structural	Spillway Weir Notch Inserts				X	
Structural	Structural	Fewer Fish Screens		X	X		X
Structural	Structural	Improved Fish Passage Turbines at John Day	X	X	X	X	X
Structural	Structural	Lamprey Passage Structures	X	X	X	X	X
Structural	Structural	Turbine Strainer Lamprey Exclusion	X	X	X	X	X
Structural	Structural	Bypass Screen Modifications for Lamprey	X	X	X	X	X
Structural	Structural	Closeable Floating Orifice Gates					X
Structural	Structural	Lamprey Passage Ladder Modifications	X	X	X	X	X
Structural	Dam Breach	Breach Snake Embankments			X		
Structural	Dam Breach	Lower Snake Infrastructure Drawdown			X		
Operational	Dam Breach	Drawdown Operating Procedures			X		
Operational	Dam Breach	Drawdown Contingency Plans			X		
Operational	Fish Passage	Block Spill Test (Base + 120/115%)	X				
Operational	Fish Passage	Summer Spill Stop Trigger	X				
Operational	Fish Passage	Early Start Transport	X				X
Operational	Fish Passage	Contingency Reserves within Juvenile Fish Passage Spill	X	X	X	X	X
Operational	Fish Passage	Spill to 110% TDG		X			
Operational	Fish Passage	Spring & Fall Transport				X	
Operational	Fish Passage	No Summer Transport				X	
Operational	Fish Passage	Reduced Summer Spill			X		
Operational	Fish Passage	Spill to 125% TDG				X	
Operational	Fish Passage	Spring Spill to 120% TDG			X		
Operational	Fish Passage	Juvenile Fish Passage Spill Operations					X
Operational	Fish Passage	Spill for Adult Steelhead				X	
Operational	Fish Passage	Increase Juvenile Fish Transportation		X			
Operational	Water Management	Modified Draft at Libby	X	X	X	X	X
Operational	Water Management	December Libby Target Elevation	X	X	X	X	
Operational	Water Management	Update System FRM Calculation at Grand Coulee	X	X	X	X	X
Operational	Water Management	Planned Draft Rate at Grand Coulee	X	X	X	X	X
Operational	Water Management	Grand Coulee Maintenance Operations	X	X	X	X	X
Operational	Water Management	Winter System FRM Space	X	X		X	
Operational	Water Supply	Lake Roosevelt Additional Water Supply	X		X	X	X
Operational	Water Supply	Hungry Horse Additional Water Supply	X		X	X	
Operational	Water Supply	Chief Joseph Dam Project Addt'l Water Supply	X		X	X	
Operational	Hydropower	Increased Forebay Range Flexibility	X				X
Operational	Hydropower	Slightly Deeper Draft for Hydropower		X			
Operational	Hydropower	Slightly Deeper Draft for Hydropower (Dworshak)					X
Operational	Hydropower	Fall Operational Flexibility for Hydropower (Grand Coulee)					X
Operational	Hydropower	Ramping Rates for Safety		X	X		
Operational	Hydropower	John Day Full Pool		X	X		X
Operational	Hydropower	Full Range Reservoir Operations		X			
Operational	Hydropower	Full Range Turbine Operations		X			
Operational	Hydropower	Above 1% Turbine Operations			X	X	X
Operational	Hydropower	Zero Generation Operations		X			X
Operational	Other Operational Measures	McNary Flow Target				X	
Operational	Other Operational Measures	Drawdown to MOP				X	
Operational	Other Operational Measures	Predator Disruption Operations	X				X
Operational	Other Operational Measures	Modified Dworshak Summer Draft	X				
Operational	Other Operational Measures	Sliding Scale at Libby and Hungry Horse	X	X	X	X	X
Operational	Other Operational Measures	Winter Stage for Riparian				X	

Exhibit 3. Summary of Results Provided to EIS Workgroups for all Alternatives

EIS Workgroup	Results Provided
Transmission	• Average Generation for all Projects (14x80 matrices in aMW, from pre-Lack-of-Market HYDSIM study) • Raw Independent and Small Hydro Data • Max and Min Generation from HOSS
Transmission Rates Analysis	The Dalles Regulated Outflow (14x80 matrix in cfs)
Power Rates Analysis	• Purchase Table to Support 4(h)(10)(C) Calculation • Hydsim and HOSS study results to load data-base for socioeconomic analysis • Grand Coulee 14x80 generation matrix to support Colville Payment calculation • Loss of Load Probability results and CVaR parameters determined Replacement Resources for Low Cost and Low Carbon Scenarios
Water Quality Team (for Spill Allocation Process)	• Hydro Availability Hydsim input • Lack of Market data from AURORA run • Detailed Description of Spill Operation at each Project

Exhibit 4. Modeling Sheets for each Alternative

Detailed modeling information is provided in this exhibit for each CRSO EIS alternative. Each sheet contains a table of contents, a summary of the objectives, changes from the NAA, and a project-by-project listing of the considerations made for each project to meet the objectives.

Modeling Data Sheet: No Action Alternative

Alternative Modeling Summary – No Action Alternative

Table E4 - 2. Alternative Summary – No Action Alternative

Name:	CRSO No Action Alternative
CRSO Projects:	Projects are modeled to represent the current 2016 operating rules and constraints
Flood Risk	U.S. projects follow FCOP with current URCs Canadian projects follow FCOP with current URCs On Call FRM (after FLEX in ResSim)
Power	Coordinated Treaty Hydropower Operations Operating criteria and U.S. objectives (both power and non-power) based on current Treaty planning methodologies and procedures based on AOP22 including Critical Rule Curves (CRCs) and Power Discharge Requirements (PDRs). Loads and resources from AOP22 Flex operation at Mica with modified operation (additional flow augmentation) at Arrow (in ResSim)
Biological and Water Supply Objectives	Implements current operations and objectives
Modeling System Configuration	Current configuration of the Columbia River System with no major changes in levees, dams, and reservoirs from the current system
Canadian Treaty Projects:	Current Treaty operating protocols and procedures
Hydrologic Data Sets Used for Monte Carlo Evaluation	ResSim & HydSim: 80-year 2010 Level Modified Flows from 1929 - 2008. 9-year Extended Observed flows from 2008 – 2016 are needed only for the Water Quality analysis. Adjustments to both these stream flows sets are made in this study according to the Bureau of Reclamation’s updated Grand Coulee pumping schedule for the Columbia Basin Project in their February 1, 2016, preliminary PNCA data submittal for OY17, plus full implementation of Odessa and M&I.
Hydrologic Data Sets Used for Monte Carlo Evaluation	ResSim: 106-year dataset based on 80-year 2010 Level Modified Flows, plus 26 synthetic water years (17 spring synthetics and 9 winter synthetics)
Water Supply Forecast Used for Monte Carlo Evaluation	Refined water supply forecasts developed at the Corps (not Rate Case forecasts)
Water Supply Forecast Used for FRA Evaluation	FRA water supply forecasts adjusted for statistical consistency

Note: all elevations are in NGVD 29

HydSim Assumptions (General)

- Continuous 80 year study
- Begin October 1, 1928 and ends September 30, 2008
- 14 periods averages, with April and August split into two periods each, with the first fifteen days as the first period and the rest of the month as the second period.
- Non-federal projects are run to the resulting contents from the AER step. This allows the federal projects to operate without causing the non-Federal projects to adjust operations to meet system load.
- Outages for all projects are from 2026 projections from BPA Federal Hydro Projects Operations
- Initial contents for the major federal projects are from the 2016-2018 finalized Rate Case.
- The HydSim hydro availability file reflects:
    - Average availability of the turbines based on current 5-year maintenance plan, expressed as a percent of capacity.
    - Operating at 1 percent efficiency. Turbine operations at the four lower Snake River projects (Lower Granite, Little Goose, Lower Monumental and Ice Harbor) and the four lower Columbia River projects (McNary, John Day, The Dalles and Bonneville) are required to operate within 1 percent of peak efficiency April 1 through October 31 for fish survival benefits. This will reduce turbine availability at those projects in those periods.
    - Installation of fish screens. Turbine availability at a project is reduced when fish screens are in place.
    - Reserve requirements distributed through the system. Carrying reserves reduces turbine availability. The size of the reduction depends total system reserve requirements, and on what portion of the system's reserves are allocated to any particular project in any particular time period. The Minimum Operating Pool at the lower Snake River projects do not allow them to carry reserves during fish passage season.
- H/K tables used in calculations to convert flows and head to generation are based on historical observations.
- Spill levels when spill plan involves Total Dissolved Gas ("TDG") amounts are based on the spill level estimates created by the Water Quality Team in December 2018.
- Market calculations when estimating Lack of Market spill are based on Fiscal Year 2022 estimates of regional load, market conditions and generation resources.
- "Other spill" values based on 2016 PNCA data submittals encompassing leakage, lockage, and other flows that do not go through the spillway or the turbines.

Projects

Canadian Projects

GENERAL CANADIAN OPERATION

- Canadian projects operate for power per TSR based on the AOP22 and DOP18 updates.
- Canadian projects operate in consideration of SRDs for flood risk
- Canadian operation includes proportional draft.
- HydSim Canadian operation is initialized to the 80-year TSR22 study including proportional draft with the following additions:
    - Flow augmentation as detailed in the table below
    - The trout spawning operation is included at Arrow where April 16 through April 30 flows are at least 15,000 cfs and May and June flows are equal to or greater than the preceding month whenever possible. No more than a 5,000 cfs decrease is allowed.
    - Canadian Operations include On Call

ON CALL LOGIC (MICA, ARROW, DUNCAN, GRAND COULEE)

HydSim Considerations

- HydSim uses On Call URCs January to April as provided by Corps
- HydSim refill based on Power operation
- Non Power Uses (NPU) Storage and release of water for NPU are as outlined below:

Table E4 - 3. Non Power Uses Canadian Storage and Release

NPU Element	MAF	Storage Location	Target Storage Schedule	Target Release Schedule
Flow Augmentation - Normal Year	1.0	Treaty (Arrow/Mica)	***January – March*** Subject to: January: Minimum flow at Arrow of 20 kcfs. February-March: minimum flow at Arrow of 10 kcfs	***May – July*** Except if dry conditions, release May-July or May-June if required to support MCN minimum flow objectives.
Flow Augmentation - Dry Conditions*	1.0	Treaty (Arrow/Mica)	***January – February*** Subject to: January: Minimum flow at Arrow of 30 kcfs. February: minimum flow at Arrow of 10 kcfs	***February- March*** If dry conditions, release ½ balance in February and/or and full balance in March.
NTSA dry period provision**	0.5	Non-Treaty (Mica)	N/A	***May-June*** In dry years, release uniformly during May-June through Arrow

Notes:
*SOA Dry Conditions = When the February or March Water Supply Forecast (April – August) at The Dalles is <75 MAF
**NTSA Dry Year = When the May Water Supply Forecast (April – August) at The Dalles is <72.5 MAF

MICA
Flows

- Min Flows: 0 cfs
- Max Flows: can vary by period due to higher priority constraints

Elevation/Content

- Min Elevation: can vary by period due to higher priority constraints
- Max Elevation: 2,470 ft (5,825.1 ksfd)

HydSim Considerations

- NPU storage occurs at Mica
- Release all NPU storage by July 31

Specific Operations for Flood Risk:

- Upper rule curves per the FCOP are considered in operations
- On-call operations, per the FCOP, may be implemented in certain years

Specific Operations/Assumptions in Power Modeling:

- See General Canadian Operation (above)

Specific Operations/Assumptions in BiOp Modeling:

- See General Canadian Operation (above)

DUNCAN
Flows

- Min flows: 100 cfs
- Max flows: 10,000 cfs
- Targets:
  - Refill May-Jun at 0.1 kcfs, then pass inflow if treaty full.

Elevation/Content

- Min elevation: 1,794.2 ft (0 ksfd)
- Max elevation: 1,892 ft (705.8 ksfd)

HydSim Considerations

- Operates to TSR, constrained by PDP or ECC

Specific Operations/Assumptions in Flood Risk Modeling:

- Upper rule curves per the FCOP are considered in operations.
- On-call operations, per the FCOP are implemented in certain years.

Specific Operations/Assumptions in Power Modeling:

- See General Canadian Operation (above)

Specific Operations/Assumptions in BiOp Modeling:

- See General Canadian Operation (above)

ARROW
Flows:

- Min flow: 5,000 cfs
- Max flow: can vary by period due to higher priority constraints

Elevation/Content:

- Min elevation: 1,377.9 ft (0 ksfd)
- Max elevation: 1,444 ft (3,579.6 ksfd)

HydSim Considerations

- Operates to TSR, constrained by PDP or ECC

Specific Operations/Assumptions in Flood Risk Modeling:

- Generally operates to FLEX outflows at the Border unless supporting Grand Coulee to meet the ICF
- On-call operations, per the FCOP, may be implemented in certain years

Specific Operations/Assumptions in Power Modeling:

- See General Canadian Operation (above)

Specific Operations/Assumptions in BiOp Modeling:

- Follow the table contained in General Canadian Operation (above) for flow augmentation and provisional draft storage and release target schedules
- Re-store the additional 0.5 MAF back into Canada evenly in May/June when TDA unregulated forecast is above average (May-350 kcfs, June 450 kcfs)
- If another dry year follows a previous dry year so the volume has not been re-stored, then it is not possible to release an additional 0.5 MAF until that volume has been replenished.
- For trout spawning, Arrow outflow operates to minimum flow of 15,000 cfs in April 15, between 15,000 cfs and 25,000 cfs in April 30, between 15,000 cfs and 35,000 cfs in May-June. During April through June the outflow at Arrow cannot decline unless the TSR balance by June 30 is below the target composite TSR balance plus any remaining Flow Augmentation volume. Then the outflow is allowed to reduce up to 5,000 cfs in Trout Spawning periods.

CORRA LINN
Flows:

- Min flow:
- Max flow:

Elevation/Content:

- Min elevation: 1,738 ft (0 ksfd)
- Max elevation: 1,770 ft (1,953.4 ksfd)

HydSim Considerations

- Project follows IJC rule curve as possible

Specific Operations/Assumptions in Flood Risk Modeling:

- None, follows IJC rule curve as possible.

Specific Operations/Assumptions in Power Modeling:

- See General Canadian Operations (above)

Specific Operations/Assumptions in BiOp Modeling:

- See General Canadian Operations (above)

US Headwater

LIBBY
Flows:

- Min flow: 4,000 cfs
- Max flow: 25,000 cfs (max 20,000 cfs in Nov/Dec)

Elevation/Content:

- Min elevation: 2,287 ft (0 ksfd)
- Max elevation: 2,459 ft (2,510.5 ksfd)
- Targets:

HydSim Considerations

- Shift flows to previous months to prevent spill, January-April, with max outflow 25,000 cfs
- Maximum end of July content: 2,395 ksfd (2,454 ft)
- Allow June fill when flow out is greater than 30,000 cfs
- Otherwise max desired discharge, May-Aug: 25,000 cfs
- Summer draft operation: “Montana Proposal” of ending 10 ft below full by the end of September (20 ft below in dry years)

Specific Operations/Assumptions in Flood Risk Modeling:

- Begin refill 10 days before ICF date or if FCRC triggers refill
- VARQ flows and elevations (including variable end-of-December URC drafts)
- Target refill to 5 ft from full by July 31
- Attempt to keep flows below 1,764 ft (NGVD29) at Bonners Ferry
- Attempt to limit spill during refill, keeping space reserved for flood control
- Special discharge regulation schedule to manage reservoir space below full
- Anticipatory drafts during the last part of the month in case WSF changes significantly
- Operate for winter flood risk management

Specific Operations/Assumptions in Power Modeling:

- 5.0 Maf of space between its maximum forebay elevation of 2,459 ft NGVD29 and minimum forebay elevation of 2,287 ft NGVD29 is operated to maximize power while maintaining other authorized purposes. Libby has five generating units with an estimated discharge capacity estimate of up to 5,200 cubic feet per second (cfs) each

Specific Operations/Assumptions in BiOp Modeling:

- Project outflow minimum per the Bull Trout BiOP:
  - May 15 – September 30: 6 kcfs minimum
  - July 1 (or after sturgeon pulse) – August 31: tiered minimum varying from 6 kcfs to 9 kcfs per the May final Libby April-August WSF
- Sturgeon Operation starting on May 15 per the tiered volumes based on the May Final April-August WSF for Libby. Target 2,454 ft by the end of July.
- Summer Flow Augmentation: draft to 2,449 or 2,439 ft by the end of September depending on the May final April-August WSF for The Dalles. If less than 72.5 MAF (low 20 percent water year), draft to the lower elevation. Target 2.5 ft above end of September values by the end of August to facilitate reaching the September targets without double peaking.

HUNGRY HORSE
Flows:

- Min flow: 300 cfs
- Max flow: 8,900 cfs powerhouse capacity, 14,000 cfs max outflow
- Target flows: minimum flows based on WMP minimum flows table.

Elevation/Content:

- Min elevation: 3,336 ft (0 ksfd)
- Max elevation: 3,560 ft (1,503.44 ksfd)
- Targets:

  - Summer draft target for end of September "Montana Proposal", 20 ft from full in driest years; 10 ft from full in other years.

HydSim Considerations

- Force to be on Qmin or at flood control elevation January to March.
- April 15th and April 30th max elevation 3,545 ft (1,330.2 ksfd)
- June max content 3,558 (1,480.1 ksfd)
- Target 3,550 ft in AG1 and 3,540 ft in AG2
- Shape February-April to avoid spill
- Restrict flows in June to smooth summer flows
- Dry year refill strategy: refill more slowly in the driest 20 percent of years. When WSF for May to Sept @ HGH < 1,450, HGH Qmin is 50 percent of COLF Qmin

Specific Operations/Assumptions in Power Modeling

- January, February and March minimum elevations are set as Variable Draft Limits ("VDLs"). These VDLs are a minimum elevation with a 75 percent probability of reaching the April 10th elevation target for refill. Hungry Horse can operate between the VDLs and URC depending on power needs.
- When applying Lack of Market adjustments, when possible, reductions in generation may be realized by reducing draft at HGH.

Specific Operations/Assumptions in BiOp Modeling

- Maximum rate-of-change rules
- BiOp minimum flows vary based on the WSF:
  - Hungry Horse must release water to maintain a minimum flow (3,200 cfs to 3,500 cfs) at Columbia Falls
  - The minimum discharge varies between 400 cfs and 900 cfs.
- April and May flows shaped for smooth transition to VARQ flows. Adjusts flows near full pool to prevent overfilling

DWORSHAK
Flows:

- Min flow: 1,600 cfs (1,500 cfs powerhouse minimum plus 100 cfs hatchery)
- Max flow: 14,000 cfs powerhouse capacity, 25,000 cfs max outflow for flood control

Elevation/Content:

- Min elevation: 1,445 ft (0 ksfd)
- Max elevation: 1,600 ft (1,016 ksfd)

HydSim Considerations

- Max outflow at 25,000 cfs in order to meet elevation considerations; target period average flows of 14,000 cfs
- Shift flood control space to GCL when April to July Forecast at DWR > 3.0 MAF
- Reduce spill for January to April, up to 8,000 cfs, shifting outflows to earlier period.
- Smooth summer drafts with
  - End of August target of 1,535 ft
  - Target summer flow of 11,000 cfs in July and Aug1, with max Qo of 14,000.
  - Keep the flow drop from August 15th to August 30th under 25 percent drop.
- Draft July 1 to August 31 to support lower Snake BiOp objectives
- 100 cfs hatchery minimum flow modelled as "other spill"

Specific Operations/Assumptions in Flood Risk Modeling:

- Upper rules curves during draft are based on both local and system SRDs
- Shift to GCL allowed. Full shift usually followed until April 1st. Partial shift in April may occur as a result of other operations, but the full shift on April 15th is otherwise ignored; beginning April 15, reservoir releases to target April 30 elevation.
- Maximum release of 25,000 cfs for channel capacity
- Control flow at Spalding to 105,000 cfs as possible
- Upper rules curves during draft are based on both local and system SRDs
- Shift to GCL allowed. Full shift usually followed until April 1st. Partial shift in April may occur as a result of other operations, but the full shift on April 15th is otherwise ignored; beginning April 15, reservoir releases to target April 30 elevation.
- Maximum release of 25,000 cfs for channel capacity
- Control flow at Spalding to 105,000 cfs as possible
- Begin refill 2 days before ICF date, unless FCRC triggers refill
- Target refill by June 30
- Attempt to limit spill during refill

Specific Operations/Assumptions in Power Modeling:

- Lack of Market spill level one is at 30 percent of outflow, up to TDG gas cap per TMT spill priority list.

Specific Operations/Assumptions in BiOp Modeling:

- TDG cap of 110 percent assumed at 14,500 cfs

- Draft July 1 – August 31 to support lower Snake BiOp objectives, but refilling by June 30th takes precedence.

Specific Operations/Assumptions for Flood Risk:

- Upper rules curves during draft are based on both local and system SRDs
- Shift to GCL allowed. Full shift usually followed until April 1st. Partial shift in April may occur as a result of other operations, but the full shift on April 15th is otherwise ignored; beginning April 15, reservoir releases to target April 30 elevation.
- Maximum release of 25,000 cfs for channel capacity
- Control flow at Spalding to 105,000 cfs as possible
- Begin refill 2 days before ICF date, unless FCRC triggers refill
- Target refill by June 30
- Attempt to limit spill during refill

BROWNLEE
Flows:

- Min flow: 5,000 cfs
- Max flow: 35,000 cfs, can vary by period due to higher priority constraints

Elevation/Content:

- Min elevation: 1,976 ft (0 ksfd)
- Max elevation: 2,078.5 ft (502.9 ksfd)

HydSim Considerations

- Generic annual operation with the following in overrides in the OPER study step:
  - Hells Canyon minimums govern Brownlee outflow:
    - minimum flow of 9,000 cfs November through the middle of June; second half of June minimum of 5,000 cfs
    - Hells Canyon maximum Qout in January of 30,000 cfs
  - December end of month content target of 443.2 ksfd; January end of month content target 409.5 ksfd
  - Allow 30 kcfs outflow to have a higher priority than content target
  - Max Qout in all periods 35,000 cfs
  - Target end of month contents
    - July: 391.5 ksfd
    - August1: 373.5 ksfd
    - August2 349.4 ksfd

  - September: 309.7 ksfd

Specific Operations/Assumptions in Flood Risk Modeling:

- Upper rules curves during draft are based on current SRDS
- Target refill by June 30.

Specific Operations/Assumptions in Power Modeling:

- Generic operation based on the AER.

Specific Operations/Assumptions in BiOp Modeling:

- Fall Chinook operation: 8,500-12,000 cfs flows from October 18-December 10.

GRAND COULEE
Flows:

- Min flow: 30,000 cfs
- Max flow: can vary by period due to higher priority constraints

Elevation/Content:

- Min elevation: 1,208 ft
- Max elevation: 1,290 ft (considered full at 1,288 ft)

HydSim Considerations

- OnCall GCL URCs received from ResSim and incorporated in HYMOD
- GCL draft rate limits are 1.3 ft/day for elevations above 1,240 ft, and 1 foot/day for elevations below 1,240 ft, switch in the HydDef.
- Targets:
  - October: Operate between 1,283 ft and 1,288 ft to keep BON Qo < 110 kcfs
  - November: Operate between 1,275 ft and 1,288 ft to meet BON Qo of 115 kcfs
  - December: Operate between 1,270 ft and 1,288 ft to meet BON qo of 125-140 kcfs
  - January-February: Upper limit 1,288 ft
  - June lower draft limit of 1,285 ft for MCN flow targets; upper draft limit of 1,288 ft; target 1,287 ft
  - Jul-AG2 fill no higher than 1,288 ft for flexibility
  - September: variable target, as September operation is based on economics
- Increase AG1 elevation target by up to 2 ft to smooth MCN Qo between AG1-AG2 (if drop is greater than 30 kcfs)
- GCL contents adjusted in January-March to smooth BON Qo.
- GCL can release to maintain a minimum of 70 kcfs at BON.

- AG2 draft target is variable based on July Water Supply forecast, either 2,217.5 ksfd or 2,295.3 ksfd; AG1 draft target is set to be higher than the AG2 target by 78 ksfd.
- Drumgate operations are set for February, May, April1 and April2 URCs if the Drumgate criteria are met. If the Drumgate criteria are met, the URCs are set to February: 1,267 ft; March, April1 and April2: 1,255 ft
- Whether a year meets Drumgate criteria are decided with the following priorities:
  - Forecast: based solely on the February forecast of the April 30 URC; if the April 30 URC is at 1,255 ft or lower, then the February-April 30 URCs is set as above.
  - Frequency: If frequency criteria (1 in 3 years, 2 in five years, 3 in seven years) are not met, force years to become Drumgate years with the Drumgate URCs.
  - Range Rule: If the February forecast of the April 30th URC is within 10 ft of the Drumgate elevation *and* the previous year was not a Drumgate year, force February-April URCs to Drumgate elevations.
- Variable Draft Limits (VDLs) in January-March set as a lower draft limit to maintain an 85 percent probability of reaching the April 10 elevation objective; set 10 ft below URC; Absolute minimum VDL: elevation 1,260 ft in January, 1,250 ft in February, 1,240 ft in March
- When applying Lack of Market adjustments, when possible, reductions in generation may be realized by reducing draft at GCL.

Specific Operations/Assumptions in Power Modeling:

- The September end of month elevations can vary widely due to power market considerations; this variation is simulated through 80 years of fixed end of month targets that vary according to January-July water volume at The Dalles.
- January, February and March minimum elevations are set as Variable Draft Limits (“VDLs”). These VDLs are a minimum elevation with an 85 percent probability of reaching the April 10th elevation target for refill. Grand Coulee can operate between the VDLs and URC depending on power needs.
- Based on flows at Bonneville in January, February, and March, Grand Coulee’s outflows may be adjusted to attempt to equally distribute flows over this period.
- Lack of Market spill applied at GCL per TMT spill priority list; assumes regulating outlet (“RO”) spill in March to June, and drumgate spill in remainder of the year.
- When applying Lack of Market adjustments, when possible, reductions in generation may be realized by reducing draft at GCL.

Specific Operations/Assumptions in BiOp Modeling:

- Vernita Bar and Steelhead flow objectives are met by drafting Grand Coulee.

Specific Operations/Assumptions for Flood Risk Modeling:

- Upper rules curves are based on current SRDs, adjusted for upstream storage.
- Minimum flow 30,000 cfs

- Supports minimum flows downstream of Bonneville (between 70 and 100 kcfs depending on average inflows)
- Refill begins 1 day before the ICF
- Refill operations target a straight-line refill to an end-of-June value of 1,287 ft. If the 5-day average flows at The Dalles are above 500 kcfs, the refill operation targets an elevation towards 1,282 ft to allow for more space to be reserved for flood risk management. If the project is filling too fast, the ICF is also adjusted upward. In July, final refill will occur after the 4th of July where Grand Coulee fills 25 percent of the remaining storage each day and targets a full elevation of 1,290 ft on July 7th.
- When needed, Grand Coulee refills in coordination with Arrow (SynRes) to control flows at TDA
- Full shift at GCL assumed between DWR and GCL. No Brownlee shift.
- On Call: Grand Coulee drafts to empty by April 30 (subject to draft rate limitations)

BANKS LAKE

Columbia Basin Irrigation Project Pumping (Banks Lake) data submittal estimates of pumping, which are based on the average of the past five years actual pumping and include the equivalent of 5 ft (65.5 ksfd) flow augmentation in August and the associated increase in pumping to return those 5 ft to Banks Lake. In ResSim, Banks Lake is modeled as a diversion (net pumping provided by USBR). Return flows are included in the 2010 Level Modified Flows.

Lower Snake River Projects

HYDSIM CONSIDERATIONS

- Lower Snake projects first-coded in HYMOD file to an average annual operation with Minimum Operating Pool ("MOP") during set period, and full the rest of the year.
  - LWG: on MOP April 3 – October 31, 733 ft/Full = 738 ft (245.8 ksfd)
  - LGS: on MOP April 3 – September 1, 633 ft/ Full = 638 ft.
  - LMN: on MOP Apil 3 – September 1, 537 ft/Normal Pool 540 ft
  - IHR: on MOP April 3 – September 1, 437 ft/Full = 440 ft
- Spill operation based on 2017 Fish Passage plan (see BiOp section) During fish passage season, the lower Snake projects are required to operate within 1 percent peak generation efficiency resulting in a decrease in availability at those projects in those periods.

Specific Operations/Assumptions in Flood Risk Modeling:

- None – same as above.

Specific Operations/Assumptions in Power Modeling:

- Lack of Market spill modelled per TMT spill priority list includes lower Snake projects in all periods.

- No reserves are carried by lower Snake projects when operating in MOP; reserves are allocated to the lower Snake River projects during all other periods, resulting in a reduction in the turbine availability for those projects in those periods.

Specific Operations/Assumptions in BiOp Modeling:

- Spill Operation based on 2017 Fish Passage Plan
  - IHR
    - April 3 – April 28: 45 kcfs daytime and Water Quality TDG waiver level at night.
    - April 29th through July 13: Alternating 2 days each, 30 percent of total outflow and 45 kcfs spill in daytime and Water Quality TDG waiver level at night
    - July 14th – August 31: 45 kcfs daytime and Water Quality TDG waiver level at night
  - LMN
    - April 3 – June 20: Spill to Water Quality TDG waiver level all hours
    - June 21 – August 31: Spill 17 kcfs all hours
  - LGS
    - April 3 – August 31: Spill 30 percent of total outflow all hours.
  - LWG
    - April 3 – June 20: Spill 20 kcfs all hours
    - June 21 – August 31: Spill 18 kcfs all hours

Mid-Columbia and Lower-Columbia River Projects

HYDSIM CONSIDERATIONS

- Mid-Columbia Projects:
  - Wells spill criteria: From April 12 to August 6 spill 6.5 percent when CHJ Qo < 140 kcfs; spill 10,200 cfs otherwise
  - Chelan: First coded to TSR
  - Priest Rapids:
    - default flow 36,000 cfs;
    - December-May flows dependent on Wanapum Qo
    - Tier1 GCL Qi Threshold: 90 kcfs/ PRD Qmin: 100 kcfs
    - Tier2 GCL Qi Threshold: 120 kcfs/ PRD Qmin 115 kcfs
- Lower Columbia Projects:
  - BON: model at 74.1 ft in all periods

- TDA: 158.1 ft
- MCN: 338.7 ft
- JDA includes Minimum Irrigation Pool ("MIP"): OCT-MAR, 265 ft; AP1-SEP: 262.5 ft

- Noxon operates to a FC operation from TSR ECC
- Spill operation based on 2017 Fish Passage plan (see BiOp section)
- During fish passage season, Bonneville and McNary projects are required to operate within 1 percent peak generation efficiency resulting in a decrease in availability at those projects in those periods.

Specific Operations/Assumptions in Flood Risk Modeling:

- JDA: Assist with winter FRM operations.

Specific Operations/Assumptions in Power Modeling:

- Lack of Market spill modelled per TMT spill priority list includes mid- and lower Columbia projects in all periods.
- Reserves are allocated to the lower Columbia River projects resulting in lower turbine availability at those projects; during fish passage season, McNary project does not hold any reserves.

Specific Operations/Assumptions in BiOp Modeling:

- GCL releases to support Priest Rapids/Vernita Bar steelhead flow objectives.
- Spill Operation at lower Columbia projects are based on 2017 Fish Passage Plan
    - BON: note that corner collector flows of 5,000 cfs are included in "other spill"; the corner collector is only operational when spill is at least 50,000 cfs.
        - April 10 – June 15: 100 kcfs all hours
        - June 16 – August 31: Alternating 2 days each of 85 kcfs day and 121 kcfs at night (day/night hours as outlined in the 2017 FPP), and 95 kcfs all hours
        - Spill for ladder attraction year round, daylight hours only; February and March are halved due to one ladder being closed for maintenance each month.
    - TDA
        - April 10 – August 31: Spill 40 percent of total outflow all hours
    - JDA: note that the minimum spill is 30 kcfs due to structural reasons.
        - April 10 – April 27: Spill 30 percent of total outflow all hours
        - April 28 – July 20: alternating 2 day blocks of spill 30 percent of total outflow all hours and spill 40 percent of total outflow all hours
        - July 21 – August 31: spill 30 percent of total outflow all hours

    - September 1 – November 30 spill for ladder attraction, daylight hours only
  - MCN
    - April 10 – June 15: spill 40 percent of total outflow all hours
    - June 16 – August 31: spill 50 percent of total outflow all hours

Other US projects

SKQ
Flows:

- Min flow: 3,200 cfs
- Max flow: can vary by period due to higher priority constraints

Elevation/Content:

- Min elevation: 2,883.0 ft
- Max elevation: 2,893.0 ft (614.7 ksfd)

HydSim Considerations

- Coded to annual target elevations: 2,891 ft (488.6 ksfd) in October, 2,890 (426.3 ksfd) in November, 2,888 ft (302.8 ksfd) in December, 2,886.3 ft (198.8 ksfd) in January, 2,884.7 ft (101.8 ksfd) in February, 2,883.5 ft (29.9 ksfd) in March, 2,883.8 ft (47.8 ksfd) in April 15, 2,885.3 ft (138.1 ksfd) in April 30, 2,890 ft (426.3 ksfd) in May, full at 2,893 ft (614.7 ksfd) June through August, and 2,892.5 ft (583.1 ksfd) in September.

Specific Operations/Assumptions in Flood Risk Modeling:

- Delay refill after June 15 (but no later than June 30) for years with large and/or late runoff (based on remaining Hungry Horse forecast)

Specific Operations/Assumptions in Power Modeling:

- See HydSim Considerations (above)

ALBENI FALLS
Flows:

- Min flow: 4,000 cfs
- Max flow: 27,000 cfs powerhouse max

Elevation/Content:

- Min elevation: 2,050.99 ft
- Max elevation: 2,062.5 ft

HydSim Considerations

- Targets the following end of month contents:
  - October: 146.1 ksfd

- November through March: 68.6 ksfd
- April 15: 146.1 ksfd
- April 30: 234.7 ksfd
- May: 419 ksfd
- June through August: 570.7 ksfd
- September: 512.4 ksfd

Specific Operations/Assumptions in Flood Risk Modeling:

- Delay refill after June 15 (but no later than June 30) for years with large and/or late runoff (based on remaining Hungry Horse forecast)

Specific Operations/Assumptions in Power Modeling:

- Generic operation, see HydSim Considerations (above)

POST FALLS
Flows:

- Min flow: can vary by period depending on higher priority constraints
- Max flow: can vary by period depending on higher priority constraints

Elevation/Content:

- Min elevation: 2,116.7 ft
- Max elevation: 2,139 ft

HydSim Considerations

- Called Coeur d'Alene Lake: First code to the AER ECC curve.
  - October: 68 ksfd
  - November 47.3 ksfd
  - December: 26.9 ksfd
  - January: 6.7 ksfd
  - February: 0.0 ksfd
  - March: 40.1 ksfd
  - April 15: 84.4 ksfd
  - April 30 through August: 112.5 ksfd
  - September: 91.1 ksfd

Specific Operations/Assumptions in Flood Risk Modeling:

- None – same as above.

Specific Operations/Assumptions in Power Modeling:

- None

Specific Operations/Assumptions in BiOp Modeling:

- None

Modeling Data Sheet: Multi-Objective Alternative 1 (MO1)

Alternative Modeling Summary – Multiple-Objective 1

Table E4 - 4 Alternative Modeling Summary – MO1

Name:	CRSO Multi Object Alternative 1
CRSO Projects	Modified U.S. operations at multiple reservoirs
Flood Risk	Changes were made to the Grand Coulee and Libby upper rule curves for flood risk management. Additionally, winter flood space was included at Grand Coulee. The changes in rule curves designed with an intent to maintain the current level of flood risk.
Power	Some modifications to generation practices that are designed to increase hydropower generation efficiency.
Biological and Water Supply Objectives	Fully meet existing water supply obligations and provide for authorized additional regional water supply. Improve adult, juvenile, and resident fish migration, passage, rearing, and/or survival. Reduce greenhouse gas emissions in the Pacific Northwest.
Modeling System Configuration	Same as the No Action Alternative.
Canadian Treaty Projects	Same as the No Action Alternative.
Hydrologic Data Sets Used for Monte Carlo Evaluation	Same as the No Action Alternative.
Hydrologic Data Sets Used for Monte Carlo Evaluation	Same as the No Action Alternative.
Water Supply Forecast Used for Monte Carlo Evaluation	Same as the No Action Alternative.

Note: all elevations are in NGVD 29

Changes to HydSim Assumptions (General)

- The flows in powerhouse surface passage routes to be constructed at McNary and Ice Harbor projects are reflected by an 8 kcfs and 4 kcfs, respectively, increase in “other spill” at those projects, with the same start and end dates as other fish passage spill at the project.

- Upgrades to adjustable spillway weirs assumed to be included in the spill totals already present.
- Spring spill designed in a block pattern, with 6 weeks of "performance standard plus" spill patterns and 6 weeks of "Spill to Gas Cap" spill in alternating order every year.
- Summer spill in "performance standard plus", with the ending in August at the lower Snake projects based on the historical average date when counts of passing sub-yearling chinook surpassed 300 for four consecutive days, 2010-2017; lower Columbia projects end spill on August 31.
- Contingency reserves may be held within fish passage spill on the lower Snake River and lower Columbia River projects. This reduces the reserve obligation held by other projects in the system, resulting in a higher availability at those projects.
- Changes to flood risk management are incorporated via Corps-provided URCs and refill tables
- Changes to the Upstream Storage Correction method incorporated via an updated GCL URC shift algorithm, as described in the Grand Coulee section.
- Updated availability of Grand Coulee reflects ongoing maintenance of power plants that is more accelerated than current outages to represent a broader range of possible hydraulic capacity during maintenance activities are represented in the HYAVAIL file.
- Water Supply measures (Increased water pumped from Lake Roosevelt and Increased Chief Joseph diversions, and increased Flathead River diversions) are incorporated via a negative adjustment to the flows into relevant projects.
- Changes for Adult fish: Modified timing of lower Snake River Basin reservoir draft described in Dworshak section.
- Changes for resident fish: Changes to summer draft at Libby and Hungry Horse described in the relevant project sections
- John Day change for Avian Predators described in lower Columbia section.
- Updated John Day H/K tables based on estimates of 4.5 percent efficiency improvement after installation of new turbines was unintentionally omitted from the Plant Change file.
- All other assumptions are unchanged from the No Action Alternative

Projects

Canadian Projects

Canadian Projects are unchanged from NAA

US Headwater

LIBBY
HydSim Considerations

- Change to Libby draft and refill operations incorporated via updated URCs and refill table provided from ResSim . They operate to local flood control needs below 6.9MAF and to system needs (same as NAA_FC by end of April) above 6.9 MAF.
- Changes to Libby VarQ incorporated in updated algorithm for setting summer flows and releases.
- End of December elevation target set to 2,420 ft in all years .
- Summer draft operation: Based on the local Libby water supply forecast, set end of September elevation target by interpolating from the following table :

Lib May A-A WSF		September Elev. Target	
Percentile	**kaf**	**feet**	**ksfd**
0	0	2,439	2,061.34
15	4,656.0	2,439	2,061.34
25	5,007.0	2,449	2,280.3
75	6,782.0	2,449	2,280.3
85	7,328.0	2,454	2,394.889
100	99,999	2,454	2,394.889

- All other operations and constraints are same as NAA.

HUNGRY HORSE
HydSim Considerations

- Summer draft operation: Based on the local Hungry Horse water supply forecast, set end of September elevation target by interpolating from the following table :

HGH April-August Volume		September Elev. Target	
Percentile	**kaf**	**feet**	**ksfd**
0	0	3,535.8	1,228.7
10	1,407.0	3,535.8	1,228.7
20	1,579.0	3,546	1,341.3
100	9,999	3,546	1,341.3

- This table accommodates the 3,540 ft and 3,550 ft targets of the original sliding scale draft less an adjustment for the additional irrigation for water supply flexibility.
- COLF minimum flows are increased by 493 cfs when the flow augmentation draft is 20 ft.
- All other operations are the same as No Action Alternative.

DWORSHAK
HydSim Considerations

- Change summer draft operation to provide earlier and later cold water releases for adult fish. (O15)
  - Summer draft begins in June.
  - Target July 31 draft target of 1,560 ft in most years; allow up to 1,565 ft in wettest years.
  - Minimum August 30 elevation of 1,540 ft in wettest 20 percent of water years based on the April-August water supply forecast; 1,545 ft in all other years. Not a target.
  - Target outflows of 4.5 kcfs in AG1 and AG2 to retain water for cooling outflows in September.
  - Target September 30 elevation of 1,520 ft
  - Allow max outflows through entire month of September
- All other operations same as No Action Alternative.

BROWNLEE

No changes from No Action Alternative

GRAND COULEE
HydSim Considerations

- A new Grand Coulee Storage Reservation Diagram ("SRD") is implemented via updated URCs received from ResSim, and an updated refill percentage table. This new SRD was created using the planning draft rate of 0.8 ft/day. This draft rate does not affect operations planning. The SRD also represents increased space to protect against rain-induced flooding. *This increased space in December was inadvertently omitted from the HydSim runs; this space was included starting in January.*
- A new method was implemented to adjust the URCs for upstream storage. The new method used an unadjusted water supply forecast for The Dalles to determine the end of April target contents and then any correction (in terms of a lower target) for when upstream storage reservoirs are higher than flood control would dictate. The amount of the reduction in storage is calculated based on curves that weight the storage in upstream projects by relative flood risk benefits. This new algorithm is used in place of the previous GCL URC shift algorithm.
- The Hydro availability file HYAVAIL has been updated to reflect increased limitations on availably hydraulic capacity through each power plant and spillway to represent maintenance activities at Grand Coulee that are more accelerated than those used in NAA.
- Increased pumping from Lake Roosevelt is modelled as a reduction of natural flows into Grand Coulee.

LOWER SNAKE RIVER PROJECTS
HydSim Considerations

- An additional 0.5 ft of forebay operating range allows the lower Snake River projects to carry some reserves during fish passage season, and is reflected in the HYAVAIL file.
- Contingency reserves may be carried within lower Snake River juvenile fish passage spill. This will reduce the amount of reserves needed to be held at other (non-spilling) projects, resulting in increased availability in the HYAVAIL file for those projects.
- The spring spill operation is a block pattern whose order alternates every year. Spill is calculated on a month-average basis, prorated using a start date of April 3, switching from one block to the other on May 11 every year, and switching to summer spill June 21 every year. The spill operation would be as outlined below.
  - IHR
    - Block 1: Spill 30 percent of total outflow up to waiver-level gascap
    - Block 2: Spill to waiver-level gascap.
  - LMN
    - Block 1: Spill in the Bulk pattern to 120 percent TDG
    - Block 2: Spill in the Uniform pattern to 120 percent TDG
  - LGS
    - Block 1: Spill 30 percent of total outflow up to waiver-level gascap
    - Block 2: Spill to waiver level gascap
  - LWG
    - Block 1: Spill 20 kcfs
    - Block 2: Spill to waiver-level gascap
- The summer spill starting June 21 every year, and would end when the count of the subyearling chinook passing a project exceed 300 for four consecutive days. For modelling purposes, the counts from 2010-2017 (when the projects all had the same structures in place and construction was completed) were tallied and the average “end date” was calculated for each project. The spill calculations where then completed using these end dates to prorate month averages. The spill operation that resulted would be as outlined below.
  - IHR
    - Spill 30 percent of total outflow
    - End date August 6
  - LMN
    - Spill 17 kcfs

    - End date August 6
  - LGS
    - Spill 30 percent of total outflow
    - End date August 21
  - LWG
    - Spill 18 kcfs
    - End date August 18

MID-COLUMBIA AND LOWER-COLUMBIA RIVER PROJECTS
HydSim Considerations

- Contingency reserves may be carried within lower Columbia juvenile fish passage spill. This will reduce the amount of reserves needed to be held at other (non-spilling) projects, resulting in increased availability in the HYAVAIL file for those projects.
- John Day has an additional 0.5 ft of forebay operating range, though this does not impact the amount of reserves we attribute to that project.
- Maintain John Day reservoir elevations to disrupt juvenile salmonid predator reproduction via 1 ft higher minimum elevations (resulting in an operating range of 263.5-265.0 ft) April 1 through May 31 (
- The spring spill operation is a block pattern whose order alternates every year. Spill is calculated on a month-average basis, prorated using a start date of April 10, switching from one block to the other on May 11 every year, and switching to summer spill June 16 every year. The spill operation would be as outlined below.
  - BON:
    - Block 1: Spill 100 kcfs
    - Block 2: Spill to waiver-level gas cap
    - Ladder attraction spill the same as NAA
  - TDA
    - Block 1: spill 40 percent of total outflow to waiver-level gas cap
    - Block 2: spill waiver-level gas cap all hours
  - JDA
    - Block 1: spill 32 percent of total outflow to waiver-level gascap
    - Block 2: spill waiver-level gas cap all hours
    - Ladder attraction spill the same as NAA

- MCN
  - Block 1: Spill 48 percent of total outflow to waiver-level gas cap
  - Block 2: spill waiver-level gas cap all hours

- The summer spill operation is a "performance plus" level of spill, starting June 16 all years and continuing to August 31.
  - BON: spill 95 kcfs all hours
  - TDA: spill 40 percent of total flow to waiver-level gas cap
  - JDA: spill 35 percent of total flow to waiver-level gas cap
  - MCN: spill 57 percent of total flow to waiver-level gas cap
- An additional powerhouse surface passage ("PHSP") route to be constructed at McNary project is modelled by accounting for 8 kcfs flowing through this new structure via an incremental 8,000 cfs in the "other spill" category, April through the end of August.
- With the PHSP route, fish screens will no longer be installed at McNary project. This will result in an increase in the availability ratios reflected in the HYAVAIL file.
- *Installation of high-efficiency/capacity turbines at John Day were unintentionally omitted from the H/K table (Plant change input file) and should have reflected a 4.5 percent increase in efficiency.* The outage and availability values were appropriately updated in the HYAVAIL file.

OTHER US PROJECTS
SKQ

No change to SKQ from the No Action Alternative.

Albeni Falls

No change to Albeni Falls from the No Action Alternative.

Post Falls

No change to Post Falls from the No Action Alternative.

Modeling Data Sheet: Multi-Objective Alternative 2 (MO2)

Alternative Modeling Summary – Multiple-Objective 2

Table E4 - 5. Alternative Modeling Summary – MO2

Name:	CRSO Multi Object Alternative 2
CRSO Projects	Modified U.S. operations at multiple reservoirs
Flood Risk	Changes were made to the Grand Coulee and Libby upper rule curves for flood risk management. Additionally, winter flood space was included at Grand Coulee. The changes in rule curves designed with an intent to maintain the current level of flood risk.
Power	Some modifications to generation practices that are designed to increase hydropower generation efficiency.
Biological and Water Supply Objectives	Fully meet existing water supply obligations, same as the No Action Alternative. Improve adult, juvenile, and resident fish migration, passage, rearing, and/or survival. Reduce greenhouse gas emissions in the Pacific Northwest.
Modeling System Configuration	Same as the No Action Alternative.
Canadian Treaty Projects	Same as the No Action Alternative.
Hydrologic Data Sets Used for Monte Carlo Evaluation	Same as the No Action Alternative.
Hydrologic Data Sets Used for Monte Carlo Evaluation	Same as the No Action Alternative.
Water Supply Forecast Used for Monte Carlo Evaluation	Same as the No Action Alternative.

Note: all elevations are in NGVD29

Changes to HydSim Assumptions (General)

- Increased flows to account for powerhouse surface passage routes constructed at John Day, McNary and Ice Harbor projects reflected by an increase of 8 kcfs, 8 kcfs and 4 kcfs, respectively, in “other spill” at those projects, with the same start and end dates as other fish passage spill.
- The powerhouse surface passage routes eliminate the need to install fish screens, resulting in an increase in turbine availability from the No Action Alternative for periods where there would have been fish screens installed.
- Upgrades to adjustable spillway weirs (ASW) assume ASW spill of 11 kcfs per weir in spring and 7 kcfs per weir in summer. If spill at the projects needs to be increased over that as called for by measure O1 to accommodate the new ASW, it was increased to cover the

required spill. The end of spring spill is June 15 in the lower Columbia projects, and June 20 on the lower Snake River projects.

- Fish passage spill is limited to 110 percent total dissolved gas (TDG), but is marginally higher where additional spill is required for powerhouse surface passage (PHSP), weirs, and/or adult ladder attraction. Spill starts April 3rd at lower Snake River projects and April 10th at lower Columbia River projects; fish passage spill ends July 31.
- Flow and pool elevation restrictions are lifted as outlined in individual projects.
- Restrictions to operate turbines within 1 percent of peak efficiency are eliminated, resulting in increased availability during fish passage season.
- Contingency reserves were held within fish passage spill on the lower Snake River and lower Columbia River projects. This reduced the reserve obligation held by other projects in the system, resulting in a higher availability at those projects.
- Changes to flood risk management were incorporated via the Corps-provided URCs and refill tables.
- The variable end-of-December draft target at Libby was replaced with a single draft target.
- Changes to the Upstream Storage Correction method were incorporated via an updated GCL URC shift algorithm, as described in the Grand Coulee section.
- Grand Coulee turbine availability was modified to reflect ongoing maintenance that is more accelerated than current outages.
- Summer elevation and draft targets were modified at Libby and Hungry Horse as described.
- *Updated John Day H/K tables based on estimates of 4.5 percent efficiency improvement after installation of new turbines was unintentionally omitted from the Plant Change file.*
- All other assumptions are unchanged from the No Action Alternative

Projects

Canadian Projects

Canadian Projects are unchanged from NAA

US Headwater

LIBBY
HydSim Considerations

- Change to Libby draft and refill operations incorporated via updated URCs and refill table provided from ResSim. They operate to local flood control needs below 6.9MAF and to system needs (same as NAA_FC by end of April) above 6.9 MAF.
- Changes to Libby VarQ incorporated in updated algorithm for setting summer flows and releases.

- End of December elevation target set to 2,400 ft in all years, with an extra 20 ft of draft for hydropower).
- Summer draft operation: Based on the local Libby water supply forecast, set end of September elevation target by interpolating from the following table :

Lib May A-A WSF		September Elev. Target	
Percentile	**kaf**	**feet**	**ksfd**
0	0	2,439	2,061.34
15	4,656.0	2,439	2,061.34
25	5,007.0	2,449	2,280.3
75	6,782.0	2,449	2,280.3
85	7,328.0	2,454	2,394.889
100	99,999	2,454	2,394.889

- All other operations and constraints are same as NAA.

HUNGRY HORSE
HydSim Considerations

- Summer draft operation: Based on the local Hungry Horse water supply forecast, set end of September elevation target by interpolating from the following table :

HGH April-Aug Volume		September Elev. Target	
Percentile	**kaf**	**feet**	**ksfd**
0	0	3,540	1,275.1
10	1,407.0	3,540	1,275.1
20	1,579.0	3,550	1,386.7
100	9,999	3,550	1,386.7

- Draft deeper for hydropower: Set April 10th target to 10 ft below URC; set January, February, and March lower limits to achieve a 90 percent probability of filling to the April 10th target. Set April 15, April 30 and May 31 targets to 10 ft below URC.
- All other operations are the same as No Action Alternative.

DWORSHAK
HydSim Considerations

- Draft deeper for hydropower: Set April 10th target to 10 ft below URC; set January, February, and March lower limits to achieve a 90 percent probability of filling to the April 10th target. Set April 15, April 30 and May 31 targets to 10 ft below URC.
- All other operations same as No Action Alternative.

BROWNLEE

No changes from No Action Alternative

GRAND COULEE
HydSim Considerations

- A new Grand Coulee Storage Reservation Diagram ("SRD") is implemented via updated URCs received from ResSim, and an updated refill percentage table. This new SRD was created using the planning draft rate of 0.8 ft/day. This draft rate does not affect operations planning. The SRD also represents increased space to protect against rain-induced flooding. *This increased space in December was inadvertently omitted from the HydSim runs; this space was included starting in January.*
- A new method was implemented to adjust the URCs for upstream storage. The new method used an unadjusted water supply forecast for The Dalles to determine the end of April target contents and then any correction (in terms of a lower target) for when upstream storage reservoirs are higher than flood control would dictate. The amount of the reduction in storage is calculated based on curves that weight the storage in upstream projects by relative flood risk benefits. This new algorithm is used in place of the No Action Alternative GCL URC shift algorithm.
- The Hydro availability file HYAVAIL has been updated to reflect increased limitations on hydraulic capacity through each power plant and spillway to represent maintenance activities at Grand Coulee that are more accelerated than those used in the No Action Alternative.
- Draft deeper for hydropower:
    - September target minimum is 1,277 ft; October minimum target is 1,283 ft. As both month-end targets are a hydropower operation, the end elevations are variable depending on the year's market conditions. A similar method to No Action Alternative correlates flow at The Dalles (as a proxy for market strength) with how deep Grand Coulee should be drafted in a year.
    - The April 10^{th} target will be 10 ft below URC; the January, February and March minimums will be set to have a 90 percent probability of achieving the April 10^{th} target.
    - Contents will be adjusted January and February for a hydropower operation.
- All other operations same as No Action Alternative.

LOWER SNAKE RIVER PROJECTS
HydSim Considerations

- An additional powerhouse surface passage ("PHSP") route to be constructed at Ice Harbor project is modelled by accounting for 4 kcfs flowing through this new structure via an incremental 4,000 cfs in the "other spill" category, April through the end of July.
- Spillway weirs are replaced with adjustable spillway weirs (ASWs), with flows of 11 kcfs in spring through June 20 and 7 kcfs in summer. LGS already has an ASW so this does not apply at that project.

- The spill operation is as close to 110 percent TDG as feasible given operational or structural minimums. Spill is April 3 through July 31.
  - IHR
    - 110 percent TDG spill: 10 kcfs
    - April-May 110 percent TDG spill will be overwritten with 11 for ASW.
  - LMN
    - April 110 percent TDG spill: 15 kcfs
    - May 110 percent TDG spill is 10 kcfs; will be overwritten with 11 for measure S4
    - June 110 percent TDG spill is 10 kcfs which is sufficient to cover the ASW with the June 20 end of 11 kcfs and June 21 start of 7 kcfs
  - LGS
    - April 110 percent TDG spill: 15 kcfs
    - May- July 110% TDG spill: 10 kcfs
  - LWG
    - 110 percent TDG spill: 15 kcfs
    - July is 110 percent TDG spill is 5 kcfs so will be overwritten with 7 kcfs for measure S4
- Using the full range of forebay operating range allows the lower Snake River projects to carry more reserves during fish passage season, and is reflected in the HYAVAIL file. Set lower Snake River projects' maximum elevations to full, and first code elevations at full to represent the larger operating range.
- Operate turbines across their full range of capacity (no longer restrict turbine operations to within 1 percent of peak efficiency during fish passage season). This will increase their capacity and therefore increase their availability.
- Contingency reserves may be carried within lower Snake River juvenile fish passage spill. This will reduce the amount of reserves needed to be held at other (non-spilling) projects, resulting in increased availability in the HYAVAIL file for those projects.

MID-COLUMBIA AND LOWER-COLUMBIA RIVER PROJECTS
HydSim Considerations

- Installation of high-efficiency/capacity turbines at John Day were unintentionally omitted from the H/K table (Plant change input file) and should have reflected a 4.5 percent increase in efficiency. The outage and availability values were appropriately updated in the HYAVAIL file.

- An additional powerhouse surface passage ("PHSP") route to be constructed at McNary and John Day projects is modelled by accounting for 8 kcfs flowing through this new structure via an incremental 8 kcfs in the "other spill" category from April through the end of July.
- With the PHSP route, fish screens will no longer be installed at McNary and John Day projects. This will result in an increase in the availability ratios in fish passage season, reflected in the HYAVAIL file.
- Spillway weirs at McNary and John Day projects are replaced with Adjustable spillway weirs (ASWs), with flows of 11 kcfs in spring through June 20 and 7 kcfs in summer. Spill at John Day (see below) is sufficient to include these flows but spill at McNary needs to be adjusted.
- Contingency reserves may be carried within lower Columbia juvenile fish passage spill. This will reduce the amount of reserves needed to be held at other (non-spilling) projects, resulting in increased availability in the HYAVAIL file for those projects.
- John Day may operate within the full reservoir operating range year round. Upper limits at John Day are set to full (as opposed to a lower seasonal max reflecting the minimum irrigation pool plus 1.5 ft in the No Action Alternative), and first-coded to 2/3 full to represent flexibility in the monthly time step model.
- The spill operation is as close to 110 percent TDG as feasible given operational or structural minimums. Spill is from April3 through July 31.
  - BON:
    - Spill at 110 percent TDG is only 5 kcfs; minimum spill to operate the corner collector is 50 kcfs. This is very close to the 115 percent TDG spill (45 kcfs), so spill is set to 50 kcfs from April 3 through July 31.
    - Corner collector spill is 5 kcfs, and is accounted for in the SO spill. The corner collector spill in March and August is removed, since spill is below 50 kcfs.
  - TDA
    - Spill 40 percent, with spill cap at 110 percent TDG spill levels.
  - JDA
    - 110 percent TDG spill at John Day is between 5 kcfs and 15 kcfs; however, when spill at John Day is below 30 percent of outflows, dangerous eddies form. Therefore spill at John Day is set to 30 percent of outflow and the 115 percent TDG spill is used as a cap. This will still result in some periods with spill below 30 percent when inflows are low, but overall far fewer dangerous spill-related eddies are expected to form.
  - MCN
    - 110 percent TDG spill at McNary is between 5 kcfs and 15 kcfs; however, Structural Measure 4 has the two spillway weirs upgraded to ASWs with flows of 11 kcfs each through June 15, so spill is 22 kcfs for the spring spill through June 15

- Summer spill (starting June 16) is set to 110 percent TDG which is enough to cover 2 ASWs at 7 kcfs each as outlined by Structural Measure 4.

OTHER US PROJECTS
SKQ

No change to SKQ from the No Action Alternative.

Albeni Falls

- No change to Albeni Falls from the No Action Alternative.

Post Falls

- No change to Post Falls from the No Action Alternative.

Modeling Data Sheet: Multi-Objective Alternative 3 (MO3)

Alternative Modeling Summary – Multiple-Objective 3

Table E4 - 6. Alternative Summary – MO3

Name:	CRSO Multi Object Alternative 3
CRSO Projects	Modified U.S. operations at multiple reservoirs
Flood Risk	Changes were made to the Grand Coulee and Libby upper rule curves for flood risk management. The changes in rule curves designed with an intent to maintain the current level of flood risk.
Power	Some modifications to generation practices that are designed to increase hydropower generation efficiency.
Biological and Water Supply Objectives	Fully meet existing water supply obligations and provide for authorized additional regional water supply. Improve adult, juvenile, and resident fish migration, passage, rearing, and/or survival. Reduce greenhouse gas emissions in the Pacific Northwest.
Modeling System Configuration	Same as the No Action Alternative.
Canadian Treaty Projects	Same as the No Action Alternative.
Hydrologic Data Sets Used for Monte Carlo Evaluation	Same as the No Action Alternative.
Hodrologic Data Sets Used for Monte Carlo Evaluation	Same as the No Action Alternative.
Water Supply Forecast Used for Monte Carlo Evaluation	Same as the No Action Alternative.

Note: all elevations are in NGVD 29

Changes to HydSim Assumptions (General)

- Lower Snake River dams are simulated as removed by designating them as non-generating reservoirs and passing inflow; in HydSim all inputs associated with generation, flow requirements, and content targets are removed.
- Increased flows to account for powerhouse surface passage routes (PHSP) to be constructed at McNary project are reflected by an 8 kcfs increase in "other spill" with the same start and end dates as other fish passage spill at the project.
- The powerhouse surface passage routes eliminate the need to install fish screens, resulting in an increase in turbine availability from the No Action Alternative for the duration in those periods where there would have been fish screens installed.
- Upgrades to adjustable spillway weirs (ASWs) assumed to be included in the spill totals already present.
- Spring fish passage spill is set to levels determined to cap at 120 percent total dissolved gas (TDG), or as close as possible while still maintaining minimum turbine flow requirements. Spring spill starts April 10 at all lower Columbia River projects, and ends June 15.
- Summer spill at the lower Columbia River projects is the same as the No Action Alternative but will end at midnight July 31.
- The state of Washington spill cap waiver is assumed to be 120 percent TDG during both spring and summer spill season (no 115 percent in the downstream forebay requirement) to accommodate the spring spill regime.
- Flow and pool elevation restrictions at John Day are lifted as outlined lower Columbia River projects section.
- Operation of turbines within and above 1 percent peak efficiency only increases turbine availability at relevant projects during the fish passage season. This change is represented in the HYAVAIL file.
- Summer elevation and draft targets were modified at Libby and Hungry Horse as described in the relevant project sections.
- Contingency reserves may be held within fish passage spill on the lower Columbia River projects. This reduced the reserve obligation held by other projects in the system, resulting in a higher availability at those projects. These changes are reflected in the HYAVAIL file.
- Changes to flood risk management were incorporated via Corps-provided URCs, SRDs, and refill tables.
- The end-of-December variable draft target at Libby was replaced with a single draft target.
- Changes to the Upstream Storage Correction method incorporated via an updated GCL URC shift algorithm, as described in the Grand Coulee section.
- Grand Coulee turbine availability was modified to reflect ongoing maintenance that is more accelerated than current outages.

- Water Supply measures (Increased water pumped from Lake Roosevelt and Increased Chief Joseph diversions, and increased Flathead River diversions) are incorporated via a negative adjustment to the flows into relevant projects.
- *Updated John Day H/K tables based on estimates of 4.5* percent *efficiency improvement after installation of new turbines was unintentionally omitted from the Plant Change file.*
- All other assumptions are unchanged from the No Action Alternative

Projects

Canadian Projects

Canadian Projects are unchanged from NAA

US Headwater

LIBBY
HydSim Considerations

- Change to Libby draft and refill operations incorporated via updated URCs and refill table provided from ResSim . They operate to local flood control needs below 6.9 MAF and to system needs (same as NAA_FC by end of April) above 6.9 MAF.
- Changes to Libby VarQ incorporated in updated algorithm for setting summer flows and releases.
- End of December elevation target set to 2,420 ft in all years, with allowance for additional draft of 20 ft.
- Summer draft operation: Based on the local Libby water supply forecast, set end of September elevation target by interpolating from the following table :

Lib May A-A WSF		September Elev. Target	
Percentile	**kaf**	**Feet**	**ksfd**
0	0	2,439	2,061.34
15	4,656.0	2,439	2,061.34
25	5,007.0	2,449	2,280.3
75	6,782.0	2,449	2,280.3
85	7,328.0	2,454	2,394.889
100	99,999	2,454	2,394.889

- All other operations and constraints are same as the No Action Alternative.

HUNGRY HORSE
HydSim Considerations

- Summer draft operation: Based on the local Hungry Horse water supply forecast, set end of September elevation target by interpolating from the following table :

HGH April-August Volume		September Elev. Target	
Percentile	**kaf**	**Feet**	**ksfd**
0	0	3,535.8	1,228.7
10	1,407.0	3,535.8	1,228.7
20	1,579.0	3,546	1,341.3
100	9,999	3,546	1,341.3

- This table accommodates the 3,540 ft and 3,550 ft targets of the original sliding scale draft less an adjustment for the additional irrigation for water supply flexibility.
- COLF minimum flows are increased by 493 cfs when the flow augmentation draft is 20 ft.
- All other operations and constraints are same as the No Action Alternative.

DWORSHAK

- Due to the conversion of all lower Snake River projects to non-generating reservoirs, all flow targets for them have been removed. All codes that require Dworshak to be drafted for lower Snake River projects flow requirements were also removed.

BROWNLEE

No changes from No Action Alternative

GRAND COULEE
HydSim Considerations

- A new Grand Coulee Storage Reservation Diagram ("SRD") is implemented via updated URCs received from ResSim, and an updated refill percentage table. This new SRD was created using the planning draft rate of 0.8 ft/day. This draft rate does not affect operations planning.
- A new method was implemented to adjust the URCs for upstream storage. The new method used an unadjusted water supply forecast for The Dalles to determine the end of April target contents and then any correction (in terms of a lower target) for when upstream storage reservoirs are higher than flood control would dictate. The amount of the reduction in storage is calculated based on curves that weight the storage in upstream projects by relative flood risk benefits. This new algorithm is used in place of the No Action Alternative GCL URC shift algorithm.
- The Hydro availability file HYAVAIL has been updated to reflect increased limitations on hydraulic capacity through each power plant and spillway to represent maintenance activities at Grand Coulee that are more accelerated than those used in the No Action Alternative.
- All other operations and constraints are same as the No Action Alternative.

LOWER SNAKE RIVER PROJECTS
HydSim Considerations

- All lower Snake River projects are reclassified to non-generating reservoirs that will pass inflow.
  - Deleted all codes that require Dworshak to be drafted for lower Snake River projects flow requirements.
  - Deleted all codes that required drafting for water budget for the lower Snake River projects.
  - Commented out all references to spill at the lower Snake River projects.
  - Deleted all upper rule curves for lower Snake River projects.
  - Deleted all availability ratios for lower Snake River projects from the HYAVAIL file.
  - Removed all lower Snake River projects from the Spill Allocation file for allocating over generation spill.
  - Removed other references as required (e.g. H/K tables, plant update information, rule curves, initial contents, first codes, and storage requirements).

MID- AND LOWER-COLUMBIA RIVER PROJECTS
HydSim Considerations

- Installation of high-efficiency/capacity turbines at John Day were unintentionally omitted from the H/K table (Plant change input file) and should have reflected a 4.5 percent increase in efficiency. The outage and availability values were appropriately updated in the HYAVAIL file.
- An additional powerhouse surface passage ("PHSP") route to be constructed at McNary is modelled by accounting for 8 kcfs flowing through this new structure via an incremental 8 kcfs in the "other spill" category, April through the end of July.
- With the PHSP route, fish screens will no longer be installed at McNary project. This will result in an increase in the availability ratios in fish passage season, reflected in the HYAVAIL file. (S4)
- The spring spill operation set to 120 percent TDG for all projects. Spring spill is April 10 through June 15.
- The summer spill operation is the same as the No Action Alternative, but ends July 31.
- The state of Washington spill cap waiver is assumed to be 120 percent TDG in the tailrace during both spring and summer spill season (not also restricting TDG in the downstream forebay to a maximum of 115 percent TDG).
- Contingency reserves may be carried within lower Columbia River juvenile fish passage spill. This will reduce the amount of reserves needed to be held at other (non-spilling) projects, resulting in increased availability in the HYAVAIL file for those projects.

- John Day may operate within the full reservoir operating range year round. Upper limits at John Day are set to full (as opposed to a lower seasonal max reflecting the minimum irrigation pool plus 1.5 ft in the No Action Alternative), and first-coded to 2/3 full (265 ft) to represent flexibility in the monthly time step model.
- All other operations and constraints are same as the No Action Alternative.

OTHER US PROJECTS
SKQ

No change to SKQ from the No Action Alternative.

Albeni Falls

No change to Albeni Falls from the No Action Alternative.

Post Falls

No change to Post Falls from the No Action Alternative.

Modeling Data Sheet: Multi-Objective Alternative 4 (MO4)

Alternative Modeling Summary – Multiple-Objective 4

Table E4 - 7. Alternative Summary – MO4

Name:	**CRSO Multi Object Alternative 4**
CRSO Projects	Modified U.S. operations at multiple reservoirs
Flood Risk	Changes were made to the Grand Coulee and Libby Dam upper rule curves for flood risk management. Additionally, winter flood space was included at Grand Coulee Dam. The changes in rule curves designed with an intent to maintain the current level of flood risk.
Power	Some modifications to generation and operation practices that are designed to increase hydropower generation efficiency.
Biological and Water Supply Objectives	Fully meet existing water supply obligations and provide for authorized additional regional water supply. Improve adult, juvenile, and resident fish migration, passage, rearing, and/or survival. Reduce greenhouse gas emissions in the Pacific Northwest.
Modeling System Configuration	Same as the No Action Alternative.
Canadian Treaty Projects	Same as the No Action Alternative.
Hydrologic Data Sets Used for Monte Carlo Evaluation	Same as the No Action Alternative.

Name:	**CRSO Multi Object Alternative 4**
Water Supply Forecast Used for Deterministic Evaluation	Same as the No Action Alternative.
Water Supply Forecast Used for Monte Carlo Evaluation	Same as the No Action Alternative.

Note: all elevations are in NGVD 29

Changes to HydSim Assumptions (General)

- The flows in powerhouse surface passage routes to be constructed at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, John Day, and McNary projects are reflected by a 4 kcfs (lower Snake River plants) or 8 kcfs (lower Columbia River plants) increase, in "other spill" at those projects, with the same start and end dates as other fish passage spill at the project.
- The additional structure for passage means that there will not be a need for the installation of fish screens, resulting in an increase in turbine availability from the No Action Alternative for the duration in those periods where there would have been fish screens installed.
- Additional 2 kcfs of spill October 1 – November 30 at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary and John Day dams for steelhead through a structural change in the spillway
- Fish passage spill is set to 125 percent total dissolved gas (TDG). Spill starts March 1 at all projects, and ends August 31 at all projects.
- Allow turbines to operate within and above 1 percent peak efficiency at lower Snake and lower Columbia projects during fish passage season
- Contingency reserves may be held within fish passage spill on the lower Snake River and lower Columbia River projects. This reduces the reserve obligation held by other projects in the system, resulting in a higher availability at those projects.
- Operations at Libby, Hungry Horse, Albeni Falls, and Grand Coulee projects have been altered to discharge an additional 2.0 MAF to support spring flow objectives at McNary dam. These changes are described in the relevant project sections.
- Reservoir drawdown to Minimum Operating Pool and associated changes are described in the relevant project sections.
- Changes for resident fish: Changes to summer draft at Libby and Hungry Horse described in the relevant project sections.
- Changes to flood risk management are incorporated via Corps-provided URCs, SRDs, and refill tables.
- Changes to Libby December draft described in the Libby project section.
- Changes to the Upstream Storage Correction method incorporated via an updated GCL URC shift algorithm, as described in the Grand Coulee section.

- Updated availability of Grand Coulee turbines reflects ongoing maintenance of power plants that is more accelerated than current outages to represent a broader range of possible hydraulic capacity during maintenance activities; represented in the HYAVAIL file.
- Water Supply measures (Increased water pumped from Lake Roosevelt and Increased Chief Joseph diversions, and increased Flathead River Diversions) are incorporated via a negative adjustment to the flows into relevant projects.
- *Updated John Day H/K tables based on estimates of 4.5* percent *efficiency improvement after installation of new turbines was unintentionally omitted from the Plant Change file.*
- All other assumptions are unchanged from the No Action Alternative

Projects

Canadian Projects

Canadian Projects are unchanged from NAA

US Headwater

LIBBY
HydSim Considerations

- Change to Libby draft and refill operations incorporated via updated URCs and refill table provided from ResSim. They operate to local flood control needs below 6.9 MAF and to system needs (same as NAA_FC by end of April) above 6.9 MAF.
- Changes to Libby VarQ incorporated in updated algorithm for setting summer flows and releases.
- End of December elevation target set to 2,420 ft in all years.
- Summer draft operation: Based on the local Libby water supply forecast, set end of September elevation target by interpolating from the following table :

Lib May A-A WSF		September Elev. Target	
Percentile	kaf	feet	ksfd
0	0	2,439	2,061.34
15	4,656.0	2,439	2,061.34
25	5,007.0	2,449	2,280.3
75	6,782.0	2,449	2,280.3
85	7,328.0	2,454	2,394.889
100	99,999	2,454	2,394.889

- Libby provides 26.69 percent of the required flow augmentation during May – July to meet the McNary flow target.
- All other operations and constraints are same as the No Action Alternative.
- A maximum downstream elevation of 1,753 ft at the Bonners Ferry gauge is not binding in HydSim.

HUNGRY HORSE
HydSim Considerations

- Summer draft operation: Based on the local Hungry Horse water supply forecast, set end of September elevation target by interpolating from the following table :

HGH April-August Volume		September Elev. Target	
Percentile	**kaf**	**feet**	**ksfd**
0	0	3,535.8	1,228.7
10	1,407.0	3,535.8	1,228.7
20	1,579.0	3,546	1,341.3
100	9,999	3,546	1,341.3

- This table accommodates the 3,540 ft and 3,550 ft targets of the original sliding scale draft less an adjustment for the additional irrigation for water supply flexibility.
- COLF minimum flows are increased by 493 cfs when the flow augmentation draft is 20 ft.
- Hungry Horse provides 11.6 percent of the required flow augmentation during May – July to meet the McNary flow target.
- All other operations and constraints are same as the No Action Alternative.

DWORSHAK

No changes from No Action Alternative

BROWNLEE

No changes from No Action Alternative

GRAND COULEE
HydSim Considerations

- A new Grand Coulee Storage Reservation Diagram ("SRD") is implemented via updated URCs received from ResSim, and an updated refill percentage table. This new SRD was created using the planning draft rate of 0.8 ft/day. This draft rate does not affect operations planning. The SRD also represents increased space to protect against rain-induced flooding. *This increased space in December was inadvertently omitted from the HydSim runs; this space was included starting in January.*
- A new method was implemented to adjust the URCs for upstream storage. The new method used an unadjusted water supply forecast for The Dalles to determine the end of April target contents and then any correction (in terms of a lower target) for when upstream storage reservoirs are higher than flood control would dictate. The amount of the reduction in storage is calculated based on curves that weight the storage in upstream projects by relative flood risk benefits. This new algorithm is used in place of the No Action Alternative GCL URC shift algorithm.
- The Hydro availability file HYAVAIL has been updated to reflect increased limitations on availably hydraulic capacity through each power plant and spillway to represent

maintenance activities at Grand Coulee that are more accelerated than those used in the No Action Alternative.

- Grand Coulee provides 50.0 percent of the required flow augmentation during May through July to meet the McNary flow target.
- All other operations and constraints are same as the No Action Alternative.

LOWER SNAKE RIVER PROJECTS
HydSim Considerations

- An additional powerhouse surface passage ("PHSP") route to be constructed at all four lower Snake River projects is modelled by accounting for 4 kcfs flowing through this new structure via an incremental 4 kcfs in the "other spill" category, March through the end of August for each project.
- With the PHSP route, fish screens will no longer be installed at the lower Snake River projects. This will result in an increase in the availability ratios in fish passage season, reflected in the HYAVAIL file.
- Additional spill of 2 kcfs for each lower Snake River project, October 1 to November 30 for the 'spillway notch' spill for steelhead.
- The spill operation set to 125 percent TDG for all projects. Spill is March 1 through August 31.
- Contingency reserves may be carried within lower Snake River juvenile fish passage spill. This will reduce the amount of reserves needed to be held at other (non-spilling) projects, resulting in increased availability in the HYAVAIL file for those projects.
- Lower Snake River projects are drawn down to MOP + 1.5 ft from March 15 to Aug 15. The project elevations are set to the middle of the operating range to represent within-month flexibility.
- Operate turbines within and above 1 percent peak efficiency only. This will increase their capacity and therefore increase their availability and is reflected in the availability ratios in the HYAVAIL file.
- All other operations and constraints are same as the No Action Alternative.

MID-COLUMBIA AND LOWER-COLUMBIA RIVER PROJECTS
HydSim Considerations

- Installation of high-efficiency/capacity turbines at John Day were unintentionally omitted from the H/K table (Plant change input file) and should have reflected a 4.5 percent increase in efficiency. The outage and availability values were appropriately updated in the HYAVAIL file.
- An additional powerhouse surface passage ("PHSP") route to be constructed at McNary and John Day projects is modelled by accounting for 8 kcfs flowing through this new structure via an incremental 8 kcfs in the "other spill" category for each project, March through the end of August.

- With the PHSP route, fish screens will no longer be installed at McNary and John Day projects. This will result in an increase in the availability ratios in fish passage season, reflected in the HYAVAIL file.
- The spill operation set to 125 percent TDG for all projects. Spill is March 1 through August 31.
- Contingency reserves may be carried within lower Columbia River juvenile fish passage spill. This will reduce the amount of reserves needed to be held at other (non-spilling) projects, resulting in increased availability in the HYAVAIL file for those projects.
- Lower Columbia River projects are drawn down to MOP + 1.5 ft for Bonneville, The Dalles and John Day and MOP + 1 ft at McNary from March 25 to Aug 15. The projects' elevations are set to the middle of their operating range to represent within-month flexibility.
- All other operations and constraints are same as the No Action Alternative.

OTHER US PROJECTS
SKQ

No change to SKQ from the No Action Alternative.

Albeni Falls

- Albeni Falls provides 11.71 percent of the required flow augmentation during May through July to meet the McNary flow target.

Post Falls

No change to Post Falls from the No Action Alternative.

Modeling Data Sheet: Preferred Alternative (PA)

Alternative Modeling Summary - PA

As part of ongoing ESA consultation with NMFS, a measure to use surface weir spill for adult steelhead was modified in the Preferred Alternative. This measure provides for a small volume of spill through the spillway weirs at five projects, for a few hours each week in March, October, and early November. A short discussion of its impacts are included in Appendix J.

Table E4 - 8. Alternative Modeling Summary - PA

Name:	CRSO Preferred Alternative
CRSO Projects	Modified U.S. operations at multiple reservoirs.
Flood Risk	Changes were made to the Grand Coulee and Libby upper rule curves for flood risk management. The changes in rule curves are designed with an intent to maintain the current level of flood risk.
Power	Some modifications to generation practices that are designed to increase hydropower generation efficiency.
Biological and Water Supply Objectives	Fully meet existing water supply obligations, same as the No Action Alternative. Improve adult, juvenile, and resident fish migration, passage, rearing, and/or survival. Reduce greenhouse gas emissions in the Pacific Northwest.
Modeling System Configuration	Same as the No Action Alternative.
Canadian Treaty Projects	Same as the No Action Alternative.
Hydrologic Data Sets Used for Monte Carlo Evaluation	Same as the No Action Alternative.
Hydrologic Data Sets Used for Monte Carlo Evaluation	Same as the No Action Alternative.
Water Supply Forecast Used for Monte Carlo Evaluation	Same as the No Action Alternative.

Note: all elevations are in NGVD 29

Changes to HydSim Assumptions (General)

- Increased forebay range flexibility for Lower Snake River and John Day projects. The reservoir pools gain operating flexibility from April 3 to August 31 to coincide with the juvenile fish passage season. The operating elevation range restriction at the lower Snake River projects is MOP +1.5 feet and at the John Day project MIP +2 feet, except during the period April 1 to May 31 when the John Day forebay operating range may occasionally be higher for Predation Disruption Operations.
- Updated John Day H/K tables based on estimates of 4.5% efficiency improvement after installation of new turbines are reflected in the Plant Change file.
- Spring and Summer spill designed to model the 2019-2021 Spill Operation Agreement.
- Contingency reserves may be held within fish passage spill on the lower Snake River and lower Columbia River projects. This reduces the reserve obligation held by other projects in the system, resulting in a higher availability at those projects.
- Eliminate restrictions to operate turbines within 1% of peak efficiency, resulting in increased availability during fish passage season.

- Changes to flood risk management are incorporated via USACE-provided URCs and refill tables.
- Changes to the Upstream Storage Correction method incorporated via an updated GCL URC shift algorithm, as described in the Grand Coulee section.
- Updated availability of Grand Coulee reflects ongoing maintenance of power plants that is more accelerated than current outages to represent a broader range of possible hydraulic capacity during maintenance activities are represented in the HYAVAIL file.
- An increase of approximately 45 kaf in water pumped from Lake Roosevelt is incorporated via a negative adjustment to the flows above Grand Coulee.
- Implements Variable Draft Limits at Dworshak, increasing winter draft while targeting a 95% probability of reaching the March 31st Upper Rule Curve.
- The Lake Roosevelt elevation objective of 1283 feet or higher by the end of September may be delayed to an elevation objective of 1283 feet or higher by the end of October.
- Changes for Resident fish: Changes to summer draft at Libby and Hungry Horse described in the relevant project sections.
- John Day change for Avian Predators described in Lower Columbia section.
- Cease installation of fish screens at Ice Harbor, McNary, and John Day projects, resulting in an increase in turbine availability from the No Action Alternative for the duration in those periods where there would have been fish screens installed.
- All other assumptions are unchanged from the No Action Alternative

Projects

Canadian Projects

Canadian Projects are unchanged from NAA

US Headwater

LIBBY
HydSim Considerations

- Change to Libby draft and refill operations incorporated via updated URCs and refill table provided from ResSim. They operate to local flood control needs below 6.9MAF and to system needs (same as NAA_FC by end of April) above 6.9 MAF.
- Changes to Libby VarQ incorporated in updated algorithm for setting summer flows and releases.
- Summer draft operation: Based on the local Libby water supply forecast, set end of September elevation target by interpolating from the following table:

Lib May A-A WSF		September Elev. Target	
Percentile	**kaf**	**feet**	**ksfd**
0	0	2,439	2,061.34
15	4,656.0	2,439	2,061.34
25	5,007.0	2,449	2,280.3
75	6,782.0	2,449	2,280.3
85	7,328.0	2,454	2,394.889
100	99,999	2,454	2,394.889

- All other operations and constraints are same as NAA.

HUNGRY HORSE
HydSim Considerations

- Summer draft operation: Based on the local Hungry Horse water supply forecast, set end of September elevation target by interpolating from the following table:

HGH April-Aug volume		September Elev. Target	
Percentile	**kaf**	**feet**	**ksfd**
0	0	3,540	1,275.1
10	1,407.0	3,540	1,275.1
20	1,579.0	3,550	1,386.7
100	9,999	3,550	1,386.7

- All other operations are the same as No Action Alternative.

DWORSHAK
Hydsim Considerations

- Implements Variable Draft Limits at Dworshak, increasing winter draft while targeting a 95% probability of reaching the URC on March 31st.
- All other operations same as No Action Alternative.

BROWNLEE

No changes from No Action Alternative

GRAND COULEE
Hydsim Considerations

- A new Grand Coulee Storage Reservation Diagram (“SRD”) is implemented via updated URCs received from ResSim, and an updated refill percentage table. This new SRD was created using the planning draft rate of 0.8 ft/day. This draft rate does not affect operations planning. The SRD also represents increased space to protect against rain-induced flooding.
- A new method was implemented to adjust the URCs for upstream storage. The new method used an unadjusted water supply forecast for The Dalles to determine the end of April target contents and then any correction (in terms of a lower target) for when upstream storage reservoirs are higher than flood control would dictate. The amount of the reduction

in storage is calculated based on curves that weight the storage in upstream projects by relative flood risk benefits. This new algorithm is used in place of the previous GCL URC shift algorithm.

- The Hydro availability file HYAVAIL has been updated to reflect increased limitations on availably hydraulic capacity through each power plant and spillway to represent maintenance activities at Grand Coulee that are more accelerated than those used in NAA.
- Increased pumping from Lake Roosevelt is modelled as a reduction of natural flows into Grand Coulee by 45 kaf.
- The end of September target minimum is 1277 feet; the end of October minimum target is 1283 ft. As both month-end targets are a hydropower operation, the end elevations are variable depending on the year's market conditions. A similar method to No Action Alternative correlates flow at The Dalles (as a proxy for market strength) with how deep Grand Coulee should be drafted in a year.

LOWER SNAKE RIVER PROJECTS
Hydsim Considerations

- An additional 0.5' of forebay operating range allows the Lower Snake River projects to carry some reserves during fish passage season, and is reflected in the HYAVAIL file.
- Contingency reserves may be carried within Lower Snake River juvenile fish passage spill. This will reduce the amount of reserves needed to be held at other (non-spilling) projects, resulting in increased availability in the HYAVAIL file for those projects.
- Spring and Summer spill designed to model the 2019-2021 Spill Operation Agreement.

MID-COLUMBIA AND LOWER-COLUMBIA RIVER PROJECTS
Hydsim Considerations

- Contingency reserves may be carried within Lower Columbia juvenile fish passage spill. This will reduce the amount of reserves needed to be held at other (non-spilling) projects, resulting in increased availability in the HYAVAIL file for those projects.
- John Day has an additional 0.5' of forebay operating range, though this does not impact the amount of reserves we attribute to that project.
- Maintain John Day reservoir elevations to disrupt juvenile salmonid predator reproduction via 1' higher minimum elevations (resulting in an operating range of 263.5-265.0') April 1 through May 31.
- Fish screens will no longer be installed at McNary project. This will result in an increase in the availability ratios reflected in the HYAVAIL file.
- Installation of high-efficiency/capacity turbines at John Day are reflected in an updated H/K table (Plant change input file) reflecting a 4.5% increase in efficiency and in an updated outage and availability values in the HYAVAIL file.

OTHER US PROJECTS
SKQ

No change to Kerr from the No Action Alternative.

Albeni Falls

No change to Albeni Falls from the No Action Alternative.

Post Falls

No change to Post Falls from the No Action Alternative.

Columbia River System Operations
Final Environmental Impact Statement

Appendix J
Hydropower

EXECUTIVE SUMMARY

Introduction

This appendix presents the hydropower analyses conducted for the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS). The Bonneville Power Administration (Bonneville), U.S. Army Corps of Engineers (Corps), and U.S. Bureau of Reclamation (Reclamation) are co-lead agencies in developing the CRSO EIS, which is required for the agencies' compliance with the National Environmental Policy Act (NEPA). This appendix is part of a larger set of CRSO EIS documents that detail the efforts of the co-lead agencies in evaluating alternatives for the future operation and configuration of 14 major Federal hydropower projects of the Federal Columbia River Power System (FCRPS) collectively referred to as the Columbia River System (CRS).

This appendix focuses on hydropower effects of the CRSO EIS alternatives. The hydropower studies were conducted by Bonneville in close coordination with the Corps. Bonneville analyses examined the effects of the alternatives on hydropower production, power system reliability, replacement resource needs, and other power obligations. Bonneville also reviewed the potential effects of climate change on the relative effects of the alternatives.

Hydropower results in this appendix contribute to other analyses in the CRSO EIS, including analyses of socioeconomic, air quality, and water quality effects. The results of those other effects are detailed in the appropriate appendices. Modeling details for this hydropower assessment are presented in the *Hydroregulation Appendix I* and *Hydrology and Hydraulics Appendix B (H&H Appendix B).*

Columbia River System Projects

The CRS consists of the 14 major projects operated in coordination with each other for several congressionally authorized purposes, including flood risk management (FRM), navigation, hydropower production, irrigation, fish and wildlife conservation, recreation, municipal and industrial water supply, and water quality. They are a subset of the FCRPS, a network of 31 multi-purpose dam and reservoir projects constructed in the Columbia River and its tributaries in the Pacific Northwest and operated by the Corps and Reclamation. The FCRPS also includes the transmission system built and operated by Bonneville to market and deliver electric power.

The 14 CRS projects examined in detail in the CRSO EIS include six Federal storage projects: Libby, Hungry Horse, Albeni Falls, Grand Coulee, John Day, and Dworshak; and eight Federal run-of-river projects: Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, and Bonneville.

Hydropower production at several non-Federal projects in the Columbia River basin is potentially affected by the CRSO EIS alternative. These non-Federal dams include five Mid-Columbia River dams downstream of Grand Coulee Dam and Chief Joseph Dam; several dams within the United States and Canada on the Flathead, Clark Fork, and Pend Oreille Rivers downstream of Hungry Horse and Albeni Falls Dams; and several Canadian dams on the Kootenay River downstream of Libby Dam. Notable non-Federal dams in the Columbia Basin that are not affected include three Columbia River Treaty (CRT) projects (Mica, Arrow, and Duncan) and Revelstoke Dam in Canada; and the Hells Canyon complex (Brownlee, Oxbow, and Hells Canyon Dams) on the Snake River.

The operation of these dams is coordinated for several purposes. The storage operation of the CRS storage projects, the Hells Canyon complex, and three CRT dams in Canada is coordinated for flood risk management to reduce flooding either locally or for the Columbia River reach below Bonneville Dam. United States and Canadian power production is coordinated per terms of the CRT. All the dams are connected to the Western Interconnection power system and contribute to ensuring transmission grid stability and reliability throughout the West. The 14 CRS projects are also operated to meet several objectives in Biological Opinions intended to reduce and mitigate the effects of the dams.

CRSO EIS Alternatives

In 2016 the co-lead agencies implemented a public scoping process with the public, tribes, local and state governmental agencies, other Federal agencies, non-government entities, and other stakeholders to identify issues that addressed the general purpose and need of the EIS: to review the management of the CRSO projects. The co-lead agencies used the information to develop measures to address the issues. Then the agencies combined these measures into four multiple objective (MO) alternatives. A No Action Alternative (NAA) was also developed for comparing the effects of the alternatives. A draft Preferred Alternative (PA) was then created combining measures from the studied MOs. The following alternatives are evaluated for hydropower effects in this appendix:

- NAA – includes operating rules and structures in place or committed for construction when the Notice of Intent for the EIS was published in September 2016.
- MO1 – includes a number of measures to benefit fish survival, water management, water supply, and hydropower production.
- MO2 – includes measures that emphasize power production, renewable resource integration, and reduction of use of carbon-producing generation resources while also providing for water management and some measures to benefit fish survival.
- MO3 – includes breaching of four lower Snake River dams and adds other measures beneficial to anadromous and resident fish as well as some measures for water management, water supply, and hydropower production.
- MO4 – includes other measures to aid anadromous fish survival without breaching the Snake River dams as well as some measures for resident fish, water management, water supply, and hydropower production.

- PA – combines a number of measures as the preferred alternative to meet the purpose and need, EIS objectives, and environmental, economic, and sociological criteria. In addition, new information about spill operations from the 2018 and 2019 spring fish spill pilot operations that benefit downstream migration of juvenile anadromous fish became available after the range of alternatives was developed. Using this new information, the co-lead agencies modified the measure for juvenile fish spill operation for the preferred alternative using the analysis from the range of spill levels evaluated in the MOs.

Hydropower Analyses

Bonneville conducted several analyses of the effects of the alternatives using its HYDSIM, HOSS, and other regionally accepted models. Most involved simulations for each alternative of the monthly and daily operation of the Columbia River system of dams over an 80-year record of historically based streamflows. Analyses included:

- Energy generation – United States portion of the Columbia River system (NW-US), CRS, Mid-Columbia, and Canadian portion of the Columbia River system average, lowest 10th percentile (P10), and critical water (1937) generation.
- Peak generation – CRS 120-hour peak, Heavy Load Hour P10 peak (HLH P10), and Heavy Load Hour critical water peak (HLH critical water) generation.
- Qualitative assessment of NW-US system effects on integration of renewal resources.
- Hydropower generation for use in EIS socioeconomics and air quality analyses.
- NW-US system reliability and loss-of-load probabilities (LOLP).
- Development and use of least-cost and least-carbon/least-cost resource portfolios needed for system reliability and meeting load growth.
- Hydropower generation effects on Colville tribal payment and Northwest Power Act 4(h)(10)(C) credits.

Summaries of the results follow.

Energy and Peak Generation Results

Energy results for the NW-US and CRS (Federal) systems are provided in this summary; results for Mid-Columbia, and Canadian systems are in the appendix and its exhibits. Table ES - 1 through Table ES - 6summarize the NW-US and CRS (Federal) average, P10, and critical water (1937) generation.

Peak generation results were prepared only for the CRS (Federal) system due to modeling construct. Table ES - 7 through Table ES - 12 summarize the CRS (Federal) 120 peak and HLH average, P10 and critical water peak generation.

The following summaries generally apply to all energy and peak generation metrics and all systems unless otherwise noted.

- The changes in CRS (Federal) are largely the same as for the NW-US system as it is the largest component of the NW-US system. Most of the NW-US generation changes occurred on the CRS system.
- Non-Federal Mid-Columbia system generation results are similar to the NW-US and CRS (Federal) systems because of their location below Grand Coulee. Changes in Federal operations above and at Grand Coulee directly affect the flow of water through the five Mid-Columbia projects, resulting in similar impacts.
- Little change from NAA generation occurred on the Canadian system as a result of the alternatives. All Canadian generation changes occurred at Waneta and Seven Mile Dams on the Pend d'Oreille River downstream of Hungry Horse and Albeni Falls Dams and several other projects on the Kootenay River downstream of Libby Dam.
- NW-US and CRS MO1 and the PA generation were slightly less than the NAA. Increases in CRS spill for fish passage and withdrawals for water supply resulted in NW-US and CRS average generation declines from the NAA during spring and summer months. Generation increases in January resulted from drafts at Grand Coulee and from Libby starting January at a higher elevation. Small changes were observed for the Mid-Columbia and Canadian systems.
- MO2 showed increased generation from the NAA for the NW-US system and CRS. Increased winter storage drafts and reduced amounts and duration of spill for fish passage contributed to United States and CRS increases. All other MO alternatives resulted in less NW-US and CRS generation than the NAA; NW-US and CRS reductions. Changes to the Mid-Columbia and Canadian systems were minimal as they were not affected by CRS fish passage spill measures.
- NW-US and CRS MO3 generation is reduced year-round from the loss of CRS generation at the four lower Snake River dams, although this reduction from NAA generation is offset in August by lower Columbia River projects' generation increases. The greatest reductions from the NAA occur in spring and summer due to increased fish passage spill at the lower Columbia projects. The August NW-US and CRS generation increase results from terminating CRS fish passage spill earlier than the NAA. Small changes were observed for the Mid-Columbia and Canadian systems.
- NW-US and CRS MO4 generation is reduced from NAA generation nearly year-round from increased fish passage spill during the spring and summer and the effects of additional storage use for fish migration which impacts the fall and sometimes the winter. Changes in the storage operation at the upstream CRS projects influenced generation at the Mid-Columbia and Canadian systems.

Study results are summarized within the following tables for several periods:

- The November to February (Nov – Feb) period is generally the time of greatest power demand due to colder winter temperatures; it is also a time when storage reservoir operations for FRM and refill adjust to the water supply forecast.
- The April 16 to July (Apr II – Jul) period is the annual spring runoff, system refill, and numerous measures for improving anadromous and resident fish survival.

The maximum and minimum loss periods identify those months during which the greatest generation changes occur for a specific alternative with respect to the NAA.

Table ES - 1 through Table ES - 6display the average, P10, and critical water (1937) generation for the NW-US, and CRS (Federal) systems.

Table ES - 1. NW-US System Average Generation: Change from NAA

	Average U.S. Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	14018	15672	Variable	Variable	13373
MO1	-4 (0%)	-341 (-2%)	-745 (-6%): AugI	228 (2%): Jan	-173 (-1%)
MO2	429 (3%)	728 (5%)	-380 (-3%): Mar	1574 (13%): AugI	453 (3%)
MO3	-823 (-6%)	-2059 (-13%)	-2786 (-17%): May	716 (7%): AugII	-1137 (-9%)
MO4	-73 (-1%)	-2389 (-15%)	-3549 (-26%): Mar	244 (2%): Jan	-1339 (-10%)
PA	107 (1%)	-912 (-6%)	-1647 (-10%): May	671 (7%): AugII	-229 (-2%)

Table ES - 2. NW-US System P10 Generation: Change from NAA

	P10 U.S. Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	10676	11156	Variable	Variable	10144
MO1	13 (0%)	-645 (-6%)	-1284 (-10%): May	79 (1%): Dec	-280 (-3%)
MO2	444 (4%)	544 (5%)	-458 (-5%): AprI	1158 (12%): AugI	380 (4%)
MO3	-120 (-1%)	-1793 (-16%)	-2892 (-23%): May	573 (7%): AugII	-798 (-8%)
MO4	-34 (0%)	-1105 (-10%)	-2278 (-23%): Mar	17 (0%): Dec	-826 (-8%)
PA	10 (0%)	-757 (-7%)	-1764 (-14%): May	390 (5%): AugII	-197 (-2%)

Table ES - 3. NW-US System Critical Water Generation: Change from NAA

	1937 U.S. Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	10475	11531	Variable	Variable	10297
MO1	12 (0%)	-889 (-8%)	-1390 (-12%): May	177 (2%): Jan	-385 (-4%)
MO2	168 (2%)	759 (7%)	-586 (-5%): Jan	1210 (14%): Feb	348 (3%)
MO3	-179 (-2%)	-1858 (-16%)	-2784 (-24%): May	263 (3%): AugII	-817 (-8%)
MO4	-187 (-2%)	-1456 (-13%)	-2768 (-26%): AugI	-48 (0%): Dec	-980 (-10%)
PA	-155 (-1%)	-1038 (-9%)	-1771 (-16%): May	264 (3%): Oct	-377 (-4%)

Table ES - 4. CRS (Federal) Average Generation: Change from NAA

	Average Federal Generation (aMW)				
	Nov - Feb	Apr II - Jul	Max Loss Period	Max Gain Period	Annual
NAA	8712	9746	Variable	Variable	8339
MO1	4 (0%)	-269 (-3%)	-656 (-9%): AugI	183 (2%): Jan	-132 (-2%)
MO2	326 (4%)	763 (8%)	-282 (-3%): Mar	1641 (22%): AugI	445 (5%)
MO3	-843 (-10%)	-1985 (-20%)	-2749 (-27%): May	801 (11%): AugI	-1105 (-13%)
MO4	-56 (-1%)	-2435 (-25%)	-3535 (-40%): Mar	192 (2%): Jan	-1303 (-16%)
PA	107 (1%)	-834 (-9%)	-1529 (-15%): May	725 (11%): AugII	-205 (-2%)

Table ES - 5. CRS (Federal) P10 Generation: Change from NAA

	P10 Federal Generation (aMW)				
	Nov - Feb	Apr II - Jul	Max Loss Period	Max Gain Period	Annual
NAA	6499	6880	Variable	Variable	6237
MO1	60 (1%)	-603 (-9%)	-1223 (-15%): May	83 (1%): Jan	-228 (-4%)
MO2	296 (5%)	565 (8%)	-303 (-5%): Mar	1310 (21%): AugI	354 (6%)
MO3	-338 (-5%)	-1706 (-25%)	-2785 (-35%): May	705 (13%): AugII	-804 (-13%)
MO4	-30 (0%)	-1515 (-22%)	-2232 (-36%): Mar	42 (1%): Feb	-855 (-14%)
PA	73 (1%)	-942 (-14%)	-1922 (-24%): May	505 (9%): AugII	-236 (-4%)

Table ES - 6. CRS (Federal) Critical Water Generation: Change from NAA

	1937 Federal Generation (aMW)				
	Nov - Feb	Apr II - Jul	Max Loss Period	Max Gain Period	Annual
NAA	6430	6815	Variable	Variable	6237
MO1	8 (0%)	-726 (-11%)	-1215 (-17%): May	125 (2%): Jan	-297 (-5%)
MO2	137 (2%)	824 (12%)	-408 (-6%): Jan	1341 (20%): AugI	378 (6%)
MO3	-241 (-4%)	-1706 (-25%)	-2727 (-38%): May	655 (10%): AugI	-748 (-12%)
MO4	-156 (-2%)	-1517 (-22%)	-2357 (-30%): Jun	-65 (-1%): Dec	-888 (-14%)
PA	-108 (-2%)	-975 (-14%)	-1749 (-24%): May	252 (4%): AugII	-328 (-5%)

Table ES - 7 through Table ES - 12 display the average, P10, and critical water (1937) peak generation for the CRS (Federal) Peak Load (120 Hour), and HLH metrics.

Table ES - 7. CRS (Federal) Peak Load (120 Hour) Generation: Change from NAA

	Average Federal 120 Hour Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	11220	12082	Variable	Variable	10784
MO1	-30 (0%)	-2 (0%)	-728 (-7%): AugI	179 (1%): Jun	-72 (-1%)
MO2	310 (3%)	1013 (8%)	-327 (-3%): Mar	1235 (10%): May	509 (5%)
MO3	-1078 (-10%)	-2004 (-17%)	-2660 (-21%): May	796 (9%): AugII	-1210 (-11%)
MO4	-70 (-1%)	-2383 (-20%)	-4146 (-36%): Mar	78 (1%): Jan	-1400 (-13%)
PA	64 (1%)	-587 (-5%)	-1212 (-10%): May	597 (6%): AugII	-113 (-1%)

Table ES - 8. CRS (Federal) Peak Load (120 Hour) P10 Generation: Change from NAA

	P10 Federal 120 Hour Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	8963	9805	Variable	Variable	8769
MO1	38 (0%)	-616 (-6%)	-1193 (-13%): AugI	103 (2%): AprI	-265 (-3%)
MO2	340 (4%)	704 (7%)	-399 (-5%): Mar	999 (13%): AugII	415 (5%)
MO3	-317 (-4%)	-1679 (-17%)	-2371 (-21%): May	670 (8%): AugII	-787 (-9%)
MO4	-25 (0%)	-1854 (-19%)	-3103 (-36%): Mar	44 (1%): Feb	-1153 (-13%)
PA	59 (1%)	-826 (-8%)	-1539 (-14%): May	394 (5%): Sep	-174 (-2%)

Table ES - 9. CRS (Federal) Peak Load (120 Hour) Critical Water Generation: Change from NAA

	1937 Federal 120 Hour Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	8981	9724	Variable	Variable	8842
MO1	10 (0%)	-837 (-9%)	-1717 (-16%): AugI	162 (2%): AprI	-371 (-4%)
MO2	224 (2%)	884 (9%)	-268 (-3%): Jan	1164 (10%): Jun	419 (5%)
MO3	-249 (-3%)	-1759 (-18%)	-2481 (-26%): May	485 (6%): AugII	-761 (-9%)
MO4	-102 (-1%)	-1480 (-15%)	-3948 (-37%): AugI	-30 (0%): Feb	-1070 (-12%)
PA	-27 (0%)	-773 (-8%)	-960 (-10%): May	319 (3%): Nov	-229 (-3%)

Table ES - 10. CRS (Federal) Average HLH Generation: Change from NAA

	Average HLH Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	10097	11363	Variable	Variable	9832
MO1	-22 (0%)	-136 (-1%)	-708 (-7%): AugI	157 (2%): Sep	-109 (-1%)
MO2	344 (3%)	636 (6%)	-361 (-3%): Mar	1242 (15%): AugII	397 (4%)
MO3	-1015 (-10%)	-2199 (-19%)	-3003 (-25%): May	828 (10%): AugII	-1250 (-13%)
MO4	-72 (-1%)	-2586 (-23%)	-3969 (-39%): Mar	113 (1%): Jan	-1430 (-15%)
PA	75 (1%)	-687 (-6%)	-1357 (-11%): May	579 (7%): AugII	-160 (-2%)

Table ES - 11. CRS (Federal) P10 HLH Generation: Change from NAA

	P10 HLH Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	7702	8807	Variable	Variable	7688
MO1	77 (1%)	-567 (-6%)	-1148 (-14%): AugI	135 (2%): Jan	-232 (-3%)
MO2	437 (6%)	535 (6%)	-421 (-6%): Mar	1027 (14%): AugII	385 (5%)
MO3	-398 (-5%)	-1720 (-20%)	-2513 (-25%): May	690 (10%): AugII	-841 (-11%)
MO4	-32 (0%)	-1836 (-21%)	-2955 (-40%): Mar	59 (1%): Feb	-1088 (-14%)
PA	106 (1%)	-747 (-8%)	-1537 (-15%): May	414 (6%): AugII	-143 (-2%)

Table ES - 12. CRS (Federal) Critical Water Generation: Change from NAA

	1937 HLH Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	7660	8743	Variable	Variable	7738
MO1	19 (0%)	-790 (-9%)	-1422 (-15%): AugI	152 (2%): Jan	-343 (-4%)
MO2	289 (4%)	688 (8%)	-498 (-6%): Jan	1079 (18%): Feb	376 (5%)
MO3	-264 (-3%)	-1828 (-21%)	-2773 (-32%): May	464 (6%): AugII	-805 (-10%)
MO4	-160 (-2%)	-1756 (-20%)	-3019 (-32%): AugI	-94 (-1%): Dec	-1095 (-14%)
PA	-73 (-1%)	-753 (-9%)	-1097 (-12%): May	335 (4%): Nov	-249 (-3%)

Energy and Peak Generation Summary

On an annual basis, MO1 and the draft preferred alternative have a 1 to 4 percent energy and peak reduction in generation from the NAA mostly on the CRS (Federal) system with little to no change on the Mid-Columbia and Canadian systems.

MO2 provides about 3 to 5 percent gains in energy and peak compared to the NAA. Most of this occurs on the CRS (Federal) system. Very little change occurs on the Mid-Columbia or Canadian projects.

MO3 and MO4 have 8 to 10 percent and higher reductions in energy and peak generation from the NAA, with MO4 having the largest. Again, little to no change in annual generation occurred on the Mid-Columbia and Canadian systems.

On an annual basis, the PA has energy and peak reductions in generation compared to the NAA roughly between 1 and 3 percent.

CRS (Federal) Generation for Revenue Determination

Bonneville prepared CRS energy generation estimates for the CRSO EIS socioeconomic analysts to estimate Federal revenues for each alternative. Revenue analyses and result details are provided in the *Power and Transmission Appendix H* to the CRSO EIS.

Bonneville forecasts the amount of Federal hydropower it expects to have supplied from the FCRPS to support its sale of firm power or firm requirements power[1] under long-term firm power sales contracts. Bonneville models the most adverse water year on record for the Columbia River system to determine the firm power amount of generation the FCRPS is expected to produce. The use of the water year that produced the least amount of usable power is often called critical water planning for which Bonneville uses the water-year 1937. The change in critical-year (1937) average generation of the CRS projects is the primary component in determining the change in the amount of federal hydropower that Bonneville can expect to have available for marketing long-term firm power. Generation amounts greater than critical water generation may be available for making sales of surplus power.

The CRS generation estimates show the effect of each alternative on the two types of power sold by Bonneville: firm power and secondary (surplus) power.

Firm power is used to serve Bonneville's core statutory and contractual obligations, such as Bonneville's power obligation to its long-term firm requirements customers. A change in critical-water (1937) average firm generation from the CRS projects affects the amount of firm power Bonneville can expect to have available to support its long-term firm power sales contracts.

In addition to firm power, Bonneville also sells power when water conditions are above critical water conditions. This type of power, referred to as secondary or surplus power, is available when water conditions are at historical averages as opposed to critical water levels. Bonneville forecasts the availability of secondary power by averaging generation from 80 historical water years (80-year average generation). Generation amounts greater than critical water generation may be available for making sales of surplus power.

The CRS (Federal) generation amount estimates for the socioeconomic analyses for critical water year (firm power) and 80-year average are provided in Table ES - 13.

Table ES - 13. Ave. CRS (Federal) Generation for Revenue Determination: Change from NAA

Alternative	1937 Critical Water Average Generation (aMW / % change)	80-Year Average Generation (aMW / % change)
NAA	6,237	8,340
MO1	-297 / -4.8	-132 / -1.6
MO2	378 / 6.1	445 / 5.3
MO3	-748 / -12.0	-1,105 / -13.2
MO4	-888 / -14.2	-1,302 / -15.6
PA	-328 / -5.3	-205 / -2.5

[1] Firm Requirements Power is Federal power that Bonneville makes continuously available to a customer to meet Bonneville's obligations to the customer under Section 5(b) of the Northwest Power Act (Bonneville 2018), 16 U.S.C. § 839c(b).

System Reliability

Bonneville and other regional planning entities such as the NW Council use Loss-of-Load Probability (LOLP) as a fundamental metric of power system reliability. Bonneville and NW Council use a target of 5 percent LOLP, which means that a power outage (or multiple outages) for lack of generation could occur in about one in 20 years. Hence, a lower LOLP means the system is more reliable. LOLP measures the frequency of a power outage; it does not capture the magnitude or duration of an outage. Bonneville developed the Conditional Value at Risk (CVaR) metric to assess the magnitude of average load not met for the outages.

Key reliability findings for the NW-US system are summarized in Table ES - 14. Similar summaries for the CRS (Federal), Mid-Columbia, and Canadian systems are not provided as the LOLP analysis was performed only for the northwest region.

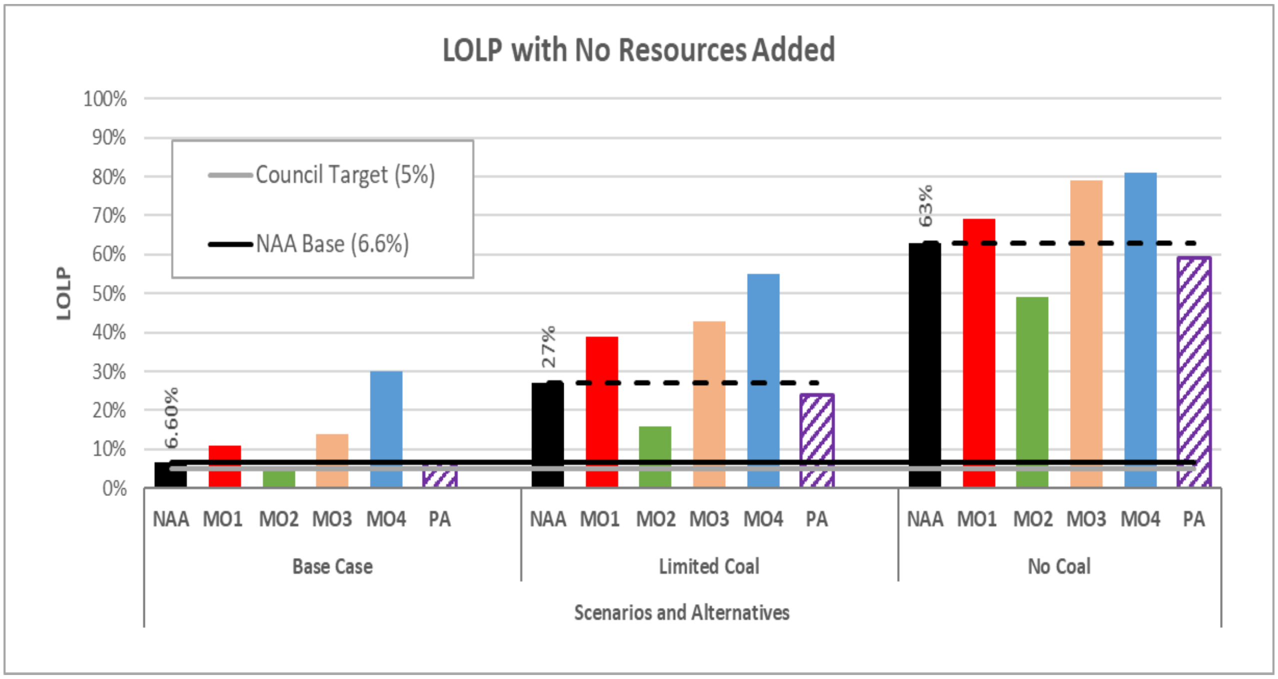
MO1 almost doubles the LOLP of the NAA due to increases in summer loss of load. Overall, MO2 impacts system loss of load the least and lowers the LOLP from 6.6 percent in the NAA coincidentally to meet the 5 percent LOLP target. Major increases in loss of load occur in MO3 due to Snake River dam breaching. Loss of load in MO4 is even greater than in MO3 due to increased fish passage spill and the flow augmentation measures. The LOLP of the PA is 6.4 percent, near that of the NAA at 6.6 percent. Summarized observations by alternative follow in Table ES - 14.

Table ES - 14. NW-US System LOLP and CVaR Summary

Alternative	LOLP (%)	Notable CVaR Results
NAA	6.6	65.1 aMW @ 2.9% LOLP in January
MO1	11.2	58.3 aMW @ 2.8% LOLP in January 23.7 aMW @ 2.5% LOLP in August I
MO2	5.0	65.5 aMW @ 2.8% LOLP in January
MO3	13.9	98.7 aMW @ 4.1% LOLP in January 34.5 aMW @ 2.3% LOLP in June
MO4	29.6	63.9aMW @ 2.8% LOLP in January 725.3 aMW @ 23.8% LOLP in August I
PA	6.4	55.6 aMW @ 2.6% LOLP in January

When Bonneville prepared the CRSO EIS analysis in 2017, several coal-fired power plants in the region were scheduled to close. These closures were accounted for in the system reliability results in Table ES - 14. Since 2017, additional coal plant closures have been announced.

Removing additional coal-fired baseload generating resources raises the LOLP of NAA and all of the MOs. Bonneville performed an additional analysis of the effect of the coal-plant closures on the LOLP; results are displayed in Figure ES - 1. The base case represents the LOLPs for the EIS using information available in 2017. The Limited Coal area represents the "updated view of the future" with 1,741 MW of coal remaining in the region. The No Coal area has no coal generation serving northwest loads.



Note: Gray line represents the NW Council's Target of 5.0%, and the black lines represents the LOLP of the NAA.

Figure ES - 1. NW-US LOLP with Removal of Coal Plants

The major increases in LOLP indicate the region needs major investments in resources to maintain the current levels of reliability.

Potential Replacement Power Portfolios and Carbon Emission Impacts

Bonneville prepared estimates of potential resource portfolios needed to be added to each CRSO EIS alternative for the power system to achieve the 6.6 percent LOLP of the NAA. Because MO2 achieved 5 percent LOLP in the base case, Bonneville estimated a potential portfolio of avoided resource additions.

Portfolios were developed for conventional least-cost additions and zero-carbon/least-cost additions using information from NW Council sources. The conventional least-cost portfolios consisted of gas-fired simple and combined-cycle generation. The zero-carbon portfolios consisted of the least-cost combinations of wind and solar generation and demand response (DR) measures. Portfolios for MO1, MO2, MO3, MO4 and the PA are in Table ES - 15 and Table ES - 16.

Table ES - 15. NW-US System Conventional Least-Cost Replacement Portfolio and Associated Change in Carbon-based Generation for the Base Case without Additional Coal-Plant Closures

Alternative	LOLP (percent)	CT capacity added to reach 6.6% LOLP (MW)	CT avg. added Generation (aMW)
MO1	11.2	560	163.1
MO2	5.0	-400 (avoided)	-244 (avoided)
MO3	13.9	1,120	607.0
MO4	29.6	3,240	708.2
PA	6.4	N/A	N/A

Note: Green font used when reduction is beneficial.

Table ES - 16. NW-US System Zero-Carbon Portfolio and Associated Change in Carbon-based Generation for the Base Case without Additional Coal-Plant Closures

Alternative	LOLP (percent)	Low Carbon Capacity Added to Reach 6.6% LOLP (MW)	Change in Existing Carbon-producing Generation (aMW)
MO1	11.2	1,200 Solar/600 DR	-70
MO2	5.0	1,510 avoided build: 250 Solar 600 DR 660 Montana Wind	-428
MO3	13.9	1,960 Solar/980 Battery/ 600 DR	583[1/]
MO4	29.6	5,000 Solar/600 DR	70
PA	6.4	N/A	171

Note: Green font used when reduction is beneficial.
1/ The increase in carbon-producing generation for MO3 when only zero-carbon resources are added stems from increased generation at existing carbon-producing power plants.

The carbon-based generation from the conventional least cost portfolio, the carbon-based generation changes from the least carbon, and the carbon generation avoided in MO2 amounts were provided to CRSO EIS analysts for estimating the socioeconomic and air quality effects of the alternatives. Details are provided in the *Power and Transmission Appendix H and Air Quality and Greenhouse Gas Appendix G* of the EIS.

Integration of Other Renewable Resources and Hydropower Flexibility

Flexibility in hourly and sub-hourly hydro operations is critical to the reliability of the power supply and its ability to adjust to changes in demand for electricity and changes in the output produced by other renewable resources. Power generation must equal load (demand) at all times. The hydropower system and natural gas plants in the region increase or decrease their generation output moment-to-moment to balance the changes in load and other generation, such as other renewable resources.

While some of the measures in the multi-objective alternatives would increase the flexibility of the hydrosystem to respond to these changes other measures would decrease the flexibility. As the amount of solar and wind power generation in the region increases, there will be more need for flexibility to respond to increasing magnitudes of solar generation variation between day and night or with changing cloud-cover and wind generation variation between calm and windy times.

Bonneville conducted a qualitative assessment of the effects of the alternatives on hydropower flexibility since its existing hydropower models do not model the short timeframes needed to assess changes in flexibility. Bonneville observed that several measures may lead to an increase in power system flexibility, including the ability to include reserves in fish passage spill, use of full operating range of run-of-river reservoirs, the expanded ability to reduce to zero generation, and the ability to operate below, within, or above the most efficient turbine operating range. Measures that reduce flexibility include minimum operating pools at the lower Snake and Columbia River projects, narrow and restricted turbine operating ranges, and large amounts of spill that reduce generation to minimum generation levels.

Bonneville concluded that MO2 has the most flexibility and improves flexibility over the NAA. MO1 has roughly the same flexibility as the NAA; MO3 and MO4 have reductions in flexibility compared to the NAA.

Colville Payments

Bonneville makes annual payments to the Confederated Tribes of the Colville Reservation as compensation for tribal lands inundated by Lake Roosevelt. The annual payment is based in part on actual generation at Grand Coulee. Effects of the alternatives are quantified in the CRSO using the distribution of forecasted annual average generation across the 80 water years. Overall, all alternatives show a reduction of Grand Coulee average 80-year annual generation compared to the NAA. Table ES - 17 summarizes the Grand Coulee generation changes. The determination of the payment is detailed in the *Power and Transmission Appendix H.*

Table ES - 17. Average Grand Coulee Generation for Colville Payment Determination

Alternative	aMW	Difference from NAA aMW (% change)
NAA	2,434	-
MO1	2,399	-35 (-1.4)
MO2	2,419	-15 (-0.6)
MO3	2,388	-46 (-1.9)
MO4	2,381	-52 (-2.2)
PA	2,405	-29 (-1.2)

4(h)(10)(C) Credits

The Northwest Power Act requires Bonneville to make expenditures to mitigate fish and wildlife and their habitats in the Columbia River Basin affected by the development and operation of the Columbia River System.[2] Bonneville fulfills this mandate by making expenditures for: (1) direct fish and wildlife program operations and maintenance; (2) direct fish and wildlife program capital projects; and (3) power purchases made to replace the federal dam system's firm generating capability lost due to fish mitigation measures. While Bonneville incurs these costs as part of its section 4(h)(10)(A) mitigation duty, the actions funded also offset the impacts of the Columbia River System's non-power purposes such as navigation, irrigation, or flood risk management. Bonneville, however, is responsible for the power share of mitigation costs only, so it must therefore recover the non-power share of its fish and wildlife mitigation expenditures in some other way. Section 4(h)(10)(C) provides that vehicle. It requires the Administrator to allocate the expenditures incurred mitigating fish and wildlife and to recoup the non-power share of those expenditures from the U.S. Treasury. The system-wide weighted average of the non-power cost allocation is 22.3%. Bonneville thus takes a 22.3% credit annually against its obligations to the U.S. Treasury for the non-power share of mitigation it funds.

The annual amount of section 4(h)(10)(C) credit is expected to vary across CRSO EIS alternatives because the hydropower operations undertaken and mitigation expenditures that Bonneville would make to protect fish and wildlife under these alternatives would vary, and, in turn, affect the amount of credit received. The methodology for determining the amount of fish and wildlife costs for these categories consists of three distinct steps: (i) obtaining Direct Fish and Wildlife Program Expenditures from accounting records; (ii) estimating fish and wildlife related power purchases using HYDSIM, Bonneville's hydro-simulation model, and (iii) allocating these expenditures between power and non-power purposes to ascertain the credit value.

The credit for each alternative is estimated in Appendix H Power and Transmission Section 4.1.4. It is based in part on the estimates in this Appendix of the differences in additional power purchases Bonneville would need to make under each alternative to implement CRS operations to protect and mitigate fish and wildlife. The difference between the alternatives in the amount of additional purchase power, also called replacement power, needed to operate the CRS to protect and mitigate fish and wildlife is shown in Table ES - 18.

The 4(h)(10)(C) credit will generally increase or decrease in kind as the cost of CRS operations for fish and wildlife increase or decrease. The estimated mitigation expenditures and associated 4(h)(10)(C) credit are discussed Appendix H Power and Transmission Section 4.1.4.

[2] Section 4(h)(10)(A), 16 U.S.C. § 839b(h)(10)(A).

Table ES - 18. Annual Replacement Power Purchases (aMW)

Alternative	Eligible Purchase w/ F&W	Eligible Purchase w/o F&W	Additional Purchase	Change from NAA (%)
NAA	397	38	359	-
MO1	417	37	381	6.1
MO2	333	38	294	-18.1
MO3	814	37	777	116.4
MO4	846	37	809	125.3
PA	454	38	416	15.9

Bonneville Climate Change Assessments

The co-lead agencies are reviewing multiple scenarios to qualitatively evaluate the potential effects of climate change on the natural streamflows in the Columbia River Basin. Details about the development and use of these scenarios are presented in Chapter 4 of the CRSO EIS.

Bonneville selected four scenarios for a quantitative hydropower assessment and assessed the relative generation changes between alternatives for each of the four climate scenarios. Bonneville concluded that climate change does not affect the overall conclusion regarding the net effect of any of the MO alternatives relative to NAA. MO2 is still the best alternative for hydropower production, system reliability, and carbon reduction compared with the NAA; MO1's generation remains the closest to NAA generation, and MO3 and MO4 generation and reliability are still much lower than the NAA, and the PA still produces slightly less generation than the NAA.

Climate change, as represented by the four scenarios, is adding some uncertainty to the annual magnitude of generation and significant uncertainty to the monthly magnitude of the effect of the MO alternatives relative to NAA.

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Abbreviations, Acronyms, and Glossary

Acronym/Abbreviation	**Meaning**
aMW	Average Megawatts
AURORA	Electric Market Forecasting Model
BC Hydro	British Columbia Hydro and Power Authority
BiOp	Biological opinion
Bonneville	Bonneville Power Administration
Corps	U.S. Army Corps of Engineers
CO_2	Carbon dioxide
CPO	Coordinated Plan of Operation
CRS	Columbia River System
CRSO	Columbia River System Operations
CRT	Columbia River Treaty
CT	Combustion Turbine
CVaR	Conditional value of risk (a measure of power outage magnitude)
DEIS	Draft Environmental Impact Statement
DR	Demand response
Draft	To lower the elevation of a reservoir (more flow out than in)
EIS	Environmental Impact Statement
FCOP	Flood Control Operating Plan
FCRPS	Federal Columbia River Power System
F&W	fish and wildlife
FELCC	Firm Energy Load Carrying Capability
FERC	Federal Energy Regulatory Commission
FRM	Flood Risk Management
FWPO	Flexible Winter Power Operations
HLH	Heavy Load Hour (6 am to 10 pm, except Sundays and Holidays)
HLH P10	Heavy-Load-Period Federal Generation from Lowest 10th Percentile
HOSS	Hourly Operations Scheduling Simulator
HYDSIM	Hydrologic Simulator Model
kcfs	Thousand cubic feet per second
LOLP	Loss-of-Load-Probability
Maf	Million acre-feet
MIP	Minimum irrigation pool
MO1	Multiple-Objective Alternative 1
MO2	Multiple-Objective Alternative 2
MO3	Multiple-Objective Alternative 3
MO4	Multiple-Objective Alternative 4

Acronym/Abbreviation	Meaning
MOP	Minimum operating pool
MW	Megawatt
NAA	No-Action Alternative
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NGVD29	National Geodetic Vertical Datum of 1929
NW Council	Northwest Power and Conservation Council
NW-US	Northwest portion of Columbia River System in the United States
P&T	Power and Transmission
PA	Preferred Alternative
PNCA	Pacific Northwest Coordination Agreement
PUD	Public Utility District
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
ResSim	Reservoir System Simulation Model
RMJOC	River Management Joint Operating Committee
SRD	Storage reservation diagram
TDG	Total dissolved gas
VarQ	Variable Flow Flood Risk Management Curves
WECC	Western Electricity Coordination Council

CHAPTER 1 - INTRODUCTION TO COLUMBIA RIVER SYSTEM OPERATIONS EIS AND HYDROPOWER

This appendix presents the hydropower analyses conducted for the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS). The Bonneville Power Administration (Bonneville), U.S. Army Corps of Engineers (Corps), and U.S. Bureau of Reclamation (Reclamation) are co-lead agencies in developing the CRSO EIS, which is required for the agencies' compliance with the National Environmental Policy Act (NEPA). This appendix is part of a larger set of CRSO DEIS documents that detail the efforts of the co-lead agencies in evaluating alternatives for the future operation and configuration of 14 major projects of the Federal Columbia River Power System (FCRPS) collectively referred to as the Columbia River System (CRS).

This appendix focuses on hydropower effects of the CRSO EIS alternatives and is supported by several other CRSO EIS documents that provide additional details on the EIS processes, alternatives, system operation and modeling, and several other uses affected by the alternatives. Details about the NEPA process and development of alternatives are presented in the CRSO EIS report. Modeling details for this hydropower assessment are presented in the *Hydroregulation Appendix I* and *Hydrology and Hydraulics Appendix B (H&H Appendix B).* Hydropower results in this appendix contribute to other analyses in the CRSO EIS, including analyses of socioeconomic, air quality, and water quality effects. The results of those other effects are detailed in the appropriate appendices.

1.1 COLUMBIA RIVER SYSTEM PROJECTS

As defined for this study, the CRS consists of the 14 major federal projects operated in coordination with each other. They are a subset of the FCRPS, a network of 31 multi-purpose Federal dam and reservoir projects constructed primarily in the Columbia River and its tributaries in the Pacific Northwest and operated by the Corps and Reclamation. The FCRPS also includes the Federal transmission system built and operated by Bonneville to market and deliver electric power.

The United States Congress authorized the Corps and Reclamation to construct, operate, and maintain the FCRPS projects to meet multiple specified purposes, including flood risk management (FRM), navigation, hydropower production, irrigation, fish and wildlife conservation, recreation, municipal and industrial water supply, and water quality. Although not every project is authorized for each of these purposes, all 14 CRS projects are authorized for hydropower.

The results of Bonneville's hydropower modeling are provided in system groupings: NW-US, CRS, Mid-Columbia, and Canadian. Exhibit 1 provides a list of the projects in these systems and indicates which projects are affected by the CRSO EIS alternatives.

1.1.1 FCRPS Projects in the CRS

The 14 CRS projects on the Columbia River and its major tributaries are operated as a coordinated system. The CRSO EIS focuses on these 14 CRS projects: Libby, Hungry Horse, Albeni Falls, Grand Coulee, Chief Joseph, Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. Figure 1-1 shows the geographic locations of the 14 projects. Table 1-1 summarizes the general characteristics of the 14 projects pertinent to hydropower.

The CRS projects examined in detail in the CRSO EIS fall into two major categories: storage and run-of-river projects. There are five Federal storage projects in the CRS: Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak. There are nine Federal run-of-river projects in the CRS: Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville.

Storage is key to operating the CRS for multiple uses. The total water storage available in the reservoirs on the Columbia River and its tributaries is approximately 55 million acre-feet (Maf). About 20 Maf of that storage capacity is in Canada. About 16 Maf is in the five CRS storage projects and the other 19 Maf is in several other Federal and non-Federal dams in the Snake River basin in southern Idaho and eastern Oregon, Yakima River Basin in Washington, and Willamette River Basin in Oregon. In general, the storage reservoirs capture streamflow during relatively high spring snowmelt flow periods. Refill is managed to reduce downstream flooding and store water for release for multiple objectives in times of relatively low streamflows during late summer and fall months.

Run-of-river projects have limited storage capacity. These projects release water at the dam at nearly the same rate it enters the reservoir. The reservoirs behind run-of-river projects often are operated for hydropower resulting in frequent, small fluctuations in water levels. Reservoir levels behind these projects typically vary only 3 to 5 feet in normal operations.

1.1.2 Other FCRPS Projects

The remaining 17 FCRPS projects are operated independently from the 14 CRS projects and are located in the upper Snake River basin in southern Idaho, the Yakima River basin in Washington, and the Willamette and Rogue River basins in Oregon. Their operation is replicated in the modeling of each alternative (i.e., project storage operations, outflows, and generation are the same in each CRSO EIS alternative).

Figure 1-1. Geographic Location for the CRSO Projects

Table 1-1. General Characteristics of the Columbia River System (CRS) Projects

Project	Reservoir/ Lake	Project Type	Storage Volume (Maf)	Hydropower (no. of units – capacity)
Libby	Koocanusa	Storage	5.0	5 units – 525 MW
Hungry Horse	Hungry Horse	Storage	3.0	4 units – 428 MW
Albeni Falls	Pend Oreille	Storage	1.2	3 units – 42 MW
Grand Coulee	Roosevelt	Storage	5.4	24 units, 6 pump/generators – 7,015 MW
Chief Joseph	Rufus Woods	Run-of-river	-	27 units – 2,000

Project	Reservoir/ Lake	Project Type	Storage Volume (Maf)	Hydropower (no. of units – capacity)
Dworshak	Dworshak	Storage	2.0	3 units – 400 MW
Lower Granite	Lower Granite	Run-of-river	-	6 units – 810 MW
Little Goose	Bryan	Run-of-river	-	6 units – 810 MW
Lower Monumental	Herbert G. West	Run-of-river	-	6 units – 810 MW
Ice Harbor	Sacajawea	Run-of-river	-	6 units – 603 MW
McNary	Wallula	Run-of-river	-	14 units – 980 MW
John Day	Umatilla	Run-of-river (with storage)	0.5	16 units – 2,480 MW
The Dalles	Celilo	Run-of-river	-	22 units – 2,080 MW
Bonneville	Bonneville	Run-of-river	-	18 units – 1,200 MW

Project information from http://www.crso.info/index.html

1.1.3 Non-Federal Dams and Reservoirs

There are numerous other dam and reservoir projects in the Columbia River and its tributaries that are operated by Federal and non-Federal entities in the United States and Canada. These include both storage and run-of-river projects that can affect or be affected by CRS project operations.

1.1.3.1 Canadian Projects

Mica, Arrow, and Duncan (Columbia River Treaty Projects[3] in Canada) are major storage projects with 15.5 Maf of Treaty storage and 5 Maf of non-Treaty storage. The 15 Maf of Treaty storage is operated by British Columbia Hydro and Power Authority (BC Hydro) for FRM and hydropower in accordance with the terms of the Columbia River Treaty (CRT). In addition, there is a separate non-Treaty storage operation under separate mutual agreements between the United States Entity and the Canadian Entity[4] to provide resident fish benefits in Canada and anadromous fish benefits in the United States. Mica, Arrow, and Revelstoke power production is not affected by the CRSO EIS alternatives. Duncan Dam does not have power facilities and its storage operation is not affected by the EIS alternatives.

Several other projects are operated by BC Hydro and other entities in Canada on the lower Kootenay and Pend d'Oreille rivers, both tributaries to the Columbia River. Power production at these dams would be affected by the CRSO EIS alternatives.

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[3] See Bonneville website for information on the Columbia River Treaty at: https://www.bpa.gov/Projects/Initiatives/Pages/Columbia-River-Treaty.aspx
[4] The Columbia River Treaty of 1964 designated Entities to implement the terms of the treaty. The U.S Entity is Administrator of Bonneville and the Commander of Corps Northwestern Division; the Canadian Entity is BC Hydro.

1.1.3.2 Mid-Columbia River Projects

Three Washington State Public Utility Districts (PUDs) operate the following five run-of-river dams in the Mid-Columbia River under licenses issued by the Federal Energy Regulatory Commission (FERC):

- Wells, operated by Douglas County PUD
- Rocky Reach and Rock Island, operated by Chelan County PUD
- Wanapum and Priest Rapids, operated by Grant County PUD

These projects are hydrologically affected by upstream Federal storage project operations, which influence flows through the PUD projects particularly from Grand Coulee Dam. Power production at the five PUD dams would be affected by the CRSO EIS alternatives.

1.1.3.3 Middle Snake River Dams

The Idaho Power Company operates three FERC-licensed dams, collectively known as the Hells Canyon Complex, located on the middle Snake River on the Oregon/Idaho border. The Hells Canyon, Oxbow, and Brownlee projects are hydropower facilities that affect flows on the lower Snake River. Hells Canyon and Oxbow are run-of-river projects downstream of Brownlee Dam. Brownlee Dam is the most significant for CRSO, as it provides a total storage capacity of 1.4 Maf, of which 980,000 acre-feet are used jointly for FRM and power production. Brownlee also is operated for recreation, navigation below Hells Canyon, and provides flow augmentation for downstream fish migration. Power production at these dams would not be affected by the CRSO EIS alternatives. Operation of these dams is replicated in all the CRSO EIS alternatives.

1.1.3.4 Other Columbia River Non-Federal Dams in the United States

There are other non-Federal dams located below the Federal storage projects at Hungry Horse and Albeni Falls dams. They include Sèliš Ksanka Qĺispè (formerly Kerr Dam), Thompson Falls, Noxon Rapids, Cabinet Gorge, Box Canyon, and Boundary Dams. All are run-of river except Sèliš Ksanka Qĺispè Dam which regulates about 1.2 Maf storage at Flathead Lake in Montana and Noxon Rapids. Power production at these dams would be affected by the CRSO EIS alternatives.

1.2 COLUMBIA RIVER SYSTEM MULTIPLE-USE OPERATIONS

Operation of the CRS results from the coordinated implementation of the numerous measures and objectives that comprise the CRT, biological opinions (BiOps), power system reliability, and several other authorized uses such as navigation, irrigation, and recreation. In coordinating system water management, the co-lead agencies generally prioritize FRM, environmental responsibilities (i.e., conservation actions for protected fish species), and other authorized uses such as navigation and irrigation before power generation to meet the daily and seasonal demand for electricity by Bonneville.

Coordinated CRS operation begins with planning. The co-lead agencies are involved in several processes pertinent to the annual, short-term, and real-time operation of the 14 CRSO projects. Major areas of involvement affecting hydropower include the planning and implementation of the CRT, development and implementation of BiOps issued by National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service, hydropower coordination under the Pacific Northwest Coordination Agreement (PNCA), and ongoing coordination discussions between the co-lead agencies and others for real-time operation.

The operating objectives of these various processes affecting hydropower are summarized in the following subsections. More operation details are provided in the CRSO EIS and the No-Action Alternative (NAA) description in Section 1.4.1 of this appendix.

1.2.1 Columbia River Treaty

The CRT requires the United States Entity and the Canadian Entity to prepare operating plans each year that are the basis for the operating rule curves for CRT projects in Canada. These rule curves guide the annual storage and release of water from the three CRT projects in Canada to meet CRT flood risk and hydropower objectives. They also incorporate the CRT Flood Control Plan[5] prepared periodically by the Corps and BC Hydro.

Since 1977, the United States and Canadian entities have mutually agreed to annual and long-term operations of 5 Maf of non-Treaty storage space in Canada. While pursuing a long-term agreement, there were eight short-term agreements between Bonneville and BC Hydro for use of non-Treaty space in Canada during the period 1977-1983. The first long-term non-Treaty storage agreement was executed in April 1984 to benefit resident fish in Canada and anadromous fish in the United States. The current non-Treaty agreement was executed in 2012.

Guidance provided by the CRT operating plans is incorporated into the CRSO EIS alternatives modeling.

1.2.2 Biological Opinions

Annual plans also are developed for purposes other than power. In particular, operations to support anadromous fish are planned through a Coordinated Plan of Operation (CPO). The co-lead agencies work with federal and state fisheries agencies and tribes to develop the CPO. The Corps' annual fish passage plan is another key plan that specifies operations for juvenile and adult fish passage facilities on the lower Snake River and lower Columbia River projects, and operations at the Chief Joseph and Dworshak projects. There also are plans to implement several measures specified in BiOps for resident fish.

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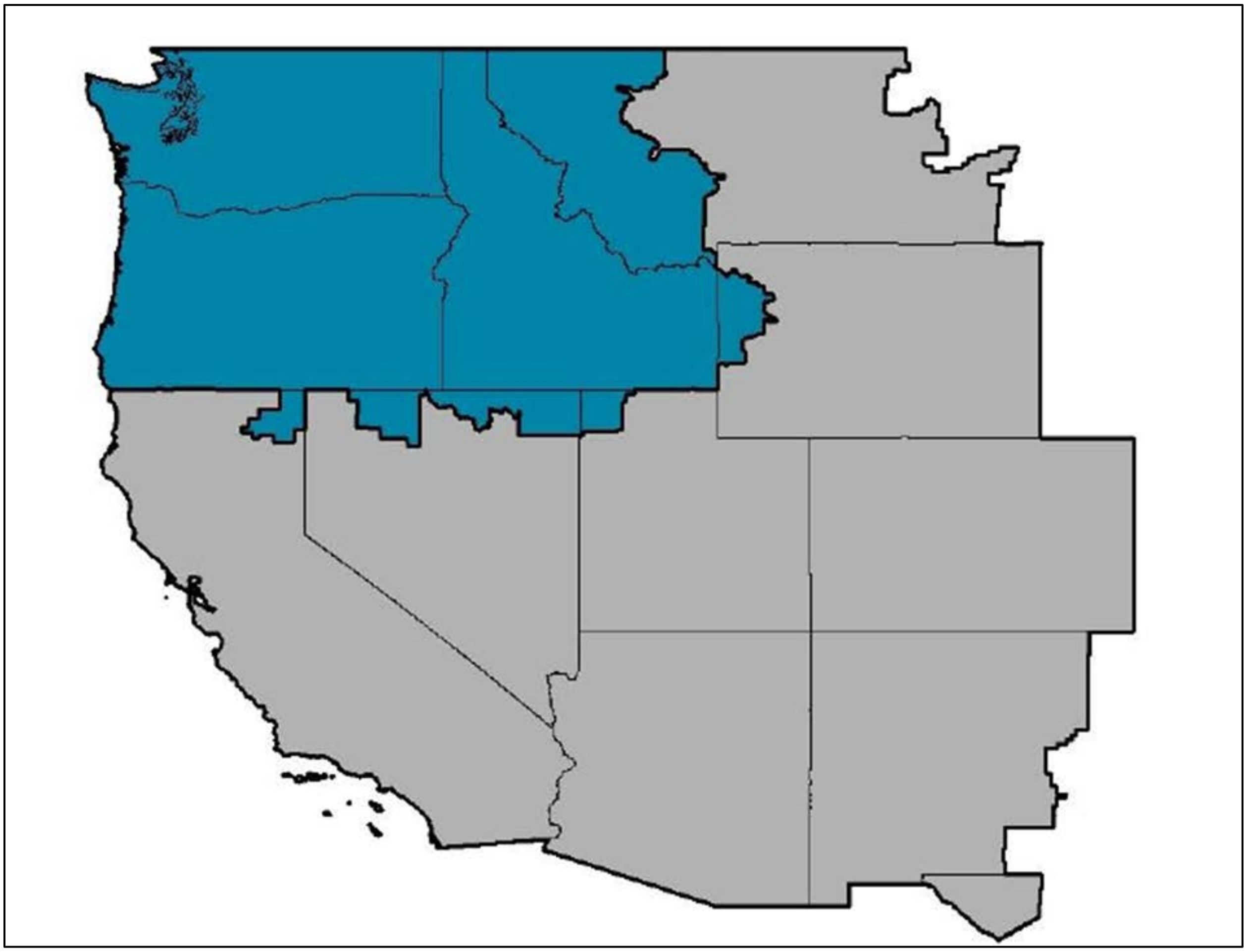
[5] Columbia River Treaty Flood Control Operating Plan (CRT FCOP), prepared by Corps for the United States Entity. May 2003.

Collectively, measures in these BiOps and plans influence storage and water release from the five storage dams in the CRS. They also influence the amount of water spilled for juvenile fish passage at eight federal run-of-river projects on the lower Snake and Columbia rivers. These storage and spill operations affect hydropower generation and system reliability and are identified in the alternative descriptions (Section 1.4 and Chapter 3 - of this appendix).

1.2.3 Power and Transmission System

The 14 CRS projects are the major producers of the federal power Bonneville sells on a long-term basis to regional power customers, such as public utilities (municipalities, PUDs, cooperatives, Federal agencies and tribal utilities), investor-owned utilities, and direct service industrial customers. Bonneville also operates and maintains 15,000 miles of high-voltage transmission lines within the Pacific Northwest. This system interconnects and integrates electric power that flows through the regional transmission system and interconnects with systems throughout the western United States and parts of Canada and Mexico. The CRSO EIS alternatives have the potential to impact the power available for sale as well as the flow of power across the transmission system. Together, these changes could affect costs for both power and transmission services, which could affect rates and, ultimately, regional and local economies. The geographic areas for the analyses of effects of the CRSO EIS alternatives on power and transmission are shown in Figure 1-2.

Bonneville regularly engages with other generating utilities and organizations such as the Northwest Power and Conservation Council (NW Council) Northwest Power Pool, Pacific Northwest Utilities Conferencing Committee, and the Western Electricity Coordination Council (WECC) to update and coordinate power resources capabilities and future needs to maintain overall system demand and reliability. Bonneville is also constantly engaged with other generating utilities and transmission grid operators on the real-time system operation.



Note: the blue shaded area bounded by the black outline is the Bonneville service area.
Source: Western Electricity Coordination Council (WECC 2018); Bonneville GIS (2018)

Figure 1-2. Power Area of Analysis – the U.S. Portion of the Western Interconnection and the Bonneville Service Area

The hydropower production and reliability information included in this appendix are used in the analyses of impacts of CRSO EIS alternatives to transmission reliability, power and transmission rates, and their socioeconomics impacts. Details of the power and transmission analyses are provided in the CRSO EIS *Power and Transmission, Appendix H.*

1.2.3.1 Pacific Northwest Coordination Agreement

The Pacific Northwest Coordination Agreement (PNCA) is an agreement for planned operations among the utilities and other entities that operate the major electric generating facilities and systems in the Pacific Northwest. Coordination is achieved through exchanges of energy and capacity among the various parties to the agreement. Parties include Bonneville, Corps, Reclamation, U.S. Entity, eight public utility districts and municipalities, and six investor-owned utilities that have hydropower resources in the Columbia River basin. The PNCA was first signed in 1964 and coincided with the development of the CRT and the eventual construction of the

AC-DC Intertie to interconnect the Pacific Northwest with the Pacific Southwest. The PNCA was renewed in 1997. It will expire in 2024.

Annual planning for coordinated power system operations occurs pursuant to the PNCA. Although there are multiple hydropower producers in the Columbia River Basin, planning studies are conducted as if the total coordinated system had a single owner, synchronizing operations to maximize power production while meeting numerous non-power operating requirements.

Studies are conducted to estimate how much power can be produced from the whole system and by each PNCA party. These studies are updated throughout the operating year and guide reservoir operations that produce the planned power capability while meeting numerous multiple-use operating requirements.

The role of the PNCA has diminished since the mid-1990s as the non-federal Mid-Columbia projects' long-term output contracts[6] with various regional utilities expired and requirements for non-power uses increased in priority. Actions to improve flows for juvenile anadromous fish migration, protect adult spawning, and improve reservoir conditions for resident fish have reduced the opportunities of the PNCA parties to influence the operation of the coordinated system. In parallel, the increased use of the wholesale market has largely replaced PNCA transactions for transferring power between utilities.

1.2.4 Seasonal Operations

Seasonal operation of the CRS results from the coordinated implementation of the numerous measures and objectives that comprise the CRT, BiOps, power system reliability, and several other authorized uses. In coordinating system water management, the co-lead agencies generally prioritize FRM and environmental responsibilities (i.e., conservation actions for protected fish species) before power generation to meet the daily and seasonal demand for electricity by Bonneville. The amount of hydropower generated at most times of the year is generally dictated not by the demand for electricity but rather by the amount of water traveling down the river. However, in emergency and emergency avoidance situations, power system operations are prioritized to protect human health and safety as well as the safety and reliability of the power grid. These emergency situations are mostly short-term and would be within the monthly averages produced by Hydrologic Simulator Model (HYDSIM).

Monthly average generation is driven primarily by natural streamflows and operation of the five major CRS storage projects: Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak. The greatest period of hydroelectric generation typically coincides with spring runoff. Much of

[6] Regional investor-owned utilities and some public utility customers purchased part of their long-term power supplies from the Mid-Columbia projects under 50-year contracts. When transmission opened up and the wholesale power markets became competitive, the Mid-Columbia project owners offered their hydro output to new market competitors and the region's utilities shifted their resource supplies away from Mid-Columbia projects.

the hydropower production at this time is also known as seasonal surplus and is the byproduct of the freshet impacting the Columbia River and its tributaries. The seasonal surplus often far exceeds the amount of firm power needed to meet Bonneville's firm power supply obligations under contract. The lowest generation generally occurs in late summer and fall.

The storage and release of water from the CRS storage projects affects hydropower production downstream at the other nine CRS dams and several non-Federal dams. The CRT projects in Canada also provide storage operations that affect downstream hydropower generation. The annual use of storage affecting generation is summarized in Figure 1-3 and the following subsections.

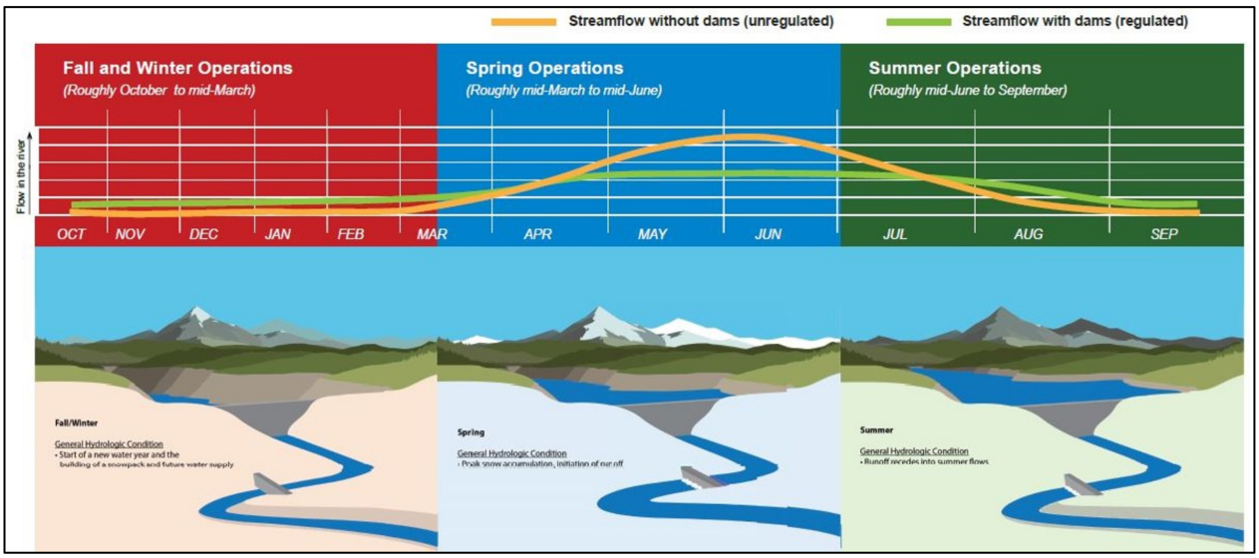


Figure 1-3. Seasonal Operations of CRS

1.2.4.1 Fall and Winter Operations

The fall-winter season generally runs from October to mid- to late-March. The previous year's snowpack melts by the start of the fall season and the seasonal snowpack begins to build. As snow accumulates in the headwaters through the fall and winter, reservoirs are drafted to provide space to capture the next spring's high flows. This draft supplements seasonally low flows and provides safe navigation corridors, generates power, benefits certain salmon spawning conditions, and helps protect wildlife habitat and cultural resources.

1.2.4.2 Spring Operations

The spring season generally runs from mid- to late-March through mid- to late-June. The snowpack usually reaches its peak snow accumulation sometime between mid-March and mid-May depending on elevation and location in the Basin. Water supply forecasts based on snowpack and other assumptions provide an indication of the spring runoff volume and timing anticipated and inform the space required for FRM operations and water supply for other uses. Once runoff begins, the Corps and Reclamation reduce the storage project outflows and begin refilling the reservoirs. The co-lead agencies balance FRM requirements, refill objectives, and flows for juvenile fish migration in the lower Columbia and Snake rivers by attempting to operate no lower than the FRM elevation for April 10th. This provides space to moderate higher flows to reduce flood risk and the amount of stored water to be released for juvenile fish migration.

The co-lead agencies adjust reservoir storage releases through April, May, and June to minimize flooding, meet fish flow objectives, and refill the reservoirs for summer.

1.2.4.3 Summer Operations

The summer season runs from approximately mid-June through September. The spring runoff is generally receding from mid-May or early June through the remainder of the summer season. Storage reservoirs reach their highest elevation during the summer months, often reaching full pool. Water stored during the spring is released throughout the summer season to augment flows for fish in the lower Columbia and lower Snake Rivers. Flows also provide water for irrigation, recreation, and power production.

During summer months, the system balances providing additional flow for augmentation downstream to aid juvenile and adult fish migration, irrigation use, and power production.

1.2.5 Real-Time Operations

The co-lead agencies operate the system on a real-time basis. Many real-time operations are not modeled in a study due to the lack of precision in model input, processing, and outputs of monthly, daily, or even hourly generation and because real-time operations respond to changing loads, weather, market, and other conditions. Hydropower operation may change on a second-to-second or hourly basis, especially at the run-of-river projects that must adjust powerhouse generation with load. These changes are considered part of the average flows and generation in study outputs, but may be addressed qualitatively when necessary.

Examples of factors that cause short-term operational adjustments that are imprecisely captured in study output averages include:

- Specific extreme weather events (warmer or colder than average climatology) affect demand for power hour-to-hour and day-to-day.
- Increases or decreases in generation from other resources such as wind or solar power generation need to be offset by changes in hydropower generation.
- Short-term real-time flow conditions may not provide enough water at a dam to meet all fish bypass flows, leakage and lockage flows, and minimum or optimum flows for turbine operations; even though all these conditions were met in a study.
- Unplanned equipment outages may result in periods of extraordinary maintenance for generators or other project facilities that may require short-term departures from conditions in the study.

- Special operations may be required for installation or maintenance of structures associated with fish passage or with transmission infrastructure.
- Short-term rainfall may cause temporary higher flows in the fall or winter that differ from study conditions. This water can be used to produce surplus (non-firm or secondary) energy or left in storage for future use if storage space is available.
- There may be times when there is not enough water to provide power to meet Bonneville's power supply obligations. Bonneville might need to purchase power on the wholesale market to meet its obligations even though such purchases were not needed to meet demands in a study using period averages.
- There may be times of temporary high flows that result in unexpected project spills when there is no market for extra hydropower generation. These short-term spills may not occur in a study based on averages.
- Power system contingency affects the available capacity of hydrogenation for lower Snake and Columbia River projects. When contingency reserves are deployed, they can affect the overall spill and powerhouse operation of the projects.

These and other situations are addressed in real-time by the co-lead agencies as they consider making short-term adjustments to operations. This often involves consultations with other interests especially when it involves power outages or impacts that may be adverse to fish and wildlife species protected under the Endangered Species Act.

1.3 ALTERNATIVES DEVELOPMENT PROCESS

The CRSO EIS team of the co-lead agencies implemented a public scoping process in 2016 to inform the public about the EIS and identify issues to be addressed. Over 400,000 comments were received from members of the public, tribes, local and state governmental agencies, non-governmental organizations, and other stakeholders.

The CRSO EIS team analyzed the scoping input and identified more than 100 distinct project objectives that required more than 500 measures to achieve. The objectives and associated measures were then grouped into eight broad single-objective alternatives. Finally, to achieve multiple objectives, measures from the single objective alternatives were combined into four multiple-objective alternatives as shown in in Exhibit 2. In addition to these four alternatives, a No Action Alternative (NAA) is used as a point of comparison as required by NEPA. The resulting 5 alternatives are modeled, evaluated, and compared with one another to determine their benefits and impacts.

1.4 DESCRIPTIONS OF THE ALTERNATIVES

The CRSO EIS contains four multiple-objective alternatives and the NAA. The NAA represents reservoir operations and dam structures in place when the Corps filed a Notice of Intent for the EIS in September 2016.

The four, multiple-objective alternatives contain different combinations of operational and structural measures to address issues identified in the CRSO EIS public scoping meetings. Operational measures include: differing storage operations at the Federal upstream storage projects and differing spill and powerhouse flow levels at the Federal downstream run-of river projects. Structural measures include: differing juvenile and adult fish passage system improvements; installation of more efficient turbines with improved fish passage at select projects; and dam breaches at the four lower Snake River dams.

Summary descriptions and effects of the NAA and four multiple-objective alternatives are provided in the following sections and limited to the measures pertinent to this hydropower assessment. More complete, detailed descriptions of the NAA and multiple-objective alternatives are provided in the CRSO EIS. Specific details for how the alternatives were modeled for hydropower assessments are provided in the CRSO EIS *Hydroregulation Appendix I* narratives and modeling data sheet exhibits. Exhibit 2 of this appendix includes a matrix that lists all the measures in each multiple-objective alternative. Measures that do not affect hydropower production are not listed in the multiple-objective alternative descriptions below.

1.4.1 No-Action Alternative (NAA)

The NAA includes the operation and structures in place or committed for construction when the Notice of Intent for the EIS was published in the Federal Register in September 2016 and applied to forecast future years. In summary, those pertinent to this hydropower assessment include:

- FRM Operations per Corps current criteria for the five CRS storage projects, three CRT projects in Canada, and United States FERC-licensed projects (Brownlee and Sèliš Ksanka Qĺispè).
- Canadian Treaty project (Mica, Arrow, and Duncan) storage operations for FRM are as defined in the Flood Control Operating Plan[7]and power operations are as defined in the 2022 Assured Operating Plan. Also includes Canadian storage operations for non-power uses as defined in current agreements between the United States Entity and the Canadian Entity.
- Project operating criteria as specified in authorizing legislation and water control manuals including minimum and maximum discharge rates of change and minimum and maximum forebay elevations.
- Flow augmentation objectives consistent with the 2008 BiOp (as amended in 2010 and 2014) issued by NMFS for salmon and steelhead, including spring and summer flow targets at Lower Granite and McNary Dams, chum spawning operations below Bonneville Dam, and spawning and rearing operations below Priest Rapids Dam.

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[7] See Columbia River Flood Control Operating Plan prepared by Corps of Engineers (May 2003) at: http://www.nwd-wc.usace.army.mil/cafe/forecast/FCOP/FCOP2003.pdf

- Spill operations for juvenile fish passage consistent with the 2008 BiOp (as amended in 2010 and 2014) issued by NMFS for salmon and steelhead, including fish passage spill operations at the eight lower Snake and Columbia River dams.
- Summer drafts at Libby and Hungry Horse dams to meet September 30 targets of 10 feet from full in most years or 20 feet from full in dry years.
- Loads/Resources for hydropower modeling are for 2022 forecasts.
- Turbine/generator maintenance for Federal projects is a generic future year based on 5-year maintenance averages and includes Grand Coulee turbine/generator overhaul plus forthcoming upgrades to McNary and Ice Harbor turbines.

1.4.2 Multiple-Objective 1 (MO1)

MO1 includes a number of measures to benefit fish as well some measures for water management, power production, and water supply. Not all measures in MO1 affect hydropower; MO1 contains the following departures from the NAA that affect the power assessment:

- Fish Passage Spill:
  - The amount of spill in MO1 is more than the NAA, but less than provided by flexible spill operations regional entities agreed to implement in 2019 and 2020.
  - Two spill blocks are used for spring fish passage. One block is spill to 120/115 percent of the total dissolved gas (TDG) cap level and the other is performance standard spill. Alternative years will have the different spill blocks first or second.
  - NAA summer spill levels are provided, but a fish-count trigger can potentially end summer spill earlier at the lower Snake River projects in August to benefit power when few juvenile fish are migrating.
  - Power contingency reserves can be carried within juvenile fish passage spill.
- Water Management:
  - Account for local runoff volumes in Libby variable discharge (VarQ)[8] draft and refill operations when the Libby water supply forecast is 6.9 Maf or less.
  - Replace Libby end-of-December variable draft target with single 2,420-foot target elevation.
  - Apply updated Upstream Storage Correction method to determine end of April draft requirement for Grand Coulee.

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[8] The VARQ FRM procedure was developed to improve the multi-purpose operation of Libby and Hungry Horse dams while not reducing the level of flood protection in the Columbia River. VarQ details are available in the CRSO EIS *Flood Risk Management Appendix K*.

- Update Grand Coulee storage reservation diagram (SRD) to account for a reduced planning draft rate limit of 0.8 feet/day and added FRM protection for winter rain-induced flooding below Bonneville Dam.
- Reduce limit on Grand Coulee maximum outflow to account for forecasted increase in outages. Use accelerated maintenance schedule for power plant and spillways instead of the NAA 5-year average.

- Water Supply
  - Increase water supply diversion from Lake Roosevelt, below Hungry Horse Dam, and from Chief Joseph.
- Storage
  - Sliding scale summer target elevation at Libby and Hungry Horse dams.
  - Dworshak cool water releases are made earlier (June and July) and later (September) with reduced flow in August.
  - Increase John Day target elevation in April and May by 1’ to reduce avian predation.
- Run-of-River
  - Increased lower Snake Dam operating range (MOP[9] + 1.5 feet).
  - Increased John Day forebay operating range (MOP + 2 feet).
- Structural:
  - Use new higher-efficiency turbines with improved fish passage survival in place of older turbines at John Day.
  - Construct powerhouse surface passage routes at McNary and Ice Harbor dams, which increases the minimum spill relevant for MO1 and affects turbine availability.

1.4.3 Multiple-Objective 2 (MO2)

MO2 represents operations that might be implemented if climate change becomes the primary policy driver in the future. More emphasis is placed on hydropower production and flexibility to integrate other renewable resources to reduce carbon emissions from fossil fuel generating resources. Not all measures in MO2 affect hydropower; MO2 contains the following departures from the NAA that affect the power assessment:

- Fish Passage Spill
  - Fish passage spill amounts are reduced from the NAA, near 110 percent TDG at most projects except when minimum spill levels are higher for powerhouse surface passage routes, for the spillway weirs, and/or for adult attraction to fish ladders.

[9] MOP or minimum operating pool is the lowest forebay operating elevation for a run-of-river project.

  - Fish passage spill is curtailed on August 1.
  - Power contingency reserves are carried within fish passage spill.
- Water Management
  - Libby VarQ draft and refill operations are modified when water supply forecast is 6.9 Maf or less.
  - Libby end-of-December variable draft procedure replaced with a 2,420-foot target elevation. Implementation of this measure in MO2 is affected by the next measure for additional draft below FRM elevations.
  - Additional draft below FRM elevation for hydropower allowed at Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak.
  - Updated upstream Storage Corrections Method is applied to the Grand Coulee SRD.
  - Update Grand Coulee SRD to account for a reduced planning draft rate limit of 0.8 feet/day and added FRM protection for winter rain-induced flooding below Bonneville Dam.
  - Reduced limit on Grand Coulee maximum outflow to account for forecasted increase in outages. Use accelerated maintenance schedule for power plant and spillways instead of NAA 5-year average.
- Water Supply
  - Water supply measures are unchanged from NAA in MO2.
- Storage
  - Sliding scale summer target elevation at Libby and Hungry Horse dams.
  - Storage projects are allowed to draft slightly deeper to meet power demand during the most valuable periods of high demand in the fall and winter allowing slightly more generation in the winter and slightly less during the spring.
- Run of River
  - Unrestricted forebay operations (i.e., no seasonal restrictions to MOP and minimum irrigation pool [MIP] provide more flexibility for power generation at the lower Snake and Columbia rivers run-of-river projects). This flexibility provides increased ability to serve peak load obligations, increased renewable resource integration capability, and energy market price effects.
  - Operate turbines across their full range of capacity year-round.
  - Zero generation operations may occur on lower Snake River projects November – February.
- Structural
  - New higher efficiency turbines with improved fish passage survival replaced older turbines at John Day.

  - Added powerhouse surface passage at John Day, McNary, and Ice Harbor Dams, which increases the minimum spill relevant for MO2 and affects turbine availability.

1.4.4 Multiple-Objective 3 (MO3)

MO3 breaches the four lower Snake River dams and adds other measures beneficial to resident and mainstem anadromous fish. For power purposes, a generic future year after the dams are removed is being modeled. Not all measures in MO3 affect hydropower; MO3 contains the following departures from the NAA that affect the power assessment:

- Dam Breach
  - Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams are breached by removing earthen embankments.
- Fish Passage Spill
  - Spring spill for fish passage at the four lower Columbia River dams up to 120 percent TDG.
  - Reduced duration of summer juvenile fish passage spill (curtailed on August 1).
  - Power contingency reserves can be carried within fish passage spill.
- Water Management
  - Libby VarQ draft and refill operations are modified when water supply forecast is 6.9 Maf or less.
  - Libby end-of-December variable draft procedure replaced with a 2,420-foot target elevation but allow power drafts down to 20 feet lower.
  - Updated upstream Storage Corrections Method is applied to the Grand Coulee SRD.
  - Update Grand Coulee SRD to account for a reduced planning draft rate limit of 0.8 feet/day.
  - Reduced limit on Grand Coulee maximum outflow to account for forecasted increase in maintenance outages. Use accelerated maintenance schedule for power plant and spillways instead of NAA 5-year average.
- Water Supply
  - Increase water supply diversion from Lake Roosevelt, below Hungry Horse Dam, and from Chief Joseph Dam (Lake Rufus Woods).
- Storage
  - Sliding scale summer target elevation at Libby and Hungry Horse dams.
- Run of River
  - John Day allowed to operate up to full pool except as needed for flood risk management.

  - Lower Columbia project turbines can be operated within and above 1 percent peak efficiency in juvenile fish passage season.
- Structural
  - New higher efficiency turbines with improved fish passage survival replaced older turbines at John Day.
  - Additional powerhouse surface passage at McNary Dam, to increase the minimum spill relevant for MO3 and affects the turbine availability.

1.4.5 Multiple-Objective 4 (MO4)

MO4 includes aggressive measures to aid anadromous fish survival without breaching the lower Snake River dams. Not all measures in MO4 affect hydropower; MO4 contains the following departures from the NAA that affect the power assessment:

- Fish Passage Spill
  - Spill through modified spillway weirs at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary and John Day projects during October and November for steelhead overshoots, overwintering steelhead, and kelt.
  - Spill to 125 percent TDG for juvenile anadromous fish passage is provided from March 1 to August 31.
  - Power contingency reserves may be carried within fish passage spill.
- Water Management
  - Libby VarQ draft and refill operations account for local runoff volumes when that same water supply forecast is 6.9 Maf or less.
  - Replace Libby end-of-December variable draft procedure with a 2,420-foot target elevation.
  - Apply updated upstream Storage Corrections Method to the Grand Coulee SRD.
  - Update Grand Coulee SRD to account for a reduced planning draft rate limit of 0.8 feet/day and added FRM protection for winter rain-induced flooding below Bonneville Dam.
  - Reduced limit on Grand Coulee maximum outflow to account for forecasted increase in maintenance outages. Use accelerated maintenance schedule for power plant and spillways instead of NAA 5-year average.
- Water Supply
  - Increase water supply diversion from Lake Roosevelt, below Hungry Horse Dam, and from Chief Joseph.

- Storage
  - Release up to 2 Maf of additional water from upstream federal storage projects to support 220 kcfs (thousand cubic feet per second) spring and 200 kcfs summer target flows at McNary.
  - Sliding scale summer target elevations at Libby and Hungry Horse dams.
  - Manage Libby outflow in November through March to limit Bonners Ferry stage to maximum of 1,753 feet National Geodetic Vertical Datum of 1929 (NGVD29) for riparian habitat protection.
- Run of River
  - The eight Lower Snake River and Lower Columbia River projects are operated within MOP+1.5 feet from mid-March to late August.
  - Operate lower Snake and Columbia River dam turbines within or above 1 percent peak efficiency during fish passage season.
- Structural
  - Construct additional powerhouse surface passage routes to meet system-wide PITPH[10] target at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, and/or John Day dams. This also increases the minimum spill relevant for MO4 and affects turbine availability.

1.4.6 Preferred Alternative (PA)

The Preferred Alternative combines a number of measures to benefit fish as well some measures for water management, power production, and water supply. The PA contains the following departures from the NAA that affect the power assessment:

- Fish Passage Spill:
  - This measure is a revised juvenile fish passage spill operation based upon results of the spring 2019 Flexible Spill Test Operation and analysis of the four MO Alternatives.
  - In a 24-hour period, the Juvenile Fish Passage Spill measure would involve 16 hours of spill operations up to 125% TDG at most projects for juvenile outmigration. For the remaining 8 hours, the projects would spill at a lower level, up to 125% TDG. These spill levels are slightly variable, depending on the project (see EIS Chapter 7). These operations would be implemented during the spring juvenile migration, April 3 – June 21, at the lower Snake River projects, and April 10 – June 16 at 5 the lower Columbia River projects. When Flex Spill ceases, the projects would transition to summer spill operations.

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[10] PITPH is a metric that estimates the proportion of juvenile fish passing a dam via the powerhouse. It is based on the relationship between the proportion of juvenile fish that pass via spill and the proportion that pass via the turbines and bypass systems at the dam.

- PA summer spill levels are described in EIS Chapter 7 with a late summer transition spill operation from August 15 - 31.
- Power contingency reserves can be carried within juvenile fish passage spill.
- As part of ongoing ESA consultations with NMFS, a measure to use surface weir spill for adult steelhead was modified in the Preferred Alternative. This measure provides for a small volume of spill through the spillway weirs at five projects, for a few hours each week in March, October, and early November.

- Water Management:
  - Account for local runoff volumes in Libby variable discharge (VarQ)[11] draft and refill operations when the Libby water supply forecast is below 6.9 Maf. Revert to NAA operation for years with water supply forecasts above 6.9 Maf.
  - Apply updated Upstream Storage Correction method to determine end of April draft requirement for Grand Coulee.
  - Update Grand Coulee storage reservation diagram (SRD) to account for a reduced planning draft rate limit of 0.8 feet/day.
  - Reduce limit on Grand Coulee maximum outflow to account for forecasted increase in outages. Use accelerated maintenance schedule for power plant and spillways instead of the NAA 5-year average.
- Water Supply
  - Increase water supply diversion from Lake Roosevelt by 45,000 acre-feet of water above the NAA.
- Storage
  - Sliding scale summer target elevation at Libby and Hungry Horse dams.
  - Dworshak will be operated with a variable draft elevation target to increase hydropower generation in the winter and reduce non-fish passage spill in the spring, while protecting the refill of the reservoir.
  - Operate John Day pool between 264.5 – 266.5 feet during April 10 – June 15 to reduce avian predation.
- Run-of-River
  - Increased lower Snake Dam operating range (MOP[12] + 1.5 feet).
  - Increased John Day forebay operating range (MOP + 2 feet).

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[11] The VARQ FRM procedure was developed to improve the multi-purpose operation of Libby and Hungry Horse dams while not reducing the level of flood protection in the Columbia River. VarQ details are available in the CRSO EIS *Flood Risk Management Appendix K*.
[12] MOP or minimum operating pool is the lowest forebay operating elevation for a run-of-river project.

    - John Day full pool measure would allow for operation of the reservoir across the full range 262.0 – 266.5 feet elevation outside of fish passage season, except as needed for structural measures
    - Zero generation operations may occur on lower Snake River projects October 15 – February with revised timing of the measure to provide hydropower flexibility to integrate new renewable resources and while minimizing impacts to ESA-listed fish.
- Structural:
    - Use new higher-efficiency turbines with improved fish passage survival in place of older turbines at John Day.
    - Construct powerhouse surface passage routes at McNary and Ice Harbor dams, which increases the minimum spill relevant for PA and affects turbine availability.

CHAPTER 2 - HYDROPOWER SYSTEM OPERATIONS REVIEW UNDER NEPA

2.1 HYDROPOWER IN THE COLUMBIA RIVER SYSTEM MANAGEMENT AREA

The Columbia River and its tributaries provide the Pacific Northwest with some of the nation's cheapest and cleanest, carbon free electric power. The Columbia River produces more hydropower than any other river in the United States. While most of the nation is powered by coal, natural gas, and a growing number of renewable resources, the Pacific Northwest runs primarily on water. Hydropower is not without its potential faults as spills can increase TDG, reservoirs can increase water temperatures, dams present fish passage challenges, and projects can leak oil and other chemicals. Nevertheless, many consider them to be clean and economical due to their use of streamflows to produce carbon-free power. Federal and non-Federal dams in the Pacific Northwest produce 50 percent of the region's electric energy and have 54 percent of its electric capacity, primarily from the Columbia River and its tributaries[13]. Most Federal power is currently sold at cost to the region's consumer-owned utilities. Other regional utilities, such as investor owned utilities, also have statutory rights to purchase federal power from Bonneville. Thus, hydropower is vitally important to the Pacific Northwest's economy.

This appendix provides the power production results of the CRSO EIS alternative for generation averages, generation peak capability, system reliability and flexibility, and carbon-fueled resource use. These hydropower results were used as input to the analyses provided in the *Power and Transmission Appendix H* and *Air Quality and Greenhouse Gas Appendix* G of the CRSO EIS.

2.2 HYDROPOWER INTERACTION WITH MULTIPLE USES

Hydropower is one of many authorized purposes of the CRS dams that affects and is affected by other authorized and incidental uses. This section summarizes how hydropower operations interact with the other uses.

2.2.1 Flood Risk Management

Hydropower and FRM are generally complimentary of each other. Columbia River flooding generally occurs with the rapid snowmelt of late spring, often in combination with spring rains. Storage reservoirs are drafted in the fall and winter months to create space to store runoff. This draft provides water used for power production during fall and winter months when streamflows are typically low to produce firm power to meet regional power customer load demands, which are typically higher than in the spring.

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[13] Pacific Northwest Hydropower for the 21st Century Power Grid. Accessed at https://www.nwcouncil.org/energy/energy-topics/hydropower

2.2.2 Anadromous Fish

Construction of certain Federal and non-Federal hydropower facilities without fish passage facilities blocked salmon and steelhead species' access to portions of the Columbia River and tributaries. The eight CRS run-of-river lower Snake and Columbia River dams have fish ladders to provide for upstream fish migration and juvenile fish bypass systems and spill programs for downstream fish migration. Grand Coulee Dam and then Chief Joseph Dam blocked access to the upper Columbia River. The Hells Canyon Complex (Idaho Power) blocked access to the upper Snake River. Dworshak blocked access to the North Fork Clearwater River. Implementation of several operational, structural, and mitigating actions to reduce the adverse effects of these projects on anadromous salmon and steelhead affect the hydropower analyses as provided herein. Flow augmentation actions are provided at different times of the year to improve in-stream conditions for juvenile fish migration in the mid and lower Columbia and lower Snake Rivers. Augmentation also is provided for spawning and rearing conditions in portions of these rivers. Flow augmentation measures that increase spring and early summer flows tend to reduce hydropower benefits. Operational measures that increase fall and winter flows can be beneficial to hydropower.

Juvenile fish passage spill operations are provided at the four lower Snake River and four lower Columbia River dams during spring and summer migration periods. Spill for juvenile fish passage generally reduces hydropower production, especially during times of normal or relatively low spring or summer flows. There are conditions during periods of relatively high spring flows when the effects of spill for passage on power are minimized from lack of need or available turbines for surplus generation.

Fish screens are installed at many powerhouses to direct juvenile fish to bypass systems. These improve fish survival, but limit power production by reducing efficiency, typically by 1 to 3 percent. In spite of efforts to provide passage through collection systems and spill, some juvenile fish migrate through the powerhouse turbines. Turbine generator units operate at ± 1 percent of their most efficient operating level, which may improve survival of fish passage through a turbine, but limits power flexibility.

John Day and the four lower Snake River dams operate at lower portions of their 3- to 5-foot operating ranges to help reduce juvenile fish reservoir migration time during the fish passage season. Power flexibility is reduced when the reservoir operating range is reduced.

There are several CRSO EIS alternative measures, especially structural and offsite mitigation actions, which would benefit anadromous fish but do not affect the hydropower analysis in this appendix including improved surface passage facilities, improved fish ladder systems, fish transportation systems (barging), and habit improvements.

2.2.3 Resident Fish

Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak dams all have operating measures to improve resident fish conditions in their reservoirs and river reaches below the dams. Operations that tend to increase minimum outflows often reduce benefits to hydropower. Operations that limit summer drafts to benefit resident fish can limit power production that may be offset by releasing retained water later in the fall or winter. Operations that limit fall and early draft (Albeni Falls) can reduce power benefits.

2.2.4 Water Quality

Water temperature and TDG are the two main water quality parameters affected by system operations. Water quality within the river system must be adequate to support aquatic life, municipal or industrial use, and water recreation. The co-lead agencies implement several temperature measures that help mitigate temperature and TDG effects and affect hydropower production.

2.2.4.1 Temperature

Minimum outflow requirements can help meet downstream temperature objectives. Libby, Hungry Horse, and Dworshak all have selective withdrawal structures for their powerhouses, which allow water to be released at different temperatures from stratified layers in their reservoirs. The release timing and amount affects power production.

2.2.4.2 Total Dissolved Gas

Spill at dams can result in increased levels of TDG, which can be harmful to fish. TDG generally increases with increased spill levels. Spills for fish passage at the Snake River and Columbia River dams is limited to state water quality standards. Waivers to the water quality standards have allowed targeting higher TDG levels for fish passage. Spill affects hydropower production by reducing the amount of water going through the turbines. During periods of particularly high flow, more water may also be spilled when there is not enough turbine capacity to route the excess water through the turbines and/or when there is a large surplus of power and no ability to market it (termed lack-of-market spill).

2.2.5 Irrigation and Water Supply

There are several federal and non-federal irrigation and water supply projects that withdraw surface water from the Columbia River and its tributaries. Irrigation withdrawals from the Columbia River and its tributaries reduce instream flows and consequently reduce the amount of water available for power production.

2.2.6 Navigation

Navigation locks provide commercial and recreational watercraft passage at the eight lower Snake River and lower Columbia River Corps-operated dams. A relatively small amount of water bypasses the powerhouses during filling and emptying the locks.

2.2.7 Recreation

Recreation facilities including parks, boat ramps, and docks have been constructed at all the federal reservoirs and in many river reaches below the dams. Reservoir recreation is generally best during warmer spring and summer months when the reservoir is full or near full and all facilities are operable. Reservoir operations are generally incidental to operations for FRM and Endangered Species Act purposes. Nevertheless, operations that promote early spring filling or limit reservoir draft in late summer can affect power production. Occasionally short-term operations support recreation, which limit operations for power.

2.2.8 Transmission

The Pacific Northwest hydropower projects and numerous non-hydropower resources connect to the Bonneville high voltage transmission system and/or interconnected with the west coast power grid which is known as the Western Interconnection. Within the WECC, Bonneville operates the Federal Columbia River Transmission system in the northwest. Bonneville's Transmission Services is responsible for transmission reliability in its territory. This includes ensuring that transmission lines have sufficient capacity to transmit power from the generating resources to the locations where the electricity is used. As part of the CRSO EIS, Bonneville is analyzing the impact of the alternatives on its transmission reliability and assessing whether new transmission infrastructure may be needed for the alternatives. Bonneville's service area and major transmission lines are shown in Figure 2-1. The CRSO EIS transmission analysis is described in *the Power and Transmission Appendix H*.

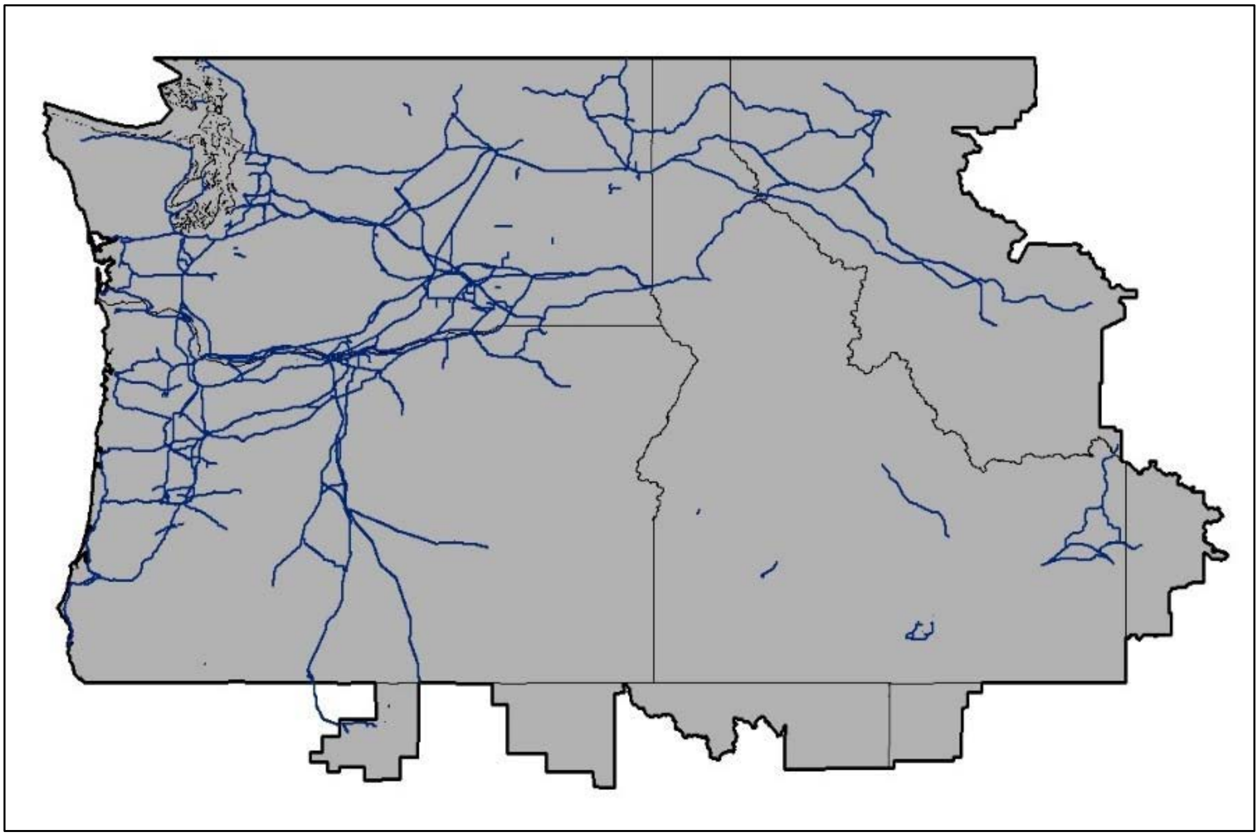

Figure 2-1. Bonneville Service Area and Transmission Lines

An important component of grid reliability is to ensure that electricity generation matches electricity demand at all times. Many of the hydropower resources on the grid can be operated to rapidly increase or decrease generation in response to fluctuating electrical demand needed to meet load or fluctuations in the generation of wind and solar and other resources, providing power flexibility that maintains a safe, reliable transmission system. The standby capacity and the ability to decrease generation are called generating reserves. Bonneville's power operations provide this service to the transmission operations. A subset of generating reserves are capacity reserves. They are used to replace generation when another generating unit stops unexpectedly or a transmission line that is importing energy suddenly cannot import the power. Contingency reserves are provided for 30-90 minutes until Bonneville can purchase power on the next cycle of the hourly spot market (i.e., the wholesale power market). Hydropower dams are a valuable tool for providing power flexibility when needed. The need for resources that can quickly respond to changes in the system is increasing as more wind and solar generation resources – resources that can vary rapidly due to changes in wind and sun within hours, minutes, and even seconds – are added in the region and the broader Western Interconnection. Hydropower can usually respond to these sudden changes and help integrate wind and solar power to the grid when there is operational flexibility for hydropower.

2.2.9 System Generation and Loads

The Pacific Northwest hydropower system consists of different hydropower systems or groupings of hydropower projects. The hydropower effects from the CRSO EIS alternatives are provided in the following groupings of projects:

- Columbia River System– includes generation from the 14 projects.
- Federal – includes the 14 CRS projects plus 17 others for a total of 31 Federal projects in the FCRPS
- Mid-Columbia projects – includes the 5 Mid-Columbia non-Federal projects which incur many of the hydropower effects from the CRSO alternatives due to their location directly downstream of Grand Coulee and Chief Joseph dams.
- NW-US system – includes Federal, Mid-Columbia projects, and other non-Federal generation.
- Canadian Treaty – includes generation from Mica and Keenleyside (Arrow) projects in Canada.
- Canadian Total – includes generation from Canadian Treaty projects and other projects in Canada on the Kootenay and Pend Oreille rivers.

To provide a safe and reliable source of electricity, Bonneville and other Northwest generating utilities must constantly match system generation to load. In addition to hydro, other resources producing firm power to meet load in the region include non-hydropower generation, such as nuclear and fossil-fueled or variable generation produced by renewable resource resources (wind and solar). Hydropower surpluses often result in opportunities to sell surpluses and thereby reduce power production at non-hydropower facilities. If such opportunities to sell excess power do not exist, surplus conditions may result in temporary storage of water in reservoirs if there is flexibility in the operation or spilling water at hydropower projects even when powerhouse units could generate additional power. During times of water surplus, especially during spring runoff, hydropower surpluses can also be used to displace gas-fired and coal-fired power generation at a relatively low cost with zero carbon emissions. Measures that increase hydropower production and/or flexibility increase hydropower benefits.

When conducting hydropower studies such as those for the CRSO EIS, the generation resulting from an alternative is often compared to a load forecast. These comparisons inform analysts of several factors including the need for additional resources, availability of surpluses, and reliability. Bonneville makes load/resource comparisons for its own loads and resources as well as comparing loads and resources for the region in various planning analyses.

Energy comparisons in the CRSO EIS are generally made by comparing HYDSIM generation output resulting from a regional residual hydropower load. Analysts estimate this residual load by subtracting forecasted generation of non-hydropower resources (nuclear and fossil-fuel generation), renewable resource generation (wind and solar), and hydropower independent resource generation (e.g., the other 17 FCRPS projects) from the regional load forecast to arrive at the portion intended to be served by the CRS projects' generation in HYDSIM.

Hourly or peak load comparisons for the CRSO EIS are made using Hourly Operations Scheduling Simulator (HOSS) output and only for the federal system; hourly studies become increasingly complex when adding the uncertainty of the forecasts and availability of resources of the entire region. Bonneville prepares a federal residual hydropower load by adjusting the Federal load forecast for Bonneville firm power sales contracts and resources not modeled in HOSS. However, for the purposes of this CRSO analysis, the ultimate metric of interest is whether or not one alternative produced more or less generation than another, so the results reported here do not include direct comparisons of generation against load.

Reliability comparisons are made for the CRSO EIS using GENEration Evaluation SYStem (GENESYS), an hourly regional (Pacific Northwest) model that stochastically games temperature derived regional loads and stochastic variability of regional resources (i.e., streamflow, forced outages, variable wind, and solar). The data input set and assumptions for this analysis uses the NW Council's 2022 Resource Adequacy Assessment.[14]

2.3 HYDROPOWER MODELS

Bonneville used the HYDSIM, HOSS, AURORA, and GENESYS models for most of its hydropower analyses in the CRSO EIS. Details of Bonneville's modeling are provided in the CRSO EIS *Hydroregulation Appendix I*.

2.3.1 HYDSIM

HYDSIM has been in use at Bonneville for decades and is well-calibrated. HYDSIM is a monthly model, where April and August are split into half-months (e.g., April I and April II) giving 14 HYDSIM periods in each water year. The model has been used for years for hydropower planning at Bonneville and Treaty coordination with Canada and regional utilities. Project inflows, outflows, powerhouse flows, and spills calculated by HYDSIM are period averages. Reservoir elevations and storage contents calculated by HYDSIM are end-of-period. The model produced average generation for each of the 14 periods in 80 water years for each of the projects. Results were calculated for four project groupings: NW-US (Pacific Northwest Federal and non-Federal), Canadian, CRS (Federal), and Mid-Columbia. Summing the generation for all projects in a group for each period resulted in 14-period average generation for each of the 80 water years. The hydropower metrics were then calculated from the final generation data.

More detail on model runs can be found in the *Hydroregulation Appendix I*. In the studies described here, the HYDSIM generation output was evaluated, generally using simple

14 Details for load descriptions are provided in Northwest Power and Conservation Council's (NW Council's) Pacific Northwest Power Supply Adequacy Assessment for 2022 at https://www.nwcouncil.org/energy/energy-advisory-committees/resource-adequacy-advisory-committee

spreadsheets, to assess the impacts on metrics for average generation, lowest 10th percentile generation, and critical water generation.

2.3.2 HOSS

Bonneville has used HOSS for many years to study peak- and off-peak generation and reliability. HOSS uses monthly HYDSIM output data to calculate an hourly generation schedule for the Federal hydropower system. This provides generation results on a finer time scale for peak generation metrics. HOSS incorporates the same HYDSIM modeling objectives such as minimum flows, maximum flows, upper rule curves, fish operations, fish passage spill, and other measures pertinent to the CRSO EIS alternatives.

HOSS results are summarized in the 14 HYDSIM periods for each of the 80 water years of the CRSO EIS studies. Generation results are provided for the Federal system only. More model run details can be found in the *Hydroregulation Appendix I*. The 120-Hour generation and HLH generation tables (14 periods by 80 water years) were then used to compute the 120-hour, 10th percentile HLH, and critical water year HLH metrics.

2.3.3 AURORA

AURORA is a production cost model, developed by Energy Exemplar, Ltd Pty., used by hundreds of utilities globally to forecast short- and long-term electricity prices. Given model inputs (resource build, load forecast, fuel cost, etc.), AURORA produces a price forecast by calculating the least cost solution of meeting system-wide load on an hourly basis, subject to a number of operating constraints. The cost of producing and delivering an additional unit of energy to a location in the system is assumed to approximate the price at that location.

Bonneville uses AURORA to create price distributions by using Monte Carlo sampling of projected loads, hydro generation, gas prices, transmission capacity, wind generation, and Columbia Generating Station (CGS) capability. Given 80 years of month-average hydropower energy estimates provided by HYDSIM for each of the CRSO EIS modeling studies, AURORA estimates month-average prices and month-average Lack of Market (LOM) spill MW quantities. LOM spill occurs in AURORA when available hydro generation exceeds transmission capabilities and system load net of lower cost or must-run generation. The AURORA LOM spill estimates are then included as LOM limits in a second pass of HYDSIM.

Energy revenue estimates are developed by applying AURORA prices to the energy differences between each alternative and the reference NAA case.

2.3.4 GENESYS

GENESYS is an economic dispatch model that uses Monte Carlo sampling to simulate short-term load uncertainty, and uncertainty in streamflows, wind, solar, and forced outages for thermal generation plants. The model performs a detailed constrained dispatch of the regulated hydropower projects in the watershed of the Columbia River and a simple dispatch of Pacific Northwest regional thermal plants against an extra-regional import market.

The model was developed by Northwest Power and Conservation Council (NWPCC), Bonneville, and other regional entities, and is used to perform studies requiring detailed hydropower dispatch for planning purposes. More specifically, NWPCC uses GENESYS for annual adequacy assessments, periodic regulated hydropower flow studies and periodic analysis of lost revenue due to hydropower dispatch change. The adequacy of the regional power supply is assessed probabilistically in GENESYS by evaluating any regional shortfall against NWPCC's adequacy target. This target was designed to assess whether the region has sufficient resources to meet growing demand for electricity in future years. Regulated hydropower flow studies have been performed for fish passage survival and life-cycle studies, and climate change scenarios.

For the CRSO EIS alternatives, the GENESYS model was run by Bonneville staff. Datasets containing hydropower generation plant parameters and constraints (inputs similar to HYDSIM and Reservoir System Simulation [ResSim]), thermal generation plant parameters and constraints, and other generation sources and constraints (i.e., wind and solar power plants) were input into the model. Power demand loads and both long- and short-term generation commitments also were entered into the model.

2.4 HYDROPOWER METRICS

Six hydropower metrics were evaluated in three different categories. In general, Bonneville uses power generation metrics to determine the expected amount of power generated by the amount of water available through powerhouses, which varies because of differing CRSO EIS alternative measures affecting total flow in the river and different allocations of the total flow between spill and generation. Reliability metrics provide the probability of a regional power outage from changes in hydropower availability and a measure to quantify generation resources system reliability restoration to a specified level. Metric details are provided in Section 2.4.2.

2.4.1 Hydropower Generation Overview

Hydropower modeling produces quantitative results for several metrics. Hydropower production changes generally improve or reduce system benefits in accordance with the following:

- Bonneville and other regional utilities generally experience higher energy demand during the winter months. Typically, there is higher spot (wholesale) market value (i.e., prices for energy) in the winter. Utilities that are short on power often face higher market prices when acquiring additional power during this time. The spring period is typically characterized by surplus generation, low energy demand, and low spot market energy values. Utilities that sell their surplus power into the market during this time generally receive smaller secondary revenues. Fall months are transitional. In the summer, demand for power is slightly less than demand for power in the winter. However, because there is generally less flow (especially later in the summer) and demand for power in the summer is increasing in the region, the summer is also a period of higher value for energy. Depending on whether a utility is long or short on power may expose them to higher spot market prices.

- Energy losses during periods of high energy demand and low flows such as winter can negatively affect the cost and ability of meeting demand. A similar loss during periods of low energy demand and high water such as spring would not have the same magnitude consequence.
- The Loss-of-Load-Probability (LOLP) presented in this analysis indicates a real consequence of generation losses during periods of high demand/low generation. Loss-of-load or curtailment are industry terms for the lights going out. Considering that most regional infrastructure depends on reliable power, an event that results in the loss of power is a human health and safety issue as well as an economic issue. Regional planning authorities and power industry standards demand that the likelihood of curtailments is held below certain levels. When the regional generating resources are determined to be inadequate to meet these standards, generating resources must be added at a significant cost to the ratepayers.
- Analysis of the tail events (such as the 10th percentile metrics) is a standard hydropower metric used to determine resource adequacy. Therefore, losses of any magnitude in this metric would directly affect future resource adequacy.
- The 120-hour capacity metric is a measure of a system's ability to meet monthly load peaks day-after-day under expected load conditions. Any decrement to this metric affects the system's ability to meet short-term peak loads.
- An average gas combustion turbine can produce about 364 MW and the Columbia Generating Station produces an average of 1,075 MW.

These factors provide some general context for quantitative and qualitative results in hydropower production and system reliability from the CRSO EIS alternatives. There is substantially more detail in the *Power and Transmission Appendix H* on the effects these hydropower generation changes have on regional power rates and other key factors.

2.4.2 Hydropower Generation Metrics

The hydropower generation metrics in this appendix are standards Bonneville uses in several types of studies involving the FCRPS including Bonneville rate cases, system reliability studies, CRT planning studies, and planning studies such as the CRSO EIS. The *Hydroregulation Appendix I* in the CRSO EIS details how the metric values are quantified. In summary, the generation metrics include:

- <u>Average generation</u>: The average electric power created from an energy source in megawatts (MW). In this appendix, the average generation is reported either by year or by

14-period averages wherein April and August are split into two periods. It is calculated by HYDSIM as the annual average or the 14-period average for the 80 water-years studied.[15]

- 10th percentile average generation: The lowest 10th percentile average generation calculated by HYDSIM from the 80 water-years studied. This metric provides an indication of how much generation can be expected month by month under dry water conditions. The 10th percentile generation level is closely related to what Bonneville studies as part of its Federal System Needs Assessment, which evaluates the ability of the FCRPS to meet projected firm load obligations under various conditions.
- Critical water-year average generation: The generation for water year 1937 (October 1, 1936 – September 30, 1937) is calculated in HYDSIM. This dry water year is the lowest average CRS power generation of all years in the 80-year study period. Production of this amount of hydropower could reasonably be expected if the 1937 conditions repeated under modern system conditions. It is an important metric in determining the need for additional resources (power) to meet the Administrator's load supply obligations or replace aging and retired generating resources. Bonneville's long-term firm power sales to its regional power customers are tied to this metric.
- 120-Hour generation: Calculated by HOSS, it is the average of 120 hours (60 hours for the split months of April and August) with the highest demand for electricity and hence the highest generation averaged for all 80 water years (5 hours/day, 6 days a week for 4 weeks).
- 10th percentile Heavy Load Hour (HLH) generation: The lowest 10th percentile HLH generation average is for hours ending 0700 to 2200 (7 am to 10 pm) of all 80 water years. The Heavy Load Hours are a standard definition in the utility industry referring to blocks of time with relatively higher demand for power. Electric power is routinely traded in the wholesale power market in HLH blocks.
- Critical water year HLH generation: The HLH generation for water year 1937.

2.4.3 Hydropower Revenue Metrics

Estimates of hydropower revenue values are reported in millions of dollars for energy and capacity. Determining revenue value is complex and includes estimating hydropower generation, hydropower revenue, and the challenges of forecasting power prices. Power prices involve forecasts of regional and west-coast-wide power demand and supply and economic conditions historically uncertain. The *Hydroregulation Appendix I* provides hydropower generation computation details. This appendix provides the estimated amounts of hydropower average energy generation and critical water generation for the federal system in Chapter 3.6. The *Power and Transmission Appendix H* provides revenue value effects on Bonneville's rates and other economic factors.

[15] The hydropower studies used 80 historic water years as proxies for the potential future water supply. The 80 water years are from the 2010 Modified Flow studies.

2.4.4 System Reliability Metrics

The North American Electric Reliability Corporation (NERC) states there are two components of reliability: resource adequacy and security.[16]

Resource adequacy is the ability of the power system to meet aggregate energy and capacity demand at any time. While there is no regional resource adequacy standard, Bonneville is required by the Northwest Power Act to meet its long-term requirements customers' "firm power load", which means providing power on a continuous, uninterrupted, and on demand basis.[17] Measuring LOLP is a useful metric in evaluating the adequacy of the power supply in the region to meet the firm power needs of Bonneville and other utilities' loads. A high LOLP generally indicates that the power supply in the region is constrained, increasing the probability that a system event, such as an extreme weather event or the loss of a generator, could result in a power shortage or blackout.

Security is defined as the ability of the system to withstand sudden disturbances such as sudden losses of transmission lines or generators. The focus of this analysis is on resource adequacy. (Bonneville is required to carry reserves to be able to increase generation in the case of a disturbance. The required level of reserves was included in the modeling as a fixed input value.)

Bonneville and the NWPCC use LOLP as a fundamental metric of power system reliability. LOLP measures the frequency of a power outage; it does not capture the magnitude or duration of an outage. Bonneville and NWPCC use a target of 5 percent LOLP (i.e., an adequate power supply should have a 5 percent or less likelihood of at least one load curtailment (power shortage or rolling blackouts) event occurring in 1 year).

Bonneville uses the Conditional Value at Risk (CVaR) metric to provide this information. CVaR is expressed in megawatt-months of curtailments during months with the highest probability of an outage and represents the quantity of energy not served.

2.4.5 Integration of Renewable Resources in the System

The metric for resource integration is system generation flexibility. Bonneville models do not have an effective metric to accurately capture changes in flexibility, especially within an hour or from hour-to-hour. A qualitative assessment was prepared based on Bonneville real-time power scheduling experience.

2.4.6 Carbon Emission Metrics

The CRSO EIS co-lead agencies measure carbon emissions in metric tons of carbon dioxide (CO_2) released into the atmosphere. The amount of CO_2 emitted results from changes to fossil-fueled

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[16] *See* 2019 State of Reliability, NERC, at 2, June 2019, *available* https://www.nerc.com/pa/RAPA/PA/Performance%20Analysis%20DL/NERC_SOR_2019.pdf.
[17] *See* 16 U.S.C. § 839c(b)(1); *see also* S. Rep. 96th Cong. 1st Sess. No. 272, 1980 at p. 26.

power production due to hydropower production changes from the CRSO EIS alternatives. When Bonneville determines it has surplus power (energy, capacity, or both), Bonneville often sells such power to purchasers that either operate or acquire fossil-fueled power. Such purchasers in turn may reduce or turn off their generating plants. Conversely, when there is less hydropower generation than needed to meet demand, fossil-fuel generation may increase to meet the demand. The fossil-fueled production effects of the alternatives are determined in Bonneville's development of potential replacement power resource portfolios and analysis of their potential use in this appendix (Chapter 4.2). The CRSO DEIS *Air Quality and Greenhouse Gas Appendix G* and *Power and Transmission Appendix H* discuss the effects of the CO_2 changes resulting from the changes in fossil fuel production.

2.4.6.1 Methodology

There are numerous generating units supplying power to the Pacific Northwest power system. At any given time, some of these units will be hydroelectric, nuclear, and perhaps wind and solar generating units that do not emit CO_2 while others likely will be coal or natural gas-fired generating units that emit CO_2.

The NWPCC's 7th Power Plan has a conservation strategy for the region to acquire nearly 4,862 average megawatts (aMW) of conservation between 2010 and 2025. Even with this amount of conservation, loads will continue to grow, albeit at a lower rate. State renewable portfolio standards will require the development of approximately 6,100 MW of installed wind capacity by 2025 in addition to the 4,266 MW of wind capacity dedicated to serving regional loads. There are also plans to close several large coal plants in the region. With these changes to the power system, particularly the retirement of large coal plants, thousands of megawatts of additional generating resources in the region for both energy and capacity are needed. New gas-fired generation in addition to the nearly 7,500 MW currently operating plants would provide needed capacity because wind and solar resources are intermittent. However, the Northwest is trending toward reducing fossil-fuel emissions and may choose not to build new gas-fired generation.

Resources, acquired by Bonneville, must be cost effective in accordance with the Northwest Power Act. The Act sets out the following resource priority: conservation, renewable resources, generating resources using waste heat or high fuel conversion efficiency resources, and then all other resources. Resource requirements of entities other than Bonneville are not covered in this CRSO EIS. However, the last resource dispatched to meet load is considered the marginal resource; it is likely to have higher operating costs than resources used before it. According to the NWPCC report, *Avoided Carbon Dioxide Production Rates of the Northwest Power System*, (NWPCC Report) typically marginal units (units that turn on/off the most in response to changes in demand) are gas-fired power plants now operating in the region and new plants forecasted to be constructed by 2025 (NWPCC 2018).

CHAPTER 3 - IMPACTS OF THE ALTERNATIVES ON HYDROPOWER

3.1 HYDROPOWER GENERATION IMPACTS

This chapter provides the values for hydropower energy and peak generation resulting from the NAA and four Multiple-Objective (MO) alternatives with comparisons to the NAA. Details on the metrics used for the comparisons are in Chapter 2.

3.1.1 Overview

Three metrics were evaluated specifically for hydropower energy generation: average generation, 10th percentile average generation (P10), and critical water year (1937) average generation. In addition, three metrics were evaluated specifically for hydropower peak generation: 120-Hour generation, 10th percentile Heavy Load Hour (HLH P10) generation, and critical water year (1937) Heavy Load Hour (HLH critical water) generation. Hydropower generation impact results for the metrics were produced for each of four systems including: the NW-US system, the 14-dam Federal system (CRS), the five-dam Mid-Columbia system, and the Canadian system (CRT and several non-Treaty projects). A list of the system dams in each system is provided in Exhibit 1.

The NW-US energy results for average, P10, and critical water generation are presented in this chapter. Generation changes from the NAA for all the systems generally reflect the changes observed for the NW-US system and discussed in Section 3.2. Exceptions for the CRS, Mid-Columbia, and Canadian systems are noted. The energy results for the CRS, Mid-Columbia, and Canadian systems are provided in Exhibit 4, Exhibit 5, and Exhibit 6.

The CRS (Federal) peak results are presented in Section 3.3; no NW-US, Mid-Columbia, or Canadian peak results were produced due to modeling limitations.

3.1.2 General Methodology

Bonneville and the Corps collaborated extensively on modeling the CRSO EIS alternatives. The Corps used ResSim to model the CRSO EIS alternatives. The resulting 80-year daily or Monte Carlo calculation values from ResSim for reservoir elevations, streamflows, and project spills were used for most of analyses performed for the CRSO EIS. Because ResSim does not include power drivers in operations and ResSim output did not provide hydropower production values for the alternatives, Bonneville produced the hydropower generation results using HYDSIM. The reservoir and streamflow conditions for each alternative over the 80-year study period in HYDSIM and ResSim studies were closely coordinated to minimize differences. Bonneville also used the HOSS model to develop estimates of the hourly operations for use in estimating peak generation values that contribute to reliability and resource integration analyses. HYDSIM and HOSS modeling and ResSim coordination details are presented in the *Hydroregulation Appendix I*. ResSim details are provided in the *Hydrology and Hydraulic Data Analysis Appendix B*.

3.2 ENERGY GENERATION RESULTS

Energy generation results for each of the CRSO EIS alternatives were produced for the U.S., CRS (Federal), Mid-Columbia, and Canadian systems. Generation results for each alternative are driven primarily by storage reservoir objectives for downstream flow measures and specified project spill measures for fish passage Section 1.4 in this document and Chapter 2 of the EIS provide details about the measures in the alternatives.

This section also compares the energy generation results between the NAA and each alternative and provides the rationale for generation changes from the NAA.

3.2.1 Energy Generation Methodologies

Bonneville used the HYDSIM model output to estimate the average generation, P10 generation, and critical water year generation for each of the alternatives. The average generation is for each of the 14 periods in each year of the 80-year study record. P10 generation is for the lowest 10th percentile average for each of the 14 periods in each year of the 80-year study record. The P10 values for each period will be from different water years, not from the P10 water year. The critical water year generation is the generation from October 1936 through September 1937 from the 80-year study record.

Key study inputs include the measures listed in Section 1.4. Modeling details are provided in the *Hydroregulation Appendix I*. After completing the HYDSIM runs, Bonneville noticed generation inadvertently did not account for new high efficiency turbines at John Day Dam in any of the MO alternatives. These new turbines will replace the existing turbines and increase power production efficiency by 4.5 percent at John Day. Time constraints did not permit model revisions for the EIS. Consequently, the MO alternative 80-year average generation values in this appendix are low by about 45 aMW with a range of 20 to 60 aMW depending on the alternative, month, and water conditions. The PA results do account for the new high efficiency turbines at John Day Dam.

In addition, HYDSIM did not pick up the elevation limit in December for providing 650 thousand acre-feet of space at Grand Coulee to protect against rain-induced flooding in MO1, MO2, and MO4. Had this elevation constraint been in effect, December generation would have increased by about 450 aMW and January and February generation would have been lower. Annual average generation was not affected.

3.2.2 NW-US Energy Generation Summaries

NW-US system energy generation results are provided from HYDSIM output for average generation in Figure 3-1 and Table 3-1, P10 average generation in Figure 3-2 and Table 3-2, and critical water generation in Figure 3-3 and Table 3-3. Complete results for the NW-US, CRS (Federal), Mid-Columbia, and Canadian systems are provided in figures and tables in the Exhibits.

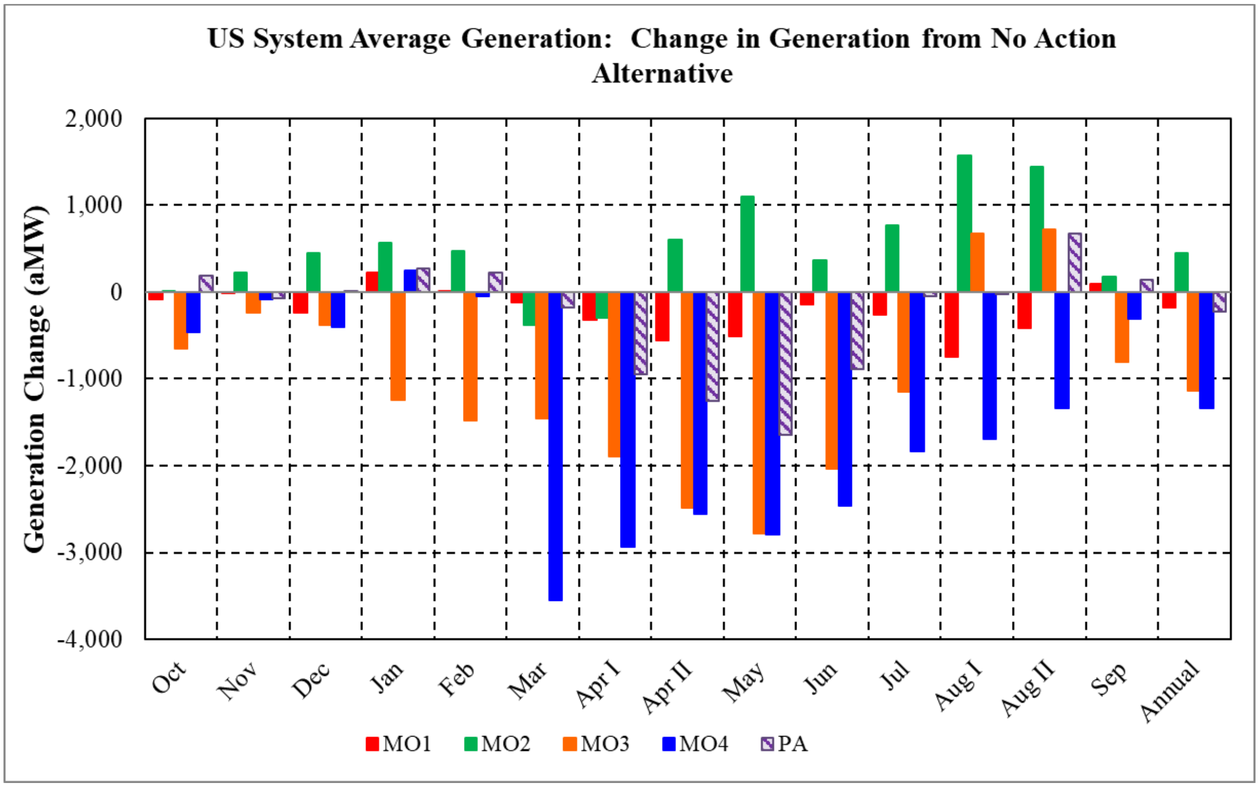

Figure 3-1. NW-US System Average Generation: Change from NAA

Table 3-1. NW-US System Average Generation: Change from NAA

US System Average Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
MO1	-83	-17	-242	228	16	-117	-317	-558	-506	-147	-258	-745	-416	92	-173
MO2	6	222	450	572	468	-380	-294	602	1,102	361	772	1,574	1,449	177	453
MO3	-646	-234	-380	-1,243	-1,481	-1,451	-1,889	-2,490	-2,786	-2,032	-1,151	678	716	-804	-1,137
MO4	-457	-83	-402	244	-49	-3,549	-2,938	-2,552	-2,793	-2,462	-1,834	-1,693	-1,336	-308	-1,339
PA	194	-68	6	270	225	-174	-951	-1,253	-1,647	-883	-41	-20	671	145	-229

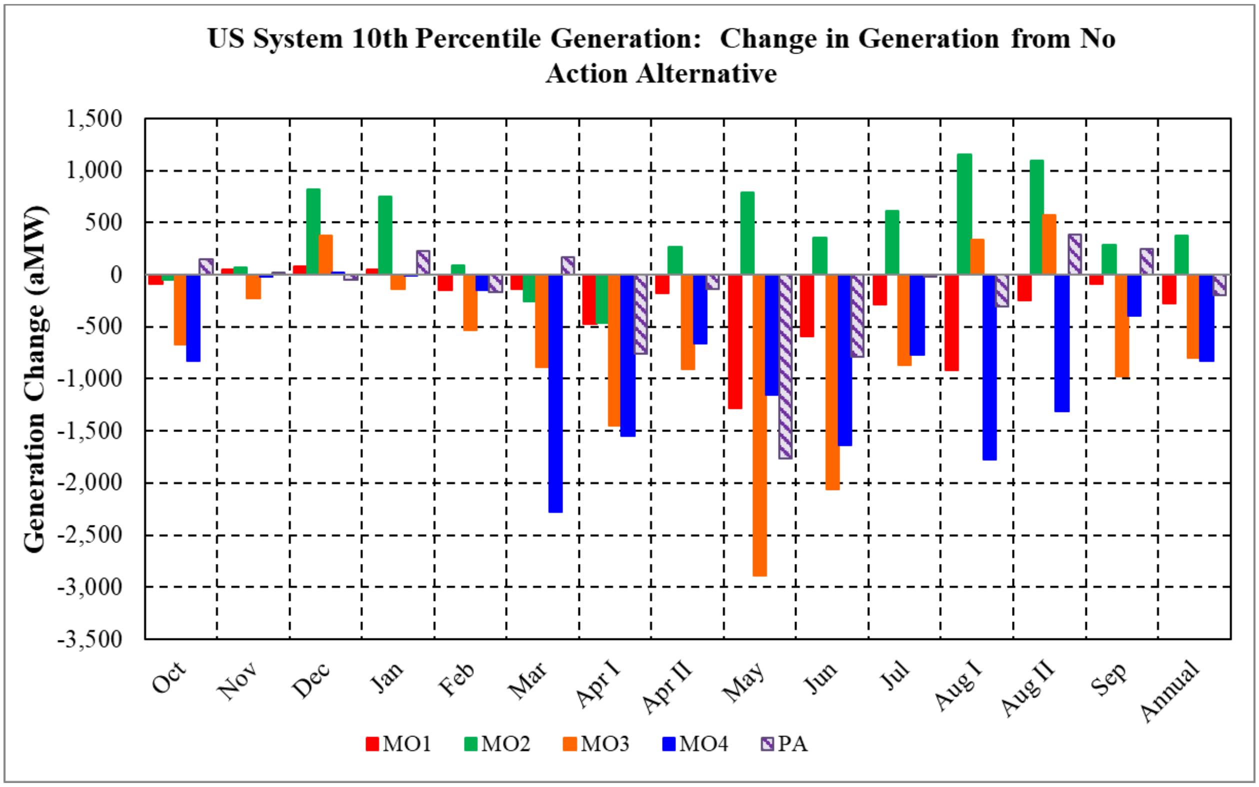

Figure 3-2. NW-US System P10 Generation: Change from NAA

Table 3-2. NW-US System P10 Generation: Change from NAA

US System 10th Percentile Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
MO1	-92	53	79	49	-143	-140	-476	-177	-1,284	-591	-284	-912	-250	-85	-280
MO2	-50	73	818	747	91	-255	-458	263	794	360	609	1,158	1,095	285	380
MO3	-665	-221	374	-140	-536	-888	-1,449	-907	-2,892	-2,056	-867	339	573	-978	-798
MO4	-830	-20	17	-2	-143	-2,278	-1,551	-663	-1,150	-1,632	-766	-1,770	-1,313	-395	-826
PA	148	20	-52	223	-167	173	-760	-132	-1,764	-788	-22	-305	390	248	-197

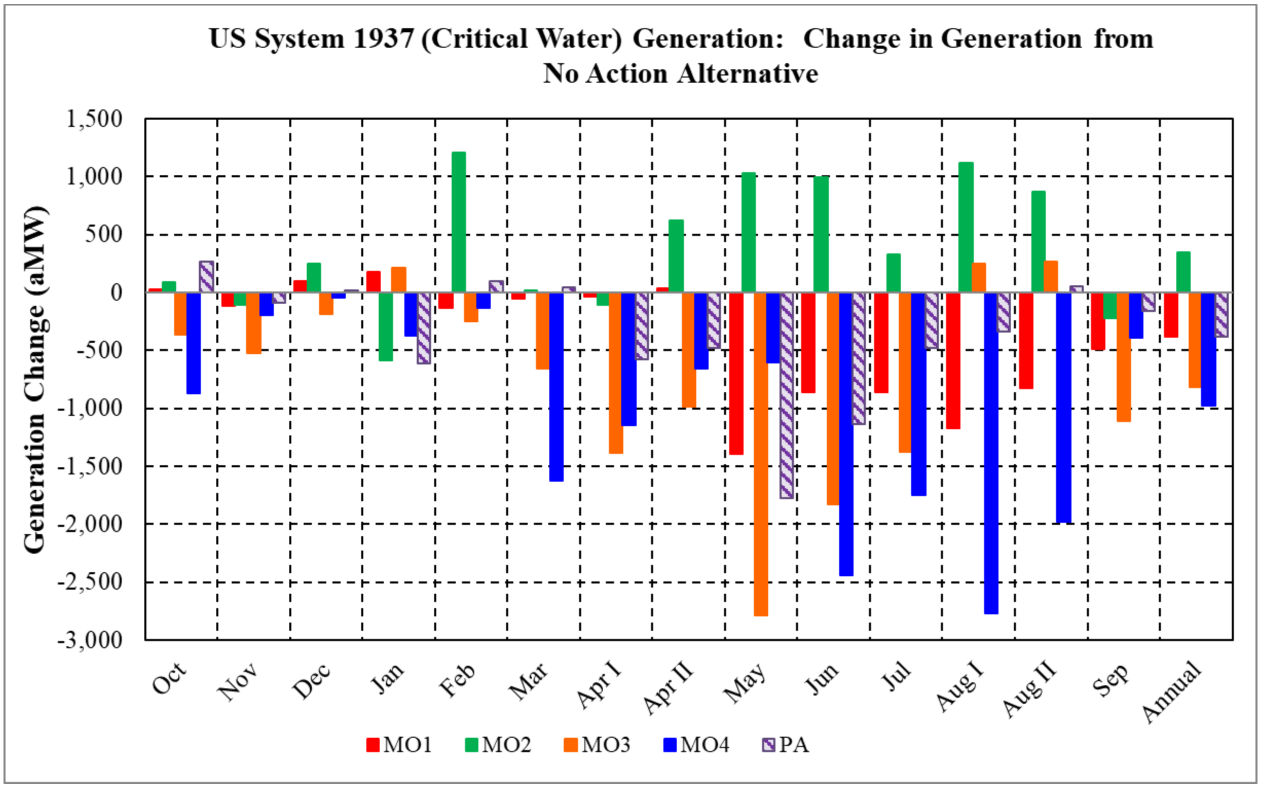

Figure 3-3. NW-US System Critical Water (1937) Generation: Change from NAA

Table 3-3. NW-US System Critical Water (1937) Generation: Change from NAA

US System 1937 (Critical Water) Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
MO1	28	-117	99	177	-129	-50	-36	35	-1,390	-858	-864	-1,172	-829	-489	-385
MO2	90	-105	245	-586	1,210	17	-106	618	1,027	994	332	1,122	866	-224	348
MO3	-366	-520	-184	217	-247	-658	-1,388	-986	-2,784	-1,831	-1,378	246	263	-1,112	-817
MO4	-873	-197	-48	-369	-131	-1,627	-1,147	-653	-601	-2,442	-1,747	-2,768	-1,976	-388	-980
PA	264	-89	16	-614	95	45	-578	-481	-1,771	-1,137	-478	-338	54	-162	-377

3.2.3 NW-US System Energy Generation: MO Comparisons to NAA

The following average generation summary is provided for the NW-US system. Similar trends were observed for the CRS and Mid-Columbia systems, though the Mid-Columbia projects are not affected by spill changes at the CRS projects. Because the Treaty projects were operated the same for each of the CRSO EIS alternatives, there was relatively little change in the Canadian system. There was no change in the Idaho Power projects because the Hells Canyon Complex and federal projects in the Upper Snake River basin as these also were operated the same for each of the CRSO EIS alternatives and are upstream of the CRS projects and not impacted by changes in flows from the CRS projects.

3.2.3.1 Energy: NAA compared to MO1

Table 3-4, Table 3-5, and Table 3-6 provide the average, P10, and critical water year differences between NAA and MO1 for the NW-US system. Positive differences indicate an increase in average generation from the NAA.

Table 3-4. NW-US System Average Generation: NAA vs. MO1

NW-US System - Generation (Average MW)														
	OCT	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**AP2**	**MAY**	**JUN**	**JUL**	**AG1**	**AG2**	**SEP**	**Annual**
NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
MO1	9,280	12,188	13,277	15,343	15,315	13,607	12,326	12,911	15,956	17,358	13,915	11,025	9,813	9,306	13,200
Change	-83	-17	-242	228	16	-117	-317	-558	-506	-147	-258	-745	-416	92	-173

Table 3-5. NW-US System P10 Generation: NAA vs. MO1

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
MO1	8,438	10,715	10,983	10,915	10,085	9,573	8,260	7,637	11,286	12,426	9,274	8,687	8,385	8,222	9,865
Change	-92	53	79	49	-143	-140	-476	-177	-1,284	-591	-284	-912	-250	-85	-280

Table 3-6. NW-US System Critical Water (1937) Generation: NAA vs. MO1

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
MO1	8,794	10,962	11,323	10,931	8,560	8,984	8,671	7,876	10,034	13,056	10,252	9,366	8,576	8,732	9,912
Change	28	-117	99	177	-129	-50	-36	35	-1,390	-858	-864	-1,172	-829	-489	-385

Figure 3-4 and Figure 3-5 also illustrate the individual project differences for major individual NW-US system projects for average and critical water (1937) generation. The solid "Sys" line indicates the Federal plus Mid-Columbia generation difference from the NAA. (The Federal plus Mid-Columbia projects constitute the majority of changes between MO1 and NAA, but there would also be some changes at the other non-Federal projects comprising the NW US system.) The individual project blocks indicate the amount of change in project average generation from the NAA. Project blocks above the zero line indicate a project generated more than the NAA; blocks below the zero line indicate less generation than the NAA. Detailed information for the individual project differences is provided in Exhibit 3.

The individual projects in Figure 3-4 include the 14 CRS projects plus the 5 Mid-Columbia projects: Grand Coulee (GCL), Chief Joseph (CHJ), Wells (WEL), Rocky Reach (RRC), Rock Island (RKI), Wanapum (WAN), Priest Rapids (PRD), McNary (MCN), The Dalles (TDA), John Day (JDA), Bonneville (BON), Libby (LIB), Hungry Horse (HGH), Dworshak (DWR), Lower Granite (LWG), Little Goose (LGS), Lower Monumental (LMN), and Ice Harbor (IHR).

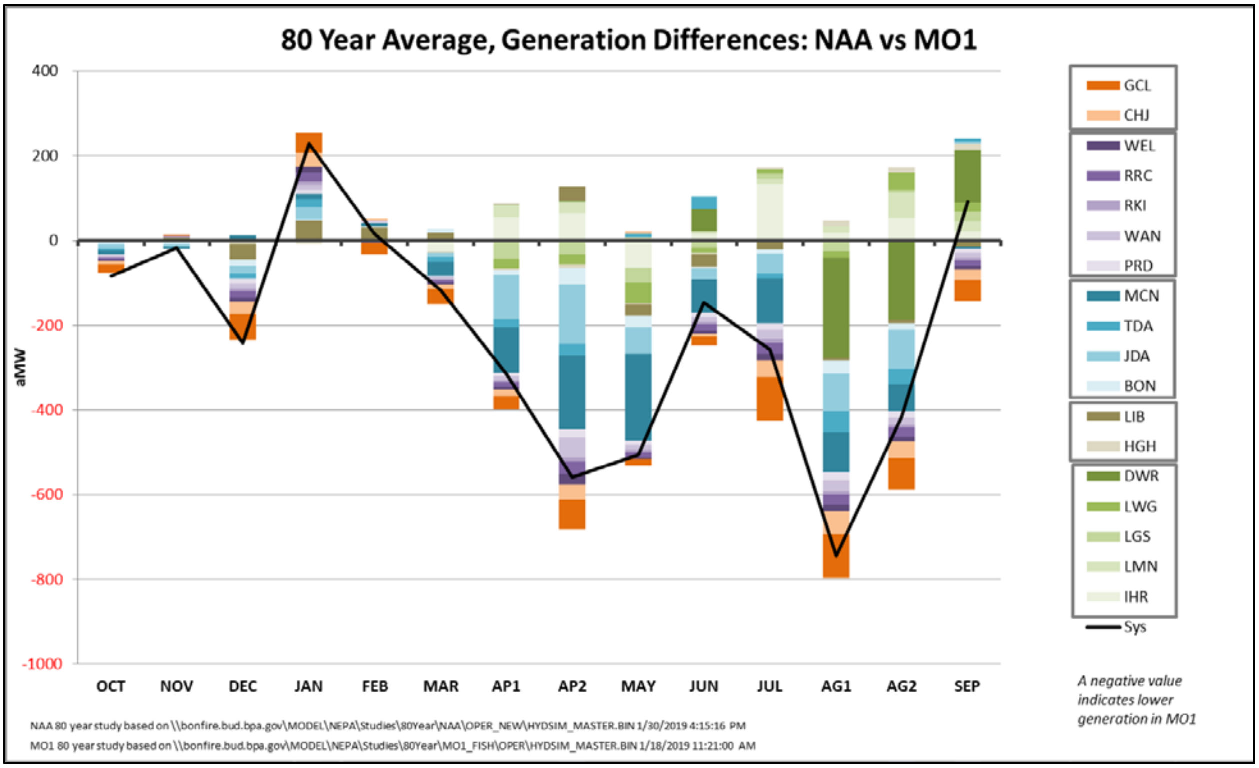

Figure 3-4. NW-US System and Project Average Generation: NAA vs. MO1

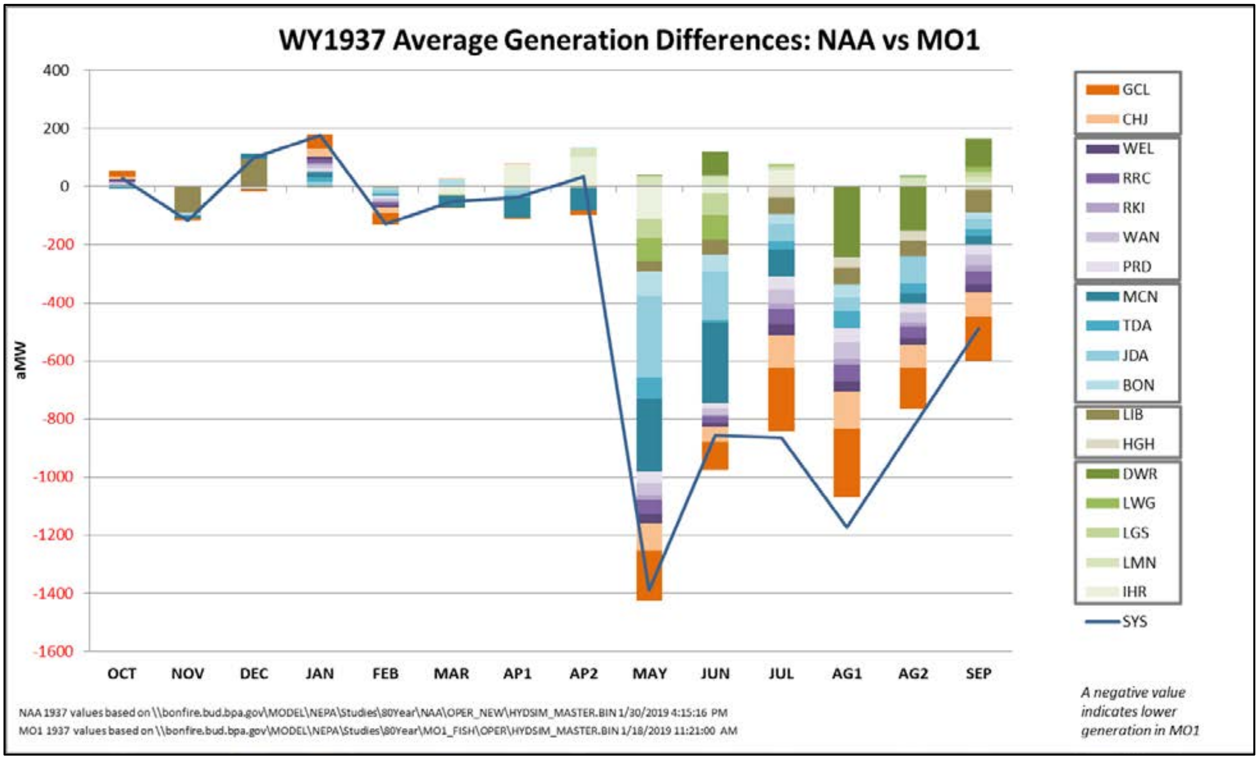

Figure 3-5. NW-US System and Project Critical Water Generation: NAA vs. MO1

Generation changes between NAA and MO1 primarily result from the following:

December: The reduction in generation in December is partially due to Libby ending December at a target of 2,420 feet NGVD29 (about 3.8 feet higher on average than the NAA variable target); the reduction in inflows to Grand Coulee, combined with essentially the same end of month elevation, means there is less generation both at the project and at all the projects downstream. However, the December operation at Grand Coulee for protection against rain-induced flooding that was inadvertently not picked up in HYDSIM would have offset this effect. This additional month of the operation would have increased December generation in years where an increase in flows was possible and decreased January generation by up to 450 MW in the years with the largest effect.

January: The largest portion of the increase in average generation in January is the result of Grand Coulee changes. In MO1, Grand Coulee ends December slightly higher, and ends January on average almost 2 feet lower, than NAA. This, in addition to changes from FRM (specifically winter flood operations that vacate additional space and maintain that space through March in case of rain events), increased generation at Grand Coulee (and therefore also the downstream projects).

March-June: Based on preliminary modeling, the hydro modelers initially expected to see an increase in spill and potentially flow constraints at Grand Coulee during the drawdown in late spring and possibly during refill if drawdown before run-off was not fully achieved in very large water years due to Grand Coulee maintenance operations measure. However, when the complete MOs were modeled together with the measure for a 0.8-foot planned draft rate, the Grand Coulee maintenance measure did not appear to have a significant effect on operations.

April-May: MO1 is generating less in the spring because MO1 greatly increased spring spill. Both blocks of the alternating block pattern have higher spill than the NAA spring spill levels. In alternating years, the block for the first half of spring spill (through May 11) is either to 120 percent TDG in the tailrace limited to 115 percent in the forebay or slightly higher spill levels than the overall spring spill in NAA and the 2017 Fish Passage Plan.

June-July: MO1 generates less power because its summer spill is slightly higher than in the NAA. Some of the decrease in generation is offset by higher releases from Dworshak in June and July. The higher Dworshak outflows also allow the lower Snake River projects that spill to a fixed amount to generate more than in the NAA; the additional outflows also offset some generation loss at the lower Snake River projects that have summer spill set to a greater percent of outflow than in the NAA.

August: The MO1 change in the operation at Dworshak moves some of the August outflow into June, July, and September resulting in less outflow from Dworshak and in the lower Snake River projects during August. This combined with higher MO1 summer spill results in less generation, which is somewhat offset in the second half of August due to MO1's end date for summer spill at the lower Snake River projects being earlier than NAA's. In some periods (primarily in August due to the reduced flows from Dworshak), HYDSIM modeling showed that not enough water flows in the lower Snake River to meet minimum turbine flows, powerhouse surface passage spill, and flow needed for the navigation locks and fish ladders. This exemplifies how little water is flowing in the lower Snake River in August and matches the observation of very little generation in August.

September: The small generation increase in September is due to the slight increase in outflows at Dworshak and the projects downstream as part of the MO1 adult fish measure. This increase offsets the generation decreases at Grand Coulee and Chief Joseph resulting from lower inflow due to an ending elevation increase at Libby in many years (a result of the sliding scale measure).

MO1: P10 VS. AVERAGE GENERATION

As observed with the annual average of 80 years, the annual average generation for the P10 driest years in MO1 (Table 3-5) are lower than NAA. In the P10, the difference between generation in MO1 and NAA is larger than the difference calculated for the average of all water years. Looking at the specific months, this effect is strongest in May and June.

In turn, November and December have a slight increase in generation for the 10th percentile driest years compared to No Action unlike the month-average generation for all water years.

MO1: CRITICAL WATER VS. AVERAGE GENERATION

In the critical water (Table 3-6), MO1 loses more generation than P10 generation relative to NAA than in the 80-year average. The annual loss in critical water generation is a primary input to the agency's calculation of the minimum annual power it can depend on generating with the hydro-system even in a "bad year" which determined how much firm power (power guaranteed to be continuously available) from the FCRPS is available in meeting the Administrator's long-term firm power contract obligations. In order to be in a load/resource balance, any reductions in the amount of firm power produced by the FCRPS must be acquired from other resources. Taking the monthly view, the large losses in generation in July and August would likely lead to power shortages during this period as analyzed in Chapter 4 of the LOLP study.

3.2.3.2 Energy: NAA compared to MO2

Table 3-7 through Table 3-9 provide the average, P10, and critical water generation differences between NAA and MO2 for the NW-US system. Positive differences indicate an increase in average generation from the NAA. Figure 3-6 and Figure 3-7also indicate the individual project differences for major individual United States projects for average and critical water year (1937) generation. Detailed information by project for the critical water differences is provided in Exhibit 3.

Table 3-7. NW-US System Average Generation: NAA vs. MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
MO2	9,370	12,428	13,970	15,686	15,768	13,344	12,349	14,071	17,564	17,865	14,945	13,344	11,678	9,392	13,826
Change	6	222	450	572	468	-380	-294	602	1,102	361	772	1,574	1,449	177	453

Table 3-8. NW-US System P10 Average Generation: NAA vs. MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
MO2	8,480	10,736	11,722	11,613	10,319	9,458	8,278	8,077	13,364	13,377	10,166	10,757	9,729	8,592	10,524
Change	-50	73	818	747	91	-255	-458	263	794	360	609	1,158	1,095	285	380

Table 3-9. NW-US System Critical Water Generation: NAA compared to MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
MO2	8,856	10,973	11,470	10,168	9,900	9,051	8,601	8,459	12,451	14,908	11,449	11,661	10,270	8,997	10,645
Change	90	-105	245	-586	1,210	17	-106	618	1,027	994	332	1,122	866	-224	348

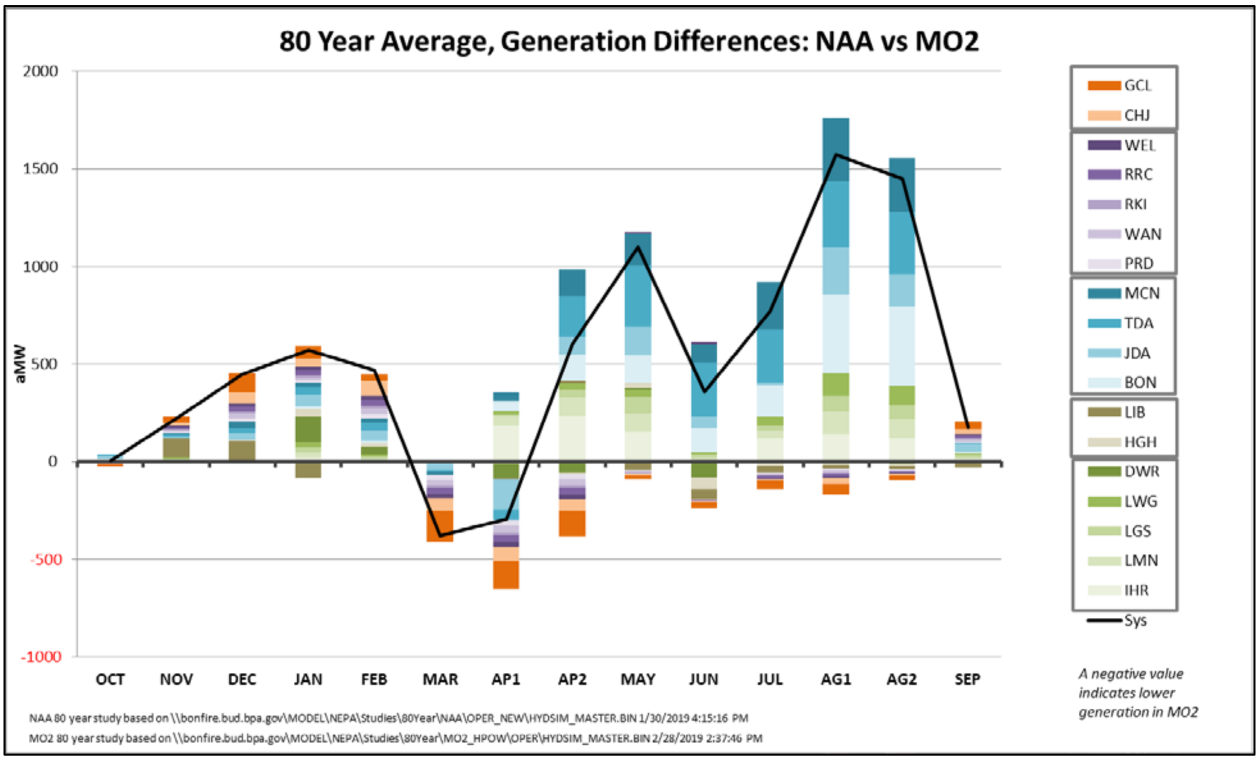

Figure 3-6. NW-US System and Project Average Generation: NAA vs. MO2

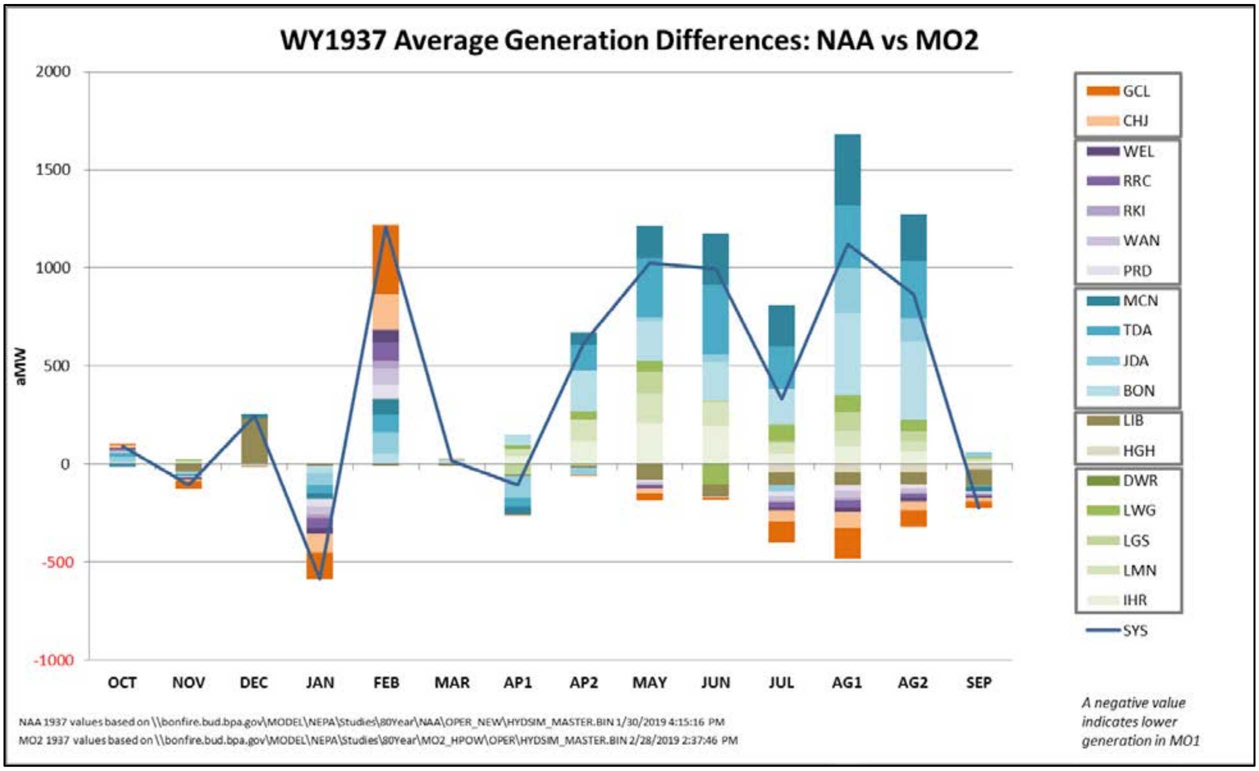

Figure 3-7. NW-US system and Project Critical Water Generation: NAA vs. MO2

Generation differences between NAA and MO2 primarily result from the following:

October – December: The generation increase from NAA is due to deeper drafts and lower end-of-month elevation targets at Libby; 2,428 feet NGVD29 at the end of November and 2,400 feet NGVD29 at the end of December. The additional draft and higher releases from Libby increase generation at the site and several projects downstream through Bonneville Dam. Had the Winter System FRM Space measure been included in December as intended, the December generation would have been even higher, by up to 450 aMW in years with the largest effect.

January – February: The generation increase from NAA is due to deeper drafts of Hungry Horse, Grand Coulee, and Dworshak in January and February. The additional draft and higher releases from all three projects increase generation at the site and several projects downstream through Bonneville Dam. Had the Winter System FRM Space measure been included in December, generation in January, and possibly February, would have been lower.

March – April I: The generation reduction is a consequence of deeper drafts of storage projects (Hungry Horse, Grand Coulee, and Dworshak) in January and February resulting in less water released in March and April I. Decreased flow lowers power production at the storage and downstream projects.

April I – August II: The generation increases from the NAA are the result of reduced spills for fish passage at the eight lower Snake River and Columbia River projects.

MO2 fish passage spill is near 110 percent TDG at most projects, except when minimum spill levels are higher for powerhouse surface passage routes, spillway weirs, and/or for adult attraction to fish ladders, which is less than NAA spill. In addition, the MO2 spill duration is shorter ending on July 31 whereas the NAA spill ends on August 31. Both MO2 actions result in generation increases, especially in August.

September: The generation increase in September results from MO2 having a slower, later reservoir fill target of October 31 rather than September 30 in the NAA. Because the refill is slower, more flow is released from Grand Coulee in September, increasing generation at the site and several projects downstream through Bonneville Dam. The flow then decreases from Grand Coulee in October as the refill is increased to meet the same end of October target elevation.

MO2: P10 AND CRITICAL WATER VS. AVERAGE GENERATION

Generation in the 10th percentile driest years and in the critical water year followed the same trend as the average generation over the 80 water years. In the critical water, MO2 gains about 350 aMW relative to NAA. The annual gain in critical water generation is a primary input to the agency's calculation of the minimum annual power. It can depend on generating with the hydro-system even in a "bad year," which determines how much firm power produced by the FCRPS is available to Bonneville to meet its long-term Regional Dialogue firm power sales contracts. The differences in generation between January and February might be adjustable in real-time generation.

3.2.3.3 Energy: NAA compared to MO3

Table 3-10 through Table 3-12 provide the average, P10, and critical water generation differences between NAA and MO3 for the NW-US system. Positive differences indicate an increase in average generation from the NAA. Figure 3-8 and Figure 3-9 also illustrate the individual project differences for major individual United States projects. Detailed information for the differences is provided in Exhibit 3.

Table 3-10. NW-US System Average Generation: NAA vs. MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
MO3	8,718	11,971	13,139	13,872	13,819	12,273	10,754	10,980	13,676	15,473	13,022	12,448	10,945	8,410	12,236
Change	-646	-234	-380	-1,243	-1,481	-1,451	-1,889	-2,490	-2,786	-2,032	-1,151	678	716	-804	-1,137

Table 3-11. NW-US System P10 Average Generation: NAA vs. MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
MO3	7,865	10,441	11,279	10,725	9,692	8,825	7,287	6,908	9,678	10,960	8,691	9,938	9,208	7,329	9,347
Change	-665	-221	374	-140	-536	-888	-1,449	-907	-2,892	-2,056	-867	339	573	-978	-798

Table 3-12. NW-US System Critical Water Generation: NAA vs. MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
MO3	8,400	10,558	11,040	10,971	8,443	8,376	7,318	6,855	8,640	12,083	9,738	10,785	9,668	8,109	9,480
Change	-366	-520	-184	217	-247	-658	-1,388	-986	-2,784	-1,831	-1,378	246	263	-1,112	-817

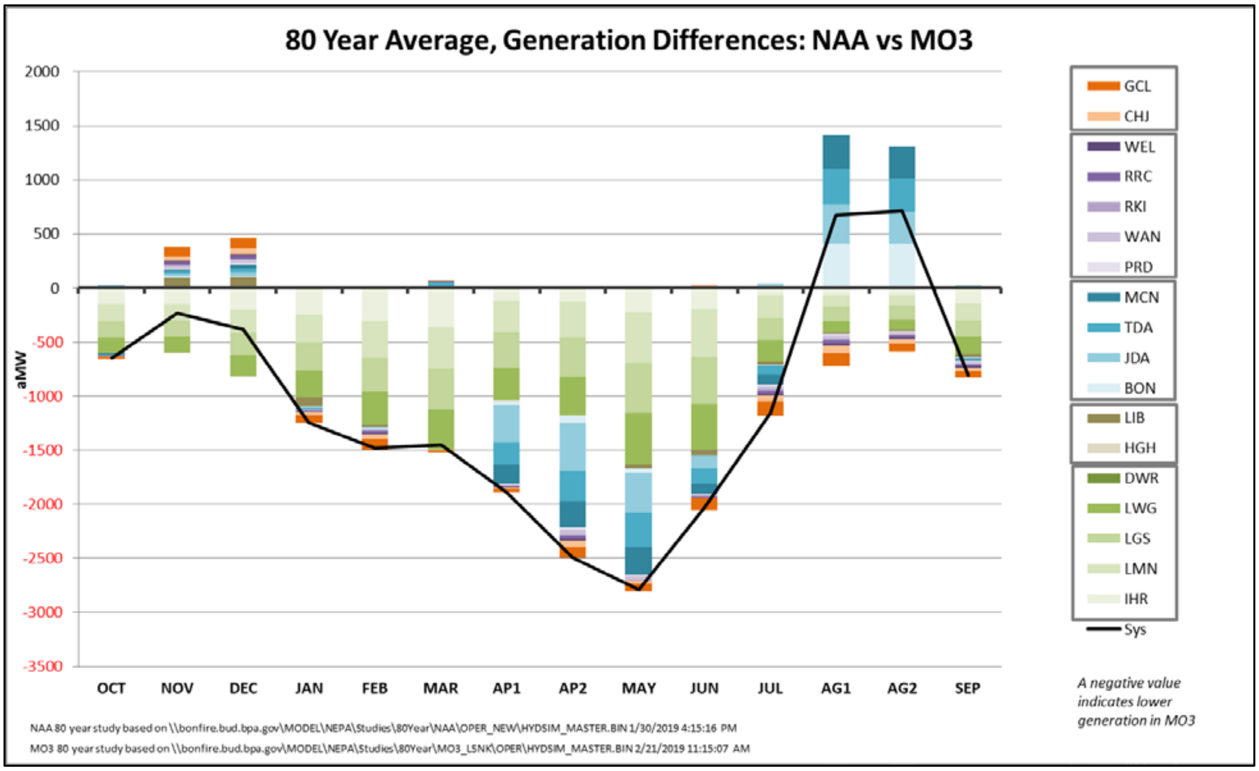

Figure 3-8. NW-US System and Project Average Generation: NAA vs. MO3

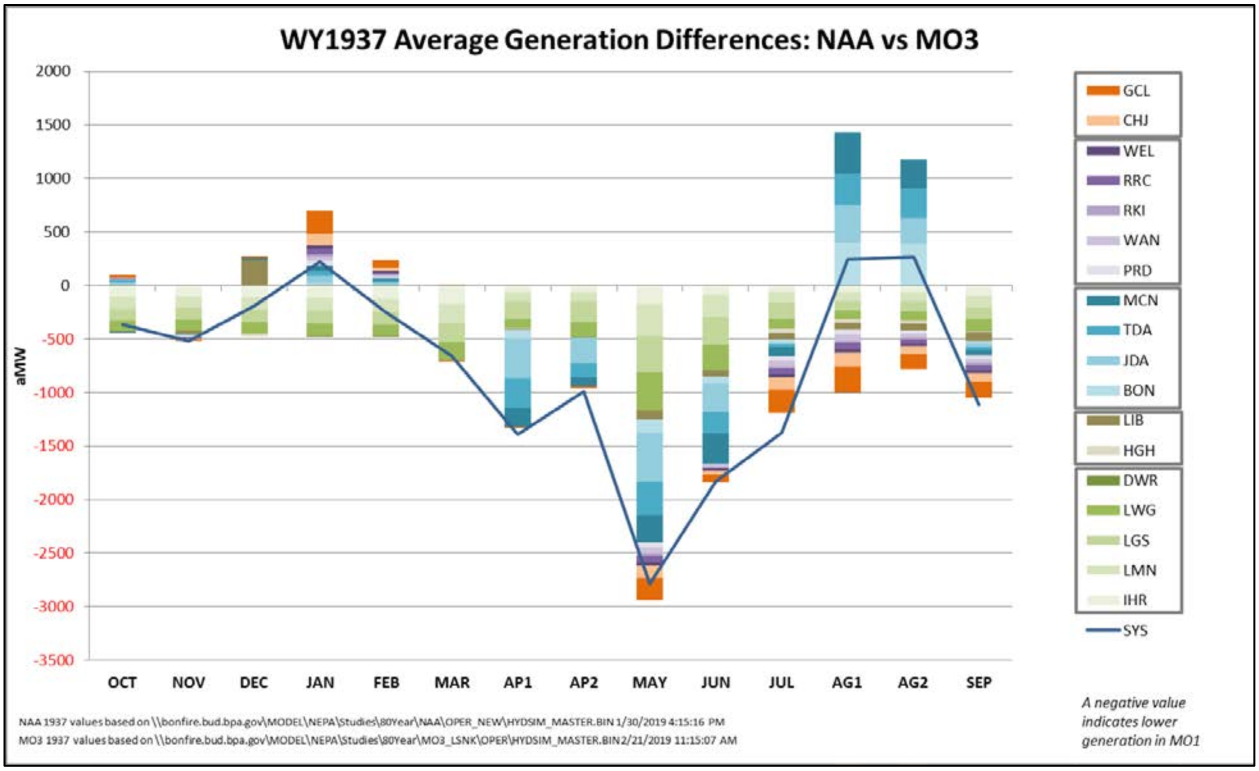

Figure 3-9. NW-US System and Project Critical Water Generation: NAA vs. MO3

Generation differences between NAA and MO3 are explained as follows:

October – September: Breaching of the four lower Snake River dams results in reduced NW-US system generation in all months except August when the lost Snake River dam generation is offset by generation increases on the Lower Columbia projects from ending spill July 31 (AG1 and AG2).

November – December: Deeper drafts to lower end-of-month elevation targets at Libby (2,428 feet NGVD29 at the end of November and 2,400 feet NGVD29 at the end of December) result in the generation increases from the NAA. The additional draft and higher releases from Libby increase generation at the site and several projects downstream through Bonneville Dam. Because these increases do not fully offset the generation losses from the removal of the four lower Snake River dams, the overall NW-US system average generation in November and December is lower than the NAA generation for the same period.

January – March: Loss of generation from the lower Snake projects is the primary driver for reduced generation.

April – July: MO3 average generation is less than NAA primarily due to the removal of the four lower Snake River dams and additional lower Columbia River spill for fish passage. MO3 spills the Lower Columbia projects to 120 percent TDG, which is higher than spill in NAA.

August: MO3 NW-US system average generation is greater than NAA primarily due to fish passage spill ending July 31, whereas NAA spill ends on August 31, offsetting the loss of Lower Snake River dam generation.

MO3: P10 AND CRITICAL WATER VS. AVERAGE GENERATION

Generation is significantly lower in MO3 compared to NAA in the 80-year average. The same trend holds true for generation in the lowest 10th percentile and critical water generation, though the loss is not quite as much. This may be because there is simply less power generated at the lower Snake River dams during drier water years, so increasing spill to 125 percent has a slightly smaller effect in the drier years. However, it is these driest years when the loss in generation would be most critical to meeting system reliability.

SENSITIVITY ASSESSMENT FOR SNAKE RIVER DAM BREACHING

Snake River dam breaching is included as one of several measures in MO3. The generation effects of dam breaching were difficult to distinguish from the total effects of the measures in MO3. Bonneville prepared a separate hydropower analysis of the impact of dam breaching because of the high-profile nature of this measure. The average annual and critical generation loss was estimated to be 1,030 aMW and 538 aMW, respectively. Details of this sensitivity analysis are in Exhibit 7.

3.2.3.4 Energy: NAA compared to MO4

Table 3-13 through Table 3-15 provide average, P10, and critical water generation differences between NAA and MO4 for the NW-US system. Positive differences indicate an increase in average generation from the NAA. Figure 3-10 and Figure 3-11 also illustrate the individual project differences for major individual United States projects for average and critical water (1937) generation. Detailed information for the project differences is provided in Exhibit 3.

Table 3-13. NW-US System Average Generation: NAA vs. MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
MO4	8,906	12,122	13,117	15,358	15,250	10,175	9,705	10,918	13,669	15,042	12,339	10,077	8,893	8,906	12,034
Change	-457	-83	-402	244	-49	-3,549	-2,938	-2,552	-2,793	-2,462	-1,834	-1,693	-1,336	-308	-1,339

Table 3-14. NW-US System Average P10 Generation: NAA vs. MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
MO3	7,700	10,643	10,921	10,864	10,085	7,435	7,185	7,151	11,420	11,385	8,792	7,829	7,322	7,912	9,319
Change	-830	-20	17	-2	-143	-2,278	-1,551	-663	-1,150	-1,632	-766	-1,770	-1,313	-395	-826

Table 3-15. NW-US System Critical Water Generation: NAA vs. MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
MO4	7,894	10,882	11,176	10,385	8,558	7,407	7,560	7,188	10,823	11,472	9,370	7,770	7,429	8,833	9,317
Change	-873	-197	-48	-369	-131	-1,627	-1,147	-653	-601	-2,442	-1,747	-2,768	-1,976	-388	-980

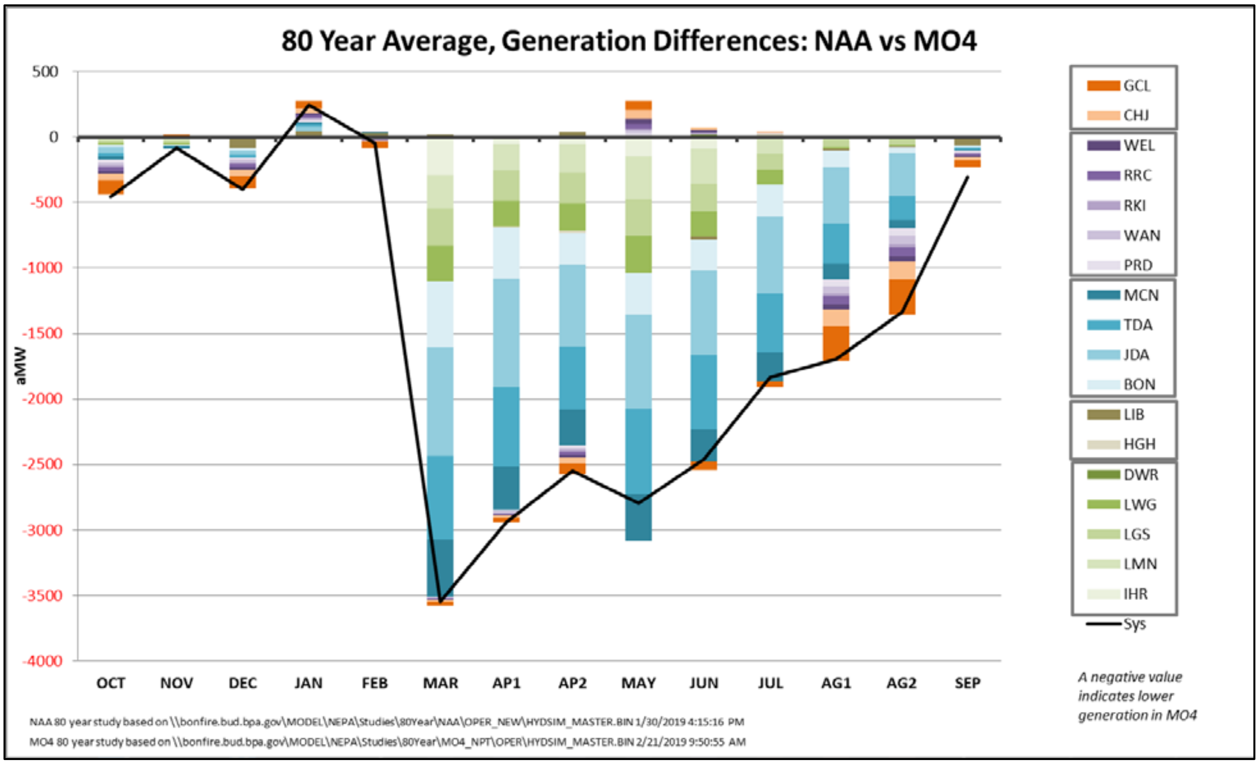

Figure 3-10. NW-US System and Project Average Generation: NAA vs. MO4

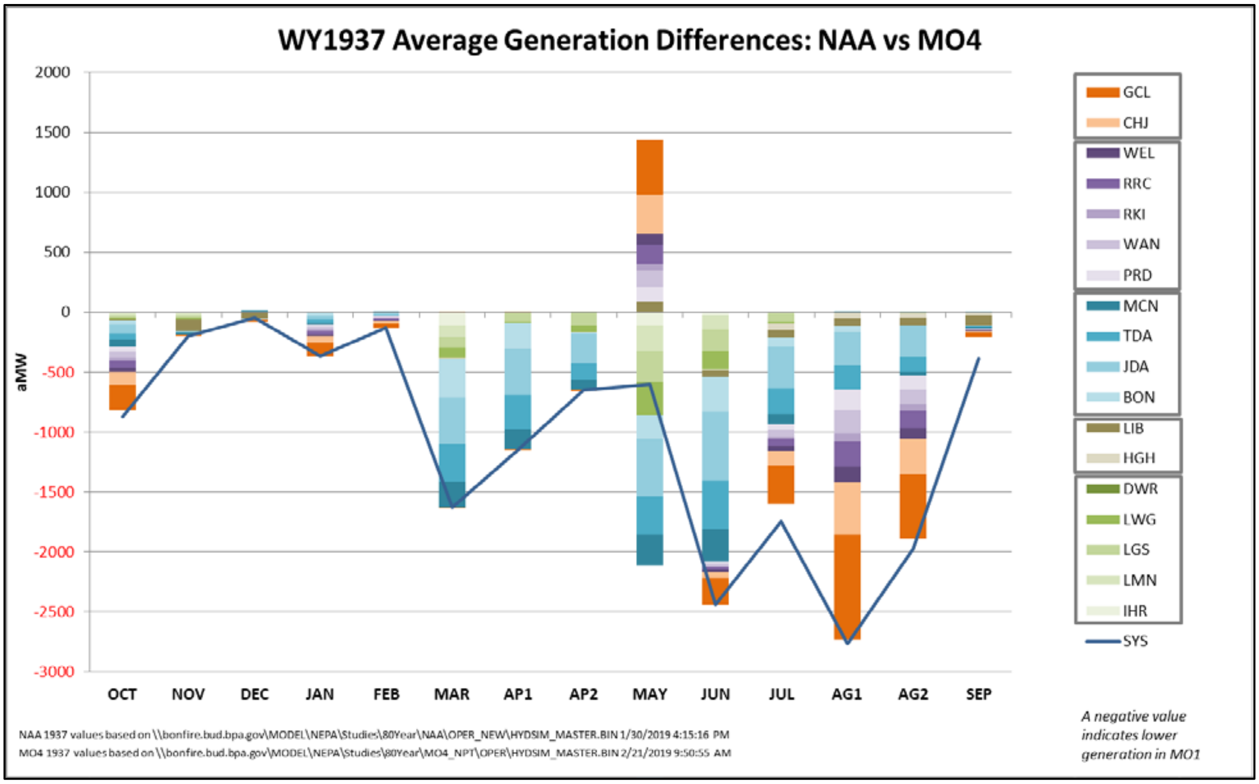

Figure 3-11. NW-US system and Project Critical Water Generation: NAA vs. MO4

Generation differences between NAA and MO4 primarily result from the following:

October: MO4 provides up to an additional 2 Maf from Grand Coulee, Libby, Hungry Horse, and Albeni Falls to meet the 220 kcfs spring and 200 cfs summer flow targets at McNary. Refilling this space in October results in an average generation reduction from the NAA.

MO4 provides lower Columbia River project spill which is not in the NAA for steelhead overshoots (adults that migrate too far up the Columbia River, overshoot their entry to a tributary, and come back down the river to swim up the tributary).

December – January: Limit Libby discharge in winter to help establish vegetation for resident fish habitat (November – March) and increase the end-of-December elevation at Libby (2,420 feet NGVD29 msl) compared to NAA, which is often at 2,411 feet NGVD29, but can be as high as 2,426.7 feet NGVD29. This releases less water in December and more in January. However, had the Winter System FRM Space measure been included in December as intended, the December generation would have been higher by up to 450 MW in the years with the largest effect, which could lead to a slight net positive December value for MO4 compared to NAA. Conversely, January and perhaps February would have had less generation, potentially resulting in both months with a reduction in generation in MO4 compared to NAA.

March – August: MO4 has significant average generation reductions from NAA during this period: Juvenile fish passage spill is raised to 125 percent TDG at all eight lower Snake and Columbia River projects; and the spill period is extended to March 1 through August 31, versus the NAA period of early April through August 31. Most of the eight fish-passage projects are generating only at their minimum generation levels during this period and spilling the remainder of the water in all water years. In March and August, all eight projects are generating only at their minimum generation in all years.

MO4 strives to meet the 220 kcfs spring flow objective at McNary by drafting upstream storage reservoirs to provide up to 2 Maf additional flow in drier years. If not all of the 2 Maf were used in the spring, flow augmentation may continue into the summer to help meet the McNary summer flow target of 200 kcfs. This measure results in incremental generation during May-June in drier years and sometimes additional generation in July. Half of the water for the flow augmentation comes from Grand Coulee and the rest comes from Hungry Horse, Libby, and Albeni Falls. By August, the storage projects are not able to sustain this discharge and flows are reduced compared to NAA, leading to a significant reduction in generation at the storage projects, plus Chief Joseph in August. The reduction in generation at these projects due to reduced flow, together with the reduced generation from 125 percent TDG spill at the fish-passage projects, leads to a significant energy deficit in August and large impacts to the LOLP for MO4 discussed in Section 4.1.2.5. Reduced flows and generation from the flow augmentation persists into September as the storage projects refill. In drier years, the project may not be able to refill, causing these projects to operate at minimum flow/generation for longer, though that condition would also be the case in some of the same years in the NAA.

MO4: P10 and Critical Water vs. Average Generation

Generation is significantly lower in MO4 compared to NAA in the 80-year average. The same trend holds true for generation in the lowest 10th percentile, though the loss is not quite as much. This may be because there is simply less power generated at the lower Snake River dams during drier water years, so removing these dams has a slightly smaller effect in the drier years. However, it is these driest years when the loss in generation would, of course, be most critical to meeting system reliability. For example, in 1937 all eight fish passage projects are generating only at their minimum generation levels and spilling the rest of the project flows.

In the critical water, the roughly 800 aMW loss in generation in MO4 compared to NAA would result in a large decrease in the amount of energy Bonneville could provide to its preference customers through long-term contracts.

3.2.3.5 Energy: NAA compared to PA

Table 3-16 through Table 3-18 provide average, P10, and critical year generation differences between NAA and PA for the NW-US system. Positive differences indicate an increase in average generation from the NAA. Figure 3-12 and Figure 3-13 also indicate the individual project differences for major individual United States projects for average and critical water (1937) generation. Detailed information for the project differences is provided in Exhibit 3.

Table 3-16. NW-US System Average Generation: NAA vs. PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
PA	9,558	12,137	13,525	15,385	15,524	13,551	11,692	12,216	14,815	16,621	14,132	11,750	10,900	9,360	13,144
Change	194	-68	6	270	225	-174	-951	-1,253	-1,647	-883	-41	-20	671	145	-229

Table 3-17. NW-US System Average P10 Generation: NAA vs. PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
PA	8,679	10,682	10,853	11,089	10,061	9,886	7,976	7,682	10,806	12,229	9,535	9,295	9,025	8,555	9,947
Change	148	20	-52	223	-167	173	-760	-132	-1,764	-788	-22	-305	390	248	-197

Table 3-18. NW-US System Critical Water Generation: NAA vs. PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
PA	9,030	10,990	11,240	10,140	8,785	9,079	8,129	7,360	9,653	12,777	10,638	10,201	9,459	9,059	9,920
Change	264	-89	16	-614	95	45	-578	-481	-1,771	-1,137	-478	-338	54	-162	-377

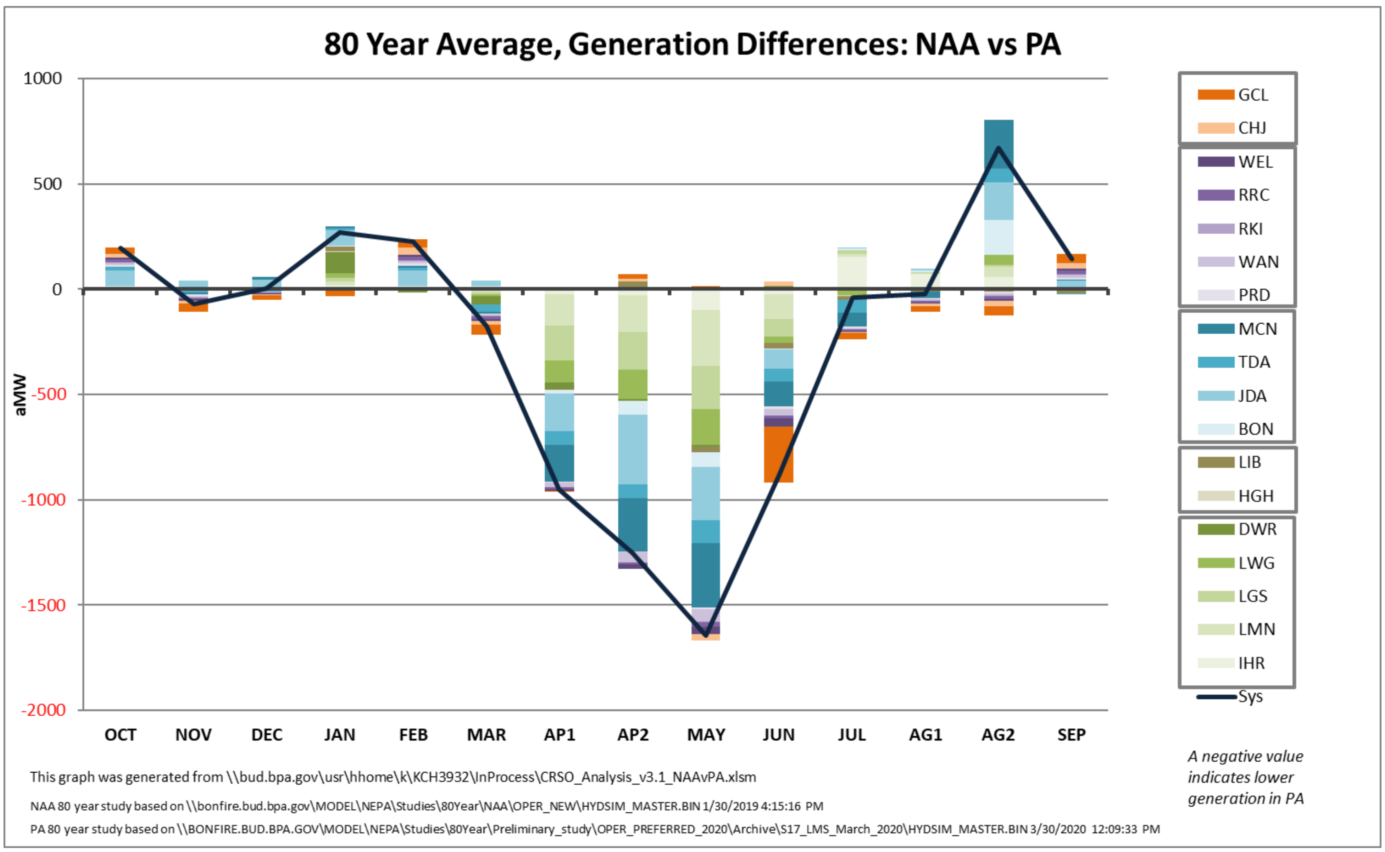

Figure 3-12. NW-US System and Project Average Generation: NAA vs. PA

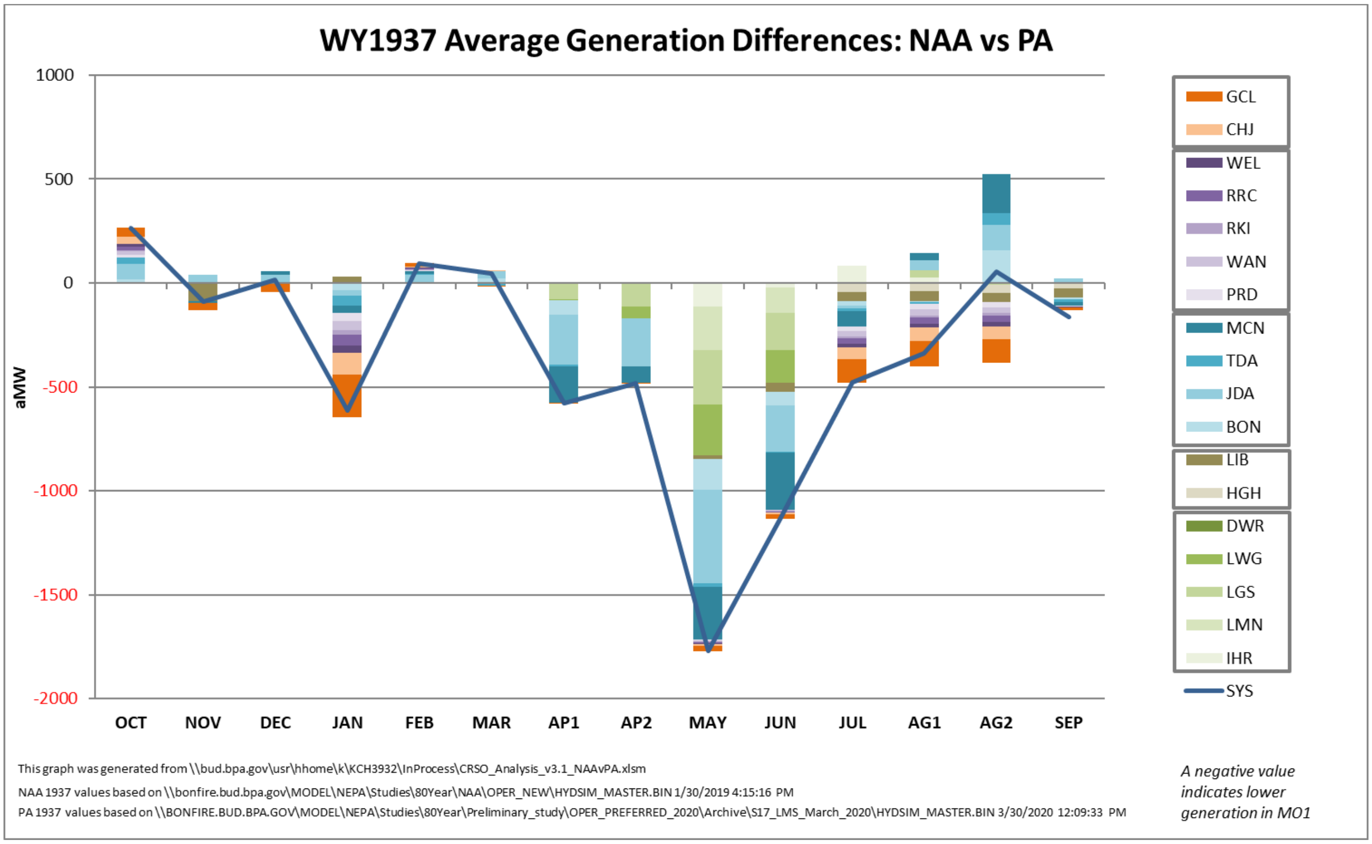

Figure 3-13. NW-US system and Project Critical Water Generation: NAA vs. PA

Generation differences between NAA and PA primarily result from the following:

September-October: The increase in average generation is the result of the flexibility to shift timing of fill at Grand Coulee as the system sets up for winter chum operations.

January-February: The increase in generation from NAA is due to deeper drafts of Dworshak in January and February. The additional draft and higher releases from Dworshak increases generation at the site and several projects downstream through Bonneville Dam.

March-August I: The decrease in generation from NAA is due to the implementation of the flex spill agreement. The flex spill agreement increases spill at the lower Columbia River projects and the Lower Snake River projects over that which is modeled in NAA.

August II: The increase in generation from NAA is due to the shift to the Late Summer Transition Spill operation. The Late Summer Transition Spill operation represents a reduction in spill at the lower Columbia River projects and the Lower Snake River projects compared to NAA.

As part of ongoing ESA consultations with NMFS, a measure to use surface weir spill for adult steelhead was modified in the Preferred Alternative. This measure provides for a small volume of spill through the spillway weirs at five projects, for a few hours each week in March, October, and early November. This measure would reduce average generation by less than 4 aMW on an annual basis, which would not affect the generation results to within rounding. On a monthly basis, it would reduce generation by less than 20 aMW, and the months included in the measure are not months that typically have reliability concerns.

PA: P10 AND CRITICAL WATER VS. AVERAGE GENERATION

Generation in the 10th percentile driest years and in the critical water year followed the same trend as the average generation over the 80 water years. The sliding scale measure reduced the summer draft at Libby and Hungry Horse compared to NAA, thus further reducing at site and downstream generation July to September.

The annual loss in critical water generation is a primary input to the agency's calculation of the minimum annual power it can depend on generating with the hydro-system even in a "bad year" which determined how much firm power (power guaranteed to be continuously available) from the FCRPS is available in meeting the Administrator's long-term firm power contract obligations. In order to be in a load/resource balance, any reductions in the amount of firm power produced by the FCRPS must be acquired from other resources.

3.3 PEAK CRS (FEDERAL) GENERATION

The peak generation results for each of the CRSO EIS alternatives are provided only for the CRS (Federal) system because HOSS is not configured to model the total NW-US or the non-Federal Mid-Columbia projects. This section provides summaries and comparisons of the CRS Peak Load (120 Hour) generation and HLH average, P10, and critical water between the NAA and each alternative. The rationales for 120 Hour generation changes from the NAA also are provided.

3.3.1 Federal Peak Generation Methodologies

Bonneville used its HOSS model to shape the HYDSIM period averages into hourly averages, and examined 120 peak hours each month (60 hours for the split months of April and August) with the highest demand for electricity and highest generation averaged for all 80 water years (5 hours/day, 6 days/week for 4 weeks). Bonneville also computed HLH metrics from the HOSS model output. For both the Peak Load (120 Hour) and the HLH metrics, the P10 generation was determined independently for each period in the 80-year study. Consequently, the P10 generation results do not correspond to a single 10^{th} lowest generation year, but instead reflect the 10^{th} lowest period of generation within the set of 80 historical water years. The critical water results reflect the October 1936 through September 1937 time frame. Key study inputs include the measures listed in Section 1.4 . Modeling details are provided in the *Hydroregulation Appendix I.*

3.3.2 CRS (Federal) Peak Generation Summary

For all alternatives, HOSS CRS (Federal) Peak Load (120 Hour) average, P10 and critical water generation results are compared to NAA in Figure 3-14 through Figure 3-16, and Table 3-19 through Table 3-21.

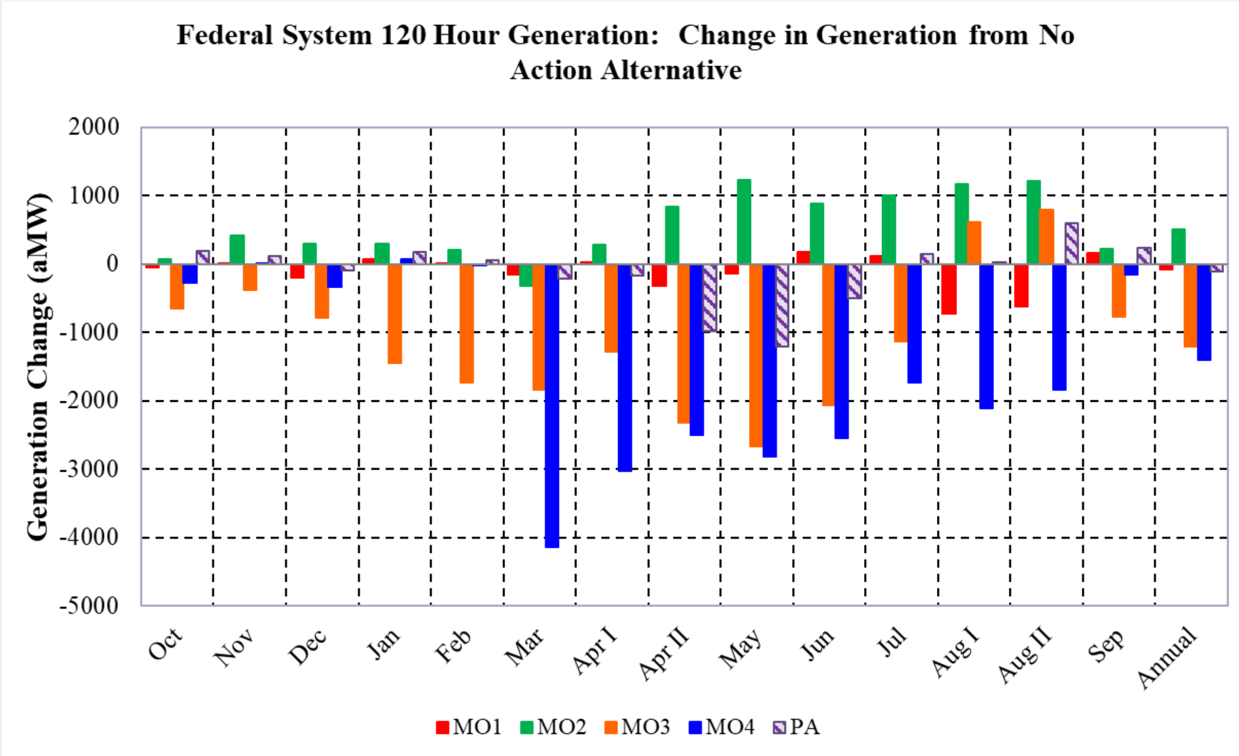

Figure 3-14. CRS (Federal) Peak Load (120 Hour) Generation: Change from NAA

Table 3-19. CRS (Federal) Peak Load (120 Hour) Generation: Change from NAA

Federal System 120 Hour Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
MO1	-51	6	-206	73	11	-156	23	-322	-134	179	109	-728	-625	155	-72
MO2	75	424	292	304	213	-327	287	835	1,235	880	1,006	1,162	1,215	224	509
MO3	-657	-375	-787	-1,455	-1,735	-1,843	-1,279	-2,324	-2,660	-2,071	-1,129	612	796	-776	-1,210
MO4	-270	9	-334	78	-25	-4,146	-3,021	-2,500	-2,818	-2,551	-1,729	-2,118	-1,833	-147	-1,400
PA	188	118	-92	181	49	-208	-164	-977	-1,212	-498	140	32	597	234	-113

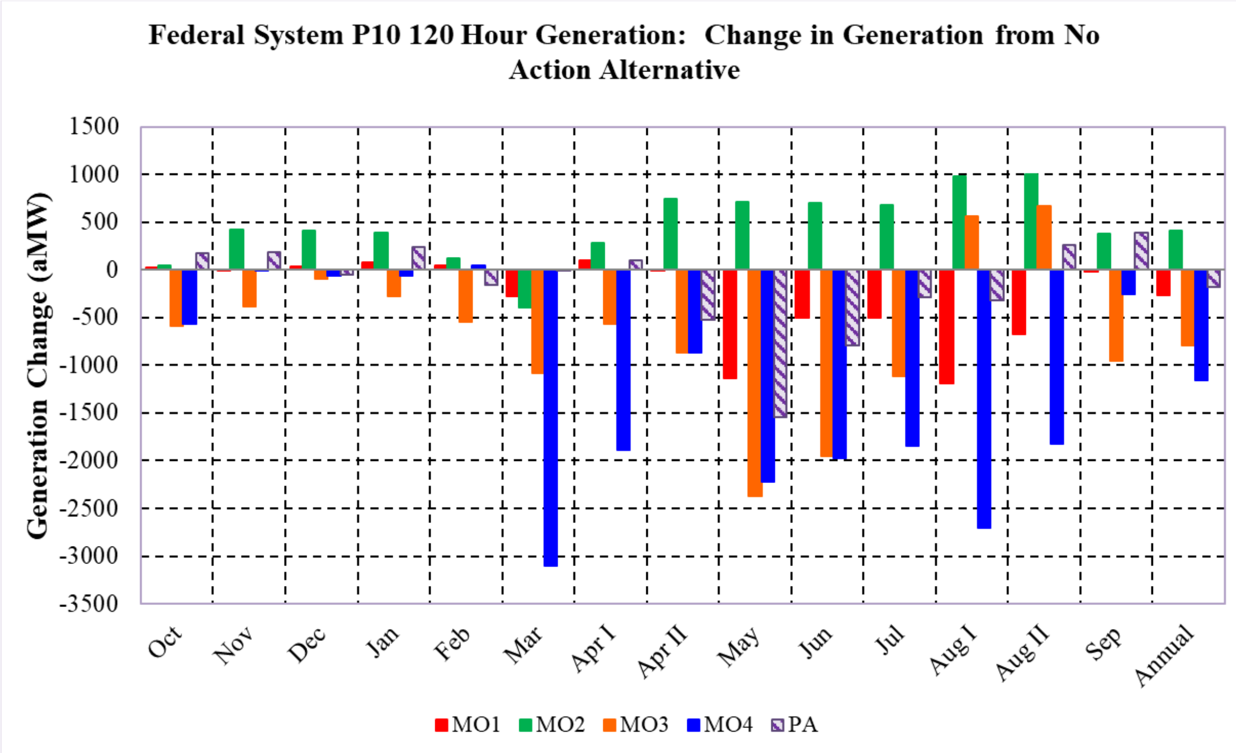

Figure 3-15. CRS (Federal) Peak Load (120 Hour) P10 Generation: Change from NAA

Table 3-20. CRS (Federal) Peak Load (120 Hour) P10 Generation: Change from NAA

Federal System P10 120 Hour Generation: Change in Generation from No Action Alternative														
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
MO1	28	-8	32	82	44	-279	103	-12	-1,135	-499	-504	-1,193	-673	-17	-265
MO2	48	421	413	386	121	-399	282	741	709	703	682	984	999	380	415
MO3	-586	-378	-87	-280	-548	-1,082	-568	-868	-2,371	-1,956	-1,111	560	670	-949	-787
MO4	-562	-8	-64	-66	44	-3,103	-1,891	-863	-2,223	-1,978	-1,845	-2,704	-1,827	-258	-1,153
PA	171	187	-55	245	-157	-11	105	-519	-1,539	-795	-290	-321	264	394	-174

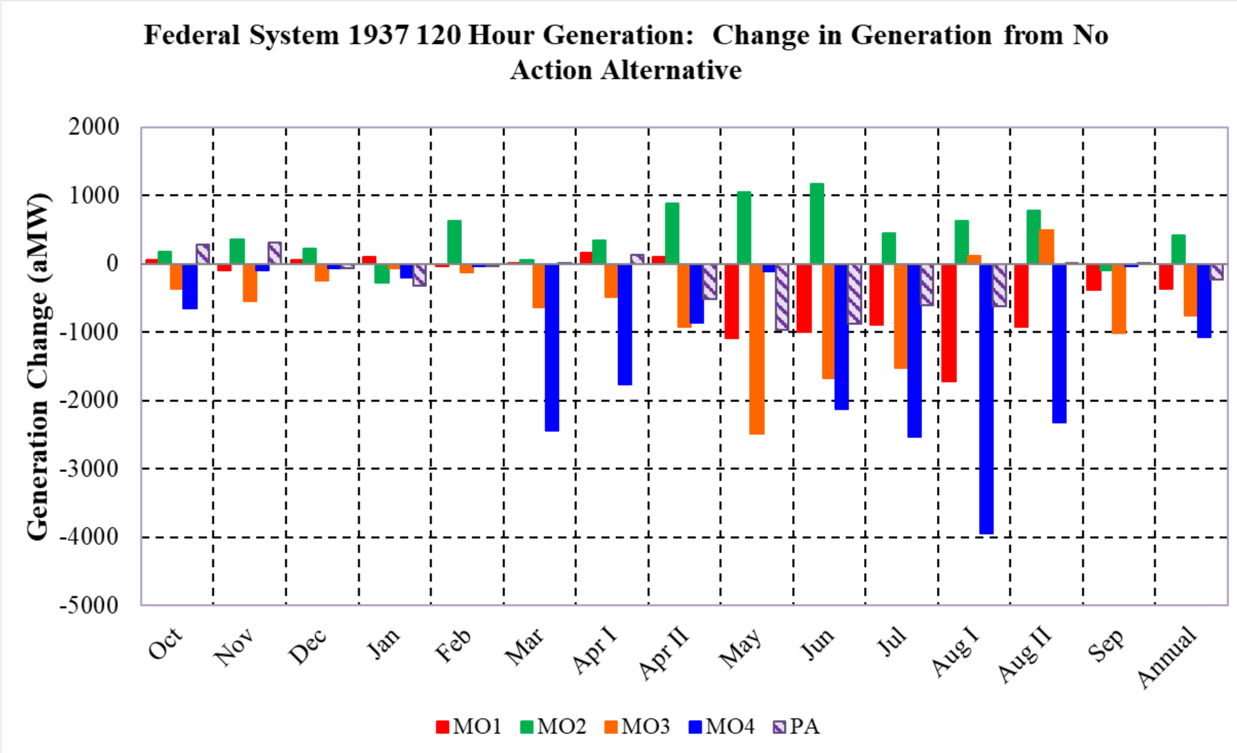

Figure 3-16. CRS (Federal) Peak Load (120 Hour) Critical Water Generation: Change from NAA

Table 3-21. CRS (Federal) Peak Load (120 Hour) Critical Water Generation: Change from NAA

Federal System 1937 120 Hour Generation: Change in Generation from No Action Alternative														
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
MO1	56	-98	59	102	-29	7	162	106	-1,088	-998	-886	-1,717	-918	-373	-371
MO2	179	359	219	-268	629	62	342	890	1,046	1,164	448	622	778	-98	419
MO3	-368	-552	-252	-69	-122	-639	-488	-920	-2,481	-1,669	-1,531	114	485	-1,015	-761
MO4	-658	-101	-68	-202	-30	-2,443	-1,760	-861	-102	-2,119	-2,538	-3,948	-2,320	-33	-1,070
PA	278	319	-59	-327	-28	12	135	-520	-960	-884	-601	-625	17	11	-229

For all alternatives, CRS (Federal) HLH average, P10 and critical water generation results are compared to the NAA and are provided in Figure 3-17 through Figure 3-19 and Table 3-22 through Table 3-24. Comparisons of the effects of the alternatives follow in Section 3.3.3.

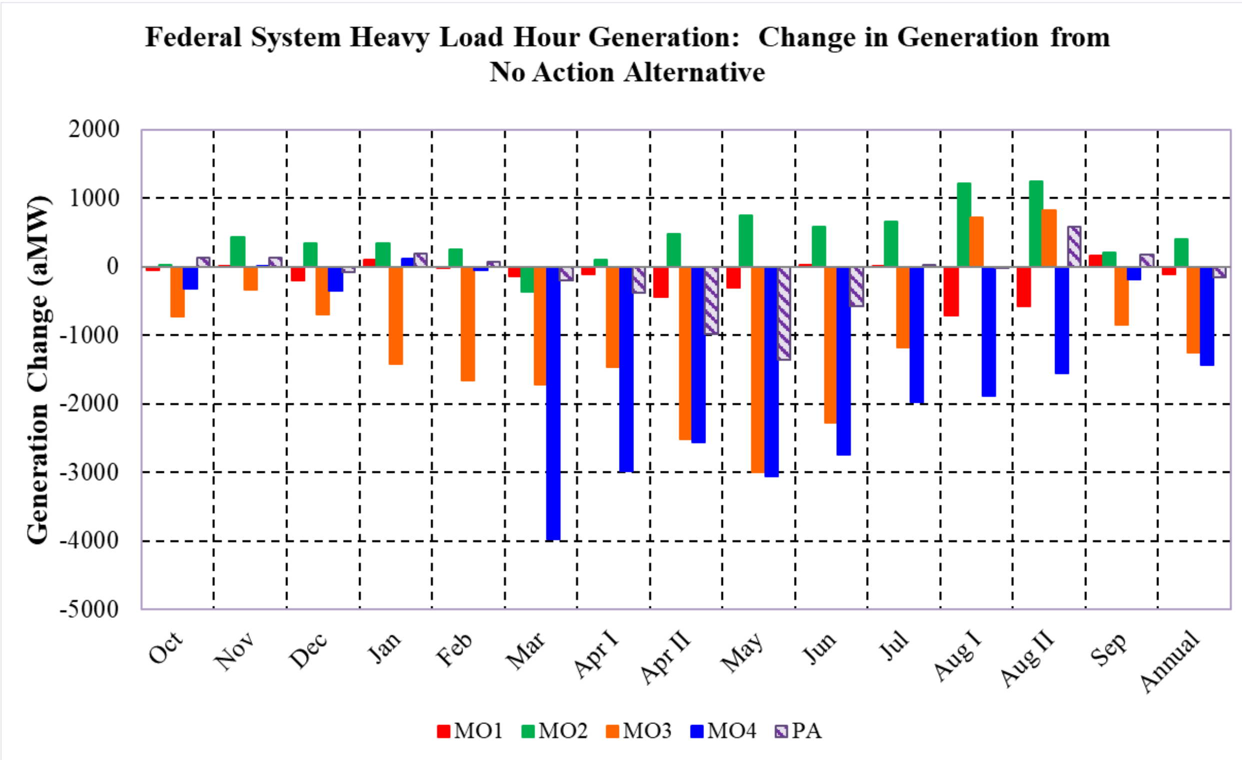

Figure 3-17. CRS (Federal) HLH Average Generation: Change from NAA

Table 3-22. CRS (Federal) HLH Average Generation: Change from NAA

Federal System Heavy Load Hour Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
MO1	-51	10	-197	108	-7	-141	-110	-436	-301	29	13	-708	-572	157	-109
MO2	21	427	345	349	250	-361	106	479	749	579	653	1,221	1,242	206	397
MO3	-732	-342	-689	-1,412	-1,658	-1,715	-1,463	-2,514	-3,003	-2,271	-1,174	719	828	-844	-1,250
MO4	-326	13	-356	113	-52	-3,969	-2,989	-2,564	-3,061	-2,738	-1,974	-1,890	-1,548	-190	-1,430
PA	126	135	-83	184	64	-206	-388	-986	-1,357	-575	20	-13	579	179	-160

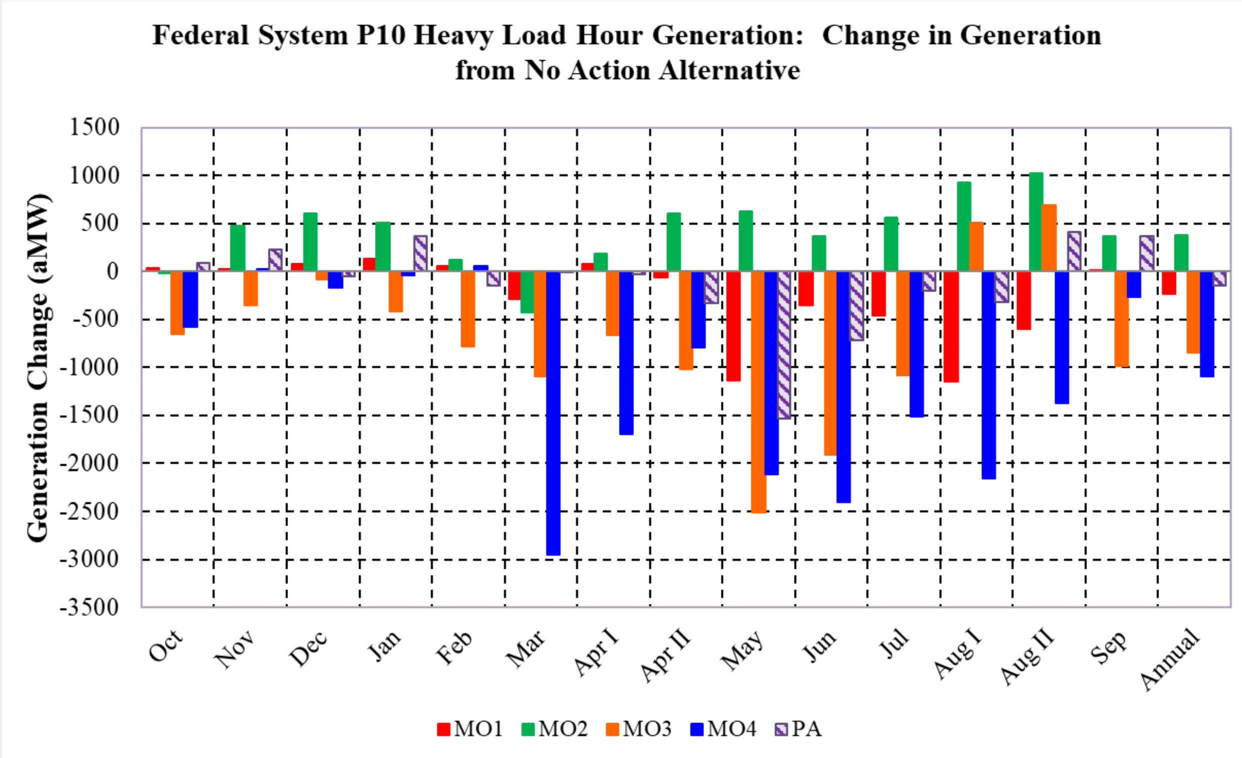

Figure 3-18. CRS (Federal) HLH P10 Generation: Change from NAA

Table 3-23. CRS (Federal) HLH P10 Generation: Change from NAA

Federal System P10 Heavy Load Hour Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
MO1	34	27	81	135	61	-283	77	-66	-1,132	-350	-455	-1,148	-601	2	-232
MO2	-16	477	607	511	123	-421	188	601	631	374	562	931	1,027	372	385
MO3	-654	-347	-85	-416	-779	-1,091	-667	-1,018	-2,513	-1,914	-1,080	513	690	-990	-841
MO4	-577	27	-169	-35	59	-2,955	-1,696	-797	-2,115	-2,405	-1,509	-2,152	-1,368	-263	-1,088
PA	85	229	-49	369	-145	-6	-25	-324	-1,537	-711	-198	-314	414	370	-143

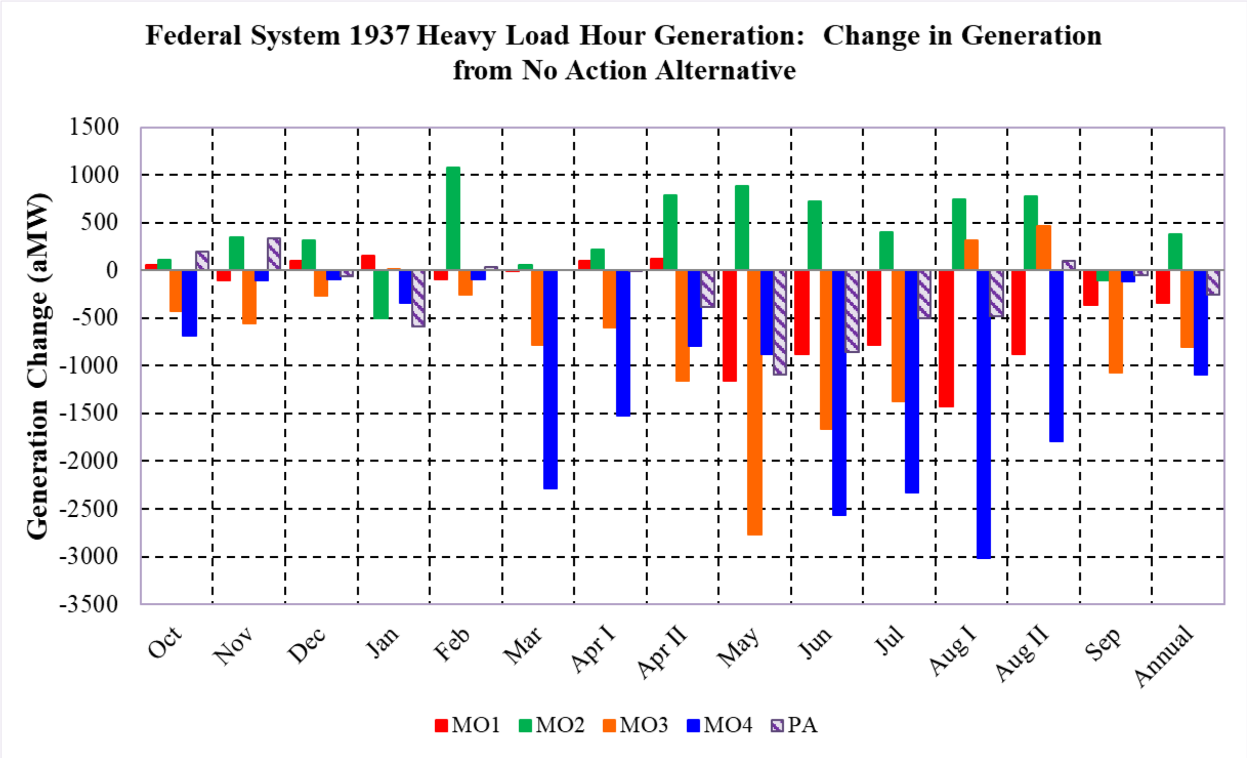

Figure 3-19. CRS (Federal) HLH Critical Water Generation: Change from NAA

Table 3-24. CRS (Federal) HLH Critical Water Generation: Change from NAA

Federal System 1937 Heavy Load Hour Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
MO1	59	-101	106	152	-94	-1	104	126	-1,156	-881	-778	-1,422	-882	-363	-343
MO2	116	343	311	-498	1,079	55	214	792	890	724	400	747	779	-104	376
MO3	-431	-558	-265	15	-258	-783	-599	-1,160	-2,773	-1,659	-1,371	319	464	-1,073	-805
MO4	-684	-105	-94	-339	-95	-2,290	-1,525	-793	-877	-2,559	-2,325	-3,019	-1,793	-117	-1,095
PA	195	335	-59	-582	37	0	-12	-378	-1,097	-852	-496	-476	96	-55	-249

3.3.3 CRS (Federal) Peak Generation: Comparisons to NAA

The following CRS peak generation comparisons are provided for the CRS (Federal) system. CRS generation results for each alternative are driven primarily by its storage reservoir objectives for downstream flow measures and specified project spill measures for fish passage. It is likely that the total NW-US, Mid-Columbia, and Canadian systems would have similar generation trends for flow-related effects of the alternatives. The fish passage spill effects would be limited to the CRS projects.

3.3.3.1 Peak Generation: NAA compared to MO1

Table 3-25 through Table 3-30 provide the CRS Peak Load (120 Hour) and HLH average, P10, and critical water generation differences between NAA and MO1 for the CRS (Federal) system. Positive differences indicate larger generation in MO1 than the NAA.

Table 3-25. CRS (Federal) Peak Load (120 Hour) Generation: NAA vs. MO1

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
MO1	7,668	9,828	10,832	11,960	12,192	11,384	9,821	9,896	12,304	13,324	11,708	10,162	8,616	8,212	10,712
Change	-51	6	-206	73	11	-156	23	-322	-134	179	109	-728	-625	155	-72

Table 3-26. CRS (Federal) Peak Load (120 Hour) P10 Generation: NAA vs. MO1

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
MO1	7,066	8,847	9,415	9,129	8,566	8,402	6,903	6,004	9,970	10,906	8,287	8,173	7,297	7,280	8,504
Change	28	-8	32	82	44	-279	103	-12	-1,135	-499	-504	-1,193	-673	-17	-265

Table 3-27. CRS (Federal) Peak Load (120 Hour) Critical Water Generation: NAA vs. MO1

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
MO1	7,383	9,411	9,514	9,142	7,797	7,964	6,907	6,123	8,454	10,555	9,043	8,919	7,567	7,595	8,471
Change	56	-98	59	102	-29	7	162	106	-1,088	-998	-886	-1,717	-918	-373	-371

Table 3-28. CRS (Federal) HLH Average Generation: NAA vs. MO1

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
MO1	6,795	8,909	9,515	10,876	11,055	10,163	9,000	9,181	11,521	12,470	10,718	9,015	7,685	7,324	9,723
Change	-51	10	-197	108	-7	-141	-110	-436	-301	29	13	-708	-572	157	-109

Table 3-29. CRS (Federal) HLH P10 Generation: NAA vs. MO1

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
MO1	6,193	7,899	8,037	7,815	7,326	7,093	6,082	5,371	8,980	9,747	7,430	7,170	6,498	6,384	7,456
Change	34	27	81	135	61	-283	77	-66	-1,132	-350	-455	-1,148	-601	2	-232

Table 3-30. CRS (Federal) HLH Critical Water Generation: NAA vs. MO1

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
MO1	6,516	8,524	8,212	7,833	6,016	6,672	6,085	5,525	7,641	9,370	8,069	7,887	6,751	6,673	7,395
Change	59	-101	106	152	-94	-1	104	126	-1,156	-881	-778	-1,422	-882	-363	-343

The differences in CRS energy results from HYDSIM contained in Exhibit 4 and the HOSS peak results here highlight how the MOs change the ability of the hydro system to increase generation during periods of higher demand, as exemplified by the heavy-load hour generation and the 120-hour generation, and to reduce generation during periods of lower demand, the light-load hours, especially the middle of the night.

September to February: Though there is a reduction in generation in some months as shown in the average generation results described in Section 3.2.3.1, the HOSS results indicate that there is no reduction in HLH generation, indicating that the system generally has enough flexibility to shape flows into the daytime in MO1 as it did in NAA by reducing generation even further during light load hours (LLH).

May to August: MO1 is generating less primarily because of the increased spill as described in Section 3.2.3.1. This reduction in period-average generation also results in a reduction in HLH generation because there is not enough flexibility in the hydropower system for all of the reductions to be during LLH.

MO1: HLH Critical Water Generation: The change in HLH critical water generation for MO1 compared to the change in CRS period-average critical water generation for MO1 in Exhibit 6 is remarkably similar. This indicates that the ability of the system to shape generation into the HLH during critical water is not appreciably changed by the measures in MO1. The impacts to HLH critical water generation in MO1 are about the same as the impacts to critical water generation described in Section 3.2.3.1.

3.3.3.2 Peak Generation: NAA compared to MO2

Table 3-31 through Table 3-36 provide the CRS Peak Load (120 Hour) and HLH average, P10, and critical water generation differences between NAA and MO2 for the CRS (Federal) system. Positive differences indicate an increase in Peak Load (120 Hour) or HLH generation from the NAA.

Table 3-31. CRS (Federal) Peak Load (120 Hour) Generation: NAA vs. MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
MO2	7,794	10,246	11,330	12,192	12,394	11,214	10,085	11,053	13,673	14,025	12,605	12,051	10,456	8,281	11,293
Change	75	424	292	304	213	-327	287	835	1,235	880	1,006	1,162	1,215	224	509

Table 3-32. CRS (Federal) Peak Load (120 Hour) P10 Generation: NAA vs. MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
MO2	7,085	9,276	9,796	9,434	8,643	8,282	7,082	6,756	11,814	12,108	9,473	10,349	8,969	7,677	9,185
Change	48	421	413	386	121	-399	282	741	709	703	682	984	999	380	415

Table 3-33. CRS (Federal) Peak Load (120 Hour) Critical Water Generation: NAA vs. MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
MO2	7,506	9,868	9,674	8,772	8,455	8,019	7,087	6,907	10,588	12,717	10,377	11,258	9,263	7,870	9,261
Change	179	359	219	-268	629	62	342	890	1,046	1,164	448	622	778	-98	419

Table 3-34. CRS (Federal) HLH Average Generation: NAA vs. MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
MO2	6,868	9,327	10,057	11,117	11,312	9,944	9,216	10,096	12,571	13,020	11,357	10,944	9,499	7,373	10,229
Change	21	427	345	349	250	-361	106	479	749	579	653	1,221	1,242	206	397

Table 3-35. CRS (Federal) HLH P10 Generation: NAA vs. MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
MO2	6,143	8,349	8,563	8,191	7,388	6,955	6,193	6,038	10,744	10,470	8,447	9,249	8,126	6,755	8,073
Change	-16	477	607	511	123	-421	188	601	631	374	562	931	1,027	372	385

Table 3-36. CRS (Federal) HLH Critical Water Generation: NAA vs. MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
MO2	6,573	8,968	8,417	7,183	7,189	6,728	6,195	6,191	9,687	10,975	9,247	10,056	8,412	6,932	8,114
Change	116	343	311	-498	1,079	55	214	792	890	724	400	747	779	-104	376

Load shaping in the HOSS studies generally follows the same trend as the CRS HYDSIM energy data shown in Exhibit 4. For the 120-hour period, MO2 increases generation relative to NAA slightly more than the average generation, indicating that there may be a slight increase in shorter-term (roughly 6 hour) flexibility to shape generation. The unusual trend between January (large loss) and February (large increase) in the critical water year mirrors that seen with HYDSIM energy within Exhibit 6, and may be able to be adjusted in actual operations to smooth generation across the two months.

With the exception of October (where the system does not change much) and March (when there is less flow and generation in the river), the system has the ability to increase overall generation and to increase generation during the HLH periods. This effect is from a combination of the flow and spill changes described earlier as well as the increased flexibility such as the increased forebay and turbine operating range of the lower Snake and lower Columbia River projects relative to NAA.

In almost all periods, the ability of the hydropower system to shape energy into HLHs is greater in MO2 compared to NAA. This can be seen by comparing the difference in period-average CRS critical water year generation for MO2 compared to NAA in Exhibit 6 with the difference in HLH critical water generation shown in Table 3-36. This effect is attributable to the increase in hydro-system flexibility in MO2 compared to NAA. Additional flexibility stems from the increase in operating range at the lower Snake and John Day projects during the fish passage season, the increased period during which the lower Snake River projects may operate with zero generation, the allowance for carrying contingency reserves within fish passage spill, having more water available for generation in winter storage projects drafted deeper, and more water during the fish passage spill season from reduced spill. January is the one month with less shaping ability, perhaps due to Libby releasing little water after drafting very low in December.

3.3.3.3 Peak Generation: NAA compared to MO3

Table 3-37 through Table 3-42 provide the CRS Peak Load (120 Hour) and HLH average, P10, and critical water generation differences between NAA and MO3 for the CRS (Federal) system. Positive differences indicate larger average generation in MO3 than the NAA.

Table 3-37. CRS (Federal) Peak Load (120 Hour) Generation: NAA vs. MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
MO3	7,062	9,447	10,251	10,433	10,446	9,697	8,519	7,894	9,778	11,075	10,470	11,501	10,037	7,282	9,573
Change	-657	-375	-787	-1,455	-1,735	-1,843	-1,279	-2,324	-2,660	-2,071	-1,129	612	796	-776	-1,210

Table 3-38. CRS (Federal) Peak Load (120 Hour) P10 Generation: NAA vs. MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
MO3	6,451	8,477	9,295	8,768	7,974	7,598	6,232	5,147	8,733	9,449	7,679	9,925	8,640	6,348	7,982
Change	-586	-378	-87	-280	-548	-1,082	-568	-868	-2,371	-1,956	-1,111	560	670	-949	-787

Table 3-39. CRS (Federal) Peak Load (120 Hour) Critical Water Generation: NAA vs. MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
MO3	6,959	8,957	9,203	8,971	7,704	7,318	6,257	5,097	7,061	9,884	8,398	10,750	8,970	6,953	8,082
Change	-368	-552	-252	-69	-122	-639	-488	-920	-2,481	-1,669	-1,531	114	485	-1,015	-761

Table 3-40. CRS (Federal) HLH Average Generation: NAA vs. MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
MO3	6,114	8,557	9,024	9,356	9,404	8,590	7,648	7,103	8,818	10,170	9,531	10,442	9,085	6,323	8,582
Change	-732	-342	-689	-1,412	-1,658	-1,715	-1,463	-2,514	-3,003	-2,271	-1,174	719	828	-844	-1,250

Table 3-41. CRS (Federal) HLH P10 Generation: NAA vs. MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
MO3	5,506	7,525	7,871	7,265	6,486	6,285	5,338	4,419	7,600	8,183	6,805	8,831	7,790	5,393	6,847
Change	-654	-347	-85	-416	-779	-1,091	-667	-1,018	-2,513	-1,914	-1,080	513	690	-990	-841

Table 3-42. CRS (Federal) HLH Critical Water Generation: NAA vs. MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
MO3	6,026	8,067	7,841	7,696	5,852	5,890	5,382	4,239	6,024	8,592	7,476	9,628	8,097	5,963	6,932
Change	-431	-558	-265	15	-258	-783	-599	-1,160	-2,773	-1,659	-1,371	319	464	-1,073	-805

The HLH and 120-hour results for MO3 are fairly similar to the CRS average generation changes displayed in Exhibit 4, except that MO3 decreases 120-hour generation even more than the average generation decrease in the winter months with less loss in April. The same patterns are seen for the HLH P10 generation compared to the CRS P10 generation from Exhibit 5, as well as the HLH generation during critical water compared to the CRS generation from Exhibit 6.

November – March: In months where the difference between MO3 and NAA is larger for the P10 HLH than for the P10 period-average shown in Exhibit 5, the system has less flexibility to shape power into the daytime. In the winter months, the larger loss in the HLH hours compared to the period-average is likely the result of the loss of generation from the lower Snake River projects. In the winter in NAA, these projects have the most flexibility to shape generation during the day. During winter months typically flows allow generation above the minimum generation but are not so high that the projects must run at full capacity all hours of the day. Thus, they are able to reduce generation during LLH and store some water for higher generation during the day in NAA.

April – August: There are two opposing influences on the ability of the hydrosystem to shape flows into the HLHs: On the one hand, in MO3 the lower Snake River projects no longer contribute to shaping. On the other hand, John Day has a larger forebay operating range than in the NAA, which gives it more room to store and release water to shape flows and generation within the day. Between April and August, a comparison of the CRS generation in Exhibit 4 and Table 3-40 shows that these two effects alternate in which one is larger, likely depending on the amount of water available in each stretch of the river.

Breaching of the four lower Snake River dams not only eliminated the period-average generation from these dams but also reduced their contribution to shaping generation into peak-load-periods.

Furthermore, in periods where flows are reduced (as explained above for period-average impacts), reduced flows generally reduce the ability of the remaining dams to shape generation into the peak-load periods (except in the highest flow periods when excess flow would be spilled and reducing flows does not initially reduce generation).

3.3.3.4 Peak Generation: NAA compared to MO4

Table 3-43 through Table 3-48 provides the CRS Peak Load (120 Hour) and HLH average, P10, and critical water generation differences between NAA and MO4 for the CRS (Federal) system. Positive differences indicate lager average generation for MO4 than the NAA.

Table 3-43. CRS (Federal) Peak Load (120 Hour) Generation: NAA vs. MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
MO4	7,449	9,831	10,704	11,966	12,156	7,395	6,777	7,718	9,620	10,594	9,870	8,772	7,408	7,911	9,384
Change	-270	9	-334	78	-25	-4,146	-3,021	-2,500	-2,818	-2,551	-1,729	-2,118	-1,833	-147	-1,400

Table 3-44. CRS (Federal) Peak Load (120 Hour) P10 Generation: NAA vs. MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
MO4	6,476	8,847	9,318	8,982	8,565	5,578	4,909	5,152	8,882	9,427	6,945	6,662	6,143	7,039	7,616
Change	-562	-8	-64	-66	44	-3,103	-1,891	-863	-2,223	-1,978	-1,845	-2,704	-1,827	-258	-1,153

Table 3-45. CRS (Federal) Peak Load (120 Hour) Critical Water Generation: NAA vs. MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
MO4	6,669	9,408	9,387	8,838	7,796	5,514	4,985	5,156	9,440	9,434	7,391	6,688	6,165	7,935	7,773
Change	-658	-101	-68	-202	-30	-2,443	-1,760	-861	-102	-2,119	-2,538	-3,948	-2,320	-33	-1,070

Table 3-46. CRS (Federal) HLH Average Generation: NAA vs. MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
MO4	6,520	8,912	9,357	10,881	11,011	6,335	6,122	7,053	8,761	9,704	8,730	7,833	6,709	6,977	8,402
Change	-326	13	-356	113	-52	-3,969	-2,989	-2,564	-3,061	-2,738	-1,974	-1,890	-1,548	-190	-1,430

Table 3-47. CRS (Federal) HLH P10 Generation: NAA vs. MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
MO4	5,582	7,899	7,787	7,646	7,324	4,421	4,309	4,640	7,998	7,691	6,376	6,166	5,731	6,120	6,600
Change	-577	27	-169	-35	59	-2,955	-1,696	-797	-2,115	-2,405	-1,509	-2,152	-1,368	-263	-1,088

Table 3-48. CRS (Federal) HLH Critical Water Generation: NAA vs. MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
MO4	5,773	8,520	8,012	7,342	6,015	4,383	4,456	4,606	7,920	7,692	6,522	6,290	5,840	6,919	6,643
Change	-684	-105	-94	-339	-95	-2,290	-1,525	-793	-877	-2,559	-2,325	-3,019	-1,793	-117	-1,095

The HLH and 120-hour results for MO4 are fairly similar to the average generation changes, with slight variations across the months, but no major patterns. On an annual basis, the 120-Hour and HLH average generation decrease slightly more than the corresponding generation for the day-average as measured by HYDSIM shown in CRS generation in Exhibit 4.

March – August: The loss in generation for HLH P10 in MO4 (Table 3-47) compared to NAA is larger than the loss in P10 period-average generation (CRS generation in Exhibit 5). This results from the loss of generation flexibility at the lower Snake and lower Columbia River projects. In MO4, in the water conditions represented in the driest 10th percentile, these projects are all generating at their minimum generation level all hours of the day. This means that there is no ability for them to store any water during the LLHs to increase generation during the HLHs.

The change in HLH critical water generation for MO4 (Table 3-48) is remarkably similar compared to the change in period-average critical water generation for MO4 in CRS generation within Exhibit 6. This indicates the ability of the system to shape generation into the HLHs during critical water is not appreciably changed by the measures in MO4. The impacts to HLH critical water generation in MO4 are about the same as the impacts to critical water generation described in Section 3.2.3.4. Thus, the reduction in generation for all hours of the critical water year translated directly to a reduction in the ability to shape generation between heavy-load hours and light-load hours. In MO4, the four lower Snake River and the four lower Columbia River projects are all or mostly operating at minimum generation with little ability to shape generation into the heavy load hours.

3.3.3.5 Peak Generation: NAA compared to PA

Table 3-49 through Table 3-54 provide the CRS Peak Load (120 Hour) and HLH average, P10, and Critical Water generation differences between NAA and PA for the CRS (Federal) system. Positive differences indicate an increase in generation from the NAA

Table 3-49. CRS (Federal) Peak Load (120 Hour) Generation: NAA vs. PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
PA	7,907	9,940	10,947	12,069	12,229	11,332	9,634	9,241	11,226	12,647	11,738	10,921	9,838	8,292	10,671
Change	188	118	-92	181	49	-208	-164	-977	-1,212	-498	140	32	597	234	-113

Table 3-50. CRS (Federal) Peak Load (120 Hour) P10 Generation: NAA vs. PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
PA	7,208	9,041	9,328	9,293	8,364	8,670	6,905	5,496	9,566	10,610	8,500	9,045	8,234	7,691	8,596
Change	171	187	-55	245	-157	-11	105	-519	-1,539	-795	-290	-321	264	394	-174

Table 3-51. CRS (Federal) Peak Load (120 Hour) Critical Water Generation: NAA vs. PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
PA	7,605	9,828	9,396	8,713	7,798	7,969	6,880	5,497	8,582	10,669	9,328	10,011	8,502	7,979	8,613
Change	278	319	-59	-327	-28	12	135	-520	-960	-884	-601	-625	17	11	-229

Table 3-52. CRS (Federal) HLH Average Generation: NAA vs. PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
PA	6,972	9,034	9,630	10,952	11,126	10,099	8,723	8,631	10,465	11,867	10,724	9,710	8,836	7,346	9,672
Change	126	135	-83	184	64	-206	-388	-986	-1,357	-575	20	-13	579	179	-160

Table 3-53. CRS (Federal) HLH P10 Generation: NAA vs. PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
PA	6,244	8,100	7,907	8,050	7,120	7,370	5,980	5,113	8,576	9,386	7,687	8,004	7,513	6,753	7,545
Change	85	229	-49	369	-145	-6	-25	-324	-1,537	-711	-198	-314	414	370	-143

Table 3-54. CRS (Federal) HLH Critical Water Generation: NAA vs. PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
PA	6,652	8,960	8,047	7,099	6,147	6,673	5,969	5,021	7,700	9,399	8,351	8,833	7,729	6,981	7,489
Change	195	335	-59	-582	37	0	-12	-378	-1,097	-852	-496	-476	96	-55	-249

For PA, the decreases in peak load and the ability to sustain the increased generation for 16 hours (during the HLHs) for PA vs NAA was nearly as much as the decrease in the CRS average generation for PA vs NAA shown in Exhibit 4.

September to February: With the exception of December, the system has the ability to slightly increase average peak load generation results and similarly HLH generation, indicating that the system generally has enough flexibility to shape flows into the daytime in PA as it did in NAA by reducing generation even further during light load hours (LLH).

March to June: PA has a large decrease in generation primarily because of the increased spill as described in Section 3.2.3.5 and shown as CRS generation within Exhibit 4. This reduction in period-average generation also results in a reduction in HLH generation because there is not enough flexibility in the hydropower system for all of the reductions to be during LLH.

July to August: PA is generating more peak load primarily because of the decreased spill from Aug 15 – 31 as described in Section 3.2.3.5 and shown in Exhibit 4. This increase in period-average generation also results in an increase in HLH generation because there is flexibility in the hydropower system during August.

3.4 OVERALL GENERATION RESULTS

Table 3-55 through Table 3-72 summarize the average, P10, and critical water (1937) generation for the NW-US, CRS (Federal), Mid-Columbia, and Canadian systems. CRS (Federal) peak generation summaries are also included for Peak Load (120 Hour) and HLH average P10, and critical water generation; peak summaries were not prepared for the NW-US, Mid-Columbia, or Canadian systems.

Study results are summarized for several periods:

- The November to February period is generally the time of greatest power demand due to colder winter temperatures; it is also a time of water-supply-forecast-based adjustments of storage reservoir operations for FRM and refill.
- The April 15 (April I) to July period is the annual spring runoff, system refill, and numerous measures for improving anadromous and resident fish survival.

The maximum and minimum loss periods identify those months during which the greatest generation changes occur for an MO alternative with respect to the NAA.

3.4.1 NW-US System

NW-US system HYDSIM results are provided for average generation, P10 generation, and critical water generation. Positive values are increases from the NAA value. Results for the NW-US system are unavailable for peak generation metrics due to HOSS modeling limitations. Summaries generally apply to all generation metrics.

MO1 generation was slightly less than the NAA. Increases in spill for fish passage and withdrawals for water supply resulted in average generation declines from the NAA during spring and summer months. Generation increases in January resulted from drafts at Grand Coulee. August generation decreases resulted from the reduced flow from Dworshak in August.

MO2 showed increased generation from the NAA for the NW-US system. Increased winter storage drafts and reduced amounts and duration of spill for fish passage contributed to increases. All other MO alternatives resulted in less generation than the NAA.

MO3 generation is reduced year-round from removal of generation at the four lower Snake River dams. The greatest reductions from the NAA occur in spring and summer due to increased fish passage spill at the lower Columbia projects. The August generation increase results from terminating fish passage spill earlier than the NAA.

MO4 generation is reduced from NAA generation nearly year-round from increased fish passage spill during the spring and summer and the effects of additional storage water use for fish migration flow augmentation. The January increase results from increased releases from Libby because the reservoir was held at a higher elevation at the end of December.

PA generation is reduced in the spring, most significantly April through mid-June from the higher spill for juvenile fish passage relative to the NAA. Generation is higher in the second half of August as juvenile fish passage spill ends earlier than in NAA. There are smaller increases in generation in September, October, January, and February from a combination of measures including the Sliding Scale at Libby and Hungry Horse, Planned Draft Rate at Grand Coulee, Modified Draft at Libby, and Deeper Draft at Dworshak.

Table 3-55. NW-US System Average Generation: Change from NAA

	Average U.S. Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	14018	15672	Variable	Variable	13373
MO1	-4 (0%)	-341 (-2%)	-745 (-6%): AugI	228 (2%): Jan	-173 (-1%)
MO2	429 (3%)	728 (5%)	-380 (-3%): Mar	1574 (13%): AugI	453 (3%)
MO3	-823 (-6%)	-2059 (-13%)	-2786 (-17%): May	716 (7%): AugII	-1137 (-9%)
MO4	-73 (-1%)	-2389 (-15%)	-3549 (-26%): Mar	244 (2%): Jan	-1339 (-10%)
PA	107 (1%)	-912 (-6%)	-1647 (-10%): May	671 (7%): AugII	-229 (-2%)

Table 3-56. NW-US System P10 Generation: Change from NAA

	P10 U.S. Generation (aMW)				
	Nov - Feb	Apr II - Jul	Max Loss Period	Max Gain Period	Annual
NAA	10676	11156	Variable	Variable	10144
MO1	13 (0%)	-645 (-6%)	-1284 (-10%): May	79 (1%): Dec	-280 (-3%)
MO2	444 (4%)	544 (5%)	-458 (-5%): AprI	1158 (12%): AugI	380 (4%)
MO3	-120 (-1%)	-1793 (-16%)	-2892 (-23%): May	573 (7%): AugII	-798 (-8%)
MO4	-34 (0%)	-1105 (-10%)	-2278 (-23%): Mar	17 (0%): Dec	-826 (-8%)
PA	10 (0%)	-757 (-7%)	-1764 (-14%): May	390 (5%): AugII	-197 (-2%)

Table 3-57. NW-US System Critical Water (1937) Generation: Change from NAA

	1937 U.S. Generation (aMW)				
	Nov - Feb	Apr II - Jul	Max Loss Period	Max Gain Period	Annual
NAA	10475	11531	Variable	Variable	10297
MO1	12 (0%)	-889 (-8%)	-1390 (-12%): May	177 (2%): Jan	-385 (-4%)
MO2	168 (2%)	759 (7%)	-586 (-5%): Jan	1210 (14%): Feb	348 (3%)
MO3	-179 (-2%)	-1858 (-16%)	-2784 (-24%): May	263 (3%): AugII	-817 (-8%)
MO4	-187 (-2%)	-1456 (-13%)	-2768 (-26%): AugI	-48 (0%): Dec	-980 (-10%)
PA	-155 (-1%)	-1038 (-9%)	-1771 (-16%): May	264 (3%): Oct	-377 (-4%)

3.4.2 CRS (Federal) System

CRS (Federal) system energy results are provided for average, P10, and critical water generation; and for Peak Load (120 Hour) and HLH average, P10, and critical water peak generation averages. Summaries generally apply to all generation metrics. The trend seen for the Federal System is largely the same as for the NW-US system. The Federal system is the largest component of the NW-US system. Most of the NW-US P10 generation loss occurred on the CRS system.

MO1 generation was slightly less than the NAA. Increases in spill for fish passage and additional withdrawals for water supply resulted in average generation declines from the NAA during spring and summer months. Generation increases in January resulted from drafts at Grand Coulee and Libby beginning January at a higher elevation. August generation decreases resulted from the reduced flow from Dworshak in August.

MO2 showed increased generation from the NAA for the CRS (Federal) system. Increased winter storage drafts and reduced amounts and duration of spill for fish passage contributed to increases. All other MO alternatives resulted in less generation than the NAA; reductions in MO3 and MO4 were substantial.

MO3 generation is reduced year-round from loss of the four lower Snake River dams.
The greatest reductions from the NAA occur in spring and summer due also to increased fish

passage spill at the four lower Columbia River projects. The August generation increase results from terminating fish passage spill earlier than the NAA.

MO4 generation is reduced from NAA generation year-round from increased fish passage spill during the spring and summer and the effects of additional storage use for fish migration flow augmentation. The January increase results from increased releases from Libby because the reservoir was held at a higher elevation at the end of December.

PA generation is reduced in the spring, most significantly April through mid-June from the higher spill for juvenile fish passage relative to the NAA. Generation is higher in the second half of August as juvenile fish passage spill ends earlier than in NAA. There are smaller increases in generation in September, October, January, and February from a combination of measures including the Sliding Scale at Libby and Hungry Horse, Planned Draft Rate at Grand Coulee, Modified Draft at Libby, and Deeper Draft at Dworshak.

Table 3-58. CRS (Federal) Average Generation: Change from NAA

	Average Federal Generation (aMW)				
	Nov - Feb	Apr II - Jul	Max Loss Period	Max Gain Period	Annual
NAA	8712	9746	Variable	Variable	8339
MO1	4 (0%)	-269 (-3%)	-656 (-9%): AugI	183 (2%): Jan	-132 (-2%)
MO2	326 (4%)	763 (8%)	-282 (-3%): Mar	1641 (22%): AugI	445 (5%)
MO3	-843 (-10%)	-1985 (-20%)	-2749 (-27%): May	801 (11%): AugI	-1105 (-13%)
MO4	-56 (-1%)	-2435 (-25%)	-3535 (-40%): Mar	192 (2%): Jan	-1303 (-16%)
PA	107 (1%)	-834 (-9%)	-1529 (-15%): May	725 (11%): AugII	-205 (-2%)

Table 3-59. CRS (Federal) P10 Generation: Change from NAA

	P10 Federal Generation (aMW)				
	Nov - Feb	Apr II - Jul	Max Loss Period	Max Gain Period	Annual
NAA	6499	6880	Variable	Variable	6237
MO1	60 (1%)	-603 (-9%)	-1223 (-15%): May	83 (1%): Jan	-228 (-4%)
MO2	296 (5%)	565 (8%)	-303 (-5%): Mar	1310 (21%): AugI	354 (6%)
MO3	-338 (-5%)	-1706 (-25%)	-2785 (-35%): May	705 (13%): AugII	-804 (-13%)
MO4	-30 (0%)	-1515 (-22%)	-2232 (-36%): Mar	42 (1%): Feb	-855 (-14%)
PA	73 (1%)	-942 (-14%)	-1922 (-24%): May	505 (9%): AugII	-236 (-4%)

Table 3-60. CRS (Federal) Critical Water Generation: Change from NAA

	1937 Federal Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	6430	6815	Variable	Variable	6237
MO1	8 (0%)	-726 (-11%)	-1215 (-17%): May	125 (2%): Jan	-297 (-5%)
MO2	137 (2%)	824 (12%)	-408 (-6%): Jan	1341 (20%): AugI	378 (6%)
MO3	-241 (-4%)	-1706 (-25%)	-2727 (-38%): May	655 (10%): AugI	-748 (-12%)
MO4	-156 (-2%)	-1517 (-22%)	-2357 (-30%): Jun	-65 (-1%): Dec	-888 (-14%)
PA	-108 (-2%)	-975 (-14%)	-1749 (-24%): May	252 (4%): AugII	-328 (-5%)

Table 3-61. CRS (Federal) Peak Load (120 Hour) Generation: Change from NAA

	Average Federal 120 Hour Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	11220	12082	Variable	Variable	10784
MO1	-30 (0%)	-2 (0%)	-728 (-7%): AugI	179 (1%): Jun	-72 (-1%)
MO2	310 (3%)	1013 (8%)	-327 (-3%): Mar	1235 (10%): May	509 (5%)
MO3	-1078 (-10%)	-2004 (-17%)	-2660 (-21%): May	796 (9%): AugII	-1210 (-11%)
MO4	-70 (-1%)	-2383 (-20%)	-4146 (-36%): Mar	78 (1%): Jan	-1400 (-13%)
PA	64 (1%)	-587 (-5%)	-1212 (-10%): May	597 (6%): AugII	-113 (-1%)

Table 3-62. CRS (Federal) Peak Load (120 Hour) P10 Generation: Change from NAA

	P10 Federal 120 Hour Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	8963	9805	Variable	Variable	8769
MO1	38 (0%)	-616 (-6%)	-1193 (-13%): AugI	103 (2%): AprI	-265 (-3%)
MO2	340 (4%)	704 (7%)	-399 (-5%): Mar	999 (13%): AugII	415 (5%)
MO3	-317 (-4%)	-1679 (-17%)	-2371 (-21%): May	670 (8%): AugII	-787 (-9%)
MO4	-25 (0%)	-1854 (-19%)	-3103 (-36%): Mar	44 (1%): Feb	-1153 (-13%)
PA	59 (1%)	-826 (-8%)	-1539 (-14%): May	394 (5%): Sep	-174 (-2%)

Table 3-63. CRS (Federal) Peak Load (120 Hour) Critical Water Generation: Change from NAA

	1937 Federal 120 Hour Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	8981	9724	Variable	Variable	8842
MO1	10 (0%)	-837 (-9%)	-1717 (-16%): AugI	162 (2%): AprI	-371 (-4%)
MO2	224 (2%)	884 (9%)	-268 (-3%): Jan	1164 (10%): Jun	419 (5%)
MO3	-249 (-3%)	-1759 (-18%)	-2481 (-26%): May	485 (6%): AugII	-761 (-9%)
MO4	-102 (-1%)	-1480 (-15%)	-3948 (-37%): AugI	-30 (0%): Feb	-1070 (-12%)
PA	-27 (0%)	-773 (-8%)	-960 (-10%): May	319 (3%): Nov	-229 (-3%)

Table 3-64. CRS (Federal) Average HLH Generation: Change from NAA

	Average HLH Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	10097	11363	Variable	Variable	9832
MO1	-22 (0%)	-136 (-1%)	-708 (-7%): AugI	157 (2%): Sep	-109 (-1%)
MO2	344 (3%)	636 (6%)	-361 (-3%): Mar	1242 (15%): AugII	397 (4%)
MO3	-1015 (-10%)	-2199 (-19%)	-3003 (-25%): May	828 (10%): AugII	-1250 (-13%)
MO4	-72 (-1%)	-2586 (-23%)	-3969 (-39%): Mar	113 (1%): Jan	-1430 (-15%)
PA	75 (1%)	-687 (-6%)	-1357 (-11%): May	579 (7%): AugII	-160 (-2%)

Table 3-65. CRS (Federal) P10 HLH Generation: Change from NAA

	P10 HLH Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	7702	8807	Variable	Variable	7688
MO1	77 (1%)	-567 (-6%)	-1148 (-14%): AugI	135 (2%): Jan	-232 (-3%)
MO2	437 (6%)	535 (6%)	-421 (-6%): Mar	1027 (14%): AugII	385 (5%)
MO3	-398 (-5%)	-1720 (-20%)	-2513 (-25%): May	690 (10%): AugII	-841 (-11%)
MO4	-32 (0%)	-1836 (-21%)	-2955 (-40%): Mar	59 (1%): Feb	-1088 (-14%)
PA	106 (1%)	-747 (-8%)	-1537 (-15%): May	414 (6%): AugII	-143 (-2%)

Table 3-66. CRS (Federal) Critical Water Generation: Change from NAA

	1937 HLH Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	7660	8743	Variable	Variable	7738
MO1	19 (0%)	-790 (-9%)	-1422 (-15%): AugI	152 (2%): Jan	-343 (-4%)
MO2	289 (4%)	688 (8%)	-498 (-6%): Jan	1079 (18%): Feb	376 (5%)
MO3	-264 (-3%)	-1828 (-21%)	-2773 (-32%): May	464 (6%): AugII	-805 (-10%)
MO4	-160 (-2%)	-1756 (-20%)	-3019 (-32%): AugI	-94 (-1%): Dec	-1095 (-14%)
PA	-73 (-1%)	-753 (-9%)	-1097 (-12%): May	335 (4%): Nov	-249 (-3%)

3.4.3 Mid-Columbia Non-Federal Projects

The Mid-Columbia non-Federal projects results are provided for average generation, P10 generation, and critical water generation for Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids Dams. Positive values are increases from the NAA value. Results are unavailable for peak generation metrics due to HOSS modeling limitations. Summaries generally apply to all generation metrics.

Mid-Columbia system generation results are in part similar to the NW-US and CRS (Federal) systems because of their location below Grand Coulee. Changes in Federal operations above and at Grand Coulee directly affect the flow of water through the five Mid-Columbia projects, resulting in similar impacts. However, changes in fish passage spill at the Federal projects and changes in flow on the lower Snake River would not affect the Mid-Columbia projects.

MO1 average generation was nearly the same as the NAA. December generation losses from draft reductions at Libby were offset by generation increases in January and February resulting from drafts at Libby and Grand Coulee.

MO2 showed no change in annual average generation from the NAA. Generation increased in the winter from increased storage drafts, which contributed to offsetting generation reductions in the spring, especially during below normal water supply conditions such as the P10 and critical water scenarios.

MO3 average generation was nearly the same as the NAA. Fall generation gains in November and December were offset by winter and spring reductions. Snake River dam breaching did not substantially affect Mid-Columbia flows and generation.

MO4 average generation was nearly the same as the NAA. Generation increased in the spring and early summer from fish migration flow augmentation. Those increases were offset with August flow reductions after termination of fish augmentation flows.

PA average generation was slightly increased in September, October, and February from a combination of measures including the Sliding Scale at Libby and Hungry Horse, Planned Draft Rate at Grand Coulee, including Modified Draft at Libby. Conversely, there are slight reductions in generation primarily in November, December, March, April, July, and August, largely from the same measures that moved water flow and generation between months. The net generation decrease may result from irrigation withdrawals for additional water supply.

Table 3-67. Mid-Columbia Average Generation: Change from NAA

	Average Mid-C Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	2759	3075	Variable	Variable	2644
MO1	5 (0%)	-71 (-2%)	-129 (-5%): AprII	65 (2%): Jan	-35 (-1%)
MO2	83 (3%)	-30 (-1%)	-141 (-6%): AprI	116 (4%): Feb	3 (0%)
MO3	28 (1%)	-71 (-2%)	-124 (-5%): AprII	103 (4%): Dec	-27 (-1%)
MO4	-6 (0%)	32 (1%)	-253 (-10%): AugII	124 (4%): May	-30 (-1%)
PA	1 (0%)	-81 (-3%)	-125 (-4%): May	53 (3%): Sep	-23 (-1%)

Table 3-68. Mid-Columbia P10 Generation: Change from NAA

	P10 Mid-C Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	2106	2227	Variable	Variable	2018
MO1	47 (2%)	-70 (-3%)	-158 (-7%): AugI	146 (8%): Feb	-31 (-2%)
MO2	110 (5%)	-14 (-1%)	-138 (-8%): Mar	347 (20%): Feb	18 (1%)

	P10 Mid-C Generation (aMW)				
	Nov - Feb	Apr II - Jul	Max Loss Period	Max Gain Period	Annual
MO3	136 (6%)	-74 (-3%)	-158 (-7%): AugI	194 (11%): Feb	6 (0%)
MO4	18 (1%)	101 (5%)	-389 (-18%): AugI	291 (12%): May	-21 (-1%)
PA	27 (1%)	-13 (-1%)	-64 (-3%): AugI	182 (10%): Feb	7 (0%)

Table 3-69. Mid-Columbia Critical Water Generation: Change from NAA

	1937 Mid-C Generation (aMW)				
	Nov - Feb	Apr II - Jul	Max Loss Period	Max Gain Period	Annual
NAA	2272	2263	Variable	Variable	2133
MO1	4 (0%)	-133 (-6%)	-218 (-9%): AugI	52 (2%): Jan	-65 (-3%)
MO2	31 (1%)	-42 (-2%)	-178 (-8%): Jan	350 (20%): Feb	-12 (-1%)
MO3	61 (3%)	-138 (-6%)	-218 (-9%): AugI	192 (8%): Jan	-47 (-2%)
MO4	-35 (-2%)	79 (3%)	-775 (-32%): AugI	574 (27%): May	-63 (-3%)
PA	-46 (-2%)	-40 (-2%)	-194 (-8%): Jan	67 (4%): Oct	-32 (-1%)

3.4.4 Canadian System

The Canadian system results are provided for average generation, P10 generation, and critical water generation for the CRT dams and several non-Treaty dams on the lower Kootenay and Pend Oreille Rivers. Positive values are increases from the NAA value. Canadian results are unavailable for peak generation metrics due to HOSS modeling limitations.

Little change from NAA generation occurred on the Canadian system as a result of the alternatives. The major projects at Mica, Revelstoke, and Arrow were unaffected as their operation was replicated identically in all the alternatives. All generation changes occurred at Waneta and Seven Mile Dams on the Pend d'Oreille River downstream of Hungry Horse and Albeni Falls Dams and several smaller projects on the Kootenay River downstream of Libby Dam.

Table 3-70. Canadian Average Generation: Change from NAA

	Average Canadian Generation (aMW)				
	Nov - Feb	Apr II - Jul	Max Loss Period	Max Gain Period	Annual
NAA	3142	4114	Variable	Variable	3401
MO1	1 (0%)	-10 (0%)	-56 (-2%): Dec	36 (1%): Jan	-2 (0%)
MO2	46 (1%)	-19 (0%)	-61 (-3%): Jan	139 (4%): Dec	7 (0%)
MO3	30 (1%)	-19 (0%)	-102 (-4%): Jan	129 (3%): Dec	2 (0%)
MO4	-13 (0%)	20 (0%)	-108 (-3%): Sep	34 (1%): Jul	-6 (0%)
PA	12 (0%)	-6 (0%)	-19 (-1%): Sep	31 (1%): Jan	1 (0%)

Table 3-71. Canadian P10 Generation: Change from NAA

	P10 Canadian Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	2452	3086	Variable	Variable	2615
MO1	27 (1%)	-61 (-2%)	-117 (-4%): Jul	74 (2%): AugII	-6 (0%)
MO2	106 (4%)	-99 (-3%)	-223 (-7%): Jul	242 (7%): Dec	7 (0%)
MO3	88 (4%)	-108 (-4%)	-220 (-7%): Jul	242 (7%): Dec	-2 (0%)
MO4	29 (1%)	63 (2%)	-106 (-4%): Sep	158 (5%): Jul	24 (1%)
PA	22 (1%)	-60 (-2%)	-115 (-4%): Jul	74 (2%): AugII	-7 (0%)

Table 3-72. Canadian Critical Water Generation: Change from NAA

	1937 Canadian Generation (aMW)				
	Nov - Feb	**Apr II - Jul**	**Max Loss Period**	**Max Gain Period**	**Annual**
NAA	3128	3149	Variable	Variable	2989
MO1	5 (0%)	-43 (-1%)	-137 (-5%): Jul	118 (3%): Dec	-32 (-1%)
MO2	70 (2%)	-41 (-1%)	-123 (-4%): Jul	307 (8%): Dec	-8 (0%)
MO3	70 (2%)	-44 (-1%)	-135 (-5%): Jul	307 (8%): Dec	-11 (0%)
MO4	-40 (-1%)	1 (0%)	-213 (-7%): Sep	183 (5%): May	-44 (-1%)
PA	-16 (-1%)	-34 (-1%)	-110 (-4%): Jul	38 (1%): Jan	-30 (-1%)

3.5 OTHER POWER AND NON-POWER OPERATIONS NOT INCLUDED IN HYDSIM AND HOSS MODELING

There are many project operations of the CRS that are not distinguishable or fully captured in the HYDSIM and HOSS modeling described above. Some of these happen on timescales that are shorter than the resolution of the models. Some are operations that are not included in models used in planning but are decided and implemented on an *ad hoc* basis during real-time operations if and when there are appropriate conditions and system flexibilities. Several examples are provided below and others are discussed in Section 1.2.5 and in the CRSO EIS.

These operations are considered to be part of the NAA and many of the MOs, and would likely be part the preferred alternative. This section provides a discussion of some of these operations and a qualitative assessment their effects and the ability of the CRSO EIS alternatives ability to implement or accommodate some of the more significant ones.

3.5.1 Operations Not Distinguishable in HYDSIM or HOSS

The following operations are considered as part of the NAA and may have short-term system effects that are not fully captured or distinguishable in HYDSIM and HOSS modeling:

- **Albeni Falls, the Flexible Winter Power Operations (FWPO):** Between December 15 and March 31, Albeni Falls can be operated to use a larger portion of its authorized operation range to meet power needs more effectively. FWPO is not implemented in the CRSO EIS studies, though the operations will continue. The Albeni Falls Dam FWPO Environmental Assessment published in 2011 covers this operation and is not superseded by the CRSO EIS[18].

- **Power shaping for demand**: CRS power operations provide weekly daily, hourly, and moment-to-moment shaping of generation in response to firm power customer load demands, variability in generating resources within Bonneville's balancing area, weather variations, and market conditions. The average variations in demand for power from month-to-month are incorporated in the HYDSIM modeling. Similarly, average variations in demand across the week such as lower demand on weekends as well as typical variations across the day with lighter demand at night are included the HOSS modeling. Similarly, average generation from wind and solar generation are included as reductions in demand. During real-time operations, changes in weather and many other factors affect demand for power. Changes in weather affect power generation from wind and solar projects. The hydropower system responds to these fluctuations on a daily, hourly, and faster time frames and will continue to do so, regardless of which alternative is selected as the preferred alternative
- **Power shaping for economic marketing:** In times of flexibility in power operations, Bonneville may buy power when wholesale prices are low or sell when prices are high. This could result in daily or hourly shaping of project releases within established ramp rates.
- **Power emergencies:** Power system emergencies can result from a loss of generating resources on or off the Bonneville system, loss of transmission, or other unexpected event. Through the Technical Management Team (a regional forum of federal agencies, states, and tribes) there is an established protocol for altering operations in the event of a power emergency to increase power generation.
- **Power contingency reserves:** An important component of grid reliability is to ensure that electricity generation matches electricity demand at all times. Many of the hydropower resources on the grid can be operated to rapidly increase or decrease generation in response to fluctuating electrical demand or fluctuations in wind and solar generation providing power flexibility when needed to meet load and maintain a safe, reliable transmission system. The standby capacity and the ability to decrease generation are called generating reserves. Bonneville's power operations provide this service to its transmission operations. A subset of generating reserves are capacity reserves. They are used to replace power when another generating unit within the Bonneville balancing area stops unexpectedly or a transmission line that is importing energy suddenly cannot import the power. Contingency reserves are provided for 30 to 90 minutes until power can be purchased on the next cycle of the hourly wholesale spot market. The flexibility of hydropower resources are a valuable tool for providing reserves.

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[18] See Albeni Falls Dam Flexible Winter Power Operations Final EA (October 2011) at https://www.bpa.gov/efw/Analysis/NEPADocuments/Pages/Albeni-Falls-Dam.aspx.

- **Fish passage spill averaging**: In Bonneville modelling of MO1, MO3, and MO4, the spill is averaged over 12 or 24-hour periods as consistent with the water quality criterion and with the expectation that a similar approach would be in new criteria at the higher spill levels. Averaging spill would enable brief periods of slightly lower spill and higher generation to be balanced with other periods of the reverse conditions. Such an operational decision would be made during the course of the operating day. The increase in the ability to shape power generation across the day through spill averaging increases Bonneville's ability to shape generation to meet load, for marketing, and to support integration of wind and solar generation.
- **Libby December Draft:** In MO2 and MO3, Libby may draft 20 feet below the December target elevation for power. In CRSO modeling, Libby was always modeled as exercising this option. However, the exact operation would be decided based on any given year's conditions such as a warm December with less demand for power with an expectation for a colder January or February.
- **Grand Coulee Winter FRM Space:** In HYDSIM modeling of MO1, MO2, and MO4, Grand Coulee draft a few feet below full by mid-December to create space that can be filled in the event of a heavy winter rain event. In HYDSIM, this space at Grand Coulee is kept empty for the duration of the winter. However, if such a rain event were to occur, the space would be filled during the rain event and emptied again following the event.
- **Miscellaneous:** Several other operations are implemented in-season such as special elevations for Tribal fishing under their Treaty rights, weekend recreational events, reservoir elevations for loading or unloading special cargo, and maintenance work. These are described in the EIS for NAA and are expected to continue.

3.5.2 Qualitative Effects of the MO Alternatives

The following discussions provide a qualitative assessment of the power effects of measures that are considered parts of the CRSO EIS alternatives and are not distinguishable or fully captured in HYDSIM or HOSS modeling.

3.5.2.1 All Multiple-Objective Alternatives

Power contingency reserves are carried within juvenile fish passage spill for all MO alternatives. This increases the available capacity of hydro generation at the lower Snake and Columbia River projects. Holding the contingency reserves within the fish passage spill rarely affects fish passage spill amounts because the reserves are rarely used. Furthermore, contingency reserves can usually be deployed without reducing fish passage spill. In high flow conditions, this measure will reduce the incidence of spill stemming from lack-of-turbine capacity (which may lead to TDG above the water quality criterion) because the powerhouse will not need to reserve as much capacity outside fish passage spill.

HYDSIM does not shape powerhouse flows to meet weekly, daily, hourly, and real-time demands. All alternatives are considered to have shaping within the historic range of operations and impacts should be within historical flow changes.

MO1 ALTERNATIVE

In MO1 the forebay operating range at the Lower Snake River and John Day projects is increased by 0.5 feet during fish passage season. This flexibility is the same range being used in 2019 and is still smaller than the historic range of operations during the fall and winter time frame.

MO2 ALTERNATIVE

MO2 includes the operation of the lower Snake and Columbia River and projects at full reservoir operating range year-round except at John Day when it is operated for FRM. This type of flexibility is within the historic range of operations and impacts would be similar to historical elevation impacts during the fall and winter time frames when the projects operate at the full reservoir range.

Lower Snake and Columbia turbines can operate across their full range of capacity all year in MO2. This measure will increase generation and turbine flow capacities to reduce the amount of lack-of-turbine spill. The increased full-range use of turbine capacity was included in the CRSO EIS modeling. The increased use of turbine range would increase slightly the amount of within-day shaping to meet fluctuations in demand and would be within the historic range of operations and impacts would be similar to historic impacts.

MO2 also includes a measure that allows the Lower Snake River projects to shut off generation unless limited by grid stability requirements from September through March. This allows the projects to reduce generation when there is little demand and store the water for use at a later time when generation is in peak demand. This operation and its effects are within the historic range of operations typically observed in the mid-December through February winter months. Although the generation reduces the project flow to zero, the tailwater below the dam does not dry out because the downstream reservoir extends to the base of the upstream dam.

In both MO2 and MO3, the ramping rate limitations at all projects are defined for safety or geotechnical concerns such as erosion. More flexibility in ramping rates does not increase the total generation but increases the ability to shape flows and power generation within-day to meet fluctuations in demand.

ResSim models at the daily time step so within-day ramping was not captured. In power operations, projects would be shaped to the extent feasible to maximize generation during peak demand and minimize generation during low demand, while passing the necessary water across the day. For example, in the winter the project would pass the day average flow in a shape where the project was ramped down to minimum generation at night and ramp up over the morning peak demand. If the ramp rates allowed, another ramp down during midday to save water for the evening peak demand would likely occur, with an additional ramp down to minimums again for the overnight low demand period. The ramping limitations for safety or geotechnical concerns would need to be provided to calculate how much within day shaping of the flow would be allowed. If ramping rates are too restrictive for much within-day ramping, the projects would shape to have higher generation during the weekdays and lower generation on the weekends as allowed. Within-hour shaping would not be utilized on the headwater projects.

MO3 ALTERNATIVE

As stated above, MO3 includes no flow and ramping restrictions except those defined for safety or geotechnical concerns such as erosion. It also includes expanded John Day reservoir ranges similar to MO2.

MO3 also includes allowance for the Lower Columbia projects to operate turbines within and above the 1 percent peak efficiency range. This expands the turbine range on the upper end of the operating range which increases the turbine capacity to reduce the amount of lack-of-turbine spill. The increased turbine capacity would increase slightly the amount of within-day shaping to meet fluctuations in demand for electricity and fluctuations in generation from wind and solar power in the region, but is within the historic range of operations. Impacts should be similar to the historical impacts during the winter time frames when the projects operate at the full turbine range.

MO4 ALTERNATIVE

MO4 also includes the allowance for the Lower Columbia and Lower Snake River projects to operate turbines within and above the 1 percent range around peak efficiency. This expands the turbine range on the upper end of the operating range, which increases the turbine capacity to reduce the amount of lack-of-turbine spill. The increased turbine capacity would increase the amount of within-day shaping to meet fluctuations in demand, but is within the historic range of operations. Impacts should be similar to the historical impacts during the winter time frames when the projects operate at the full turbine range.

MO4 includes additional reservoir drawdowns to the Lower Columbia River projects. This will restrict the ability of those projects to meet fluctuations in power demand and to respond to fluctuations in wind and solar power generation. Though Lower Snake River projects are allowed to operate within MOP+1.5’, which provides some offset to this, Grand Coulee and Chief Joseph will need to absorb more of the fluctuations in generation to meet power demand and obligations to integrate renewable energy.

PREFERRED ALTERNATIVE

In the PA the forebay operating range at the Lower Snake River and John Day projects is increased by 0.5 feet during fish passage season. This flexibility is the same range being used in

2019 and is still smaller than the historic range of operations during the fall and winter time frame.

PA includes the operation of John Day at full reservoir operating range year-round except at when it is operated for FRM. This type of flexibility is within the historic range of operations and impacts would be similar to historical elevation impacts during the fall and winter time frames when the projects operate at the full reservoir range.

PA also includes a measure that allows the Lower Snake River projects to shut off generation unless limited by grid stability requirements from October through February with revised timing to provide hydropower flexibility while minimizing impacts to ESA-listed fish. This allows the projects to reduce generation when there is little demand and store the water for use at a later time when generation is in peak demand. This operation and its effects are within the historic range of operations typically observed in the mid-December through February winter months. Although the generation reduces the project flow to zero, the tailwater below the dam does not dry out because the downstream reservoir extends to the base of the upstream dam.

3.6 HYDROPOWER GENERATION FOR REVENUE IMPACT ANALYSES

Bonneville prepared CRS energy generation estimates for the NAA and each CRSO EIS action alternative. The CRSO EIS socioeconomic analysis used generation amounts to estimate Federal revenues for each alternative. Revenue analyses and result details are provided in the *Power and Transmission Appendix H* to the CRSO EIS.

Bonneville markets firm power (power that is made continuously available expect for reasons of force majeure) under long-term firm power sales contracts. The FCRPS constitutes the largest system of resources that produce firm power, which is determined using the critical water year (1937). The change in annual average generation of the CRS projects is the primary component in determining the change in the amount of the Federal Base System Bonneville uses to support its long-term firm power sales contracts.

Bonneville used the HYDSIM model to estimate energy generation for each period during the 80-year study period. The average critical water (1937) generation was used to estimate the amount of firm power that the FCRPS is expected to produce. Bonneville is currently selling firm power through September 2028 under long-term Regional Dialogue firm power sales contracts. The contract and Bonneville's current priority firm power rate design (the Tiered Rates Methodology) 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 non-federal resources Bonneville has acquired to meet its firm power supply contractual obligations. In the event the Tier 1 System Firm Critical Output decreases, such as through a reduction in the CRS's firm power capability, the resulting reduction would likely lead to a change in the supply of federal power to Bonneville's customers at the Tier 1 system rate. Customers that elected to serve their own loads above the Tier 1 System Firm Critical Output would be have to find other sources of supply to meet their load needs.[19] Generation amounts greater than the Tier 1 System Firm Critical Output may be available for surplus sales if not first needed to meet Bonneville's firm power obligations. The CRS generation amount estimates for the socioeconomic analyses are provided in Table 3-73.

Table 3-73. Average CRS (Federal) Generation for Revenue Determination

Alternative	1937 Average Generation Change from NAA (aMW / %)	80-Year Average Generation Change from NAA (aMW / %)
NAA	6,237	8,340
MO1	-297 / -4.8	-132 / -1.6
MO2	378 / 6.1	445 / 5.3
MO3	-748 / -12.0	-1,105 / -13.2
MO4	-888 / -14.2	1,302 / -15.6
PA	-328 / -5.3	-205 / -2.5

[19] Bonneville may sell power to these customers to meet their power needs if Bonneville has surplus power available. The availability of this power, however, is uncertain.

CHAPTER 4 - SYSTEM RELIABILITY

4.1 OVERVIEW

The Loss of Load Probability (LOLP) studies for the CRSO EIS evaluate the NW-US system's ability to meet forecasted electric load in 2022. Generation amounts for each CRSO EIS alternative plus other resources from the NWPCC's 2017 Resource Adequacy Assessment (NWPCC 2017a) are compared to the forecasted load for 2022. The analyses involve Pacific Northwest generating resources, assumptions of power imports and exports, regional loads, temperature correlated wind generation profiles, planned generating resource retirements, power conservation expectations, and new generating resource additions. Conservation and new resource assumptions are from the NWPCC's 7th Power Plan (NWPCC 2016).

It is important to note that since the analysis for LOLP in the CRSO EIS was launched in 2017, utilities in the Pacific Northwest have announced the retirement of additional coal generation plants. Therefore, the analysis described here may be viewed as "the 2017 view of the future." BPA is performing additional analyses to evaluate how these results would differ with fewer coal plants serving northwest loads.

Bonneville and other regional planning entities such as the NWPCC use LOLP as a fundamental metric of power system reliability. LOLP measures the frequency of years with one or more power outages in a Monte Carlo analysis or multiple operating years and conditions; it does not capture the magnitude or duration of an outage. Bonneville and NWPCC use a target of 5 percent LOLP.

4.1.1 Methodology

Bonneville used the NWPCC's GENESYS model to conduct the studies and ran 6,160 Monte Carlo simulations for each CRSO EIS alternative involving hydropower, wind, and solar energy variability; forced outages on thermal plant generation; and hourly historical temperature variations (1929 to 2006). This provided the LOLP frequency, how many games out of 6,160 had instances of insufficient resources to meet the demand, but did not measure the magnitude or duration of an outage. Bonneville prepared a CVaR analysis to assess the magnitude and seasonality of the outages.

The reliability analyses were regional (NW-US) and were not performed for the CRS (Federal), Mid-Columbia, or Canadian systems. Because the utilities in the region can buy and sell power bilaterally with one another that is surplus to their retail load needs, the loss of generation by one entity can have adverse consequences to utilities relying on such generation. If the Federal system loses generation, BPA may be obligated to acquire resources to replace losses in the Federal Base System consistent with Bonneville's long-term firm power sales contracts or its customers may do so. However, even if Bonneville does not acquire replacement resources, if regional reliability would be below the levels of the No Action Alternative, other utilities would need to acquire resources to maintain reliability. The wholesale power costs impacts to Bonneville's power rates of replacement resources for both the Bonneville-acquired and the non-Bonneville acquired resources is discussed in each MO in Chapter 3.7 of the EIS. The regional retail rate impacts of these replacements is discussed in the socioeconomic analysis in the CRSO EIS *Power and Transmission Appendix H*.

4.1.2 Lost-of-Load Probability Results

4.1.2.1 No-Action Alternative

Bonneville's analysis of the LOLP for the NAA is 6.6 percent for the Pacific Northwest, which means there was at least one outage in 6.6 percent of the simulation games. An LOLP of 6.6 percent means that the region would experience a significant power shortage (or recurring power shortages) in roughly one in every 15 years. These are power shortages because loads are greater than the power system's ability to generate electricity and are not power outages on the distribution system such as when a tree hits a power line and blacks out a neighborhood for a few hours. An LOLP event could result in rolling blackouts lasting up to several days.

Because the 6.6 percent LOLP value is above the regional target, regional utility planners (and potentially Bonneville is requested by its customers) should be building or acquiring new generating resources with firm capacity. Only wind and solar are currently planned, and they do not have firm generation capacity. However, the region has accepted this higher level of LOLP over the past 5 years, and it has become the status quo. This does not meet the 5 percent LOLP target, but the 6.6 percent LOLP of the NAA will serve as the measure of comparison for the effects of the other CRSO EIS alternatives.

CVaR techniques evaluate the amount of monthly average energy not served in the worst 5 percent (308 games) of the GENESYS games in which load was not met. For example, the NAA results in Figure 4-1 and Table 4-1 indicate there was an average load loss of 65.1 aMW in 2.9 percent of the worst 5 percent of the games (about nine games).

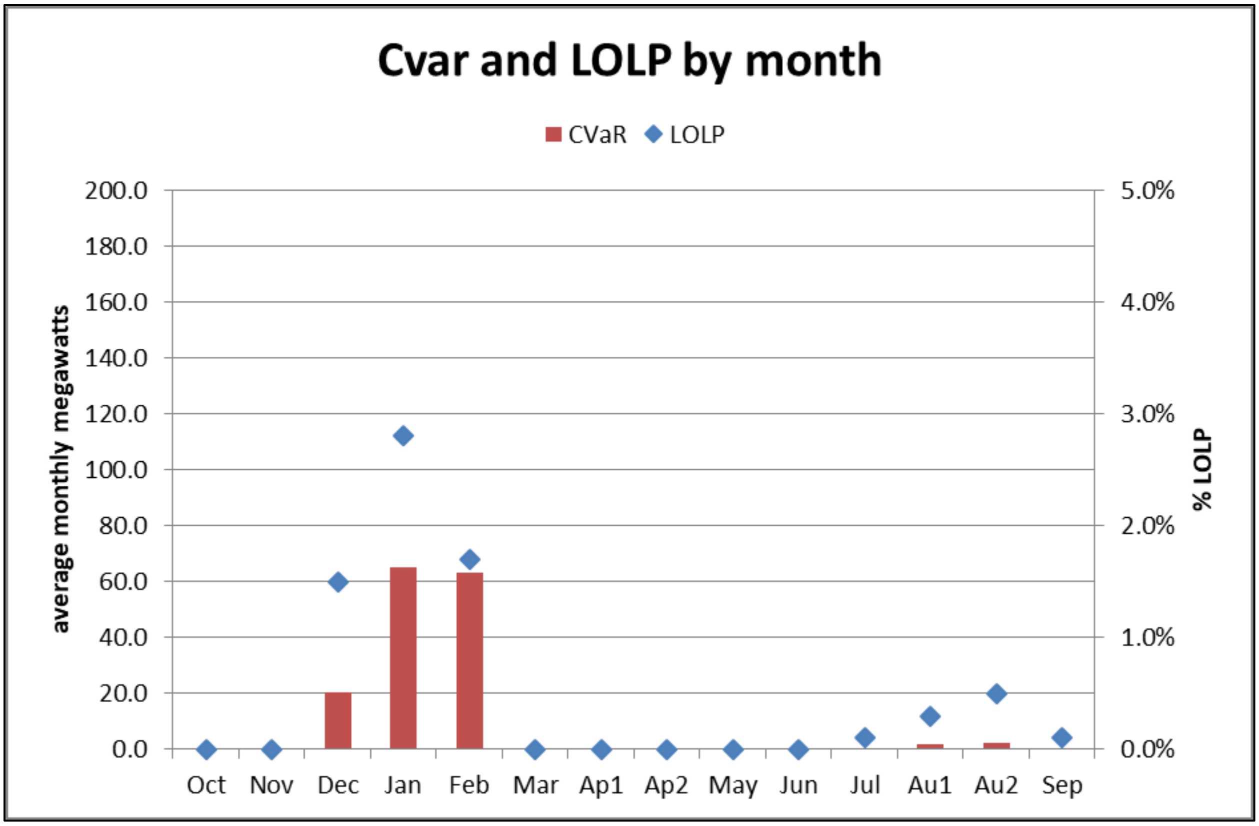


Figure 4-1. NW-US System CVaR and LOLP by Month for NAA

Table 4-1. NW-US System LOLP and CVaR by Month for NAA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
LOLP (%)	0.0	0.0	1.5	2.9	1.8	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.6	0.2
CVaR (aMW)	0.0	0.0	21.2	67.3	64.3	0.0	0.0	0.0	0.0	0.0	0.5	2.3	2.5	0.2

Bonneville estimates that the monthly CVaR varies from 0 to 67.2 aMW before any replacement resources are added. Load loss was highest in the winter months peaking at 2.9 percent in January. Summer months had considerably smaller events, but were not free of loss-of-load events. The Pacific Northwest has traditionally focused on winter as the period of reliability concern. However, with increasing population and an increasing use of air conditioning, summer months are emerging as reliability concerns as well.

Note that the sum of the 14-period LOLP results do not add up to the annual LOLP results because some games had loss-of-load events in more than one month. Each year counts only once in the annual LOLP.

4.1.2.2 MO1: Change from NAA

Bonneville estimates the LOLP for MO1 is 11.2 percent for the Pacific Northwest, which means there was an outage (or multiple outages) in 11.2 percent of the simulation games or approximately one every 9 years. Bonneville and/or Bonneville's public power customers would need to build or acquire new firm resources to meet the 5 percent LOLP target or the 6.6 percent level of NAA.

Bonneville estimates the monthly CVaR varies from 0 to 60.8 aMW. Load loss was its highest during the winter months peaking at 2.8 percent in February. Though smaller than the winter outages, in MO1 significantly more outages occurred in August compared to NAA where there were relatively few. Detailed results are provided in Figure 4-2 and Table 4-2.

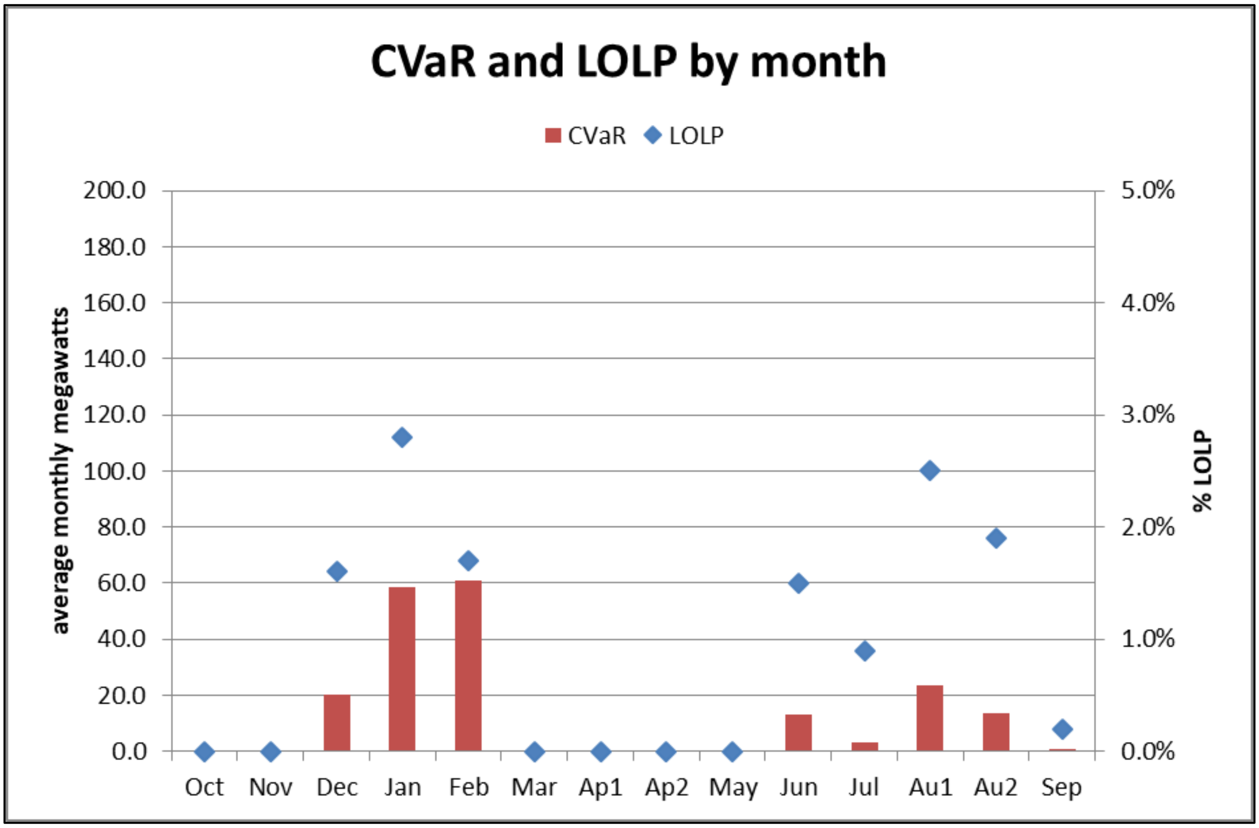


Figure 4-2. NW-US System CVaR and LOLP by Month for MO1

Table 4-2. NW-US System LOLP and CVaR by Month for MO1

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
LOLP (%)	0.0	0.0	1.6	2.8	1.7	0.0	0.0	0.0	0.0	1.5	0.9	2.5	1.9	0.2
CVaR (aMW)	0.0	0.0	20.2	58.3	60.8	0.0	0.0	0.0	0.0	12.9	3.0	23.7	13.4	0.5

The LOLP changes from the NAA (6.6 percent) to MO1 (11.2 percent) primarily result from:

- Less fall draft from Libby through December affected December through February water supply at Grand Coulee and below.
- Reduced flows in August from Dworshak affected flows in the lower Snake and Columbia Rivers.
- An increase in fish passage spill compared to NAA in the spring.

4.1.2.3 MO2: Change from NAA

Bonneville estimates the LOLP for MO2 is 5.0 percent for the Pacific Northwest, which means there was one or more outages in 5.0 percent of the simulation periods or approximately in one of every 20 years. This alternative improves the NW-US system LOLP coincidentally to the NW Council target without Bonneville and/or Bonneville's public power customers adding or acquiring new generating resources by increasing the capability of the hydropower system.

Bonneville estimates the monthly CVaR varies from 0 to 65.5 aMW. Load loss was highest during the winter months, peaking at 2.8 percent in January. This was the only alternative without an August outage. Detailed results are provided in Figure 4-3 and Table 4-3.

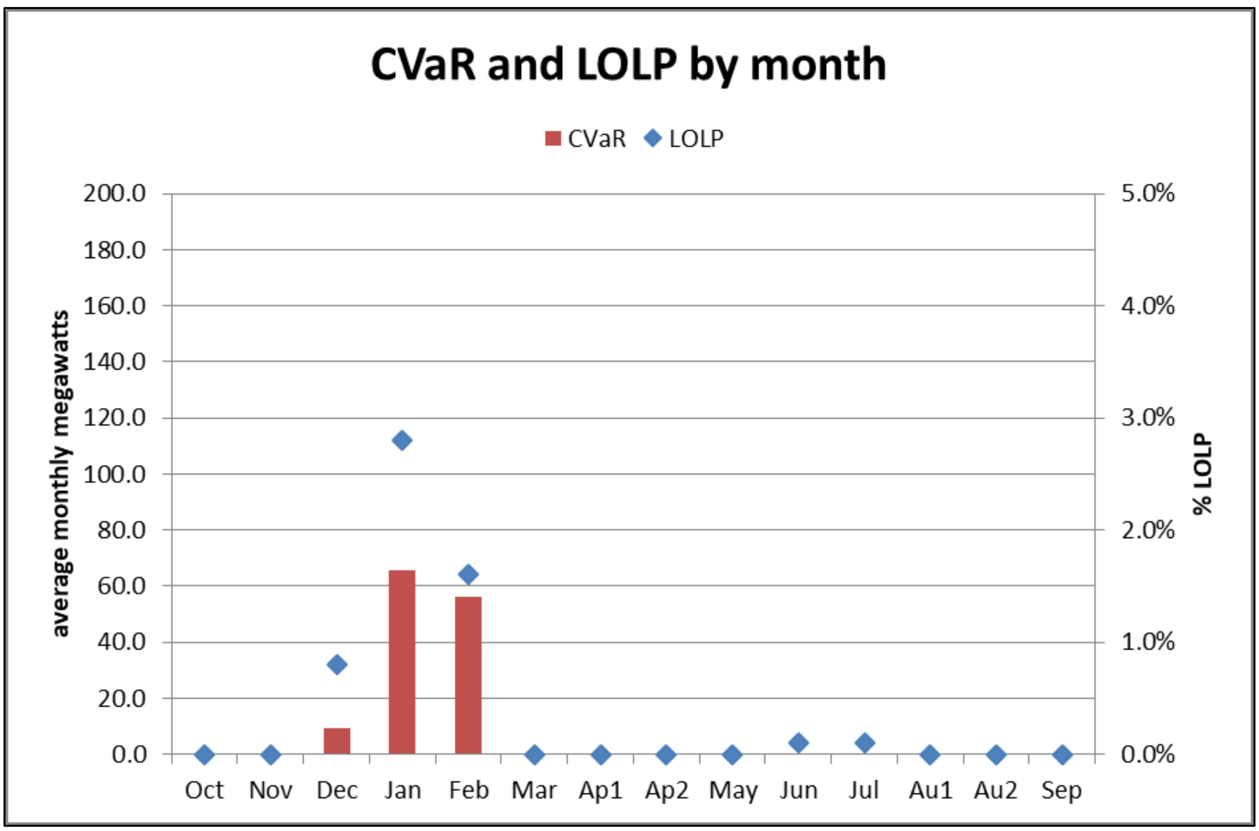


Figure 4-3. NW-US System CVaR and LOLP by Month for MO2

Table 4-3. NW-US System LOLP and CVaR by Month for MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
LOLP (%)	0.0	0.0	0.8	2.8	1.6	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
CVaR (aMW)	0.0	0.0	9.1	65.5	56.3	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0

The LOLP changes from the NAA (6.6 percent) to MO2 (5.0 percent) primarily result from:

- Summer fish passage spill was limited to near 110 percent TDG and ends in August.
- Storage projects drafted slightly deeper in winter and early spring providing more water supply to the Columbia and Snake River projects for winter generation.
- After Grand Coulee's summer draft, refill to 1,283 feet NGVD29 was extended to the end of October (MO2) versus September (NAA).

4.1.2.4 MO3: Change from NAA

Bonneville estimates the LOLP for MO3 is 13.9 percent for the Pacific Northwest, which means there was one or more outages in 13.9 percent of the simulation periods or in nearly one in every 7 years. Bonneville and/or Bonneville's public power customers would need to build or acquire new firm resources to meet the 5 percent LOLP target or to meet the 6.6 percent LOLP of NAA.

Bonneville estimates that the monthly CVaR varies from 0 to 98.7 aMW. Load loss was highest during the winter months peaking at 4.1 percent in January. Though smaller than the winter event, appreciable outages also occurred from June through August. Detailed results are provided in Figure 4-4 and Table 4-4.

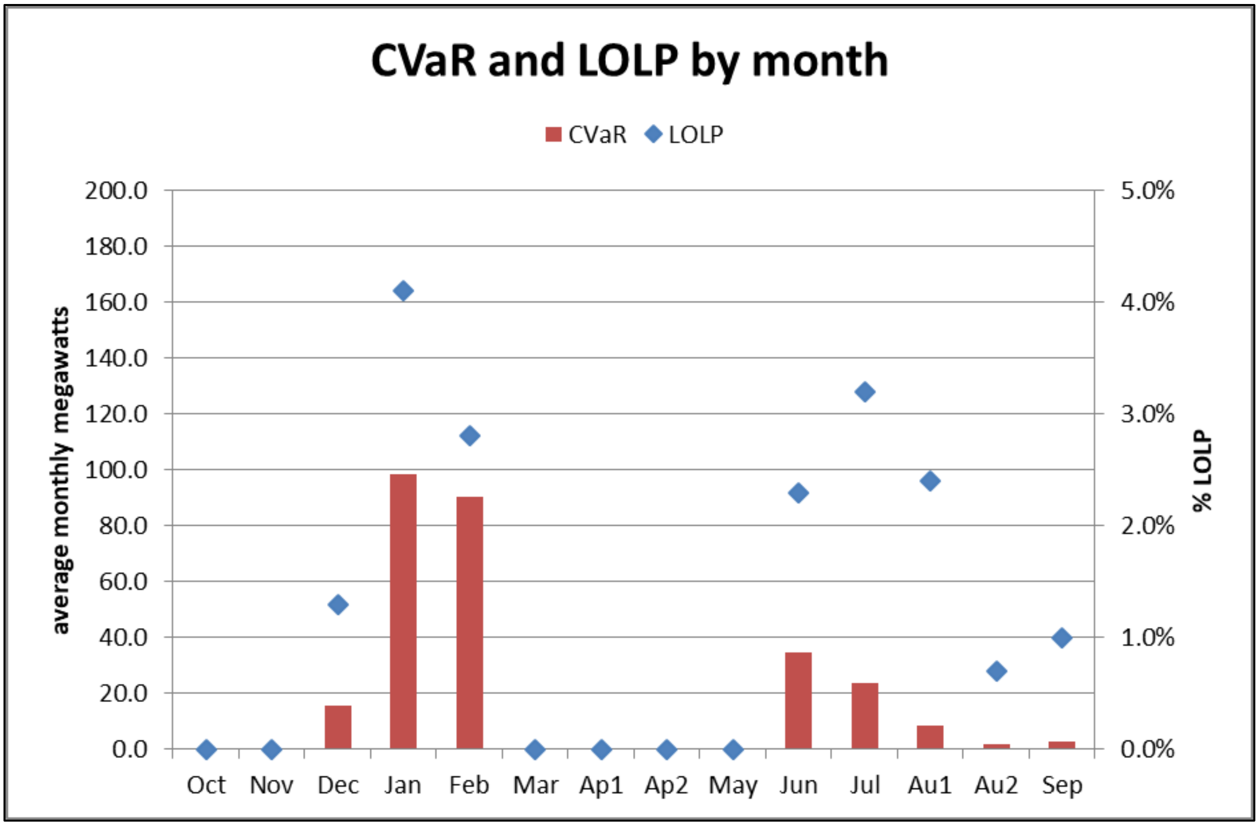


Figure 4-4. NW-US System CVaR and LOLP by Month for MO3

Table 4-4. NW-US System LOLP and CVaR by Month for MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
LOLP (%)	0.0	0.0	1.3	4.1	2.8	0.0	0.0	0.0	0.0	2.3	3.2	2.4	0.7	1.0
CVaR (aMW)	0.0	0.0	15.8	98.7	90.2	0.0	0.1	0.0	0.0	34.5	23.7	8.7	1.9	3.0

The LOLP changes from the NAA (6.6 percent) to MO3 (13.9 percent) primarily result from:

- Breaching the four lower Snake River dams reduced year-round generation.
- Spring spill for fish passage at lower Columbia dams was raised to 120 percent TDG, which reduced generation at the four projects.
- Summer spill for fish passage was ended on August 1, which increased August power production at the lower Columbia dams.
- Deeper draft from Libby in December provided more flow at Grand Coulee and below in December but reduced the January flows.

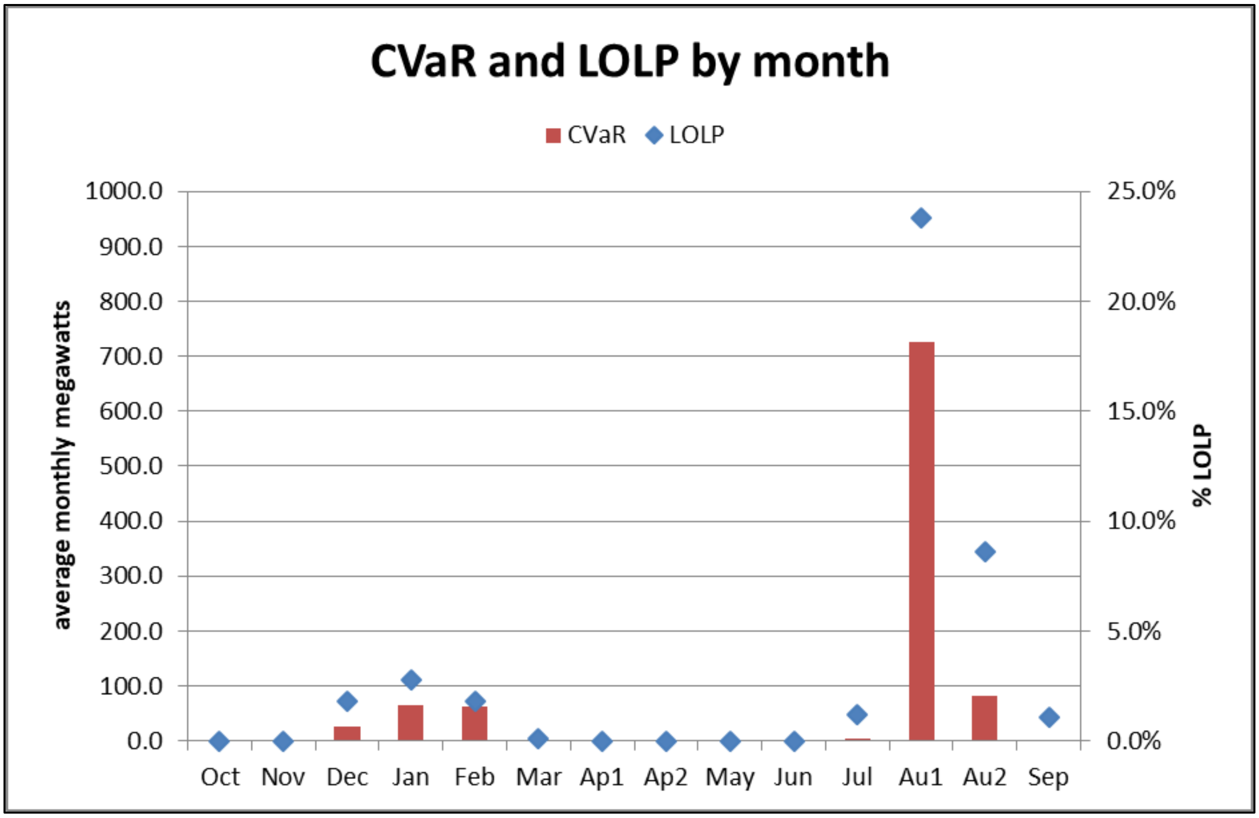
4.1.2.5 MO4: Change from NAA

Bonneville estimates the LOLP for the NAA is 29.6 percent for the Pacific Northwest, which means there was an outage in 29.6 percent of the simulation games meaning that the northwest region might experience significant power outages roughly in one of every 3 years. Bonneville and/or Bonneville's public power customers would need to build or acquire new firm resources to meet the 5 percent LOLP target or to meet the 6.6 percent LOLP of NAA.

Bonneville estimates the monthly CVaR varies from 0 to 725.3 aMW. Load loss was highest during the summer months peaking at 23.8 percent in the first part of August. This would mean that roughly in one of every 4 years there would be extensive rolling blackouts in the region in early August. Because the CVaR is very high at 725.3 aMW, the rolling blackouts would require significant portions of the northwest to lose power. Detailed results are provided in Figure 4-5 and Table 4-5. Note the scale change for CVaR in Figure 4-5; zero to 1,000 aMW versus zero to 200 aMW in the other alternatives in this section.

The LOLP changes from the NAA (6.6 percent) to MO4 (29.6 percent) primarily result from:

- Fish passage spills at lower Columbia dams were raised to 125 percent TDG from March through August, which reduced generation to minimum generation at the four lower Snake and four lower Columbia River projects in most years.
- Flow augmentation of up to 2 Maf from upstream storage projects that support spring and sometimes early summer flows on the lower Columbia River reduce flows in August to October, sometimes even longer.



Note that the graph for MO4 is on a different scale compared to the graph for NAA and the other MOs.

Figure 4-5. NW-US System CVaR and LOLP by Month for MO4

Table 4-5. NW-US System LOLP and CVaR by Month for MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
LOLP (%)	0.0	0.0	1.8	2.8	1.8	0.1	0.0	0.0	0.0	0.0	1.2	23.8	8.6	1.1
CVaR (aMW)	0.0	0.0	26.1	63.9	61.5	0.4	0.1	0.0	0.0	0.0	3.9	725.3	81.1	2.9

4.1.2.6 PA: Change from NAA

Bonneville estimates the LOLP for the PA is 6.4 percent for the Pacific Northwest, which means there was an outage in 6.4 percent of the simulation games. This is essentially the same as the 6.6 percent LOLP of the NAA. Less fall draft from Libby is affecting December through February inflows at Grand Coulee and downstream. Bonneville estimates the monthly CVaR varies from 0 to 60 aMW. Load loss was highest during the winter months, peaking at 2.6 percent in January. Detailed results are provided in Figure 4-6 and Table 4-6.

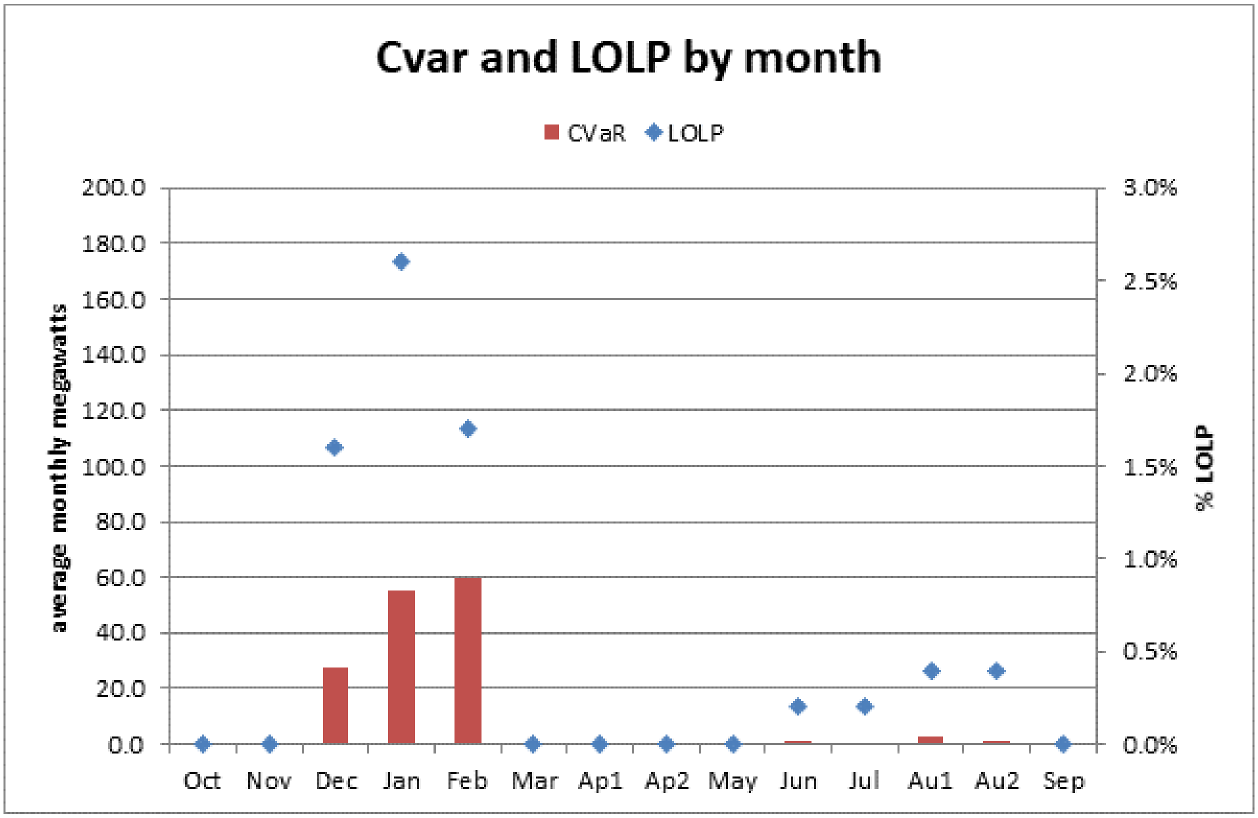


Figure 4-6. NW-US System CVaR and LOLP by Month for PA

Table 4-6. NW-US System LOLP and CVaR by Month for PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
LOLP (%)	0.0	0.0	1.6	2.6	1.7	0.0	0.0	0.0	0.0	0.2	0.2	0.4	0.4	0.0
CVaR (aMW)	0.0	0.0	27.6	55.6	59.9	0.0	0.0	0.0	0.0	1.0	0.4	3.0	1.3	0.0

4.1.3 Summary of Key Findings

Key reliability findings for the NW-US system are summarized in Table 4-7. Similar summaries for the CRS (Federal), Mid-Columbia, and Canadian systems are not provided.

MO1 almost doubles the LOLP of the NAA due to increases in summer loss of load. Overall, MO2 impacts system loss-of-load the least and lowers the LOLP from 6.6 percent in the NAA coincidentally to meet the 5 percent industry target. Major increases in loss of load occur in MO3 due to Snake River dam breaching. Loss of load in MO4 is even greater than in MO3 due to increased fish passage spill and the flow augmentation measure. The PA essentially has the same LOLP as the NAA. Each alternative's key reliability findings are described briefly below.

Table 4-7. NW-US System LOLP and CVaR Summary

Alternative	LOLP (%)	Notable CVaR Results
NAA	6.6	65.1 aMW @ 2.9% LOLP in January
MO1	11.2	58.3 aMW @ 2.8% LOLP in January 23.7 aMW @ 2.5% LOLP in August I
MO2	5.0	65.5 aMW @ 2.8% LOLP in January
MO3	13.9	98.7 aMW @ 4.1% LOLP in January 34.5 aMW @ 2.3% LOLP in June
MO4	29.6	63.9aMW @ 2.8% LOLP in January 725.3 aMW @ 23.8% LOLP in August I
PA	6.4	55.6 aMW @ 2.6% LOLP in January

4.1.3.1 NAA

The system 6.6 percent LOLP does not meet the 5 percent industry target which is an indication that Bonneville and/or Bonneville's public power customers the region should be building or acquiring generating resources with firm capacity to meet the 5 percent LOLP target. Loss of load is most likely to occur in the winter months with a little loss of load occurring during the summer months.

4.1.3.2 NAA compared to MO1

Changing the timing of flows from Dworshak and increased fish passage spill raised the overall NAA LOLP from 6.6 percent to 11.2 percent in MO1. Unserved winter load was similar to the NAA. There was a moderate increase from the NAA in unserved load in the summer months due to fish passage spill.

4.1.3.3 NAA compared to MO2

MO2's increased hydropower operations total generation and flexibility lowered the overall LOLP coincidentally to the 5 percent industry target. Reduced fish passage spill levels and duration eliminated almost all spring and summer loss of load. Winter load loss was just slightly better than the NAA.

4.1.3.4 NAA compared to MO3

MO3 removal of the lower Snake River power production raised the LOLP from 6.6 percent in the NAA to 13.9 percent. There were substantial increases in winter and summer load losses.

4.1.3.5 NAA compared to MO4

MO4 increased spill and flow measures raised the overall system LOLP from 6.6 percent in the NAA to 29.6 percent. The increased spill to 125 percent TDG and additional storage releases to meet McNary flow targets resulted in major increases in loss of load in the summer compared to the NAA. Winter loss of load was similar to the NAA.

4.1.3.6 Preferred Alternative (PA)

The PA results were similar to the NAA. Similarly, loss of load is most likely to occur in the winter months with a little loss of load occurring during the summer months.

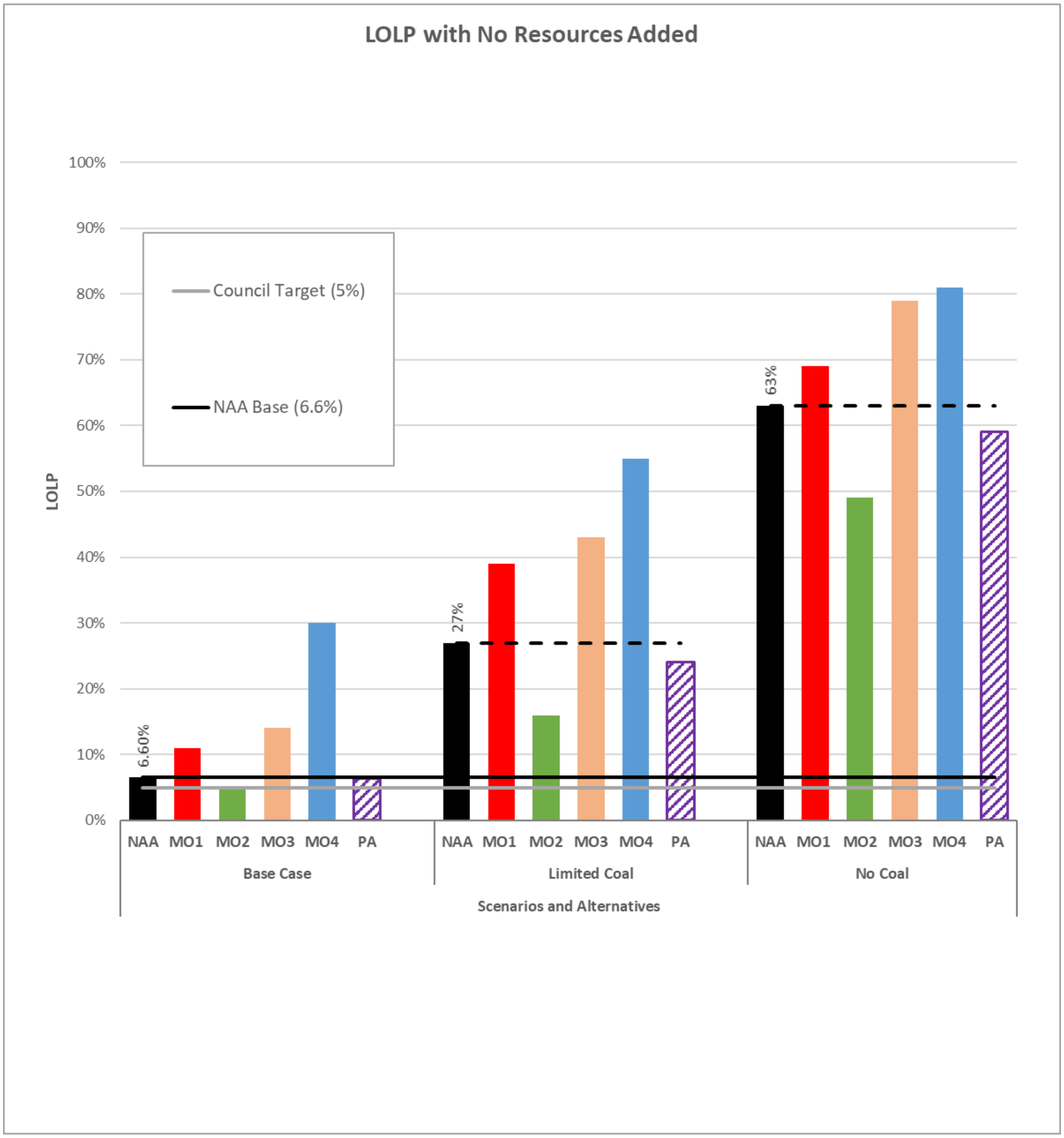
4.1.4 LOLP in the Context of Additional Coal-Plant Retirements

When Bonneville prepared the CRSO EIS analysis in 2017, several coal-fired power plants in the region were scheduled to close. These closures were accounted for in the system reliability analyses discussed in Chapter 4. Since 2017, additional and accelerated coal plant closures have been announced. These closures were not accounted for in the reliability analyses in Chapter 4.

The CRSO EIS reliability studies include 4,246 MW of combined regional coal plant generation, including Centralia Coal plant in Washington (owned by Transalta, an Independent Power Producer) and the remaining coal plants owned and/or used by the region's investor-owned utilities to serve their retail load demand: Colstrip, Hardin, and Montana 1 in Montana; Jim Bridger in Wyoming; and North Valmy in Nevada. These coal plants all contributed to meeting the regional 6.6 percent LOLP for the NAA. Recent closure announcements are providing an "updated view of the future" with only 1,741 MW of coal plant availability by the end of the 2020s that is provided at the partially closed Colstrip and Jim Bridger plants.

Further, the state of Washington recently passed the *Washington Clean Energy Transformation Act* (Senate Bill 5116) to eliminate coal generation by 2025 and be carbon neutral by 2045. If other states in the Pacific Northwest follow Washington and commit to removing coal-fired power plants with a goal of achieving carbon neutrality or better, it is unlikely that new gas plants would be built in the region.

Removing coal-fired baseload generating resources and replacing them with new renewable resources instead of replacing them with gas-fired generation raises the LOLP of NAA and all of the MOs. Consequently, Bonneville supplemented the original analysis with a reassessment of the LOLP results with two scenarios of future coal- fired generation without new gas-fired generation. Results are displayed in Figure 4-7. The base case represents the LOLPs for the EIS with the original information available in 2017. The Limited Coal area represents the "updated view of the future" with 1,741 MW of coal remaining in the region. The No Coal area has no coal generation.



Note: The gray line represents the NW Council's Target at 5.0%, and the black lines represent the LOLP of the NAA.

Figure 4-7. NW-US LOLP with Removal of Coal Plants

The "conventional least cost" analysis in Section 4.2.3 with gas-fired replacement resources is still valuable in giving a price range for replacement resources considering that some renewable resource technology would continue to fall in price. The major increases in LOLP indicate the region's utilities serving load need major investments in carbon-free resources to maintain the current levels of reliability. Bonneville did not carry the analysis of limited coal and no coal all the way through the EIS because such an analysis would involve substantial assumptions about how investor-owned utilities would choose to replace their coal and because it did not have the tools to extrapolate the market that far into new conditions. However, Bonneville did carry forward qualitative assessments that are added to the base case analysis to document the potential effect of the additional coal closures.

4.2 POTENTIAL REPLACEMENT POWER PORTFOLIOS AND CARBON EMISSION IMPACTS

In Section 4.1, Bonneville provided estimates of the system reliability for the NAA and each of the MO alternatives. This section provides information on the development of two sets of potential resource portfolios needed to increase the reliability of MO1, MO3, and MO4 to the 6.6 percent LOLP of the NAA. This chapter also provides information on the development of each portfolio and the estimated amount of generation and carbon production from those portfolios when they are combined with the hydropower production of each MO.

The CO_2 estimates from the fossil fuel generation from the conventional least-cost portfolio are available in the air quality assessments in the CRSO EIS *Air Quality and Greenhouse Gas Appendix G.* The resource portfolios and their potential costs and future uses also impact utility revenues and power rates; these are discussed in the CRSO EIS *Power and Transmission Appendix H.*

4.2.1 Overview

During any given time, there are numerous generating units supplying power to the Pacific Northwest power system. Some power will be produced by hydroelectric, wind, solar power, and nuclear resources, which do not emit CO_2; other power will likely be produced by coal or natural gas-fired generating units that emit CO_2. Increases in generation from hydropower and other renewables will often reduce or even eliminate the need to meet power loads with higher marginal-cost, carbon-emitting resources. Conversely, reducing hydropower can increase the need to operate existing gas and coal-fired generators even if other renewable generation is increased because wind and solar power are not able to meet demand at all times; hydropower reductions can also result in a need to build new carbon-producing generators. Hydroelectric, wind, and other renewables are generally the first used to meet demands before natural gas and coal fired units, due to their lower marginal cost, i.e., low "fuel" costs.

The last resource that is used or dispatched to meet load is considered the marginal resource. Bonneville studies dispatched the lowest cost marginal resource to meet the gap between hydro generation and loads.

4.2.2 Potential Replacement Power Portfolio Methodology

The regional target for the LOLP as set by the NW Council is 5.0 percent, though the NW Council model currently shows an LOLP of 6.6 percent. To evaluate the impact of each alternative, Bonneville assessed what new resources would be needed in the region to lower the LOLP of MO1, MO3, and MO4 to the 6.6 percent LOLP of the NAA. For MO2, which had a lower LOLP than NAA, Bonneville determined what resource builds could be avoided with MO2 compared to NAA. Further, for each alternative, the analysis identified two different potential portfolios of resources for each alternative. One portfolio consisted of the least-cost resources and the other consisted of zero-carbon emitting, least-cost resources.

Bonneville developed screening studies for MO1, MO3, and MO4 to find the lowest cost portfolio for resources[20] relative to their contribution to lowering the LOLP to the NAA LOLP of 6.6 percent. Screened resources included gas-fired resources[21] (both simple and combined cycle), solar, wind in the Columbia River Gorge (Gorge Wind), Montana wind (capped at 660 MW as this will be the transmission capability available after Colstrip 1 and 2 coal-fired generation units are retired), demand response (DR) at the NW Council's 7th Power Plan target (600 MW), and batteries. Resource characteristics (i.e., hourly capacity profiles) were sourced from the NW Council's Resource Adequacy Advisory Committee.

Resources costs were sourced from the 6th Power Plan, the 7th Power Plan, the 7th Power Plan Mid-Term Assessment, or staff experts at the NW Council except battery costs (sourced from recent integrated resource plans) as they were not updated in the Mid-Term assessment. Resource cost portfolios included:

- Variable costs of the resources including fuel costs.
- Variable cost of the power system changes due to inclusion of a new resource (i.e., adding solar into the power system usually reduced the need to burn gas and coal, and all portfolios have changes in power purchases and export sales).
- Capital costs of those resources amortized over their expected life span at the weighted cost of capital in the region.
- Only larger quantity resources that are commercially available were evaluated. Other resources may reach commercial scale viability in the coming years, but they are currently too speculative, so this analysis did not include them in potential replacement resource portfolios. For example, battery storage currently is limited to a few hours, and the potential replacement resource portfolios did not include long-duration battery storage. Similarly, while new pumped storage operations are being explored in the Northwest, these too would have limited duration. And both batteries and pumped storage provide capacity on a short-term basis; energy losses during discharge and recharging make them net energy consuming. Small modular nuclear power was not considered either as it is an untested source of power.

These portfolio costs were divided by the LOLP benefit (the drop-in percent of LOLP from the alternative without added resources) to calculate the lowest cost replacement resources per unit of the reduction in LOLP.

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[20] Note if Bonneville acquires long term (greater than 5 years) or major resources such resources must be "cost effective" as that term is defined by the Northwest Power Act.
[21] According to the NW Council report *Marginal Carbon Dioxide Production Rates of the Northwest Power System*, the lowest cost marginal units are typically gas-fired power plants until 2025 (NW Council 2008).

The lowest cost portfolio included gas-fired combustion turbine (CT) resources. The zero-carbon portfolio included Montana wind, solar, and DR resources. Once portfolios were selected, resources were added into the study until the LOLP of the alternative was equivalent to the NAA (6.6 percent).

These portfolios of resources were added to the GENESYS model, and they were dispatched to meet regional loads. The addition of these resources also impacted how much the region had to rely on independent power producers and exports and imports from out-of-region markets. The portfolios that included renewable resources also reduced the need to burn fossil fuels such as natural gas and coal, except in MO3 where there was a significant need for additional generation in the winter.

For each MO, two portfolios of potential replacement resources were identified.
The conventional least-cost portfolios turned out to be only gas-fired generation. The zero-carbon, least cost portfolios were a combination of demand response, solar, and Montana wind.

MO2 achieved the five percent LOLP target without the need to add additional resources.
An "avoided resource" portfolio was developed by determining the portfolio needed to reduce the NAA LOLP from 6.6 percent to 5.0 percent.

4.2.3 Potential Replacement Power Portfolios and Carbon-based Generation Results

Bonneville prepared aMW generation estimates from carbon producing CT resources for the NW-US only. The generating resources could be financed and used by Bonneville or by other entities in the northwest. For the conventional least-cost portfolio, the results include the amount of gas and coal power capacity and average generation needed to reach the NAA LOLP of 6.6 percent. The results for least-cost resource additions are in Table 4-8.

Table 4-8. NW-US System Conventional Least-Cost Replacement Portfolio and Associated Change in Carbon-based Generation for the Base Case without Additional Coal-Plant Closures

Alternative	LOLP (percent)	CT Capacity Added to Reach 6.6% LOLP (MW)	CT Avg. Added Generation (aMW)
MO1	11.2	560	163.1
MO2	5.0	avoided build: 440	-244
MO3	13.9	1,120	607.0
MO4	29.6	3,240	708.2
PA	6.4	N/A	N/A

Note: Green font used when reduction is beneficial.

For the zero-carbon portfolios, a mix of solar and DR resources were added to achieve the NAA LOLP of 6.6 percent. In these cases, the existing fossil-fuel generating resources would change their generation, decreasing when solar and/or wind are abundant and increasing when the system needs more capacity.

Bonneville also determined that the increased hydropower production in MO2 resulted in the NW-US system meeting the 5.0 percent LOLP industry target without adding new resources. If resources are built for the NAA in the future, MO2 would reduce the amount of new resources need. Thus, MO2 results in avoided addition of new gas-fueled resources. Bonneville estimated the "avoided build" by developing a least-cost resource portfolio that improved the NAA LOLP from 6.6 percent to 5.0 percent. Similarly, Bonneville developed a zero-carbon resource portfolio to estimate the avoided cost of adding renewable resources.

The increase in hydropower generation from the NAA to MO2 resulted in the avoidance of adding 440 MW of gas CT capacity, which would have generated about 244 aMW annually, using the conventional least-cost portfolio. In the zero-carbon portfolio, the hydropower increases would have avoided the need to acquire about 1,510 MW of renewable energy resources. MO2 avoided resource builds are also included in Table 4-8 and Table 4-9.

Table 4-9. NW-US System Zero-Carbon Portfolio and Associated Change in Carbon-based Generation for the Base Case without Additional Coal-Plant Closures

Alternative	LOLP (percent)	Low Carbon Capacity Added to Reach 6.6% LOLP (MW)	Change in Existing Carbon-producing Generation (aMW)
MO1	11.2	1,200 Solar/600 DR	-70
MO2	5.0	1,510 avoided build: 250 Solar 600 DR 660 Montana Wind	-428
MO3	13.9	1,960 Solar/980 Battery/600 DR	457 1/
MO4	29.6	5,000 Solar/600 DR	70
PA	6.4	N/A	171

Note: Green font used when reduction is beneficial.
1/ The increase in carbon-producing generation for MO3 when only zero-carbon resources are added stems from increased generation at existing carbon-producing power plants.

Bonneville used the GENESYS model to develop the conventional least cost and no carbon resource portfolios and estimated the amount of generation produced by those portfolios for each alternative. This information provided input to the air quality analysis in the CRSO EIS *Air Quality and Greenhouse Gas Appendix G.*

4.2.3.1 Power Rates Modeling

The capital and operating costs of the resource portfolios are important components for analyzing the power rate impacts of the alternatives. Bonneville used the AURORA model to estimate the operating costs of the resource portfolios for rate impacts. Details are provided in the CRSO EIS *Power and Transmission Appendix H.*

4.2.4 Summary of Potential Replacement Resource Portfolios and Results

Bonneville prepared two replacement resource portfolios: a conventional least cost portfolio and a least carbon portfolio to estimate what would be required to restore the LOLP of the alternatives to the LOLP of NAA. Both portfolios relied on information in the NWPPC Seventh Power Plan (NWPPC 2016).

The conventional least cost portfolio is composed of gas-fired combustion turbines that are currently identified as having the least construction and operating costs. The gas-fired turbines emit carbon to the atmosphere, but at a lesser rate than the existing regional coal-fired generation.

The zero carbon portfolio is also a conventional least-cost portfolio with respect to renewable resources. It is composed of load reduction, wind, and solar generation.

MO1, MO3, and MO4 result in increased generation from carbon-fueled resources in the least-cost and zero-carbon scenarios. The increased generation in MO3 and MO4 is more than MO1 because of the need to add more resources for the reduced generation from breaching the Snake River dams (MO3) or additional fish passage spill and flow augmentation measures (MO4).

MO2 results in less carbon producing generation than the other MO alternatives and NAA; it also achieves the 5 percent LOLP industry target. MO2 improved the reliability of the NAA to the 5 percent LOLP target and increased hydropower availability and avoided the need to add 440 MW of gas-fired or 1,510 MW of renewable resources in the region.

4.2.5 Potential Replacement Resource Portfolios in the Context of Coal-Plant Retirements

Additional retirements of existing regional coal-fired generating plants used primarily by investor-owned utilities to serve their retail loads have been announced since the development of the CRSO EIS replacement portfolios. As mentioned in Section 4.1.4, more coal plants are slated to be retired and the LOLP of NAA and the MOs will go up significantly.

Updated reliability studies by Bonneville reveal that substantial generating resources will be needed to replace these plants to keep the region at the current LOLP of about 6.6 percent. If regional utilities choose to replace the coal generation with solar and wind, not gas-fired generation, then there will be fewer baseload resources in the region. As coal-fired generation is removed the amount of solar and wind that will need to be added to each MO to get to the NAA LOLP will increase more rapidly as there is a diminishing value for solar and wind when trying to meet power needs at all hours, not just during periods of ample wind and/or ample solar power. Because of the diminishing benefit of wind and solar as larger amounts are needed to replace baseload coal-fired generation, Bonneville estimated that storage (battery or pumped-storage hydropower) would become cost-effective.

Table 4-10 shows the amount of additional resources that would return each case to the current NAA LOLP of 6.6 percent. In this analysis, the amount of wind that can be imported from Montana is higher than that assumed in Section 4.2.3 because more transmission capacity from Montana will be freed up as more coal-plants are retired.

Table 4-10. Additional NW-US Resources Required to Meet 6.6% LOLP for Replacing Coal and Hydropower Generation

MW of:	DR/1	MT Wind/1	Solar/1	Storage/1
NAA (base case)	0 + 0	0 + 0	0 + 0	0 + 0
Preferred	Same Reliability as NAA			
MO1 (base case)	0 + 600	0 + 0	0 + 1,200	0 + 0
MO2 (base case)	More Reliable than NAA (base case)			
MO3 (base case)	0 + 600	0 + 0	0 + 1,960	0 + 980
MO4 (base case)	0 + 600	0 + 0	0 + 5,000	0 + 0
NAA (limited coal)	600 + 0	1696 + 0	4,000 + 0	2,500 + 0
Preferred	600 + 0	1696 + 0	4,000 - 200	2,500 + 0
MO1 (limited coal)	600 + 0	1696 + 0	4,000 + 500	2,500 + 0
MO2 (limited coal)	600 + 0	1696 + 0	4,000 - 2,900	2,500 + 0
MO3 (limited coal)	600 + 0	1696 + 0	4,000 + 3,200	2,500 + 1,000
MO4 (limited coal)	600 + 0	1696 + 0	4,000 + 3,200	2,500 + 0
NAA (no coal)	600 + 0	1696 + 0	22,000 + 0	4,000 + 0
Preferred	600 + 0	1696 + 0	22,000 - 1,000	4,000 + 0
MO1 (no coal)	600 + 0	1696 + 0	22,000 - 1,000	4,000 + 0
MO2 (no coal)	600 + 0	1696 + 0	22,000 - 6,100	4,000 + 0
MO3 (no coal)	600 + 0	1696 + 0	22,000 + 6,000	4,000 + 1,000
MO4 (no coal)	600 + 0	1696 + 0	22,000 + 1,400	4,000 + 0

1/ The two numbers in each entry represent the quantity of potential replacement resources identified for the region to replace (1) the additional coal retirements (0 MW in all cases for the base case) and (2) lost hydropower generation in the EIS alternatives.

The CRSO is concerned more with a decision on selection of the future preferred operation of the CRS and not directly with the retirement of coal-fired plants owned by investor-owned utilities in the region. However, regional reliability depends on all utilities, and the loss of baseload generation in the region affects the value of the hydropower produced by the CRS.

Figure 4-8 below shows the marginal resources needed for each MO to return its LOLP to the NAA LOLP for each coal-retirement scenario.

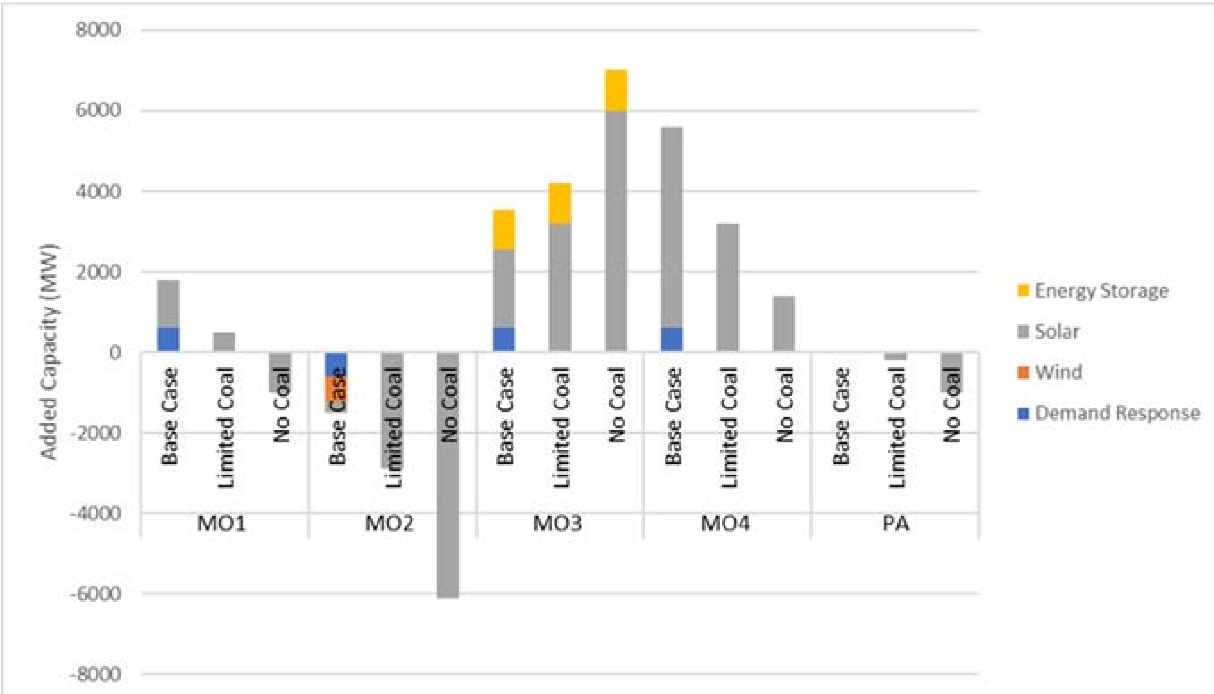


Figure 4-8. Marginal Resources to Build above the NAA for the Base Case, Limited Coal and No Coal Scenarios in MW

As more coal-plants are removed from the northwest system, the amount of additional resources needed for MO3 increases relative to NAA because fewer baseload resources are available, and solar and storage show diminishing returns. Similarly, the "avoided build" value of MO2 increases as the region retires coal plants. Less intuitively, as the region adds renewable resources to replace increasing amounts of retired coal, the additional resource needs for MO1 and MO4 compared to NAA decrease. This is likely to occur because NAA adds so much solar to meet demand year-round that there would more energy produced by solar available in the summer, the period when MO1 and MO4 have more LOLP events than NAA. For MO1 and MO4, if resources are added to replace the lost hydropower from changes in CRS operations, then there is the potential that these resources could reduce the amount of resources needed by the region to replace coal-based generation as plants are retired in coming years. Conversely, for MO3, as more coal plants retire, the amount of resources needed to maintain reliability attributable to changes in CRS operations increases.

4.3 INTEGRATION OF OTHER RENEWABLE RESOURCES AND HYDROSYSTEM FLEXIBILITY ANALYSIS

BPA maintains operating reserves on the hydropower system for responding to load fluctuations and for integrating the existing fleet of wind and solar. Operating reserves are provided by generating units that are connected to the transmission system and can rapidly increase or decrease to respond to changing demands. The current operating reserves are included in NAA and the MOs.

Flexibility in hourly and sub-hourly operations is critical to the reliability of the power supply. Power generation must equal load (demand) at all times. But load fluctuates as people operate appliances or businesses and industries operate their facilities. On the generation side, wind and solar generation changes throughout the day. Occasionally and often unexpectedly, traditional power plants experience a sudden outage or a transmission interruption changes the import or export of power. The hydropower system and natural gas plants in the region increase or decrease generation moment-to-moment to balance the changes in load and other generation.

Some of the measures in the multi-objective alternatives would increase the flexibility of the hydrosystem to respond to these changes; some measures would decrease the flexibility. As the amount of solar and wind generation output in the region increases, there will be more need for flexible generation to follow such increases. However, because there are no new gas plants being constructed in the region, it may be that the hydrosystem is called upon to supply the flexible generation to support increasing wind and solar output.

When there is no fish passage spill requirement on the four lower Columbia River and four lower Snake River projects, these projects, plus Grand Coulee and Chief Joseph, all can adjust generation as needed to balance loads and resources. During the fish passage spill season and when lower Snake River and John Day operating ranges are restricted to MOP and MIP operations, the operational flexibility for the lower Columbia River and lower Snake River projects to supply this generation response is diminished.

The following is a qualitative assessment of how the MO alternatives change the flexibility of the hydrosystem.

4.3.1 MO1 Compared to NAA

Overall some increase, some decrease in flexibility:

- Slightly larger forebay ranges for MOP and MIP will double the usable forebay range and increase the flexibility to store or release water and increase or decrease hourly generation at the lower Snake River projects and John Day from April through July.
- Counting contingency reserves within fish passage spill increases allows the hydrosystem to increase generation and increases the system’s flexibility.
- Averaging spill over 24-hour blocks would enable brief periods of slightly lower spill and higher generation to be balanced with other periods of the reverse conditions.
- Increased spring spill, increased water supply withdrawals, and reduced flows in August on the lower Snake River decrease flexibility slightly.

4.3.2 MO2 Compared to NAA

Overall, significant increase in flexibility:

- Less spill plus moving some water from the spring into winter increase generation considerably and increases flexibility particularly during low-flow periods.
- Having the full forebay range (no MOP or MIP restriction during the fish passage season) on the lower Snake projects and John Day permits use of the full 3- to 5-foot forebay operating ranges year-round, which greatly enhance the ability to store/release water in the run-of-river projects over the course of a day to decrease/increase generation on an hourly basis. With this increase in operating range, the projects will be able to adjust generation much more to changing load and to help integrate other renewable resources like wind and solar.
- Under high flow conditions in April and May, less spill will mean turbines are fully loaded more often, reducing flexibility slightly in April and May. This is a trade-off between more generation in MO2 versus flexibility under these conditions.
- Counting contingency reserves within fish passage spill allows the hydrosystem to increase generation and increases the system’s flexibility.
- The ability to reduce to zero generation more often would increase the ability for the regional grid to use wind and solar when they are generating. It also increases the ability of the projects to reduce generation during periods of low demand, perhaps reducing spill for lack-of-market or sales of power at a time of low economic value.

4.3.3 MO3 Compared to NAA

Overall, significant decrease in flexibility:

- Breaching the lower Snake River dams will reduce hydrosystem flexibility compared to NAA, except in the lowest-flow conditions when the dams would also not have had much flexibility in NAA.
- Because spring fish passage spill is higher in MO3 than in NAA on the lower Columbia River projects, these projects will also lose flexibility. Generation at McNary, in particular, will be at minimum generation more often than in NAA and have less flexibility to respond to changes in load or changes in wind and solar generation.
- Conversely, allowing turbines to operate within and also above the 1 percent efficiency range during the fish passage season will increase the flexibility at the lower Columbia River projects except during very high flows when the project is operating continuously at maximum available turbine generation.
- Having the full forebay range (no MIP restriction during the fish passage season) at John Day gives the project a 4.5 foot forebay operating range, which enhances the ability to store/release water over the course of a day to decrease/increase generation on an hourly basis. With this increase in operating range, the project will be able to adjust generation more to changing load and obligations and to help integrate other renewable resources like wind and solar.
- Counting contingency reserves within fish passage spill increases allows the hydrosystem to increase generation and increases the system’s flexibility.

- Averaging spill over 12- or 24-hour periods would enable brief periods of slightly lower spill and higher generation to be balanced with other periods of the reverse conditions. Such an operational decision would be made during the course of the operating day.
- Stopping fish passage spill in August will also give the lower Columbia River projects more flexibility.

4.3.4 MO4 Compared to NAA

Overall, significant decrease in flexibility:

- Spilling to 125 percent TDG diverts most of the water from the turbines to the spillways. March-July, the lower Columbia and lower Snake River projects are generating only at minimum generation levels in most water years. Thus, they only rarely have any flexibility for load following and integrating other renewable sources. In all water years, all eight projects are on minimum generation in August and cannot provide any load shaping, renewables integration, or operating reserves.
- Having all of the lower Columbia and Snake River projects operate at or near MOP with a restricted forebay operating range during the fish passage season further removes flexibility at McNary, The Dalles, and Bonneville dams in those rare periods when there might be enough water available for power generation above the minimum. While the increased forebay operating ranges on the Lower Snake River projects might provide some offset, these projects are largely at minimum generation levels continuously in MO4 while fish passage spill is up to 125% TDG spill and do not have any flexibility despite the larger operating range.

4.3.5 PA Compared to NAA

Overall some increase with spring months showing a decrease in flexibility:

- Slightly larger forebay ranges for MOP and MIP will double the usable forebay range and increase the flexibility to store or release water and increase or decrease hourly generation at the lower Snake River projects and John Day from April through July.
- Counting contingency reserves within fish passage spill increases allows the hydrosystem to increase generation and increases the system's flexibility.
- Increased spring spill and increased water supply withdrawals decrease flexibility. Flexible spill hours and decreased spill in August increase flexibility.
- The ability to reduce to zero generation more often would increase the ability for the regional grid to use wind and solar when they are generating. It also increases the ability of the projects to reduce generation during periods of low demand, perhaps reducing spill for lack-of-market or sales of power at a time of low economic value.

4.3.6 Flexibility Summary for the CRS

Because the emphasis on system flexibility is relatively new due to the recent increased penetration of wind and solar resources, Bonneville does not have modeling tools to assess hour-to-hour and within-hour flexibility quantitatively which made it difficult to quantify the range of flexibility.[22] The results show a similarity in flexibility and the ability to meet changing loads and obligations and to integrate renewable resources in the NAA, MO1, and MO2, with MO2 having slightly more flexibility. There are definite reductions in flexibility in MO3 and MO4.

The qualitative discussion from Bonneville points to key measures that increase flexibility based on their experience with the existing system and renewable resources already in place. Those measures include:

- Increases in the forebay operating ranges beyond MIP and MOP at run-of-river projects.
- Inclusion of system operating reserves in fish passage spills.
- Increases in turbine efficiency operating ranges beyond ±1 percent of best efficiency.
- The ability to operate at zero generation more often, outside the fish passage season, at the lower Snake River Projects

Operations that decrease flexibility include:

- Decreases in the forebay operating ranges to MOP at all run-of-river projects.
- Increases in fish passage spill that reduce the amount of water available for generation.

[22] Assuming flexibility is implemented, Bonneville would do so in accordance with the statutory preference and priority given to public bodies and cooperatives prior to offering such power as a flexible integration product.

CHAPTER 5 - OTHER BONNEVILLE POWER OBLIGATIONS

5.1 COLVILLE PAYMENTS

Since Fiscal Year 1995, Bonneville has been making annual payments to the Confederated Tribes of the Colville Reservation as compensation for tribal lands inundated by Lake Roosevelt, which is formed by Grand Coulee Dam. The Spokane Tribe will likely also be receiving payments in the future. The annual payment is based on actual generation at Grand Coulee. The effects of the alternatives are being estimated by the use of average annual generation as modeled with 80 water years. Table 5-1 provides a summary of the annual values for Grand Coulee generation for each of the CRSO EIS alternatives.

The monetary value of the payment considers several terms in addition to Grand Coulee generation including Bonneville's power sales revenues and sales price escalators. Details of the monetary value are provided in the *Power and Transmission Appendix H*. Table 5-1 summarizes the generation amounts used in the socioeconomic analysis.

Table 5-1. Average Grand Coulee Generation for Colville Payment Determination

Alternative	aMW	Difference from NAA aMW (% change)
NAA	2,434	-
MO1	2,399	-35 (-1.4)
MO2	2,419	-15 (-0.6)
MO3	2,388	-46 (-1.9)
MO4	2,381	-52 (-2.2)
PA	2,405	-29 (-1.2)

All MO alternatives produced less generation at Grand Coulee than the NAA, but they were relatively minor changes from the NAA averages. Analyses of the payment revenue for the CRSO DEIS alternatives are provided in the *Power and Transmission Appendix H.*

5.2 4(H)(10)(C) CREDITS FOR REPLACEMENT POWER

The Northwest Power Act requires Bonneville to make expenditures to mitigate fish and wildlife and their habitats in the Columbia River Basin affected by the development and operation of the Columbia River System.[23] Bonneville fulfills this mandate by making expenditures for: (1) direct fish and wildlife program operations and maintenance; (2) direct fish and wildlife program capital; and (3) power purchases made to replace the federal dam system's firm generating capability lost due to fish mitigation measures. While Bonneville incurs these costs as part of its section 4(h)(10)(A) mitigation duty, the actions funded also offset the impacts of the Columbia River System's non-power purposes such as navigation, irrigation, or flood risk

[23] Section 4(h)(10)(A), 16 U.S.C. § 839b(h)(10)(A).

management. Bonneville, however, is responsible for the power share of mitigation costs only, so it must therefore recover the non-power share of its fish and wildlife mitigation expenditures in some other way. Section 4(h)(10)(C) provides that vehicle. It requires the Administrator to allocate the expenditures incurred mitigating fish and wildlife and to recoup the non-power share of those expenditures from the U.S. Treasury. The system-wide weighted average of the non-power cost allocation is 22.3%. Bonneville thus takes a 22.3% credit annually against its obligations to the U.S. Treasury for the non-power share of mitigation it funds.

The annual amount of section 4(h)(10)(C) credit is expected to vary across CRSO EIS alternatives because the hydropower operations undertaken and mitigation expenditures that Bonneville would make to protect fish and wildlife under these alternatives would vary, and, in turn, affect the amount of credit received. The methodology for determining the amount of fish and wildlife costs for these categories consists of three distinct steps: (i) obtaining Direct Fish and Wildlife Program expenditures from accounting records; (ii) estimating fish and wildlife related power purchase costs using HYDSIM, Bonneville's hydrosimulation model, and (iii) allocating these expenditures between power and non-power purposes to ascertain the credit value.

This appendix addresses only the power purchase or replacement power costs element of the methodology. The direct fish and wildlife program expenditures allocable under section 4(h)(10)(C) are described in Appendix H, Power and Transmission Section 4.1.4.

5.2.1 Methodology

Each year, the 4(h)(10)(C) credit results in part from the operations to protect and mitigate fish and wildlife by providing spill to aid fish passage at the lower Snake River and lower Columbia River dams and reservoir storage operations to improve flows and reservoir elevations for fish migration, spawning, incubation, and rearing throughout the Columbia River Basin. The cost of power purchased to replace the firm hydroelectric system capability lost due to these fish mitigation measures is eligible for credit under 4(h)(10)(C). There is no simple way to account for the energy differences due to operations for fish and wildlife based solely on actual operation data. Instead, hydroregulation modeling is used to estimate how much energy could have been produced without fish and wildlife operations.

Bonneville purchases power for a number of reasons, including purchases to replace generation lost due to fish mitigation measures. The 4(h)(10)(C) methodology was developed in 1995 (using models that historically have been used in Bonneville's rate cases) to conservatively capture the replacement power purchases required as a result of changes in hydro system operations to benefit fish and wildlife. The 4(h)(10)(C) credit calculation includes the effect of replacement power purchases attributable to fish measures. The methodology Bonneville uses identifies purchase amounts (relative to the same presumed load) for operations both with fish measures and without them in order to estimate the difference. This method avoids including the impacts of Bonneville's marketing decisions in the amount of fish credits Bonneville earns.

First, it is necessary to determine the total costs associated with operating the Federal Columbia River Power System in a manner that mitigates the impacts on fish and wildlife, and then to assign a portion of those costs to non-power purposes. This involves comparing how the hydro system actually operated while providing mitigating operations for fish against how the hydro system would have operated without any fish constraints or considerations.

More specifically, the need to purchase electricity to meet Bonneville load due to changes in river operations to benefit fish arises from: 1) operations that store water for later release to increase flow; 2) operations that spill water over a dam's spillway rather than use it to generate electricity; and 3) operations which maintain water at certain elevations in order to protect spawning habitat or aid juvenile emigration.

For each year, actual hydro conditions and market prices were used to develop the credits. To start, the quantity of replacement power necessitated by fish operations must be identified. To do this, the actual/historical water available this year is used to assess power production with a computer model, the hydroregulation model, using the current hydro system configuration. Two hydroregulation studies are necessary. The first study, with fish, models the river operation for fish mitigation. The second study, without fish, models what river operations would be like without any consideration or water constraints for the benefit of fish.

Following this, Bonneville's surplus/deficit situation under each of these studies is assessed. In order that Bonneville's surplus/deficit situation not be a function of Bonneville marketing decisions, the calculation uses the Bonneville load that could have been served with certainty under conditions in the worst water year, without fish mitigation requirements. This is known as the Firm Energy Load Carrying Capability (FELCC) of the hydro system – a concept developed for use in the Pacific Northwest Coordination Agreement planning process in the 1960s and in continuous use under those agreements from 1964 to the current year. FELCC is an estimate of the generation guaranteed to be available from the federal hydro system under the worst water conditions and therefore is the amount of firm power that Bonneville would have been entitled to sell. The use of the FELCC, as an estimate of Bonneville's firm load, results in a fair and replicable calculation.

Bonneville's surplus/deficit situation using FELCC as load and the actual/historical water conditions given the without fish hydro study was compared to the surplus/deficit situation using FELCC as load and the actual/historical water conditions given the with fish hydro study. Situations that led to an increase in purchases were netted with situations that led to a reduction in purchases and were summed across the monthly periods to provide the amount of incremental energy in megawatt hours (MWhs) purchased as a result of fish mitigation for the year. Using a published price index of actual month average historical market prices, the prices were multiplied by the estimate of the change in purchased MWhs to determine the replacement power cost for the year. The price index utilized aligns with Bonneville's trading floor practices. Figure 5-1 illustrates the process of determining the 4(h)10(C) power purchase amounts.

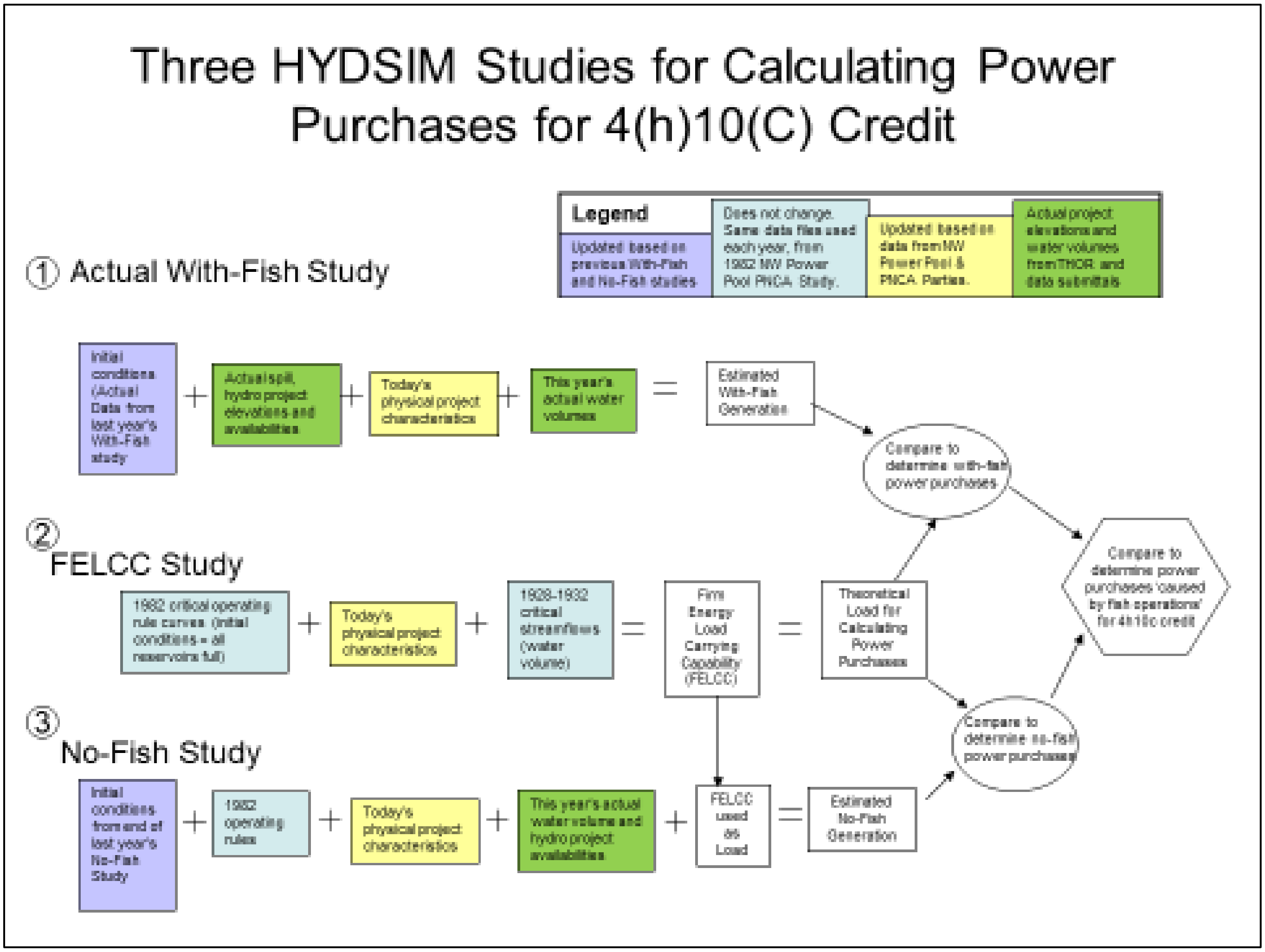


Figure 5-1. HYDSIM Studies for Calculating 4(h)(10)(C) Credit

5.2.2 Results

The estimated average annual replacement power purchases and associated 4(h)(10)(C) credits for each alternative with and without fish and wildlife measures are provided in Table 5-2.

Table 5-2. Annual Replacement Power Purchases (aMW)

Alternative	Eligible Purchase w/ F&W	Eligible Purchase w/o F&W	Additional Purchase	Change from NAA (%)
NAA	397	38	359	-
MO1	417	37	381	6.1
MO2	333	38	294	-18.1
MO3	814	37	777	116.4
MO4	846	37	809	125.3
PA	454	38	416	15.9

The average purchase results directly reflect the level of measures implemented for the benefit of Columbia and Snake River salmonids. The replacement power costs and associated credit tend to increase as those measures are added to the NAA.

5.2.2.1 MO and PA Comparisons to the NAA

- MO1 has a moderate increase in purchases from the NAA primarily due to increased fish passage spill.
- MO2 purchases are lower than the NAA as there are fewer spill measures that reduce hydropower production.
- MO3 purchases are higher than the NAA because of the generation loss from total loss of generation at the four lower Snake River dams.
- MO4 purchases are higher due to increased fish passage spill and additional flow augmentation.
- PA has higher purchases than the NAA primarily due to increased fish passage spill.

5.2.2.2 Summary of 4(h)(10)(C) Credits

The 4(h)(10)(C) credit will generally increase or decrease in kind as Bonneville's expenditures for fish and wildlife measures increase or decrease. The estimated expenditures and associated 4(h)(10)(C) credit are discussed Appendix H Power and Transmission Section 4.1.4.

CHAPTER 6 - POTENTIAL IMPACTS OF CLIMATE CHANGE ON HYDROPOWER

The methodology, analyses, and conclusions in this section do not comply with the policies or technical guidance of the Corps or Reclamation for evaluating the preparedness and resilience of water resource systems using climate change affected hydrology. Bonneville required a quantitative analysis of power generation and revenue to include in this appendix of the CRSO EIS. It was not possible for Bonneville to use an approach that would meet the policies or technical guidance of the Corps or Reclamation under the time frame of the EIS. The technical approach and findings contained in this section are those of the Bonneville and should not be construed as an official Department of the Army or Department of Interior position, policy, or decision.

6.1 OVERVIEW

The River Management Joint Operating Committee (RMJOC) of the co-lead agencies is continuously evaluating climate change to identify potential vulnerabilities, risk, and resiliency of the FCRPS. The co-lead agencies used the unregulated (naturalized) streamflow scenarios developed by the University of Washington for Part 1 of the RMJOC-II study[24] to assess potential climate-related impacts for the CRSO EIS. The 160 unregulated streamflow projections in this study provide a wide range of projected climate change impacts on CRS streamflows. The full range of 160 unregulated scenarios is considered in a qualitative sense for the other resources evaluated in the CRSO EIS, Chapter 4.

Additionally, Bonneville selected four 30-year scenarios from the RMJOC-II projections to substitute for the 80-year Modified Flows (1929–2008) that were used in HYDSIM modeling of the NAA and MO alternatives. Each climate scenario has a 30-year projection (2020–2049) of flows based on temperature and precipitation assumptions of the scenario.

The hydrologic changes from these projections resulted in changes to the CRS reservoir elevations, streamflows, and hydropower generation. The effects of these changes were assessed quantitatively for potential climate-related impacts on power generation in the CRS. Having a quantifiable understanding of how future climate may impact EIS alternatives was important to Bonneville's understanding of impacts to generation and revenue in the future. For the other multiple uses, climate change effects are being derived qualitatively from the RMJOC-II unregulated streamflow projections. These assessments are presented in Chapter 4 of the CRSO EIS.

Projected future changes in temperature, precipitation, snowpack, and streamflow will impact hydropower generation in the basin. While these changes may be significant, there is uncertainty about the magnitude of monthly and annual impacts to power generation given the uncertainties in the degree of warming and changes in precipitation trends. For this analysis,

[24] [https://www.bpa.gov/p/Generation/Hydro/hydro/cc/RMJOC-II-Report-Part-I.pdf]

Bonneville focused on understanding whether projected changes in climate would result in differences in the impacts of a given alternative on hydropower relative to the NAA.

6.2 GENERAL METHODOLOGY

Bonneville used HYDSIM to produce generation results to assess impacts to hydropower under four different RMJOC-II climate scenarios for the 2030s (2020-2049), substituting the four 30-year climate scenarios for the historic 80-year Modified Flows (1929-2008) for each of the EIS alternatives. For this analysis, Bonneville selected a set of climate change scenarios that roughly represented a range of annual streamflow volumes and resulting hydropower impacts for the United States system of the Northwest (NW-US). The scenarios Bonneville selected are all projections based on the RCP 8.5 emissions scenario. The four scenarios represent a reasonable range of potential climate change impacts and provide a quantifiable basis for understanding how future changes in climate may impact generation. These four scenarios do not represent all possible future climate outcomes, nor do they represent a statistical sampling of all of the scenarios studied for the RMJOC-II report.

As noted in the CRSO EIS *Hydroregulation Appendix I*, Bonneville selected the following climate scenarios for the hydropower analyses:

- CC1: CanESM2-MACA-PRMS-P1.

  CC1 is the warmest on all RMJOC-II scenarios, with a basin average temperature increase of 5.3°F between the historical period (1970-1999) and the 2030s (2020-2049). It was also one of the wetter scenarios on a basin-average perspective, with a precipitation increase between the historical period and the 2030s of about 7 percent (warmest/wettest scenario). Although other scenarios in the set of 160 showed even higher future precipitation and annual volume, this scenario was on the high end of projected annual runoff compared to the other 160 scenarios (around 161 million acre feet by the 2030s, compared to the historical annual runoff of around 132 million acre feet). It also projected highest annual average volume runoff into Grand Coulee in the 2030s. The PRMS hydrologic model results tended to project higher winter flows than the other hydrologic model iterations used for RMJOC-II, but also lower summer flows.

- CC2: MIROC5-BCSD-VIC-P3

  CC2 indicates little less warming (about 4.4°F) and a little less of a precipitation increase (about 5 percent) than CC1 between the historical period and the 2030s. This yielded an annual volume of about 155 Maf at The Dalles. One interesting characteristic of this scenario was that the MIROC5 tended to concentrate future precipitation increases above Grand Coulee, with some decrease in precipitation in the Snake River Basin. The VIC hydrologic model parameterization used for this scenario (P3) tended to show lower flows in the winter and spring periods, but higher and slightly later spring peak flows compared to the other hydrologic model iterations.

- CC3: HadGEM2-CC-MACA-VIC-P1

  CC3 is similar to CC2 in that it projects about 4.5°F of warming by the 2030s, on average, and about a 7 percent precipitation increase. The difference in this scenario, though, is that more of the precipitation and annual volume increases tended to be larger in the Snake Basin compared to the upper Columbia. This VIC hydrologic model parameterization (P1) was the most closely calibrated hydrologic model used in RMJOC-II, and thus tended to perform best in the historical period, but with a tendency for higher winter flows compared to the other VIC parameterizations.

- CC4: GFDL-ESM2M-BCSD-VIC-P2

  CC4 projects are still significant, but less warming across the Columbia Basin, with an average temperature increase around 2.5°F by the 2030s relative to the historical period. However, it is also the driest climate model projection used for RMJOC-II for the 2030s, with a slight decrease in annual precipitation (about 2 percent). As a result, it projects the lowest average annual volume for the Columbia Basin at around 138 Maf – similar to what is currently experienced in the Columbia Basin in the historical period. The VIC hydrologic model parameterization (P2) also tended to have lower winter and spring flows compared to the PRMS and VIC-P1 parameterizations, but higher and earlier spring runoffs, with lower summer flows.

Bonneville assessed the relative changes between the alternatives for each climate change scenario. The NAA average and P10 generation was estimated for the 80-year streamflow record and each of the four 30-year climate scenarios. The average and P10 generation was also estimated for each of the alternatives. Those results are provided in tables for each of the alternative discussions in Section 6.3. The alternative changes in generation were then compared to see how the changes under the climate change scenarios compared to the changes with the 80-year streamflows. These comparisons are provided for each alternative in Section 6.3.

Unlike the analysis performed with the 80-year streamflow records, these studies did not include lack-of-market spill because Aurora, the model that calculates the lack-of-market spill, models generation across the whole western interconnection but does not have information on other changes in the west that might occur with climate change. Consequently, the 80-year average and tenth percentile (P10) generation climate scenario amounts will not exactly match amounts in the CRSO EIS alternatives for the historic 80-year Modified Flows.

6.3 POWER IMPACT ASSESSMENT OF THE CLIMATE CHANGE SCENARIOS

These assessments compare the generation of each of the CRSO EIS alternatives for the historic 80-year Modified Flows with the four climate change scenarios. Monthly and annual generation production estimates were developed for average annual generation and the tenth percentile lowest generation in each set (P10) for the NW-US." This section describes the impacts in generation for each MO as compared to the NAA changes for each of the four climate scenarios. The purpose is to understand whether, under a reasonable sampling of projected changes in climate, there is a difference in the impacts of a given alternative on hydropower relative to the NAA.

This section describes how the change in generation for each alternative compared to NAA changes with the different streamflow scenarios evaluated for climate change. Thus, this is a comparison of the deltas for the purpose of observing whether the climate assumptions affect the relative differences between the NAA and the alternatives.

Figure 6-1, Figure 6-2, Table 6-1 and Table 6-2 show the differences between the NAA generation for the historical streamflow modeling and the four climate change scenarios. Figure 6-1 and Table 6-1 show the NW-US system average monthly generation for the 80 water years for the historical streamflows and the 30 water years for the climate change scenarios. Table 6-2 shows the generation for the 10th percentile lowest generation conditions within each of the respective streamflow sets.

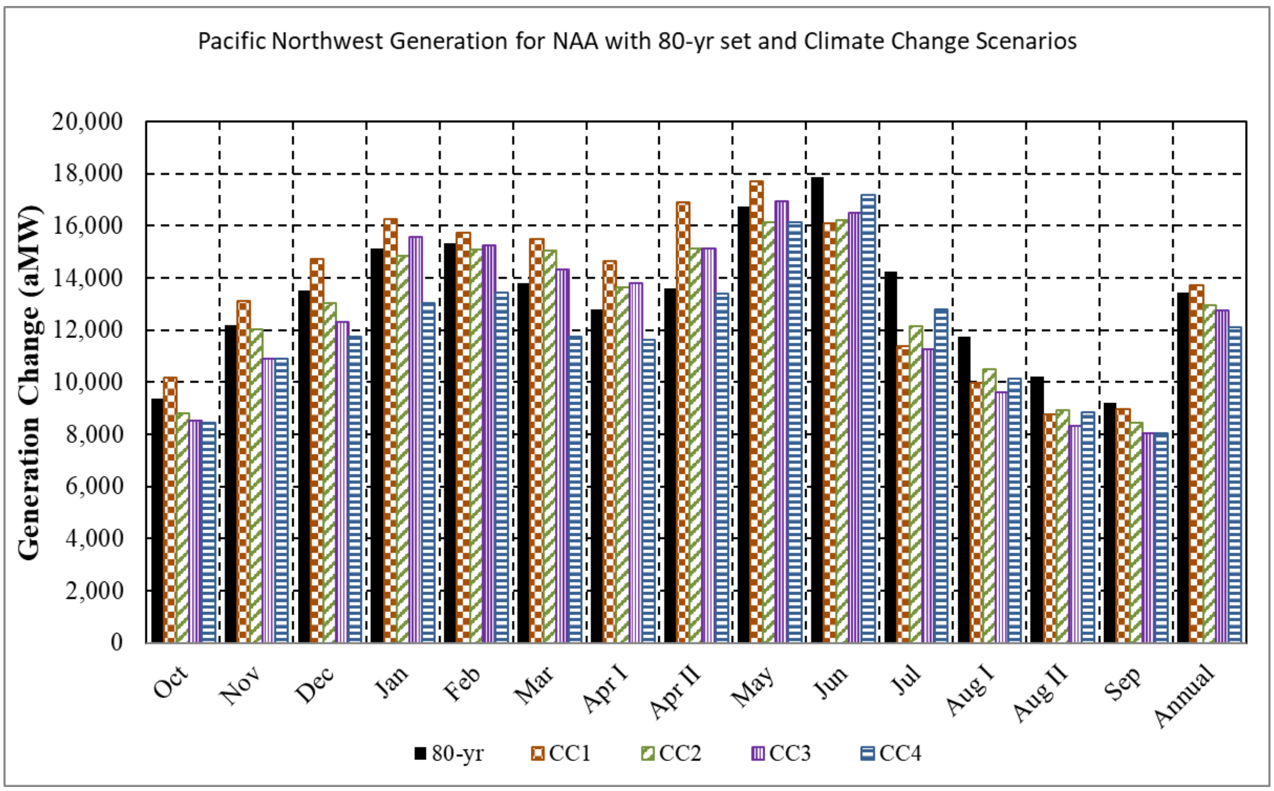


Figure 6-1. Pacific Northwest United States Average Generation Changes for Historic and Climate Change Scenarios for the NAA

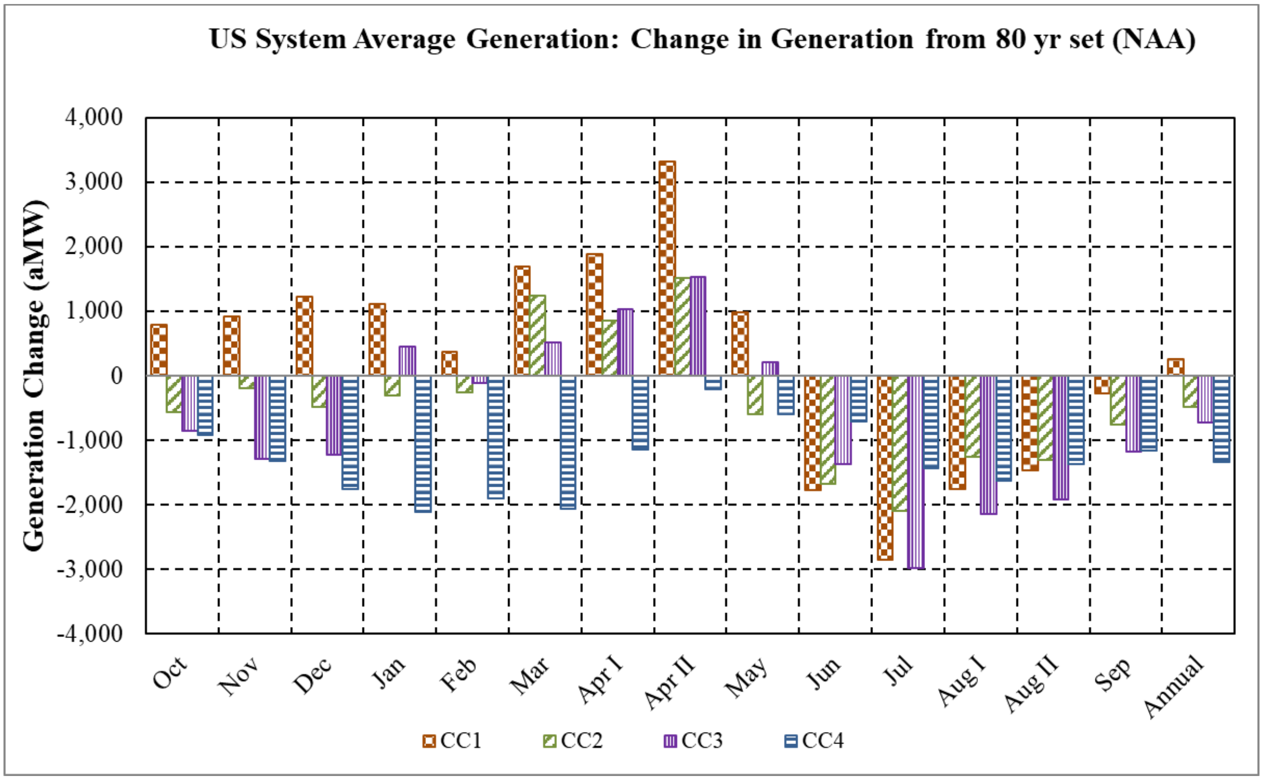


Figure 6-2. Difference in Generation for the NAA for four Climate Change Scenarios compared to the historical 80-yr historical for the NW-US system

Table 6-1. NAA Average Generation for Climate Change Scenarios

US System Average Generation: No Action Alternative Generation Results														
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
Historical 80 Yr	9,365	12,207	13,524	15,138	15,341	13,799	12,774	13,599	16,744	17,877	14,247	11,740	10,233	9,216	13,455
CC1	10,162	13,130	14,743	16,245	15,718	15,483	14,655	16,914	17,727	16,109	11,391	9,982	8,772	8,949	13,720
CC2	8,804	12,017	13,046	14,830	15,086	15,038	13,632	15,119	16,148	16,205	12,156	10,482	8,935	8,461	12,973
CC3	8,508	10,918	12,300	15,582	15,234	14,314	13,809	15,123	16,961	16,516	11,273	9,605	8,315	8,037	12,737
CC4	8,448	10,881	11,763	13,025	13,448	11,743	11,625	13,396	16,155	17,173	12,808	10,122	8,865	8,057	12,113

Table 6-2. NAA P10 Generation for Climate Change Scenarios

US System 10th Percentile Generation: No Action Alternative Generation Results															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
Historical 80 Yr	8,531	10,662	10,904	10,866	10,228	9,713	8,740	7,814	12,626	13,047	9,557	9,365	8,635	8,307	10,142
CC1	7,243	9,909	11,747	12,740	11,687	11,608	9,635	12,969	15,750	13,092	7,876	8,011	7,667	6,939	10,639
CC2	7,666	10,110	11,183	11,367	10,837	9,713	9,180	10,181	12,013	10,879	7,449	8,080	7,419	7,292	9,653
CC3	6,946	9,629	10,858	12,062	11,522	10,779	10,505	11,140	13,450	11,545	8,165	8,259	7,371	6,169	9,971
CC4	7,327	9,909	9,912	10,369	9,784	8,832	8,523	9,265	13,163	14,032	8,992	8,370	7,718	6,860	9,672

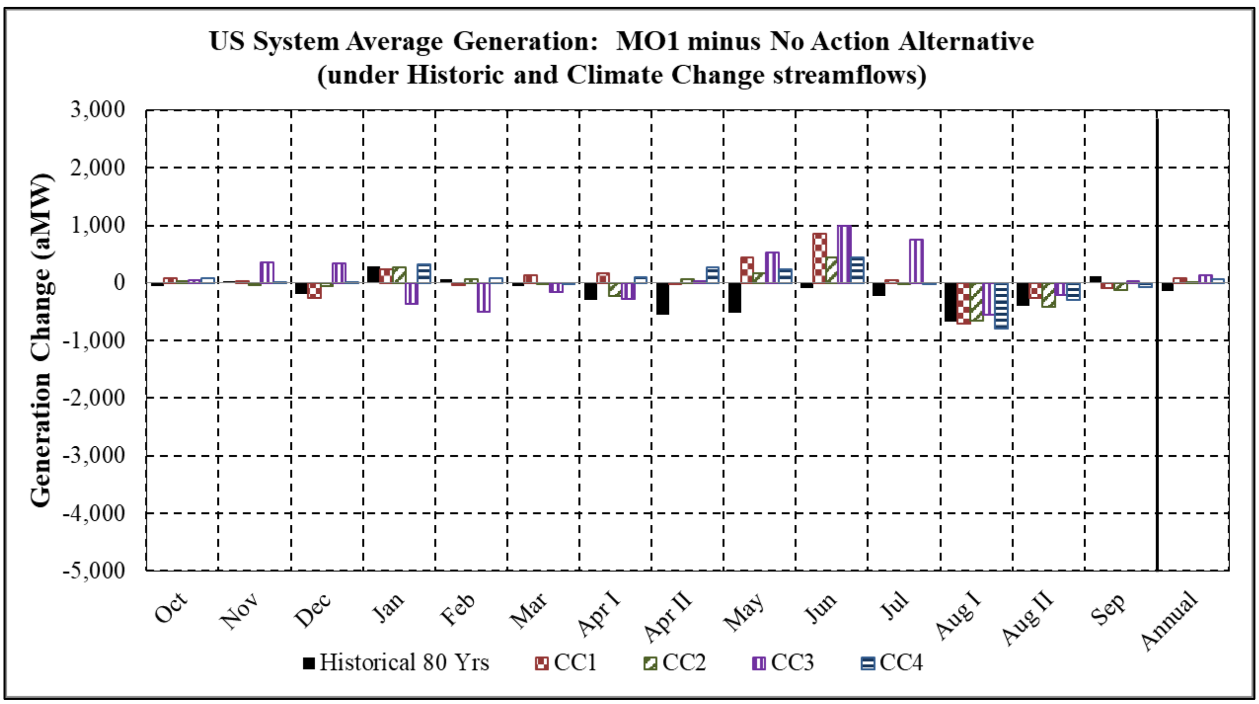
On an annual average basis, the climate change scenarios did not change the overall conclusions of how much each alternative differed from the NAA. The impacts to hydropower generation of an alternative compared to the NAA changed by 50 to 250 aMW under the four climate scenarios, which is generally smaller than the differences between each alternative and the NAA under the 80-year Modified Flows. Thus, while climate change impacts the overall generation of the system and adds additional uncertainty to the impact each alternative has on hydropower relative to the NAA, it does not change the power analysis conclusions of the relative impact of one alternative versus another. The results indicate that climate change is affecting generation in all alternatives roughly the same, especially on an annual average basis. While there are some notable differences described below, particularly on a monthly basis, the overall impacts of the alternatives are not changing relative to the NAA. The one exception is MO1 which differs from NAA modestly, with the climate change scenarios indicating MO1 may result in slightly (only about 130 aMW) more energy than the NAA.

These results do not measure the projected impact climate change will have on operations, which may be large overall. Bonneville, the Corps, and Reclamation are separately studying the projected magnitude of the impact climate change will have on the operation of the hydro-system through the RMJOC-II study.

6.3.1 Assessment of MO1 with Historic and Climate Change Scenarios

6.3.1.1 MO1 Average Generation

The changes in the NW-US system average generation between the NAA and MO1 are provided in Figure 6-3 and Table 6-3. The MO1 average generation differences in Table 6-3 are the differences between NAA average generation in Table 6-1 and the average MO1 generation.



Note: The scale on the y-axis is chosen so that the graphs for all four MOs have the same scale.

Figure 6-3. NW-US Average Generation Changes for Historic and Climate Change Scenarios for MO1 Relative to NAA

Table 6-3. NW-US Average Generation Changes for Historic and Climate Change Scenarios for MO1 and the Differences Relative to NAA

US System Average Generation: MO1 minus No Action Alternative					(under Historic and Climate Change streamflows)									
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
Historical 80 Yr:	-51	26	-195	283	67	-58	-298	-548	-514	-88	-223	-680	-390	124	-134
CC1	90	24	-262	238	-29	133	162	-6	444	855	41	-713	-259	-91	86
CC2	31	-34	-55	265	65	-24	-218	70	163	437	-15	-649	-413	-130	8
CC3	55	354	347	-369	-496	-160	-281	24	535	986	760	-560	-201	26	131
CC4	80	4	10	324	75	-16	93	274	239	451	-25	-792	-299	-69	59

MO1 produces less energy than the NAA in the average of the 80 water-years of the historical streamflows. In the four climate change scenarios, MO1 produces slightly more energy than the NAA on average. These results indicate that under climate change MO1 may produce more annual energy than the NAA. The largest increase in generation as compared to the NAA in these scenarios is in the spring (April II to June). August I (which was a large contributor to reliability concerns) remains significantly lower than the NAA even with climate change, indicating that there are still reliability concerns in this time period with climate change. Other months show minimal or mixed changes in generation for the different climate scenarios, underscoring that the additional uncertainty of climate change increases the uncertainty of future generation.

6.3.1.2 MO1 P10 Generation

The changes in NW-US P10 generation between the NAA and MO1 are provided in Figure 6-4 and Table 6-4. The MO1 P10 generation differences in Table 6-4 are the differences between NAA P10 generation in Table 6-2 and the MO1 P10 generation.

For P10 generation, MO1 produces less energy than the NAA in the average of 80 water-years of the historical streamflows. In three of the four climate change scenarios MO1 still produces less energy than the NAA, but the decrease is smaller than that in the average historical generation. In one climate change scenario, MO13 produces slightly more energy than the NAA. The variation in monthly impact from climate change on the difference between MO1 and the NAA is even larger for the P10 set than it is for the differences in average generation portrayed in Figure 6-3 and Table 6-3. This underscores that additional uncertainty is introduced by climate change, particularly in lower generation situations

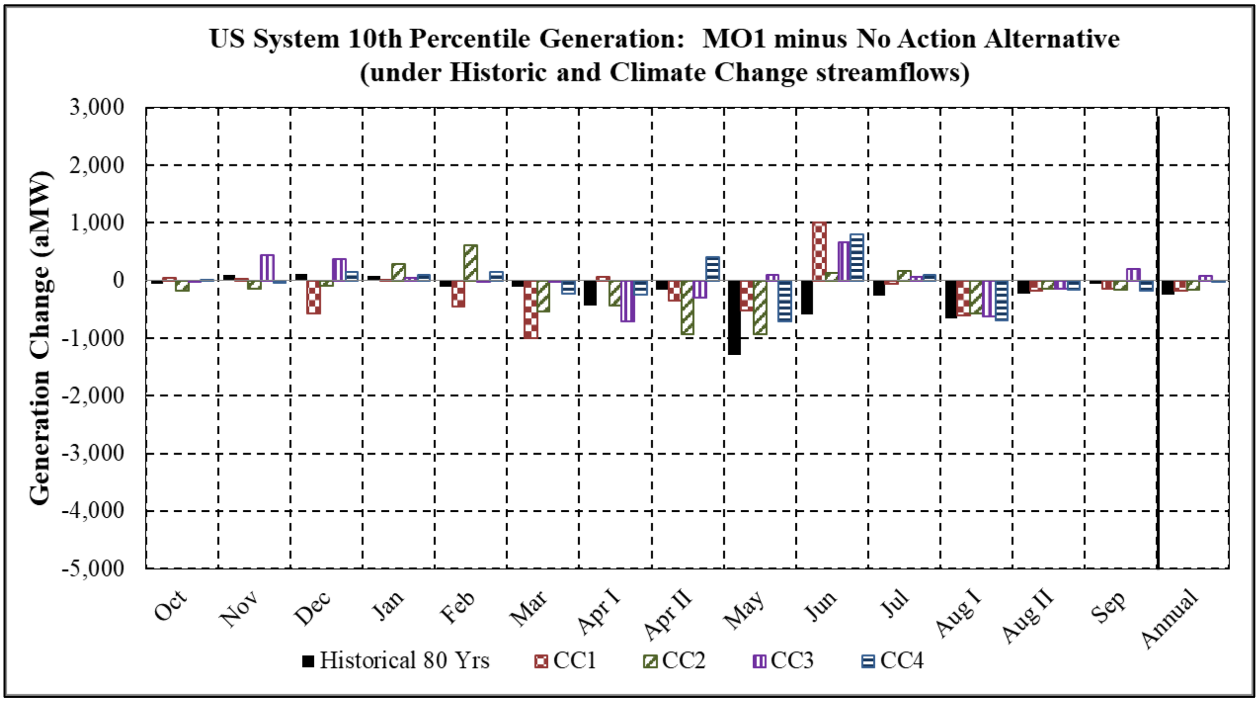


Figure 6-4. NW-US P10 Generation Changes for Historic and Climate Change for MO1 Relative to NAA

Table 6-4. NW-US P10 Generation Changes for Historic and Climate Change for MO1 and the Differences Relative to NAA

US System 10th Percentile Generation: MO1 minus No Action Alternative (under Historic and Climate Change streamflows)														
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
Historical 80 Yrs	-62	92	119	88	-107	-101	-440	-151	-1,291	-580	-256	-653	-225	-56	-242
CC1	48	30	-575	18	-448	-1,006	59	-349	-522	1,000	-64	-605	-184	-143	-185
CC2	-171	-137	-91	290	618	-544	-435	-927	-940	136	169	-563	-135	-160	-160
CC3	-1	444	373	40	-16	-12	-707	-291	101	659	69	-620	-144	198	81
CC4	10	-38	154	102	149	-224	-245	407	-704	797	96	-696	-156	-184	-18

6.3.2 Assessment of MO2 with Historic and Climate Change Scenarios

6.3.2.1 MO2 Average Generation

The changes in NW-US system average generation between the NAA and MO2 are provided in Figure 6-5 and Table 6-5. The MO2 average generation differences in Table 6-5 are the differences between NAA average generation in Table 6-1 and the average MO2 generation.

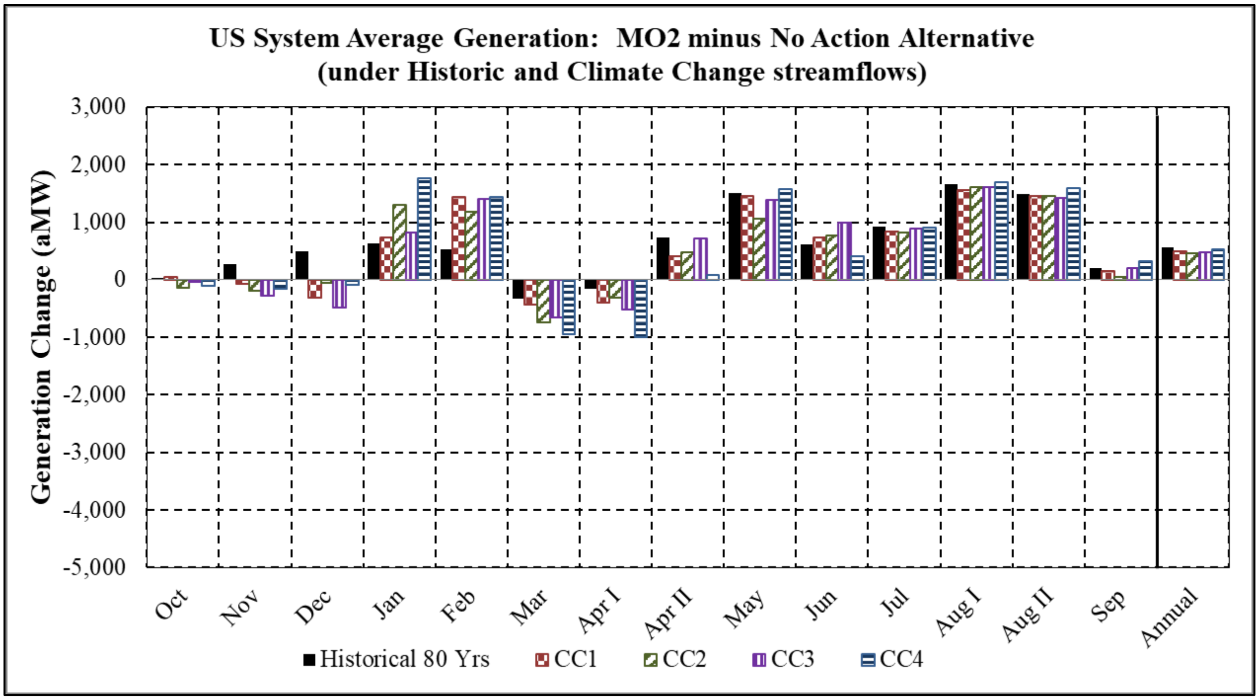


Figure 6-5. NW-US Average Generation Changes for Historic and Climate Change Scenarios for MO2 Relative to NAA

Table 6-5. NW-US Average Generation Changes for Historic and Climate Change Scenarios for MO2 and the Differences Relative to NAA

US System Average Generation: MO2 minus No Action Alternative						(under Historic and Climate Change streamflows)									
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
Historical 80 Yr	39	267	500	632	525	-333	-165	740	1,501	617	917	1,662	1,494	205	564
CC1	41	-74	-317	731	1,443	-432	-404	405	1,449	737	837	1,560	1,457	145	501
CC2	-137	-192	-60	1,293	1,182	-745	-316	477	1,057	768	817	1,609	1,450	53	468
CC3	-45	-273	-477	816	1,405	-648	-512	718	1,386	996	889	1,610	1,414	208	484
CC4	-100	-162	-88	1,766	1,439	-949	-1,003	91	1,569	415	901	1,695	1,584	323	523

MO2 produces more energy than the NAA over all 80 water years of the historical streamflows. In the four climate change scenarios, MO2 also produces more energy than the NAA, but the difference is slightly less than with the historical streamflows. These results indicate that under climate change, MO2 would also produce more annual energy than the NAA. Thus, the conclusion from the studies that MO2 is beneficial for power remains unchanged. On a monthly basis, the climate change scenarios indicate that January and February gain generation relative to the NAA while December, March and April may lose generation. The gains in hydropower in the winter months to serve peak loads are more valuable than changes in the spring months. Other months show minimal or mixed changes in generation for the different climate scenarios, underscoring the additional uncertainty about generation under future climate scenarios.

6.3.2.2 MO2 P10 Generation

The changes in NW-US P10 generation between the NAA and MO2 are provided in Figure 6-6 and Table 6-6. The MO2 P10 generation differences in Table 6-6 are the differences between NAA P10 generation in Table 6-2 and the MO2 P10 generation.

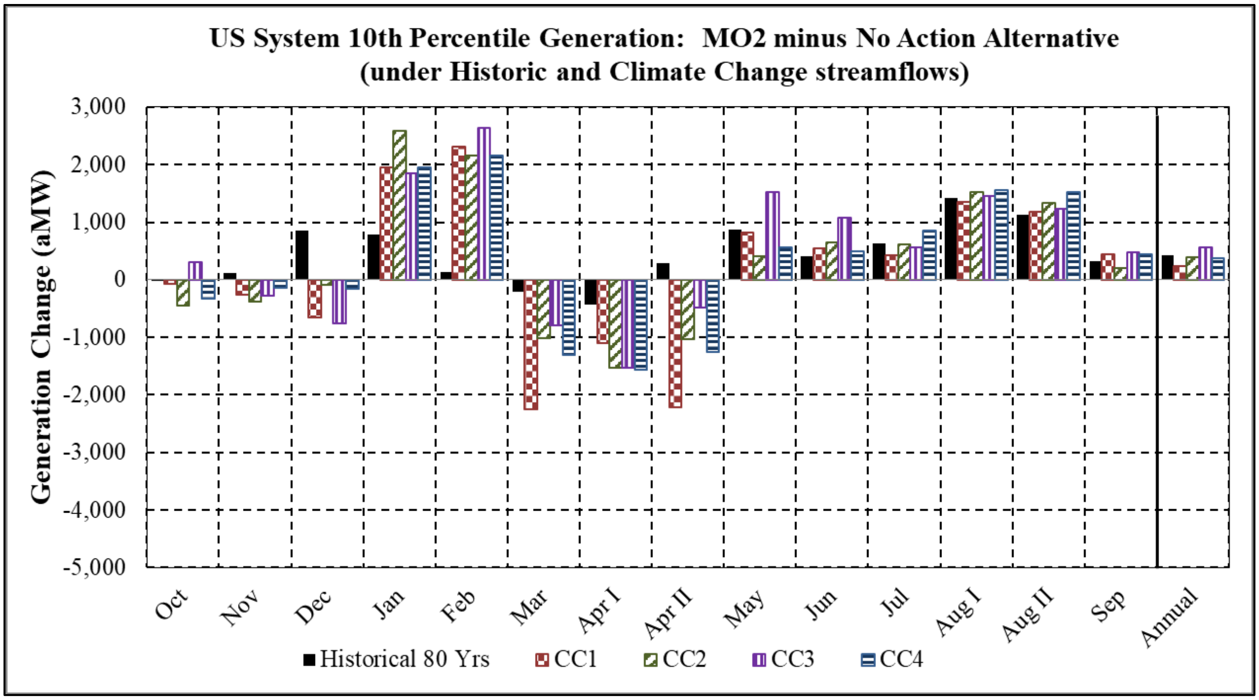


Figure 6-6. NW-US P10 Generation Changes for Historic and Climate Change Scenarios for MO2 Relative to NAA

Table 6-6. NW-US P10 Generation Changes for Historic and Climate Change Scenarios for MO2 and the Differences Relative to NAA

US System 10th Percentile Generation: MO2 minus No Action Alternative (under Historic and Climate Change streamflows)														
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
Historical 80 Yr	-21	111	861	790	130	-217	-431	287	876	409	637	1,429	1,127	315	429
CC1	-69	-257	-654	1,954	2,321	-2,247	-1,103	-2,219	819	554	431	1,349	1,178	441	229
CC2	-443	-387	-93	2,581	2,154	-1,014	-1,522	-1,041	414	648	615	1,515	1,337	198	394
CC3	300	-280	-754	1,856	2,645	-797	-1,527	-478	1,527	1,080	571	1,461	1,232	484	570
CC4	-322	-132	-155	1,952	2,165	-1,307	-1,562	-1,263	563	489	846	1,558	1,521	437	380

For P10 generation, MO2 produces more energy than the NAA in the average of 80 water years of the historical streamflows. In the climate change scenarios, MO2 still produces more P10 energy than the NAA. In three of the climate scenarios the increase is smaller than that in the average historical generation and in one climate change scenario MO2 produces even more energy relative to the NAA. The variation in monthly impact from climate change on the difference between MO2 and the NAA is even larger for the P10 set than it is for the differences in average generation portrayed in Figure 6-5 and Table 6-5.

6.3.3 Assessment of MO3 with Historic and Climate Change Scenarios

6.3.3.1 MO3 Average Generation

The changes in NW-US system average generation between the NAA and MO3 are provided in Figure 6-7 and Table 6-7. The MO3 average generation differences in Table 6-7 are the differences between NAA average generation in Table 6-1 and the average MO3 generation.

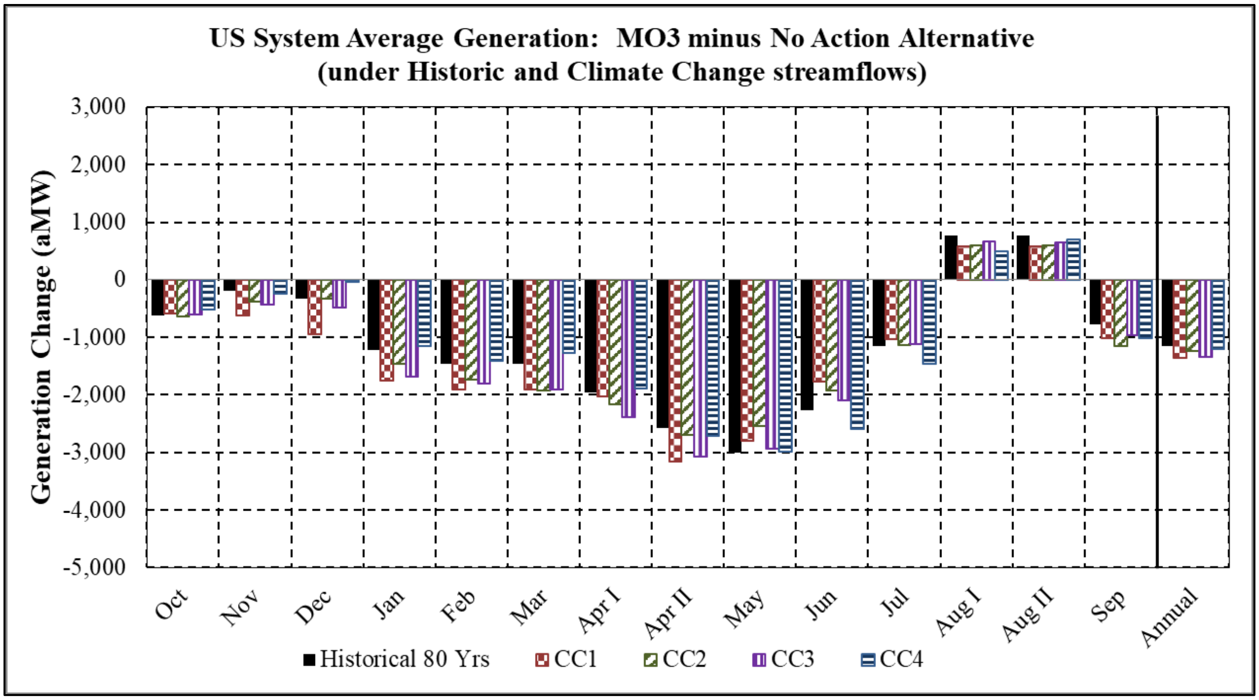


Figure 6-7. NW-US Average Generation Changes for Historic and Climate Change Scenarios for MO3 Relative to NAA

Table 6-7. NW-US Average Generation Changes for Historic and Climate Change Scenarios for MO3 and the Differences Relative to NAA

US System Average Generation: MO3 minus No Action Alternative						(under Historic and Climate Change streamflows)									
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
Historical 80 Yrs	-614	-191	-332	-1,214	-1,466	-1,458	-1,951	-2,570	-3,002	-2,263	-1,148	764	761	-772	-1,158
CC1	-591	-627	-955	-1,749	-1,907	-1,914	-2,032	-3,156	-2,791	-1,776	-1,024	575	576	-1,016	-1,358
CC2	-631	-389	-327	-1,456	-1,739	-1,920	-2,166	-2,688	-2,545	-1,919	-1,129	601	596	-1,153	-1,247
CC3	-595	-430	-491	-1,687	-1,800	-1,899	-2,386	-3,075	-2,943	-2,088	-1,112	674	654	-956	-1,333
CC4	-525	-242	-45	-1,153	-1,417	-1,270	-1,896	-2,708	-2,994	-2,597	-1,469	495	708	-1,008	-1,196

MO3 produces less average energy than NAA over all 80-water years of the historical streamflows. In the four climate change scenarios, MO3 produces even less energy than NAA. These results indicate that under climate change, MO3 would likely produce even less annual energy than the NAA compared to the analysis with the historical streamflows. Thus, the conclusion in the studies that MO3 has significant negative impacts to power remains unchanged. Many of the months show even larger trends in decreases in power generation with climate change. Other months show slight increases, or a mix of increases and decreases.

6.3.3.2 MO3 P10 Generation

The changes in NW-US P10 generation between the NAA and MO3 are provided in Figure 6-8 and Table 6-8. The MO3 P10 generation differences in Table 6-8 are the differences between NAA P10 generation in Table 6-2 and the MO3 P10 generation.

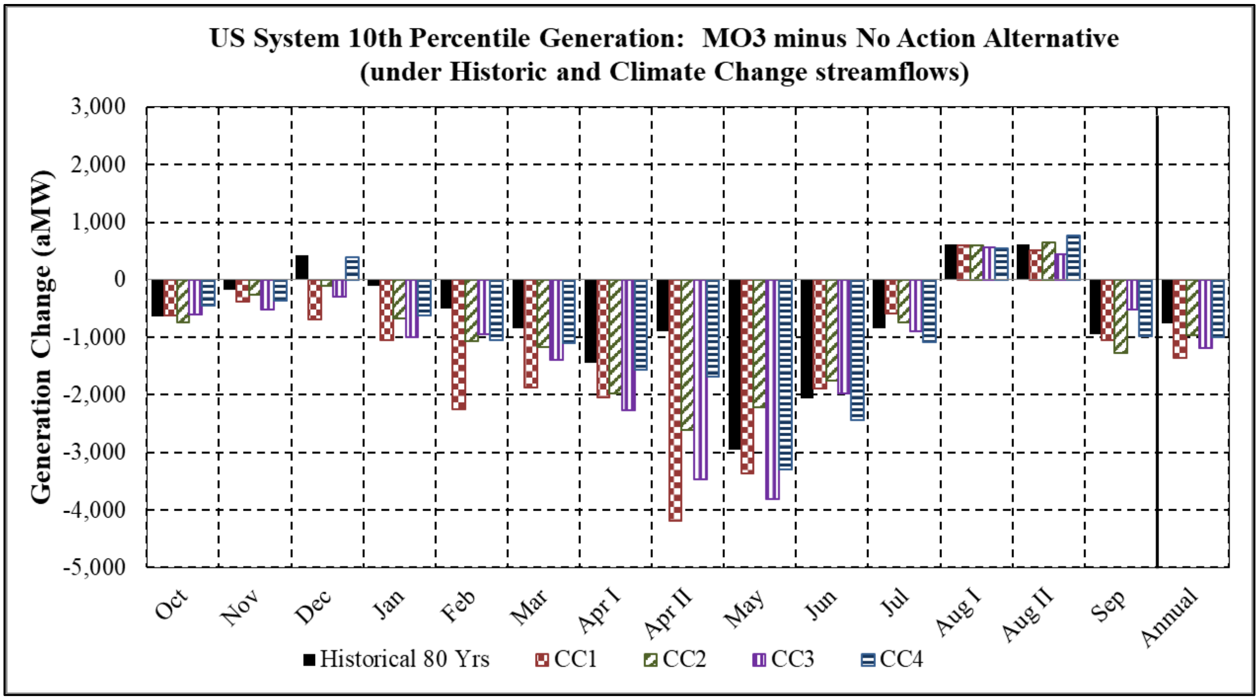


Figure 6-8. NW-US P10 Generation Changes for Historic and Climate Change Scenarios for MO3 Relative to NAA

Table 6-8. NW-US P10 Generation Changes for Historic and Climate Change Scenarios for MO3 and the Differences Relative to NAA

US System 10th Percentile Generation: MO3 minus No Action Alternative (under Historic and Climate Change streamflows)															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
Historical 80 Yrs	-635	-181	418	-100	-495	-838	-1,436	-889	-2,946	-2,060	-835	615	611	-951	-763
CC1	-624	-383	-695	-1,050	-2,251	-1,879	-2,051	-4,182	-3,358	-1,896	-579	593	509	-1,048	-1,351
CC2	-743	-262	-108	-670	-1,063	-1,178	-1,979	-2,609	-2,221	-1,760	-746	603	646	-1,279	-970
CC3	-606	-525	-289	-998	-955	-1,398	-2,266	-3,467	-3,815	-1,969	-901	571	440	-526	-1,194
CC4	-450	-361	398	-620	-1,049	-1,109	-1,572	-1,680	-3,295	-2,435	-1,090	552	771	-983	-992

For P10 generation, MO3 produces less energy than the NAA in the average of 80 water years of the historical streamflows. In all four climate change scenarios, MO3 produces even less energy compared to the NAA. This trend is especially evident from November through April, with some months and some climate change scenarios showing very large reductions in generation relative to the NAA. In one instance (April II) the variation between climate change scenarios is over 3,000 MW. Thus, MO3 could have a greater negative impact on power generation compared to the NAA in the future, but the magnitude of this effect is considerably uncertain.

6.3.4 Assessment of MO4 with Historic and Climate Change Scenarios

6.3.4.1 MO4 Average Generation

The difference in NW-US system average generation between the NAA (Table 6-1) and MO4 are provided in Figure 6-9 and Table 6-9.

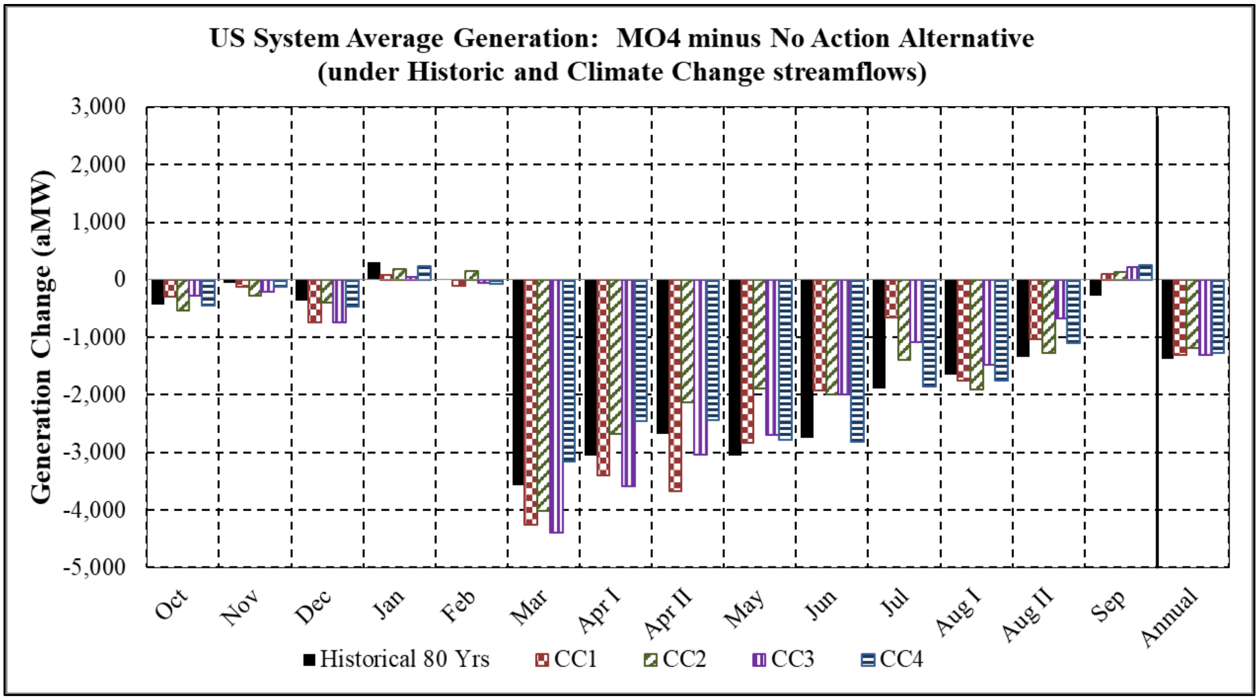


Figure 6-9. NW-US Average Generation Changes for Historic and Climate Change Scenarios for MO4 Relative to NAA

Table 6-9. NW-US Average Generation Changes for Historic and Climate Change Scenarios for MO4 and the Differences Relative to NAA

US System Average Generation: MO4 minus No Action Alternative (under Historic and Climate Change streamflows)															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
Historical 80 Yrs	-432	-49	-360	299	1	-3,575	-3,059	-2,673	-3,056	-2,741	-1,890	-1,646	-1,334	-284	-1,380
CC1	-303	-128	-737	76	-108	-4,249	-3,392	-3,667	-2,830	-1,916	-663	-1,759	-1,024	93	-1,315
CC2	-535	-279	-395	184	145	-4,019	-2,677	-2,122	-1,881	-1,992	-1,385	-1,910	-1,278	131	-1,179
CC3	-284	-212	-744	48	-62	-4,387	-3,590	-3,033	-2,694	-1,988	-1,090	-1,473	-677	214	-1,308
CC4	-457	-118	-460	244	-67	-3,159	-2,449	-2,438	-2,778	-2,820	-1,854	-1,756	-1,106	258	-1,266

MO4 produces significantly less energy than NAA over all 80 water years of the historical streamflows. In the four climate change scenarios, MO4 produces less energy than NAA, though the loss is slightly less. These results indicate that under climate change, MO4 would produce significantly less annual energy than the NAA. Thus, the conclusion from the studies that MO4 has significant negative impacts to power remains unchanged. On a monthly basis, November through January have slightly greater decreases in energy in MO4 compared with the NAA with climate change, and May, June, July, August II, and September generally have slightly smaller decreases in energy with the climate change streamflows. Other results are more uncertain. August I, the period with the most significant reliability concern (based on hydropower impact assessments with the historical streamflows (discussed in Section 3.2 of this document and in the CRSO EIS), shows the potential for either slightly smaller or slightly larger losses depending on the climate change scenario. March and April show large variation and mixed results between climate change scenarios.

6.3.4.2 MO4 P10 Generation

The difference in NW-US P10 generation between the NAA (Table 6-2) and MO4 are provided in Figure 6-10 and Table 6-10.

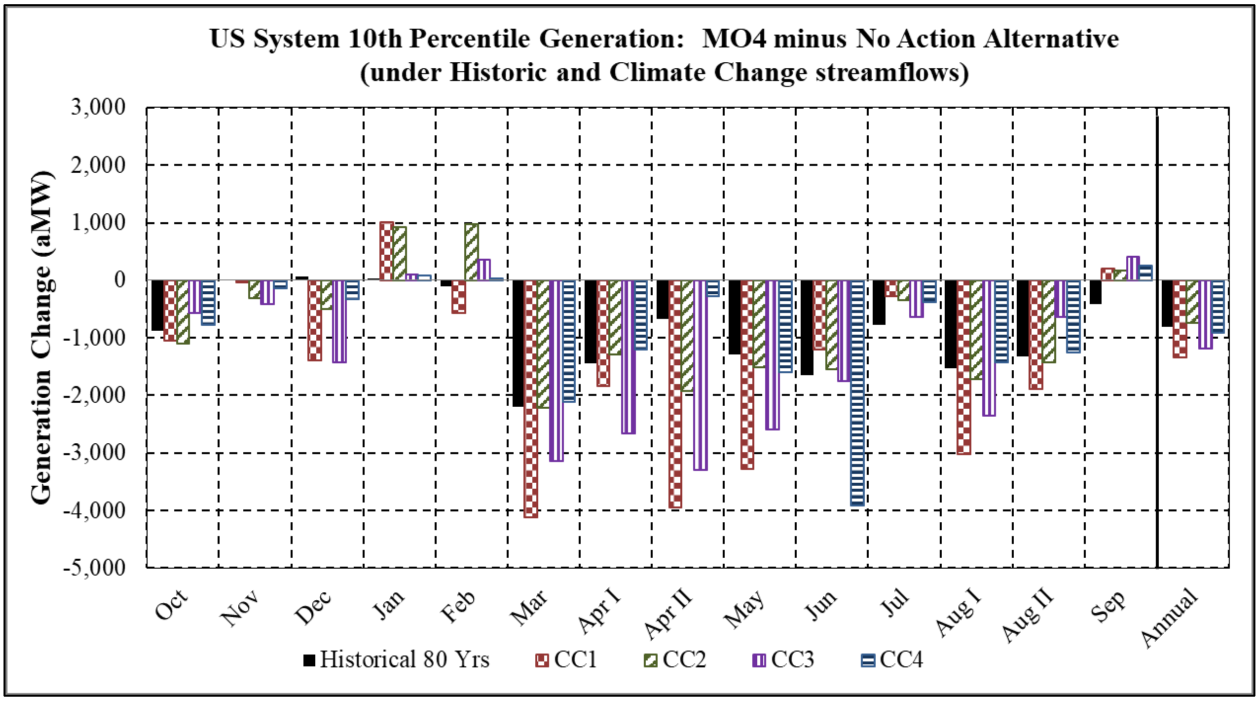


Figure 6-10. NW-US P10 Generation Changes for Historic and Climate Change Scenarios for MO4 Relative to NAA

Table 6-10. NW-US P10 Generation Changes for Historic and Climate Change Scenarios for MO4 and the Differences Relative to NAA

US System 10th Percentile Generation: MO4 minus No Action Alternative (under Historic and Climate Change streamflows)															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
Historical 80 Yrs	-871	19	63	37	-107	-2,204	-1,449	-676	-1,292	-1,648	-771	-1,525	-1,317	-410	-811
CC1	-1,048	-37	-1,397	1,005	-561	-4,127	-1,845	-3,955	-3,282	-1,201	-272	-3,021	-1,898	208	-1,348
CC2	-1,099	-310	-499	921	972	-2,224	-1,296	-1,927	-1,518	-1,550	-347	-1,723	-1,422	175	-734
CC3	-574	-410	-1,426	100	362	-3,145	-2,654	-3,302	-2,592	-1,751	-640	-2,346	-640	401	-1,189
CC4	-783	-139	-324	88	23	-2,120	-1,199	-285	-1,597	-3,908	-384	-1,428	-1,253	256	-919

For P10 generation, MO4 produces less energy than the NAA in the average of 80 water years of the historical streamflows. In three of the four climate change scenarios, MO4 produces even less energy compared to the NAA on an annual basis. The monthly differences between MO4 and the NAA are more pronounced than the annual average effect with significant variation between climate change scenarios. The scenarios show the potential of over 1,000 MW losses in December, 1,000 MW less loss in January and February, and possibly 1,000 to over 3,000 MW additional losses March to June and August. This again highlights the uncertainty of projected climate change impacts on generation. Regardless, these four climate scenarios do not change the conclusion that MO4 has a large negative impact on hydropower compared to the NAA, but climate change is another factor that makes the magnitude of this impact considerably uncertain.

6.3.5 Assessment of PA with Historic and Climate Change Scenarios

6.3.5.1 PA Average Generation

The changes in the NW-US system average generation between the NAA and the PA are provided in Figure 6-11 and Table 6-11. The PA average generation differences in Table 6-11 are the differences between NAA average generation in Table 6-1 and the average PA generation.

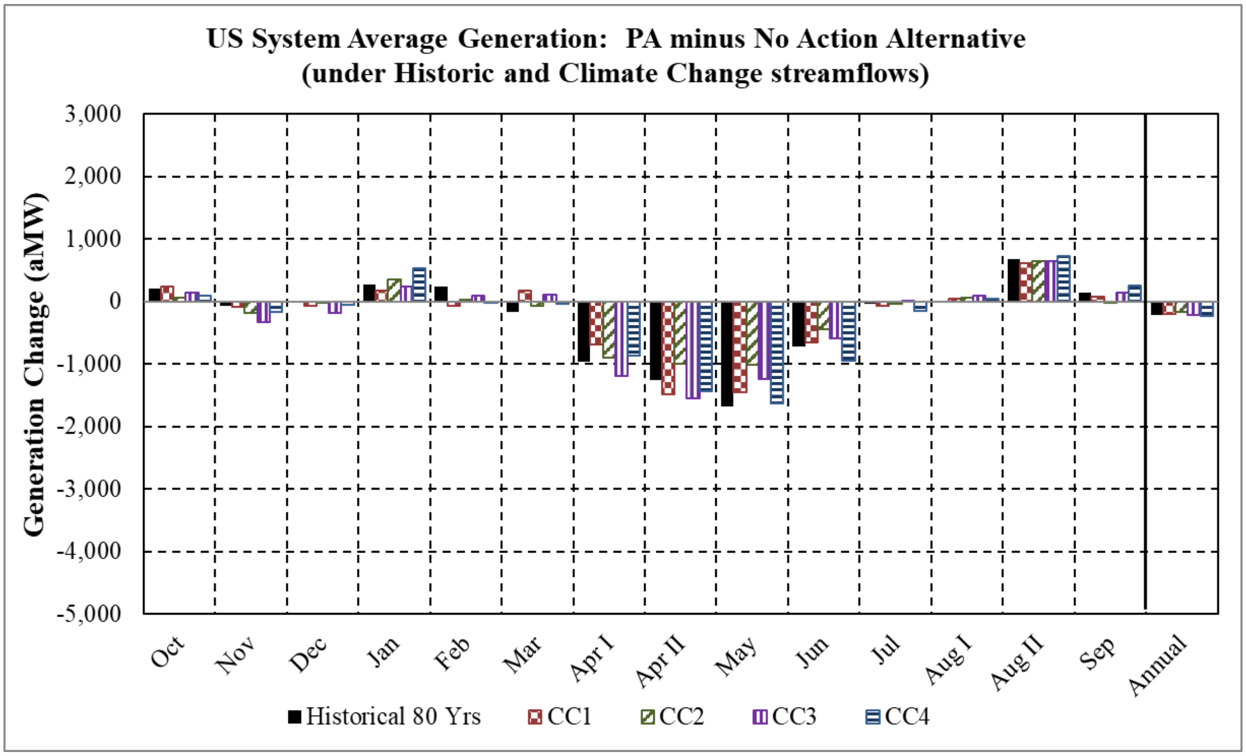


Figure 6-11. NW-US Average Generation Changes for Historic and Climate Change Scenarios for PA Relative to NAA

Table 6-11. NW-US Average Generation Changes for Historic and Climate Change Scenarios for PA and the Differences Relative to NAA

US System Average Generation: PA minus No Action Alternative						(under Historic and Climate Change streamflows)									
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
Historical 80 Yı	201	-65	7	277	231	-162	-964	-1,265	-1,684	-715	-44	18	675	146	-215
CC1	236	-93	-74	178	-72	167	-682	-1,484	-1,454	-649	-66	45	605	72	-207
CC2	62	-185	-23	345	28	-65	-905	-994	-1,019	-451	-37	60	645	-7	-160
CC3	136	-328	-190	245	90	112	-1,199	-1,555	-1,248	-599	2	90	645	148	-218
CC4	88	-170	-58	535	-9	-36	-872	-1,436	-1,630	-955	-146	40	726	249	-240

The PA produces less energy than the NAA in the average of the 80 water-years of the historical streamflows. In all four climate change scenarios, the PA also produces less energy than the NAA, with some uncertainty about whether climate change will result in slightly less or slightly more energy reduction than as compared to the difference between the NAA and PA for the 80 water-years of the historical streamflows. November, December, and February all result in even larger decreases in generation with climate change for the PA as compared to the NAA, indicating that there are still reliability concerns in this time period with climate change. March and the first half of August result in larger increases or smaller decreases in generation. Other months show minimal or mixed changes in generation for the different climate scenarios, underscoring that the additional uncertainty of climate change increases the uncertainty of future generation.

6.3.5.2 PA P10 Generation

The changes in NW-US P10 generation between the NAA and PA are provided in Figure 6-12and Table 6-12. The PA P10 generation differences in Table 6-12 are the differences between NAA P10 generation in Table 6-2 and the PA P10 generation.

For P10 generation, generally the drier years, the PA produces less energy than the NAA in the average of 80 water-years of the historical streamflows. In all climate change scenarios the PA produces even less energy than the NAA, with one scenario producing nearly three times less energy than the difference between the PA and NAA in the average historical water generation. There is large monthly variation in energy production between the historical water generation and four climate scenarios, underscoring that additional uncertainty is introduced by climate change. November and March through June almost all result in decreases in P10 generation with the climate change scenarios as compared to the 80-water years of historical streamflows for the PA. In August, most climate change scenarios result in increases in P10 generation.

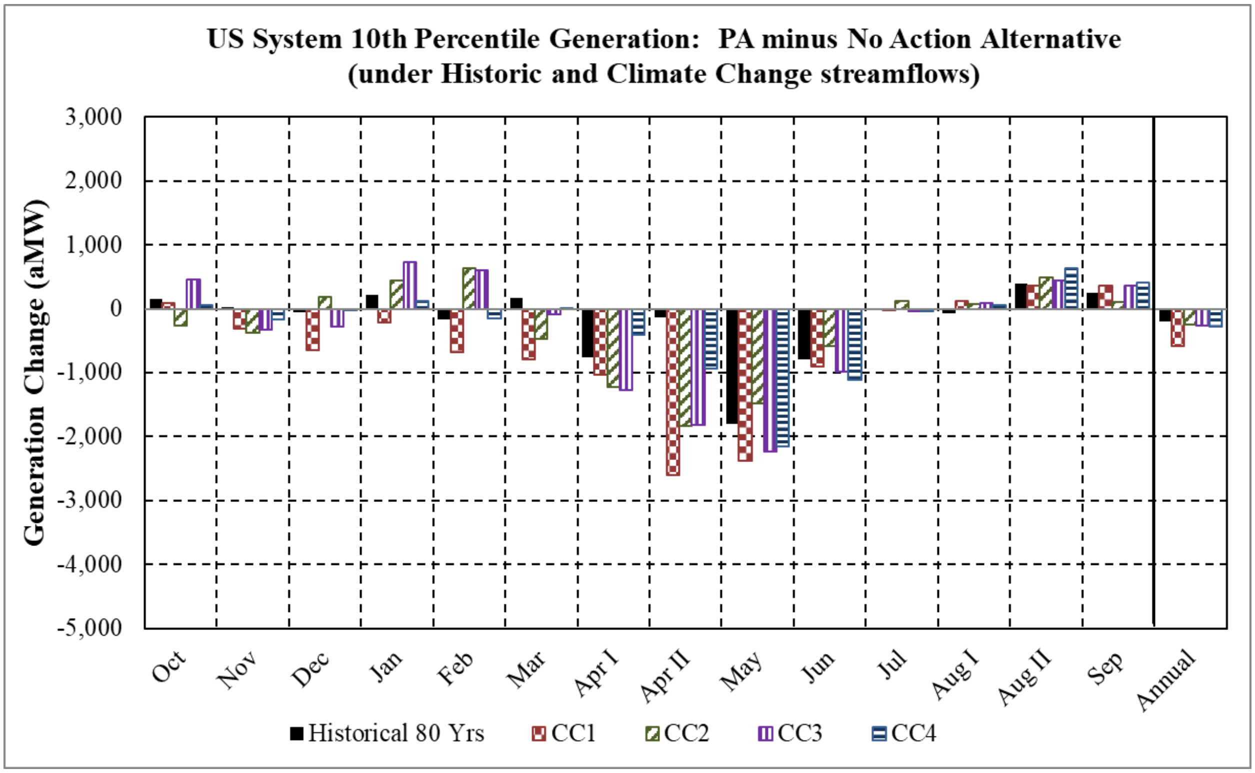


Figure 6-12. NW-US P10 Generation Changes for Historic and Climate Change Scenarios for PA Relative to NAA

Table 6-12. NW-US P10 Generation Changes for Historic and Climate Change Scenarios for PA and the Differences Relative to NAA

US System 10th Percentile Generation: PA minus No Action Alternative							(under Historic and Climate Change streamflows)								
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
Historical 80 Yı	149	21	-52	223	-166	173	-765	-132	-1,808	-791	-21	-70	390	248	-192
CC1	92	-306	-647	-218	-674	-789	-1,037	-2,601	-2,378	-911	-26	119	361	355	-588
CC2	-262	-373	187	438	634	-466	-1,227	-1,834	-1,487	-577	118	67	491	110	-247
CC3	458	-331	-279	734	597	-84	-1,270	-1,817	-2,234	-980	-47	95	440	369	-259
CC4	63	-168	-18	115	-146	12	-405	-939	-2,160	-1,108	-44	62	631	412	-280

6.4 ENERGY DEMAND (LOADS)

Warming regional temperatures are expected to impact energy demand (load) as well. For this analysis (both in the 80-year Modified Flows and for the four climate change scenarios), loads were held constant between alternatives.[25] However, by the 2030s, loads are likely to increase in the June through August period, and possibly into September as well, due to increasing air

[25] There are some indirect effects of changes in load on operations through the Columbia River Treaty, but for the CRSO studies, the operations of the Canadian Treaty projects was kept constant.

conditioning demand and longer air conditioning season. In the winter months (roughly December through February), loads are likely to decrease as increasing regional temperatures lower the need for heating. This has important potential implications for reliability.

The power shortages (Section 4.1.2) in December through February under the NAA and all alternatives could be reduced into the 2030s as loads in those months decrease. Conversely, the summer shortages that increase in MO1, MO3, and MO4 as compared to the NAA are likely to be further exacerbated as temperatures and load in those months increase. The four climate scenarios do not alter those conclusions and add additional uncertainty given the variability between climate scenarios in monthly average and P10 generation amounts. Recent research supports these conclusions. An NW Council and Pacific Northwest National Laboratories study found that combined climate change impacts on loads and hydropower may lead to decreases in winter shortfalls and increases in summer shortfalls as increases in peak loads for cooling coincide with decreases in hydropower generation (NW Council 2018).

6.5 SUMMARY OF NW-US GENERATION CHANGES FOR HISTORIC AND CLIMATE CHANGE SCENARIOS

Climate change adds uncertainty to the annual magnitude of generation, and significant uncertainty to the monthly magnitude of the effect of the alternatives relative to the NAA. It does not change the general conclusions from the power analysis of the relative impact of one alternative versus another. The results indicate that while climate change is very likely to impact hydropower generation in the future, it is likely to affect generation in all alternatives relative to the NAA roughly the same: MO2 is still the best alternative for hydropower and system reliability compared with the NAA; MO1 still produces the smallest change relative to the NAA; MO3 and MO4 still have significant decreases in generation and reliability as compared to the NAA, and the PA still produces less generation than the NAA. Additionally, rising temperatures will likely decrease winter and increase summer energy demand in the region, which is likely to decrease winter shortfalls and increase summer shortfalls. This exacerbates reliability concerns in the summer period, particularly for MO1, MO3, and MO4 which already showed increased concerns as compared to the NAA.

There is much more detail on the overall effects of climate change on multiple uses in the CRSO EIS.

CHAPTER 7 - REFERENCES

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Exhibit 1. Project List for NW-US, CRS (Federal), Mid-Columbia, and Canadian Systems

This exhibit provides a list of projects Bonneville modelled for the CRSO EIS. The projects highlighted with an asterisk (*) are affected by the CRSO EIS alternatives. The remaining projects are not affected by the alternatives but are part of the Bonneville hydropower models; their operation is replicated in each alternative.

Identification of Hydropower Projects within each Group

	Hydro Project Grouping			
Projects	**US System**	**Canadian System**	**Mid-Columbia**	**Federal System (CRS)**
Cushman 1	✓			
Cushman 2	✓			
Alder	✓			
Lagrand	✓			
Ross	✓			
Diablo	✓			
Gorge	✓			
Upper Baker	✓			
Lower Baker	✓			
Mica		✓		
Revelstoke		✓		
Arrow		✓		
Libby*	✓			✓
Bonners Ferry *	✓			
Duncan				
Corra Linn*		✓		
Canal Plant*		✓		
Upper Bonnington*		✓		
Lower Bonnington*		✓		
South Slocan*		✓		
Brilliant*		✓		
Hungry Horse*	✓			✓
Columbia Falls*	✓			
SQT (Kerr)*	✓			
Thompson Falls*	✓			
Noxon Rapids*	✓			
Cabinet Gorge*	✓			
Priest Lake				

	Hydro Project Grouping			
Projects	**US System**	**Canadian System**	**Mid-Columbia**	**Federal System (CRS)**
Albeni Falls*	✓			✓
Box Canyon*	✓			
Boundary*	✓			
Seven Mile*		✓		
Waneta*		✓		
Coeur d'Alene Lake				
Post Falls	✓			
Upper Falls	✓			
Monroe Street	✓			
Nine Mile	✓			
Long Lake	✓			
Little Falls	✓			
Grand Coulee*	✓			✓
Chief Joseph*	✓			✓
Wells*	✓		✓	
Chelan	✓			
Rocky Reach*	✓		✓	
Rock Island*	✓		✓	
Wanapum*	✓		✓	
Priest Rapids*	✓		✓	
Brownlee				
Oxbow				
Hells Canyon				
Dworshak*	✓			✓
Lower Granite*	✓			✓
Little Goose*	✓			✓
Lower Monumental*	✓			✓
Ice Harbor*	✓			✓
McNary*	✓			✓
John Day*	✓			✓
Round Butte	✓			
Pelton	✓			
Pelton Rereg	✓			
The Dalles*	✓			✓
Bonneville*	✓			✓
Timothy	✓			
Oak Grove	✓			

Projects	Hydro Project Grouping: US System	Canadian System	Mid-Columbia	Federal System (CRS)
North Fork	✓			
Faraday	✓			
River Mill	✓			
Swift 1	✓			
Swift 2	✓			
Yale	✓			
Merwin	✓			
Packwood Lake				
Mossyrock	✓			
Mayfield	✓			

(* indicates project may be directly affected by CRSO EIS Alternatives)

Exhibit 2. CRSO Alternative Crosswalk

	Measure Category	CRSO Measure Name	Multi-Objective #1 (MO1)	Multi-Objective #2 (MO2)	Multi-Objective #3 (MO3)	Multi-Objective #4 (MO4)	Preferred Alternative (PA)
Structural	Structural	Additional Powerhouse Surface Passage	X	X	X	X	
		Upgrade to Adjustable Spillway Weirs	X	X	X		
		Lower Granite Trap Modifications	X			X	X
		Modify Bonneville Ladder Serpentine Weir	X		X		X
		Lower Snake Ladder Pumps	X	X		X	
		Spillway Weir Notch Inserts				X	
		Fewer Fish Screens		X	X		X
		Improved Fish Passage Turbines at John Day	X	X	X	X	X
		Lamprey Passage Structures	X	X	X	X	X
		Turbine Strainer Lamprey Exclusion	X	X	X	X	X
		Bypass Screen Modifications for Lamprey	X	X	X	X	X
		Closeable Floating Orifice Gates					X
		Lamprey Passage Ladder Modifications	X	X	X	X	X
	Dam Breach	Breach Snake Embankments			X		
		Lower Snake Infrastructure Drawdown			X		
Operational		Drawdown Operating Procedures			X		
		Drawdown Contingency Plans			X		
	Fish Passage	Block Spill Test (Base + 120/115%)	X				
		Summer Spill Stop Trigger	X				
		Early Start Transport	X				X
		Contingency Reserves within Juvenile Fish Passage Spill	X	X	X	X	X
		Spill to 110% TDG		X			
		Spring & Fall Transport				X	
		No Summer Transport				X	
		Reduced Summer Spill			X		
		Spill to 125% TDG				X	
		Spring Spill to 120% TDG			X		
		Juvenile Fish Passage Spill Operations					X
		Spill for Adult Steelhead				X	
		Increase Juvenile Fish Transportation		X			
	Water Management	Modified Draft at Libby	X	X	X	X	X
		December Libby Target Elevation	X	X	X	X	
		Update System FRM Calculation at Grand Coulee	X	X	X	X	X
		Planned Draft Rate at Grand Coulee	X	X	X	X	X
		Grand Coulee Maintenance Operations	X	X	X	X	X
		Winter System FRM Space	X	X		X	
	Water Supply	Lake Roosevelt Additional Water Supply	X		X	X	X
		Hungry Horse Additional Water Supply	X		X	X	
		Chief Joseph Dam Project Addt'l Water Supply	X		X	X	
	Hydropower	Increased Forebay Range Flexibility	X				X
		Slightly Deeper Draft for Hydropower		X			
		Slightly Deeper Draft for Hydropower (Dworshak)					X
		Fall Operational Flexibility for Hydropower (Grand Coulee)					X
		Ramping Rates for Safety		X	X		
		John Day Full Pool		X	X		X
		Full Range Reservoir Operations		X			
		Full Range Turbine Operations		X			
		Above 1% Turbine Operations			X	X	X
		Zero Generation Operations		X			X
	Other Operational Measures	McNary Flow Target				X	
		Drawdown to MOP				X	
		Predator Disruption Operations	X				X
		Modified Dworshak Summer Draft	X				
		Sliding Scale at Libby and Hungry Horse	X	X	X	X	X
		Winter Stage for Riparian				X	

Exhibit 3. Average and Critical Water Generation Effects on U.S. Projects

This exhibit provides detailed average and critical water generation data by project for several major NW-US system projects. The generation details supplement the graphs in Section 3.2

Negative numbers indicate an alternative produced less hydropower than the NAA.

80 Year Average Generation Differences: NAA vs MO1

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
SYS	-83	-17	-242	228	16	-117	-317	-558	-506	-147	-258	-745	-416	92
GCL	-18	2	-60	47	-28	-34	-31	-72	-16	-22	-104	-104	-73	-48
CHJ	-9	1	-30	33	4	-13	-16	-35	6	-5	-40	-53	-40	-25
WEL	-3	1	-9	13	1	-4	-7	-25	-4	-8	-15	-16	-13	-9
RRC	-4	1	-15	22	-2	-6	-11	-29	-13	-16	-26	-25	-20	-13
RKI	-2	0	-6	8	-0	-3	-4	-9	-5	-6	-9	-8	-7	-6
WAN	-4	1	-12	11	3	-4	-9	-48	-11	-9	-20	-24	-18	-11
PRD	-3	1	-11	11	3	-4	-8	-18	-11	-11	-17	-21	-16	-10
MCN	-9	-4	10	11	8	-33	-108	-175	-205	-79	-105	-93	-62	-4
TDA	-4	1	-13	20	-3	-11	-20	-26	8	29	-12	-51	-36	7
JDA	-11	-6	-18	29	0	-10	-103	-142	-62	-25	-47	-88	-92	4
BON	-8	-5	-14	2	1	10	-12	-39	-26	-4	-8	-30	-16	0
LIB	2	5	-38	44	28	15	1	34	-29	-30	-22	-7	-7	-16
HGH	-1	-4	-8	-7	0	-4	-5	-7	-1	-3	4	13	13	16
DWR	0	0	1	2	2	-0	0	1	1	52	1	-237	-188	122
LWG	0	0	0	0	0	0	-23	-24	-49	-12	10	-15	40	22
LGS	0	0	0	0	0	1	-42	-33	-34	-18	13	-25	7	23
LMN	0	0	0	0	0	1	29	28	8	5	13	16	59	23
IHR	0	0	0	0	0	-26	55	64	-65	17	133	18	54	22

WY1937 Average Generation Differences: NAA vs MO1

WY for comparison: **1937**

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
SYS	28	-117	99	177	-129	-50	-36	35	-1390	-858	-864	-1172	-829	-489
GCL	19	-9	-7	48	-39	-2	-6	-12	-174	-97	-217	-238	-141	-153
CHJ	10	-0	-0	28	-20	0	0	-0	-95	-51	-114	-127	-78	-83
WEL	3	-0	-0	9	-7	0	0	-0	-29	-15	-36	-36	-25	-29
RRC	5	-0	-0	14	-11	0	0	-0	-49	-23	-53	-57	-39	-44
RKI	2	-0	-0	5	-5	0	0	-0	-16	-7	-18	-20	-14	-20
WAN	4	-0	-0	12	-9	0	0	-0	-42	-22	-51	-56	-35	-37
PRD	4	-0	-0	11	-8	0	0	-0	-38	-19	-45	-49	-31	-34
MCN	-4	-7	19	20	2	-41	-70	-79	-252	-275	-90	2	-33	-29
TDA	5	-0	-0	13	-9	0	-8	-0	-73	-8	-28	-59	-35	-25
JDA	-0	-7	-0	17	-12	0	-16	-3	-280	-170	-61	-45	-95	-36
BON	-2	-6	-8	0	-9	24	-9	0	-87	-57	-34	-48	2	-22
LIB	-1	-87	96	-1	-2	-2	-2	-2	-34	-51	-56	-56	-55	-77
HGH	-0	-0	-1	-1	-1	-1	-0	-0	-0	-0	-38	-38	-34	-12
DWR	0	0	0	0	0	0	0	0	0	82	-0	-243	-150	99
LWG	0	0	0	0	0	0	0	0	-81	-85	7	0	6	16
LGS	0	0	0	0	0	0	0	0	-65	-76	5	0	3	17
LMN	0	0	0	0	0	0	0	30	37	37	7	0	21	17
IHR	0	0	0	0	0	-29	75	102	-111	-23	58	0	6	17

80 Year Average Generation Differences: NAA vs MO2

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
SYS	6	222	450	572	468	-380	-294	602	1102	361	772	1574	1449	177
GCL	-13	30	97	63	34	-162	-143	-130	-16	-32	-43	-59	-22	40
CHJ	-2	20	53	44	77	-63	-71	-61	-11	-8	-7	-30	-11	25
WEL	-1	6	17	17	21	-22	-24	-22	6	11	-6	-9	-4	9
RRC	-1	10	27	28	31	-34	-38	-37	-3	-3	-10	-14	-6	13
RKI	-0	4	10	10	12	-14	-16	-13	-3	-1	-4	-4	-2	6
WAN	-1	8	22	15	28	-25	-33	-29	-7	1	-8	-13	-5	11
PRD	-1	7	20	14	24	-23	-30	-26	-5	-4	-7	-11	-4	10
MCN	-8	3	34	18	20	-17	43	139	165	92	243	326	277	1
TDA	11	13	25	44	42	-8	-50	208	313	280	273	336	319	3
JDA	17	10	33	61	50	-38	-157	87	144	59	14	241	166	39
BON	3	2	7	11	14	4	49	136	144	122	160	406	405	8
LIB	1	95	104	-84	-9	4	-4	14	-42	-50	-36	-17	-17	-27
HGH	0	0	2	38	15	3	0	-7	22	-59	-14	-10	-9	1
DWR	0	0	0	134	42	-2	-76	-56	14	-81	-4	-5	-12	0
LWG	7	8	0	25	9	-1	22	36	34	8	50	114	100	8
LGS	-0	5	0	25	10	0	-10	38	86	17	26	83	69	12
LMN	-0	5	0	25	10	0	56	92	91	19	39	114	100	11
IHR	-0	5	0	24	9	-1	184	236	156	4	118	141	120	12

WY1937 Average Generation Differences: NAA vs MO2

WY for comparison: **1937**

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
SYS	90	-105	246	-586	1210	17	-106	618	1027	994	332	1122	866	-224
GCL	7	-44	-2	-135	353	0	-0	-0	-39	-9	-108	-154	-85	-36
CHJ	13	-9	-0	-96	182	0	0	-0	-23	-4	-55	-81	-47	-17
WEL	5	-3	-0	-32	62	0	0	-0	-7	-1	-17	-23	-15	-6
RRC	7	-5	-0	-49	94	0	0	-0	-12	-2	-25	-36	-24	-9
RKI	3	-2	-0	-18	41	0	0	-0	-4	-1	-9	-13	-9	-4
WAN	6	-4	-0	-42	80	0	0	-0	-10	-2	-24	-36	-21	-7
PRD	5	-3	-0	-37	73	0	0	-0	-9	-1	-21	-32	-19	-7
MCN	-11	-7	19	-29	82	1	-39	62	162	261	211	361	240	-25
TDA	19	-0	-0	-45	85	0	-44	132	303	359	216	319	290	1
JDA	26	-7	-0	-58	110	0	-113	-38	17	36	-34	234	118	14
BON	8	-6	-8	-39	55	24	54	209	206	196	182	414	397	-3
LIB	-2	-38	237	-8	-8	-8	-8	-8	-81	-61	-64	-63	-62	-83
HGH	0	0	0	0	0	0	0	0	0	0	-42	-41	-41	-27
DWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LWG	5	7	0	0	0	0	23	43	54	-103	85	89	61	6
LGS	0	5	0	0	0	0	-52	-8	110	7	7	92	51	10
LMN	0	5	0	0	0	0	33	108	150	123	56	81	52	10
IHR	0	5	0	0	0	0	40	117	210	194	52	91	63	12

80 Year Average Generation Differences: NAA vs MO3

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
SYS	-646	-234	-380	-1243	-1481	-1451	-1889	-2490	-2786	-2032	-1151	678	716	-804
GCL	-18	84	99	-66	-97	-10	-29	-103	-69	-112	-137	-127	-77	-59
CHJ	-9	43	52	-30	-48	2	-16	-53	-31	14	-56	-66	-40	-31
WEL	-3	15	18	-7	-11	0	-5	-20	10	-2	-18	-19	-13	-11
RRC	-5	23	29	-11	-20	2	-8	-30	-4	-11	-29	-30	-20	-17
RKI	-2	9	11	-4	-7	0	-3	-10	-5	-7	-11	-10	-7	-7
WAN	-4	19	24	-3	-7	0	-7	-44	-33	-13	-24	-28	-17	-14
PRD	-3	17	21	-3	-6	1	-6	-20	-11	-8	-20	-24	-16	-13
MCN	-10	13	36	3	5	-3	-177	-240	-259	-89	-90	320	299	-22
TDA	9	25	29	-9	-1	42	-206	-282	-316	-141	-86	321	307	-5
JDA	13	25	35	-12	-19	10	-346	-444	-370	-124	37	364	295	6
BON	2	10	8	-7	-1	-0	-29	-62	-36	6	-5	398	398	-8
LIB	1	95	104	-84	-9	4	-4	14	-42	-50	-36	-17	-17	-27
HGH	-1	-4	-8	-0	3	-3	-13	-8	-1	-3	4	13	13	16
DWR	0	0	0	0	-0	-1	0	1	3	9	0	0	0	0
LWG	-145	-145	-201	-250	-311	-373	-295	-359	-475	-425	-196	-98	-90	-158
LGS	-154	-149	-203	-254	-315	-375	-331	-362	-458	-432	-203	-137	-129	-154
LMN	-156	-153	-210	-263	-336	-392	-291	-333	-471	-445	-210	-105	-96	-154
IHR	-148	-146	-200	-244	-309	-358	-118	-125	-224	-193	-66	-66	-66	-145

WY1937 Average Generation Differences: NAA vs MO3

WY for comparison: **1937**

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
SYS	-366	-520	-184	217	-247	-658	-1388	-986	-2784	-1831	-1378	246	263	-1112
GCL	19	-18	22	216	66	-1	-5	-11	-208	-70	-215	-238	-141	-153
CHJ	10	-9	-0	103	34	0	0	-0	-116	-38	-113	-127	-78	-83
WEL	3	-3	-0	34	12	0	0	-0	-36	-11	-35	-36	-25	-29
RRC	5	-5	-0	53	18	0	0	-0	-60	-17	-53	-57	-39	-44
RKI	2	-2	-0	20	8	0	0	-0	-20	-5	-18	-20	-14	-20
WAN	4	-4	-0	45	15	0	0	-0	-52	-17	-50	-56	-35	-37
PRD	4	-3	-0	40	14	0	0	-0	-47	-14	-45	-49	-31	-34
MCN	-13	-7	19	50	23	1	-179	-85	-259	-282	-84	384	269	-52
TDA	17	-0	-0	48	16	0	-274	-130	-311	-196	-32	298	275	-30
JDA	24	-7	-0	62	21	0	-373	-242	-461	-270	4	350	244	-26
BON	7	-6	-8	24	8	1	-85	0	-122	-63	-38	400	387	-24
LIB	-2	-38	237	-8	-8	-8	-8	-8	-81	-61	-64	-63	-62	-83
HGH	-0	-0	-1	-1	-1	-1	-0	-0	-0	-0	-38	-38	-34	-12
DWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LWG	-102	-102	-112	-117	-110	-169	-86	-138	-357	-239	-91	-80	-80	-115
LGS	-108	-106	-113	-119	-111	-171	-161	-191	-342	-258	-149	-80	-93	-110
LMN	-112	-107	-117	-120	-130	-184	-85	-84	-296	-205	-99	-85	-85	-104
IHR	-107	-103	-113	-115	-123	-175	-67	-66	-176	-88	-66	-67	-67	-97

80 Year Average Generation Differences: NAA vs MO4

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
SYS	-457	-83	-402	244	-49	-3549	-2938	-2552	-2793	-2462	-1834	-1693	-1336	-308
GCL	-105	3	-97	54	-50	-31	-30	-86	73	-59	-41	-266	-262	-52
CHJ	-53	2	-49	37	-3	-10	-16	-43	69	20	14	-128	-138	-25
WEL	-19	1	-16	15	-3	-4	-7	-18	38	23	0	-39	-44	-9
RRC	-28	1	-25	25	-7	-6	-9	-27	37	2	-1	-60	-69	-13
RKI	-12	0	-10	9	-2	-3	-4	-10	8	-3	-1	-20	-26	-6
WAN	-23	2	-21	12	0	-5	-19	-20	23	8	2	-58	-61	-11
PRD	-22	1	-18	11	0	-4	-7	-18	18	2	2	-51	-55	-10
MCN	-30	-13	3	11	6	-437	-328	-272	-360	-243	-217	-118	-67	-9
TDA	-24	1	-22	22	-9	-639	-610	-478	-653	-569	-453	-308	-183	-11
JDA	-41	-9	-30	33	-6	-831	-828	-628	-719	-645	-583	-432	-326	-7
BON	-21	-3	-19	3	-1	-500	-387	-241	-315	-237	-248	-129	-45	-12
LIB	1	2	-80	42	29	16	1	34	1	-23	-0	-8	-10	-49
HGH	-1	-3	-6	-10	-1	2	-11	-16	7	3	24	9	10	-15
DWR	0	0	0	0	-0	-3	0	1	3	15	1	0	0	0
LWG	-14	-14	0	0	1	-274	-193	-215	-283	-193	-115	-17	-9	0
LGS	-15	-15	0	0	-0	-280	-235	-228	-283	-214	-122	-56	-48	0
LMN	-15	-15	0	0	0	-257	-202	-221	-326	-262	-126	-20	-12	0
IHR	-14	-14	0	0	-0	-290	-52	-55	-147	-92	-1	1	0	0

WY1937 Average Generation Differences: NAA vs MO4

WY for comparison: **1937**

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
SYS	-873	-197	-48	-369	-131	-1627	-1147	-653	-601	-2442	-1747	-2768	-1976	-388
GCL	-209	-9	-23	-114	-39	-2	-6	-12	462	-221	-324	-870	-540	-36
CHJ	-107	-0	-0	-54	-20	0	0	-0	320	-51	-123	-440	-289	-11
WEL	-38	-0	-0	-18	-7	0	0	-0	94	-15	-38	-133	-92	-4
RRC	-57	-0	-0	-28	-11	0	0	-0	159	-23	-58	-203	-144	-6
RKI	-25	-0	-0	-10	-5	0	0	-0	56	-7	-19	-68	-54	-3
WAN	-47	-0	-0	-24	-9	0	0	-0	141	-22	-55	-195	-128	-5
PRD	-43	-0	-0	-21	-8	0	0	-0	124	-19	-49	-175	-115	-5
MCN	-62	-17	19	-12	2	-213	-166	-72	-252	-273	-87	6	-31	-12
TDA	-50	-0	-0	-25	-9	-315	-283	-140	-324	-400	-212	-199	-125	-5
JDA	-73	-10	-0	-33	-12	-389	-386	-254	-475	-578	-346	-278	-263	0
BON	-41	-6	-8	-25	-9	-324	-216	-4	-199	-291	-75	-49	2	-7
LIB	-4	-93	-50	-1	-2	-2	-2	-2	84	-58	-63	-61	-60	-82
HGH	-2	-2	-2	-2	-2	-2	-2	-2	-1	-1	-61	-56	-35	-28
DWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LWG	-14	-14	0	0	0	-87	-5	-57	-276	-159	-10	1	0	0
LGS	-15	-15	0	0	0	-88	-81	-110	-261	-178	-68	1	-12	0
LMN	-15	-15	0	0	0	-98	-0	0	-211	-121	-14	0	0	0
IHR	-14	-14	0	0	0	-107	-0	0	-111	-23	1	1	0	0

80 Year Average SystemGeneration Differences: NAA vs PA

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
SYS	194	-68	6	270	225	-174	-951	-1253	-1647	-883	-41	-20	671	145
GCL	30	-38	-22	-23	40	-48	-1	20	9	-269	-33	-29	-46	44
CHJ	21	-15	-7	-3	34	-18	1	12	-30	20	-2	-14	-24	27
WEL	7	-5	-2	-1	10	-7	-11	-24	-36	-35	-4	-4	-8	10
RRC	11	-8	-4	-2	16	-11	-8	-6	-20	-15	-8	-6	-12	14
RKI	5	-3	-1	-0	6	-4	-2	-0	-3	-1	-3	-2	-4	6
WAN	9	-6	-3	-1	11	-6	-20	-52	-57	-28	-6	-6	-10	12
PRD	8	-6	-3	-1	9	-6	-2	2	-9	-13	-5	-5	-10	11
MCN	1	-11	14	8	11	-7	-177	-256	-306	-120	-69	-31	233	3
TDA	19	-8	-4	10	11	-33	-64	-62	-108	-62	-58	-1	64	-0
JDA	71	34	44	74	77	26	-179	-333	-256	-91	6	8	177	41
BON	13	-6	-2	4	5	8	-19	-67	-67	-3	6	10	168	-1
LIB	4	7	-2	24	7	5	-1	36	-28	-28	-21	-6	-6	-14
HGH	0	0	2	2	1	-1	1	-0	4	2	-4	-4	-4	-3
DWR	0	0	0	103	-9	-38	-32	-8	-6	14	0	-1	-0	-0
LWG	0	0	0	19	-1	-9	-106	-141	-169	-28	-27	1	46	-0
LGS	0	0	0	19	-1	-9	-163	-176	-205	-85	18	5	11	-0
LMN	0	0	0	19	-2	-9	-148	-177	-265	-118	14	2	47	-0
IHR	0	0	0	18	-2	-7	-25	-27	-100	-22	154	72	59	-0

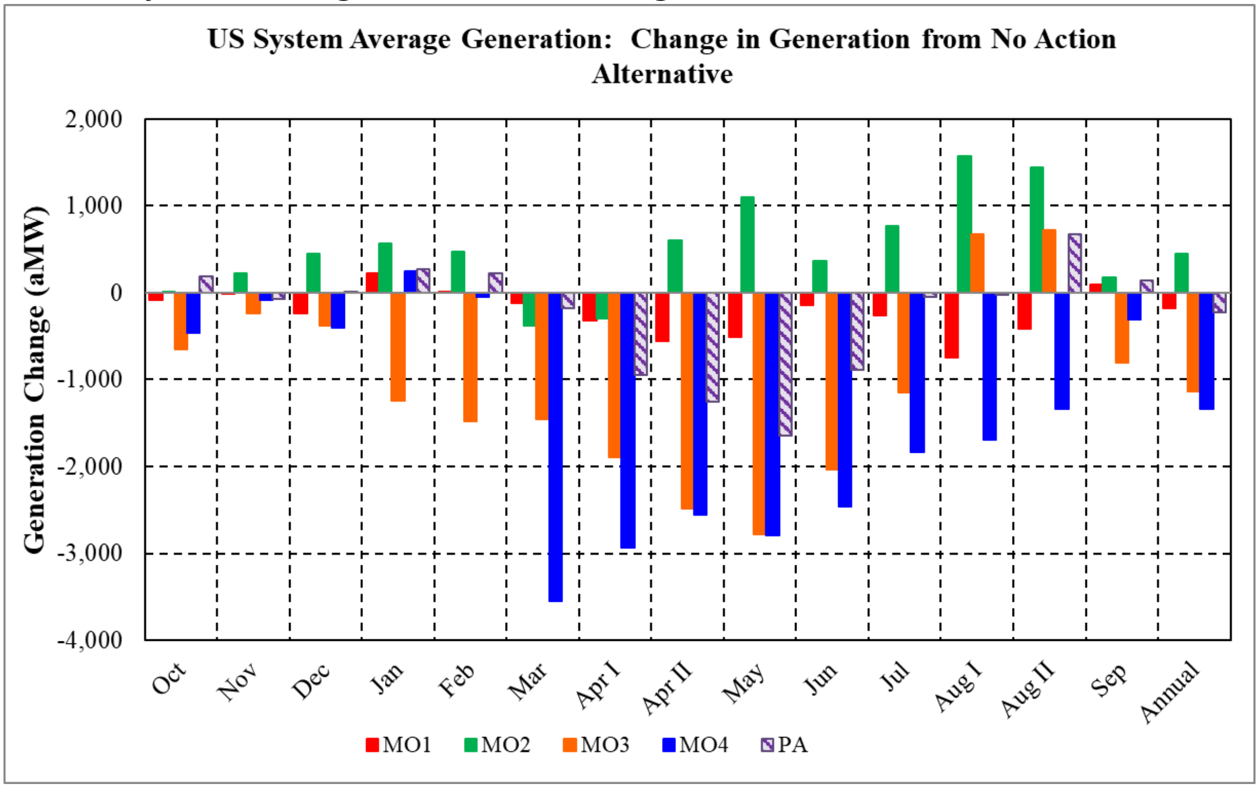
WY1937 Average Generation Differences: NAA vs PA

WY for comparison: **1937**

	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
SYS	264	-89	16	-614	95	45	-578	-481	-1771	-1137	-478	-338	54	-162
GCL	45	-35	-43	-204	16	-0	-1	-2	-23	-22	-113	-124	-115	-10
CHJ	34	-0	-0	-104	8	0	0	-0	-12	-10	-58	-65	-63	-3
WEL	12	-0	-0	-34	3	0	0	-0	-4	-3	-18	-19	-20	-1
RRC	18	-0	-0	-53	4	0	0	-0	-6	-4	-27	-29	-32	-1
RKI	8	-0	-0	-20	2	0	0	-0	-2	-1	-9	-10	-11	-1
WAN	15	-0	-0	-46	4	0	0	-0	-5	-4	-26	-29	-28	-1
PRD	14	-0	-0	-40	3	0	0	-0	-5	-4	-22	-25	-25	-1
MCN	-3	-7	19	-32	13	1	-177	-79	-253	-275	-72	36	189	-18
TDA	28	-0	-0	-49	4	-12	-10	-0	-18	-2	-16	-10	57	-14
JDA	76	41	40	-28	37	35	-240	-230	-449	-221	-14	51	123	21
BON	18	-0	-0	-33	3	23	-68	0	-146	-68	-20	-6	149	-10
LIB	-1	-87	0	30	-0	-1	-1	-1	-21	-41	-45	-44	-43	-42
HGH	0	0	0	0	0	0	0	0	0	0	-42	-41	-41	-27
DWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LWG	0	0	0	0	0	0	-3	-58	-242	-159	-1	0	6	0
LGS	0	0	0	0	0	0	-79	-111	-262	-179	0	31	-7	0
LMN	0	0	0	0	0	0	0	0	-212	-121	0	0	0	0
IHR	0	0	0	0	0	0	0	0	-111	-23	81	28	0	0

Exhibit 4. Annual Average Generation for NW-US, CRS (Federal), Mid-Columbia, and Canadian Systems – All Alternatives

NW-US System Average Generation: Change from NAA



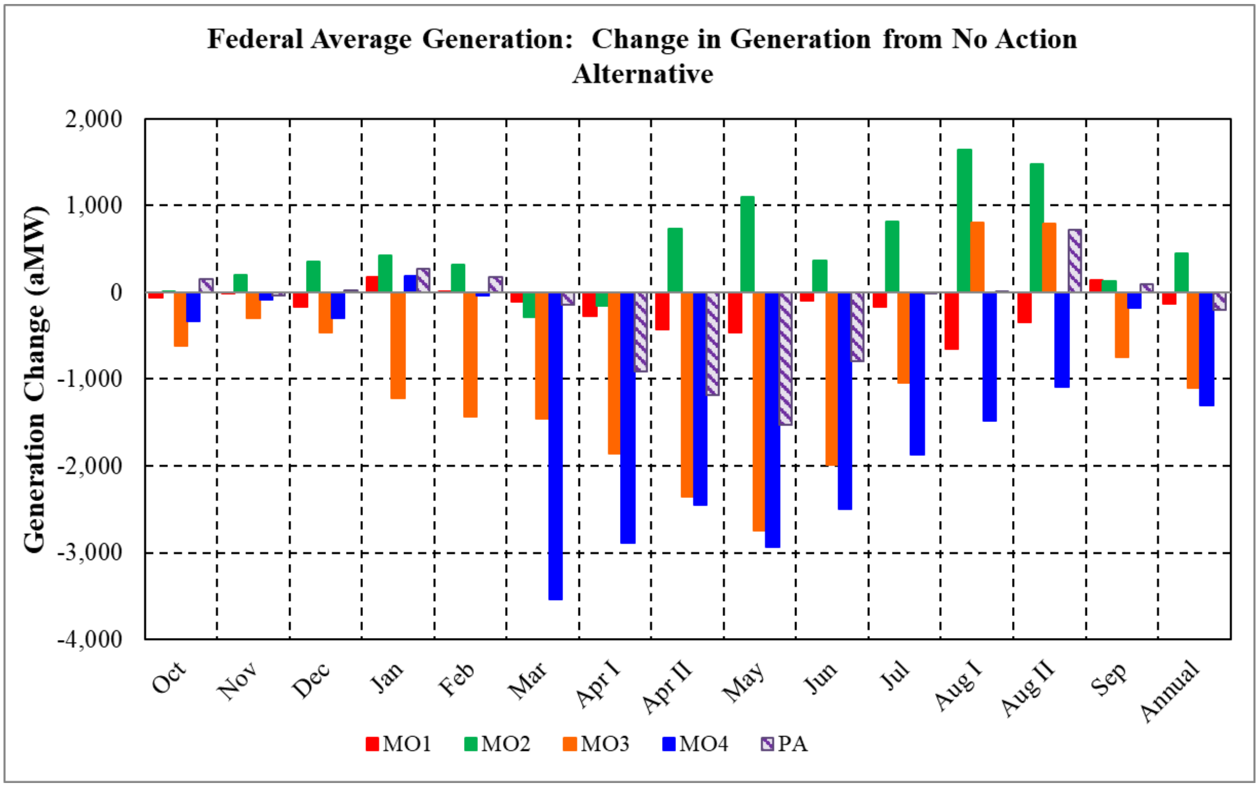
US System Average Generation: Change in Generation from No Action Alternative

	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
MO1	9,280	12,188	13,277	15,343	15,315	13,607	12,326	12,911	15,956	17,358	13,915	11,025	9,813	9,306	13,200
MO2	9,370	12,428	13,970	15,686	15,768	13,344	12,349	14,071	17,564	17,865	14,945	13,344	11,678	9,392	13,826
MO3	8,718	11,971	13,139	13,872	13,819	12,273	10,754	10,980	13,676	15,473	13,022	12,448	10,945	8,410	12,236
MO4	8,906	12,122	13,117	15,358	15,250	10,175	9,705	10,918	13,669	15,042	12,339	10,077	8,893	8,906	12,034
PA	9,558	12,137	13,525	15,385	15,524	13,551	11,692	12,216	14,815	16,621	14,132	11,750	10,900	9,360	13,144

US System Average Generation: Change in Generation from No Action Alternative

	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
MO1	-83	-17	-242	228	16	-117	-317	-558	-506	-147	-258	-745	-416	92	-173
MO2	6	222	450	572	468	-380	-294	602	1,102	361	772	1,574	1,449	177	453
MO3	-646	-234	-380	-1,243	-1,481	-1,451	-1,889	-2,490	-2,786	-2,032	-1,151	678	716	-804	-1,137
MO4	-457	-83	-402	244	-49	-3,549	-2,938	-2,552	-2,793	-2,462	-1,834	-1,693	-1,336	-308	-1,339
PA	194	-68	6	270	225	-174	-951	-1,253	-1,647	-883	-41	-20	671	145	-229

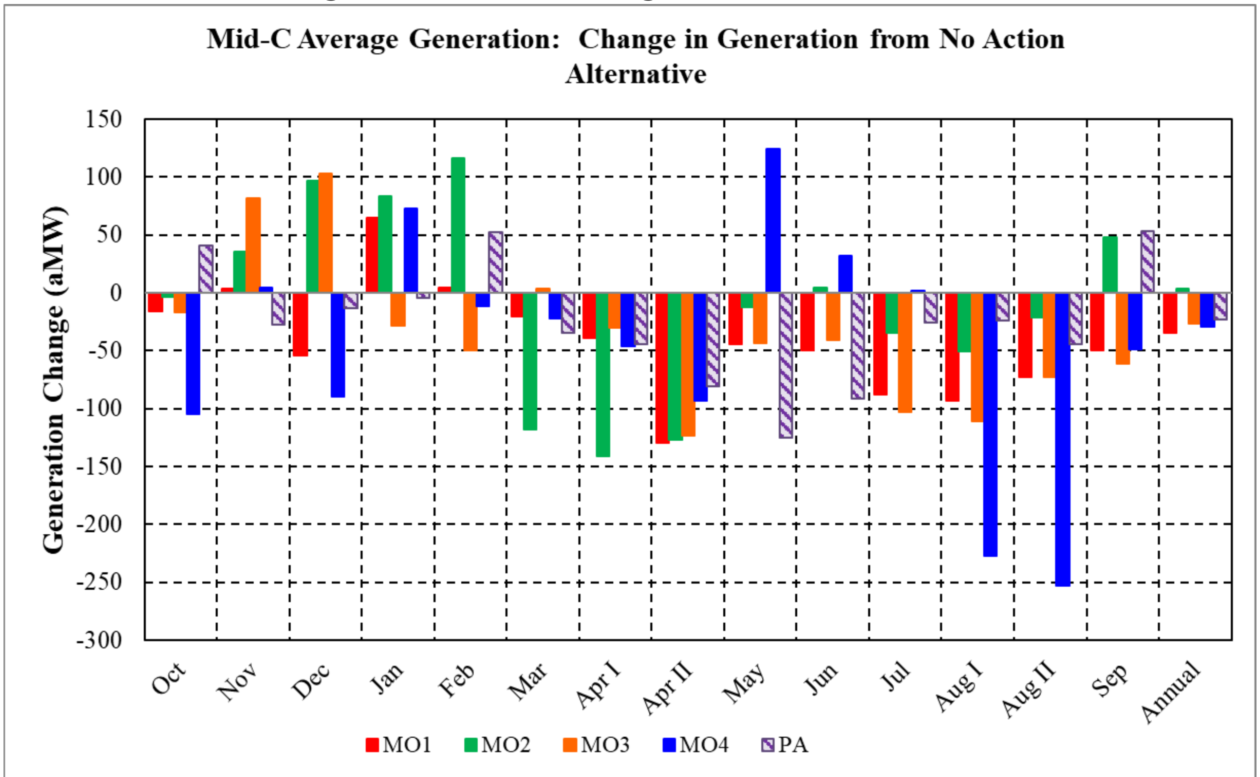
CRS (Federal) Average Generation: Change from NAA



Federal Average Generation: Change in Generation from No Action Alternative	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	5,548	7,420	8,302	9,453	9,730	8,819	7,842	8,220	10,324	10,895	8,796	7,592	6,455	5,843	8,339
MO1	5,491	7,410	8,133	9,636	9,744	8,717	7,567	7,794	9,858	10,800	8,631	6,936	6,113	5,990	8,207
MO2	5,565	7,617	8,656	9,880	10,053	8,537	7,685	8,953	11,424	11,266	9,614	9,232	7,940	5,976	8,784
MO3	4,931	7,120	7,841	8,239	8,292	7,362	5,987	5,864	7,575	8,910	7,752	8,392	7,252	5,100	7,234
MO4	5,215	7,341	8,002	9,646	9,695	5,284	4,951	5,773	7,391	8,394	6,929	6,118	5,365	5,661	7,036
PA	5,707	7,383	8,323	9,727	9,903	8,678	6,928	7,041	8,794	10,104	8,781	7,605	7,180	5,941	8,134

Federal Average Generation: Change in Generation from No Action Alternative	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	5,548	7,420	8,302	9,453	9,730	8,819	7,842	8,220	10,324	10,895	8,796	7,592	6,455	5,843	8,339
MO1	-57	-10	-168	183	14	-102	-275	-426	-466	-94	-165	-656	-343	147	-132
MO2	18	197	354	426	324	-282	-157	733	1,100	371	818	1,641	1,484	132	445
MO3	-617	-300	-461	-1,215	-1,437	-1,457	-1,855	-2,356	-2,749	-1,984	-1,044	801	797	-743	-1,105
MO4	-333	-79	-300	192	-35	-3,535	-2,891	-2,447	-2,932	-2,501	-1,866	-1,474	-1,091	-182	-1,303
PA	159	-37	21	274	174	-141	-915	-1,179	-1,529	-790	-15	13	725	97	-205

Mid-Columbia Average Generation: Change from NAA



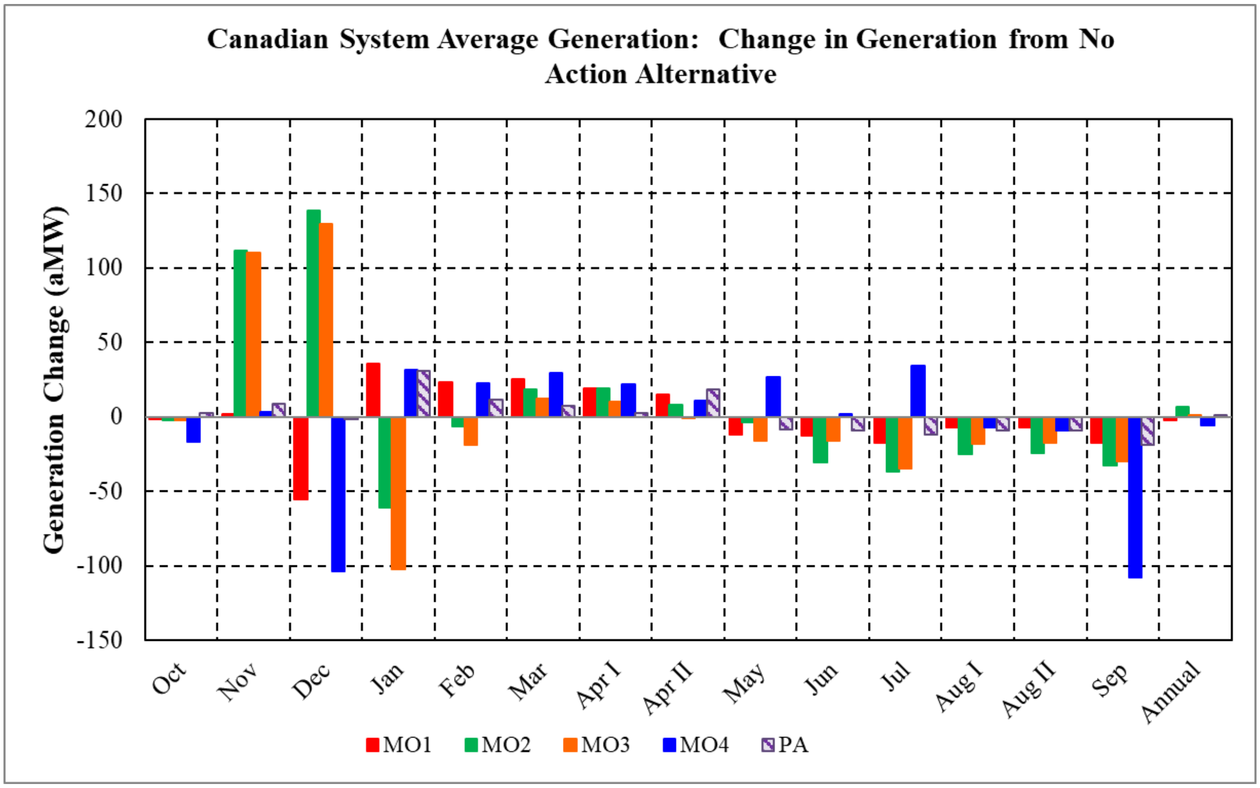
Mid-C Average Generation: Change in Generation from No Action Alternative

	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	1,834	2,499	2,666	2,982	2,892	2,482	2,399	2,610	3,217	3,337	2,904	2,691	2,467	1,845	2,644
MO1	1,818	2,503	2,613	3,047	2,897	2,461	2,360	2,481	3,173	3,287	2,815	2,597	2,394	1,796	2,609
MO2	1,830	2,535	2,763	3,065	3,008	2,364	2,258	2,483	3,205	3,341	2,869	2,640	2,446	1,894	2,647
MO3	1,818	2,580	2,769	2,953	2,842	2,485	2,369	2,486	3,174	3,297	2,801	2,580	2,394	1,784	2,617
MO4	1,730	2,503	2,577	3,055	2,881	2,459	2,353	2,517	3,341	3,369	2,905	2,464	2,214	1,797	2,614
PA	1,875	2,471	2,653	2,977	2,944	2,447	2,355	2,529	3,092	3,245	2,878	2,667	2,423	1,899	2,621

Mid-C Average Generation: Change in Generation from No Action Alternative

	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	1,834	2,499	2,666	2,982	2,892	2,482	2,399	2,610	3,217	3,337	2,904	2,691	2,467	1,845	2,644
MO1	-16	4	-54	65	5	-21	-39	-129	-44	-50	-88	-94	-73	-50	-35
MO2	-4	36	97	83	116	-118	-141	-127	-12	4	-35	-50	-21	48	3
MO3	-17	82	103	-29	-50	3	-30	-124	-43	-40	-103	-111	-73	-62	-27
MO4	-104	5	-89	73	-11	-23	-46	-93	124	32	1	-227	-253	-48	-30
PA	41	-28	-14	-5	52	-35	-44	-80	-125	-92	-26	-24	-44	53	-23

Canadian Average Generation: Change from NAA

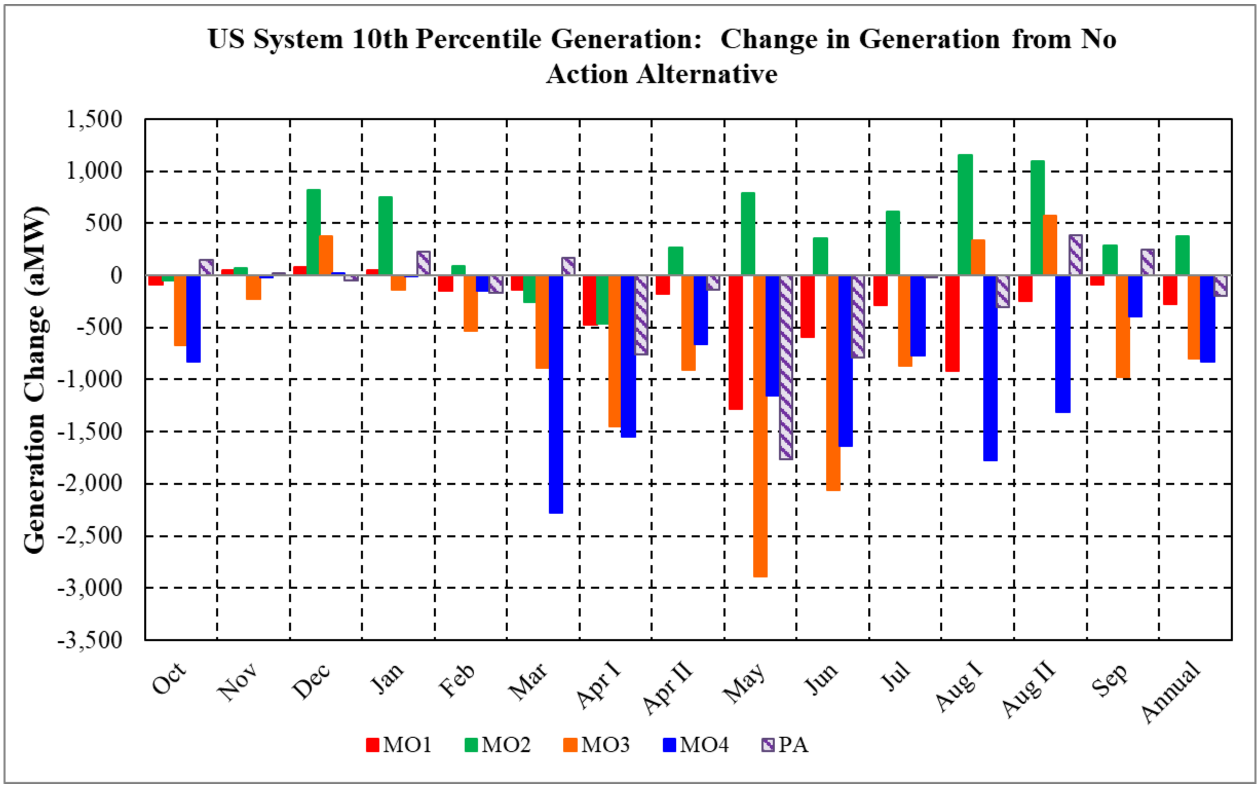


Canadian System Average Generation: Change in Generation from No Action Alternative														
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	2,522	3,219	3,709	2,379	3,276	2,360	2,429	2,698	3,917	4,281	4,836	4,761	4,136	3,285	3,401
MO1	2,520	3,221	3,653	2,415	3,300	2,385	2,448	2,713	3,905	4,268	4,818	4,754	4,129	3,268	3,399
MO2	2,520	3,330	3,848	2,319	3,270	2,378	2,448	2,705	3,913	4,250	4,799	4,736	4,112	3,252	3,408
MO3	2,520	3,329	3,839	2,277	3,257	2,372	2,439	2,697	3,901	4,265	4,801	4,743	4,119	3,255	3,402
MO4	2,505	3,222	3,606	2,411	3,299	2,390	2,451	2,708	3,943	4,283	4,870	4,754	4,127	3,177	3,395
PA	2,524	3,227	3,708	2,410	3,288	2,367	2,431	2,716	3,908	4,272	4,824	4,752	4,127	3,267	3,401

Canadian System Average Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
All Water Years															
NAA	2,522	3,219	3,709	2,379	3,276	2,360	2,429	2,698	3,917	4,281	4,836	4,761	4,136	3,285	3,401
MO1	-2	2	-56	36	23	25	19	15	-12	-13	-18	-7	-7	-17	-2
MO2	-2	111	139	-61	-7	18	19	8	-3	-31	-37	-25	-24	-33	7
MO3	-2	111	129	-102	-19	12	10	-1	-16	-16	-35	-18	-18	-30	2
MO4	-17	3	-103	32	22	29	22	11	27	2	34	-7	-9	-108	-6
PA	2	8	-2	31	12	7	2	18	-8	-9	-12	-9	-9	-19	1

Exhibit 5. P(10) Generation for NW-US, CRS (Federal), Mid-Columbia, and Canadian Systems – All Alternatives

NW-US System P10 Generation: Change from NAA



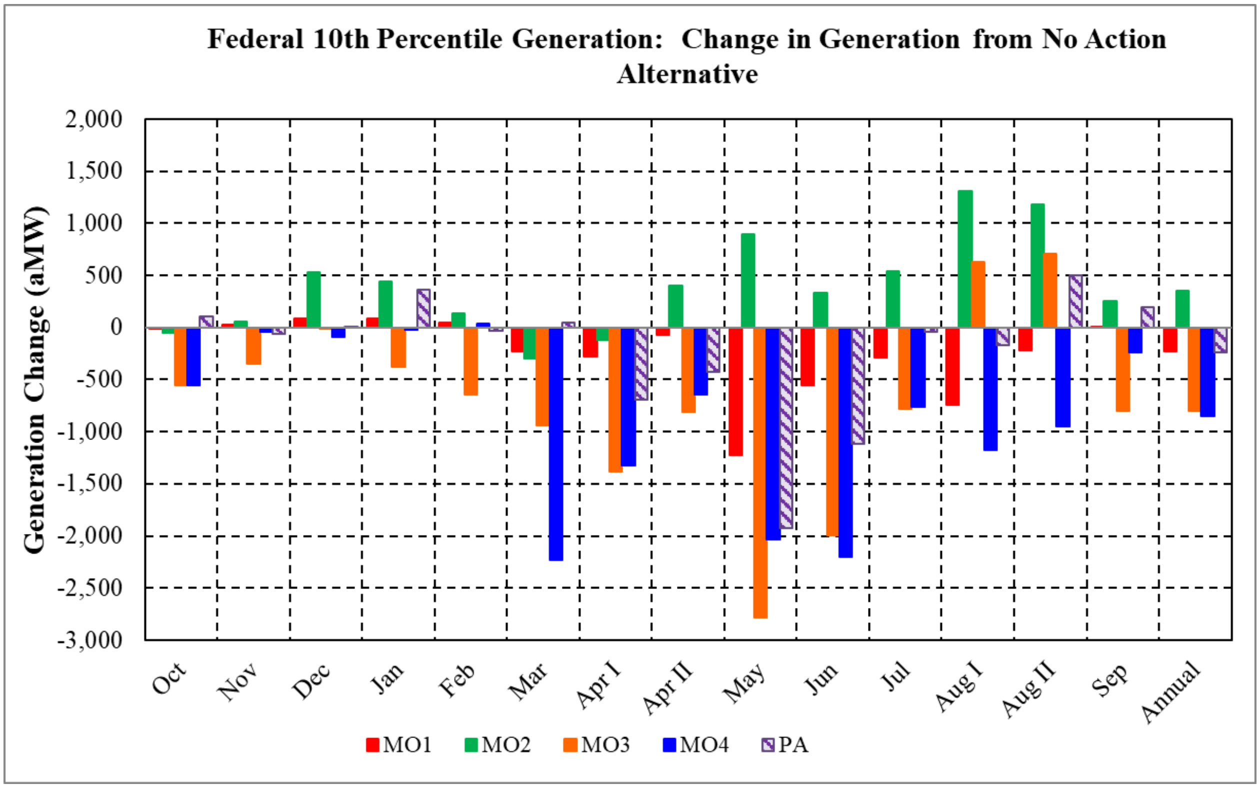
US System 10th Percentile Generation: Change in Generation from No Action Alternative

	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
MO1	8,438	10,715	10,983	10,915	10,085	9,573	8,260	7,637	11,286	12,426	9,274	8,687	8,385	8,222	9,865
MO2	8,480	10,736	11,722	11,613	10,319	9,458	8,278	8,077	13,364	13,377	10,166	10,757	9,729	8,592	10,524
MO3	7,865	10,441	11,279	10,725	9,692	8,825	7,287	6,908	9,678	10,960	8,691	9,938	9,208	7,329	9,347
MO4	7,700	10,643	10,921	10,864	10,085	7,435	7,185	7,151	11,420	11,385	8,792	7,829	7,322	7,912	9,319
PA	8,679	10,682	10,853	11,089	10,061	9,886	7,976	7,682	10,806	12,229	9,535	9,295	9,025	8,555	9,947

US System 10th Percentile Generation: Change in Generation from No Action Alternative

	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
MO1	-92	53	79	49	-143	-140	-476	-177	-1,284	-591	-284	-912	-250	-85	-280
MO2	-50	73	818	747	91	-255	-458	263	794	360	609	1,158	1,095	285	380
MO3	-665	-221	374	-140	-536	-888	-1,449	-907	-2,892	-2,056	-867	339	573	-978	-798
MO4	-830	-20	17	-2	-143	-2,278	-1,551	-663	-1,150	-1,632	-766	-1,770	-1,313	-395	-826
PA	148	20	-52	223	-167	173	-760	-132	-1,764	-788	-22	-305	390	248	-197

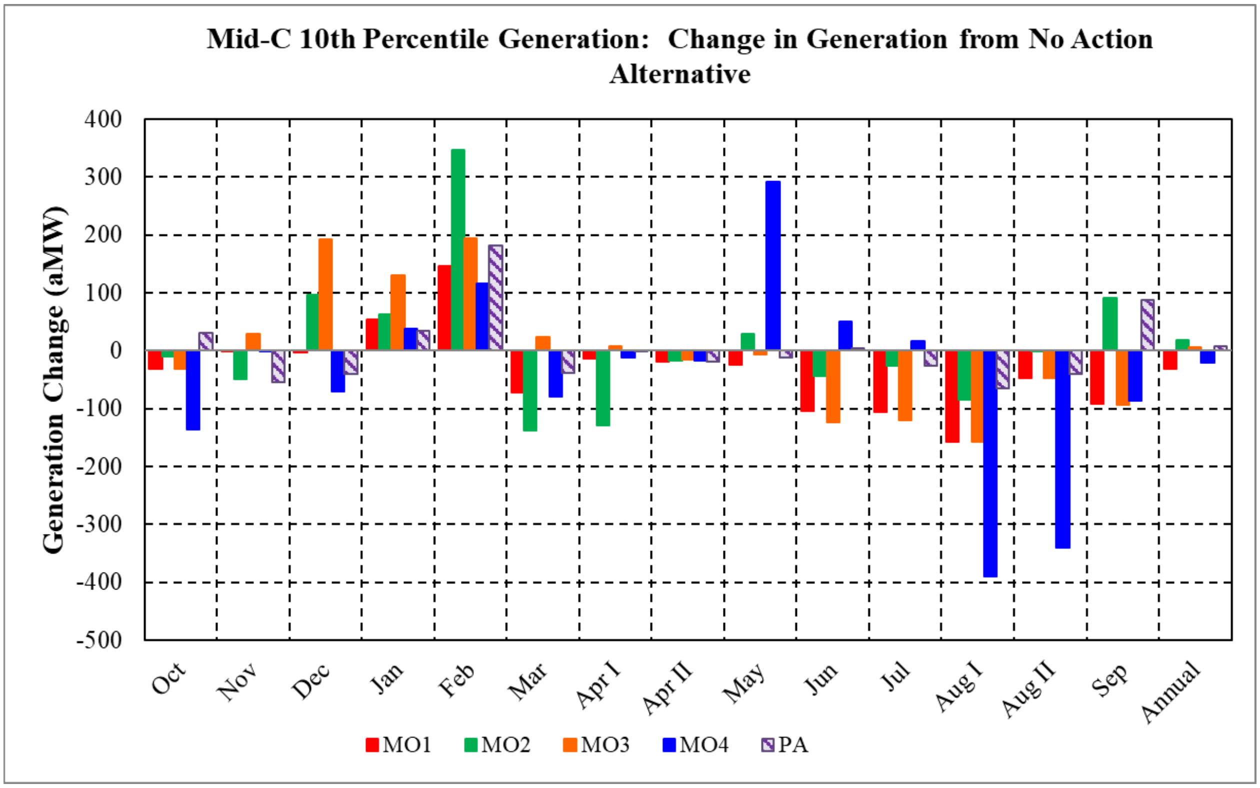
CRS (Federal) P10 Generation: Change from NAA



Federal 10th Percentile Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	5,029	6,575	6,741	6,452	6,202	6,156	5,043	4,472	8,031	7,851	5,954	6,202	5,495	5,239	6,237
MO1	5,026	6,603	6,824	6,535	6,245	5,923	4,765	4,402	6,808	7,296	5,666	5,464	5,271	5,245	6,009
MO2	4,975	6,631	7,266	6,896	6,337	5,853	4,921	4,873	8,928	8,183	6,493	7,512	6,676	5,495	6,591
MO3	4,476	6,225	6,732	6,075	5,556	5,220	3,659	3,658	5,246	5,859	5,173	6,834	6,200	4,434	5,433
MO4	4,476	6,531	6,649	6,430	6,244	3,924	3,715	3,832	5,996	5,653	5,196	5,026	4,545	5,004	5,382
PA	5,132	6,514	6,748	6,815	6,172	6,200	4,353	4,042	6,109	6,738	5,909	6,034	6,000	5,437	6,001

Federal 10th Percentile Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	5,029	6,575	6,741	6,452	6,202	6,156	5,043	4,472	8,031	7,851	5,954	6,202	5,495	5,239	6,237
MO1	-3	28	83	83	43	-233	-278	-71	-1,223	-555	-287	-738	-224	6	-228
MO2	-54	56	526	444	135	-303	-122	401	897	332	540	1,310	1,181	255	354
MO3	-553	-349	-9	-377	-646	-935	-1,383	-814	-2,785	-1,992	-780	632	705	-805	-804
MO4	-553	-43	-92	-22	42	-2,232	-1,328	-640	-2,035	-2,198	-757	-1,175	-950	-236	-855
PA	103	-61	8	363	-30	44	-689	-431	-1,922	-1,113	-44	-168	505	198	-236

Mid-Columbia P10 Generation: Change from NAA



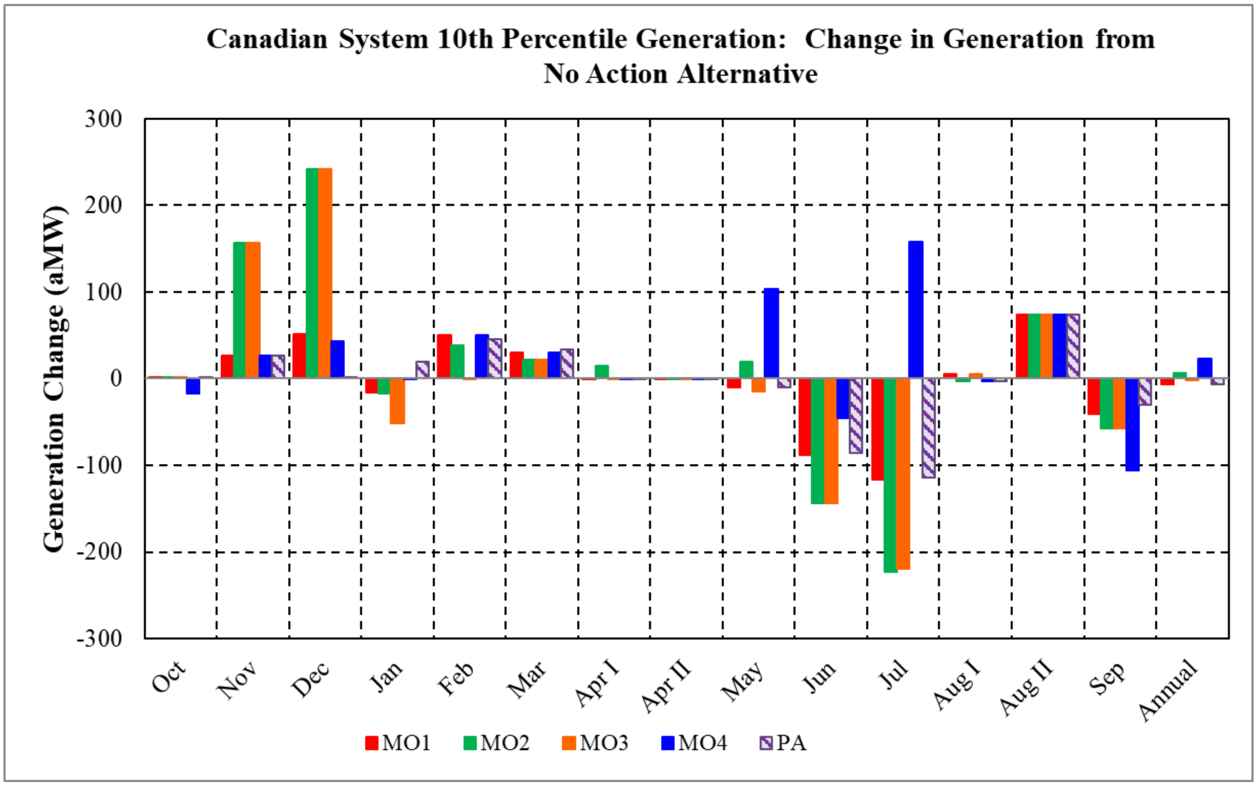
Mid-C 10th Percentile Generation: Change in Generation from No Action Alternative

	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	1,623	2,224	2,234	2,188	1,747	1,784	1,692	1,444	2,437	2,659	1,979	2,167	2,091	1,612	2,018
MO1	1,592	2,223	2,231	2,242	1,893	1,712	1,678	1,426	2,412	2,554	1,873	2,009	2,044	1,521	1,987
MO2	1,612	2,174	2,330	2,251	2,095	1,646	1,563	1,428	2,465	2,615	1,953	2,083	2,090	1,703	2,036
MO3	1,592	2,253	2,427	2,318	1,941	1,809	1,700	1,430	2,429	2,535	1,858	2,009	2,044	1,518	2,024
MO4	1,487	2,223	2,164	2,226	1,863	1,706	1,680	1,428	2,728	2,710	1,995	1,778	1,752	1,525	1,996
PA	1,654	2,170	2,193	2,222	1,929	1,746	1,691	1,425	2,424	2,663	1,954	2,103	2,050	1,700	2,025

Mid-C 10th Percentile Generation: Change in Generation from No Action Alternative

	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	1,623	2,224	2,234	2,188	1,747	1,784	1,692	1,444	2,437	2,659	1,979	2,167	2,091	1,612	2,018
MO1	-31	-1	-3	53	146	-72	-14	-19	-24	-105	-106	-158	-47	-91	-31
MO2	-11	-50	96	62	347	-138	-129	-17	28	-44	-26	-84	-1	91	18
MO3	-31	29	193	129	194	24	8	-15	-7	-124	-121	-158	-47	-94	6
MO4	-136	-1	-70	38	116	-79	-12	-17	291	50	16	-389	-339	-87	-21
PA	31	-55	-41	34	182	-38	-1	-19	-13	4	-25	-64	-41	88	7

Canadian P10 Generation: Change from NAA

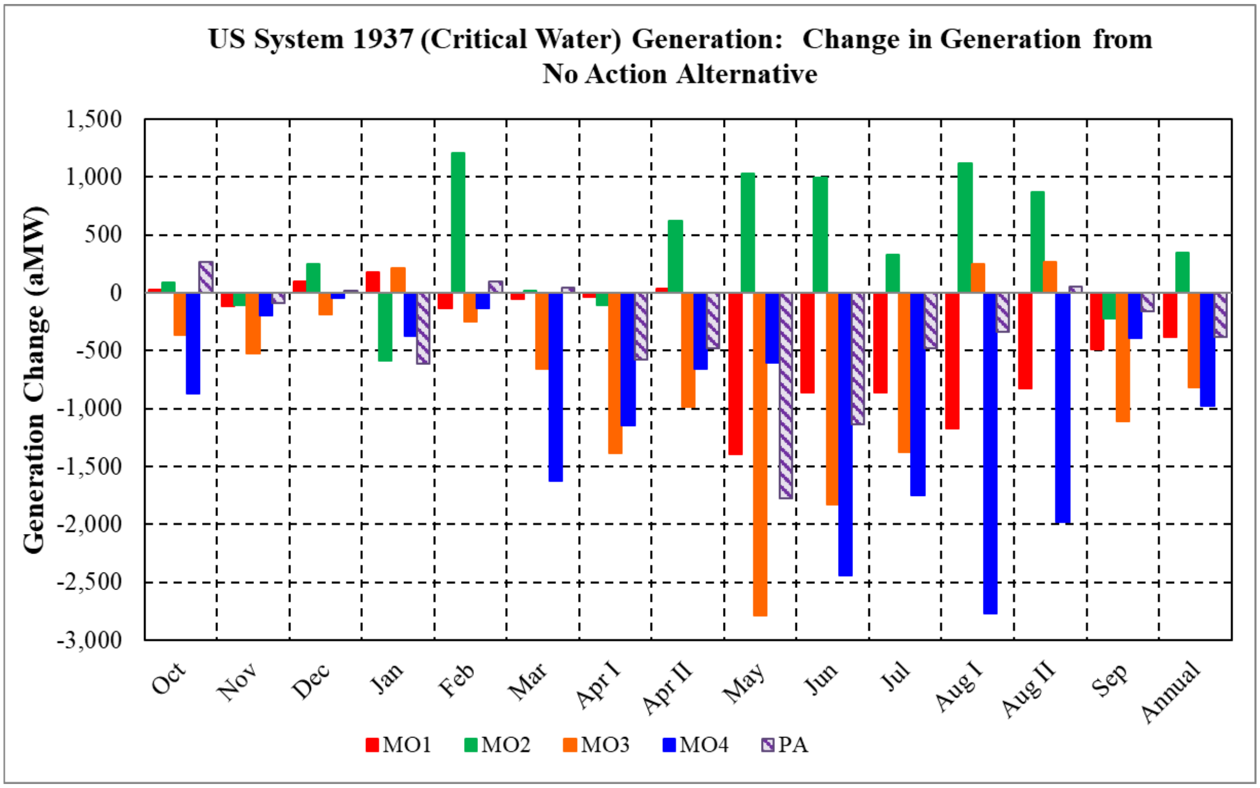


Canadian System 10th Percentile Generation: Change in Generation from No Action Alternative	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	2,114	2,653	3,338	1,799	1,979	1,800	1,528	1,655	3,268	3,598	3,101	3,079	3,170	2,957	2,615
MO1	2,114	2,679	3,390	1,783	2,029	1,830	1,528	1,654	3,258	3,509	2,985	3,085	3,243	2,917	2,608
MO2	2,114	2,810	3,580	1,782	2,017	1,822	1,543	1,654	3,288	3,454	2,879	3,076	3,243	2,900	2,621
MO3	2,114	2,810	3,580	1,748	1,978	1,822	1,528	1,654	3,254	3,454	2,882	3,085	3,243	2,900	2,613
MO4	2,097	2,679	3,382	1,799	2,029	1,830	1,528	1,654	3,372	3,552	3,260	3,077	3,243	2,851	2,638
PA	2,114	2,679	3,338	1,819	2,024	1,833	1,528	1,655	3,258	3,512	2,987	3,076	3,243	2,927	2,608

Canadian System 10th Percentile Generation: Change in Generation from No Action Alternative	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
10th Percentile															
NAA	2,114	2,653	3,338	1,799	1,979	1,800	1,528	1,655	3,268	3,598	3,101	3,079	3,170	2,957	2,615
MO1	0	26	52	-16	50	30	0	0	-10	-88	-117	5	74	-41	-6
MO2	0	157	242	-17	38	22	15	0	19	-144	-223	-3	74	-57	7
MO3	0	157	242	-52	-1	22	0	0	-15	-144	-220	5	74	-57	-2
MO4	-17	26	43	0	50	30	0	0	104	-46	158	-3	74	-106	24
PA	0	26	0	19	45	33	0	0	-10	-85	-115	-3	74	-30	-7

Exhibit 6. Critical Water (1937) Generation for NW-US, CRS (Federal), Mid-Columbia, and Canadian Systems – All Alternatives

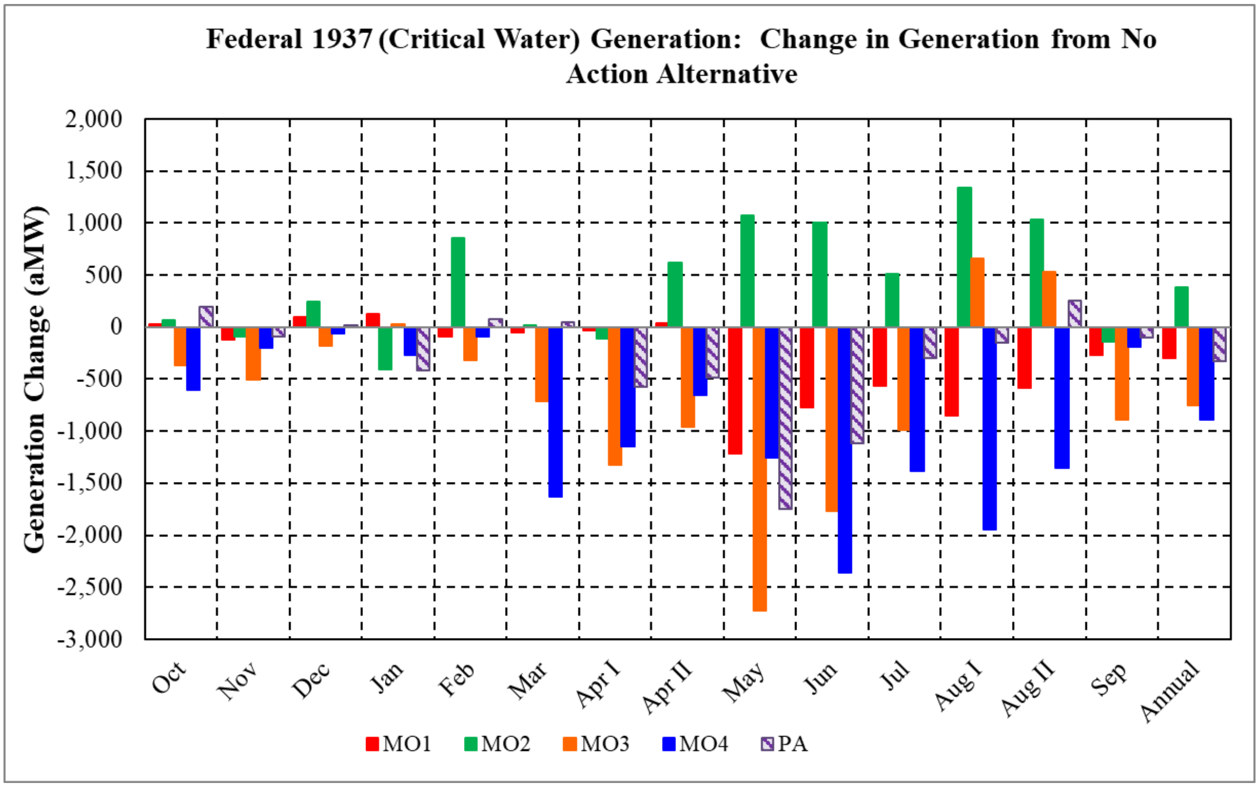
NW-US System Critical Water (1937) Generation: Change from NAA



US System 1937 (Critical Water) Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
MO1	8,794	10,962	11,323	10,931	8,560	8,984	8,671	7,876	10,034	13,056	10,252	9,366	8,576	8,732	9,912
MO2	8,856	10,973	11,470	10,168	9,900	9,051	8,601	8,459	12,451	14,908	11,449	11,661	10,270	8,997	10,645
MO3	8,400	10,558	11,040	10,971	8,443	8,376	7,318	6,855	8,640	12,083	9,738	10,785	9,668	8,109	9,480
MO4	7,894	10,882	11,176	10,385	8,558	7,407	7,560	7,188	10,823	11,472	9,370	7,770	7,429	8,833	9,317
PA	9,030	10,990	11,240	10,140	8,785	9,079	8,129	7,360	9,653	12,777	10,638	10,201	9,459	9,059	9,920

US System 1937 (Critical Water) Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
MO1	28	-117	99	177	-129	-50	-36	35	-1,390	-858	-864	-1,172	-829	-489	-385
MO2	90	-105	245	-586	1,210	17	-106	618	1,027	994	332	1,122	866	-224	348
MO3	-366	-520	-184	217	-247	-658	-1,388	-986	-2,784	-1,831	-1,378	246	263	-1,112	-817
MO4	-873	-197	-48	-369	-131	-1,627	-1,147	-653	-601	-2,442	-1,747	-2,768	-1,976	-388	-980
PA	264	-89	16	-614	95	45	-578	-481	-1,771	-1,137	-478	-338	54	-162	-377

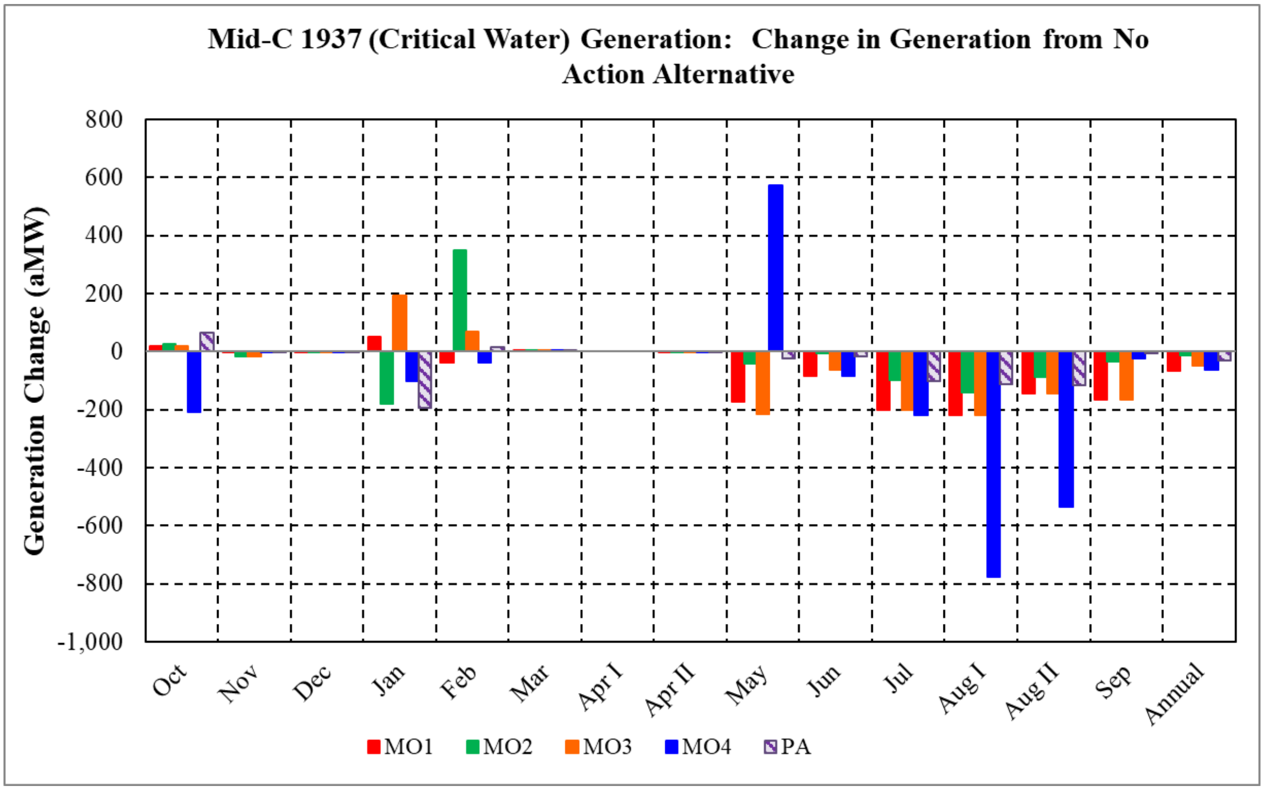
CRS (Federal) Critical Water (1937) Generation: Change from NAA



Federal 1937 (Critical Water) Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	5,221	7,137	6,853	6,421	5,213	5,553	5,013	4,441	7,187	7,857	6,585	6,740	5,927	5,688	6,237
MO1	5,247	7,020	6,952	6,546	5,123	5,502	4,977	4,476	5,972	7,084	6,024	5,888	5,341	5,416	5,940
MO2	5,285	7,048	7,098	6,013	6,073	5,569	4,907	5,059	8,257	8,857	7,092	8,081	6,961	5,550	6,615
MO3	4,853	6,633	6,669	6,446	4,899	4,845	3,688	3,485	4,460	6,084	5,600	7,395	6,460	4,799	5,489
MO4	4,614	6,940	6,788	6,154	5,121	3,925	3,866	3,788	5,935	5,500	5,198	4,791	4,570	5,500	5,349
PA	5,418	7,048	6,869	6,001	5,292	5,598	4,435	3,960	5,438	6,736	6,287	6,593	6,179	5,585	5,909

Federal 1937 (Critical Water) Generation: Change in Generation from No Action Alternative															
	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	5,221	7,137	6,853	6,421	5,213	5,553	5,013	4,441	7,187	7,857	6,585	6,740	5,927	5,688	6,237
MO1	26	-117	99	125	-90	-50	-36	35	-1,215	-773	-561	-852	-586	-272	-297
MO2	64	-89	246	-408	860	17	-106	618	1,070	1,001	507	1,341	1,034	-138	378
MO3	-368	-504	-184	25	-314	-707	-1,324	-956	-2,727	-1,772	-985	655	533	-889	-748
MO4	-607	-197	-65	-267	-92	-1,628	-1,147	-653	-1,252	-2,357	-1,386	-1,949	-1,357	-188	-888
PA	197	-89	16	-420	79	45	-578	-481	-1,749	-1,121	-298	-146	252	-103	-328

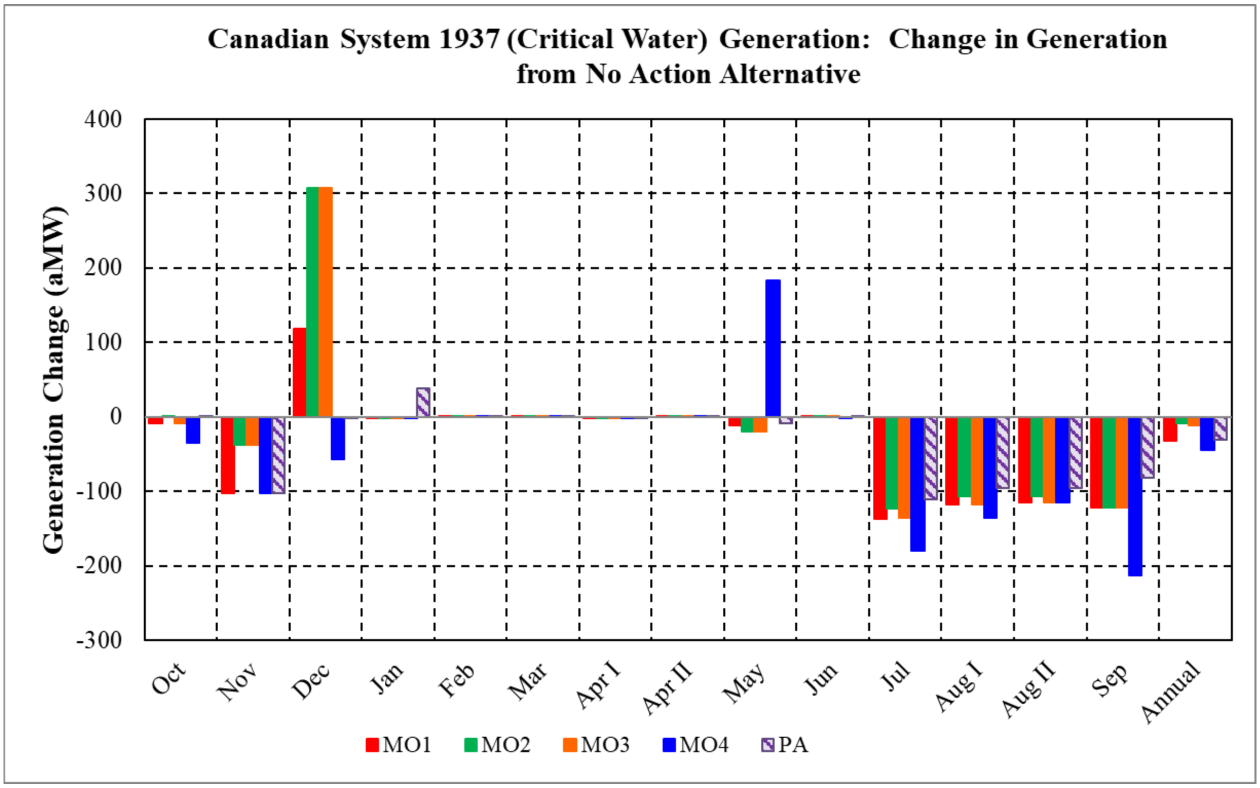
Mid-Columbia Critical Water (1937) Generation: Change from NAA



Mid-C 1937 (Critical Water) Generation: Change in Generation from No Action Alternative	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	1,796	2,521	2,446	2,328	1,750	1,713	1,707	1,430	2,123	2,848	2,241	2,439	2,272	1,877	2,133
MO1	1,815	2,521	2,446	2,381	1,710	1,713	1,707	1,430	1,948	2,763	2,038	2,221	2,128	1,713	2,068
MO2	1,822	2,504	2,446	2,150	2,100	1,713	1,707	1,430	2,080	2,842	2,144	2,299	2,185	1,844	2,120
MO3	1,815	2,504	2,446	2,521	1,817	1,713	1,707	1,430	1,908	2,785	2,040	2,221	2,128	1,713	2,085
MO4	1,586	2,521	2,446	2,227	1,710	1,713	1,707	1,430	2,696	2,763	2,022	1,664	1,738	1,854	2,069
PA	1,863	2,521	2,446	2,134	1,766	1,713	1,707	1,430	2,101	2,833	2,139	2,327	2,156	1,871	2,101

Mid-C 1937 (Critical Water) Generation: Change in Generation from No Action Alternative	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	1,796	2,521	2,446	2,328	1,750	1,713	1,707	1,430	2,123	2,848	2,241	2,439	2,272	1,877	2,133
MO1	19	0	0	52	-39	0	0	0	-175	-85	-203	-218	-144	-164	-65
MO2	26	-17	0	-178	350	0	0	0	-43	-7	-96	-140	-86	-33	-12
MO3	19	-17	0	192	67	0	0	0	-214	-64	-201	-218	-144	-164	-47
MO4	-210	0	0	-101	-39	0	0	0	574	-85	-218	-775	-534	-22	-63
PA	67	0	0	-194	16	0	0	0	-22	-16	-102	-112	-116	-5	-32

Canadian Critical Water (1937) Generation: Change from NAA



Canadian System 1937 (Critical Water) Generation: Change in Generation from No Action Alternative	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	2,076	3,528	3,644	2,813	2,479	2,212	1,597	1,633	3,334	3,932	2,939	3,432	4,537	3,254	2,989
MO1	2,067	3,425	3,761	2,813	2,479	2,212	1,597	1,633	3,323	3,933	2,802	3,314	4,422	3,132	2,957
MO2	2,076	3,489	3,951	2,813	2,479	2,212	1,597	1,633	3,314	3,933	2,816	3,326	4,430	3,132	2,981
MO3	2,067	3,489	3,951	2,813	2,479	2,212	1,597	1,633	3,314	3,933	2,804	3,314	4,422	3,132	2,978
MO4	2,041	3,425	3,586	2,813	2,479	2,212	1,597	1,633	3,517	3,930	2,760	3,296	4,422	3,041	2,945
PA	2,076	3,425	3,644	2,851	2,479	2,212	1,597	1,633	3,325	3,933	2,829	3,337	4,442	3,171	2,959

Canadian System 1937 (Critical Water) Generation: Change in Generation from No Action Alternative	October	November	December	January	February	March	April I	April II	May	June	July	August I	August II	September	Annual
Water Year 1937 (Critical Water)															
NAA	2,076	3,528	3,644	2,813	2,479	2,212	1,597	1,633	3,334	3,932	2,939	3,432	4,537	3,254	2,989
MO1	-9	-102	118	0	0	0	0	0	-11	1	-137	-118	-115	-122	-32
MO2	0	-38	307	0	0	0	0	0	-20	2	-123	-106	-107	-122	-8
MO3	-9	-38	307	0	0	0	0	0	-20	2	-135	-118	-115	-122	-11
MO4	-35	-102	-57	0	0	0	0	0	183	-1	-179	-136	-115	-213	-44
PA	0	-102	0	38	0	0	0	0	-9	1	-110	-95	-95	-82	-30

Exhibit 7. Hydropower Generation Impacts of Snake River Dam Breaching

This exhibit examines the hydropower effects of breaching Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams as a single measure alternative.

Overview

Bonneville prepared the hydropower analyses because of the high-profile nature of this measure. Snake River dam breaching is included as one of several measures in MO3.
The generation effects of dam breaching were difficult to distinguish from the total effects of the measures in MO3. This analysis assesses the loss of lower Snake River generation due to breaching as a single measure.

Methodology

Bonneville used the HYDSIM model to estimate the generation averages for the 14 periods in each of the 80 years study record for the NAA. Detailed inputs for the NAA study are in the *Hydroregulation Appendix I* of the CRSO EIS. Bonneville modified the NAA by simply treating the four lower Snake River dams as gauge points with no powerhouses. All other NAA input was unchanged.

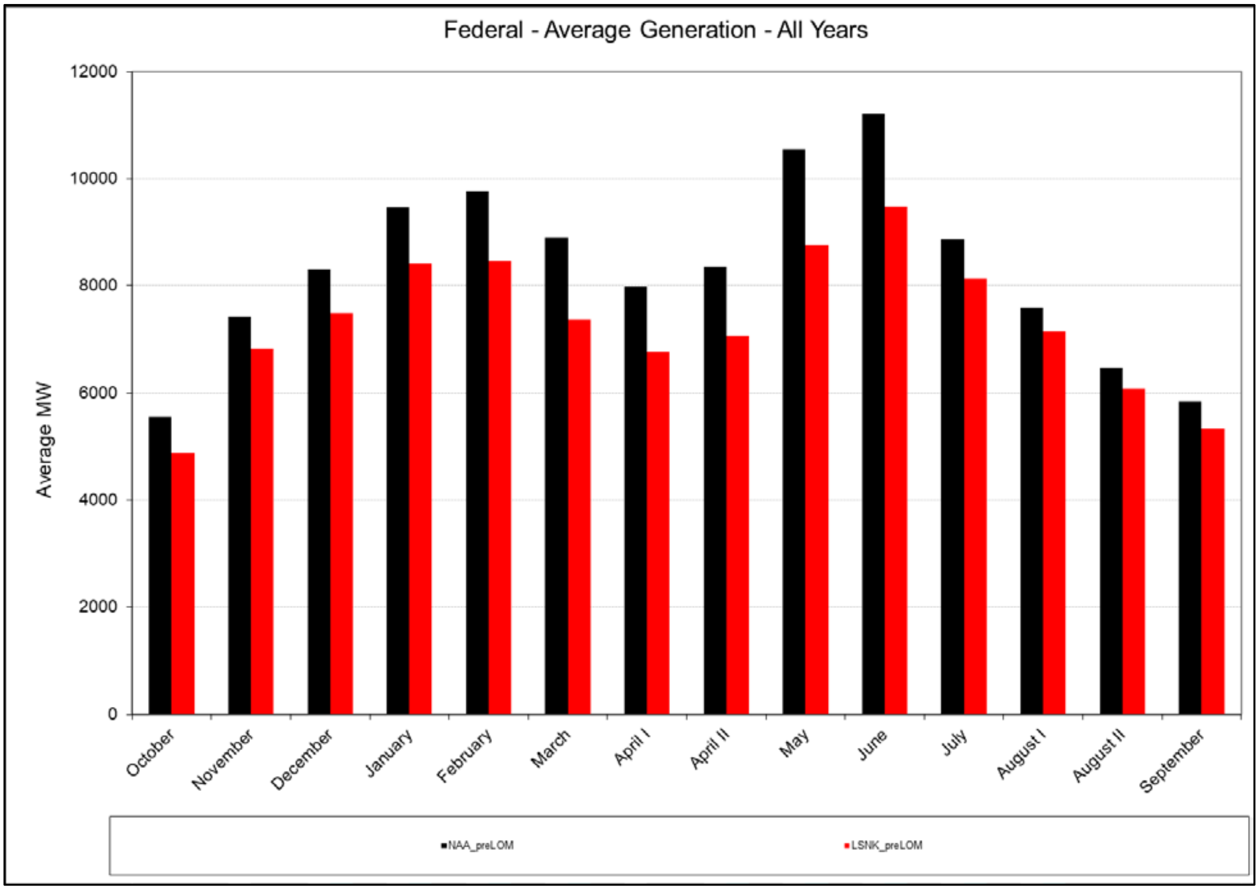
Results

Because the four Snake River dams are Federal dams operated by the Corps, results are provided only for the CRS (Federal) system average and critical water generation.

Average Generation

Average CRS (Federal) system results and changes from the NAA are provided below.

CRS (Federal) Average Generation: NAA without Lower Snake River Dam Generation

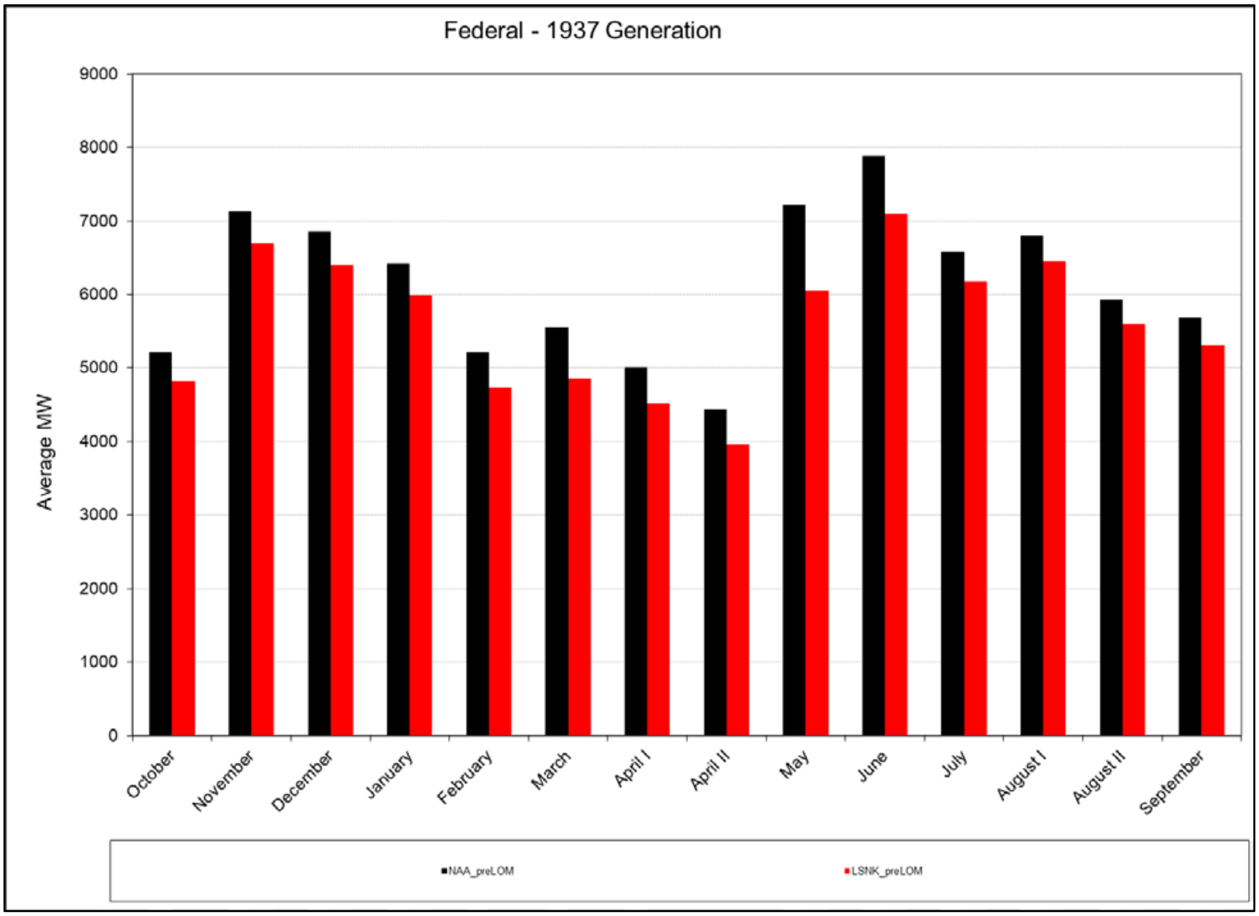


	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	5,549	7,422	8,306	9,465	9,763	8,889	7,978	8,356	10,542	11,207	8,871	7,585	6,459	5,844	8,411
Dam Br.	4,877	6,834	7,489	8,417	8,458	7,367	6,762	7,061	8,759	9,481	8,129	7,148	6,074	5,332	7,381
Change	-672	-588	-817	-1,048	-1,306	-1,522	-1,216	-1,294	-1,783	-1,726	-741	-436	-385	-512	-1,030
% Change	-12.1	-7.9	-9.8	-11.1	-13.4	-17.1	-15.2	-15.5	-16.9	-15.4	-8.4	-5.8	-6.0	-8.8	-12.2

Critical Water (1937) Generation

Critical Water (1937) CRS (Federal) system results and changes from the NAA are provided below.

CRS (Federal) Critical Water (1937) Generation: NAA without Lower Snake River Dams



	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NAA	5,221	7,137	6,853	6,421	5,213	5,553	5,014	4,441	7,215	7,889	6,583	6,800	5,927	5,689	6,245
No Dams	4,826	6,695	6,402	5,994	4,735	4,854	4,523	3,962	6,044	7,097	6,178	6,458	5,603	5,316	5,706
Change	-396	-441	-450	-427	-478	-699	-491	-479	-1,170	-791	-405	-342	-324	-373	-538
% Change	-7.6%	-6.2%	-6.6%	-6.7%	-9.2%	-12.6%	-9.8%	-10.8%	-16.2%	-10.0%	-6.2%	-5.0%	-5.5%	-6.6%	-8.6%

Breaching of the four Snake River dams results in year-round generation losses that reflect Snake River seasonal flows. Generation losses are low in September through November because of generally lower natural streamflows. Losses are higher in January through March from higher natural flows and storage releases from upstream reservoirs. Losses remain relatively high April through June from spring runoff flows; losses would be higher, but generation is already reduced during these months for fish passage spills. Losses are relatively low in August due to low flows and already lower generation in the NAA for fish passage spills.

Exhibit 8. Generation Summaries for MO Alternatives

This exhibit provides summaries of the energy and peak generation metrics.

MO1 Generation Results Summary: NAA vs. MO1

		OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NW-US System **Average**	NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
	MO1	9,280	12,188	13,277	15,343	15,315	13,607	12,326	12,911	15,956	17,358	13,915	11,025	9,813	9,306	13,200
	Change	-83	-17	-242	228	16	-117	-317	-558	-506	-147	-258	-745	-416	92	-173
NW-US System **P10**	NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
	MO1	8,438	10,715	10,983	10,915	10,085	9,573	8,260	7,637	11,286	12,426	9,274	8,687	8,385	8,222	9,865
	Change	-92	53	79	49	-143	-140	-476	-177	-1,284	-591	-284	-912	-250	-85	-280
NW-US System **Critical Water**	NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
	MO1	8,794	10,962	11,323	10,931	8,560	8,984	8,671	7,876	10,034	13,056	10,252	9,366	8,576	8,732	9,912
	Change	28	-117	99	177	-129	-50	-36	35	-1,390	-858	-864	-1,172	-829	-489	-385
CRS Fed **Peak Load 120hr**	NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
	MO1	7,668	9,828	10,832	11,960	12,192	11,384	9,821	9,896	12,304	13,324	11,708	10,162	8,616	8,212	10,712
	Change	-51	6	-206	73	11	-156	23	-322	-134	179	109	-728	-625	155	-72
CRS Fed **Peak Load 120hr P10**	NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
	MO1	7,066	8,847	9,415	9,129	8,566	8,402	6,903	6,004	9,970	10,906	8,287	8,173	7,297	7,280	8,504
	Change	28	-8	32	82	44	-279	103	-12	-1,135	-499	-504	-1,193	-673	-17	-265
CRS Fed **Peak Load 120hr Critical Yr**	NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
	MO1	7,383	9,411	9,514	9,142	7,797	7,964	6,907	6,123	8,454	10,555	9,043	8,919	7,567	7,595	8,471
	Change	56	-98	59	102	-29	7	162	106	-1,088	-998	-886	-1,717	-918	-373	-371
CRS Fed **HLH Ave**	NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
	MO1	6,795	8,909	9,515	10,876	11,055	10,163	9,000	9,181	11,521	12,470	10,718	9,015	7,685	7,324	9,723
	Change	-51	10	-197	108	-7	-141	-110	-436	-301	29	13	-708	-572	157	-109
CRS Fed **HLH P10**	NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
	MO1	6,193	7,899	8,037	7,815	7,326	7,093	6,082	5,371	8,980	9,747	7,430	7,170	6,498	6,384	7,456
	Change	34	27	81	135	61	-283	77	-66	-1,132	-350	-455	-1,148	-601	2	-232
CRS Fed **HLH Critical Yr**	NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
	MO1	6,516	8,524	8,212	7,833	6,016	6,672	6,085	5,525	7,641	9,370	8,069	7,887	6,751	6,673	7,395
	Change	59	-101	106	152	-94	-1	104	126	-1,156	-881	-778	-1,422	-882	-363	-343

MO2 Generation Results Summary: NAA vs. MO2

		OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NW-US System **Average**	NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
	MO2	9,370	12,428	13,970	15,686	15,768	13,344	12,349	14,071	17,564	17,865	14,945	13,344	11,678	9,392	13,826
	Change	6	222	450	572	468	-380	-294	602	1,102	361	772	1,574	1,449	177	453
NW-US System **P10**	NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
	MO2	8,480	10,736	11,722	11,613	10,319	9,458	8,278	8,077	13,364	13,377	10,166	10,757	9,729	8,592	10,524
	Change	-50	73	818	747	91	-255	-458	263	794	360	609	1,158	1,095	285	380
NW-US System **Critical Water**	NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
	MO2	8,856	10,973	11,470	10,168	9,900	9,051	8,601	8,459	12,451	14,908	11,449	11,661	10,270	8,997	10,645
	Change	90	-105	245	-586	1,210	17	-106	618	1,027	994	332	1,122	866	-224	348
CRS Fed **Peak Load 120hr**	NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
	MO2	7,794	10,246	11,330	12,192	12,394	11,214	10,085	11,053	13,673	14,025	12,605	12,051	10,456	8,281	11,293
	Change	75	424	292	304	213	-327	287	835	1,235	880	1,006	1,162	1,215	224	509
CRS Fed **Peak Load 120hr P10**	NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
	MO2	7,085	9,276	9,796	9,434	8,643	8,282	7,082	6,756	11,814	12,108	9,473	10,349	8,969	7,677	9,185
	Change	48	421	413	386	121	-399	282	741	709	703	682	984	999	380	415
CRS Fed **Peak Load 120hr Critical Yr**	NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
	MO2	7,506	9,868	9,674	8,772	8,455	8,019	7,087	6,907	10,588	12,717	10,377	11,258	9,263	7,870	9,261
	Change	179	359	219	-268	629	62	342	890	1,046	1,164	448	622	778	-98	419
CRS Fed **HLH Ave**	NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
	MO2	6,868	9,327	10,057	11,117	11,312	9,944	9,216	10,096	12,571	13,020	11,357	10,944	9,499	7,373	10,229
	Change	21	427	345	349	250	-361	106	479	749	579	653	1,221	1,242	206	397
CRS Fed **HLH P10**	NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
	MO2	6,143	8,349	8,563	8,191	7,388	6,955	6,193	6,038	10,744	10,470	8,447	9,249	8,126	6,755	8,073
	Change	-16	477	607	511	123	-421	188	601	631	374	562	931	1,027	372	385
CRS Fed **HLH Critical Yr**	NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
	MO2	6,573	8,968	8,417	7,183	7,189	6,728	6,195	6,191	9,687	10,975	9,247	10,056	8,412	6,932	8,114
	Change	116	343	311	-498	1,079	55	214	792	890	724	400	747	779	-104	376

MO3 Generation Results Summary: NAA vs. MO3

		OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NW-US System **Average**	NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
	MO3	8,718	11,971	13,139	13,872	13,819	12,273	10,754	10,980	13,676	15,473	13,022	12,448	10,945	8,410	12,236
	Change	-646	-234	-380	-1,243	-1,481	-1,451	-1,889	-2,490	-2,786	-2,032	-1,151	678	716	-804	-1,137
NW-US System **P10**	NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
	MO3	7,865	10,441	11,279	10,725	9,692	8,825	7,287	6,908	9,678	10,960	8,691	9,938	9,208	7,329	9,347
	Change	-665	-221	374	-140	-536	-888	-1,449	-907	-2,892	-2,056	-867	339	573	-978	-798
NW-US System **Critical Water**	NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
	MO3	8,400	10,558	11,040	10,971	8,443	8,376	7,318	6,855	8,640	12,083	9,738	10,785	9,668	8,109	9,480
	Change	-366	-520	-184	217	-247	-658	-1,388	-986	-2,784	-1,831	-1,378	246	263	-1,112	-817
CRS Fed **Peak Load 120hr**	NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
	MO3	7,062	9,447	10,251	10,433	10,446	9,697	8,519	7,894	9,778	11,075	10,470	11,501	10,037	7,282	9,573
	Change	-657	-375	-787	-1,455	-1,735	-1,843	-1,279	-2,324	-2,660	-2,071	-1,129	612	796	-776	-1,210
CRS Fed **Peak Load 120hr P10**	NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
	MO3	6,451	8,477	9,295	8,768	7,974	7,598	6,232	5,147	8,733	9,449	7,679	9,925	8,640	6,348	7,982
	Change	-586	-378	-87	-280	-548	-1,082	-568	-868	-2,371	-1,956	-1,111	560	670	-949	-787
CRS Fed **Peak Load 120hr Critical Yr**	NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
	MO3	6,959	8,957	9,203	8,971	7,704	7,318	6,257	5,097	7,061	9,884	8,398	10,750	8,970	6,953	8,082
	Change	-368	-552	-252	-69	-122	-639	-488	-920	-2,481	-1,669	-1,531	114	485	-1,015	-761
CRS Fed **HLH Ave**	NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
	MO3	6,114	8,557	9,024	9,356	9,404	8,590	7,648	7,103	8,818	10,170	9,531	10,442	9,085	6,323	8,582
	Change	-732	-342	-689	-1,412	-1,658	-1,715	-1,463	-2,514	-3,003	-2,271	-1,174	719	828	-844	-1,250
CRS Fed **HLH P10**	NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
	MO3	5,506	7,525	7,871	7,265	6,486	6,285	5,338	4,419	7,600	8,183	6,805	8,831	7,790	5,393	6,847
	Change	-654	-347	-85	-416	-779	-1,091	-667	-1,018	-2,513	-1,914	-1,080	513	690	-990	-841
CRS Fed **HLH Critical Yr**	NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
	MO3	6,026	8,067	7,841	7,696	5,852	5,890	5,382	4,239	6,024	8,592	7,476	9,628	8,097	5,963	6,932
	Change	-431	-558	-265	15	-258	-783	-599	-1,160	-2,773	-1,659	-1,371	319	464	-1,073	-805

MO4 Generation Results Summary: NAA vs. MO4

		OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NW-US System **Average**	NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
	MO4	8,906	12,122	13,117	15,358	15,250	10,175	9,705	10,918	13,669	15,042	12,339	10,077	8,893	8,906	12,034
	Change	-457	-83	-402	244	-49	-3,549	-2,938	-2,552	-2,793	-2,462	-1,834	-1,693	-1,336	-308	-1,339
NW-US System **P10**	NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
	MO4	7,700	10,643	10,921	10,864	10,085	7,435	7,185	7,151	11,420	11,385	8,792	7,829	7,322	7,912	9,319
	Change	-830	-20	17	-2	-143	-2,278	-1,551	-663	-1,150	-1,632	-766	-1,770	-1,313	-395	-826
NW-US System **Critical Water**	NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
	MO4	7,894	10,882	11,176	10,385	8,558	7,407	7,560	7,188	10,823	11,472	9,370	7,770	7,429	8,833	9,317
	Change	-873	-197	-48	-369	-131	-1,627	-1,147	-653	-601	-2,442	-1,747	-2,768	-1,976	-388	-980
CRS Fed **Peak Load 120hr**	NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
	MO4	7,449	9,831	10,704	11,966	12,156	7,395	6,777	7,718	9,620	10,594	9,870	8,772	7,408	7,911	9,384
	Change	-270	9	-334	78	-25	-4,146	-3,021	-2,500	-2,818	-2,551	-1,729	-2,118	-1,833	-147	-1,400
CRS Fed **Peak Load 120hr P10**	NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
	MO4	6,476	8,847	9,318	8,982	8,565	5,578	4,909	5,152	8,882	9,427	6,945	6,662	6,143	7,039	7,616
	Change	-562	-8	-64	-66	44	-3,103	-1,891	-863	-2,223	-1,978	-1,845	-2,704	-1,827	-258	-1,153
CRS Fed **Peak Load 120hr Critical Yr**	NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
	MO4	6,669	9,408	9,387	8,838	7,796	5,514	4,985	5,156	9,440	9,434	7,391	6,688	6,165	7,935	7,773
	Change	-658	-101	-68	-202	-30	-2,443	-1,760	-861	-102	-2,119	-2,538	-3,948	-2,320	-33	-1,070
CRS Fed **HLH Ave**	NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
	MO4	6,520	8,912	9,357	10,881	11,011	6,335	6,122	7,053	8,761	9,704	8,730	7,833	6,709	6,977	8,402
	Change	-326	13	-356	113	-52	-3,969	-2,989	-2,564	-3,061	-2,738	-1,974	-1,890	-1,548	-190	-1,430
CRS Fed **HLH P10**	NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
	MO4	5,582	7,899	7,787	7,646	7,324	4,421	4,309	4,640	7,998	7,691	6,376	6,166	5,731	6,120	6,600
	Change	-577	27	-169	-35	59	-2,955	-1,696	-797	-2,115	-2,405	-1,509	-2,152	-1,368	-263	-1,088
CRS Fed **HLH Critical Yr**	NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
	MO4	5,773	8,520	8,012	7,342	6,015	4,383	4,456	4,606	7,920	7,692	6,522	6,290	5,840	6,919	6,643
	Change	-684	-105	-94	-339	-95	-2,290	-1,525	-793	-877	-2,559	-2,325	-3,019	-1,793	-117	-1,095

PA Generation Results Summary: NAA vs. PA

		OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP	Annual
NW-US System **Average**	NAA	9,364	12,205	13,519	15,115	15,299	13,724	12,643	13,469	16,462	17,504	14,173	11,770	10,229	9,215	13,373
	PA	9,558	12,137	13,525	15,385	15,524	13,551	11,692	12,216	14,815	16,621	14,132	11,750	10,900	9,360	13,144
	Change	194	-68	6	270	225	-174	-951	-1,253	-1,647	-883	-41	-20	671	145	-229
NW-US System **P10**	NAA	8,530	10,662	10,904	10,866	10,228	9,713	8,736	7,814	12,570	13,017	9,557	9,599	8,635	8,307	10,144
	PA	8,679	10,682	10,853	11,089	10,061	9,886	7,976	7,682	10,806	12,229	9,535	9,295	9,025	8,555	9,947
	Change	148	20	-52	223	-167	173	-760	-132	-1,764	-788	-22	-305	390	248	-197
NW-US System **Critical Water**	NAA	8,766	11,079	11,224	10,754	8,690	9,034	8,707	7,841	11,424	13,914	11,117	10,539	9,405	9,221	10,297
	PA	9,030	10,990	11,240	10,140	8,785	9,079	8,129	7,360	9,653	12,777	10,638	10,201	9,459	9,059	9,920
	Change	264	-89	16	-614	95	45	-578	-481	-1,771	-1,137	-478	-338	54	-162	-377
CRS Fed **Peak Load 120hr**	NAA	7,719	9,822	11,038	11,888	12,181	11,540	9,798	10,218	12,438	13,145	11,599	10,890	9,241	8,058	10,784
	PA	7,907	9,940	10,947	12,069	12,229	11,332	9,634	9,241	11,226	12,647	11,738	10,921	9,838	8,292	10,671
	Change	188	118	-92	181	49	-208	-164	-977	-1,212	-498	140	32	597	234	-113
CRS Fed **Peak Load 120hr P10**	NAA	7,037	8,855	9,383	9,047	8,522	8,681	6,800	6,015	11,105	11,405	8,791	9,366	7,970	7,297	8,769
	PA	7,208	9,041	9,328	9,293	8,364	8,670	6,905	5,496	9,566	10,610	8,500	9,045	8,234	7,691	8,596
	Change	171	187	-55	245	-157	-11	105	-519	-1,539	-795	-290	-321	264	394	-174
CRS Fed **Peak Load 120hr Critical Yr**	NAA	7,327	9,509	9,455	9,040	7,826	7,957	6,745	6,017	9,542	11,553	9,929	10,636	8,485	7,968	8,842
	PA	7,605	9,828	9,396	8,713	7,798	7,969	6,880	5,497	8,582	10,669	9,328	10,011	8,502	7,979	8,613
	Change	278	319	-59	-327	-28	12	135	-520	-960	-884	-601	-625	17	11	-229
CRS Fed **HLH Ave**	NAA	6,846	8,899	9,713	10,768	11,062	10,305	9,110	9,617	11,822	12,442	10,704	9,723	8,257	7,167	9,832
	PA	6,972	9,034	9,630	10,952	11,126	10,099	8,723	8,631	10,465	11,867	10,724	9,710	8,836	7,346	9,672
	Change	126	135	-83	184	64	-206	-388	-986	-1,357	-575	20	-13	579	179	-160
CRS Fed **HLH P10**	NAA	6,159	7,872	7,956	7,681	7,265	7,376	6,005	5,437	10,113	10,097	7,885	8,318	7,099	6,383	7,688
	PA	6,244	8,100	7,907	8,050	7,120	7,370	5,980	5,113	8,576	9,386	7,687	8,004	7,513	6,753	7,545
	Change	85	229	-49	369	-145	-6	-25	-324	-1,537	-711	-198	-314	414	370	-143
CRS Fed **HLH Critical Yr**	NAA	6,457	8,625	8,106	7,681	6,110	6,673	5,981	5,399	8,797	10,251	8,847	9,309	7,633	7,036	7,738
	PA	6,652	8,960	8,047	7,099	6,147	6,673	5,969	5,021	7,700	9,399	8,351	8,833	7,729	6,981	7,489
	Change	195	335	-59	-582	37	0	-12	-378	-1,097	-852	-496	-476	96	-55	-249

Exhibit 9. Average Annual Generation for Revenue Determination

This exhibit provides 80 years of monthly generation used for estimating Bonneville's hydropower sales revenue and supplements the information in Section 3.6. A summary of 1937 generation that was used to determine Bonneville's FELCC is also provided in the attached tables.

Summary of 1937 Generation Used to Determine Bonneville's FELCC

CRSO Alternative	WY	OCT	NOV	DEC	JAN	FEB	MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	SEP	AVG.
NAA	1937	5,221	7,137	6,853	6,421	5,213	5,553	5,013	4,441	7,187	7,857	6,585	6,740	5,927	5,688	6,237
MO1	1937	5,247	7,020	6,952	6,546	5,123	5,502	4,977	4,476	5,972	7,084	6,024	5,888	5,341	5,416	5,940
MO2	1937	5,285	7,048	7,098	6,013	6,073	5,569	4,907	5,059	8,257	8,857	7,092	8,081	6,961	5,550	6,615
MO3	1937	4,853	6,633	6,669	6,446	4,899	4,845	3,688	3,485	4,460	6,084	5,600	7,395	6,460	4,799	5,489
MO4	1937	4,614	6,940	6,788	6,154	5,121	3,925	3,866	3,788	5,935	5,500	5,198	4,791	4,570	5,500	5,349
PA	1937	5,418	7,048	6,869	6,001	5,292	5,598	4,435	3,960	5,438	6,736	6,287	6,593	6,179	5,585	5,909

NAA: Average Annual Generation for Bonneville Revenue Determination

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	SEP	AVG.
1929	5,053	6,729	6,790	6,911	6,903	6,258	5,018	4,476	6,441	9,073	5,534	6,477	5,844	5,606	6,343
1930	5,280	6,966	6,363	6,013	6,463	5,939	5,481	5,580	6,394	7,802	6,971	7,239	6,356	6,071	6,378
1931	5,334	6,831	6,872	5,846	5,724	6,158	5,716	4,334	6,568	7,071	6,649	7,135	6,086	5,517	6,187
1932	4,970	6,495	6,640	6,276	4,840	8,647	9,361	10,862	11,873	12,199	7,960	6,869	6,592	5,969	7,731
1933	5,371	6,425	8,611	10,249	11,120	9,420	7,131	6,764	10,102	13,008	11,509	9,338	7,983	5,926	8,936
1934	6,055	9,980	12,467	13,098	13,146	10,889	11,627	11,033	10,744	10,106	5,750	6,280	5,860	5,301	9,552
1935	5,303	5,900	7,650	9,538	10,640	8,058	6,206	7,435	9,710	9,244	8,642	8,893	6,020	5,334	7,843
1936	5,163	6,745	6,785	6,087	6,130	6,464	6,121	9,056	12,742	11,105	7,476	6,359	5,724	5,200	7,295
1937	5,221	7,137	6,853	6,421	5,213	5,553	5,013	4,441	7,187	7,857	6,585	6,740	5,927	5,688	6,237
1938	5,271	6,575	7,816	9,651	9,633	9,063	9,195	11,259	11,101	10,626	8,787	5,811	5,363	5,739	8,329
1939	5,424	6,495	6,479	7,893	8,412	6,795	6,538	8,425	10,216	7,215	6,961	6,212	5,791	5,373	7,055
1940	5,412	7,292	7,206	8,188	6,210	8,601	8,495	9,493	9,932	8,027	5,976	6,333	5,596	5,537	7,281
1941	5,426	7,656	7,821	7,221	6,943	7,228	5,463	4,252	7,015	8,301	6,368	6,864	5,872	5,716	6,741
1942	5,352	7,474	9,132	9,756	8,745	6,321	6,061	7,145	8,622	11,692	9,463	7,538	6,924	6,157	8,040
1943	5,452	6,239	7,198	10,286	10,958	9,561	11,826	11,780	11,032	12,687	11,686	7,635	6,457	5,565	9,110
1944	5,020	6,706	6,546	6,711	7,368	5,850	4,816	3,972	5,672	7,354	5,607	6,784	5,632	5,443	6,066
1945	5,225	6,826	6,882	6,084	5,704	5,854	4,964	4,042	9,110	11,152	6,205	6,502	5,759	5,462	6,597
1946	5,065	6,871	7,876	9,275	8,843	9,802	10,216	11,345	11,493	10,819	9,496	7,575	6,478	5,874	8,598
1947	5,058	7,255	10,882	11,599	11,853	10,322	7,998	8,239	11,629	11,025	9,347	7,233	5,927	5,866	9,115
1948	7,821	8,867	9,377	11,448	11,726	8,285	7,239	10,767	12,988	12,884	9,176	9,139	7,838	6,279	9,687
1949	5,641	7,034	7,093	9,127	8,482	10,134	8,075	11,257	12,531	10,044	6,384	6,027	5,156	5,213	8,075
1950	5,007	6,571	7,989	11,100	11,250	10,859	10,652	9,863	10,564	12,764	12,387	8,595	7,727	6,057	9,403
1951	6,266	9,186	10,993	12,736	13,597	12,142	11,416	10,578	11,287	10,555	9,784	8,611	6,530	5,868	10,060
1952	7,283	8,048	9,382	10,910	11,032	8,768	10,061	11,901	12,916	10,907	9,325	7,817	5,823	5,183	9,290
1953	5,030	7,025	6,718	7,558	11,849	7,627	5,119	5,469	10,253	13,288	10,870	7,023	6,760	5,956	8,170
1954	5,410	7,337	8,617	10,778	11,738	9,560	7,973	8,767	11,213	12,282	12,211	10,320	10,059	7,898	9,623
1955	5,741	8,253	8,693	7,621	8,017	5,625	6,356	5,394	9,291	13,077	12,223	9,097	7,433	5,779	8,204
1956	5,682	8,712	10,926	13,142	12,992	11,309	11,039	11,755	12,325	13,193	10,346	7,906	6,655	5,913	10,257

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	SEP	AVG.
1957	5,735	6,966	8,712	9,525	8,256	9,118	8,791	8,374	13,051	13,692	7,332	6,298	5,500	5,547	8,534
1958	5,183	6,841	7,191	9,693	9,959	8,185	7,182	9,537	13,224	12,452	7,517	6,398	5,883	5,626	8,351
1959	5,297	8,051	10,349	12,629	13,013	9,527	9,263	8,661	10,421	12,778	11,833	8,717	7,061	8,682	9,929
1960	9,048	10,070	10,319	10,591	10,178	8,578	10,509	10,315	9,866	11,333	9,040	8,195	5,856	5,644	9,334
1961	5,425	7,366	7,953	10,085	10,525	10,651	8,328	7,890	11,066	12,616	7,483	6,731	6,136	5,537	8,590
1962	4,931	6,830	7,778	8,889	11,062	6,736	8,666	10,604	10,511	11,264	7,596	7,843	6,622	5,614	8,146
1963	5,841	8,237	9,959	9,910	10,813	7,244	6,247	5,578	9,910	10,982	8,795	8,054	6,291	6,188	8,398
1964	5,235	6,762	7,906	7,835	9,407	6,227	8,030	6,685	10,676	13,334	12,062	9,300	6,995	6,790	8,469
1965	6,393	7,892	11,120	13,589	14,460	11,897	7,560	10,550	11,640	12,725	9,348	9,340	7,945	5,797	10,191
1966	5,784	6,864	8,224	9,004	10,478	7,263	8,007	7,905	8,825	9,927	8,645	7,728	5,994	5,640	7,937
1967	5,126	6,616	8,700	11,050	12,475	9,684	7,818	6,721	10,359	12,682	10,923	8,287	6,420	6,125	9,009
1968	5,559	7,581	8,303	9,904	10,722	10,218	5,383	4,835	9,375	11,444	9,335	8,606	7,223	7,359	8,562
1969	6,584	8,873	9,405	12,456	13,097	11,110	10,183	10,803	12,497	11,586	8,809	6,783	5,600	5,743	9,714
1970	5,410	7,152	7,302	9,255	11,039	7,411	5,713	5,480	10,624	12,730	6,799	6,810	5,839	5,377	7,894
1971	5,190	6,796	7,898	12,990	14,156	12,193	10,747	10,547	12,550	13,361	11,480	9,310	6,895	6,137	10,098
1972	5,734	7,159	8,535	11,997	13,011	13,337	11,124	9,552	12,050	12,819	11,540	9,717	8,704	6,373	10,169
1973	5,781	7,303	8,061	8,545	8,808	6,606	5,043	3,964	8,125	8,379	6,198	6,911	5,591	5,539	6,998
1974	5,176	6,620	9,133	13,879	13,794	13,205	11,449	11,669	11,590	12,735	12,389	9,301	8,269	6,063	10,394
1975	5,062	6,688	7,295	9,222	9,944	9,790	6,638	7,607	10,376	12,864	12,480	8,225	7,410	6,486	8,757
1976	6,576	9,164	12,055	12,281	12,849	10,598	10,774	10,715	12,448	11,474	11,617	11,044	11,099	8,297	10,763
1977	5,990	6,768	6,914	7,183	7,688	5,762	4,221	3,641	6,351	6,707	5,625	6,787	5,860	4,932	6,174
1978	4,650	6,611	8,541	9,320	7,902	9,356	9,952	8,695	10,580	10,530	10,482	6,847	5,936	6,985	8,392
1979	6,049	7,228	6,961	8,575	7,105	7,791	7,048	7,482	10,679	8,363	5,958	6,320	5,447	5,575	7,288
1980	5,312	6,775	6,423	8,584	8,046	6,609	5,154	7,699	12,781	12,099	7,395	5,983	5,582	5,800	7,666
1981	5,333	7,112	10,032	11,375	12,156	7,492	5,041	5,282	10,527	13,386	10,570	9,594	8,122	6,133	8,995
1982	5,301	7,642	8,313	10,595	13,372	13,503	10,095	9,061	11,741	12,867	12,619	9,344	7,707	7,161	10,081
1983	6,496	7,647	8,972	11,119	10,845	12,257	8,743	8,373	10,652	11,542	11,802	9,268	7,378	6,326	9,543
1984	5,622	9,464	9,200	11,001	10,744	10,458	9,040	10,717	10,584	12,491	11,315	8,600	6,669	6,338	9,552
1985	5,632	7,498	8,144	9,424	9,113	7,456	8,441	9,202	10,364	7,958	5,781	5,835	5,156	5,510	7,588

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	SEP	AVG.
1986	5,826	8,230	8,459	9,987	11,683	12,681	10,025	9,664	10,454	11,303	7,649	7,108	5,770	5,479	8,982
1987	5,036	7,211	8,305	8,228	6,903	7,787	6,145	7,302	10,204	8,486	5,499	6,300	5,446	5,339	7,136
1988	5,128	6,739	6,417	6,025	5,453	5,614	5,199	6,123	8,531	7,994	7,086	6,804	5,997	5,583	6,389
1989	5,070	6,891	7,679	6,763	5,832	8,017	8,432	10,179	10,411	8,341	6,692	6,638	5,740	5,407	7,224
1990	5,282	7,671	8,846	9,471	11,794	9,213	7,362	10,391	9,034	11,679	9,783	8,620	6,760	5,453	8,708
1991	5,022	9,422	9,691	10,798	12,509	9,245	8,672	8,011	10,346	11,018	11,413	9,496	7,722	5,405	9,298
1992	5,259	6,908	6,269	7,591	7,057	7,280	5,762	5,570	9,110	7,520	5,651	6,455	5,784	5,372	6,650
1993	5,254	7,010	6,984	6,437	5,291	6,955	6,689	5,633	10,646	9,672	7,428	6,716	5,968	5,500	6,985
1994	5,259	7,182	7,088	6,454	7,177	6,209	4,999	7,328	8,438	7,743	6,708	6,549	5,705	5,604	6,674
1995	5,202	6,454	7,241	7,600	8,065	9,512	7,048	6,779	9,960	12,098	8,591	7,151	6,161	6,101	7,863
1996	6,369	10,243	13,435	13,523	14,111	13,197	10,545	11,537	11,396	12,927	11,616	9,108	6,522	5,966	10,959
1997	5,352	7,373	9,326	14,166	14,346	13,458	11,257	11,749	12,333	13,127	11,784	9,183	7,521	7,076	10,661
1998	8,259	8,554	8,124	8,804	10,643	7,954	5,973	6,676	12,664	13,120	9,296	8,046	5,540	5,464	8,820
1999	5,116	6,405	9,066	12,252	11,463	13,474	9,711	10,767	9,842	11,824	11,604	10,533	9,531	5,748	9,753
2000	5,084	9,389	9,936	10,158	9,841	9,332	9,780	10,989	10,173	8,793	8,345	8,020	5,558	5,464	8,632
2001	5,252	6,741	6,830	7,066	7,464	6,133	4,766	3,974	6,521	6,421	5,914	6,827	5,668	4,957	6,153
2002	4,491	6,630	7,148	6,654	6,339	7,391	7,921	10,066	10,072	12,511	10,395	6,251	5,584	5,379	7,662
2003	5,347	7,056	6,743	6,839	6,255	8,589	7,750	8,877	9,652	11,264	6,556	5,973	5,423	5,037	7,280
2004	5,272	7,732	8,188	7,843	7,326	7,062	6,815	7,123	8,680	9,482	6,431	5,857	6,065	5,861	7,231
2005	5,936	7,248	8,838	8,823	9,065	7,407	6,432	5,526	9,788	8,820	7,251	6,636	5,752	5,242	7,544
2006	5,031	7,486	8,122	10,111	12,333	8,591	10,938	11,120	12,445	12,452	7,678	5,982	5,229	4,916	8,785
2007	4,814	7,429	8,179	10,272	8,851	10,900	8,863	8,632	9,862	9,268	8,078	6,465	5,356	4,711	8,083
2008	5,373	7,395	6,852	8,361	8,030	8,142	5,922	5,753	10,940	13,225	9,767	6,104	6,270	5,578	7,974
Average	5,548	7,420	8,302	9,453	9,726	8,819	7,842	8,220	10,324	10,895	8,796	7,592	6,455	5,843	8,340

MO1: Average Annual Generation for Bonneville Revenue Determination

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1929	5,065	6,708	6,697	6,886	7,115	5,876	4,999	4,550	5,016	8,608	5,446	5,885	5,595	5,555	6,112
1930	5,363	6,946	6,477	6,390	6,460	5,881	4,631	4,764	5,679	7,477	6,442	6,305	5,850	5,716	6,130
1931	5,399	7,055	7,201	6,374	5,617	6,073	5,825	4,341	5,217	5,997	6,593	6,693	5,920	5,816	6,064
1932	5,014	6,474	6,519	6,328	4,966	8,514	9,058	10,078	11,936	12,174	7,698	6,233	6,188	6,086	7,628
1933	5,241	6,609	8,048	10,306	11,085	9,666	7,336	6,773	9,342	13,213	11,672	8,800	7,339	6,280	8,868
1934	5,774	9,321	12,303	13,067	12,877	10,722	11,609	11,108	11,036	10,123	5,550	5,457	5,549	5,308	9,388
1935	5,344	5,877	7,085	9,617	10,823	7,799	6,053	7,127	9,121	8,732	8,651	7,728	5,710	5,443	7,632
1936	5,134	6,709	6,799	6,299	6,119	6,401	5,284	7,102	12,420	11,098	7,240	5,886	5,592	5,400	7,132
1937	5,247	7,020	6,952	6,546	5,123	5,502	4,977	4,476	5,972	7,084	6,024	5,888	5,341	5,416	5,940
1938	5,268	7,136	7,384	10,119	9,397	9,188	8,503	10,555	11,264	10,830	8,613	5,271	5,186	5,967	8,318
1939	5,279	6,472	6,468	7,918	8,499	6,708	6,116	7,791	9,080	6,934	6,830	5,912	5,669	5,589	6,867
1940	5,437	6,980	7,478	8,156	6,640	8,068	7,748	8,184	9,123	8,175	5,635	5,594	5,412	5,700	7,072
1941	5,242	7,625	8,178	6,998	6,259	6,249	6,304	4,441	6,787	6,893	6,420	6,526	5,972	6,333	6,552
1942	5,133	7,271	8,847	10,334	8,225	5,927	4,993	6,605	8,023	11,805	9,360	6,251	6,330	6,028	7,750
1943	5,389	6,527	7,064	10,595	11,283	9,430	11,643	11,925	10,614	12,667	11,580	6,903	6,083	5,576	9,064
1944	5,058	6,697	6,719	7,254	7,550	5,260	4,044	3,540	4,621	6,677	5,641	6,424	5,703	5,824	5,922
1945	5,176	6,795	7,088	6,089	5,713	5,809	4,992	3,905	7,926	10,853	5,968	5,921	5,564	5,515	6,427
1946	5,107	6,637	7,408	9,433	9,577	9,305	9,422	11,146	11,985	10,922	9,225	6,799	6,126	5,941	8,515
1947	4,950	7,489	10,439	11,792	12,090	10,328	7,937	8,139	11,441	10,564	9,242	6,445	5,532	6,012	9,016
1948	7,799	8,844	8,837	11,764	11,526	8,482	6,805	9,467	13,389	13,363	8,833	8,272	7,257	6,486	9,594
1949	5,438	7,323	7,221	9,068	8,505	10,350	8,277	11,646	12,472	9,191	5,903	5,150	4,868	5,249	7,970
1950	5,064	6,551	7,523	11,115	11,211	11,144	10,067	9,120	10,081	13,124	13,017	8,143	7,012	6,422	9,357
1951	6,056	9,141	10,672	12,647	13,584	12,115	11,828	11,196	11,569	10,074	9,513	7,744	6,117	5,831	9,948
1952	7,444	8,018	8,840	11,270	11,373	8,877	9,344	11,422	13,158	11,037	9,175	6,883	5,567	5,214	9,244
1953	5,106	6,973	6,827	7,838	11,554	7,692	5,212	5,242	9,348	13,531	10,743	6,287	6,362	6,082	8,077
1954	5,365	7,306	8,187	10,927	11,323	10,080	6,885	7,632	11,503	12,809	12,747	9,431	9,485	8,276	9,597
1955	5,641	8,370	8,143	8,335	8,049	5,384	6,155	5,670	8,216	13,385	12,646	8,936	6,384	6,177	8,154
1956	5,624	8,690	10,469	13,109	12,724	11,304	10,922	12,147	12,764	13,667	10,066	7,143	6,248	6,012	10,209

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1957	5,588	7,134	8,339	9,240	8,107	8,784	10,661	8,930	13,372	13,941	7,080	5,725	5,276	5,631	8,539
1958	5,213	6,810	6,985	9,903	10,241	8,291	6,291	7,910	12,991	12,695	7,147	5,827	5,702	5,704	8,222
1959	5,317	7,992	9,896	12,754	12,800	9,879	8,972	8,909	10,016	13,102	11,740	7,867	6,557	8,923	9,857
1960	8,870	10,057	10,030	10,925	10,204	8,493	10,346	9,093	9,517	11,518	9,009	7,075	5,581	5,847	9,201
1961	5,366	7,232	7,519	10,344	9,671	10,834	9,930	7,604	10,706	13,030	7,212	6,058	5,784	5,447	8,493
1962	5,027	6,958	7,344	9,141	11,185	6,652	7,986	9,463	10,199	11,493	7,410	7,117	6,255	5,617	8,008
1963	5,903	8,208	9,432	10,118	11,019	7,159	6,397	5,660	8,679	10,890	8,846	7,209	5,912	6,448	8,254
1964	5,075	6,732	7,472	8,655	9,112	6,180	7,015	5,216	10,268	13,794	12,078	8,524	6,604	7,229	8,348
1965	6,203	7,862	10,662	13,612	14,392	11,856	7,842	10,495	11,416	12,745	9,233	8,671	7,602	6,182	10,098
1966	5,650	6,546	7,851	9,591	10,096	7,179	7,089	6,248	8,418	10,093	8,358	7,091	5,700	5,607	7,688
1967	5,151	6,688	8,327	11,125	12,333	10,212	7,779	6,629	9,437	12,987	10,800	7,570	6,210	6,014	8,908
1968	5,460	7,710	7,870	10,149	10,924	10,354	4,529	4,225	8,495	11,578	8,924	7,841	7,044	7,680	8,405
1969	6,364	8,770	8,949	12,658	12,923	11,372	10,521	11,437	12,785	11,580	8,344	6,131	5,388	5,543	9,646
1970	5,480	7,395	7,660	9,629	10,610	7,325	4,790	4,408	9,762	12,791	6,788	6,359	5,730	5,639	7,789
1971	5,236	6,657	7,180	12,942	14,228	11,862	10,936	11,180	12,888	13,569	11,266	8,463	6,437	6,231	10,017
1972	5,634	7,448	8,103	11,826	13,330	13,130	11,342	8,847	12,376	13,158	11,299	8,989	8,035	6,774	10,130
1973	5,907	7,272	8,418	9,002	8,700	6,333	4,443	3,932	6,887	7,489	5,669	6,052	5,167	5,167	6,710
1974	5,251	7,201	8,711	13,795	13,691	12,944	11,439	11,827	11,983	13,222	12,934	8,969	7,149	6,730	10,493
1975	4,946	6,783	7,780	9,241	10,105	9,643	6,558	7,640	9,594	12,931	12,336	7,421	6,956	7,006	8,712
1976	6,380	9,015	11,768	12,715	12,702	10,784	10,195	10,013	12,623	11,539	11,601	10,496	11,038	8,865	10,738
1977	5,676	6,615	7,001	7,634	7,840	5,076	4,173	3,696	4,854	5,216	5,547	6,636	5,962	5,311	5,907
1978	4,724	6,546	8,837	9,112	7,888	9,226	8,531	7,591	10,851	10,468	10,312	6,231	5,695	7,330	8,281
1979	5,819	7,197	7,320	8,368	7,856	7,001	6,572	6,505	10,713	7,718	5,761	5,708	5,290	5,660	7,118
1980	5,333	6,681	6,606	8,632	7,730	6,627	4,354	6,659	12,965	12,279	7,097	5,401	5,279	5,741	7,544
1981	5,295	7,082	10,095	11,357	11,631	7,406	5,125	5,506	9,535	13,666	10,336	9,106	7,388	6,331	8,841
1982	5,251	7,612	8,471	10,711	13,161	13,407	9,229	8,095	11,915	12,967	12,751	9,050	6,833	7,632	10,021
1983	6,276	7,616	8,891	11,345	10,957	12,604	8,676	8,384	9,816	11,197	11,720	8,775	6,523	6,593	9,428
1984	5,434	9,448	8,771	11,062	10,833	10,421	8,406	9,863	9,842	12,849	11,340	7,968	6,395	6,734	9,410
1985	5,417	7,468	7,711	10,022	8,613	6,879	8,930	8,858	9,873	7,671	5,630	5,056	4,978	5,677	7,396

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1986	5,731	8,071	8,027	9,756	11,486	13,195	9,988	9,143	9,900	11,792	7,052	6,446	5,602	5,515	8,821
1987	5,040	7,180	7,872	8,424	7,539	7,345	6,273	7,504	9,608	7,570	5,101	5,464	4,995	5,001	6,897
1988	5,052	7,020	7,016	6,026	5,956	5,980	4,327	5,145	6,811	7,808	6,671	6,167	5,609	5,406	6,198
1989	5,101	7,116	7,353	6,962	6,052	7,990	9,007	10,503	9,795	7,519	6,363	5,704	5,489	5,337	7,083
1990	5,207	7,534	8,460	10,174	11,482	9,191	6,500	9,126	8,634	11,987	9,423	7,926	6,381	5,621	8,534
1991	4,977	9,264	9,334	10,898	12,486	9,458	8,929	7,927	9,785	10,739	11,374	8,984	7,068	5,761	9,188
1992	5,046	6,779	6,367	7,705	7,794	6,829	4,992	4,487	7,775	7,157	5,502	5,873	5,451	5,357	6,388
1993	5,130	6,980	7,344	6,438	5,297	6,822	6,559	5,307	10,105	9,092	7,255	6,480	5,980	5,973	6,895
1994	5,252	6,969	7,169	6,371	7,064	6,149	4,081	6,342	7,726	7,312	6,130	5,964	5,374	5,440	6,367
1995	5,283	6,925	6,826	7,990	8,521	9,565	7,166	5,953	9,157	12,148	8,479	6,010	5,980	6,266	7,802
1996	5,905	10,142	13,331	13,485	14,250	12,893	9,431	11,810	11,425	12,986	11,637	8,467	6,254	5,915	10,817
1997	5,260	7,064	8,909	14,130	14,205	13,060	11,910	12,120	12,761	13,512	11,850	8,803	6,851	7,576	10,656
1998	8,057	8,177	8,481	9,038	10,495	7,867	4,980	5,338	11,960	13,334	9,282	7,599	5,633	5,809	8,678
1999	5,091	6,264	8,354	12,224	11,671	13,235	9,954	11,303	9,362	11,692	11,625	9,895	9,391	6,202	9,659
2000	4,902	8,965	9,521	10,420	10,085	9,401	9,062	10,889	10,318	8,253	7,874	7,377	5,302	5,290	8,437
2001	5,270	6,686	7,190	7,518	7,427	5,627	4,780	4,050	4,834	5,293	5,851	6,323	5,552	5,167	5,927
2002	4,575	6,645	6,877	6,855	6,679	7,332	7,257	9,110	9,346	12,979	10,154	5,671	5,299	5,457	7,546
2003	5,398	7,069	7,051	7,065	6,650	8,151	7,978	8,650	8,649	10,787	6,041	5,399	5,229	5,059	7,125
2004	5,351	7,701	7,755	7,979	7,613	6,978	5,712	5,801	7,924	9,490	6,216	5,251	5,655	6,058	7,018
2005	5,729	7,577	8,965	9,618	9,017	6,940	6,193	5,415	8,454	8,200	7,032	6,104	5,450	5,130	7,346
2006	5,122	7,604	7,690	10,827	12,037	8,568	10,621	10,315	12,481	12,769	7,418	5,411	5,024	4,913	8,730
2007	4,905	7,399	7,673	10,453	9,281	10,753	8,759	8,173	9,187	8,888	7,736	5,729	5,136	4,608	7,892
2008	5,463	7,408	7,211	8,329	8,248	7,972	4,868	4,218	10,757	13,527	9,366	5,505	5,891	5,794	7,858
Average	5,491	7,410	8,133	9,636	9,741	8,717	7,567	7,794	9,858	10,800	8,631	6,936	6,113	5,990	8,208

MO2: Average Annual Generation for Bonneville Revenue Determination

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1929	5,315	6,803	6,854	7,413	7,310	5,990	4,923	4,986	7,140	9,776	6,014	8,084	7,167	5,987	6,758
1930	5,224	7,042	6,634	6,311	6,339	5,983	6,073	6,687	8,400	8,300	7,123	8,343	7,287	5,831	6,783
1931	5,298	7,253	7,758	6,016	6,021	6,176	5,852	4,799	7,819	7,094	7,134	8,526	7,156	5,707	6,626
1932	5,056	6,568	6,672	6,187	5,948	8,747	9,677	11,267	13,263	12,376	9,048	8,615	8,229	5,924	8,229
1933	5,474	6,818	8,733	11,174	10,971	8,118	6,489	8,066	11,104	13,454	12,305	11,190	9,804	6,014	9,323
1934	6,017	9,760	12,515	12,920	12,820	11,286	12,120	12,551	11,930	10,653	6,266	7,370	7,094	5,542	9,920
1935	5,253	5,865	7,552	10,814	11,157	7,195	4,110	7,540	11,176	9,885	10,011	10,292	7,500	5,530	8,252
1936	5,363	6,734	7,042	6,794	6,668	7,108	5,740	8,999	13,821	10,778	8,224	7,943	7,111	5,508	7,751
1937	5,285	7,048	7,098	6,013	6,073	5,569	4,907	5,059	8,257	8,857	7,092	8,081	6,961	5,550	6,615
1938	5,402	6,342	7,940	10,316	10,125	9,053	7,526	12,854	12,556	11,423	9,993	7,405	6,679	5,918	8,851
1939	5,490	6,459	7,285	8,995	8,822	6,585	5,935	7,487	11,224	7,079	7,902	8,095	7,329	5,834	7,507
1940	5,327	7,203	8,120	7,772	7,366	9,365	8,151	9,233	11,469	8,805	6,291	7,309	6,707	5,576	7,753
1941	5,384	7,258	8,731	7,569	5,847	6,643	6,161	4,519	8,960	8,650	7,248	8,627	7,432	5,860	7,139
1942	5,411	7,644	9,367	10,188	9,253	5,853	6,050	7,711	9,873	12,148	10,663	8,930	8,342	6,042	8,493
1943	5,480	6,840	7,621	11,417	11,711	7,648	11,339	13,357	12,433	12,683	12,345	9,614	8,238	5,595	9,570
1944	5,063	6,795	7,332	7,601	7,532	5,202	4,863	4,391	6,133	7,945	6,343	8,439	6,993	5,672	6,492
1945	5,288	6,805	7,652	6,296	5,004	6,045	5,011	4,819	10,732	11,960	6,871	8,075	7,090	5,536	7,070
1946	5,106	6,606	7,998	9,750	9,544	9,026	9,411	13,220	12,744	11,455	10,478	9,288	7,897	5,909	9,040
1947	5,137	7,734	10,991	11,543	12,501	9,373	8,032	10,022	13,032	11,422	10,294	8,463	7,274	5,893	9,554
1948	7,887	9,232	9,482	11,696	11,437	8,401	7,316	11,712	13,568	13,118	10,260	10,965	9,600	6,128	10,081
1949	5,699	7,659	7,779	9,341	9,868	9,223	8,683	11,980	13,163	9,774	6,981	7,252	6,290	5,369	8,486
1950	5,035	6,648	8,138	11,325	12,216	9,906	10,632	11,201	11,658	13,317	13,318	10,565	9,600	5,989	9,866
1951	6,180	9,521	11,191	12,342	13,815	12,398	12,211	12,024	12,525	11,384	10,620	10,297	7,844	5,554	10,540
1952	7,623	8,429	9,488	11,542	11,892	7,663	9,679	12,645	13,545	11,588	10,438	9,589	7,201	5,520	9,765
1953	5,046	7,068	6,984	8,966	11,182	7,408	4,739	6,141	11,619	13,592	11,958	8,776	8,489	6,081	8,650
1954	5,416	7,624	8,738	11,210	11,778	9,086	7,995	10,295	12,393	12,888	13,176	11,977	11,681	7,923	10,094
1955	5,999	8,711	8,814	8,921	8,135	5,432	6,097	5,977	10,219	13,717	13,119	10,983	9,054	5,927	8,758
1956	5,647	9,021	11,031	12,814	12,776	11,530	11,772	12,375	13,042	13,615	11,302	9,792	8,409	5,783	10,637

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1957	5,714	7,498	8,891	9,474	9,558	8,532	10,381	8,492	13,556	13,964	8,314	8,045	7,028	5,843	9,019
1958	5,168	7,038	7,545	10,476	11,365	7,336	5,554	10,147	13,745	12,653	8,196	8,149	7,439	5,898	8,737
1959	5,207	8,355	10,457	12,515	12,488	9,555	9,172	10,495	11,963	13,349	12,460	10,499	8,677	8,761	10,361
1960	9,509	10,432	10,509	10,698	10,816	8,774	10,817	10,513	10,973	11,658	10,290	9,786	7,417	5,825	9,890
1961	5,506	7,477	8,075	10,134	10,981	11,032	8,608	7,513	12,245	13,049	8,369	8,259	7,500	5,811	9,040
1962	4,851	7,165	7,900	10,643	10,760	5,767	7,967	11,659	11,780	11,757	8,687	9,710	8,306	5,907	8,651
1963	5,643	8,578	10,065	10,520	11,034	6,925	5,812	6,216	10,923	11,721	10,197	9,400	7,840	6,366	8,872
1964	5,418	6,881	8,028	9,037	9,770	5,093	6,902	7,981	12,065	13,678	12,970	11,224	8,817	6,883	8,935
1965	6,440	8,256	11,234	13,309	14,266	11,932	8,103	11,927	13,189	12,594	10,614	11,251	9,837	5,908	10,677
1966	5,756	6,851	8,453	10,109	10,080	6,897	7,002	8,552	10,337	10,541	9,650	9,556	7,322	5,822	8,383
1967	5,213	6,820	8,878	11,657	12,126	9,269	7,913	7,315	11,437	13,107	11,772	9,994	7,834	6,059	9,391
1968	5,560	8,037	8,425	10,720	11,178	10,369	5,083	4,393	9,759	12,182	10,170	10,388	8,943	7,484	9,020
1969	6,677	9,221	9,511	12,622	12,419	10,961	10,930	12,321	13,230	12,251	9,553	8,392	6,913	5,643	10,098
1970	5,246	7,726	8,217	9,918	11,549	7,684	5,569	4,879	11,097	12,704	7,889	8,810	7,586	5,899	8,425
1971	5,186	6,758	7,818	12,895	14,017	11,977	11,126	12,125	13,280	13,801	12,141	11,169	8,562	5,932	10,418
1972	5,729	7,787	8,657	12,176	13,038	13,300	12,127	11,024	12,802	13,262	12,156	11,407	10,455	6,201	10,630
1973	6,093	7,622	8,970	9,057	8,253	6,348	4,639	4,440	8,924	9,182	6,549	8,231	6,549	5,535	7,370
1974	5,128	7,411	9,335	13,638	13,674	13,088	12,284	12,460	12,541	13,170	13,306	11,094	10,042	6,407	10,874
1975	5,318	6,860	8,306	10,447	9,979	7,903	6,524	8,930	11,553	12,885	13,235	10,185	9,298	6,537	9,208
1976	6,608	9,381	12,254	12,538	12,530	10,377	11,123	12,078	13,226	11,941	12,379	12,842	12,864	8,540	11,187
1977	6,119	6,726	7,787	8,180	7,897	4,833	4,026	3,776	6,452	6,764	5,996	8,153	7,017	5,338	6,460
1978	4,742	6,634	9,354	8,828	9,364	8,562	9,569	8,799	12,368	10,800	11,475	8,654	7,588	7,100	8,877
1979	6,133	7,542	7,877	8,549	8,718	8,423	5,639	5,784	12,550	8,128	6,681	7,793	6,792	5,724	7,779
1980	5,426	6,551	6,644	8,334	7,159	6,735	5,281	9,630	13,789	12,737	8,358	7,513	6,955	5,791	8,020
1981	5,335	7,401	10,660	11,381	11,847	7,565	5,093	5,857	11,861	14,225	11,578	11,488	9,921	6,316	9,521
1982	5,355	7,882	9,022	11,131	13,112	12,989	10,429	10,751	12,718	13,235	13,456	11,325	9,568	7,267	10,587
1983	6,584	8,014	9,408	10,999	11,788	12,513	8,523	9,639	11,746	11,081	12,608	11,195	8,995	6,379	10,022
1984	5,691	9,707	9,306	11,629	11,692	10,443	8,142	11,895	11,288	12,625	12,188	10,587	8,423	6,365	10,030
1985	5,711	7,812	8,266	10,310	9,988	6,400	7,380	9,849	11,842	8,866	6,510	7,018	6,366	5,588	8,037

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1986	5,787	8,564	8,581	9,796	11,960	13,362	10,453	11,470	11,349	11,817	8,252	8,808	7,134	5,696	9,488
1987	5,057	7,425	8,427	8,132	8,205	7,446	6,221	7,128	11,942	7,963	5,775	7,408	6,340	5,394	7,441
1988	4,977	7,047	7,497	6,010	5,964	6,082	5,208	7,790	8,928	8,860	7,496	8,065	6,947	5,516	6,867
1989	4,817	7,208	7,909	7,376	6,316	7,667	8,467	11,714	11,686	9,090	7,308	7,641	6,922	5,498	7,694
1990	5,137	7,959	9,043	10,277	11,908	9,403	7,260	10,602	10,021	12,276	10,615	10,482	8,495	5,625	9,205
1991	4,961	9,635	9,866	11,654	11,954	9,430	8,038	8,677	11,643	11,853	12,077	11,370	9,456	5,513	9,770
1992	5,411	6,884	6,984	7,910	8,140	6,930	5,180	5,784	9,877	7,450	6,207	7,885	7,013	5,702	7,036
1993	4,895	7,133	7,901	6,602	3,989	7,546	7,670	5,918	12,373	9,162	8,599	9,030	8,063	6,030	7,493
1994	5,218	7,080	7,342	7,180	6,867	6,226	5,048	8,611	9,577	8,189	6,958	7,784	6,612	5,753	7,035
1995	5,191	7,029	7,386	8,238	9,312	9,242	6,303	5,988	11,641	12,030	10,005	8,508	7,855	6,204	8,381
1996	6,022	10,552	13,449	13,253	14,363	13,241	10,435	13,097	12,750	13,245	12,416	11,019	8,203	5,815	11,365
1997	5,364	7,383	9,431	13,999	14,109	13,067	11,976	12,366	12,805	13,475	12,715	11,165	9,464	7,205	10,986
1998	8,472	8,614	9,032	9,361	10,876	7,989	5,842	6,314	12,818	13,008	10,733	10,254	7,372	5,922	9,303
1999	5,266	6,364	8,957	12,231	12,568	12,555	9,923	12,371	11,234	12,378	12,244	12,246	11,180	5,794	10,197
2000	5,252	9,128	10,139	10,504	10,939	9,028	8,882	12,443	11,983	8,439	9,131	9,869	6,818	5,418	9,074
2001	5,192	6,990	7,748	8,501	7,618	5,562	4,710	4,307	6,727	6,905	6,211	8,001	6,643	5,466	6,559
2002	4,506	6,232	7,491	7,557	7,581	5,853	7,147	11,992	11,088	13,138	11,358	7,939	7,104	5,561	8,119
2003	5,252	7,273	7,678	6,907	7,269	8,621	8,441	8,939	10,884	11,621	6,854	7,503	6,809	5,338	7,794
2004	5,045	7,893	8,309	8,481	8,879	6,833	5,644	7,096	9,866	10,132	6,873	7,203	7,323	5,661	7,628
2005	5,968	7,950	9,598	10,091	9,175	7,039	5,577	5,552	10,654	9,238	8,176	8,285	7,038	5,661	8,064
2006	4,683	7,948	8,243	11,813	11,556	8,600	10,285	11,655	13,351	12,556	8,702	7,548	6,499	5,434	9,220
2007	4,739	7,446	8,301	10,434	10,238	10,737	8,159	8,900	11,219	9,150	8,995	7,814	6,601	5,178	8,509
2008	5,041	7,738	7,768	8,886	8,917	6,894	4,710	6,180	12,456	13,644	10,834	7,767	7,956	5,826	8,443
Average	5,565	7,617	8,656	9,880	10,051	8,537	7,685	8,953	11,424	11,266	9,614	9,232	7,940	5,976	8,785

MO3: Average Annual Generation for Bonneville Revenue Determination

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1929	4,562	6,318	6,619	6,250	6,576	5,363	3,712	3,622	3,787	6,400	4,545	7,288	6,574	4,888	5,484
1930	4,964	6,614	6,389	6,083	5,565	5,081	3,802	3,861	4,318	5,618	5,684	7,676	6,766	4,922	5,526
1931	4,925	7,018	7,314	5,264	5,791	5,360	4,302	3,662	3,997	5,311	6,005	8,009	6,795	4,997	5,614
1932	4,622	6,338	6,233	5,583	4,122	6,723	7,280	8,323	9,290	9,978	6,969	7,825	7,582	5,243	6,724
1933	4,810	6,449	8,056	9,225	9,747	8,460	5,789	4,790	7,740	11,225	10,732	10,486	8,958	5,523	8,076
1934	5,328	9,050	10,914	11,254	11,508	9,326	10,319	9,241	9,115	9,007	5,225	6,835	6,723	4,765	8,483
1935	4,984	5,326	7,203	8,655	9,699	7,375	4,486	4,531	7,481	7,437	8,082	9,491	6,960	4,793	6,971
1936	4,750	6,294	6,701	6,004	6,111	5,272	4,265	4,234	9,646	9,085	6,468	7,238	6,558	4,524	6,337
1937	4,853	6,633	6,669	6,446	4,899	4,845	3,688	3,485	4,460	6,084	5,600	7,395	6,460	4,799	5,489
1938	4,870	6,172	7,170	8,595	8,154	7,494	6,925	8,160	8,711	8,221	7,755	6,596	6,102	5,210	7,183
1939	4,768	5,948	6,813	7,167	7,653	5,289	4,077	5,026	7,042	5,519	6,386	7,423	6,828	4,948	6,096
1940	5,020	6,866	7,485	7,342	5,721	6,204	6,304	6,321	6,658	6,591	5,249	6,850	6,351	4,896	6,249
1941	4,707	6,919	7,991	5,814	5,648	5,460	4,795	3,782	5,276	5,443	5,596	7,877	6,823	5,210	5,812
1942	4,522	6,961	8,141	8,135	7,698	5,318	4,078	3,967	5,671	9,533	8,401	7,831	7,674	5,263	6,781
1943	4,945	6,385	6,735	8,771	9,115	7,284	9,230	9,120	8,309	10,148	9,898	8,458	7,345	4,487	7,753
1944	4,484	6,335	6,818	6,164	6,907	4,995	3,420	3,228	3,508	4,825	4,780	7,660	6,391	4,855	5,330
1945	4,720	6,481	7,099	5,330	4,814	4,848	3,546	3,020	5,474	8,725	4,933	7,246	6,438	4,462	5,588
1946	4,610	6,271	7,055	7,827	7,133	7,755	7,808	8,477	9,497	9,236	8,424	8,390	7,356	5,049	7,409
1947	4,270	7,146	9,262	10,086	9,977	8,558	5,720	5,419	8,705	9,024	8,442	7,752	6,768	5,163	7,781
1948	7,284	8,516	8,419	9,155	10,591	7,219	5,724	7,325	10,874	11,138	7,823	9,870	8,729	5,475	8,520
1949	4,896	7,169	7,170	8,324	7,190	7,793	5,983	7,879	9,579	7,718	5,285	6,478	5,790	4,351	6,878
1950	4,531	6,115	7,656	9,634	9,588	9,156	8,168	6,871	7,591	10,963	11,359	9,684	8,465	5,223	8,196
1951	5,331	8,642	9,886	10,843	11,131	10,570	9,738	8,442	9,060	8,513	8,540	9,380	7,372	4,994	8,736
1952	6,718	7,724	8,380	9,581	9,415	7,519	6,883	8,518	10,009	8,306	8,287	8,318	6,692	4,389	7,961
1953	4,609	6,602	6,606	7,223	9,130	6,363	3,568	3,492	7,481	11,427	9,379	7,814	7,682	5,248	7,100
1954	4,850	7,209	8,032	9,576	9,553	8,661	5,772	5,920	8,738	10,687	11,386	10,992	10,743	7,406	8,568
1955	5,126	8,262	8,118	6,938	7,448	4,906	4,550	3,888	6,195	11,143	11,279	10,139	8,133	5,170	7,326
1956	5,139	8,453	9,537	10,744	11,035	9,757	9,464	9,965	10,142	11,565	9,148	8,779	7,538	4,972	9,022

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1957	4,983	6,982	8,041	8,047	6,037	6,999	8,422	6,300	10,907	11,677	6,299	7,145	6,284	4,776	7,409
1958	4,639	6,721	6,776	8,781	8,398	6,831	5,180	5,962	10,158	10,656	6,320	7,258	6,741	4,892	7,221
1959	4,707	7,593	9,056	10,296	11,262	8,590	6,846	6,659	8,189	10,876	10,828	9,533	7,898	8,058	8,725
1960	8,065	9,516	9,614	9,365	9,011	7,045	8,923	7,563	7,336	9,310	8,431	8,783	6,699	5,033	8,221
1961	4,858	7,075	7,433	8,985	7,854	10,034	8,270	5,496	8,753	11,708	6,781	7,576	6,947	4,692	7,692
1962	4,498	6,835	7,285	7,800	9,480	5,478	6,373	7,401	7,898	9,078	6,656	8,784	7,563	4,834	7,056
1963	5,116	7,871	8,880	8,855	9,004	6,200	4,419	4,006	6,328	8,905	8,005	8,577	7,231	5,588	7,229
1964	4,556	6,584	7,390	6,783	8,675	5,255	5,410	4,299	7,625	11,665	10,860	10,127	7,956	6,124	7,443
1965	5,639	7,715	9,458	10,870	11,665	9,974	5,531	6,835	8,782	10,377	7,932	10,096	8,820	4,937	8,569
1966	4,944	6,330	7,694	7,787	9,287	6,264	5,840	5,262	6,441	8,462	7,923	8,841	6,780	4,878	6,933
1967	4,671	6,586	8,130	9,647	10,605	8,902	6,087	5,112	7,257	10,999	9,734	9,232	7,330	5,218	7,954
1968	4,825	7,468	7,644	9,080	8,527	9,005	3,783	3,914	6,411	9,600	8,375	9,609	7,940	6,774	7,526
1969	5,678	8,364	8,620	10,270	11,142	9,714	8,168	8,554	9,942	10,023	7,658	7,613	6,305	4,747	8,439
1970	4,918	7,325	7,536	7,755	9,609	6,119	4,248	4,183	6,466	9,652	5,500	7,870	6,808	4,621	6,733
1971	4,596	6,007	7,083	10,399	11,546	9,971	8,683	7,838	9,971	11,671	9,834	10,050	7,707	5,104	8,592
1972	4,802	7,201	7,737	9,864	10,859	10,719	10,013	7,106	9,883	11,118	10,205	10,407	9,550	5,567	8,871
1973	5,081	7,010	7,976	7,427	7,076	5,721	3,661	3,453	5,322	6,360	5,125	7,504	5,990	4,439	5,983
1974	4,731	6,646	7,947	11,289	11,587	10,720	10,056	9,220	9,386	10,994	11,183	10,023	8,971	5,568	9,087
1975	4,351	6,670	7,542	7,972	8,495	7,849	4,380	5,154	7,105	11,122	10,567	8,944	8,170	5,741	7,558
1976	5,377	8,603	10,378	10,055	11,070	9,202	7,908	7,836	9,692	9,081	10,535	11,814	11,884	7,781	9,292
1977	4,932	6,231	7,134	6,486	7,129	5,058	3,244	3,135	4,435	4,787	5,058	7,649	6,615	4,325	5,486
1978	4,210	6,372	7,990	7,346	6,340	7,037	6,810	5,779	7,870	8,227	9,133	7,689	6,709	6,383	7,040
1979	5,258	7,124	7,267	7,525	6,425	6,029	4,839	4,650	8,217	6,346	5,176	7,055	6,148	4,809	6,297
1980	4,870	6,069	6,406	6,970	6,690	5,614	3,522	5,250	10,305	10,107	6,295	6,693	6,276	4,835	6,587
1981	4,792	6,906	9,560	9,684	10,489	6,495	3,510	3,906	7,474	11,596	9,575	10,764	9,036	5,555	7,966
1982	4,752	7,488	8,169	9,363	10,016	11,083	7,424	6,212	9,245	10,368	11,026	10,266	8,484	6,593	8,688
1983	5,406	7,364	8,317	9,657	8,504	10,183	6,667	5,691	7,231	8,547	10,387	10,223	7,900	5,609	8,042
1984	4,577	8,884	8,200	9,378	8,990	7,916	6,500	7,106	6,473	10,352	9,619	9,302	7,442	5,457	7,911
1985	4,581	7,063	7,397	8,054	8,062	5,692	6,216	5,522	7,764	6,301	5,153	6,232	5,789	4,484	6,359

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1986	4,953	7,672	7,761	8,868	7,495	10,733	7,956	6,924	7,068	9,503	6,425	8,028	6,528	4,573	7,481
1987	4,376	6,902	7,585	7,506	6,153	6,606	4,741	4,860	8,053	6,943	4,716	6,816	5,891	4,375	6,201
1988	4,644	6,978	7,009	5,320	5,360	5,205	3,840	3,931	4,969	6,202	6,116	7,486	6,508	4,533	5,604
1989	4,711	6,923	7,358	6,216	5,056	6,321	5,319	6,842	7,832	6,265	5,819	7,063	6,429	4,566	6,168
1990	4,678	7,390	8,404	9,090	10,307	7,969	5,527	7,390	6,840	10,246	8,807	9,691	7,812	4,878	7,802
1991	4,483	9,061	9,288	9,768	11,010	8,575	7,367	5,750	8,090	9,380	10,528	10,670	8,692	5,041	8,442
1992	4,624	6,341	6,570	7,039	6,342	6,376	4,276	4,170	6,085	5,598	5,069	7,338	6,623	4,744	5,836
1993	4,774	6,907	7,408	5,191	5,031	5,654	4,556	3,744	7,026	6,090	6,389	8,031	7,173	5,059	5,951
1994	4,728	6,598	6,892	6,164	6,814	5,222	3,447	4,921	5,646	5,886	5,564	7,250	6,206	4,704	5,755
1995	4,871	6,863	6,821	6,769	6,382	7,987	4,864	3,908	6,672	9,796	7,298	7,524	7,080	5,461	6,720
1996	5,252	9,519	11,184	11,211	11,373	10,894	7,848	9,124	8,721	10,583	10,499	10,016	7,439	5,029	9,285
1997	4,693	6,852	8,309	11,182	11,593	10,859	10,044	9,503	10,646	11,395	10,505	9,897	8,440	6,487	9,275
1998	7,419	7,884	8,145	8,095	8,900	6,473	4,017	4,169	8,511	10,875	8,267	9,232	6,662	4,884	7,618
1999	4,410	5,756	8,226	10,152	9,538	10,961	8,208	8,057	6,901	9,524	10,514	11,271	10,474	5,176	8,349
2000	4,357	8,766	9,182	9,123	8,293	7,693	7,703	8,698	7,835	6,512	7,379	9,110	6,267	4,484	7,456
2001	4,668	6,578	7,107	6,426	6,925	5,034	3,642	3,469	3,668	4,662	5,284	7,714	6,443	4,337	5,437
2002	4,118	6,075	6,879	5,823	5,319	5,846	5,791	7,640	7,197	10,987	9,425	7,130	6,393	4,532	6,645
2003	4,962	6,952	7,176	6,457	5,475	6,692	5,961	5,486	6,306	9,155	5,310	6,789	6,250	4,235	6,250
2004	4,920	7,496	7,779	7,269	6,472	5,727	4,689	4,869	5,616	7,257	5,347	6,440	6,627	4,940	6,177
2005	5,184	7,406	8,824	8,144	8,439	6,675	4,725	4,219	5,999	6,843	6,493	7,572	6,483	4,442	6,656
2006	4,674	7,498	7,589	8,831	10,704	7,123	8,692	7,544	9,694	10,913	6,891	6,829	5,938	4,152	7,689
2007	4,403	7,091	7,519	9,233	7,607	9,400	7,295	6,219	7,368	8,114	7,367	7,181	6,104	3,968	7,124
2008	4,935	7,238	7,119	7,408	7,060	6,280	4,101	3,683	8,021	11,274	8,292	6,880	7,165	4,790	6,946
Average	**4,931**	**7,120**	**7,841**	**8,239**	**8,291**	**7,362**	**5,987**	**5,864**	**7,575**	**8,910**	**7,752**	**8,392**	**7,252**	**5,100**	**7,235**

MO4: Average Annual Generation for Bonneville Revenue Determination

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1929	4,993	6,636	6,697	6,986	6,994	3,944	3,918	3,916	5,386	6,191	4,695	5,126	4,735	5,086	5,526
1930	4,690	6,871	6,393	6,186	6,459	4,021	3,919	4,227	5,796	5,612	5,654	5,395	4,862	5,471	5,521
1931	4,726	6,975	6,900	6,286	5,616	4,231	3,827	3,811	5,739	5,516	6,007	5,535	5,185	5,439	5,551
1932	4,340	6,399	6,408	6,062	4,965	4,321	5,301	7,089	8,202	8,505	6,146	5,953	5,882	5,686	6,095
1933	5,168	6,537	8,091	10,434	10,916	6,030	5,008	5,048	6,970	11,382	8,773	7,810	6,442	5,962	7,678
1934	5,702	9,301	12,301	13,067	12,880	6,479	7,684	8,045	7,982	8,071	5,178	5,398	5,389	5,081	8,245
1935	5,273	5,805	7,085	9,586	10,418	5,512	4,452	4,727	6,902	6,513	6,984	7,118	5,244	5,184	6,648
1936	5,063	6,637	6,829	6,371	6,119	3,914	4,161	4,807	8,942	7,948	7,539	5,077	4,654	5,369	6,174
1937	4,614	6,940	6,788	6,154	5,121	3,925	3,866	3,788	5,935	5,500	5,198	4,791	4,570	5,500	5,349
1938	4,593	7,048	6,669	10,117	9,376	4,918	5,230	7,347	7,444	6,815	6,674	5,161	4,941	5,703	6,706
1939	5,207	6,400	6,468	8,048	8,343	3,795	3,786	5,443	6,689	7,517	5,935	5,200	4,786	5,346	6,096
1940	4,783	6,899	7,055	8,222	6,558	4,309	5,146	6,015	6,331	7,236	5,542	4,470	4,530	5,728	6,056
1941	4,608	7,539	7,588	6,997	6,258	4,097	4,549	3,956	6,665	5,228	5,420	5,277	4,894	5,986	5,807
1942	4,462	7,193	8,558	10,277	8,223	3,823	3,574	4,684	6,443	7,871	7,137	5,674	5,001	5,338	6,556
1943	4,873	6,455	7,063	10,632	11,103	4,898	7,459	9,180	7,383	9,234	7,826	6,212	5,377	5,070	7,357
1944	4,987	6,624	6,719	7,254	7,549	3,756	3,644	3,529	5,154	4,695	4,808	5,102	4,694	5,630	5,464
1945	4,502	6,718	6,851	6,077	5,703	3,774	3,722	3,124	6,268	7,386	5,459	5,013	4,589	5,247	5,513
1946	4,434	6,556	6,933	9,420	9,411	4,765	5,778	7,826	8,336	7,707	7,143	6,405	5,508	5,650	6,907
1947	4,878	7,419	10,452	11,821	11,976	5,873	4,763	5,481	7,889	7,454	7,216	6,042	5,187	5,726	7,596
1948	7,878	8,784	8,880	11,754	11,525	5,199	4,885	6,710	11,186	12,892	6,503	7,117	6,423	6,028	8,585
1949	5,366	7,251	7,221	9,087	8,483	5,514	4,719	7,580	9,345	6,282	5,031	5,059	4,727	4,853	6,612
1950	4,992	6,478	7,523	11,115	11,203	6,182	5,931	6,295	6,666	10,870	9,740	6,900	6,197	5,819	7,746
1951	5,986	9,089	10,686	12,670	13,513	7,450	7,219	7,411	8,035	6,840	7,232	6,986	5,462	5,524	8,349
1952	7,492	7,947	8,883	11,330	11,247	5,084	5,155	8,521	10,038	7,097	7,001	6,377	5,058	4,933	7,792
1953	5,034	6,901	6,827	7,837	11,543	4,605	3,701	3,820	6,728	11,620	7,657	5,840	5,859	5,762	6,973
1954	5,293	7,234	8,187	10,967	11,198	6,021	4,883	5,739	7,661	9,167	9,596	7,962	7,856	7,946	8,022
1955	5,570	8,298	8,173	8,348	8,050	3,983	4,234	4,304	6,606	10,217	9,353	7,048	5,929	5,368	7,051
1956	5,284	8,635	10,451	13,108	12,725	6,207	6,688	10,776	9,967	11,485	7,459	6,420	5,722	5,575	8,788

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1957	5,515	7,062	8,339	9,374	7,960	4,567	6,011	6,000	11,453	11,440	5,743	5,494	5,018	5,344	7,331
1958	5,141	6,738	6,985	10,007	10,096	4,895	4,496	5,433	10,004	9,148	5,957	5,603	5,338	5,435	7,050
1959	5,245	7,922	9,917	12,751	12,800	5,915	5,389	6,443	7,115	10,033	8,757	7,134	5,870	8,834	8,441
1960	9,098	10,005	10,013	10,925	10,205	4,954	6,422	6,866	6,695	7,749	7,233	6,686	5,143	5,528	7,904
1961	5,294	7,161	7,519	10,343	9,651	6,823	6,571	5,544	7,828	11,223	6,247	5,919	5,571	5,188	7,405
1962	4,955	6,886	7,344	9,183	11,166	4,151	4,787	6,700	7,003	7,567	5,941	6,667	5,658	5,333	6,753
1963	5,831	8,136	9,473	10,217	10,881	4,552	4,198	4,304	6,164	7,433	7,416	6,246	5,368	5,930	7,151
1964	4,736	6,660	7,472	8,653	9,111	4,021	4,624	4,686	6,803	12,651	8,817	7,518	5,838	6,811	7,238
1965	6,136	7,790	10,683	13,612	14,440	6,862	4,802	6,546	7,914	10,397	6,591	7,489	6,271	5,750	8,523
1966	5,578	6,474	7,851	9,588	10,094	4,663	4,877	5,464	6,931	7,408	7,678	5,725	5,130	5,373	6,834
1967	4,477	6,603	7,818	11,095	12,160	6,313	5,395	5,443	6,464	11,116	7,927	6,992	5,523	5,725	7,580
1968	5,388	7,639	7,870	10,186	10,907	6,275	3,900	4,214	6,840	7,850	7,170	6,783	5,991	7,216	7,302
1969	6,120	8,713	8,991	12,649	12,923	6,764	5,826	7,640	9,399	8,209	6,715	5,908	5,156	5,265	8,138
1970	5,407	7,324	7,661	9,628	10,589	4,391	4,099	4,308	6,389	9,796	6,614	5,322	4,887	5,260	6,835
1971	4,563	6,579	6,791	12,812	14,202	6,897	6,402	7,192	9,981	12,424	7,861	7,426	5,724	5,742	8,392
1972	5,562	7,376	8,103	11,847	13,322	10,672	7,290	6,457	9,190	12,867	8,163	7,557	7,048	6,220	8,940
1973	5,836	7,200	8,418	9,001	8,700	4,226	3,832	3,575	6,840	5,984	4,992	5,028	4,546	5,141	6,223
1974	4,578	7,115	8,133	13,789	13,679	7,807	7,413	8,793	8,495	12,714	9,442	7,383	6,457	6,135	8,873
1975	4,873	6,711	7,780	9,352	9,974	5,651	4,057	5,368	6,596	11,456	8,520	6,500	6,079	6,426	7,340
1976	6,343	8,960	11,784	12,717	12,704	6,404	6,061	6,937	9,301	7,609	8,563	8,604	8,622	8,587	8,999
1977	5,605	6,543	7,001	7,634	7,839	3,840	3,541	3,438	6,068	4,940	5,275	5,513	4,873	4,889	5,683
1978	4,052	6,470	8,550	9,246	7,874	4,929	4,886	5,777	7,349	6,468	7,407	5,863	5,314	7,062	6,687
1979	5,749	7,125	7,320	8,368	7,856	4,017	4,557	4,951	7,422	6,845	5,706	4,883	4,589	5,577	6,279
1980	4,670	6,599	6,090	8,543	7,728	4,094	3,573	5,405	9,330	8,421	7,082	4,477	4,450	5,610	6,421
1981	4,622	6,993	9,415	11,333	11,617	4,538	3,657	4,274	7,051	10,542	8,073	8,092	6,593	6,011	7,599
1982	5,179	7,540	8,471	10,710	13,174	8,292	5,527	5,648	8,217	10,717	9,031	7,546	6,059	7,254	8,380
1983	6,218	7,544	8,892	11,344	10,963	7,578	4,881	5,584	6,462	7,576	8,424	7,529	5,649	6,234	7,738
1984	5,363	9,394	8,771	11,181	10,721	5,195	4,670	6,726	6,256	11,050	7,795	6,953	5,571	6,425	7,822
1985	5,345	7,397	7,711	10,061	8,592	4,117	4,647	5,175	6,800	5,745	5,078	5,041	4,826	5,428	6,330

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1986	5,660	8,043	8,027	9,756	11,486	8,554	5,828	6,368	6,624	7,987	7,296	5,331	4,813	5,232	7,460
1987	4,368	7,095	7,422	8,549	7,383	4,392	4,478	5,554	7,431	7,788	4,880	4,417	4,235	4,988	6,125
1988	4,528	7,005	6,444	6,025	5,955	4,058	3,716	4,361	6,420	5,805	5,812	5,123	4,756	5,287	5,523
1989	4,435	7,035	6,893	6,905	5,990	4,086	4,919	6,460	6,882	5,601	5,512	5,544	5,125	5,075	5,783
1990	5,134	7,499	8,468	10,172	11,465	5,759	4,827	6,631	6,776	8,584	7,452	7,168	5,633	5,143	7,353
1991	4,794	9,228	9,357	10,959	12,384	6,124	6,160	5,915	7,061	7,677	8,512	7,879	6,304	5,437	7,858
1992	4,973	6,707	6,367	7,832	7,646	4,485	4,280	4,446	7,086	6,333	4,974	5,169	4,580	4,977	5,878
1993	4,479	6,904	7,060	6,436	5,296	3,762	3,724	3,874	6,676	6,099	7,002	5,484	4,352	5,026	5,624
1994	4,582	6,896	7,169	6,371	7,063	4,085	3,672	5,427	6,822	6,347	5,286	5,050	4,665	5,210	5,759
1995	4,615	6,844	6,359	7,988	8,499	5,465	4,040	4,157	5,997	8,610	6,385	5,492	4,826	5,861	6,304
1996	5,712	10,118	13,325	13,483	14,241	7,999	5,747	8,347	7,803	10,170	8,495	7,459	5,574	5,652	9,194
1997	5,187	6,992	8,909	14,129	14,190	8,034	7,373	9,668	11,526	12,838	8,467	7,240	6,113	7,204	9,354
1998	8,174	8,107	8,481	9,035	10,497	4,515	3,834	4,782	8,710	9,727	6,801	6,835	4,981	5,561	7,464
1999	5,020	6,191	8,355	12,222	11,780	7,991	6,011	7,229	6,139	8,915	8,494	8,126	7,647	5,751	7,927
2000	4,829	8,912	9,558	10,484	9,956	5,295	5,870	7,655	7,050	5,657	6,507	6,905	4,897	5,021	7,149
2001	5,198	6,613	7,190	7,518	7,427	3,776	3,653	3,603	5,389	4,870	5,242	5,253	4,690	5,052	5,563
2002	3,900	6,570	6,404	6,975	6,516	4,594	4,775	6,820	6,662	9,470	7,846	5,504	5,124	5,005	6,247
2003	5,326	6,997	7,051	7,065	6,650	4,727	4,856	5,968	6,307	7,449	6,717	4,744	4,360	5,027	6,100
2004	4,678	7,613	7,129	8,100	7,450	4,072	4,271	4,911	5,956	6,392	6,080	4,583	4,517	5,525	6,003
2005	5,059	7,496	8,464	9,599	9,016	4,859	4,487	4,498	5,987	7,369	6,798	5,672	4,302	4,519	6,538
2006	4,460	7,525	7,468	10,710	12,038	4,957	6,169	7,050	9,344	9,307	6,202	5,356	4,891	4,651	7,331
2007	4,833	7,329	7,673	10,533	9,154	6,302	5,723	6,222	6,712	7,245	7,560	5,389	4,377	4,640	6,890
2008	4,977	7,324	6,719	8,450	8,105	4,783	4,106	3,834	6,893	11,021	6,902	5,350	5,537	5,313	6,648
Average	**5,215**	**7,341**	**8,002**	**9,646**	**9,693**	**5,284**	**4,951**	**5,773**	**7,391**	**8,394**	**6,929**	**6,118**	**5,365**	**5,661**	**7,038**

PA: Average Annual Generation for Bonneville Revenue Determination

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1929	5,483	6,737	6,824	6,832	6,727	6,295	4,412	4,051	4,693	7,898	5,530	6,510	6,340	5,894	6,125
1930	5,355	6,799	6,409	6,903	6,190	5,680	4,347	4,259	5,363	6,545	6,634	7,002	6,652	5,971	6,082
1931	5,430	7,037	6,947	6,061	5,804	6,202	4,825	3,944	5,056	6,394	6,792	7,332	6,735	6,029	6,101
1932	5,213	6,501	6,670	5,979	5,588	8,452	8,533	9,062	10,457	11,428	7,938	6,942	7,375	5,833	7,505
1933	5,606	6,431	8,681	10,578	11,563	8,840	6,435	6,258	8,094	12,721	11,575	9,350	8,973	5,933	8,781
1934	6,148	9,724	12,427	13,020	13,056	10,752	11,364	9,800	9,638	9,479	5,729	6,003	6,361	5,521	9,331
1935	5,384	5,916	7,066	9,979	10,831	8,109	5,437	5,975	7,858	8,123	8,851	8,497	6,685	5,438	7,556
1936	5,495	6,694	6,748	6,066	6,002	6,837	4,690	6,471	11,555	10,044	7,468	6,520	6,395	5,614	7,053
1937	5,418	7,048	6,869	6,001	5,292	5,598	4,435	3,960	5,438	6,736	6,287	6,593	6,179	5,585	5,909
1938	5,537	6,907	7,884	10,295	9,561	9,102	7,670	9,737	9,973	9,686	8,817	5,874	5,940	5,825	8,176
1939	5,624	6,512	6,418	7,980	8,445	6,841	4,999	6,185	8,100	7,038	7,042	6,556	6,496	5,742	6,815
1940	5,459	7,022	7,056	8,449	7,172	7,999	7,221	7,589	7,692	7,577	5,814	6,034	6,041	5,599	6,939
1941	5,558	7,583	7,888	6,852	6,564	6,541	5,574	4,461	6,118	6,531	6,657	7,241	6,911	6,041	6,538
1942	5,543	7,438	9,195	10,225	8,806	6,365	4,853	5,298	6,515	10,563	9,447	6,956	7,484	5,950	7,692
1943	5,612	6,452	7,564	10,726	11,546	9,047	11,854	11,548	9,550	11,777	11,678	7,747	7,370	5,498	9,040
1944	5,194	6,728	6,587	6,664	7,232	5,909	4,103	3,628	4,223	5,727	5,913	7,151	6,534	5,851	5,890
1945	5,423	6,768	6,934	6,141	5,746	5,898	4,308	3,744	6,834	10,422	6,315	6,627	6,449	5,720	6,398
1946	5,238	6,555	7,771	9,515	9,885	8,915	8,970	10,157	10,298	9,960	9,336	7,573	7,196	5,813	8,344
1947	5,266	7,352	10,948	11,705	11,954	10,426	6,660	7,193	9,990	10,056	9,357	7,026	6,620	5,943	8,884
1948	8,011	8,896	9,444	11,515	11,791	8,336	6,424	9,302	12,358	13,049	9,023	9,108	8,709	6,037	9,597
1949	5,832	7,277	7,155	10,041	8,465	9,973	6,932	9,935	11,438	8,562	6,118	5,742	5,636	5,324	7,859
1950	5,163	6,582	7,754	11,700	11,594	10,266	9,757	8,473	8,695	12,256	13,054	8,736	8,768	5,895	9,225
1951	6,441	9,186	11,064	12,671	13,625	12,151	11,113	9,391	10,210	9,634	9,673	8,514	7,283	5,629	9,850
1952	7,754	8,059	9,449	11,402	11,425	8,882	8,761	10,951	11,976	9,845	9,285	7,921	6,621	5,463	9,218
1953	5,176	6,985	6,747	8,207	11,325	7,629	4,354	4,173	8,628	12,885	10,836	7,035	7,630	5,987	7,979
1954	5,549	7,244	8,687	11,390	11,871	9,357	6,320	7,316	9,868	11,220	12,620	10,245	10,886	7,837	9,412
1955	6,146	8,335	8,762	7,678	8,073	5,650	5,433	4,528	7,570	12,115	12,490	9,148	8,367	5,867	8,036
1956	5,779	8,693	11,001	13,091	12,714	11,902	10,501	11,988	11,533	12,774	10,164	7,965	7,542	5,687	10,187

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1957	5,846	7,117	8,783	9,414	9,025	8,095	9,379	7,345	12,623	12,885	7,282	6,407	6,190	5,747	8,451
1958	5,299	6,789	7,111	10,252	10,292	8,327	5,616	7,126	12,079	11,568	7,367	6,509	6,596	5,803	8,139
1959	5,338	7,977	10,422	12,746	12,968	9,848	7,535	7,651	8,786	11,870	11,766	8,645	7,825	8,688	9,666
1960	9,659	10,111	10,394	10,706	10,550	8,379	9,793	8,464	8,275	10,520	9,160	7,906	6,577	5,731	9,148
1961	5,637	7,092	8,018	10,783	9,887	10,397	8,853	6,818	9,480	12,093	7,426	6,717	6,667	5,717	8,412
1962	4,993	6,859	7,764	9,259	11,545	6,367	7,130	8,861	8,849	10,351	7,609	7,903	7,447	5,813	7,895
1963	5,771	8,203	10,032	10,174	10,865	7,289	5,038	4,532	7,835	10,294	9,051	7,713	7,085	6,277	8,150
1964	5,547	6,661	7,797	7,890	9,706	6,268	6,634	5,635	8,514	13,410	12,105	9,362	7,944	6,791	8,280
1965	6,570	7,878	11,194	13,538	14,388	11,927	6,738	9,002	10,871	11,409	9,416	9,479	9,045	5,895	10,001
1966	5,885	6,514	8,243	9,065	10,540	7,310	6,788	6,067	7,368	8,902	8,621	7,856	6,524	5,729	7,632
1967	5,345	6,675	8,576	11,375	12,630	9,803	6,621	5,757	8,388	12,406	10,892	8,315	7,129	5,895	8,803
1968	5,690	7,660	8,371	10,907	10,205	10,345	4,357	4,275	7,556	10,648	9,083	8,644	8,159	7,392	8,380
1969	6,810	8,875	9,472	12,514	13,057	11,144	9,706	9,707	11,273	10,678	8,564	6,814	6,156	5,753	9,506
1970	5,377	7,343	7,364	9,438	11,272	7,497	4,869	4,493	8,428	12,528	6,983	7,095	6,741	5,799	7,776
1971	5,314	6,691	7,429	13,024	14,161	11,942	10,139	9,331	11,845	13,371	11,340	9,308	7,716	5,910	9,914
1972	5,859	7,404	8,604	12,508	13,284	13,095	11,119	8,137	10,919	13,022	11,377	9,665	9,614	6,271	10,128
1973	6,236	7,244	8,127	9,043	8,732	6,649	4,409	3,701	6,368	7,192	5,831	6,686	5,758	5,470	6,755
1974	5,260	7,026	9,297	13,758	13,678	12,901	11,753	10,593	10,457	12,910	12,848	9,283	9,184	6,292	10,387
1975	5,448	6,791	7,197	9,719	10,576	9,271	5,590	6,239	8,417	12,694	12,518	8,298	8,408	6,442	8,603
1976	6,749	9,166	12,131	12,410	12,868	10,882	9,791	9,252	11,549	10,682	11,618	11,120	12,245	8,461	10,646
1977	6,247	6,658	6,805	7,197	7,768	5,810	3,747	3,474	5,176	5,473	5,873	7,114	6,666	5,523	6,080
1978	4,872	6,243	8,607	9,465	9,103	8,623	7,797	7,841	8,986	9,147	10,478	6,958	6,746	7,007	8,098
1979	6,265	7,159	7,020	8,775	7,681	7,534	5,574	5,354	9,644	7,284	5,932	6,323	6,022	5,780	7,061
1980	5,558	6,708	6,191	8,491	8,162	6,758	4,314	6,323	11,508	11,428	7,303	5,992	6,125	5,693	7,429
1981	5,467	7,017	10,097	11,357	12,162	7,539	4,068	4,560	8,736	12,487	10,453	9,618	9,082	6,227	8,752
1982	5,485	7,503	8,384	11,114	13,723	12,900	8,803	7,721	10,560	12,685	12,870	9,421	8,724	7,177	9,958
1983	6,699	7,635	9,040	11,423	11,840	12,041	7,437	7,128	8,587	10,591	11,769	9,309	8,168	6,288	9,321
1984	5,818	9,378	9,267	11,255	11,005	10,335	8,002	8,798	8,610	12,612	11,288	8,742	7,630	6,352	9,367
1985	5,842	7,430	8,212	10,158	9,048	6,962	7,040	7,814	8,344	7,163	5,777	5,618	5,562	5,582	7,284

Water Year	OCT 1-31	NOV 1-30	DEC 1-31	JAN 1-31	FEB 1-28	MAR 1-31	APR 1-15	APR 16-30	MAY 1-31	JUN 1-30	JUL 1-31	AUG 1-15	AUG 16-31	SEP 1-30	Avg.
1986	5,913	8,197	8,527	10,237	10,931	12,979	9,659	8,472	8,346	10,912	7,283	7,162	6,359	5,596	8,713
1987	5,187	7,043	8,373	8,293	7,705	7,129	5,362	6,478	9,023	7,606	5,276	6,029	5,595	5,312	6,887
1988	5,106	6,937	6,549	6,267	5,784	6,108	4,381	5,164	6,021	7,006	6,947	6,787	6,365	5,726	6,152
1989	5,076	7,000	7,745	7,361	5,961	7,688	7,320	9,248	8,829	7,127	6,540	6,244	6,174	5,402	6,943
1990	5,359	7,582	8,918	10,189	11,597	9,200	6,264	8,329	7,737	10,706	9,567	8,680	7,643	5,592	8,473
1991	5,135	9,334	9,767	11,157	12,412	9,208	7,732	7,505	8,389	10,057	11,395	9,515	8,700	5,425	9,066
1992	5,547	6,820	6,302	7,754	7,282	7,331	5,065	4,994	7,131	6,738	5,683	6,475	6,263	5,621	6,467
1993	5,055	6,846	7,046	6,877	5,339	6,925	5,110	3,952	9,200	8,708	7,509	7,245	7,189	5,936	6,780
1994	5,350	7,014	7,105	6,653	6,757	6,328	4,250	6,187	6,865	6,708	6,338	6,538	5,992	5,757	6,361
1995	5,323	6,643	7,324	7,911	8,931	9,157	5,708	4,556	8,056	11,496	8,695	6,757	7,003	6,112	7,631
1996	6,480	10,207	13,337	13,446	14,195	13,172	8,938	10,574	10,192	12,309	11,633	9,170	7,461	5,826	10,731
1997	5,495	7,000	9,393	14,140	14,198	13,094	11,310	11,008	12,245	13,215	11,851	9,307	8,591	7,107	10,635
1998	8,523	8,239	8,193	9,464	10,511	8,006	4,903	5,183	11,249	12,172	9,444	8,386	6,524	5,825	8,669
1999	5,395	6,297	8,579	12,322	12,340	12,849	8,967	9,421	8,187	11,180	11,696	10,631	10,565	5,811	9,530
2000	5,383	8,892	10,006	10,610	10,132	9,369	8,483	9,713	8,795	7,131	8,099	8,142	6,041	5,386	8,328
2001	5,323	6,694	6,798	7,382	7,516	6,180	4,131	3,678	4,544	5,387	6,073	7,048	6,338	5,582	6,000
2002	4,639	6,291	7,359	7,047	7,200	6,715	6,436	8,448	8,370	11,589	10,302	6,336	6,272	5,466	7,392
2003	5,385	7,111	6,796	7,675	6,333	7,886	6,562	7,589	7,718	10,334	6,240	6,042	6,001	5,336	6,993
2004	5,176	7,665	8,256	8,157	7,662	6,865	5,443	5,694	6,669	8,156	6,401	5,868	6,617	5,688	6,873
2005	6,102	7,573	9,183	9,343	9,115	7,452	5,622	4,763	7,457	7,793	7,268	6,735	6,215	5,564	7,371
2006	4,812	7,569	8,190	10,928	12,343	8,457	10,123	9,248	11,659	11,445	7,653	6,031	5,686	5,337	8,632
2007	4,867	7,065	8,248	10,626	9,639	10,328	8,125	6,976	8,277	8,589	7,972	6,341	5,811	5,082	7,853
2008	5,172	7,357	6,913	8,893	8,810	7,579	5,388	4,726	8,842	12,621	9,557	6,166	7,103	5,731	7,760
Average	5707	7383	8323	9727	9900	8678	6928	7041	8794	10104	8781	7605	7180	5941	8135

Columbia River System Operations
Final Environmental Impact Statement

Appendix K
Flood Risk Management

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CHAPTER 1 - INTRODUCTION

The purpose of the flood risk analysis is to assess the risk of an area to flooding and determine if there is a difference in flood risk under the Action Alternatives, or the Multi-Objective Alternatives (MO's) and the Preferred Alternative (PA), when compared to the No Action Alternative. 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 protect against these hazards, and finally, the consequences of these hazards reaching communities or property (i.e., the harm that may be caused). As described by FEMA, flood hazards measure the potential for inundation that involves risks to life, health, property, and natural floodplain resources and functions. The National Weather Service (NWS) ranks the level of flood hazard by river stage providing a tool for assessing changing conditions at specific locations.

This appendix provides an overview of the methodology used to estimate changes in flood risk from changes that could occur under the MO's and PA, as presented in Chapter 3.9 of the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS). The Appendix provides tabulated results of the analysis, supplementing the information provided in the EIS.

1.1 APPROACH FOR EVALUATING FLOOD RISK CONDITIONS FROM CRSO EIS ALTERNATIVE

The first step of the flood risk analysis was to establish the baseline conditions, or the anticipated flood risk conditions the No Action Alternative. The flood risk analysis utilized the hydrologic modeling output of estimated river flows and stages based on the 5,000 simulated water years (refer to H&H Appendix A for more information on hydrologic modeling). The No Action Alternative flood risk conditions were determined using the H & H modeling described in Section 3.2 of the EIS, as well as in the H&H Appendix A, which includes rule-based reservoir operations and assumed future conditions

Flood risk conditions were then estimated using a sample of annual peak flows and stages for each of the simulated water years at the gage locations throughout the CRSO study area.
The flood risk analysis for the MO's and PA followed the same process of using the H&H hydrologic model output and estimating annual peak flows and stages for the same simulated water years at specified gage locations. The peaks figures were then compared to thresholds for flood hazards established by the National Weather Service (NWS) to evaluate changing flood risk conditions: The National Weather Service (NWS) ranks flood hazards by river stage, measured as gage height, and includes the following categories:

- **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.

These NWS categories are used to assess flood hazard conditions under the No Action, MO's and PA for the Columbia River System. Flood risk or the assessment of flood hazards were completed for sample locations throughout the study area (the Columbia River system and the urban and rural areas that could potentially be affected by a change in flood risk conditions). The following section describes the gage locations used for the analysis and is followed by a section describing how river stages and heights were evaluated to assess changes in flood conditions.

1.2 GAGE LOCATIONS USED IN THIS ANALYSIS

The analysis used flow and stage estimates at 14 river gages. These gage locations were selected because they provide a good representative sample of potential flood hazard locations throughout the study area, as they are either located near populated areas or are commonly used to communicate estimated flood levels for a given area. Given this, the gage locations characterize the flood hazards and consequences in the river reaches where they are located.

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 (https://water.weather.gov/ahps). These gages are useful in assessing the thresholds at which river and possible flood conditions become hazardous (Figure 1-1).

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.
The thresholds for each flood hazard category for each gage location are presented in Table 1-1 and Table 2-1, as measured in elevation (feet).

Table 1-1. Thresholds for Flood Hazard Categories at Gage Locations

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 & 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	2066.6	2067.5	2070	2073
A	R25 to R27	Clark Fork Near Plains, Mt	2467.9	2468.9	2470.9	2472.4
A	R28	Columbia Falls, MT Gage	2993.8	2994.3	2999.3	3003.3
A	R29	Bonners Ferry, ID Gage	1760.8	1767.8	1773.8	1781.8
B	R21	Grand Coulee Pool	Simulations do not exceed normal full pool level of 1,290 ft (NGVD29) under any alternative			
B	R20	Chief Joseph Pool	Simulations do not exceed normal full pool level of 956 ft (NGVD29) under any alternative			
B	R19	Wells Pool	Simulations do not exceed normal full pool level of 781 ft (NGVD29) under any alternative			
B	R18	Rocky Reach Pool	Simulations do not exceed normal full pool level of 707 ft (NGVD29) under any alternative			
B	R17	Rock Island Pool	Simulations do not exceed normal full pool level of 613 ft (NGVD29) under any alternative			
B	R16	Wanapum Pool	Simulations do not exceed normal full pool level of 570 ft (NGVD29) under any alternative			
B	R15	Priest Rapids Pool	Simulations do not exceed normal full pool level of 488 ft (NGVD29) under any alternative			
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 any alternative			
C	R07	Lower Monumental Pool	Simulations do not exceed normal full pool level of 540 ft (NGVD29) under any alternative			
C	R08	Little Goose Pool	Simulations do not exceed normal full pool level of 638 ft (NGVD29) under any alternative			
C	R09	Anatone, WA Gage	829.2	830.2	833.2	834.2
C	R09	Orofino, ID Gage	1010.2	1011.2	1012.7	1014.2
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 any alternative			
D	R03	The Dalles Pool	Simulations do not exceed normal full pool level of 160 ft (NGVD29) under any alternative			
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 any alternative			
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

[1/] Flow thresholds are in thousands of cfs (kcfs).

Note: Vertical datum for stages was adjusted to NAVD88 from NWS datum (typically NGVD29) where applicable using National Geodetic Survey conversion factors.

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

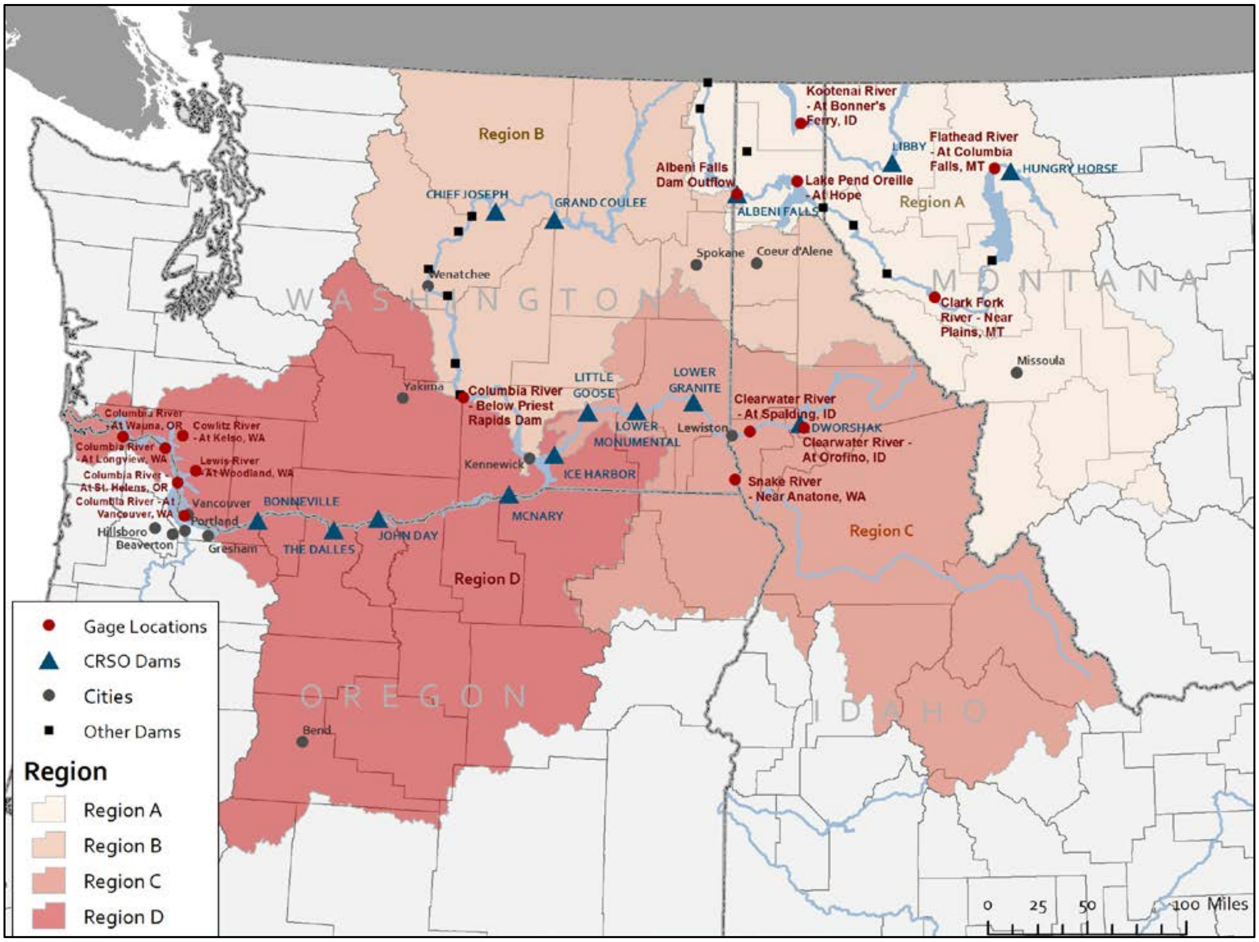

Figure 1-1. Gage Locations for the CRSO EIS Flood Risk Analysis

Note: The gage locations on the above map as well as historical stage/flow and flood hazard category threshold data used in this assessment are taken from the National Weather Service Advanced Hydrologic Prediction Service at https://water.weather.gov/ahps/.

1.3 EVALUATING ANNUAL EXCEEDANCE PROBABILITY FOR FLOOD HAZARDS

For each gage location used in this analysis, flood risk is defined by determining the Annual Exceedance Probability (AEP) from the H&H analysis that corresponds to the various NWS stage or flow thresholds for that location. The H&H analysis includes a rule-based reservoir operations model of the Columbia River basin and a flow-stage transformation tool, and a product of the analysis is annual and seasonal peak stage and flow frequency statistics throughout the basin. These modeling tools are described in detail in the Appendix A. AEPs were identified at each gage location for four flood hazard categories (action stage, flood stage, moderate stage, and major stage) for the No Action Alternative and each CRSO alternative. The differences between AEP in each of the CRSO alternatives and the No Action Alternative were the metric used to evaluate changes in flood risk.

The results of this flood risk analysis are shown in tables in the following section. The sections are divided by alternative first, then by region. The tables for the No Action Alternative contain the AEP results for each flood hazard stage category at each of the gage locations. The tables for the Action Alternatives present the changes in AEP, which are calculated as the difference in AEP from the No Action Alternative to a given alternative.

1.4 UNCERTAINTIES AND STUDY LIMITATIONS

To evaluate the effects of the CRSO alternatives on flood risk management, a number of assumptions were required to address uncertainties and data limitations. The key assumption to the analysis is that assessing flood hazards, as measured by thresholds at specific gage location, would provide a reasonable assessment of changes in flood risk conditions for the CRSO EIS, while addressing the varied flood risk conditions that occur throughout the Columbia River Basin. Fortunately, because there were already established gage locations for evaluating flood hazard conditions it was possible to establish a set of sample locations that provided a good representation of conditions throughout the study area. Thus allowing both a comprehensive flood risk analysis and a localized evaluation to occur.

The key uncertainty for the flood risk analysis is the accuracy of the AEP results from the H&H model, and the use of these results to reflect the change in hazard conditions under the MO's and PA. It is recognized that the H&H model is more uncertain for very rare flooding conditions, defined in this analysis as less than 1 percent AEP. Similarly, changes in AEP at a given location and stage are assumed to be accurate at approximately 1 percent (due to modeling challenges), thus change values are reported to the whole percent reflecting this uncertainty. Additional notes on AEP results, such as limitations of use and model anomalies, are included in the footnotes associated with the results tables presented in the following section and discussed in greater detail in Appendix A, Part 1 - H&H Data Analysis.

CHAPTER 2 - ALTERNATIVES ANALYSIS

This section provides detailed results of the flood risk analysis completed to assess the risk of flooding by evaluating the difference in flood risk under the No Action Alternative with flood risk, measured as AEP for each of the Multi-Objective Alternatives (MO's) and the Preferred Alternative (PA).

2.1 NO ACTION ALTERNATIVE

The detailed AEP results for each flood hazard category under the No Action Alternative are identified by region and by gage location in the following sections.

2.1.1 Region A

Region A includes four gage locations: Pend Oreille River Outflow from Below Albeni Falls, Clark Fork Near Plains, MT, Columbia Falls, MT, and Bonner's Ferry, ID. The AEP's for each consequence threshold for each gage under the No Action Alternative are summarized in Table 2-1. 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. Communities around the Columbia Falls, Montana, gage include Kalispell, Montana, and surrounding towns. These comparisons are not intended to quantify the differences in risk across regions, but rather to orient the reader to the table and the probabilities contained therein that provide as a baseline for comparison with the action alternatives.

Table 2-1. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in Region A, by Hazard Category

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
3 (A)	Pend Oreille River Outflow from Albeni Falls*	50%	34%	9%	6%
4 (A)	Clark Fork Near Plains, MT	12%	5%	<1%	<1%
2 (A)	Columbia Falls, MT Gage	83%	73%	<1%	<1%
1 (A)	Bonner's Ferry, ID Gage	85%	<1%	<1%	<1%

Note: Modeled estimates are rounded to the nearest whole percentage. *Measured in flow.

2.1.2 Region B

Region B includes one gage location: the gage called "Below Priest's Rapids." The AEP's for each consequence threshold for this gage under the No Action Alternative are summarized in Table 2-2. As shown, AEP is less than 1 percent for all thresholds at this gage under the No Action Alternative. As noted in Table 1-1, there are no changes in AEP above Priest Rapids Dam.

This does not mean those elevations cannot be exceeded, however these areas were not affected in any CRSO alternative (either No Action or the action alternatives).

Table 2-2. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in Region B, by Hazard Category

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
5 (B)	Below Priest Rapids, WA Gage	<1%	<1%	<1%	<1%

Note: Modeled estimates are rounded to the nearest whole percentage.

2.1.3 Region C

Region C includes three gage locations: Anatone, WA; Orofino, ID, and Spalding, ID. The AEP's for each consequence threshold for each gage under the No Action Alternative are summarized in Table 2-3. As shown, the Spalding gage on the Clearwater River exhibits the highest AEP at moderate and major flood stages under the No Action Alternative. As noted in Table 1-1, there are no changes in AEP in reaches R06, R07, and R08. This does not mean those elevations cannot be exceeded, however there are no changes related to CRSO EIS that have the potential to affect AEP in these reaches.

Table 2-3. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in Region C, by Hazard Category

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
8 (C)	Anatone, WA Gage	28%	14%	2%	2%
7 (C)	Orofino, ID Gage	20%	13%	3%	<1%
6 (C)	Spalding, ID Gage	57%	41%	28%	23%

Note: Modeled estimates are rounded to the nearest whole percentage.

2.1.4 Region D

Region D includes six gage locations: Vancouver, WA; St. Helens, OR; Woodland, WA; Kelso, WA; Longview, WA; and Wauna, OR. The flood risk AEP's for each flood stage for this gage under the No Action Alternative are summarized in Table 2-4.

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 and 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 AEP at moderate and major flood stages under the No Action Alternative.

Table 2-4. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in Region D, by Hazard Category

Region	Gage Location	Season	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
9 (D)	Vancouver, WA	Annual	43%	32%	11%	3%
9 (D)	Vancouver, WA	Winter	38%	28%	10%	3%
9 (D)	Vancouver, WA	Spring	22%	14%	2%	<1%
10 (D)	St. Helens, OR	Annual	26%	16%	11%	6%
10 (D)	St. Helens, OR	Winter	23%	14%	10%	5%
10 (D)	St. Helens, OR	Spring	9%	6%	1%	<1%
11 (D)	Woodland, WA	Annual	45%	32%	-	12%
11 (D)	Woodland, WA	Winter	45%	32%	-	12%
11 (D)	Woodland, WA	Spring	3%	<1%	-	<1%
13 (D)	Kelso, WA	Annual	53%	19%	7%	6%
13 (D)	Kelso, WA	Winter	49%	17%	6%	5%
13 (D)	Kelso, WA	Spring	11%	2%	1%	<1%
12 (D)	Longview, WA	Annual	24%	12%	8%	3%
12 (D)	Longview, WA	Winter	22%	12%	8%	3%
12 (D)	Longview, WA	Spring	9%	2%	<1%	<1%
14 (D)	Wauna, OR	Annual	4%	3%	-	3%
14 (D)	Wauna, OR	Winter	3%	%	-	3%
14 (D)	Wauna, OR	Spring	<1%	0%	-	0%

Note: Modeled estimates are rounded to the nearest whole percentage.
Sources: National Weather Service Hydrograph Data and H&H analysis.

2.2 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.

2.2.1 Region A

Table 2-5 presents the anticipated changes in AEP that would occur under MO1 at gage locations in Region A. Under typical to lower annual peak flow conditions, AEP would be anticipated to decrease under this alternative. In particular, the AEP at Bonners Ferry, Idaho, would decrease by 6 percent under MO1 at the action stage. This would be caused by a variety of operational measures at Libby Dam that would result in deeper drafts earlier in the spring, including the *Modified Draft at Libby* measure. Because this decrease occurs at the Action Stage, which does not result in flood consequences, but is rather an indication that flood monitoring would occur, it has a negligible effect on flood risk. The Canadian 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 *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. Because the 7% AEP decrease occurs at the action stage, which does not result in flood consequences, it has a negligible effect on flood risk.

Related to the change at Hungry Horse, some minor decreases in AEP (1 to 2 percent) would be evident in the action and moderate flood stages on the Pend Oreille River outflow from below Albeni Falls. There would not be changes in flood risk at the Clark Fork gage near Plains, Montana.

Table 2-5. Changes in Flood Risk Annual Exceedance Probabilities under MO1 in Region A

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
3 (A)	Pend Oreille River Outflow from Albeni Falls	-1%	-1%	No change	No change
4 (A)	Clark Fork Near Plains, MT	No change	No change	No change	No change
2 (A)	Columbia Falls, MT Gage	-1%	-2%	No change	No change
1 (A)	Bonner's Ferry, ID Gage	-6%	No change	No change	No change

2.2.2 Region B

Table 2-6 presents the anticipated changes in AEP that would occur under MO1 at gage locations in Region B. As noted in Table 1-1, there are no changes in AEP above Priest Rapids Dam. This does not mean those elevations cannot be exceeded, however these areas were not affected in any CRSO alternative (either No Action or the action alternatives). No changes to flood risk are anticipated in Region B under MO1.

Table 2-6. Changes in Flood Risk Annual Exceedance Probabilities under MO1 in Region B

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
5 (B)	Below Priest Rapids, WA Gage	No change	No change	No change	No change

Note: Modeled estimates are rounded to the nearest whole percentage.

2.2.3 Region C

Table 2-7 presents the anticipated changes in AEP that would occur under MO1 at gage locations in Region C. As noted in Table 1-1, there are no changes in AEP in reaches R06, R07, and R08. This does not mean those elevations cannot be exceeded, however there are no changes related to CRSO EIS that have the potential to affect AEP in these reaches. No changes to flood risk are anticipated in Region C under MO1.

Table 2-7. Changes in Flood Risk Annual Exceedance Probabilities under MO1 in Region C[1/]

Region	Consequence Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
8 (C)	Anatone, WA Gage	No change	No change	No change	No change
7 (C)	Orofino, ID Gage	No change	No change	No change	No change
6 (C)	Spalding, ID Gage[1/]	No change	No change	No change	No change

Note: [1/] Estimated using comparable flow metrics.

2.2.4 Region D

Table 2-8 presents the anticipated changes in in AEP that would occur under MO1 at gage locations in Region D.

Under MO1, it is anticipated that there are minor decreases in AEP in Region D. In particular, there are negligible changes at the action stages and minor decreases at higher flood stages. Where changes occur, the modeling results suggest minor increases at the action stage, and minor decreases at flood stage. There are small increases at the action stage. Because this increase occurs at the Action Stage, which does not result in flood consequences, it has a negligible effect on flood risk.[1] Due to the *Winter System FRM Space* measure at Grand Coulee Dam, which would result 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 AEPs would be 1 to 4 percent lower for larger flood conditions near the mainstem Columbia River. The Vancouver, Washington, gage shows a decrease in AEP 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.[2]

Table 2-8. Changes in Flood Risk Annual Exceedance Probabilities under MO1 in Region D

Region	Consequence Location	Season	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
9 (D)	Vancouver, WA	Annual	1%	-1%	No change	No change
9 (D)	Vancouver, WA	Winter	-2%	-1%	No change	No change
9 (D)	Vancouver, WA	Spring	-1%	-1%	No change	No change
10 (D)	St. Helens, OR	Annual	-1%	-1%	No change	-1%
10 (D)	St. Helens, OR	Winter	-1%	-2%	No change	No change
10 (D)	St. Helens, OR	Spring	No change	No change	No change	No change
11 (D)	Woodland, WA	Annual	1%	-1%	No change	No change
11 (D)	Woodland, WA	Winter	1%	-1%	No change	No change

[1] Personal communication with A. Marshall, Reservoir Regulation Team Lead Operations Manager for Northwest Division Columbia Basin Water Management, February 2020.
[2] 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.

Region	Consequence Location	Season	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
11 (D)	Woodland, WA	Spring	No change	No change	No change	No change
13 (D)	Kelso, WA	Annual	No change	-3%	-1%	-2%
13 (D)	Kelso, WA	Winter	-2%	-4%	-1%	-1%
13 (D)	Kelso, WA	Spring	No change	No change	No change	No change
12 (D)	Longview, WA	Annual	-2%	-1%	No change	No change
12 (D)	Longview, WA	Winter	-3%	-2%	-1%	No change
12 (D)	Longview, WA	Spring	No change	No change	No change	No change
14 (D)	Wauna, OR	Annual	1%	No change	No change	No change
14 (D)	Wauna, OR	Winter	1%	No change	No change	No change
14 (D)	Wauna, OR	Spring	No change	No change	No change	No change

Note: A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage. AEP calculated at the Woodland and Kelso gages includes reflect some model anomalies and should not be used directly. 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 changes in mainstem Columbia flows

2.3 MULTIPLE OBJECTIVE ALTERNATIVE 2

This section describes changes in flood risk, as measured in terms of changes in AEP, for MO2.

2.3.1 Region A

Table 2-9 presents the anticipated changes in AEP that would occur under MO2 at gage locations in Region A. Overall, there would be little change to flood risk anticipated under MO2 in Region A. Changes in flood risk in the Kootenai River Basin under MO2 would be similar to those under MO1. Note, H&H model output shows minor increases in peak flows at Columbia Falls, MT; however, these changes are a modeling artifact related to modeled refill logic in the ResSim model made during the simulations of the *Deeper Drafts for Hydropower* measure under MO2. As such, flood risk is not anticipated to change at this gage. In fact, any changes, should any occur, would be expected to decrease at Columbia Falls, MT as a result of Hungry Horse reservoir being drafted deeper during the spring months.

At the Bonners Ferry, Idaho, gage, negligible changes would be expected at flood stages, and there would be a 7 percent decrease in AEP at the action stage primarily due to the *Modified Draft at Libby* measure. Because this decrease occurs at the Action Stage, which does not result in flood consequences, it has a negligible effect on flood risk, however it could reduce the number of instances where flood risk monitoring is required. There would not be anticipated changes in flood risk in the Flathead and Pend Oreille River Basins under MO2.[3] No effect to Canada is anticipated downstream of Bonners Ferry under MO2.

[3] 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*

Table 2-9. Changes in Flood Risk Annual Exceedance Probabilities under MO2 in Region A

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
3 (A)	Pend Oreille River Outflow from Albeni Falls[1/]	-1%	No change	No change	No change
4 (A)	Clark Fork Near Plains, MT	No change	No change	No change	No change
2 (A)	Columbia Falls, MT Gage[2]	3%	7%	No change	No change
1 (A)	Bonner's Ferry, ID Gage	-7%	No change	No change	No change

Note: A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage.
[1/] Measured in flow.
[2/] 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 Deeper Drafts 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.

2.3.2 Region B

Table 2-10 presents the anticipated changes in AEP that would occur under MO2 at gage locations in Region B. As noted in Table 1-1, there are no changes in AEP above Priest Rapids Dam. This does not mean those elevations cannot be exceeded, however there are no changes related to CRSO EIS that have the potential to affect AEP in these reaches. No changes to flood risk are anticipated in Region B under MO2.

Table 2-10. Changes in Flood Risk Annual Exceedance Probabilities under MO2 in Region B

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
5 (B)	Below Priest Rapids, WA Gage	No change	No change	No change	No change

Note: A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage.

2.3.3 Region C

Table 2-11 presents the anticipated changes in AEP that would occur under MO2 at gage locations in Region C. Some minor changes in AEP would be anticipated under MO2 in Region C at the Orofino, ID gage, with minor decreases at major and minor flood stages and minor increases at the action (lowest) stage. Because the increase occurs at the Action Stage, which does not result in flood consequences, it has a negligible effect on flood risk. *The storage projects may be drafted slightly deeper for hydropower* measure would result in increased outflow from Dworshak and higher peak flows during typical, non-flood years. As noted in Table 1-1, there are no changes in AEP in reaches R06, R07, and R08. This does not mean those

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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.

elevations cannot be exceeded, however there are no changes related to CRSO EIS that have the potential to affect AEP in these reaches.

Table 2-11. Changes in Flood Risk Annual Exceedance Probabilities under MO2 in Region C[1/]

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
8 (C)	Anatone, WA Gage	No change	No change	No change	No change
7 (C)	Orofino, ID Gage	1%	No change	-1%	-1%
6 (C)	Spalding, ID Gage[2/]	No change	No change	No change	No change

[1/] A decrease in AEP means that a decrease in flood risk is expected. Modeled estimates are rounded to the nearest whole percentage.
[2/] Estimated using comparable flow metrics.

2.3.4 Region D

There would be little change 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 would result 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 AEPs would be 1 to 4 percent lower for larger flood conditions near the mainstem Columbia River. The Vancouver, Washington, gage shows a decrease in AEP at the action and flood stages of 1 to 2 percent, and negligible changes at the moderate and major flood stages. Similar changes would occur 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.[4] There are small increases at the action stage. Because this increase occurs at the Action Stage, which does not result in flood consequences, it has a negligible effect on flood risk. The model is showing some small increase at the flood stage on the order of 1% point. Based on professional judgment, this small increase can be attributed to an artifact of the modeling process, which relies on a daily timestep computation of flows. In real time operations, which occur on an hourly basis, it is unlikely any increase in AEP would occur at these locations as a result of the action alternative.[5]

Table 2-12 presents the anticipated changes in AEP that would occur under MO1 at gage locations in Region D.

[4] 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.
[5] Personal communication with A. Marshall, Reservoir Regulation Team Lead Operations Manager for Northwest Division Columbia Basin Water Management, February 2020.

Table 2-12. Changes in Flood Risk Annual Exceedance Probabilities under MO2 in Region D

Region	Gage Location	Season	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
9 (D)	Vancouver, WA	Annual	-1%	-1%	No change	No change
9 (D)	Vancouver, WA	Winter	-1%	No change	No change	No change
9 (D)	Vancouver, WA	Spring	No change	-1%	No change	No change
10 (D)	St. Helens, OR	Annual	-1%	No change	-1%	-1%
10 (D)	St. Helens, OR	Winter	-1%	No change	No change	No change
10 (D)	St. Helens, OR	Spring	No change	1%	No change	No change
11 (D)	Woodland, WA	Annual	2%	-1%	No change	No change
11 (D)	Woodland, WA	Winter	-1%	-1%	No change	No change
11 (D)	Woodland, WA	Spring	No change	No change	No change	No change
13 (D)	Kelso, WA	Annual	-2%	-3%	-3%	-3%
13 (D)	Kelso, WA	Winter	-1%	-4%	-3%	-2%
13 (D)	Kelso, WA	Spring	No change	No change	No change	No change
12 (D)	Longview, WA	Annual	-3%	-1%	-1%	No change
12 (D)	Longview, WA	Winter	-1%	-2%	-1%	No change
12 (D)	Longview, WA	Spring	No change	No change	No change	No change
14 (D)	Wauna, OR	Annual	1%	No change	No change	No change
14 (D)	Wauna, OR	Winter	No change	No change	No change	No change
14 (D)	Wauna, OR	Spring	No change	No change	No change	No change

Note: A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage. AEP calculated at the Woodland and Kelso gages includes reflect some model anomalies and should not be used directly. 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 changes in mainstem Columbia flows.

2.4 MULTIPLE OBJECTIVE ALTERNATIVE 3

2.4.1 Region A

Table 2-13 presents the anticipated changes in AEP that would occur under MO3 at gage locations in Region A. There is little change to flood risk anticipated under MO3. Additionally, under some flow conditions, flood risk would be anticipated to decrease in probability at some locations. In particular, the AEP at Bonners Ferry, Idaho, would decrease by 7 percent under MO3 at the action stage. Because this decrease occurs at the Action Stage, which does not result in flood consequences, it has a negligible effect on flood risk. AEP would be reduced by 1 percent at the action stage and 2 percent at the flood stage at Columbia Falls, Montana. No effect to Canada would be anticipated downstream of Bonners Ferry under MO3.

Table 2-13. Changes in Flood Risk Annual Exceedance Probabilities under MO3 in Region A

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
3 (A)	Pend Oreille River Outflow from Albeni Falls	No change	-1%	No change	No change
4 (A)	Clark Fork Near Plains, MT	No change	No change	No change	No change
2 (A)	Columbia Falls, MT Gage	-1%	-2%	No change	No change
1 (A)	Bonner's Ferry, ID Gage	-7%	No change	No change	No change

Note: A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage.
1/ Measured in flow.

2.4.2 Region B

Table 2-14 presents the anticipated changes in AEP that would occur under MO3 at gage locations in Region B. As noted in Table 1-1, there are no changes in AEP above Priest Rapids Dam. This does not mean those elevations cannot be exceeded, however these areas were not affected in any CRSO alternative (either No Action or the action alternatives). No changes to flood risk are anticipated in Region B under MO3.

Table 2-14. Changes in Flood Risk Annual Exceedance Probabilities under MO3 in Region B

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
5 (B)	Below Priest Rapids, WA Gage	No change	No change	No change	No change

Note: Modeled estimates are rounded to the nearest whole percentage.

2.4.3 Region C

Table 2-15 presents the anticipated changes in AEP that would occur under MO3 at gage locations in Region C. With the breaching of the lower Snake River dams and the draining of Lower Granite Reservoir under MO3, sediment flushing would occur and river stages would be reduced, reducing flood risk near the confluence of the Clearwater and Snake Rivers near Lewiston, ID.. However overall, in Region C under MO3, no increase to flood risk is expected.[6]

Table 2-15. Changes in Flood Risk Annual Exceedance Probabilities under MO3 in Region C[1/]

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
8 (C)	Anatone, WA Gage	No change	No change	No change	No change
7 (C)	Orofino, ID Gage	No change	No change	No change	No change
6 (C)	Spalding, ID Gage[2/]	No change	No change	No change	No change

[6] 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.

1/ A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage.
2/ Estimated using comparable flow metrics.

2.4.4 Region D

Table 2-16 presents the anticipated changes in AEP that would occur under MO3 at gage locations in Region D. There would be little change anticipated to flood risk in Region D under MO3. Due to the *Winter System FRM Space* measure at Grand Coulee Dam, which would result in more storage in December and January to reduce Columbia River flows coincident with peak flood conditions in the Portland/Vancouver area in reach R01, winter and annual AEPs would be lower for larger flood conditions near the mainstem Columbia River. Under flow conditions at some locations, AEP would decrease in probability by 1 to 2 percent. There are small increases at the action stage. Because this increase occurs at the Action Stage, which does not result in flood consequences, it has a negligible effect on flood risk. The model is showing some small increase at the flood stage on the order of 1% point. Based on professional judgment, this small increase can be attributed to an artifact of the modeling process, which relies on a daily timestep computation of flows. In real time operations, which occur on an hourly basis, it is unlikely any increase in AEP would occur at these locations as a result of the action alternative.[7]

Table 2-16. Changes in Flood Risk Annual Exceedance Probabilities under MO3 in Region D

Region	Gage Location	Season	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
9 (D)	Vancouver, WA	Annual	-1%	No change	No change	No change
9 (D)	Vancouver, WA	Winter	-3%	No change	No change	No change
9 (D)	Vancouver, WA	Spring	-1%	-1%	No change	No change
10 (D)	St. Helens, OR	Annual	-1%	1%	No change	-1%
10 (D)	St. Helens, OR	Winter	-1%	1%	No change	No change
10 (D)	St. Helens, OR	Spring	No change	No change	No change	No change
11 (D)	Woodland, WA	Annual	-1%	No change	No change	No change
11 (D)	Woodland, WA	Winter	-1%	No change	No change	No change
11 (D)	Woodland, WA	Spring	No change	No change	No change	No change
13 (D)	Kelso, WA	Annual	No change	-2%	-2%	-2%
13 (D)	Kelso, WA	Winter	-1%	-2%	-1%	-1%
13 (D)	Kelso, WA	Spring	1%	No change	No change	No change
12 (D)	Longview, WA	Annual	No change	No change	No change	No change
12 (D)	Longview, WA	Winter	-2%	No change	No change	No change
12 (D)	Longview, WA	Spring	No change	No change	No change	No change
14 (D)	Wauna, OR	Annual	No change	No change	No change	No change
14 (D)	Wauna, OR	Winter	1%	No change	No change	No change
14 (D)	Wauna, OR	Spring	No change	No change	No change	No change

[7] Personal communication with A. Marshall, Reservoir Regulation Team Lead Operations Manager for Northwest Division Columbia Basin Water Management, February 2020.

Note: A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage. AEP calculated at the Woodland and Kelso gages includes reflect some model anomalies and should not be used directly. 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 changes in mainstem Columbia flows.

2.5 MULTIPLE OBJECTIVE ALTERNATIVE 4

2.5.1 Region A

Table 2-17 presents the anticipated changes in AEP that would occur under MO4 at gage locations in Region A. There is little change anticipated to AEP in Region A under MO4. Additionally, under flow conditions at some locations, flood risk would decrease in probability. The AEP 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. Because this decrease occurs at the Action Stage, which does not result in flood consequences, it has a negligible effect on flood risk. The AEP 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 change would be anticipated at the Pend Oreille River outflow from below Albeni Falls gage.

Table 2-17. Changes in Flood Risk Annual Exceedance Probabilities under MO4 in Region A

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
3 (A)	Pend Oreille River Outflow from Albeni Falls	No change	No change	No change	No change
4 (A)	Clark Fork Near Plains, MT	No change	No change	No change	No change
2 (A)	Columbia Falls, MT Gage	No change	-2%	No change	No change
1 (A)	Bonner’s Ferry, ID Gage	-5%	No change	No change	No change

Note: A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage.

2.5.2 Region B

Table 2-18 presents the anticipated changes in AEP that would occur under MO4 at gage locations in Region B. As noted in Table 1-1, there are no changes in AEP above Priest Rapids Dam. This does not mean those elevations cannot be exceeded, however these areas were not affected in any CRSO alternative (either No Action or the action alternatives). No changes to flood risk are anticipated in Region B under MO4.

Table 2-18. Changes in Flood Risk Annual Exceedance Probabilities under MO4 in Region B

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
5 (B)	Below Priest Rapids, WA Gage	No change	No change	No change	No change

Note: Modeled estimates are rounded to the nearest whole percentage.

2.5.3 Region C

Table 2-19 presents the anticipated changes in AEP that would occur under MO4 at gage locations in Region C. As noted in Table 1-1, there are no changes in AEP in reaches R06, R07, and R08. This does not mean those elevations cannot be exceeded, however these areas were not affected in any CRSO alternative (either No Action or the action alternatives). No effect to flood risk is expected in Region C under MO4.

Table 2-19. Changes in Flood Risk Annual Exceedance Probabilities under MO4 in Region C[1/]

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
8 (C)	Anatone, WA Gage	No change	No change	No change	No change
7 (C)	Orofino, ID Gage	No change	No change	No change	No change
6 (C)	Spalding, ID Gage[2/]	No change	No change	No change	No change

[1/] A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage.
[2/] Estimated using comparable flow metrics.

2.5.4 Region D

Table 2-20 presents the anticipated changes in AEP that would occur under MO4 at gage locations in Region D. 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 AEPs are 1 to 4 percent lower for larger flood conditions near the mainstem Columbia River. The Vancouver, Washington, gage shows a decrease in AEP 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 AEP at the Woodland and Kelso, Washington, gages would be similar to but likely smaller than those on the mainstem Columbia River downstream.[8] The model is showing some small increase at the flood stage on the order of 1% point. Based on professional judgment, this small increase can be attributed to an artifact of the modeling process, which relies on a daily timestep computation of flows. In real time operations, which occur on an hourly basis, it is unlikely any increase in AEP would occur at these locations as a result of the action alternative

[8] 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.

Table 2-20. Changes in Flood Risk Annual Exceedance Probabilities under MO4 in Region D

Region	Gage Location	Season	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
9 (D)	Vancouver, WA	Annual	-2%	-2%	No change	No change
9 (D)	Vancouver, WA	Winter	-1%	-1%	No change	No change
9 (D)	Vancouver, WA	Spring	-2%	-2%	No change	No change
10 (D)	St. Helens, OR	Annual	-1%	-1%	No change	-1%
10 (D)	St. Helens, OR	Winter	-9%	-2%	No change	No change
10 (D)	St. Helens, OR	Spring	No change	No change	No change	No change
11 (D)	Woodland, WA	Annual	-1%	-1%	No change	No change
11 (D)	Woodland, WA	Winter	-13%	-1%	No change	No change
11 (D)	Woodland, WA	Spring	No change	No change	No change	No change
13 (D)	Kelso, WA	Annual	No change	-2%	-1%	-1%
13 (D)	Kelso, WA	Winter	-3%	-2%	-1%	-1%
13 (D)	Kelso, WA	Spring	No change	1%	No change	No change
12 (D)	Longview, WA	Annual	-2%	-1%	-1%	No change
12 (D)	Longview, WA	Winter	-1%	-2%	No change	No change
12 (D)	Longview, WA	Spring	-1%	No change	No change	No change
14 (D)	Wauna, OR	Annual	No change	No change	No change	No change
14 (D)	Wauna, OR	Winter	No change	No change	No change	No change
14 (D)	Wauna, OR	Spring	No change	No change	No change	No change

Note: A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage. AEP calculated at the Woodland and Kelso gages includes reflect some model anomalies and should not be used directly. 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 changes in mainstem Columbia flows.

2.6 PREFERRED ALTERNATIVE

2.6.1 Region A

Table 2-21 presents the anticipated changes in AEP that would occur under the Preferred Alternative at gage locations in Region A. Under typical to lower annual peak flow conditions, flood risk would be anticipated to decrease in probability under this alternative. In particular, the AEP at Bonners Ferry, Idaho, would decrease by 6 percent under MO1 at the action stage. This would be caused by a variety of operational measures at Libby Dam that would result in deeper drafts earlier in the spring, including the *Modified Draft at Libby* measure. Because this decrease occurs at the Action Stage, which does not result in flood consequences, it has a negligible effect on flood risk. There would be negligible changes to the probability of higher flood stage at the Bonners Ferry gage, thus no effect to flood risk conditions are expected. The Canadian Border is downstream of Bonners Ferry. No effect to Canada is anticipated under MO1.

Table 2-21. Changes in Flood Risk Annual Exceedance Probabilities under the Preferred Alternative in Region A

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
3 (A)	Pend Oreille River Outflow from Albeni Falls	No change	No change	No change	No change
4 (A)	Clark Fork Near Plains, MT	No change	No change	No change	No change
2 (A)	Columbia Falls, MT Gage	No change	No Change	No change	No change
1 (A)	Bonner's Ferry, ID Gage	-6%	No change	No change	No change

Note: A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage.

2.6.2 Region B

Table 2-22 presents the anticipated changes in AEP that would occur under the Preferred Alternative at gage locations in Region B. As noted in Table 1-1, there are no changes in AEP above Priest Rapids Dam. This does not mean those elevations cannot be exceeded, however these areas were not affected in any CRSO alternative (either No Action or the action alternatives). No changes to flood risk are anticipated in Region B under the Preferred Alternative.

Table 2-22. Changes in Flood Risk Annual Exceedance Probabilities under the Preferred Alternative in Region B

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
5 (B)	Below Priest Rapids, WA Gage	No change	No change	No change	No change

Note: Modeled estimates are rounded to the nearest whole percentage.

2.6.3 Region C

Table 2-23 presents the anticipated changes in AEP that would occur under the Preferred Alternative at gage locations in Region C. Some changes in AEP would be anticipated under MO2 in Region C at the Spalding, ID gage, with minor decreases at the major flood stage and minor increases at the action (lowest) stage. Because the increase occurs at the Action Stage, which does not result in flood consequences, it has a negligible effect on flood risk. As noted in Table 1-1, there are no changes in AEP in reaches R06, R07, and R08. This does not mean those elevations cannot be exceeded, however these areas were not affected in any CRSO alternative (either No Action or the action alternatives).

Table 2-23. Changes in Flood Risk Annual Exceedance Probabilities under the Preferred Alternative in Region C[1/]

Region	Gage Location	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
8 (C)	Anatone, WA Gage	No change	No change	No change	No change
7 (C)	Orofino, ID Gage	No change	No change	No change	No change
6 (C)	Spalding, ID Gage[2/]	1%	No change	No change	-3%

[1/] A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage.
[2/] Estimated using comparable flow metrics.

2.6.4 Region D

Table 2-24 presents the anticipated changes in AEP that would occur under the Preferred Alternative at gage locations in Region D. 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 *Updated System FRM Space Calculation* 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 AEPs flows are 1 to 3 percent lower for larger flood conditions near the mainstem Columbia River. Downstream at the St. Helens, Oregon, and Longview, Washington, gages would experience decreases in AEP at those stages. Changes in AEP at the Woodland and Kelso, Washington, gages would be similar to but likely smaller than those on the mainstem Columbia River downstream.[9] There are small increases at the action stage. Because these increases occur at the Action Stage, which does not result in flood consequences, they have a negligible effect on flood risk. The model is showing some small increase at the flood stage on the order of 1% point. Based on professional judgment, this small increase can be attributed to an artifact of the modeling process, which relies on a daily timestep computation of flows. In real time operations, which occur on an hourly basis, it is unlikely any increase in AEP would occur at these locations as a result of the action alternative.

[9] 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.

Table 2-24. Changes in Flood Risk Annual Exceedance Probabilities under the Preferred Alternative in Region D

Region	Gage Location	Season	Action Stage	Flood Stage	Moderate Flood Stage	Major Flood Stage
9 (D)	Vancouver, WA	Annual	1%	1%	No change	No change
9 (D)	Vancouver, WA	Winter	No Change	1%	No change	No change
9 (D)	Vancouver, WA	Spring	No Change	No Change	No change	No change
10 (D)	St. Helens, OR	Annual	No change	No change	No change	No change
10 (D)	St. Helens, OR	Winter	No Change	1%	No change	No change
10 (D)	St. Helens, OR	Spring	No change	No change	No change	No change
11 (D)	Woodland, WA	Annual	2%	No Change	No change	No change
11 (D)	Woodland, WA	Winter	2%	No Change	No change	No change
11 (D)	Woodland, WA	Spring	No change	No change	No change	No change
13 (D)	Kelso, WA	Annual	-3%	-1%	-2%	-1%
13 (D)	Kelso, WA	Winter	-3%	-1%	-1%	-1%
13 (D)	Kelso, WA	Spring	No change	No Change	No change	No change
12 (D)	Longview, WA	Annual	-1%	-1%	No Change	No change
12 (D)	Longview, WA	Winter	-1%	-2%	No change	No change
12 (D)	Longview, WA	Spring	-1%	No change	No change	No change
14 (D)	Wauna, OR	Annual	No change	No change	No change	No change
14 (D)	Wauna, OR	Winter	No change	No change	No change	No change
14 (D)	Wauna, OR	Spring	No change	No change	No change	No change

Note: A decrease in AEP means that a decrease in flood risk is expected, while an increase in AEP means that an increase in flood risk is expected when compared to the No Action Alternative. Modeled estimates are rounded to the nearest whole percentage. AEP calculated at the Woodland and Kelso gages includes reflect some model anomalies and should not be used directly. 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 changes in mainstem Columbia flows.

CHAPTER 3 - REFERENCES

National Weather Service Hydrograph Data and H&H analysis.

Personal communication with A. Marshall, Reservoir Regulation Team Lead Operations Manager for Northwest Division Columbia Basin Water Management, February 2020.

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Appendix L
Navigation and Transportation

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CHAPTER 1 - INTRODUCTION

The purpose of this Navigation and Transportation Appendix is to provide supplemental information on the navigation and transportation analysis completed for the Columbia River System Operations (CRSO) Environmental Impact (EIS).

1.1 APPROACH FOR EVALUATING CONSEQUENCES NAVIGATION AND TRANSPORTATION SYSTEM EFFECTS FROM CRSO EIS ALTERNATIVES

The conceptual flow chart shown in Figure 1-1 demonstrates, in a generalized manner, how the CRSO EIS alternatives may result in socioeconomic impacts to navigation and transportation industries. c, or in the case of breaching the four lower Snake River projects, system changes would eliminate the shallow draft navigation channel for the majority of the lower Snake River, and would lead to changes in operational costs. Under MO3 which includes breaching of the four lower Snake River projects, it is assumed that the lower Snake River shallow draft navigation channel would no longer be operable. , Analysis industry behaviors and associated operational costs may lead to regional economic changes, including changes in industry and consumer spending patterns, including impacts on employment. Other social effects (not shown in Figure 1-1) can result from all of these effects, including changes in air emissions, accident rates, as well as changes in community well-being, community cohesion, or other social effects.

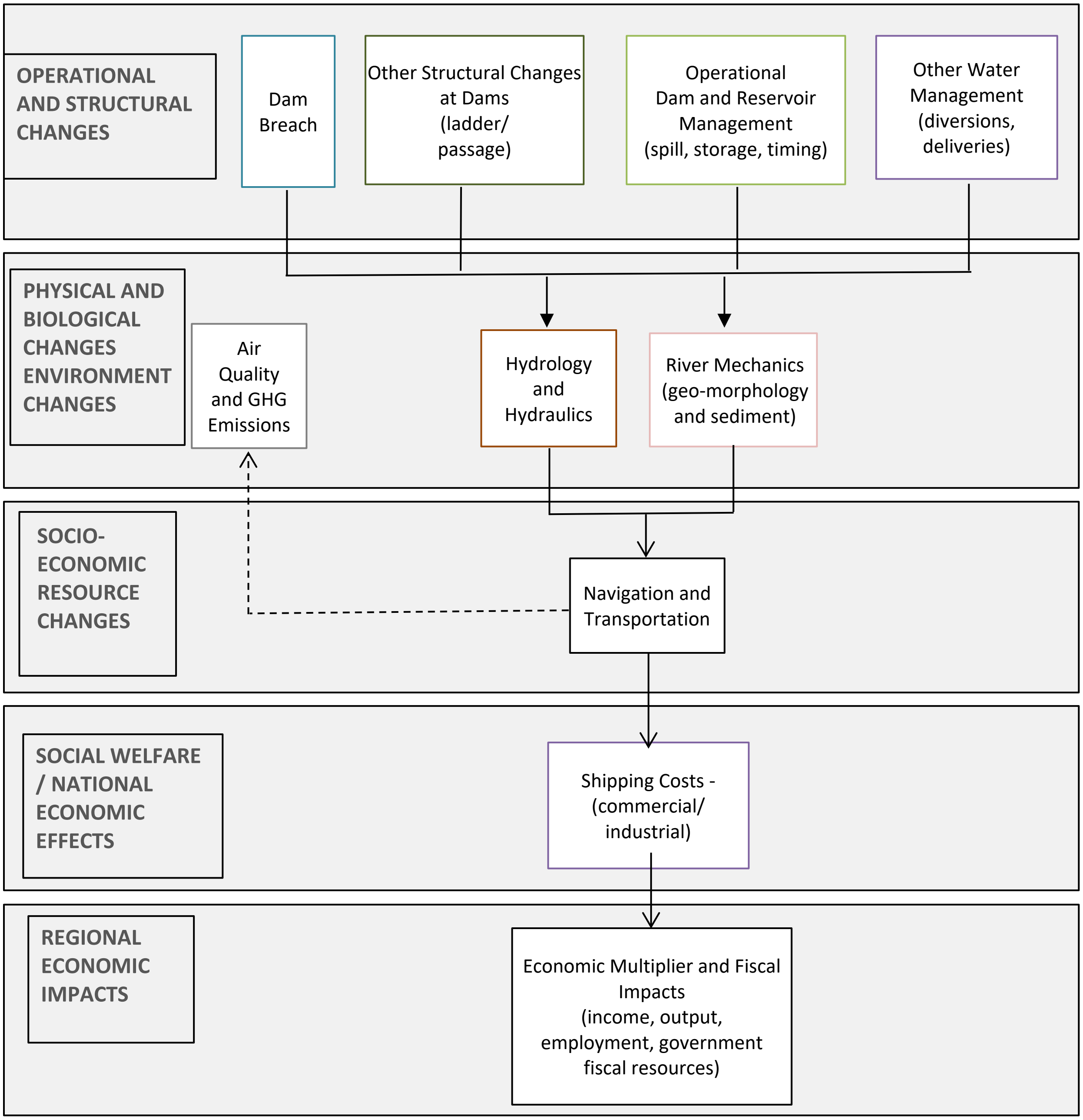


Figure 1-1. Conceptual Diagram of Flow of Socioeconomic Effects from Navigation Changes

The analysis assesses impacts of action alternatives associated with changes to commercial navigation, commercial cruise line operations, ferry operations, and related transportation systems (e.g. road and/or railway). Impacts 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 CRSO EIS alternatives 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. It 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, changes in the benefits of commercial navigation activities are measured in terms of the transportation rate savings, which are equivalent to the change in transportation costs in this case.
- 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 management alternatives, so too might the distribution of regional economic activity. Other regional effects may be associated with changes in cruise line or ferry operations.
- Other social effects are community and social effects that are relevant to various CRSO alternatives, but are not addressed under social welfare or regional economic effects. If commercial navigation freight is moved to other transportation modes, impacts to air emissions as well as accident rates can result. Other impacts may include impacts to community well-being, identity and cohesion. The Tribal Perspectives and Cultural Resources sections provide additional information about ongoing effects as well unique effects of Action alternatives on tribal ceremonial activities, subsistence activities, and other cultural practices.

This appendix focuses on describing approaches used to develop the social welfare effects analysis for commercial navigation activities. Additional analysis of related industries, as well as the regional economic analysis and other social effects analysis is described in section 3.10 of the CRSO EIS. This appendix also briefly summarizes all of the effects of the No Action Alternative and the MOs in a summary section at for each MO and for the Preferred Alternative.

1.2 MODELING TECHNIQUES

In this report, commercial navigation and transportation systems refers to movements of cargo by waterway, road, or rail within the CRSO region. Impacts to these cargo movements were assessed using two models, the Snake Columbia Economic Navigation Tool (SCENT) and the Transportation Optimization Model (TOM). While the SCENT calculates changes in transportation costs attributable to operational measures, or changes in flows and/or navigation channel depths on the commercially navigable portions of the Columbia and Snake Rivers, the TOM assesses the impact to transportation system under a dam breach scenario where navigation on the LSR is eliminated. The SCENT was used to evaluate operations-based impacts for all alternatives (MO1, MO2, MO3, and MO4). The TOM was only used to analyze the impacts from MO3. Both models are discussed in this appendix.

1.3 UNCERTAINTIES AND STUDY LIMITATIONS

To develop estimates of the economic effects of CRSO alternatives on navigation and transportation, a number of assumptions were required to address uncertainties and data limitations that exist. Generally speaking, the key uncertainty in this analysis is the specific response of the commercial navigation and transportation industries to changes in river conditions for navigation purposes that would occur under CRSO EIS alternatives. The analysis addresses this uncertainty by using the best available information available to develop reasonable assumptions about likely industry responses. A list of key uncertainties in the analysis as well as how they were addressed in the EIS is presented below:

- Under MO1, MO2, MO4, and the Preferred Alternative, understanding how navigation conditions would change and how they would affect operating decisions, is driven by modeling system conditions, and relating changing system conditions to navigation operations decisions and associated operating costs. The H&H data sets create statistical distribution from the historical data allows for the SCENT to account for natural variation in hydrology and for the uncertainty in forecasts. Uncertainties associated with navigation operating decisions cannot be completed eliminated, however the SCENT does utilize primary data from a survey of Columbia River System operators (completed in 2015), where they provided input on the characteristics that affect shippers operational decisions
- Under MO3, the specific response of shippers to the unavailability of the lower Snake River for commercial navigation is uncertain. A transportation optimization model was developed for this EIS to assess the movements of grain shipments under a dam breach scenario where navigation on the lower Snake River would be eliminated. It is assumed that 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), and when confronted with this choice they would select the least cost route. The model parameters were developed from multiple sources in order to replicate transportation alternatives facing grain shippers, including attributes such as the capacities of each facility, mode alternatives, 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 transportation rates, which would affect the modal choices.
- Information was gathered through a survey of shippers (completed in 2019), to evaluate how goods would move through the system if the lower Snake River navigation channel is made inoperable under MO3. Because shipping rate data is privately negotiated and to keep a competitive advantage, shippers do not typically want to publicly reveal their rates. The response rate for the survey was 48 percent. Although there may be a lack of confidence in some of the rate data presented in the EIS, it is the best possible estimate that is available to replicate a rate that is decided upon privately.
- The volume of commodities that would be shipped on the lower Snake River under the No Action Alternative is uncertain. The analysis addressed this uncertainty by leveraging historical volumes information, and taking into consideration current changes that may

impact those volumes (new shuttle rail facilities being built). 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 for the TOM[1]. 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. A key market force is the market prices for grain, which are primarily determined internationally. The price point for grain at any point in time may cause the growers and elevator managers to adjust storage stocks, leading to volume movements that vary from year to year. Further, many grain shippers buy/sell rail services on the secondary freight market and depending on the year may choose to not utilize rail services but instead sell those contracts and move 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. 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 for this analysis, is assumed to remain constant over time, even as modest increases in grain production and technological improvements in yield are anticipated over time. The variability of grain volumes moving down the Snake River over the past 10 years is relatively low, with a standard deviation of 0.29 million tons. This implies a range of 1.7 to 2.9 million tons annually (with two standard deviations, or a probability of 95%). Thus, the utilization of 2.4 million tons seems a reasonable estimate, particularly since the data on volumes does not include the opening of the Endicott shuttle rail facility which will likely compete for grain volumes that currently move down the Snake River. Even when evaluating the last 20 years, a period that included time prior to the introduction of shuttle rail facilities in the Pacific Northwest, the mean volume of grain moving down the Snake River was 2.9 million tons, with a range of 1.6 million tons to 3.9 million tons (with two standard deviations, or a probability of 95%).

- Under MO3, impacts to the rail industry are dependent on private sector choices. It is uncertain how rail rates will respond during a dam breach scenario. To account for this uncertainty, EIS evaluates a range of rail rate scenarios, ranging from no increase to 50 percent. The modeling effort shows that if rail rates are not increased, rail freight volumes would likely exceed current capacity, which would put upward pressure on rail rates. If rail rates increase by 50 percent, truck transport To Columbia River facilities would be relatively attractive to shippers, which would put competitive pressure on rail companies to not

[1] Note, that for the SCENT the shipment list (i.e. commodity movements), modeled are based on 2016 data, which was the most recent year of data availability at the time of modeling. The movements on the CSNS was slightly lower in 2016 than other recent years (4 percent lower than the 10-year average, per Waterborne Statistics data, 2020 but well within the standard deviation of the 10 year average.

increase rail rates much higher. As such, the modeled range of increased rates appears reasonable. The results of these scenarios are presented in Section 3.10.3.5.

- Rail line improvements and availability of line segments is uncertain. Because rail lines are largely maintained by private entities, anticipating specific future improvements and availability is challenging. For example, it is uncertain whether shortline rail will resume transporting shipments from grain elevators to river ports. Research conducted as part of the EIS suggested that elevator to river port movements via short line rail are not currently occurring. The effect of changing this assumption and allowing movements on these shortlines during a breach scenario would reduce the anticipated increases in shipping costs. An additional TOM scenario that includes this type of shortline movement is presented in Annex A of Appendix L. Under MO3, improvements to infrastructure, air emissions, and the number of highway accidents all depend on how rail rates will change.
- Under the MO3 scenario, it is moderately uncertain how farmers will respond to increases in transportation costs. Potential effects on farmers associated with increased transportation costs are evaluated under MO3 in Section 3.10.3.5. The EIS recognizes that there is no guarantee wheat grown in the Northwest will be competitive now or in the future because there are many factors that influence international commodity markets (e.g., trade agreements, the U.S. dollar, global supply, etc.). However, the analysis finds that the cost to transport wheat to market would continue to be significantly lower than costs paid by other wheat growers in other parts of United States (e.g., the Dakotas and Midwest). 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.
- Under MO3, the specific response of the cruise ship industry to the unavailability of the lower Snake River for commercial navigation is uncertain. The EIS acknowledges this uncertainty and qualitatively evaluates a range of potential impacts that may occur, including the high end possibility that the cruise line industry would cease all operations in the Lower Columbia and Snake Rivers even though the Lower Columbia River would remain open to cruise lines.

CHAPTER 2 - SCENT - MODELING IMPACTS THAT MAKE CHANGES TO RIVER FLOW AND TIMING

2.1 MODEL OVERVIEW

Social welfare, or national economic development (NED) benefits are realized through the reduction in transportation costs associated with a waterway transportation system, therefore the difference in costs between water transportation and the next least costly transportation alternative are the benefits of inland waterway system. Therefore, to measure how the benefits of the Columbia Snake Navigation System (CSNS) change in response to the CRSO alternatives, the SCENT calculates the additional transportation costs attributable to changes in flows on the commercially navigable portions of the Columbia and Snake Rivers. As shown in Figure 2-1, the SCENT calculates the additional cost from changes in river conditions using data on hydrological conditions, vessel costs, river operator behavior, and other data. These calculations are performed by the following three major components: 1) Hydraulic &Hydrology (H&H) Module; 2) Consequences Module; and 3) SCENT Combination Module. This section discusses the each of general approach used by the SCENT as well as the raw data, modules, and outputs of the model is discussed in this section.

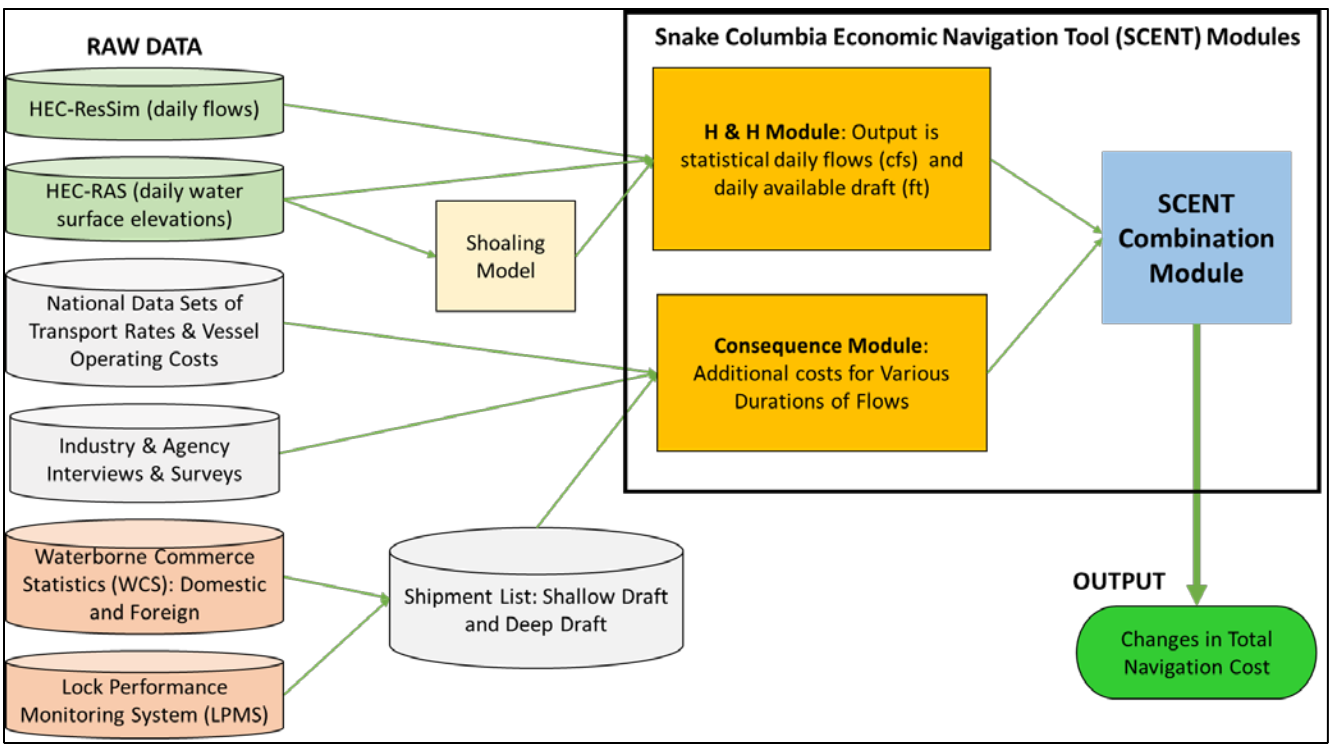


Figure 2-1. Flowchart of Snake Columbia Economic Navigation Tool Process

2.2 ASSUMPTIONS

The following assumptions were used in the SCENT model evaluation of impacts to navigation from CRSO-EIS alternatives (other than dam breaching under MO3):

- The economic analysis uses data from the hydrologic and hydraulic (H&H) modeling of the river system. The analysis assumes that the H&H models reasonably estimate river flows and reservoir levels over the 50-year period of analysis under each of the CRSO-EIS alternatives as well as No Action Alternative).
- The shipment list (i.e. commodity movements), modeled within SCENT are based on 2016 data, which was the most recent year of data availability at the time of modeling. Because there was a planned shutdown of the Snake River at the end of 2016 of a few weeks, the freight tonnage on the Snake River as well as on the overall on the CSNS was slightly lower in 2016 than other recent years (4 percent lower than the 10-year average, per Waterborne Statistics data, 2020). The commodity movement assumptions remain the same for all simulations and years. This assumption was made due to the complexity and uncertainty in forecasting commercial river traffic over the period of analysis.
- The SCENT assumes all shipments will move from their origin to their destination. If an alternative results in a flow or draft restriction that limits the normal movement, like a four-barge-tow being reduced down to a three-barge-tow, another movement will occur to get the remaining, single barge to its destination (which is captured as an increased transportation cost).

2.3 SCENT MODEL COMPONENTS

The calculations described in section 2.1 Model Overview are performed with three model ‘module. The modules are: 1) Hydraulic &Hydrology (H&H) Module; 2) Consequences Module; and 3) SCENT Combination Module. This section discusses the each these modules including the data inputs, outputs, and ultimately model results that are the basis of the SCENT analysis completed to assess operations based changes for the CRSO EIS alternatives.

2.3.1 H&H Module

As shown in Figure 2-2 and Figure 2-3, the H&H Module relies on two standard USACE H&H models to generate the inputs necessary for analyzing the shallow draft and deep draft impacts. To estimate impacts for the shallow draft reaches, the model evaluates changes in flows. H&H output developed for CRSO EIS, includes the USACE HEC-Reservoir System Simulation (ResSim) model that created 5,000 years of daily flows. Creating statistical distribution from the historical data allows for the SCENT to account for natural variation in hydrology and for the uncertainty in forecasts. An example output of the H&H Module, shown in Figure 2-2, is a table of flows by reach (Columbia River deep draft, Columbia River shallow draft, and Snake River Shallow Draft), by type (Low, Normal, High, Very High, or Too High), by duration in days, and by total number of occurrences for each quarter of every year.

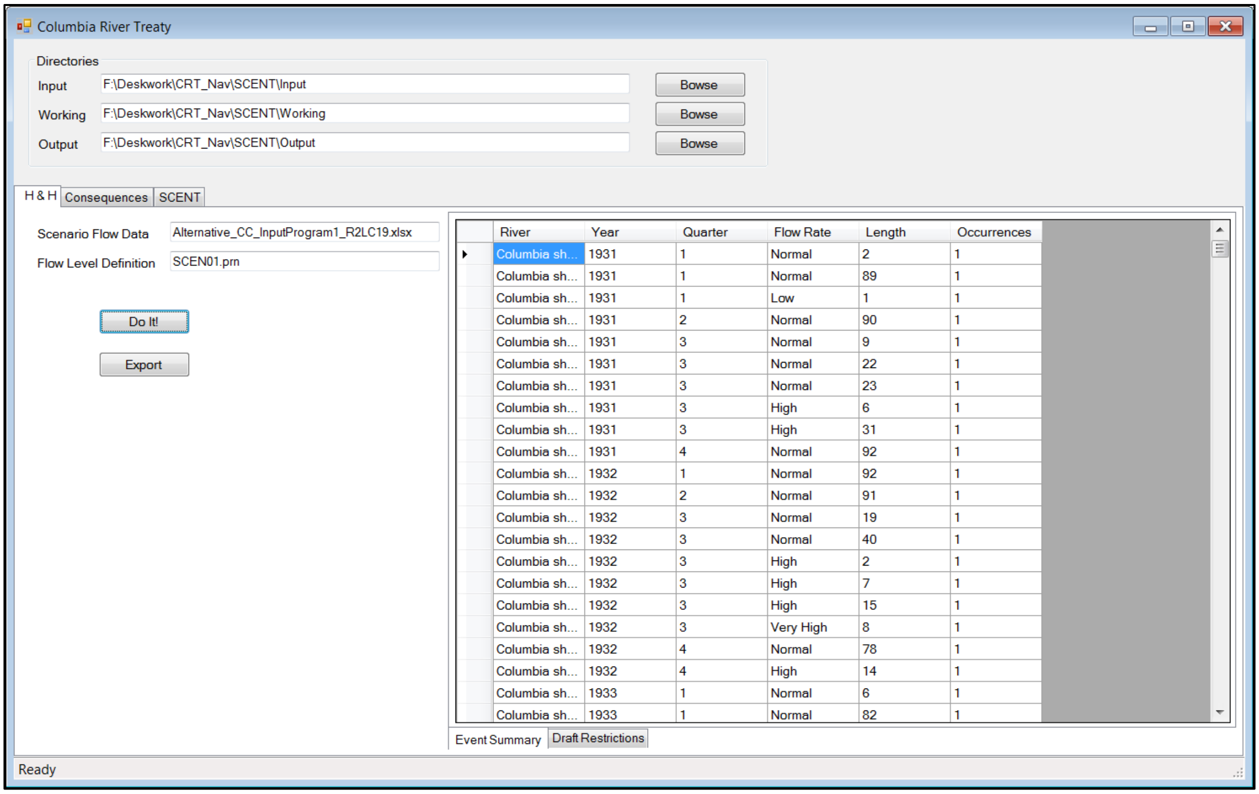


Figure 2-2. Output of H&H Module for Shallow Draft Traffic

For the deep draft analysis, as shown in Figure 2-3, the SCENT relies on the H&H data output again (USACE HEC-RAS model) along with a shoaling model to analyze the impacts on changing draft depths within the Lower Columbia River navigation channel (below Bonneville Dam). The HEC-RAS model estimates the daily water surface elevations in feet. The shoaling model combines the daily water surface elevations with depth curves to estimate the daily draft available for vessels traveling on the deep draft portion of the Columbia Snake.

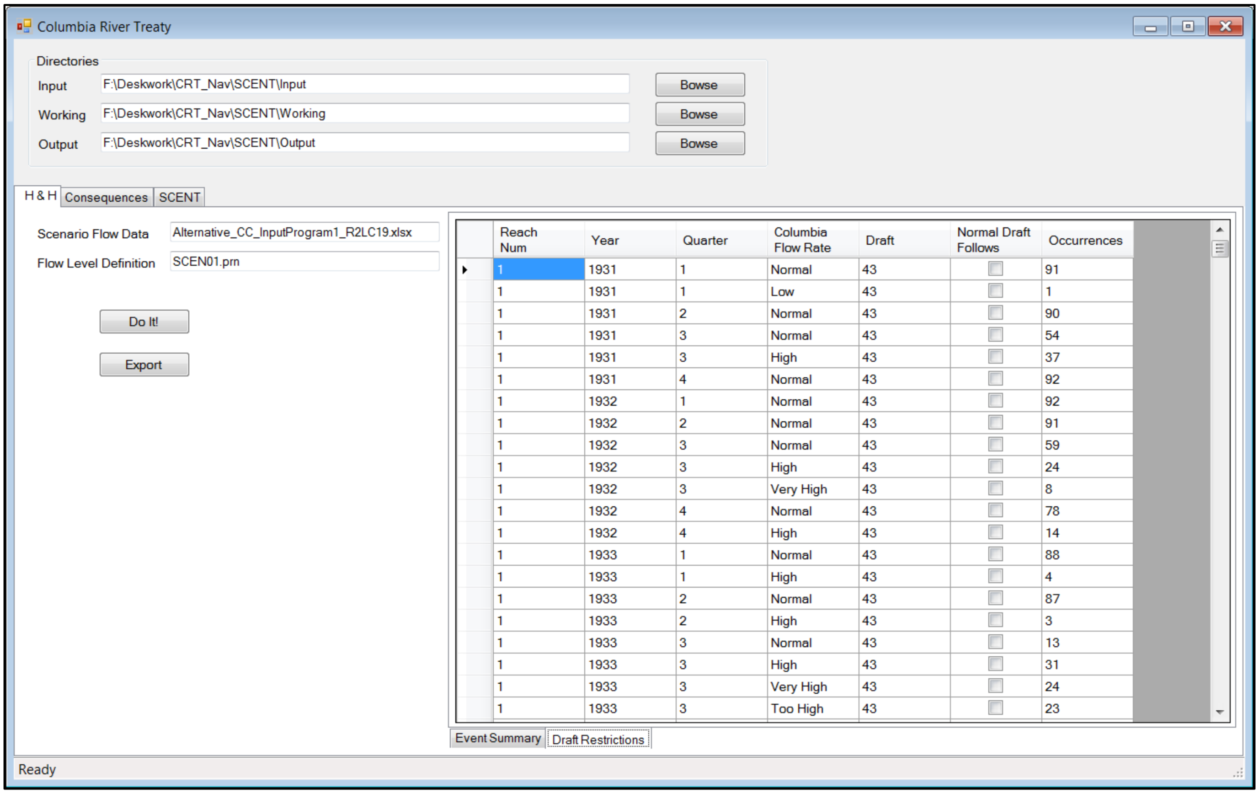


Figure 2-3. Output of H&H Module for Deep Draft Traffic

2.3.2 Consequences Module

The Consequence Module uses shipper reactions to changes in flows, miles traveled and locks transited for each movement, and other information to calculate the increased costs to commercial navigation activities when compared with normal flow conditions. Data sources for estimating the change in costs for changing flow and draft conditions in this module are described below.

National Data Set of Transportation Rates and Vessel Operating Costs: This database is maintained by the USACE Planning Center of Expertise for Inland Navigation and Risk-Informed Economics Division (PCXIN-RED). The PCXIN-RED built this database on vessel operating costs reports from USACE Institute for Water Resources entitled Shallow-Draft / Inland Vessel Operating Costs (2017) and Deep-Draft Vessel Operating Costs (2016). The costs within the database include the costs of loading, shipping, and unloading commodities, tugboat and tractor assistance costs, fuel costs, and other costs.

Industry & Agency Interviews & Surveys: Surveys of inland shippers, deep draft shippers, inland carriers, and ship assist companies (companies that provide tugs/towboats to assist large ships moving along the Lower Columbia) were conducted in the late summer of 2014 through the spring of 2015. The surveys gathered information on the characteristics that affect shippers operational decisions (i.e. flow, stage, depth and velocity), the thresholds associated with these characteristics, and the responses (i.e. change to barge and/or tow configuration, light loading, etc.). Table 2-1 summarizes flow thresholds that were identified based on the survey responses.

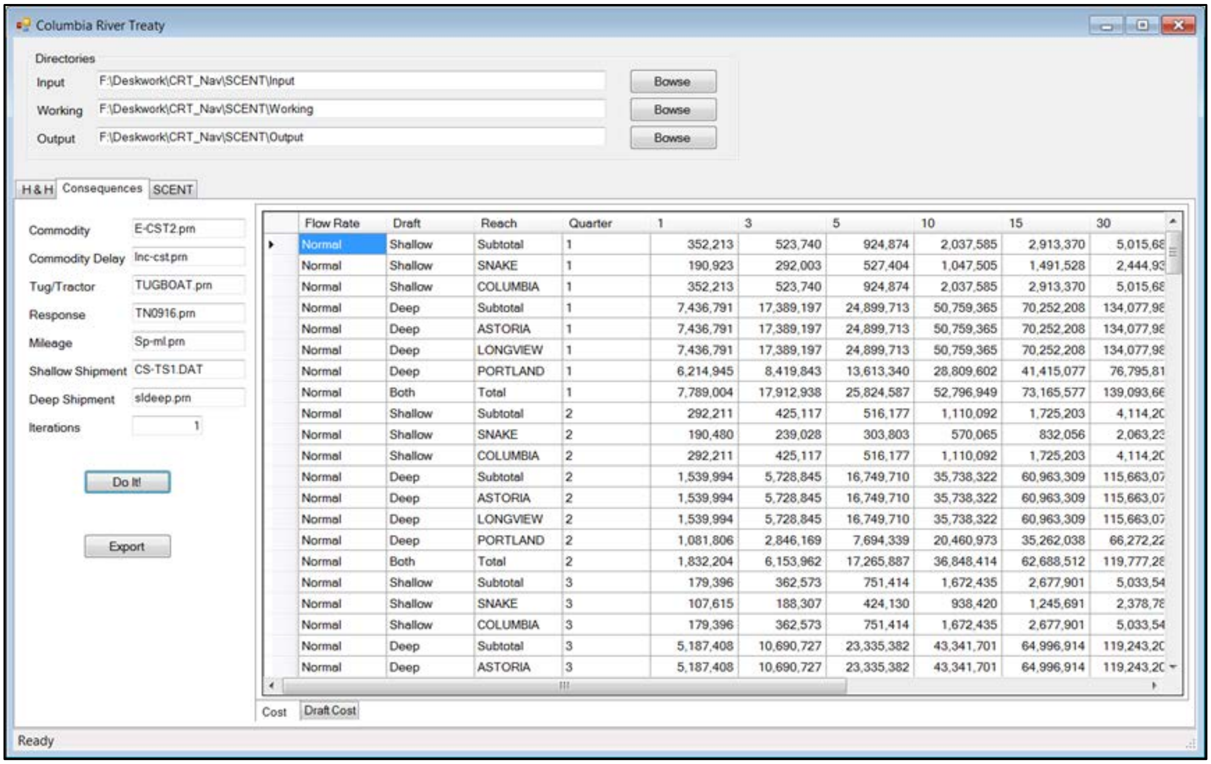
Table 2-1. Flow Range Categories for Commercial Navigation on the CSNS (kcfs)

Flow Category	Columbia Shallow/Deep	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	180-1000

Potential responses for shallow draft vessels include waiting for flows to return to normal, change the tow configuration, change the amount loaded into the barge or the number of barge trips required, or ship the cargo by rail or some other mode. 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. All of these responses and added costs were transformed into a disruption response matrix. The disruption response matrix takes into account the flow condition and duration, and shipment dispatch day to determine whether a movement will wait out the disruption, cut barges or divert to rail or truck.

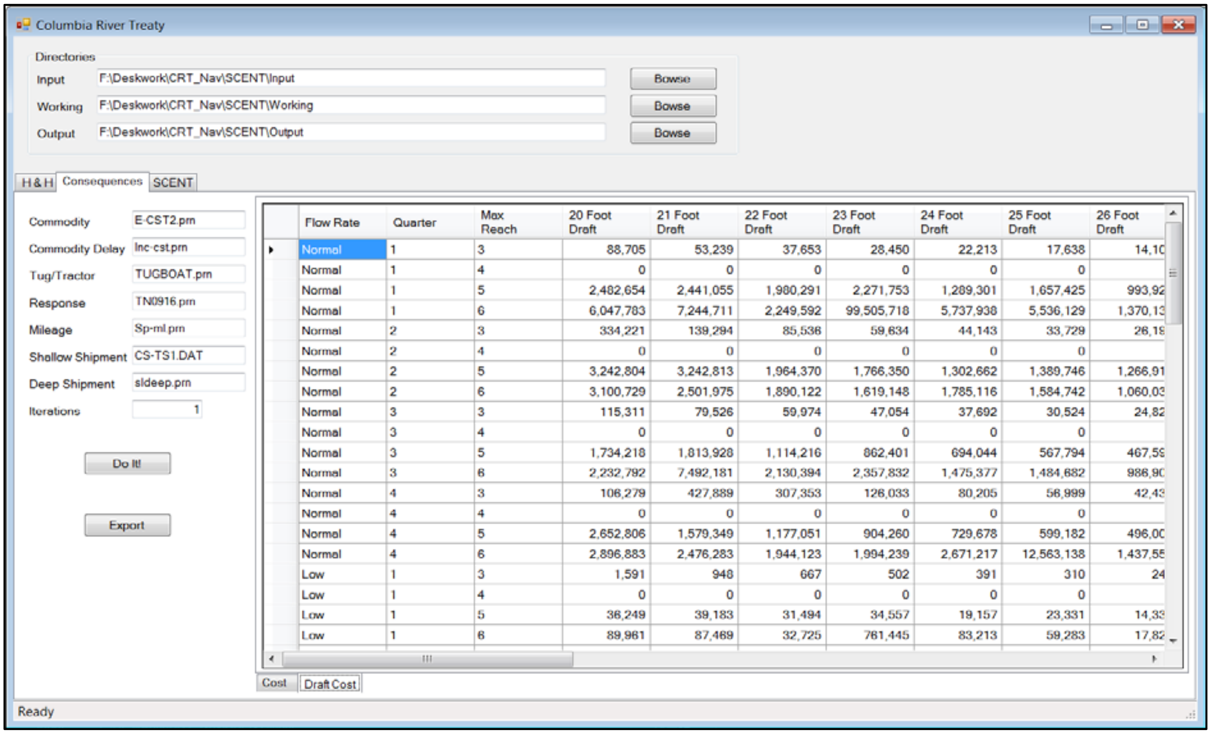
Shipment List: Shallow Draft and Deep Draft: The shipment list includes all shallow draft and deep draft commodity movements that occurred on the CSNS in 2016 (2016 was the most recent data available at the time of SCENT modeling). While somewhat aged, the 2016 data are still useful for the purpose of SCENT, which is to determine how system operational changes impact the ability of shippers/carriers to move commodities on the CSNS. The shipment lists are derived from USACE Waterborne Commerce Statistics Center (WCSC) database and the USACE Lock Performance Monitoring System (LPMS). For domestic movements, the WCSC gathers data on the commodity shipped, the origin, the destination, and other information from operators moving on the CSNS. For international movements, the WCSC compiles a database from multiple sources including operators, the Port Import/Export Report Service (PIERS), Census Bureau, and US Customs and Border Protection. The USACE LPMS database records information such as the towboat identification number, the number and draft of barges in the tow, the direction of the movement, the arrival and lockage time, and other similar information, but it does not include origin and destination information. Combining the WCSC and LPMS data provides the SCENT with shipment lists showing the number and type of vessels carrying each commodity, the miles traveled for each vessel, the number of locks transited for each vessel, and the origin and destination for each model.

As shown in Figure 2-4 and Figure 2-5 (below), the Consequences Module uses the above data to calculate transportation costs throughout the system (Figure 2-4) and the costs to operate at different drafts (Figure 2-5).



Flow Rate	Draft	Reach	Quarter	1	3	5	10	15	30
Normal	Shallow	Subtotal	1	352,213	523,740	924,874	2,037,585	2,913,370	5,015,68
Normal	Shallow	SNAKE	1	190,923	292,003	527,404	1,047,505	1,491,528	2,444,93
Normal	Shallow	COLUMBIA	1	352,213	523,740	924,874	2,037,585	2,913,370	5,015,68
Normal	Deep	Subtotal	1	7,436,791	17,389,197	24,899,713	50,759,365	70,252,208	134,077,98
Normal	Deep	ASTORIA	1	7,436,791	17,389,197	24,899,713	50,759,365	70,252,208	134,077,98
Normal	Deep	LONGVIEW	1	7,436,791	17,389,197	24,899,713	50,759,365	70,252,208	134,077,98
Normal	Deep	PORTLAND	1	6,214,945	8,419,843	13,613,340	28,809,602	41,415,077	76,795,81
Normal	Both	Total	1	7,789,004	17,912,938	25,824,587	52,796,949	73,165,577	139,093,66
Normal	Shallow	Subtotal	2	292,211	425,117	516,177	1,110,092	1,725,203	4,114,20
Normal	Shallow	SNAKE	2	190,480	239,028	303,803	570,065	832,056	2,063,23
Normal	Shallow	COLUMBIA	2	292,211	425,117	516,177	1,110,092	1,725,203	4,114,20
Normal	Deep	Subtotal	2	1,539,994	5,728,845	16,749,710	35,738,322	60,963,309	115,663,07
Normal	Deep	ASTORIA	2	1,539,994	5,728,845	16,749,710	35,738,322	60,963,309	115,663,07
Normal	Deep	LONGVIEW	2	1,539,994	5,728,845	16,749,710	35,738,322	60,963,309	115,663,07
Normal	Deep	PORTLAND	2	1,081,806	2,846,169	7,694,339	20,460,973	35,262,038	66,272,22
Normal	Both	Total	2	1,832,204	6,153,962	17,265,887	36,848,414	62,688,512	119,777,28
Normal	Shallow	Subtotal	3	179,396	362,573	751,414	1,672,435	2,677,901	5,033,54
Normal	Shallow	SNAKE	3	107,615	188,307	424,130	938,420	1,245,691	2,378,78
Normal	Shallow	COLUMBIA	3	179,396	362,573	751,414	1,672,435	2,677,901	5,033,54
Normal	Deep	Subtotal	3	5,187,408	10,690,727	23,335,382	43,341,701	64,996,914	119,243,20
Normal	Deep	ASTORIA	3	5,187,408	10,690,727	23,335,382	43,341,701	64,996,914	119,243,20

Figure 2-4. Consequence Module Output for Transportation Costs



Flow Rate	Quarter	Max Reach	20 Foot Draft	21 Foot Draft	22 Foot Draft	23 Foot Draft	24 Foot Draft	25 Foot Draft	26 Foot Draft
Normal	1	3	88,705	53,239	37,653	28,450	22,213	17,638	14,10
Normal	1	4	0	0	0	0	0	0	
Normal	1	5	2,482,654	2,441,055	1,980,291	2,271,753	1,289,301	1,657,425	993,92
Normal	1	6	6,047,783	7,244,711	2,249,592	99,505,718	5,737,938	5,536,129	1,370,13
Normal	2	3	334,221	139,294	85,536	59,634	44,143	33,729	26,19
Normal	2	4	0	0	0	0	0	0	
Normal	2	5	3,242,804	3,242,813	1,964,370	1,766,350	1,302,662	1,389,746	1,266,91
Normal	2	6	3,100,729	2,501,975	1,890,122	1,619,148	1,785,116	1,584,742	1,060,03
Normal	3	3	115,311	79,526	59,974	47,054	37,692	30,524	24,82
Normal	3	4	0	0	0	0	0	0	
Normal	3	5	1,734,218	1,813,928	1,114,216	862,401	694,044	567,794	467,59
Normal	3	6	2,232,792	7,492,181	2,130,394	2,357,832	1,475,377	1,484,682	986,90
Normal	4	3	106,279	427,889	307,353	126,033	80,205	56,999	42,43
Normal	4	4	0	0	0	0	0	0	
Normal	4	5	2,652,806	1,579,349	1,177,051	904,260	729,678	599,182	496,00
Normal	4	6	2,896,883	2,476,283	1,944,123	1,994,239	2,671,217	12,563,138	1,437,55
Low	1	3	1,591	948	667	502	391	310	24
Low	1	4	0	0	0	0	0	0	
Low	1	5	36,249	39,183	31,494	34,557	19,157	23,331	14,33
Low	1	6	89,961	87,469	32,725	761,445	83,213	59,283	17,82

Figure 2-5. Consequences Module Output for Draft Costs

2.3.3 SCENT Combination Module

The SCENT Combination Module combines the input from the H&H Module and the Consequence Module to generate the navigation transportation costs under each alternative. A comparison in transportation costs between the No Action Alternative and the MOs and the Preferred Alternative determines the impact to waterway transportation costs under each action alternative. The SCENT results are broken into the following four subcategories:

- **Deep draft** pertains to the Columbia River below Bonneville Dam;
- **Snake Shallow** refers to movements that originate and terminate on the Snake River;[2]
- **Columbia Shallow** refers to movements that originate and terminate on the Columbia River; and
- **Columbia-Snake Shallow** refers to movements that originate on the Snake and terminate on the Columbia, or vice versa.

The SCENT model estimates the average cost consequences associated with flow rates and draft restrictions in each quarter of the year as well as the total for the year based on the outputs from the H&H and Consequences models. The model provides a summary view as well as the full 50-year detailed views of both flow rate and draft restriction consequences. Figure 2-6, Figure 2-7 and Figure 2-8, present these three output displays.

[2] 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.

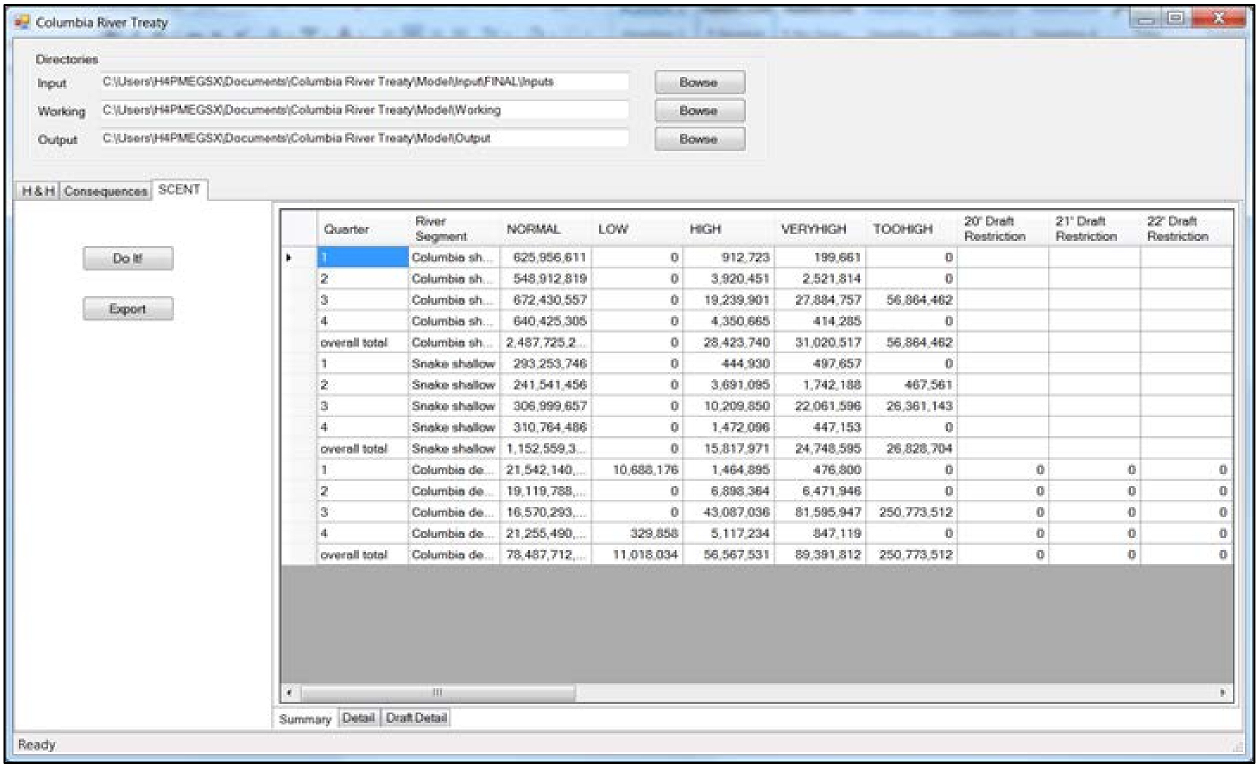


Figure 2-6. SCENT Summary Output – Costs From Flow Increases and Draft Restrictions

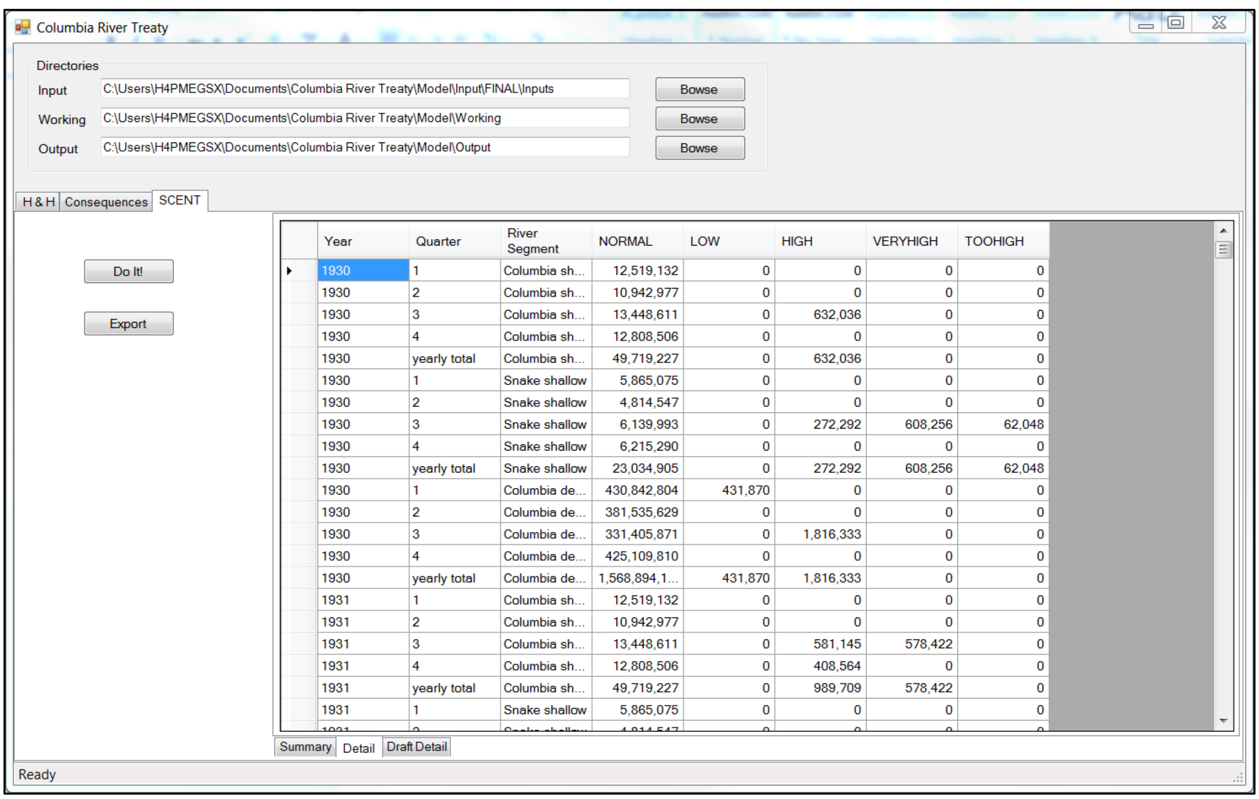


Figure 2-7. SCENT Detailed Output - Costs from Increase in Flows

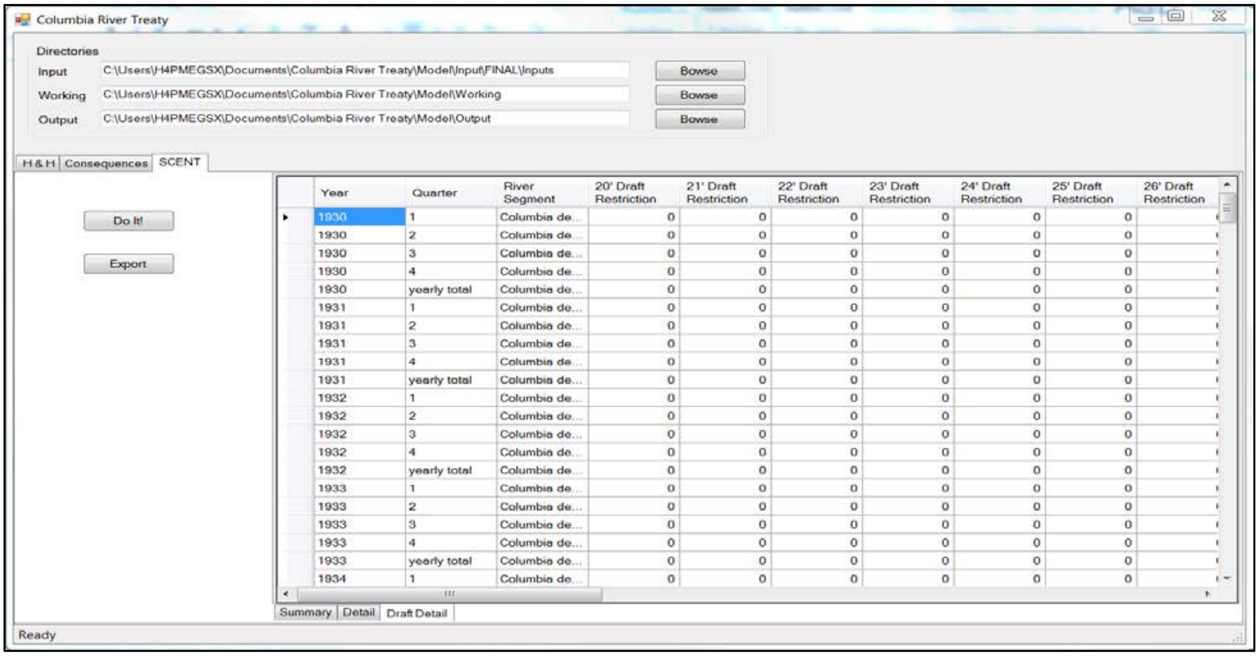


Figure 2-8. SCENT Detailed Output - Costs from Draft Restrictions

2.4 SOCIAL WELFARE EFFECTS

2.4.1 Multi-Objective 1

As described in the CRSO EIS, Navigation and Transportation Section 3.10.3.3, there are a number of planned structural measures under MO1 but they 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, there are operational measures under MO1 that could affect these things. For example, *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). 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.

2.4.1.1 SCENT Results

The H&H data used as input into the SCENT model, as presented in (Table 2-2) shows that MO1 would result in a negligible change in non-normal flow days when compared to the No Action Alternative.

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 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 2-3, the total increase in average annual costs to commercial navigation operations would be approximately $14,000. It should be noted that a standard deviation of the results was calculated for all alternatives to determine the range of costs that would be anticipated to fall within one standard deviation of the deep and shallow draft flow categories and the deep draft restrictions under the No Action Alternative. The standard deviation range was utilized to highlight those changes in additional costs that would be outside of one standard deviation of the baseline (No Action) condition.

Table 2-2. 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 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.[3]

Table 2-3. Changes in Average Annual Costs of Commercial Navigation Operations Under Multiple Objective Alternative 1 Relative to No Action Alternative (2019 Dollars), over 50 years

River Segment	Change in Costs Associated with Flow Range Categories				Changes in Costs Associated with Draft Restrictions						
	Low	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft	Total
Columbia-Snake Shallow	–	$6,000	$4,000	–	–	–	–	–	–	–	$9,000
Columbia Shallow	–	$0	$0	$0	–	–	–	–	–	–	<$1,000
Deep Draft	–	–	–	–	–	<$1,000	–	$1,000	$1,000	<$1,000	$4,000
Total	$0	$6,000	$4,000	$0	$0	<$1,000	$0	$1,000	$1,000	<$1,000	$14,000

[3] 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.

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

2.4.1.2 Summary of Effects of MO1

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.

As described in the CRSO EIS, Navigation Section 3.10.3.3, adverse effects would occur to the Inchelium-Gifford Ferry under MO1 because it would be able to operate 9 days fewer under MO1 than under the No Action Alternative during high water years, or a total of 36 consecutive days, which could represent 3,700 ferry trips. Longer inoperable periods would be expected in high water years that require more flood risk management (FRM) space in the reservoir. 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. Table 2-4 provides a summary of the navigation and transportation system effects of MO1.

Table 2-4. 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	Social Welfare Effects	Regional Economic Effects	Other Social 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.

2.4.2 Multi-Objective 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, 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). For example, *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. 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.

2.4.2.1 SCENT Results

The H&H data used as input into the SCENT model, as presented in Table 2-5, 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 2-5. 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.

SCENT modeling Table 2-6 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.

2.4.2.2 Summary Results

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 2-7 provides a summary of the navigation and transportation system effects of MO2.

Table 2-6. 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

Table 2-7. 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	Social Welfare Effects	Regional Economic Effects	OSE
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.

2.4.3 Multi-Objective 4

As described in the CRSO EIS, Navigation and Transportation Section 3.10.3.3 there are a number of planned structural measures under MO4, like the addition of spillway notch weirs or modifying turbine intake bypass screens that cause juvenile lamprey impingement, that are unlikely to have measurable impacts to navigation in the CSNS. The *Drawdown to MOP*, *Winter System FRM Space*, *Spring & Fall Transport* measures may channel flow and depths, affecting the costs for vessel movements on the CSNS, while the *Spill to 125% TDG* measure operations may affect sediment accumulate and increase shoaling in the navigation channel. 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.)

2.4.3.1 SCENT Results

Table 2-8 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 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 2-8. 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 2-9 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 2-9, 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. 2.8.2 Summary Results for MO4

Table 2-9. 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

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. Annualized dredging costs would increase by $1.03 million annually in Regions C and D associated with increased shoaling at John Day, McNary, Ice Harbor, Lower Monument and Lower Granite.

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 2-10 provides a summary of the navigation and transportation system effects of MO4.

Table 2-10. 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. Increased shoaling in the navigation channel at McNary, Ice Harbor, Lower Monument and Lower Granite.
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. Increased shoaling in the navigation channel at John Day.
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.

2.4.4 Preferred Alternative

In Region B, the effects to the operation of the Inchelium-Gifford Ferry resulted in minor effects due to the *Planned Draft Rate at Grand Coulee* measure, and would be addressed by extending the boat ramp for the Inchelium-Gifford Ferry in Lake Roosevelt. Ferry operations on Lake Roosevelt could be affected under the Preferred Alternative due to anticipated drawdowns in wet years, the wettest 20 percent of years as measured at The Dalles. In the median wet years, when Lake Roosevelt's draw down for flood risk management begins sooner than for No Action Alternative, the Inchelium-Gifford Ferry on Lake Roosevelt would not be able to operate for approximately 31 days in the year, which is four additional days than would have been anticipated under the No Action Alternative in the median wet years at this location. Effects would primarily occur on the Confederated Tribes of the Colville Reservation. Other operational measures within the Preferred Alternative 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.

The planned structural measures under the Preferred Alternative are unlikely to have measurable impacts to commercial navigation or cruise lines in the Columbia-Snake Navigation System (CSNS) because they do not affect flow or elevation of water. Some of the operational measures have the potential to affect operations on the CSNS. In particular, the *John Day Full Pool measure* as well as a combination of upstream measures, primarily at Grand Coulee and Libby Dams have the potential to impact how vessels move on the CSNS. It is expected that higher spill and variable timing of the spill over the course of a day due to the *Juvenile Fish Passage Spill* measure could result in changes to the tailraces at Lower Monumental and Lower Granite projects. The Corps would monitor the tailrace at each project to track changes that could affect safe navigation. If changes to the tailrace warrant action, coffer cells to dissipate energy may be constructed in the tailrace at either of the projects.

2.4.4.1 SCENT Results

The H&H data used as input into the SCENT model, as presented in Table 2-11, shows that the Preferred Alternative could result in approximately a one day per year decrease in navigable days under low flow conditions when compared to the No Action Alternative, and approximately a one day increase in navigable days during normal flow conditions. In all other flow conditions there would be basically negligible or no effect from the No Action Alternative.

Table 2-11. Changes in Average Commercial Navigation Flow Days Under Preferred Alternative 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	-1.2	1.2	<-0.1	<0.1	<0.1	–	–	–	–	–	–
Deep Draft	-1.2	1.2	<-0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<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 2-12 for the Preferred Alternative presents anticipated changes in average annual operating costs that would occur under the Preferred Alternative as a result of flow changes. Costs of operations under normal flow range categories would not be affected under the Preferred Alternative. [4]

The average annual extra transportation costs for transportation in the Deep Draft segment are estimated to be $93,000 less under the Preferred Alternative than under the No Action Alternative. The reason for the minor decrease in costs is that there would be slightly fewer days of low flow under this alternative related to the John Day Full Pool measure. The average

[4] 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.

annual change in transportation costs under the Preferred Alternative in the Columbia-Snake Shallow segment is estimated to be $4,000 higher than the No Action Alternative. The slight increase in cost would occur in the spring resulting from a combination of upstream measures, primarily at Grand Coulee and Libby Dams.

As shown in Table 2-12 , the total decrease in average annual costs to commercial navigation operations would be approximately $93,000.

Table 2-12. Changes in Average Annual Costs of Commercial Navigation Operations Under Preferred Alternative Relative to No Action Alternative (2019 Dollars), over 50 years

River Segment	Change in Costs Associated with Flow Range Categories				Changes in Costs Associated with Draft Restrictions						
	Low	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft	Total
Columbia-Snake Shallow	-	$1,000	$1,000	$1,000	-	-	-	-	-	-	$4,000
Columbia Shallow	-	-$1,000	$1,000	$1,000	-	-	-	-	-	-	-
Deep Draft	-$118,000	-$1,000	$4,000	$14,000	$1,000	-$2,000	$1,000	$1,000	$3,000	-	-$97,000
Total	-$118,000	-$1,000	$6,000	$16,000	$1,000	-$2,000	$1,000	$1,000	$3,000	-	-$93,000

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.

2.4.4.2 Summary Results for the Preferred Alternative

Overall effects of the Preferred Alternative on recreational visitation are anticipated to range from negligible, or basically no effect to moderate adverse to major beneficial, depending on the Region. Table 2-13 presents a summary of the Preferred Alternative 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 and associated social welfare effects are anticipated to decrease by less than 0.1 percent annually (approximately 250 visits and $2,000) in a typical year associated due to changes in boat ramp access. Expenditures associated with non-local visitation would decrease by $12,000 annually across the region, a change of less than 0.1 percent compared to the No Action Alternative. Regional economic effects of this change in expenditures would be negligible. Effects to the quality of hunting, wildlife viewing, swimming, and water sports at river recreation sites in the region under the Preferred Alternative would be generally negligible.

Table 2-13. Changes in Economic Effects of Recreation Under Preferred Alternative Relative to the No Action Alternative

Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region A	A decrease of approximately 400 water-based recreational visits would occur at Lake Koocanusa (less than 1.0 percent of water-based visitation at the site) in a typical year associated with changes in boat ramp access. In high-water-level years, water-based visitation would not change at Lake Koocanusa and would decrease by about 1.0 percent in low-water-level years. Annual social welfare benefits would decrease by $4,300 in a typical year. Negligible effects to the quality of recreation experiences would occur.	Expenditures associated with non-local recreational visits would decrease by $18,000 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 resulting in no noticeable effect to recreationist well-being when compared No Action.
Region B	An increase of approximately 200 water-based visits at Lake Roosevelt (less than 0.1 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 less than 1.0 percent. Annual social welfare benefits would increase by approximately $2,600 in a typical year. Negligible effects to the quality of recreation experiences would occur.	Expenditures associated with non-local recreational visits would increase by $7,000 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 resulting in no noticeable effect to recreationist well-being when compared No Action
Region C	No changes in reservoir visitation associated with changes in boat ramp access in a typical year or high-water-level year. A reduction of approximately 1,300 water-based visits at Dworshak Reservoir (less than one percent of water-based visitation at the site) would occur in a low-water-level year. Annual social welfare benefits would not change in typical or high-water-level years, but would decrease by about $14,000 in a low-water-level year. Moderate adverse to major beneficial effects to quality of fishing may occur. Impacts to hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions are likely to be negligible.	No changes in visitor expenditures or regional effects associated with changes in boat ramp access in most years. Regional effects of potential changes in expenditures during low-water-levels years would be negligible.	No change to visitor well-being associated with access to reservoir-based recreation. Moderate adverse to major beneficial change in recreationist well-being when compared No Action.

Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region D	No changes in reservoir visitation associated with changes in boat ramp access. Moderate adverse to major beneficial effects to quality of fishing may occur Impacts to hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions are likely to be negligible.	No changes in visitor expenditures or regional effects associated with changes in boat ramp access.	No change to visitor well-being associated with access to reservoir-based recreation. Moderate adverse to major beneficial change in recreationist well-being when compared No Action.
Total	Negligible effects to reservoir visitation (reduction of 250 visits, representing less than 0.1 percent of total visitation compared to the No Action Alternative) in a typical year, with decreases in social welfare of approximately $2,000 annually associated with changes in boat ramp access. Potential for 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 minor adverse effects to moderate improvements in recreational fishing conditions along in Regions C and D.	Expenditures associated with non-local recreational visits would decrease by $12,000 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.	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 No Action in most locations, with the exception of potential moderate beneficial social effects to anglers in Regions C and Region D.

CHAPTER 3 - TOM - MODELING IMPACTS OF CHANGES IN CHANNEL ACCESSIBILITY

This section discusses the methodology of the Transportation Optimization Model (TOM), the data sources and key modeling assumptions, the scenarios used to account for uncertainty with rail rates, and the outputs generated by the model. Additional discussion of the results are presented in Section 3.10 of the CRSO EIS.

3.1 MODEL OVERVIEW

The TOM is used to assess the movements of shipments under M03 dam breaching, where it is assumed that navigation on the lower Snake River would no longer be possible. Without lower Snake River shallow draft barge, 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 lower Snake River portion of the CSNS is predominately used to move grain (wheat) downriver, while fuel, fertilizer and some paper mill inputs (wood chips and/or shavings) are moved upriver, 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 (wheat) to market. A survey of shippers was completed for this EIS and informed the structure of the TOM, establishing how goods would move through the system if the lower Snake River navigation channel is no longer available.

The objective function of the TOM is to move wheat from where it is produced, its origin in the Pacific Northwest, through the various intermediate, and then final destinations via the various mode combinations in a least cost fashion. The diagram below (Figure 3-1) depicts these alternatives for the TOM. Wheat is produced and harvested in the field and primarily moved to export terminals in Portland, OR throughout the year, after passing through different elevators and terminal facilities. The different route and mode combinations, as shown in Table 3-1, reflect choices that shippers face in moving grain from origination (production) to final market. Model parameters that were informed by the survey of shippers 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. For the social welfare analysis, the relevant output of the TOM is the change in transportation costs as grain (wheat) reaches its final destination of Portland, OR (export terminal).

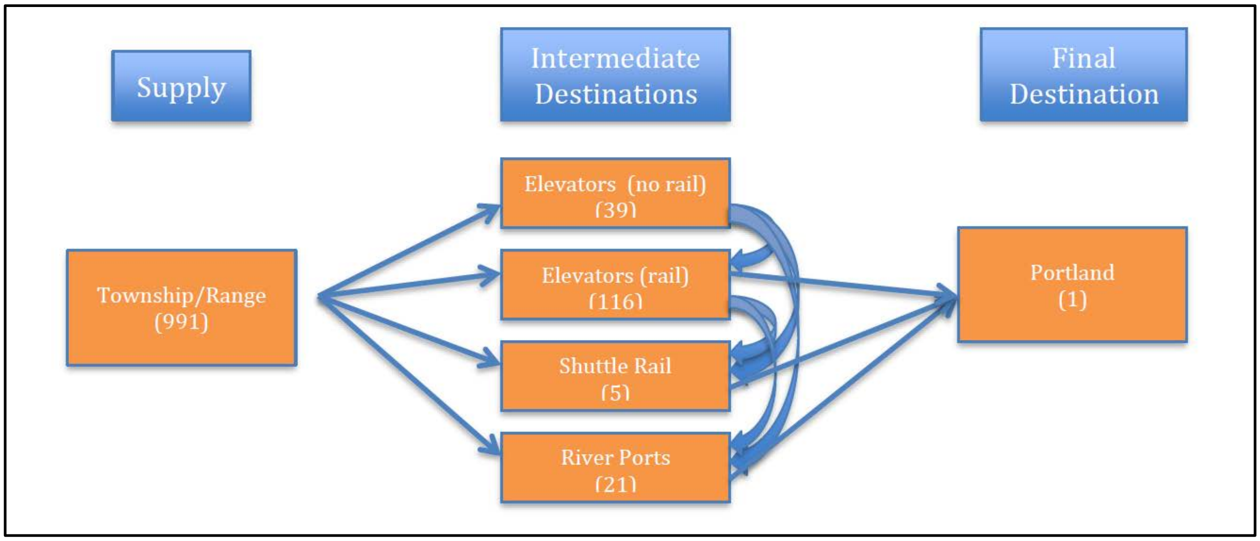


Figure 3-1. Transportation Optimization Model Schematic

Table 3-1. Origin/Destination Mode Combinations included in Transportation Optimization Model

Origination Node	Destination Node	Mode	Total Route Options
Farms (991)	Elevators no Rail (5 closest)	Truck	4,955
	Elevators with Rail (5 closest)		4,955
	Shuttle Elevators (all 5)		4,955
	River Ports (all 21)		20,811
Elevators no Rail (65)	Elevators with Rail (5 closest)		325
	Shuttle Elevators (all 5)		325
	River Ports (all 21)		1,365
Elevators with Rail (90)	Shuttle Elevators (all 5)	Truck	450
		Rail	450
	River Ports (all 21)	Truck	1,890
Shuttle Elevators (5)	Portland, OR	Rail	5
River Ports (21)		Barge	21
Total Route Combinations			40,507

3.2 DATA SOURCES

The TOM data inputs include shipment lists or commodity movements, grain production data and locations (GIS based data), transportation systems in GIS, and input from shippers gathered via survey. The complete list of sources include:

- USACE Waterborne Commerce Statistics Center (WCSC) database, and the USACE Lock Performance Monitoring System (LPMS) – USACE maintains two databases containing information on the waterway. The WCSC contains data on the type of commodity moved, the amount of the commodity moved, the origin, the destination, and other information. This data is gather by USACE National Data Center from operators using the inland waterways. The USACE LPMS data is collected by USACE employees at locks on the inland waterways and contains information such as the towboat identification number, the number and draft of barges in the tow, the direction of the movement, the arrival and lockage time. This data is collected from USACE lock operators. The WCSC and LPMS data provided the following model inputs:

- Amount and type of commodities moving on the Columbia and Lower Snake
- The name of businesses utilizing the CSNS
- The number of vessel uses the CSNS
- The mileage traveled by vessels moving on the CSNS

- Other Governmental Databases – Databases such as the State of Washington Department of Agriculture License database and listed in its Public Grain Warehouses and Grain Dealers publication provided more contacts for the stakeholder survey.

- USDA Cropscape Wheat Production – This is a GIS layer file showing average production (2014-2018) for spring and fall wheat for all counties potentially affected by changes to CSNS.

- Columbia River Basin Transportation Database – This is a GIS layer showing the location of roads and railways potentially affected by changes to CSNS. The transportation data provided all possible transportation pathways for grain to travel from origin to market

- Stakeholder Survey - Between January 2019 and continued through August 2019, the Social and Economic Sciences Research Center (SESRC) at Washington State University conducted a survey of 257 businesses utilizing the CSNS specifically the Lower Snake River. The purpose of the survey was to obtain information from shippers of agricultural products, forest products, fertilizer, or fuel on 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.

Table 3-2. CRSO Survey Disposition Summary

Category	Number
Completed Questionnaires	152
Refusals	70
Ineligible (No Shipping)	17
Ineligible (Out of Business)	1
Other Codes	6
Non-Response	69
Total Sample	315
Response Rate (Completes/Sample Size)	48.3%
Completion Rate (Completes/Completes + Refusals + No Response)	52.2%

The shipper survey conducted by the SESRC ultimately produced a collective response rate of 48.3 percent, as illustrated in Table 3-2. The majority of survey respondents were moving wheat (74%) or other agricultural Products, including peas, wood chips, and alfalfa produced in the region. The information collected from the survey informed the transportation cost functions for truck, rail and barge. The shipper survey also provided the following information for the TOM:

- Preferred alternate shipping mode if lower Snake River barge were unavailable
- Location of grain elevators
- Amount of grain moving by transportation routes
- Costs for various transportation modes

The costs for moving grain by rail, other than shuttle were gathered from the survey. The shipping rates for shuttle and barge are also developed from a combination of data from the shipper survey and port to port shipper tariffs.

3.3 ASSUMPTIONS

Several assumptions were critical for the TOM evaluation including grain supply, cost function (least cost behavior), characteristics of intermediate locations and volume. These assumptions were developed based upon existing information as described in the following sections.

3.3.1 Grain Supply

The grain supply used to estimate origination in the TOM was developed based upon a combination of USDA county level spring and fall wheat production averages (2014-2018), and GIS data. The specific location of grain production is derived from the 2017 Cropscape wheat production layer. This field-specific data was developed by the USDA based upon satellite imagery data and with information gathered from producers participating in USDA-sponsored programs. For the purpose of this study, this comprised more than 17,000 field parcels including regions in Washington, Idaho and Oregon, as illustrated in Figure 3-2 below. This far exceeded the granular scale of origination supply points that could be modeled so grain supply was aggregated to Township/Range level and the centroid of each Township/Range was utilized as the origination point (see Figure 3-2 below). This produced 991 origination supply points in TOM from which wheat is shipped. All grain shipments leaving these origination supply points (farms) utilize truck transport (assumes 1,000 bu. capacity). The cost to transport via truck is a distance based function, estimated from data collected from the survey of grain shippers. The total volume of grain production being modeled throughout the study region is 202,583,270 bushels or 6.1 million tons. Generally, wheat production in the Pacific Northwest has been consistent over time, with some year-to-year fluctuations due to weather impacts. Planted and harvested wheat acres have declined slightly over the past 50 years and wheat yields (due to technology improvements) has increased with the net impact to wheat production being relatively constant, as illustrated in Figure 3-3.

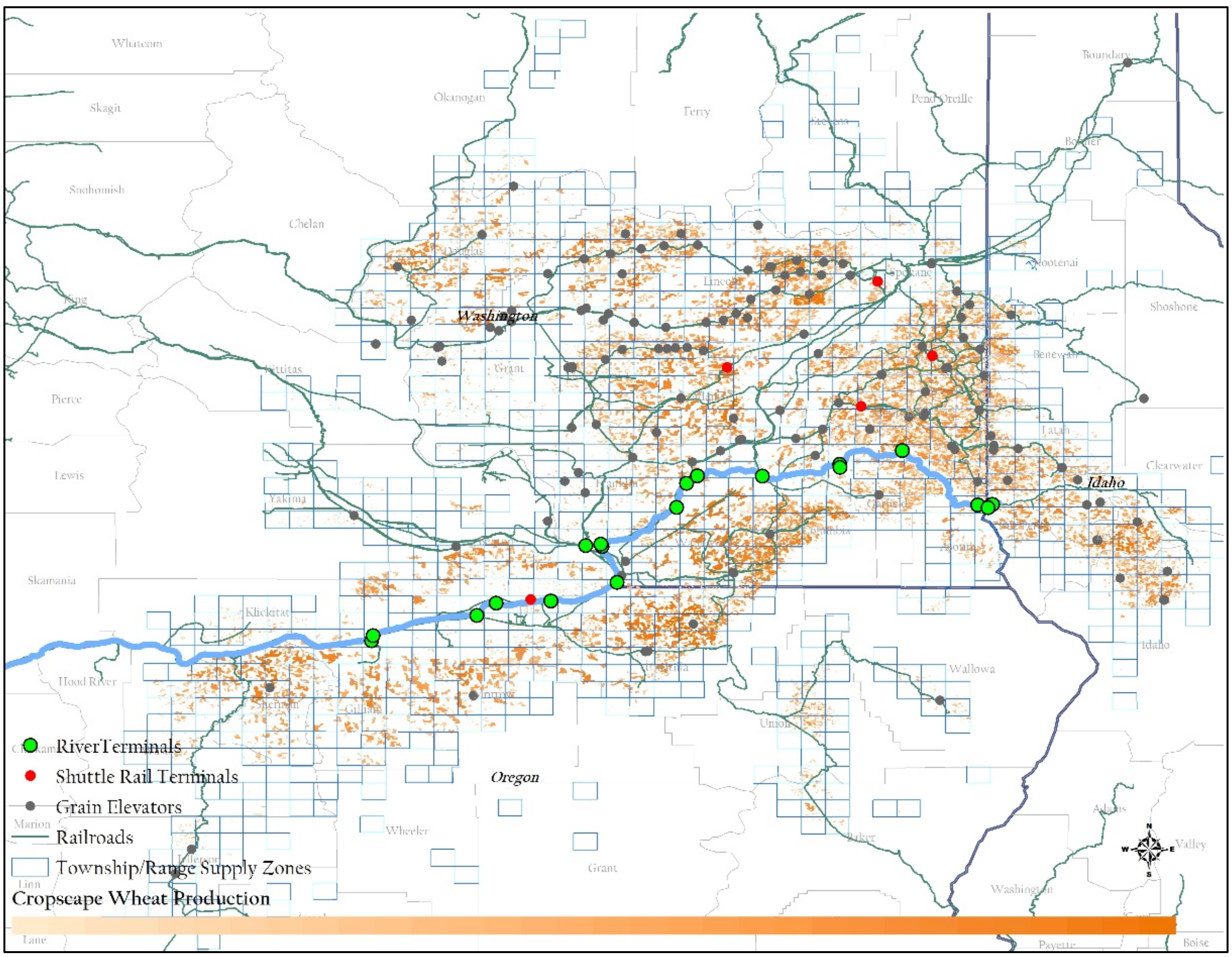


Figure 3-2. PNW Wheat Production and Facilities

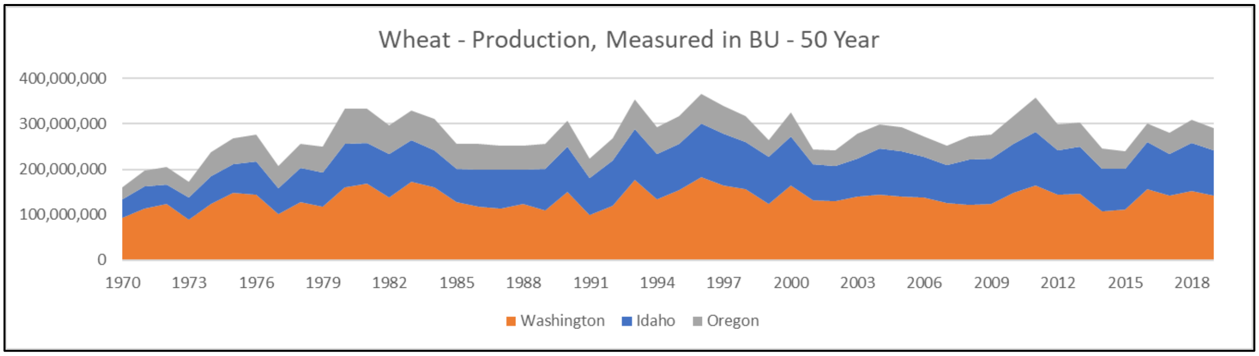


Figure 3-3. PNW Wheat Production and Facilities

3.3.2 Cost Functions

The costs for moving grain by truck utilizes the function in Figure 3-4, which was developed from based upon the SESRC shipper survey results. The costs for moving grain by rail, other than shuttle, utilizes the function in Figure 3-5, which was also developed based upon the SESRC shipper survey results. Every effort was made to obtain accurate rate data for each shipping mode. However, in most cases shuttle rail rates are negotiated between the shipper and the rail carrier and are not made public. The shipping rates for shuttle and barge were developed from a combination of data from the shipper survey and port to port shipper tariffs. There is also a handling charge of five cents per bushel included for any shipment delivered to grain elevators, shuttle facilities or river ports. The model, in terms of volume of shipments traversing particularly routes, is sensitive to fluctuations in rates which is an accurate characteristic to the way grain merchandising exists. The barge rates used in the TOM are presented in Figure 3-6. The average shuttle rail rate across the four rail shuttle facilities range between 0.50 and 0.75 cents per bushel. The grain barge freight rate assumptions are presented in Figure 3-6.

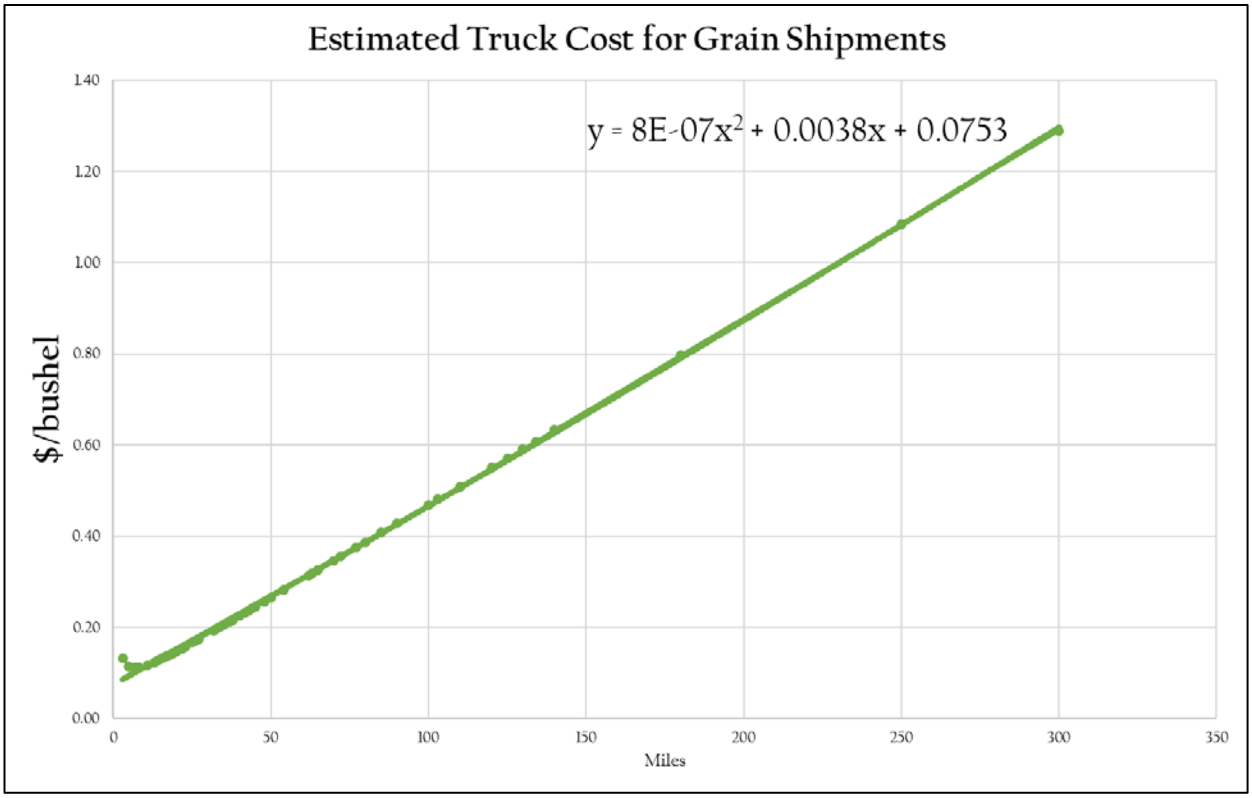


Figure 3-4. Estimated Grain Truck Cost Function

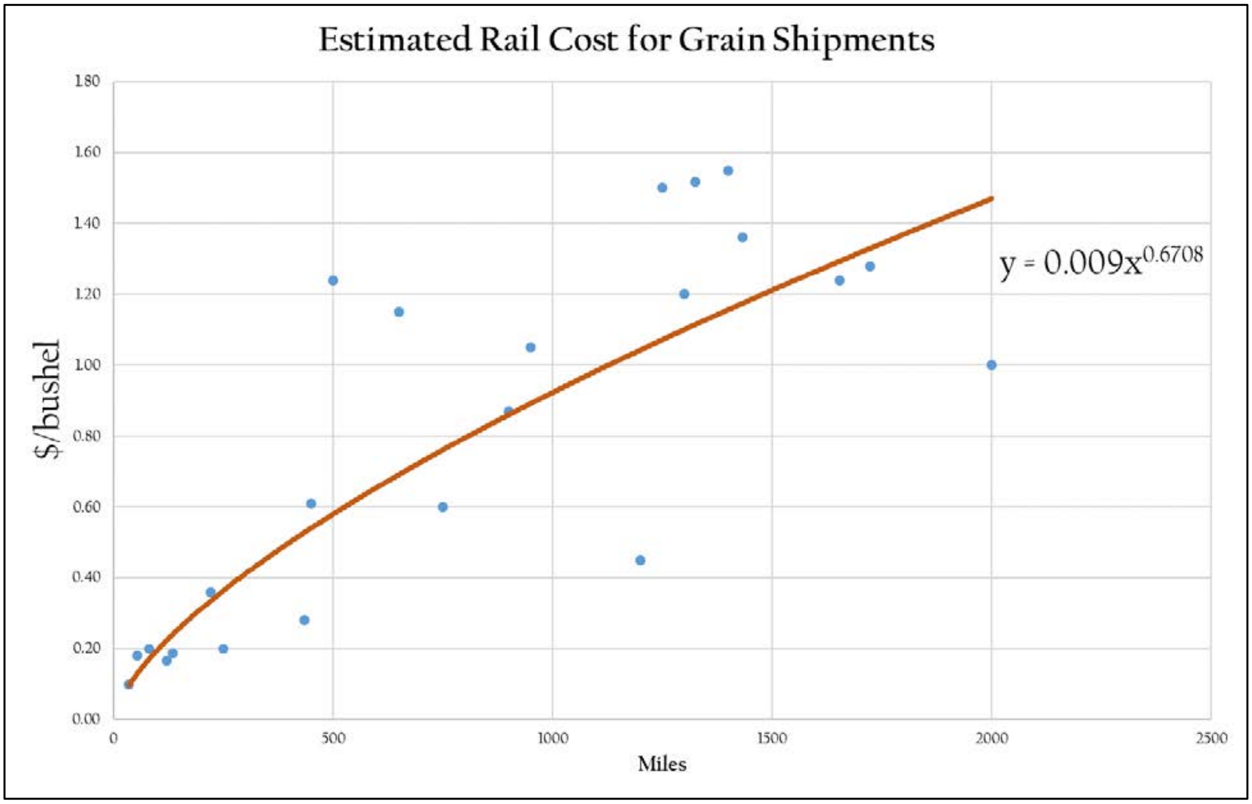


Figure 3-5. Estimated Non-Shuttle Rail Cost Function

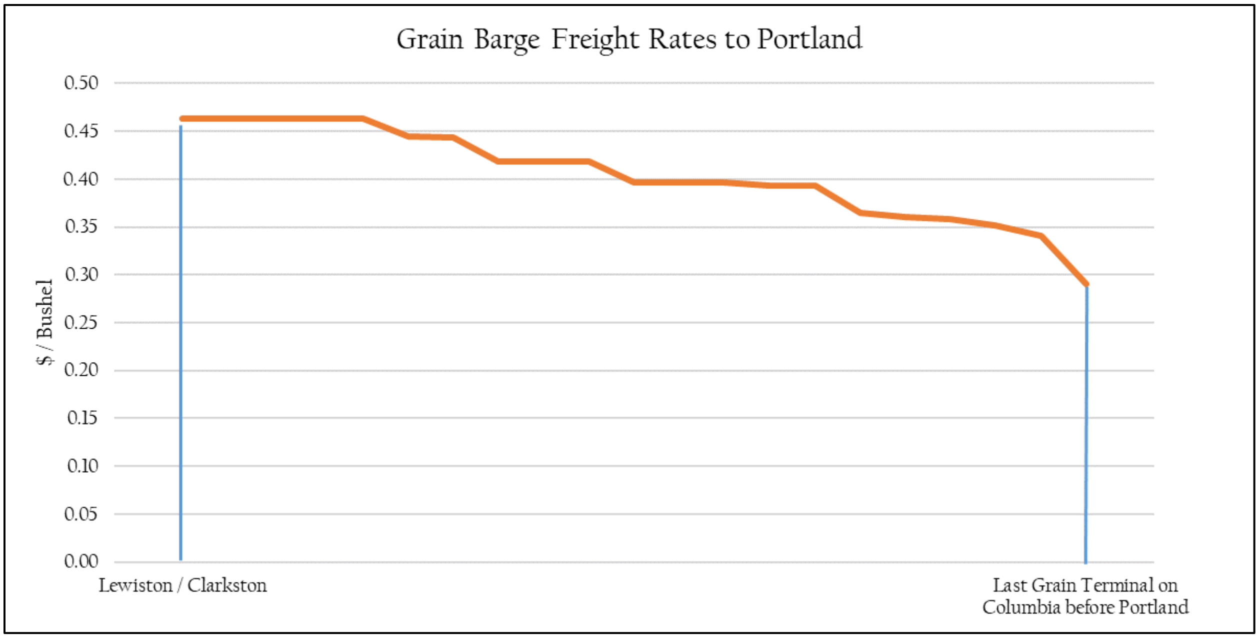


Figure 3-6. Barge Freight Rates utilized in Transportation Optimization Model

3.3.3 Intermediate Locations

Between the point of production and arriving at the final destination of the export market (Portland, OR), all grain is moved through one or more intermediate locations (Portland, OR). These include 1) elevators without rail, 2) elevator with rail access but not shuttle rail, 3) shuttle rail facilities and 4) river port elevators. The information on grain elevators and river ports was compiled from a combination of USDA grain facilities and the states warehousing licensing division.

These sources provide licensed storage capacity for elevators, but not volume processed or shipped through the facilities. Information on volumes moved and turn ratios is developed from the shipper survey. The shipment combinations for the intermediate locations include truck, rail and barge, depending on the facility type. Shipments may move from elevators without rail to those with rail or port facilities (via truck) and shipments may also move from rail facilities to the river ports (via truck). Note, in TOM, shipments cannot move from rail elevators to river ports via shuttle rail. Information gathered through personal communication with Port of Lewiston and shippers (December 2019) indicate that this modal movement for grain shipments no longer exists. Discussions with WDOT (January 2020) further corroborated these findings. These shipment combinations are designed to replicate actual choices as they currently exist for grain shippers.

Including route flexibility in the model is important, particularly for constrained optimization models where individual constraints (facility volume or others) are met and alternative routes must be available. This is especially true in the instance where one scenario involves removing one set of shipping locations (i.e. lower Snake River shallow draft barge ports) and then re-optimizing the flows. The set of route combinations (40,507) included in the constrained optimization model are provided in the table below and visually in the flow diagram. Generally, these options currently exist for any shipper moving grain to the export market. The two options not included in this model are truck shipments directly to Portland, OR and shipments from shuttle rail facilities to river ports via shuttle rail. These movements could occur, but would be relatively rare given the distance and the lower cost to move via alternative mode combinations.

3.3.4 Volume

The volume of grain that moves down the lower Snake River is assumed to be 2.4 million tons under the No Action Alternative. Figure 3-7 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 in Figure 3-7, 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 has 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. The variability on grain volumes moving down the Snake River over the past 10 years is relatively low with one standard deviation of 0.29 million tons. This implies a range of 1.7 & 2.9 million tons annually (with two standard deviations, or a probability of 95%). Even when evaluating the last 20 years, a period that included time prior to the introduction of shuttle rail facilities in the Pacific Northwest, the mean volume of grain moving down the Snake River was 2.9 million tons, with a range of 1.6 million tons to 3.9 million tons (with two standard deviations, or a probability of 95%). Thus, the utilization of 2.4 million tons seems a reasonable estimate, particularly since the data on volumes does not include the opening of the Endicott shuttle rail facility which will likely compete for grain volumes that previously moved down the Snake River.

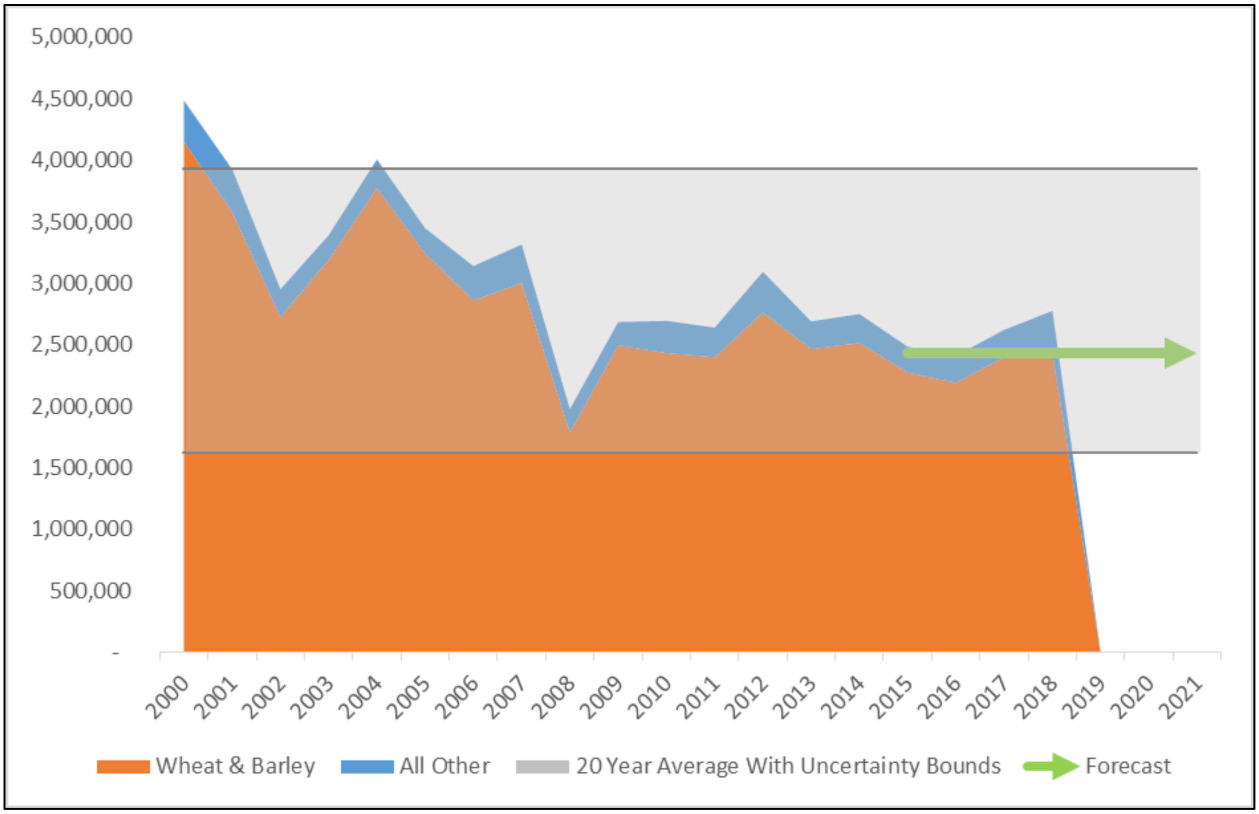


Figure 3-7. Recent Downriver Grain Shipments (tons) on the Snake River, with No Action Alternative Forecast[5] (2.4 Million Tons)

Note: Uncertainty range shown as two standard deviations around the mean over the past 20 years. 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).

3.4 SCENARIOS AND OUTPUTS

The TOM presents the following outputs to characterize the effects of scenarios evaluated:

1. Change in barge ton miles - To demonstrate how waterway traffic will change due to the alternative and scenario assumptions.
2. Change in highway ton-miles - To demonstrate how roadway traffic will change due to the alternative and scenario assumptions.[6]

[5] 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.

[6] Highway ton-miles include backhaul to more accurately calculate increased demands on road infrastructure.

3. Change in railroad ton-miles – To demonstrate how railway traffic will change due to the alternative and scenario assumptions.
4. Total transportation costs for grain – To demonstrate the impact to costs for grain production in areas potentially influenced by changes to the CSNS.
5. Change in $ per bushel – To demonstrate how the change in the transportation system will impact the cost of grain production in areas potentially influenced by changes to the CSNS.

The output from the TOM (changes in grain flows, transportation costs and ton-miles) can be displayed in geographic as well as tabular formats.

3.4.1 No Action Alternative

Table 3-3 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 3-8 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.

Table 3-3. 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

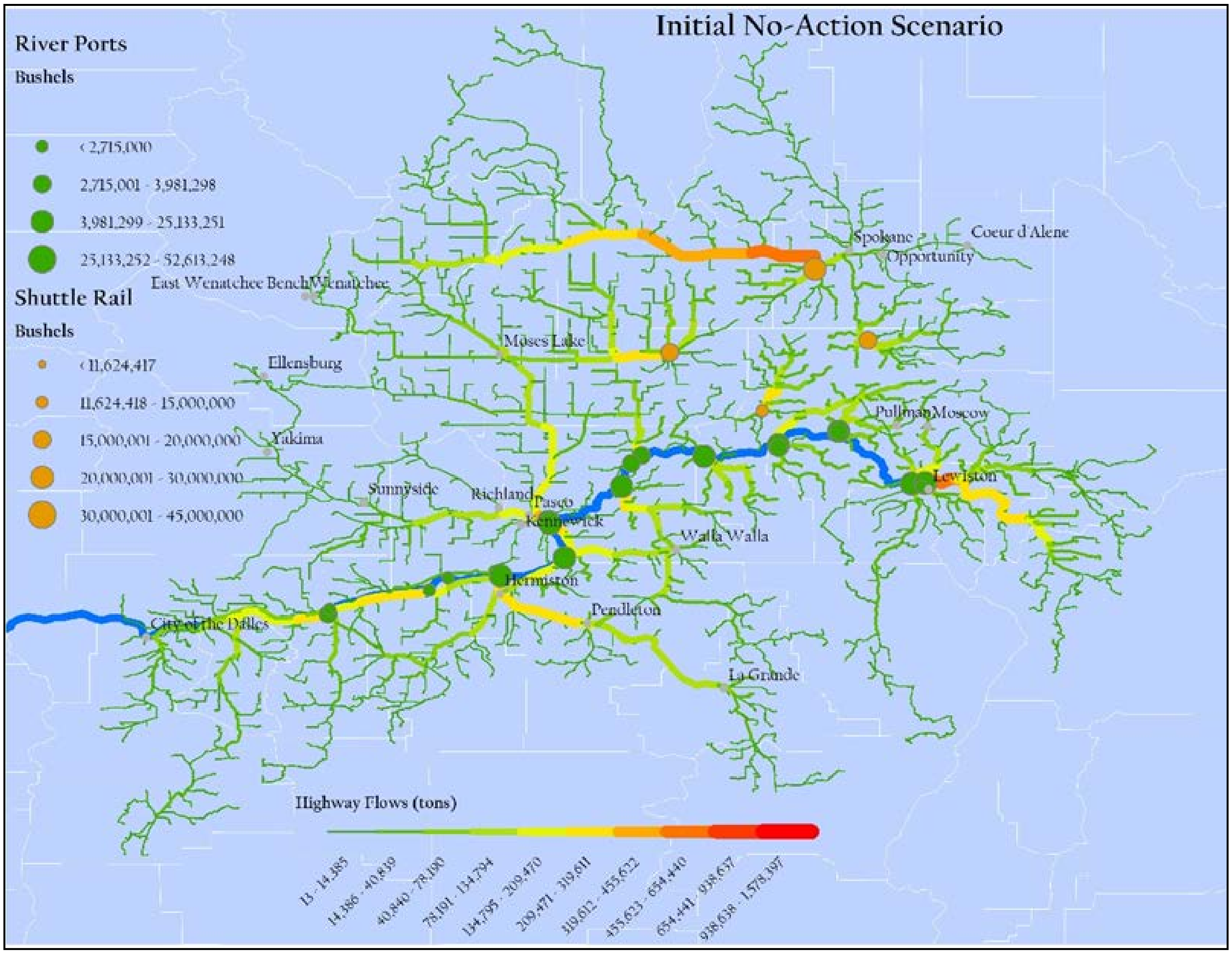


Figure 3-8. No Action Alternative Shipping Routes.
Source: Transportation optimization model, parameterized to reflect current conditions.

3.4.2 Multiple Objective 3

3.4.2.1 Social Welfare Effects to Commercial Navigation and Transportation

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 predominately 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), which terminates below the Ice Harbor Dam. Fuel comprises 27 percent of overall tonnage on the lower Snake River. Fuel movements are not modeled. 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.. The Columbia River shallow draft channel would still be operable, although dredging of the federal navigation channel at the confluence of the lower Snake River would be required to maintain operability for facilities currently within the McNary Pool. In addition, 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, WA.

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.[7] It is likely that the facilities with rail access would continue to be used to some extent for storage and transport via rail or 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., comments of Idaho Cooperating Agencies, December 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

[7] 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.

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., comments of Idaho Cooperating Agencies, December 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 (Personal communication with Port of Lewiston and shippers, December 2019). Commenters have further stated it is difficult to secure a unit train on short notice to take advantages of seasonal demand (comments of Idaho Cooperating Agencies, December 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 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 (Comments of Idaho Cooperating Agencies, December 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 RitzvilleRitzville, 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 4 trains to approximately 8 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 the Table 3-4. Figure 3-9 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.

Table 3-4. 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)	–

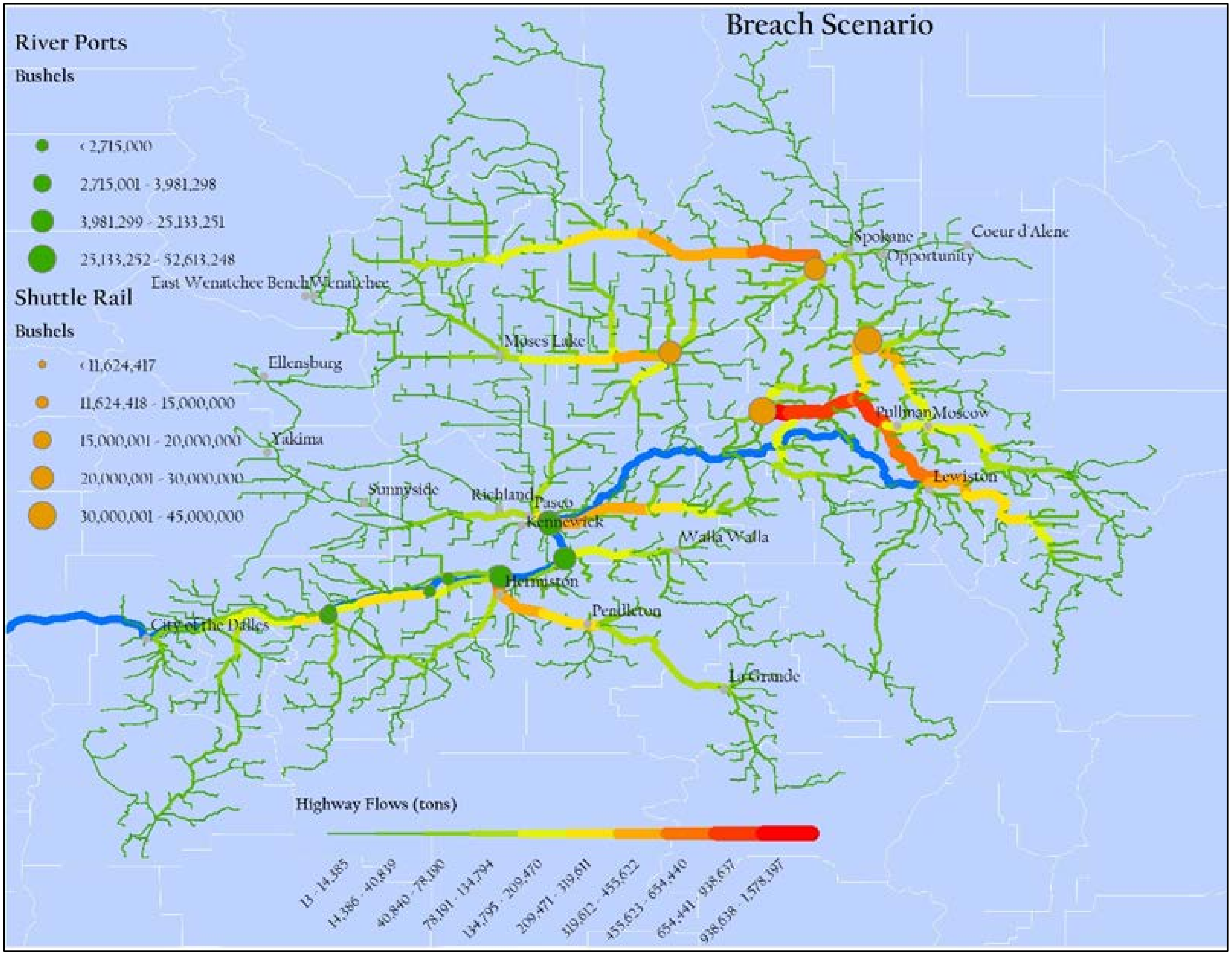


Figure 3-9. Multiple Objective Alternative 3 Scenario 1: Shipping Routes by Mode.

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% 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 4 trains to approximately 7 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 the MO3 under Scenario 2 are summarized in Table 3-5 , Figure 3-10 provides a visual depiction of commodity movements by mode for Scenario 2. As in Table 3-5, Figure 3-10 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 3-10.

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.

Table 3-5. 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	-

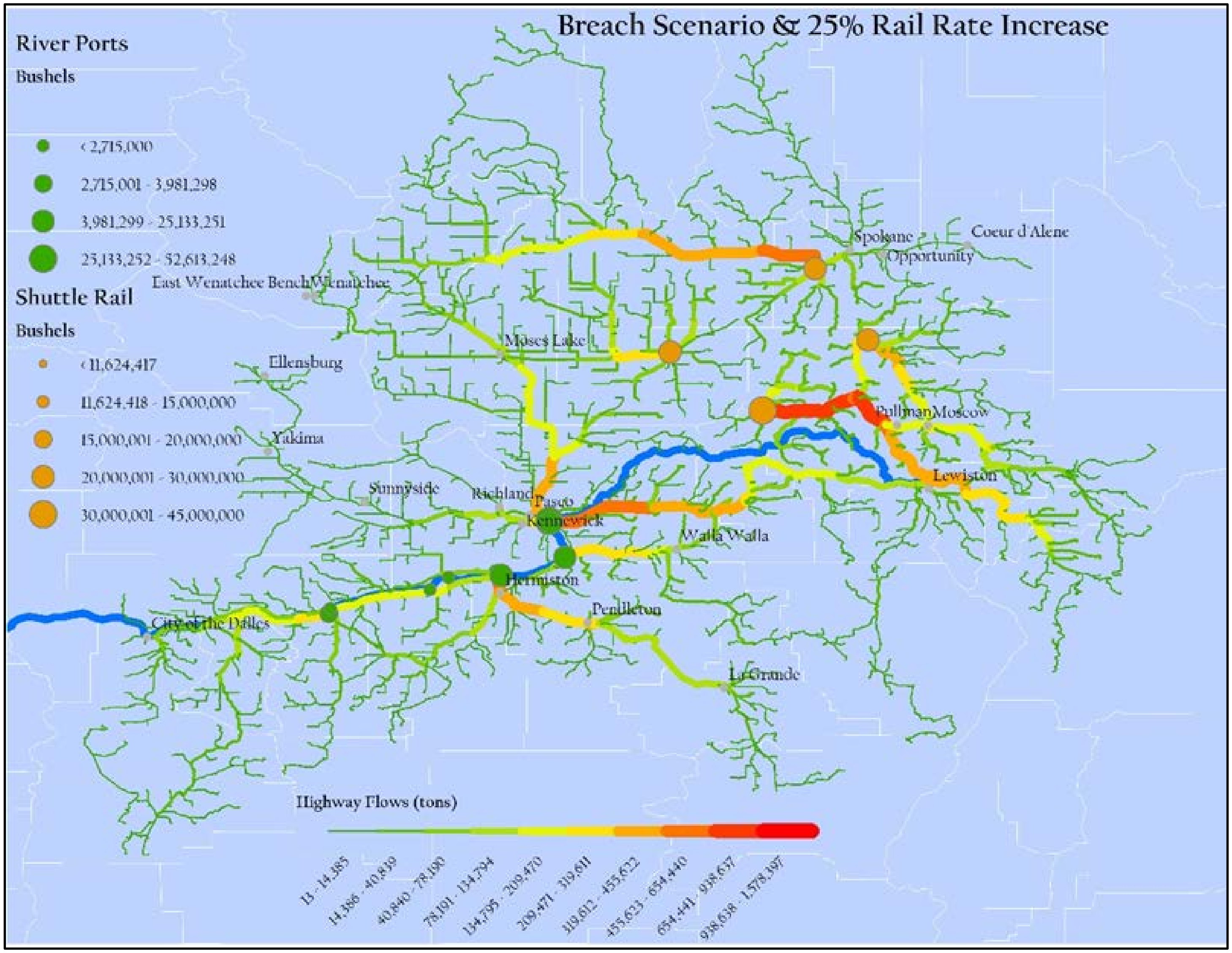


Figure 3-10. Multiple Objective Alternative 3 Scenario 2 (25 percent rail rate increase): Shipping Routes by Mode.

Source: Transportation optimization model, parameterized to reflect current conditions.

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.[8]

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 4 trains per month. Overall, the annual number of shuttle rail unit train trips in the region would increase by 2, 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.

The changes in grain flows, transportation costs, and ton-miles under the MO3 under Scenario 3 are summarized in Table 3-6, Figure 3-11 provides a visual depiction of commodity movements by mode for Scenario 3. As in Table 3-6, Figure 3-11 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 3-11

[8] 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.

Table 3-6. 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
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	–

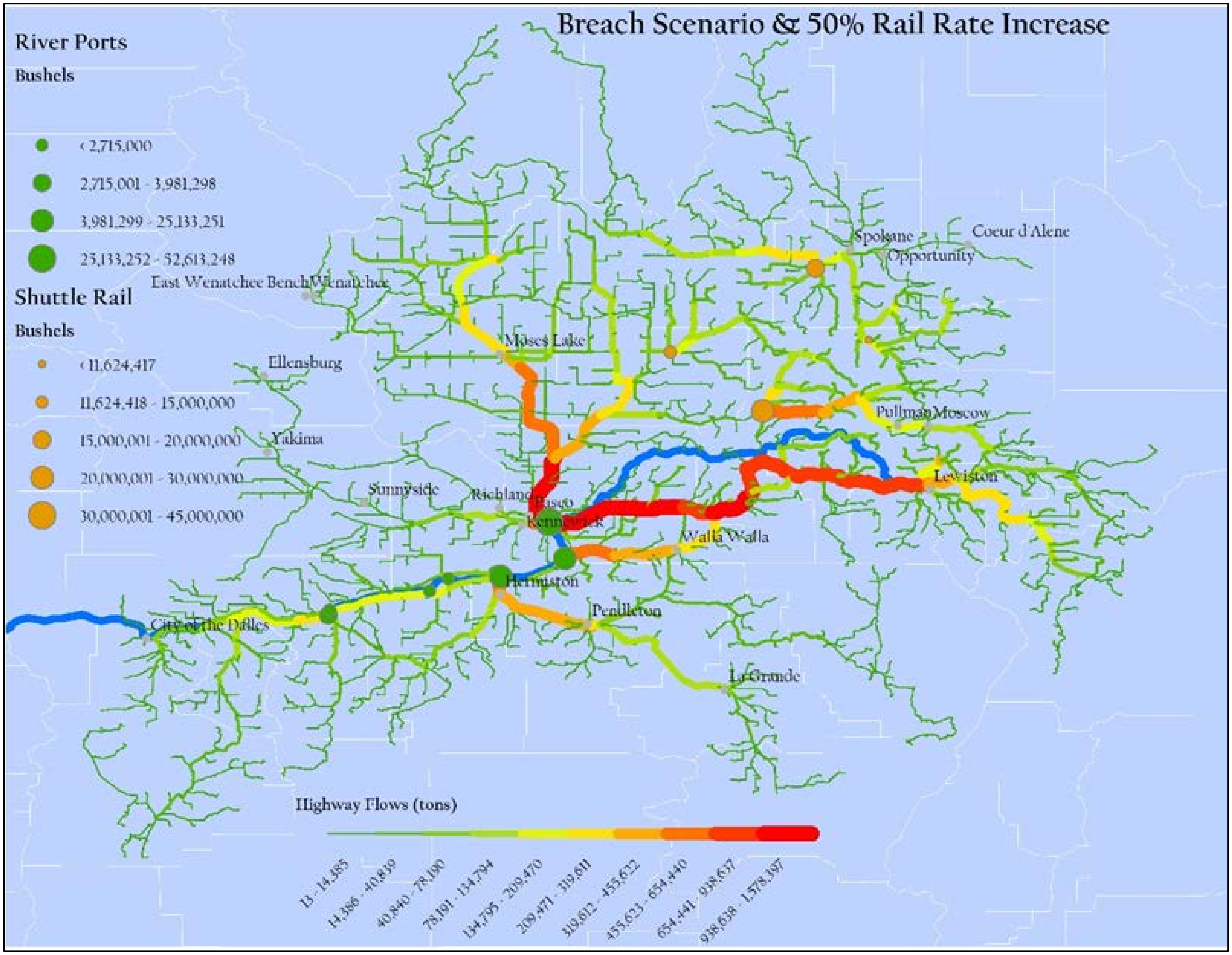


Figure 3-11. Multiple Objective Alternative 3, Scenario 3 (50 Percent Rail Rate Increase): Shipping Routes by Mode

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 the Affected Environment section, 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 below the Ice Harbor DamDam, petroleum products travel via barge in the shallow system and comprise the primary upbound commodity on the lower Snake River segment below the Ice Harbor Dam (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 (Personal communication with Shaver Transportation Company, January 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 U.S. 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 (Written communication with 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.

There have been some environmental and public safety concerns raised, particularly by the Nez Perce Tribe, about shipments of oversized loads on Highway 12. In 2013, the U.S. District Court granted an injunction that banned any oversized loads shipped by Omega Morgan on U.S.

Highway 12 until the U.S. Forest Service conducts a corridor review and consults with the Nez Perce Tribe (Nez Perce Tribe, et al v. United States Forest Service, No. 13-CV-

348-BLW (D. Idaho September 12, 2013). After an appeal filed by the U.S. Forest Service, the U.S. Forest Service and the Nez Perce settled in 2017 (Nez Perce Tribe v. U.S. Forest Service, No. l3-cv-348 (D. Idaho), on appeal, No. 13-3614S (9th Cir.). Under the settlement, oversize loads exceeding 16 feet in width or 150 feet in length or 150,000 are limited to a yearly average of two loads per month. Additionally, “megaloads” or shipments exceeding two of the three criteria above (16 feet in width or 150 feet in length or 150,000) are banned from U.S. Highway 12 entirely.

Regional Economic Effects

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. The impacts to support industries for the commercial cruise lines, and other city and local implications (e.g. firefighting planes) are described in section 3.10.3.5 of the EIS.

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 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, WA and one farmer is located near Grangeville, ID.

Example 1: Farmer Near Colfax with Many Shipping Options

The first example evaluates impacts to a farmer that is located near Colfax, WA. 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 3-12). 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 3-12). 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 3-13), 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 3-14).

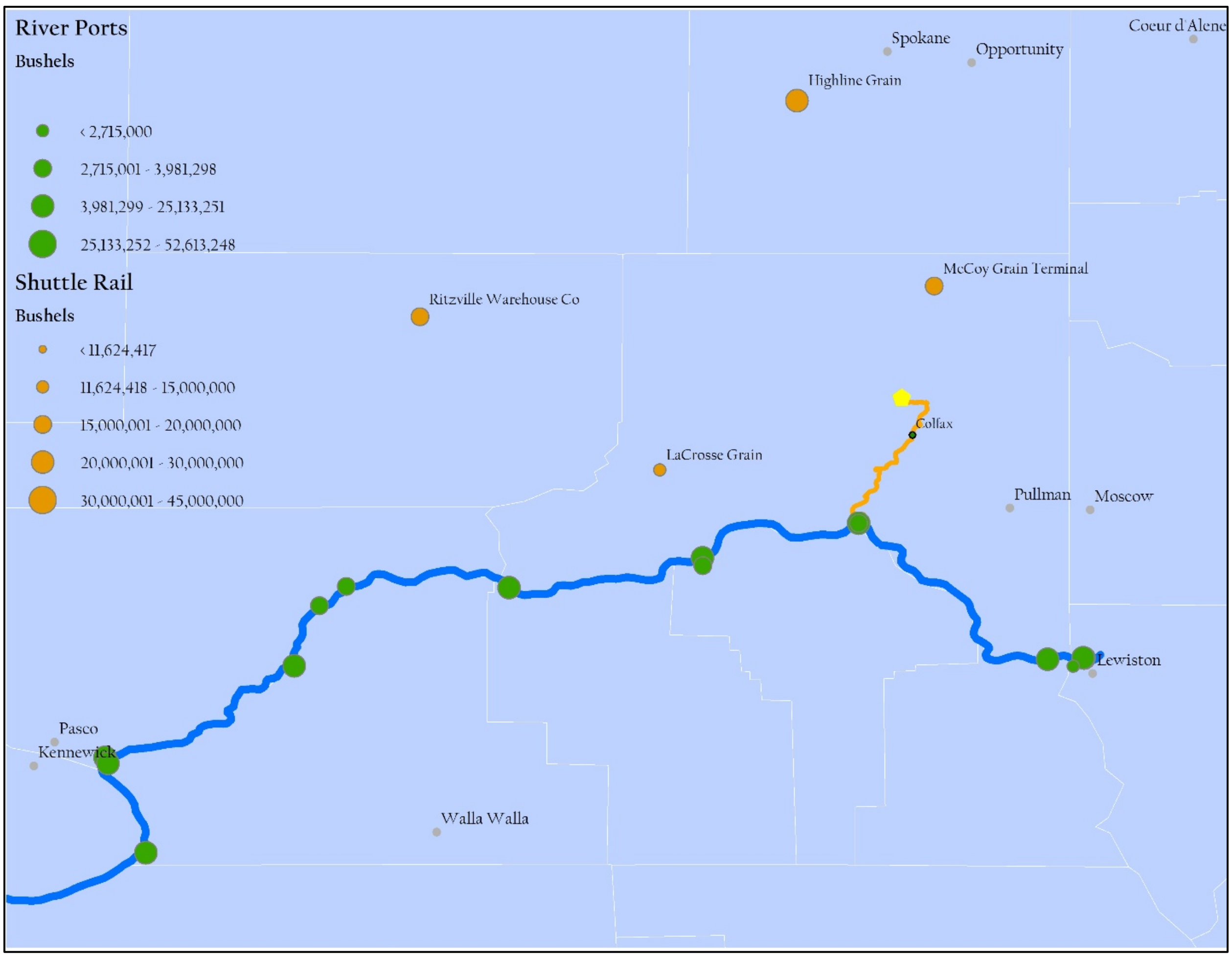


Figure 3-12. Colfax-Area Farmer Transit Route Under the No Action Scenario

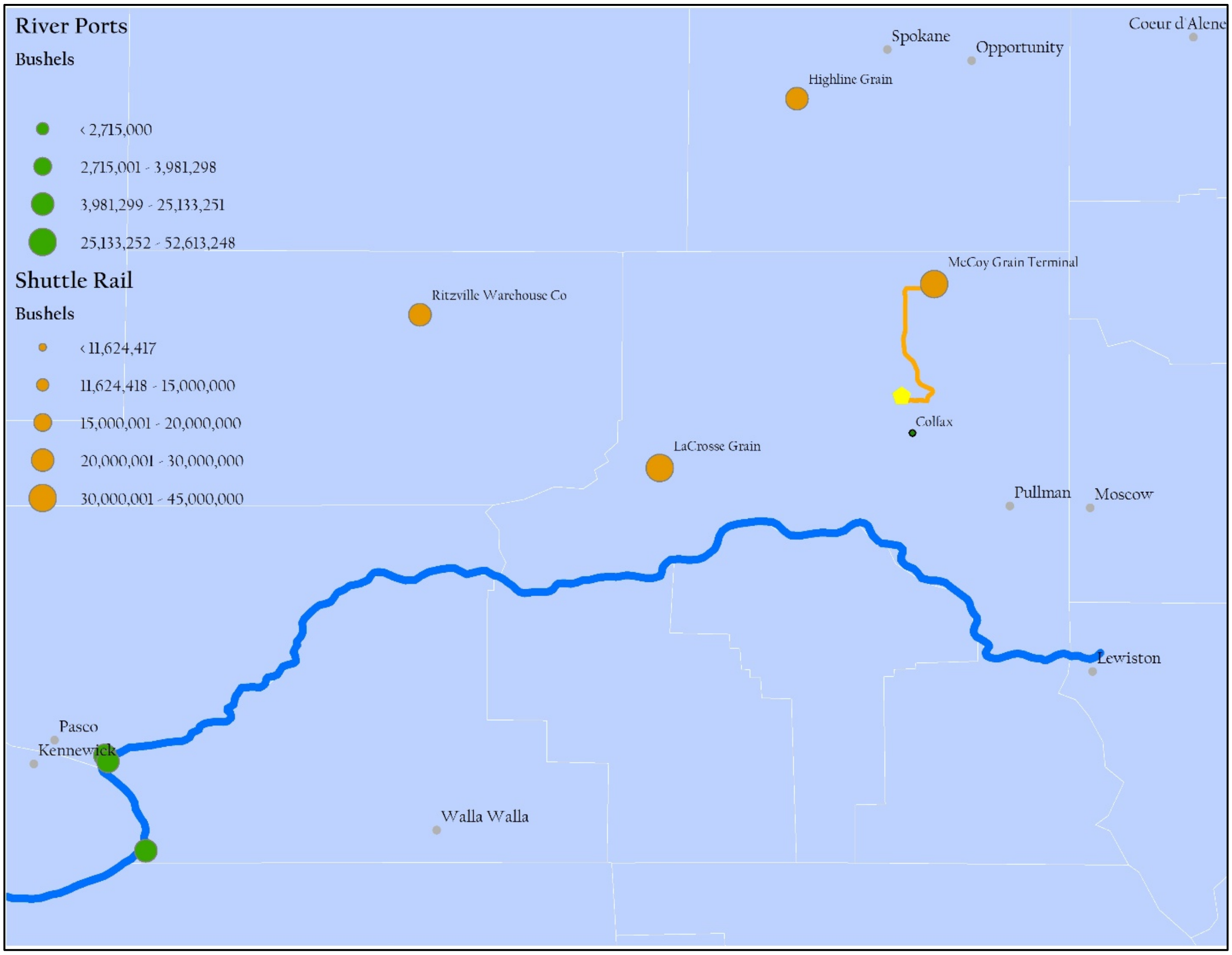


Figure 3-13. Colfax-Area Farmer Transit Route Under Scenarios 1 and 2: No Rail Rate Increase and 25% Rail Rate Increase

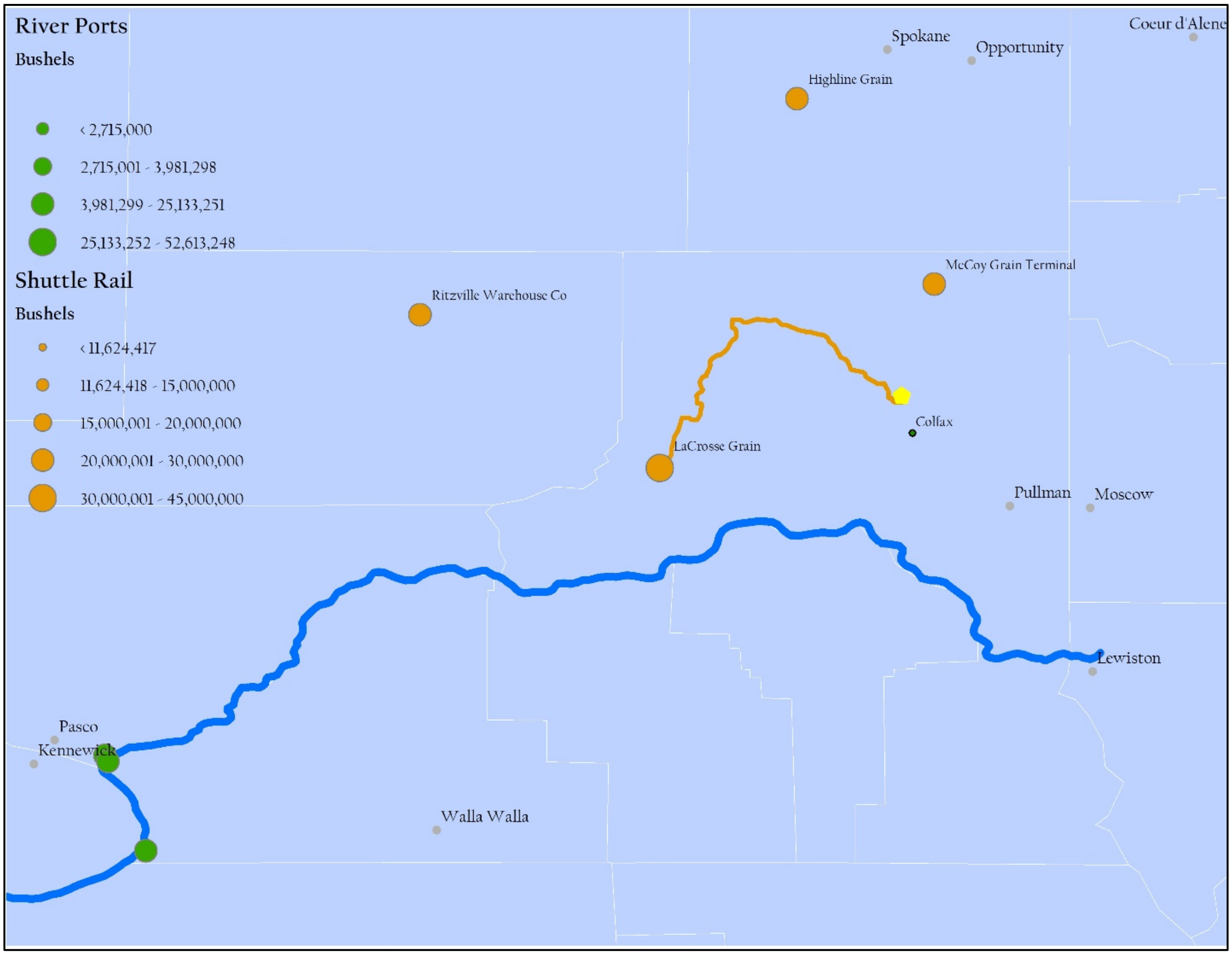


Figure 3-14. Colfax-Area Farmer Transit Route Under Scenario 3: 50% Rail Rate Increase

Example 2: Farmer near Grangeville with More Limited Shipping Options

In a second example evaluates impacts to a farmer that is located near Grangeville, ID. 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 3-15). As such, shipping costs are approximately 36 percent higher than the Colfax farmer's shipping costs under the No Action Alternative.

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) (Figure 3-16).

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 3-15. Grangeville-Area Farmer Transit Route Under the No Action Alternative

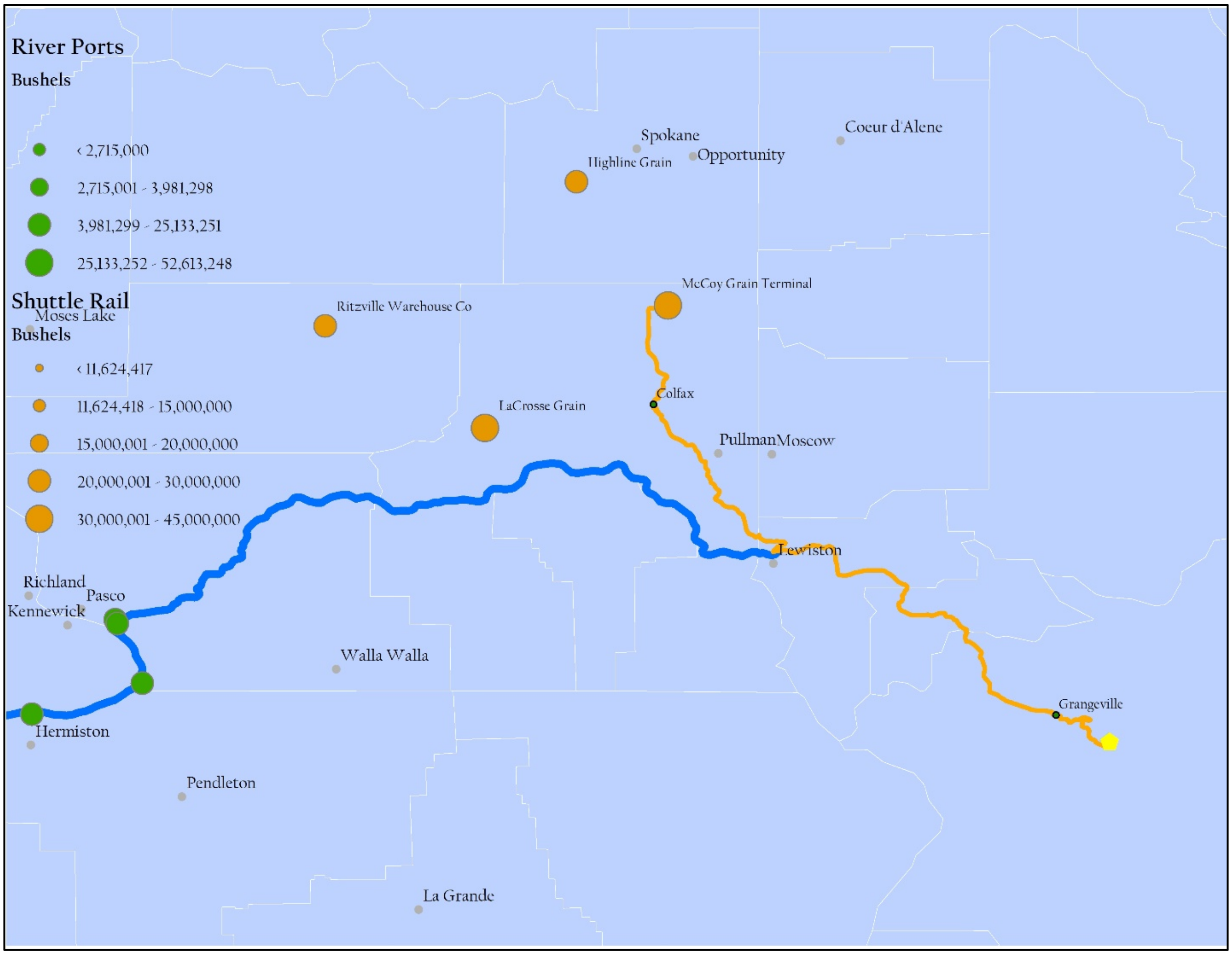


Figure 3-16. Grangeville-Area Farmer Transit Route Under Scenario 1: No Rail Rate Increase

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 US (e.g. 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 $.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 3-17).

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, US dollar etc., global supply). 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, sgrowing 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 US and world.

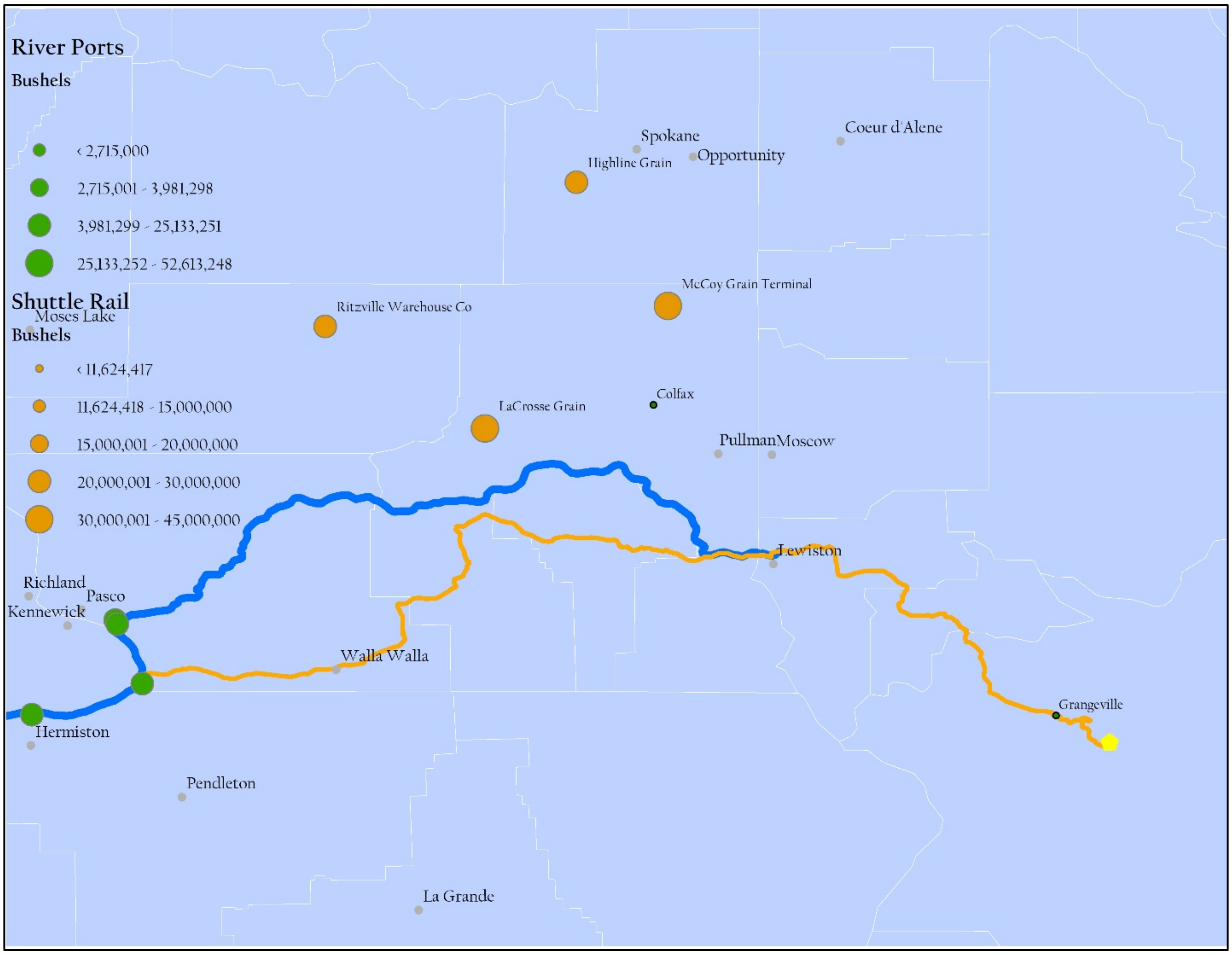


Figure 3-17 .Grangeville-area Farmer Transit Route Under Scenarios 2 and 3: 25% and 50% Rate Increase

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 upon 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 transferring 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 of these them 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 upon 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 did not occur under the no-action scenario. The net additional trips under Scenario 1 is 13,515 truck trips compared to the No Action Alternative. This increase in truck trips would result in some increased demand for gasoline, which, in turn, would marginally increase gas taxes collected, primarily in Washington and Idaho.

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 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 3-17 (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. In order to estimate roadway infrastructure costs:

1. Per ton-mile estimates of road resurfacing costs in Eastern Washington by truck and road type were acquired from published literature (Jessup and Casavant, 1998). These costs are inflated to 2019 dollars and are presented in Table 3-7.
2. An allocation of 70% combination truck and 30% farm truck are applied to the costs of road resurfacing per mile to produce a per ton-mile cost estimate across both truck types. Across both truck types, costs would be $0.01 per ton-mile on state roads and a $0.04 per ton-mile on county roads. It is assumed that 60 percent of increased traffic would occur on state roads and 40 percent would occur on county roads. These estimates are presented in Table 3-8.
3. Finally, to estimate total costs to road infrastructure, the total change in truck ton-miles from the TOM is applied to per ton-mile costs (Table 3-7).

Table 3-7. Costs of Road Resurfacing per Ton-mile (2019 Cents)

Road Type	Combination Truck (¢)	Farm Truck (¢)
Interstate	0.4	0.9
State Highway	1.0	2.4
Country	3.0	6.6

Costs to maintain roads in Eastern Washington due to the increased truck traffic would be approximately $2 million annually in Scenario 1. 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 substantially, increased pavement damage costs would be approximately $10 million annually. The increase in infrastructure costs across all MO3 Scenarios are illustrated in Table 3-9.

Table 3-8. Resurfacing Cost per Truck Ton-Mile by Road Type.

Road Type	Resurfacing Cost per Truck ton-mile (cents)	Assumed Percentage of Truck Traffic on Road Type
Interstate	-	0%
State Highway	1.4	60%
Country	4.1	40%
Weighted Damage Cost (cents/ton-mile)	2.5	-

Note: Resurfacing costs per truck ton-mile reflect the costs associated with an allocation of 70% combination trucks and 30% farm trucks. Due to the distribution of weight on their axle, farm trucks create higher costs of road surfacing per ton-mile than combination trucks.

Table 3-9. Total Increase in Pavement Costs for Each MO3 Scenario.

Scenario	Change in Truck Ton-Miles	Total Pavement Resurfacing Cost
MO3 Scenario 1	86,965,082	$2,164,375
MO3 Scenario 2	149,466,211	$3,719,894
MO3 Scenario 3	391,464,988	$9,742,727

Rail Lines and Demand for Rail Cars

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 3 (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 upon 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 (personal communications with shuttle rail manager). Based upon this it’s estimated that 1 to 2 shuttle rail facilities could be needed at a cost of $25 to $50 million.

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 4 trains to approximately 8 trains per month at each shuttle rail facility. Overall, the number of shuttle rail unit train trips in the 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 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 $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 upon available information congestion and associated capacity constraints are likely more associated with shuttle rail facilities and/or shortline rail upgrades. Similar 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 tug boat operators, shipping handlers, to boat builders. Many crew members permanently reside in the greater Portland area, but some reside in upriver areas (Personal communications with Tidewater Barge Lines and Shaver Transportation Company, January 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. (Personal communications with Tidewater Barge Lines and Shaver Transportation Company, January 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 (Personal communication with Port of Lewiston and industry stakeholders, December 2019).

ANNEX A. SENSITIVITY ANALYSIS FOR TOM MODEL ASSUMPTIONS

The TOM model is utilized to identify how grain shipments move from point of production to final export market utilizing a least cost decision rule. Stated differently, the volume and flow of grain moving from production to market (through grain elevators and on highways, rail and river) reflects all those entities engaged in the decision-making process (primarily producers and grain merchants) always choosing the minimum cost option available. But the transportation options presented does impact the outcomes and the TOM model was designed to incorporate those shipping options that were reflective of the conditions currently facing grain producers and processors. In some cases, these choices are not the same as those that were available in the past (due to industry and market changes) and likewise they do not include shipping options that could be available into the future if certain conditions were met and changes occurred. Instead, they were designed to be the most realistic given current business circumstances influencing grain movements.

The TOM model does not allow grain merchants and elevator operators to utilize rail (non-shuttle rail) to river port movements in any of the scenarios considered. This assumption increases truck grain movements and overall transportation costs relative to an assumption thatthose types of shipments would be been allowed in the model. In an earlier run of the TOM model[9], those options were allowed both in the No Action Alternative and under MO3. This model iteration found that approximately 37.5 million bushels of grain would be shipped to river ports on the Snake River utilizing non-shuttle rail under the No Action Alternative. That volume would drop to 34.7 million bushels once the Snake River ports were not available and if rail rates do not change (Scenario 1, MO3) and then jumped to 80.6 million bushels if rail rates increased to 50 percent (Scenario 3). Under those alternatives, even though rail rates increased, it would be cheaper to move via non-shuttle rail to river ports on the Columbia River as opposed to trucking to Columbia River ports. This is because the increased rail rates would push volumes away from the shuttle rail facilities. But if non-shuttle rail to river port movements are not allowed in the model, as is the case under the current results, more truck movements would occur and at a higher cost.

The rationale for removing that option came after meeting with grain shippers and discussions with the shortline railroad that operates in the region. In years past, there had been relatively significant volumes of grain moved on shortline rail lines from non-shuttle rail elevators to ports on the Snake and Columbia Rivers. But the addition of the shuttle rail facilities changed the economics of moving grain from non-shuttle rail to the river and so much of that volume that had moved via non-shuttle rail to the river is now being moved to shuttle rail facilities. Another factor that contributed was the requirement for all Class I railroads to implement Positive Train Control systems on their network. This requirement was congressionally mandated to be in

[9] The TOM model was modified significantly between the earlier and final editions, primarily related to elevators with and without rail shipping options. Comparison of results between the two is somewhat difficult but provided to allow greater context.

place by the end of 2020, but most Class I railroads have already implemented it on their networks (98%). Once implemented, the ability of shortline railroads to interchange or operate on parts of the Class I network became challenging without also adopting that technology on their locomotives. This change has impacted the ability of shortline operators to move grain from non-shuttle elevators to the river port if they must operate on the Class I network or interchange with the Class I. This is part of the reason why non-shuttle rail to river movements currently are not allowed in the model. If the shortline operators were willing to make those investments in technology and equipment, such movements could occur on the river, which would reduce future anticipated costs.

Another modeling issue involves allowing those river elevators that are located on the Snake River to also move grain to the Columbia River ports or Portland on the rail line that moves along the Snake River. Many of those river elevators between Lewiston, ID and Pasco, WA are connected on that shortline rail line which is currently operated by WATCO. Currently, those shipping options are not allowed in the TOM model results, again after discussions with those grain shippers and WATCO. Currently, grain does not move on that line in that fashion, from the Snake River ports on that rail line, primarily because as long as the river is there the barge rate is better than the rail costs to move the grain to Portland. There have been times, primarily during the river closures, when grain has moved on that rail line between Lewiston, ID and Portland, OR. But that type of movement is not very efficient (very costly) primarily because those river terminals aren’t designed to loadout rail cars efficiently. They are built to receive shipments from truck or rail and loadout barges. If the Snake River was not available, movement of grain from those facilities would be possible, but still inefficient and costly without significant investments. Most of those facilities don’t have the geographic space needed for expanding the rail loading capacity, certainly not the construction of shuttle loading facilities and the rail operator would still need to piece together trains from stopping and loading at multiple facilities, taking considerable time and money. In most cases, grain would be reallocated before arriving to the river terminal if the river was closed, since that would be the least costly option to get it to Portland, OR. It was because of these factors that these shipping options were not allowed in the TOM model.

CHAPTER 4 - LITERATURE CITED

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Appendix M
Recreation

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CHAPTER 1 - INTRODUCTION

The environmental consequences analysis for recreation evaluates how changes in reservoir, river, and habitat conditions under CRSO alternatives could affect visitation, recreational opportunities, and the value of the recreation experience. The effects of CRSO alternatives 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. Impacts to recreational visitation and associated economic effects that are anticipated to result from changes in boat ramp accessibility (i.e., access to water-based recreation) under CRSO alternatives are quantified using H&H data on changes in anticipated river flows and reservoir levels. Changes in the availability of fish, water quality, and wildlife conditions have the potential to affect the quality of the recreational experience and visitation; these effects are evaluated qualitatively using results of other resource evaluations described in the FEIS. A supplemental evaluation was conducted under MO3 to estimate the potential visitation to the lower Snake River reach in the long-term.

This appendix focuses on providing additional details that support the quantified effects to recreational visitation from changes in boat ramp accessibility on reservoirs and the resulting social welfare and regional economic effects. Additional qualitative components of the recreation analysis (how changes in resource conditions affect recreation) and other social effects are detailed in the environmental consequences section for the No Action Alternative and Multi-Objective Alternatives (MOs) in the FEIS, Section 3.11, Recreation, and in 7.5.10 for the Preferred Alternative (PA). To summarize all of the recreation effects under CRSO alternatives, including the Preferred Alternative, the summary tables and supporting descriptions that are included in Section 3.11 and Section 7.5.10 of the EIS, are also provided for each alternative as well as the No Action Alternative in this appendix.

CHAPTER 2 - REVIEW OF METHODOLOGY FOR EVALUATION OF EFFECTS TO RECREATION

The environmental consequences for recreation in this EIS are evaluated across three categories: social welfare effects, regional economic, 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. As discussed above, this appendix focuses on providing additional details to support the quantitative analysis that is described in Chapter 3.

River flows and reservoir elevations may change under the action alternatives (MOs and PA) 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 are 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.[1] A supplemental analysis applying existing information is used to quantify potential changes in recreational visitation in the long-term under for the dam breach scenario of MO3.

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). Potential effects to recreation-related resources and conditions, including fish, water quality, and wildlife and habitat conditions, provide information about changes to the quality of the recreation experience and visitation that may result from the action alternatives. The detailed qualitative analysis of these effects is described in Chapter 3 of the EIS.

Changes in river flows and stages during the peak recreation season (May through September), where changes in flow of 10 percent or more are anticipated are assumed to have the potential

[1] Maximum usable boat ramp elevations were also considered, but none of the H&H elevation data would extend above ramps under the MOs and PA relative to the No Action Alternative

to affect recreation. Smaller flow changes and changes in flows that would be outside of the peak recreation season are assumed to result in negligible effects to recreation.

2.1 SUPPLEMENTAL INFORMATION ON METHODOLOGY FOR QUANTIFYING OF SOCIAL WELFARE EFFECTS RELATED TO CHANGES IN RECREATIONAL ACCESS

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 visitation and 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. This section provides additional detail about impacts that are quantified in Section 3.11.

The analysis considers the effects of the alternatives on recreation over the 50-year period of analysis. The 50-year period of analysis provides 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 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 action alternatives as annual or annual equivalent effects over the 50-year period of analysis.

2.1.1 Assessing Recreational Visitation (Visits)

The H&H analysis provides summary elevation 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. The 50 percent exceedance water level (median water surface elevation) is referred to as the typical water year throughout this appendix. The 25th percentile is referred to as the high water year and the 75th percentile as the low water year. The analysis focuses on modeled daily water surface elevations associated with the 50th percentile (typical water year), but considers water surface elevations at the 25th and 75th percentiles to understand the possible extent of effects under various water conditions.

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 and PA relative to the No Action Alternative. All elevations are in National Geodetic Vertical Datum of 1929 (NGVD 29). Visitation data for the reservoir sites are readily available from Federal and state agencies, while visitation data for river reaches are limited. Therefore, changes in boat ramp accessibility—and associated water-based recreational visitation, including fishing, boating, and swimming—are estimated quantitatively at reservoirs only.

The methodology for estimating changes in water-based visitation at reservoirs due to changes in boat ramp accessibility is outlined in the four steps below. This discussion is supported by the graphical illustrations in Figure 2-1 through Figure 2-4. Figure 2-1 shows the minimum usable elevation for one example boat ramp; example daily water surface elevations under the No Action Alternative (NAA) at the 25th, 50th, and 75th percentiles; and example daily water surface elevations under an illustrative multiple objective action alternative (MO#) at the same percentiles. Figure 2-2 through Figure 2-4 provide separate summaries for the 25th, 50th, and 75th percentiles. The data are for illustration only and do not represent real data. Further, the recreation analysis considered multiple boat ramps within a reservoir. The figures include one example ramp for simplicity.

Figure 2-1 demonstrates that water surface elevations are highest at the 25th percentile (high water year), next highest at the 50th percentile (typical water year), and lowest at the 75th percentile (low water year). The example boat ramp in the figures would be accessible on days when the water surface elevation equals or exceeds the boat ramp's minimum usable elevation (represented as a black line).

1) **Estimate boat ramp accessibility under the No Action Alternative by reservoir**. Compare minimum usable boat ramp elevations with modeled H&H water surface elevations to evaluate boat ramp accessibility by day under the No Action Alternative. 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. Using August from the example figures below, the boat ramp is accessible under the No Action Alternative for 24 days at the 25th percentile, 19 days at the 50th percentile, and 15 days at the 75th percentile.
2) **Calculate the change in boat ramp accessibility under each MO and the PA**. Calculate the percentage change in boat ramp accessibility by month for each action alternative (MOs and the PA) relative to the No Action Alternative. This is based on the percentage change in total days that boat ramps would be accessible in each month. Again, using August from the example figures below, the boat ramp is accessible under the MO# alternative for 23 days at the 25th percentile, 10 days at the 50th percentile, and 0 days at the 75th percentile. Therefore, boat ramp accessibility is reduced by four percent under the MO# alternative relative to the No Action Alternative at the 25th percentile, and by 47 and 100 percent at the 50th and 75th percentiles, respectively.
3) **Estimate water-based visitation (visits) by reservoir under the No Action Alternative**. Monthly water-based visitation in a typical water year (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). This is described in Section 3 below along with supporting detail about how monthly water-based visitation is estimated for high- and low water years under the No

Action Alternative. Water-based visitation is estimated at the reservoir level because water-based visitation data are not available for individual access points with boat ramps in the basin.

4) **Estimate changes in water-based visitation (visits) by reservoir associated with changes in boat ramp accessibility under each MO and the PA**. 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. For illustrative purposes, assume 1,000 water-based visits occur in August in a typical water year at the one-ramp reservoir in our example. Applying the estimated decrease in boat ramp accessibility of 47 percent from Step 2 yields an estimated decrease of 470 visits in a typical water year. Assuming 1,200 visits occur in August in a high water year, 50 visits would be lost (four percent decrease in boat ramp accessibility from Step 2). Assuming 800 visits occur in August in a low water year, all 800 visits would be lost (100 percent decrease in boat ramp accessibility from Step 2).

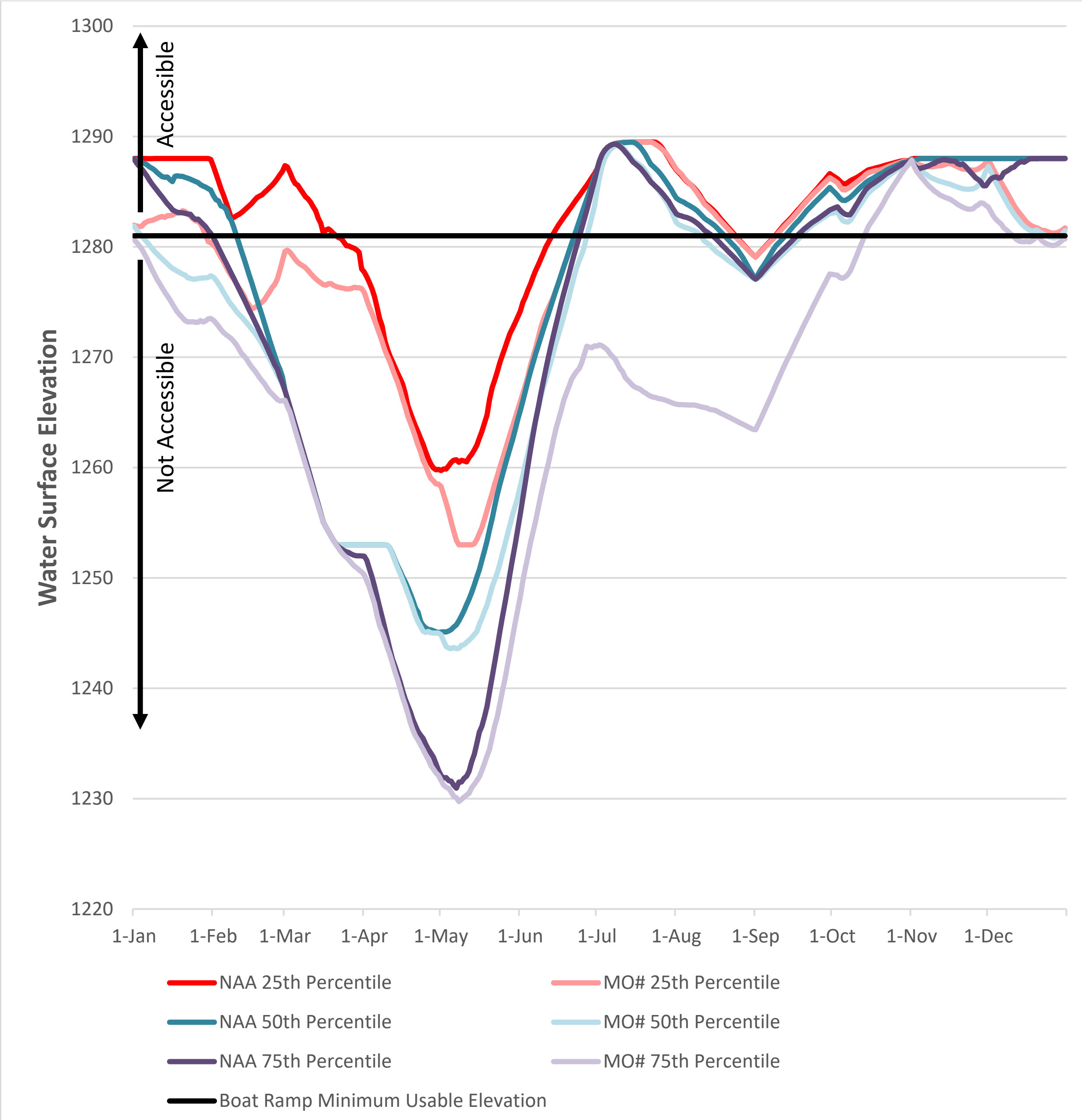

Figure 2-1. Illustration of Methodology: NAA vs. MO#, All Percentiles

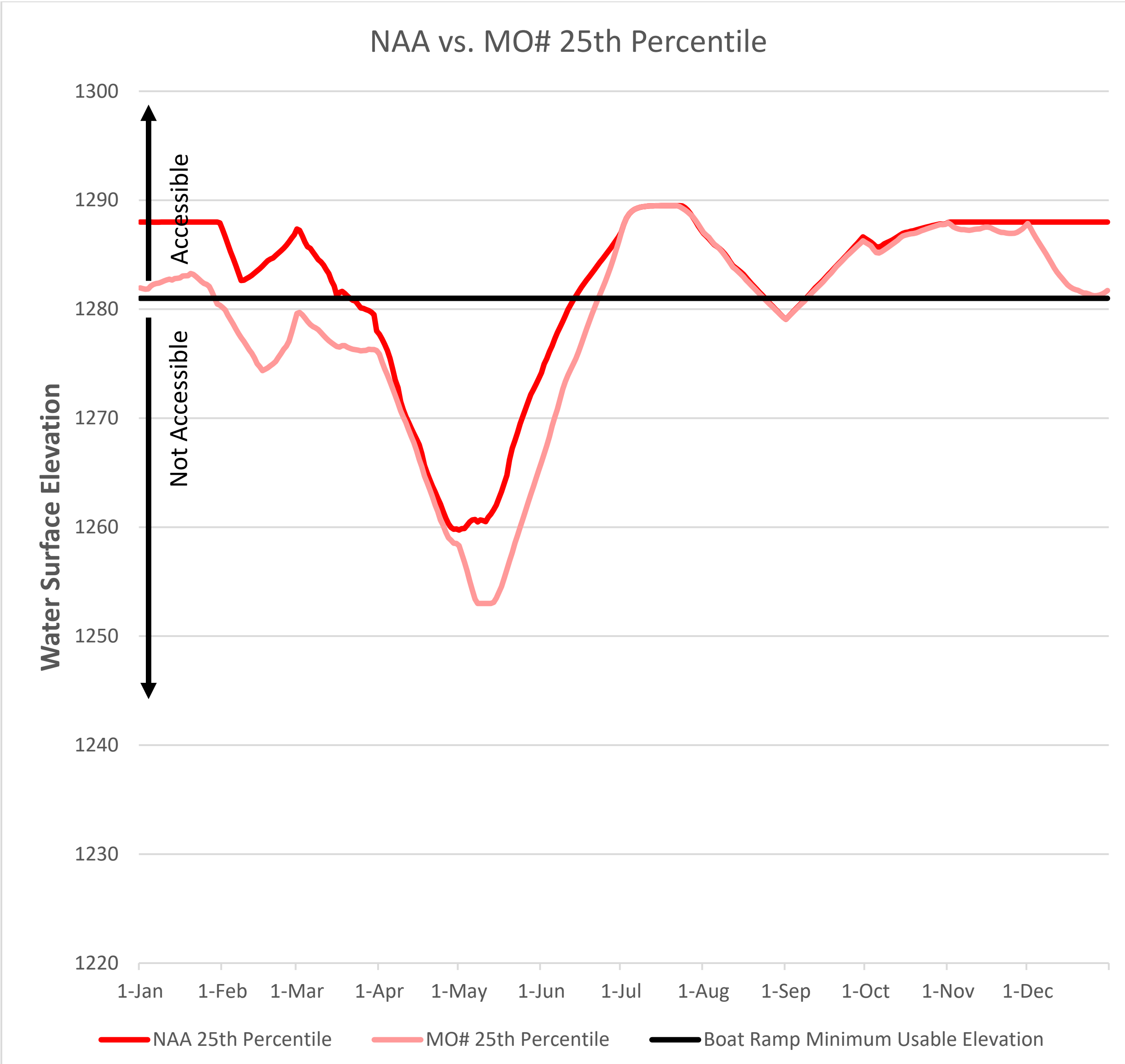

Figure 2-2. Illustration of Methodology: NAA vs. MO#, 25th Percentile

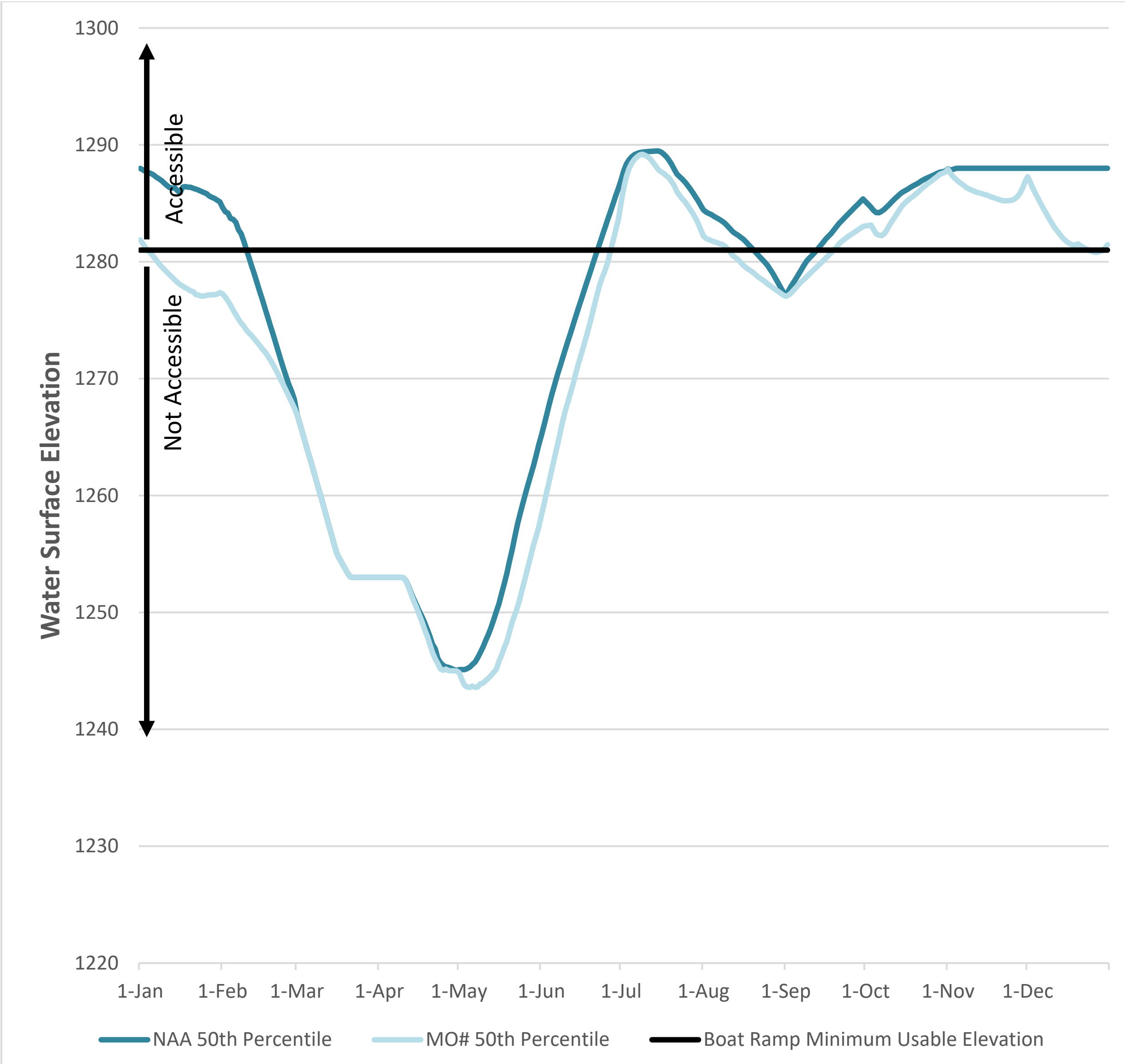

Figure 2-3. Illustration of Methodology: NAA vs. MO#, 50th Percentile

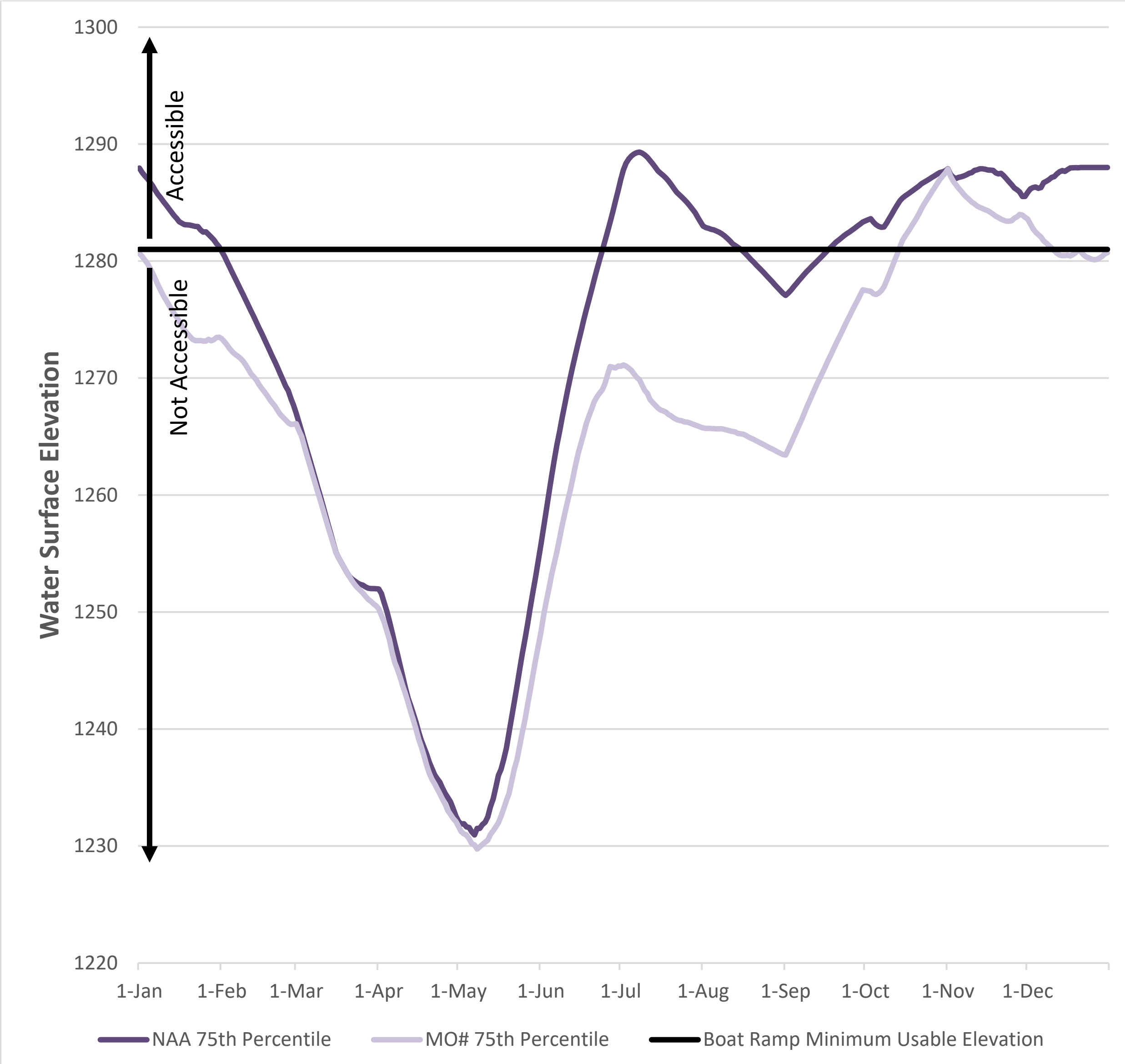

Figure 2-4. Illustration of Methodology: NAA vs. MO#, 75th Percentile

The methodology presented above includes a number of assumptions. 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 utilized in this analysis are conservative (i.e., they are more likely to overstate than understate effects of changes to water-based visitation), but the methodology is a reasonable approach given existing information. In particular, quantified effects do not take into account the potential for spatial substitution or temporal substitution.[2] Quantified effects do not take into account potential

[2] That is, if a particular boat ramp is made temporarily inaccessible by changes in reservoir elevations, a recreationist might use a different ramp, pursue a shore-based activity to the same site, or make a trip to a different site in the region. The current methodology assumes that recreationists (local and non-local visitors) would forego that particular visit and not visit other adjacent reservoirs. Quantified effects do not take into

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 (Corps and Bureau of Reclamation 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.

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.

During construction activities associated with the breaching, it is likely that both land- and water-based visitors would not be able to access the area due to safety closures. After and possibly during the breaching and infrastructure drawdown period, land-based recreational activities at lower Snake River sites may re-occur as areas are re-opened and access is provided to curious sightseers, picnickers and hikers and other 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 short-term changes in visitation and associated economic effects in the lower Snake River compared to current visitation under the No Action Alternative.

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 visitation at similar river reaches. However, the issue of recreation access is also discussed under MO3. Without the federal reservoir project, the Corps will not have a role in providing recreation facilities; therefore in order to re-establish recreation opportunities and water access in the region, there would likely be a cost impact to a

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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.

government agency to provide recreational infrastructure and access roads. The river visitation estimates in the long-term are described in this appendix, consistent with the description in Section 3.11. The potential for recreational fishing in the long term and the quality of the recreational experience under the MOs are discussed qualitatively in Section 3.11.3 of the EIS.

2.1.2 Identifying Reservoirs with Changes in Visitation Related to Recreational Access

Across the MOs and PA, a change in recreational visitation due to changes in boat ramp accessibility is anticipated at 10 CRSO reservoirs (Table 2-1). This is based on the H&H modeling results as well as information related to the lower Snake River dam breaches under MO3. Analysts evaluated whether site access would be affected in any of the 25th 50th, or 75th percentile water years. Sites marked with an "X" in Table 2-1 would experience changes in 50th percentile daily water surface elevations of one foot or more, resulting in a change in boat ramp accessibility for at least seven days annually. Sites marked with "**" in Table 2-1 would experience potential effects in low water years only. Potential changes in recreational visitation resulting from smaller changes in water elevations were not evaluated because the effects, if any, are expected to be sufficiently small to not impede access. This approach was supported by conversations with reservoir recreation managers (Corps and Bureau of Reclamation Natural Resource Managers 2019).

Sites marked with an "X*" in Table 2-1 were analyzed separately using information related to the lower Snake River dam breaches under MO3. Additional non-CRSO 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 2-1. Columbia River System Operations Reservoirs Where a Change in Boat Ramp Accessibility is Anticipated

CRSO Region	Reservoir	NAA	MO1	MO2	MO3	MO4	PA
Region A	Lake Koocanusa		X	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	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						

Notes: The sites marked with an "X" were identified as exhibiting changes in boat ramp 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 in low water years only.

2.1.3 Estimating Consumer Surplus Value of Recreational Visitation

Under the No Action Alternative, social welfare effects are evaluated by estimating the economic value (i.e., consumer surplus) resulting from average annual recreational visitation at near-river sites across the basin (water- and land-based use at reservoirs and river reaches). Under the MOs and PA, social welfare effects are evaluated by estimating the change in economic value resulting from estimated changes in recreational visitation at reservoirs. Social welfare effects are presented for a typical water year and for high or low water years where changes in visitation differ by more than 2.5 percent compared with a typical year.

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 completing a current site-specific travel cost or contingent value approach would be a preferred method, the study timeline eliminated these methods therefore the analysis relies upon readily available information. The recreation evaluation uses the UDV approach (Corps 2019; Water Resources Council 1983), which is a standard Corps approach to evaluate recreation consumer surplus benefits. 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 2019a).[3]

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. Second, UDVs are applied to the estimated recreational visitor days. Additional details for these two steps are provided below.

1) ***Convert average recreational visits to recreational days.*** This is done using information maintained by the Corps and the National Park Service (NPS) on the ratio of recreation days to visits for a limited number of recreation areas (Chang 2018a; Cullinane Thomas 2018). For reservoirs/river reaches where this ratio is not available, estimates were adapted from the closest reservoir/river reach with data.[4]

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[3] 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 $25 to $67 per day depending on the recreational activity in the Pacific Northwest.

[4] Information for Lake Koocanusa is applied to the reaches containing Flathead Lake and Hungry Horse Reservoir; information for Lake Wallula is applied to the reach containing Wanapum Lake; and information for Lake Bonneville is applied to the stretch below Bonneville Dam.

2) ***Apply UDVs to estimated recreational days from Step 1***. The UDVs are project-specific and based on existing Army Corps information. The values are developed using expert opinion and judgment, which involves assigning relative scores to individual project site areas (PSAs) based on the quality of those areas. The USACE Economic Guidance Memorandum (EGM) 19-03 (Corps 2019) provides guidelines for assigning points on a 100-point scale based on five criteria. Total possible points that can be assigned to each criterion are as follows:

   1. The quality of the recreation experience as affected by congestion (0-30 points);
   2. Availability of substitute areas in terms of travel time (0-18 points);
   3. Carrying capacity determined by level of facility development (0-14 points);
   4. Accessibility as affected by road and parking conditions (0-18 points); and
   5. Environmental quality based on aesthetics (0-20 points).

Recreation managers rate their PSAs based on the five criteria above. Each PSA is then classified as a type of site (i.e., general recreation, general hunting and fishing, specialized hunting and fishing, or other specialized recreation) and UDVs are selected based on the combination of points and site type (see Table 1 in Corps 2019). The UDV estimates were obtained from the USACE Recreation Budget Evaluation System (RecBest) (Chang 2019a). All values were updated to 2019 dollars using the Consumer Price Index (CPI; Bureau of Labor Statistics 2019) and are presented in Table 2-2. To obtain a value at the reservoir level, a weighted average was calculated across all UDVs for a project, using the PSA visitation estimates (in recreation days) as weights (Table 2-3). For reservoirs/river reaches where UDV estimates were not available, estimates were adapted from nearby locations with data.[5]

[5] See previous footnote. For Lake Roosevelt, the average UDV across all Corps sites was used.

Table 2-2. PSA-Level Unit Day Values for Columbia River Basin Reservoirs and River Reaches

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region A	Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	Blackwell Flats	21	0	3	11	8	43	1	$8.13
Region A	Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	Downstream Area	30	0	3	13	12	58	1	$9.49
Region A	Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	Dunn Creek	30	0	3	13	9	55	1	$9.26
Region A	Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	Libby Dam Left Abutment	9	18	3	14	11	55	1	$9.26
Region A	Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	Libby Dam Visitor Center	11	18	3	14	16	62	1	$9.75
Region A	Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	Ripley	19	6	3	7	12	47	1	$8.55
Region A	Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	Souse Gulch	28	14	3	14	16	75	1	$10.69
Region A	Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	Vista Point	11	18	3	13	12	57	1	$9.42
Region A	Pend Oreille River and Lake Pend Oreille	Albeni Cove	20	3	4	4	12	43	1	$8.13
Region A	Pend Oreille River and Lake Pend Oreille	Albeni Falls Dam Visitor Center	8	14	3	14	12	51	1	$8.95
Region A	Pend Oreille River and Lake Pend Oreille	Priest River	24	3	4	12	7	50	1	$8.87

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region A	Pend Oreille River and Lake Pend Oreille	Riley Creek	26	10	4	12	10	62	1	$9.75
Region A	Pend Oreille River and Lake Pend Oreille	Springy Point	22	10	3	9	11	55	1	$9.26
Region A	Pend Oreille River and Lake Pend Oreille	Trestle Creek	13	6	4	13	11	47	1	$8.55
Region A	Pend Oreille River and Lake Pend Oreille	Vista Area Lower	8	3	0	14	9	34	1	$6.88
Region A	Pend Oreille River and Lake Pend Oreille	Vista Area Upper	8	0	3	14	7	32	1	$6.57
Region B	Chief Joseph Dam and Lake Rufus Woods	Brandt's Landing	8	0	3	14	11	36	1	$7.19
Region B	Chief Joseph Dam and Lake Rufus Woods	Chief Joseph Dam Visitor Center	4	14	2	6	9	35	1	$7.04
Region B	Chief Joseph Dam and Lake Rufus Woods	Commons	10	3	3	14	9	39	1	$7.66
Region B	Chief Joseph Dam and Lake Rufus Woods	Debris Basin	6	3	2	10	9	30	1	$6.26
Region B	Chief Joseph Dam and Lake Rufus Woods	Foster Creek	8	3	3	14	9	37	1	$7.35
Region B	Chief Joseph Dam and Lake Rufus Woods	Information & Rest Area	10	6	4	14	11	45	1	$8.34
Region B	Chief Joseph Dam and Lake Rufus Woods	Lower Spillway	19	3	2	14	9	47	2	$9.42
Region B	Chief Joseph Dam and Lake Rufus Woods	North Shore Trail	4	6	4	14	9	37	1	$7.35
Region B	Chief Joseph Dam and Lake Rufus Woods	North Viewpoint	8	3	3	14	12	40	1	$7.82
Region B	Chief Joseph Dam and Lake Rufus Woods	Powerhouse Viewpoint	6	3	2	14	9	34	1	$6.88

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region B	Chief Joseph Dam and Lake Rufus Woods	Rocky Flats	12	10	3	8	15	48	1	$8.65
Region B	Chief Joseph Dam and Lake Rufus Woods	Spillway Viewpoint	4	6	2	14	12	38	1	$7.51
Region B	Chief Joseph Dam and Lake Rufus Woods	Willow Flats	17	3	2	14	12	48	1	$8.65
Region C	Clearwater River and Dworshak Dam and Reservoir	Big Eddy Recreation Area	19	3	4	14	20	60	1	$9.65
Region C	Clearwater River and Dworshak Dam and Reservoir	Bruce's Eddy Recreation Area	15	3	4	14	17	53	1	$9.10
Region C	Clearwater River and Dworshak Dam and Reservoir	Canyon Creek Recreation Area	20	6	3	5	16	50	1	$8.87
Region C	Clearwater River and Dworshak Dam and Reservoir	Cold Springs Trail	9	6	1	8	20	44	1	$8.24
Region C	Clearwater River and Dworshak Dam and Reservoir	Dam View Camping Area	4	14	3	14	12	47	1	$8.55
Region C	Clearwater River and Dworshak Dam and Reservoir	Dent Acres Recreation Area	26	14	4	10	16	70	1	$10.17
Region C	Clearwater River and Dworshak Dam and Reservoir	Dworshak Dam Viewpoint	5	6	2	12	13	38	1	$7.51
Region C	Clearwater River and Dworshak Dam and Reservoir	Dworshak Visitor Center	6	14	4	14	20	58	1	$9.49
Region C	Clearwater River and Dworshak Dam and Reservoir	Grandad Recreation Area	16	14	3	8	20	61	1	$9.70
Region C	Clearwater River and Dworshak Dam and Reservoir	Lake-Based Recreation Facilities	27	18	3	6	20	74	1	$10.59

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region C	Clearwater River and Dworshak Dam and Reservoir	Little Meadow Creek Campground	5	14	3	6	20	48	1	$8.65
Region C	Clearwater River and Dworshak Dam and Reservoir	Merry's Bay Recreation Area	17	3	3	8	17	48	1	$8.65
Region C	Clearwater River and Dworshak Dam and Reservoir	Powerhouse Road Fishing Access	4	6	3	18	15	46	2	$9.34
Region C	Lower Granite Dam and Lake	Asotin Slough	11	10	3	14	16	54	2	$10.07
Region C	Lower Granite Dam and Lake	Blyton Landing	18	3	3	14	17	55	1	$9.26
Region C	Lower Granite Dam and Lake	Chestnut Beach	8	3	3	16	15	45	1	$8.34
Region C	Lower Granite Dam and Lake	Evans Pond	6	0	3	14	16	39	2	$8.79
Region C	Lower Granite Dam and Lake	Golf Course Pond	6	0	4	14	15	39	2	$8.79
Region C	Lower Granite Dam and Lake	Greenbelt Ramp	13	0	4	16	12	45	1	$8.34
Region C	Lower Granite Dam and Lake	Hells Gate	11	10	3	14	11	49	1	$8.76
Region C	Lower Granite Dam and Lake	Lewiston Levee Recreation Trail	10	10	4	14	12	50	1	$8.87
Region C	Lower Granite Dam and Lake	Lower Granite Esplanade	8	14	3	14	8	47	1	$8.55
Region C	Lower Granite Dam and Lake	Lower Granite North Shore Tailrace Area	11	14	3	14	8	50	1	$8.87

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region C	Lower Granite Dam and Lake	Lower Granite South Shore Visitor Center	4	18	4	14	8	48	1	$8.65
Region C	Lower Granite Dam and Lake	Nisqually John Landing	18	3	3	14	17	55	1	$9.26
Region C	Lower Granite Dam and Lake	Offield Landing	16	10	3	14	9	52	1	$9.02
Region C	Lower Granite Dam and Lake	Swallows Park	17	0	3	14	16	50	1	$8.87
Region C	Lower Granite Dam and Lake	Wawawai Landing	21	3	3	14	17	58	1	$9.49
Region C	Little Goose Dam and Lake Bryan	Central Ferry Park	8	10	1	14	16	49	2	$9.57
Region C	Little Goose Dam and Lake Bryan	Illia Dunes Recreation Area	4	14	3	12	11	44	1	$8.24
Region C	Little Goose Dam and Lake Bryan	Illia Landing	16	10	3	14	16	59	1	$9.57
Region C	Little Goose Dam and Lake Bryan	Lambi Creek Recreation Area	13	14	3	14	16	60	1	$9.65
Region C	Little Goose Dam and Lake Bryan	Little Goose Esplanade	8	14	4	14	7	47	1	$8.55
Region C	Little Goose Dam and Lake Bryan	Little Goose Landing	18	10	3	14	12	57	1	$9.42
Region C	Little Goose Dam and Lake Bryan	Little Goose North Shore Tailrace	11	14	3	12	12	52	1	$9.02
Region C	Little Goose Dam and Lake Bryan	Little Goose South Shore Area	13	6	3	14	12	48	1	$8.65

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region C	Little Goose Dam and Lake Bryan	Penawawa Bay Habitat Management Unit	6	10	2	12	17	47	2	$9.42
Region C	Little Goose Dam and Lake Bryan	Rice Bar Habitat Management Unit	10	6	3	12	17	48	2	$9.50
Region C	Little Goose Dam and Lake Bryan	Willow Landing	18	10	3	12	17	60	1	$9.65
Region C	Lower Monumental Dam and Lake Herbert G. West	Ayer Boat Basin	16	14	3	10	16	59	1	$9.57
Region C	Lower Monumental Dam and Lake Herbert G. West	Devils Bench Recreation Area	16	14	3	10	16	59	1	$9.57
Region C	Lower Monumental Dam and Lake Herbert G. West	Lyons Ferry Natural Area	2	6	2	14	20	44	1	$8.24
Region C	Lower Monumental Dam and Lake Herbert G. West	Riparia Park	13	14	3	12	16	58	1	$9.49
Region C	Lower Monumental Dam and Lake Herbert G. West	Texas Rapids Park	16	14	4	14	16	64	1	$9.86
Region C	Lower Monumental Dam and Lake Herbert G. West	Tucannon Habitat Management Unit	6	6	3	14	16	45	2	$9.26
Region C	Ice Harbor Dam and Lake Sacajawea	Big Flat Habitat Management Unit	25	6	3	10	12	56	2	$10.27
Region C	Ice Harbor Dam and Lake Sacajawea	Charbonneau Park	22	3	4	10	11	50	1	$8.87
Region C	Ice Harbor Dam and Lake Sacajawea	Fishhook Park	22	6	4	10	12	54	1	$9.18

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region C	Ice Harbor Dam and Lake Sacajawea	Ice Harbor - South Shore Recreation Area	13	3	3	9	9	37	1	$7.35
Region C	Ice Harbor Dam and Lake Sacajawea	Ice Harbor - South Shore Road Fishing Area	12	3	3	10	9	37	1	$7.35
Region C	Ice Harbor Dam and Lake Sacajawea	Ice Harbor Dam Boat Ramp	13	6	3	6	8	36	1	$7.19
Region C	Ice Harbor Dam and Lake Sacajawea	Ice Harbor Dam Visitor Center	6	10	3	10	8	37	1	$7.35
Region C	Ice Harbor Dam and Lake Sacajawea	Ice Harbor North Shore Recreation Area	8	6	0	8	8	30	1	$6.26
Region C	Ice Harbor Dam and Lake Sacajawea	Indian Memorial Viewing Area	9	6	3	10	11	39	1	$7.66
Region C	Ice Harbor Dam and Lake Sacajawea	Lake Emma Recreation Area	11	3	0	10	7	31	2	$8.16
Region C	Ice Harbor Dam and Lake Sacajawea	Levey Park	17	6	3	10	12	48	1	$8.65
Region C	Ice Harbor Dam and Lake Sacajawea	Matthews Boat Ramp	16	10	3	10	8	47	1	$8.55
Region C	Ice Harbor Dam and Lake Sacajawea	Snake River Junction	13	6	3	10	11	43	1	$8.13

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region C	Ice Harbor Dam and Lake Sacajawea	Walker Pit Habitat Management Unit	18	6	1	10	12	47	2	$9.42
Region C	Ice Harbor Dam and Lake Sacajawea	Windust Park	22	10	3	14	16	65	1	$9.91
Region D	McNary Dam and Lake Wallula	Hood Park	24	6	3	12	11	56	1	$9.34
Region D	McNary Dam and Lake Wallula	Martindale	13	3	2	6	7	31	2	$8.16
Region D	McNary Dam and Lake Wallula	Mcnary Beach	20	3	3	14	8	48	1	$8.65
Region D	McNary Dam and Lake Wallula	Mcnary Wildlife Nature Area	6	10	4	10	11	41	1	$7.92
Region D	McNary Dam and Lake Wallula	Oregon Boat Ramp	7	3	2	14	8	34	1	$6.88
Region D	McNary Dam and Lake Wallula	Pacific Salmon Visitor Information Center	2	10	3	14	12	41	1	$7.92
Region D	McNary Dam and Lake Wallula	Sand Station Recreation Area	16	3	2	10	8	39	1	$7.66
Region D	McNary Dam and Lake Wallula	Spillway Park	12	14	3	14	12	55	1	$9.26
Region D	McNary Dam and Lake Wallula	Warehouse Beach	25	3	2	6	8	44	1	$8.24
Region D	McNary Dam and Lake Wallula	Washington Boat Ramp	7	3	3	12	8	33	1	$6.73
Region D	McNary Dam and Lake Wallula	West Park	8	3	3	10	11	35	1	$7.04

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region D	McNary Dam and Lake Wallula	Yakima Delta	6	6	2	10	9	33	1	$6.73
Region D	John Day Dam and Lake Umatilla	Cliffs Park	4	0	4	2	5	15	1	$5.22
Region D	John Day Dam and Lake Umatilla	Giles French Park	13	6	3	14	7	43	1	$8.13
Region D	John Day Dam and Lake Umatilla	Lepage Park	30	6	4	17	12	69	1	$10.12
Region D	John Day Dam and Lake Umatilla	Paradise Park	11	0	4	4	4	23	1	$5.71
Region D	John Day Dam and Lake Umatilla	Philippi Park	15	18	3	0	16	52	1	$9.02
Region D	John Day Dam and Lake Umatilla	Plymouth Campground	23	6	4	14	16	63	1	$9.80
Region D	John Day Dam and Lake Umatilla	Plymouth Day Use	13	3	3	14	9	42	1	$8.03
Region D	John Day Dam and Lake Umatilla	Railroad Island	9	0	3	13	8	33	1	$6.73
Region D	John Day Dam and Lake Umatilla	Rock Creek Park	11	6	4	10	8	39	1	$7.66
Region D	John Day Dam and Lake Umatilla	Roosevelt Park	23	10	3	13	8	57	1	$9.42
Region D	John Day Dam and Lake Umatilla	Sundale Park	11	6	3	14	7	41	1	$7.92
Region D	John Day Dam and Lake Umatilla	Threemile Canyon Park	20	3	2	12	8	45	1	$8.34
Region D	The Dalles Dam and Lake Celilo	Avery Park	18	3	3	11	10	45	1	$8.34
Region D	The Dalles Dam and Lake Celilo	Celilo Park	25	3	4	16	14	62	1	$9.75
Region D	The Dalles Dam and Lake Celilo	Hess Park	8	0	2	14	11	35	1	$7.04

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region D	The Dalles Dam and Lake Celilo	Rufus Landing	19	10	2	17	10	58	1	$9.49
Region D	The Dalles Dam and Lake Celilo	Seufert Park	15	3	1	13	10	42	1	$8.03
Region D	The Dalles Dam and Lake Celilo	Spearfish Park	20	3	3	9	8	43	1	$8.13
Region D	The Dalles Dam and Lake Celilo	The Dalles North Shore	14	3	2	13	8	40	1	$7.82
Region D	The Dalles Dam and Lake Celilo	The Dalles Visitor Center	11	14	4	13	10	52	1	$9.02
Region D	The Dalles Dam and Lake Celilo	The Wall	16	3	1	8	7	35	1	$7.04
Region D	Bonneville Dam and Lake	Bradford Island Recreation Area	11	0	3	14	15	43	1	$8.13
Region D	Bonneville Dam and Lake	Bradford Island Visitor Center	11	6	4	14	16	51	1	$8.95
Region D	Bonneville Dam and Lake	Fort Cascades National Historic Site	15	10	4	14	16	59	1	$9.57
Region D	Bonneville Dam and Lake	Hamilton Island Recreation Area	23	3	3	14	15	58	1	$9.49
Region D	Bonneville Dam and Lake	Navigation Lock Visitor Area	4	18	4	14	15	55	1	$9.26
Region D	Bonneville Dam and Lake	North Shore Recreation Area	8	0	3	14	15	40	1	$7.82

CRSO Region	Reservoir/River Reach	PSA	UDV1	UDV2	UDV3	UDV4	UDV5	UDV Total	RecType	Unit Day Value (2019$)
Region D	Bonneville Dam and Lake	Robins Island Recreation Area	12	6	3	14	15	50	1	$8.87
Region D	Bonneville Dam and Lake	Tanner Creek Recreation Area	13	3	3	14	15	48	1	$8.65
Region D	Bonneville Dam and Lake	Washington Shore Visitor Center Complex	13	10	4	14	16	57	1	$9.42

Notes: UDV1 is the quality of the recreation experience as affected by congestion (0-30 points). UDV2 is the availability of substitute areas in terms of travel time (0-18 points). UDV3 is the carrying capacity determined by level of facility development (0-14 points). UDV4 is the accessibility as affected by road and parking conditions (0-18 points). UDV5 is the environmental quality based on aesthetics (0-20 points). RecType is general recreation (1), general hunting and fishing (2), specialized hunting and fishing (3), or other specialized recreation (4). Unit Day Value is the resulting UDV based on the combination of points and site type (see Table 1 in Corps 2019).

Table 2-3. Unit Day Values for Columbia River Basin Reservoirs and River Reaches

CRSO Region	Reservoir/River Reach	Unit Day Value (2019$)
Region A	Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	$9.59
Region A	Flathead River above Flathead Lake and Hungry Horse Dam and Reservoir	$9.59
Region A	Clark Fork River, Flathead River below Flathead Lake, and Flathead Lake	$9.59
Region A	Pend Oreille River and Lake Pend Oreille	$8.71
Region B	Grand Coulee Dam and Lake Roosevelt	$8.79
Region B	Chief Joseph Dam and Lake Rufus Woods	$7.72
Region B	Wells Dam and Lake Pateros	ND
Region B	Rocky Reach Dam and Lake Entiat	ND
Region B	Rock Island Dam and Pool	ND
Region B	Wanapum Dam and Lake	$8.36
Region B	Priest Rapids Dam and Lake	ND
Region B	The Hanford Reach below Priest Rapids Dam	ND
Region C	Clearwater River and Dworshak Dam and Reservoir	$9.58
Region C	Snake River below Hells Canyon Dam	ND
Region C	Lower Granite Dam and Lake	$8.83
Region C	Little Goose Dam and Lake Bryan	$8.91
Region C	Lower Monumental Dam and Lake Herbert G. West	$9.56
Region C	Ice Harbor Dam and Lake Sacajawea	$8.41
Region D	McNary Dam and Lake Wallula	$8.36
Region D	John Day Dam and Lake Umatilla	$8.25
Region D	The Dalles Dam and Lake Celilo	$8.67
Region D	Bonneville Dam and Lake	$8.87
Region D	Below Bonneville Dam	$8.87

Notes: There are no visitation data for sites marked as ND (see Table 3-1 below), so no UDVs are presented.

2.2 SUPPLEMENTAL INFORMATION ON METHODOLOGY FOR CALCULATING REGIONAL ECONOMIC EFFECTS ASSOCIATED WITH CHANGES IN RECREATIONAL ACCESS

This section describes additional detail related to the methodology used to quantify regional economic effects associated with changes in recreational access. For this analysis, regional economic effects are measured in terms of changes in economic activity (jobs, labor income, and sales) related to changes in expenditures on recreational visitation by non-local visitors that are anticipated to result from changes in water access. The focus of the quantified evaluation of regional economic effects 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).

Under the No Action Alternative, regional economic effects are evaluated by estimating the economic activity resulting from average annual recreational visitation at sites across the basin (water- and land-based use at reservoirs and river reaches) by non-local visitors. Under the MOs and PA, regional economic effects are evaluated by estimating the change in jobs, labor income, and sales resulting from estimated changes in non-local visitation at reservoirs (results from the Social Welfare Effects evaluation). Regional economic effects are presented for a typical water year and for high or low water years where changes in visitation differ by more than 2.5 percent from a typical year.

Regional economic effects are estimated in two steps. First, recreational visitation (water- and land-based near-river visitation under the No Action Alternative or changes in recreational visitation under the MOs and PA) is multiplied by visitor spending estimates for recreation trips at each river reach or reservoir and aggregated for each region to estimate regional changes in visitor spending. Second, the effects of this spending on regional economic activity in terms of jobs, labor income, and sales are estimated using the input-output model, IMPLAN.[6] The regional economic effects and changes in effects would primarily be experienced in communities surrounding the recreation sites and parks (i.e., in gateway communities), although broader effects across the region could also occur. 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. Expenditures and the resulting regional economic effects are estimated separately for local and non-local visits using data on visitation patterns at affected sites (presented for the No Action Alternative in Table 3-11 below).[7] Additional details on the estimation of regional economic effects are provided in the steps below.

1) *Estimate expenditures associated with recreational visitation.* Estimates of recreational visitation (visits) are converted to match the units of the expenditure data shown in Table 2-4 and Table 2-5. This calculation converts visits to party trips by visitor segment for Corps projects and to party days or nights by visitor segment for Lake Roosevelt (NPS). This is done using project-specific or Corp District-level information (e.g., share of visitation by visitor segment, party size, trip length) maintained by the Corps and NPS (Chang 2018a; Corps 2020; Cullinane Thomas 2018). The resulting estimates are then multiplied by the expenditure profiles in the tables below to estimate total expenditures by visitor segment and spending category.

The Corps' expenditure profile was developed for six visitor segments at all projects across the country from recent surveys at a range of sites.[8] For Corps sites, local visitors live in counties

[6] For more information on the IMPLAN® system, visit http://www.implan.com/.

[7] Again, the current methodology associated with changes in water-based visitation assumes that recreationists (local and non-local visitors) when faced with reduced access would forego that particular visit and not visit other reservoirs. The specific origin of the visitor is not known for non-local visitors, precluding a regional assessment of whether the visitor spending would be local or non-local to the region.

[8] The Corps does not have expenditure profiles specific to sites in the Pacific Northwest or other regions, as the underlying surveys were not designed to generate regional-level profiles.

within 30 miles of the visited project, while non-locals live in counties beyond 30 miles. The NPS expenditure profile for Lake Roosevelt National Recreation Area was developed for six visitor segments from recent surveys. For Lake Roosevelt, local visitors live within 60 miles of the site, while non-locals live beyond 60 miles. For reservoirs/river reaches where expenditure data and supporting information were not available, estimates were adapted from nearby locations with data.[9]

Table 2-4. Corps Estimates of Typical Recreational Visitor Spending Profile: Average Spending Per Trip Per Party, 2019 Dollars

	Non-Boating Trip			Boating Trip		
Spending Category	**Local Day Visitor**	**Non-Local Day Visitor**	**Camper**	**Local Day Visitor**	**Non-Local Day Visitor**	**Camper**
Hotel	$0.00	$0.00	$2.44	$0.00	$0.00	$5.13
Camp	$0.00	$0.00	$60.36	$0.00	$0.00	$105.97
Restaurants and Bars	$11.06	$23.98	$38.98	$22.20	$31.23	$43.45
Groceries	$24.46	$26.02	$65.17	$40.51	$30.96	$68.43
Gas and oil	$26.82	$43.65	$128.11	$80.15	$130.34	$130.34
Other auto expenses	$0.59	$0.59	$0.83	$0.59	$0.59	$10.62
Other boat expenses	$0.00	$0.00	$0.00	$18.15	$18.15	$43.45
Attractions/ Entertainment and recreation fees	$4.86	$4.86	$7.41	$10.11	$10.11	$15.21
Sporting goods	$8.69	$8.69	$10.86	$18.46	$20.64	$23.90
Souvenirs/other	$6.92	$6.92	$13.03	$12.25	$14.12	$17.38
Total	**$83.38**	**$114.71**	**$327.19**	**$202.43**	**$256.13**	**$463.85**

Sources: Chang 2018b.
Notes: Campers are assumed to be non-local for purposes of estimating regional economic effects separately for local and non-local visits, though campers likely include some local visitors too.

Table 2-5. NPS Estimates of Typical Recreational Visitor Spending Profile, Lake Roosevelt: Average Spending Per Day or Night Per Party, 2019 Dollars

Spending Category	**Local Day Visitor**	**Non-Local Day Visitor**	**Camper In Park**	**Camper Out of Park**	**Lodging Out of Park**	**Other Overnight**
Motel	$0.00	$0.00	$0.00	$0.00	$149.05	$0.00
Camping Fees	$0.00	$0.00	$11.95	$47.93	$0.00	$0.00
Restaurants and bars	$15.77	$23.23	$11.83	$21.03	$52.85	$13.24
Groceries and Takeaway	$11.23	$13.70	$19.74	$17.35	$23.73	$14.71
Gas	$14.93	$18.38	$13.16	$19.25	$24.17	$11.61
Local Transportation	$1.73	$2.05	$1.11	$3.69	$2.49	$1.49
Recreation Fees	$4.06	$10.13	$7.95	$9.85	$14.14	$3.41

[9] Information for Lake Koocanusa is applied to the reaches containing Flathead Lake and Hungry Horse Reservoir; information for Lake Wallula is applied to the reach containing Wanapum Lake; and information for Lake Bonneville is applied to the stretch below Bonneville Dam.

Spending Category	Local Day Visitor	Non-Local Day Visitor	Camper In Park	Camper Out of Park	Lodging Out of Park	Other Overnight
Souvenirs and Other Expenses	$4.06	$9.11	$8.95	$15.52	$16.39	$5.30
Total	**$51.78**	**$76.60**	**$74.69**	$134.60	$282.82	**$49.76**

Sources: Cullinane Thomas 2018.
Notes: Per-day expenditures are applied to day use segments and per-night expenditures are applied to overnight users. All visitor segments other than local day visitors are assumed to be non-local for purposes of estimating regional economic effects for local and non-local visits (Cullinane Thomas et al. 2019, p. 5).

2) *Use IMPLAN to estimate regional economic effects*. Total expenditures by visitor segment and spending category from Step 1 are converted to expenditure estimates by IMPLAN sector using information maintained by the Corps and NPS (Chang 2019b; Cullinane Thomas 2019). The IMPLAN model then traces expenditures by sector through the regional economy using industry-specific multipliers to estimate the total regional economic effects in terms of jobs, labor income, and sales.

As stated above, expenditures and the resulting regional economic effects are estimated separately for local and non-local visits using data on visitation patterns at affected sites.[10] Regional economic effects are presented by CRSO region and in total for the basin. The study area for each region includes multi-county areas. IMPLAN data for these multi-county areas were used for this analysis; Table 2-6 lists the counties in each CRSO region. A county was assigned to a CRSO region if the majority of the county's area lies within the region.

Table 2-6. Counties by CRSO Region

CRSO Region A	CRSO Region B	CRSO Region C	CRSO 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)

[10] For Corps sites, *expenditures* associated with local and non-local visitation are approximated using the fraction of local and non-local *visitation* at each site. This is done because the Corps expenditure profile is generic to all sites (nationwide), whereas information about the distribution of visitor segments at Corps sites is site-specific. Visitor segments were defined as local or non-local for the purposes of this analysis as described in the note to Table 2-4. For Lake Roosevelt, expenditures associated with local and non-local visitation are estimated using the site-specific distribution of visitor segments and expenditure profile. Visitor segments were defined as local or non-local for the purposes of this analysis as described in the note to Table 2-5. For all sites, because some segments designated as non-local include local visitors, the estimates of non-local expenditures (and associated regional economic effects) may be overstated. However, any bias that may arise due to data limitations is expected to be small.

CRSO Region A	CRSO Region B	CRSO Region C	CRSO Region D
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)

2.3 KEY UNCERTAINTIES AND STUDY LIMITATIONS

The recreation analysis completed for the CRSO EIS, includes multiple areas of uncertainty. The uncertainty may be related to available information and data, modeling challenges, and or limitations for forecasting future conditions. The development of a number of assumptions was needed to address uncertainties and identify data limitations. This section describes the uncertainties, the assumptions used, and the potential impact on the results.

The primary source of uncertainty associated with the recreation analysis in this EIS is predicting how visitors would react to changes in river and reservoir conditions. To characterize the range of effects that might be experienced under the CRSO EIS alternatives, the recreation analysis considered the effects of hydrologic changes on reservoir elevations and river reaches, relating reservoir conditions to annual water-based visitation in the typical water year, as well as high and low water years. The H&H data outputs used for the CRSO EIS analysis have inherent uncertainties (discussed in greater detail in Appendix A, Part 1 - H&H Data Analysis). The quantitative evaluation for the recreation analysis 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 key sources of uncertainty associated with the recreation analysis are described below. Each source is summarized along with its likely effect on the analysis.

- Existing information on the behavior of recreationists in the Columbia River Basin in response to changes in the accessibility or quality of recreation sites is limited. As a result, the analysis assumes that recreationists will forgo trips to particular recreation sites if they are not available rather than substituting to other sites or changing time in which their trip takes place. The analysis does not take into account any mitigation actions by resource providers that may be undertaken to reduce potential effects (see Section 2.1.1 for additional detail). These modeling limitations are expected to result in overstating rather than understating effects of changes to water-based visitation and resulting estimates of social welfare and regional economic effects.

- Due to gaps in existing information, visitation estimates were not available for all sites across the basin (see Section 3.1.1 for additional detail). These data gaps likely lead to an underestimate of recreational visitation and associated economic effects that occurs in the Columbia River Basin under the No Action Alternative, particularly for river-based recreation as well as visitation at county and local sites. While overall visitation estimates would be underestimated, potential impacts from changes in boat-ramp accessibility to recreation at reservoirs/river reaches with no data under CRSO EIS alternatives are expected to be minimally affected (see Table 2-1).

- The recreation model used visitation data from state and Federal agencies for 2017-2018 to estimate recreational visitation under the No Action Alternative. This data was used because consistent visitation data for years prior to 2017 were not available from all agencies. The 2017 and 2018 visitation data were used to carry out the analysis because they represent relatively typical years in terms of water levels and recreational visitation (see Section 3.1.1 of this appendix for additional detail). They were used to estimate visitation for the period of analysis (i.e., in future years) under the No Action Alternative, which was supported by recent visitation trends at Lake Roosevelt and communication with recreation managers (see Section 3.1 of this appendix for additional detail). Visitation in future years could be lower or higher due to a range of factors so the impact of this assumption is unknown. Section 3.1.2 of this appendix describes the approach used to estimate water-based visitation under the No Action Alternative in high and low water years. This approach is reasonable for comparison across the alternatives; it is not known if this approach would result in an expected overestimate or underestimate of visitation during high and low water years.

- The quantified effects analysis assumes that changes in boat ramp accessibility will result in changes in water-based recreational activities on the reservoirs. That is, all water-based recreation is assumed to decrease when a boat ramp is inaccessible (see Section 2.1.1 for additional detail). In fact, some water-based activities, such as swimming, may not vary in the same manner as activities that rely directly on boat ramps. It is also possible that some land-based activities could be affected by reduced water levels. For example, decreased aesthetics due to lower water levels could affect camping, picnicking, and other shoreline activities. Taken altogether, the approach is still likely to be conservative (i.e., it is more likely to overstate than understate effects of changes to water-based visitation), though the extent to which effects may be overstated, if at all, is unknown.

- While most site visitation estimates were based on monthly level data from recent years, some modeled visitation estimates were based on annual historical data. These annual data were allocated to months based on the average distribution from monthly data available for other sites at the analyzed reservoirs (described in Table 3-6 below).

This approach is reasonable for comparison across the alternatives; though there is uncertainty associated with the approach.

- To support the social welfare analysis, estimated annual recreational visits for sites across the basin are converted to estimates of annual recreational days using information available for a subset of sites (see Section 2.1.3 for additional detail). Since information was unavailable for a few sites included in the analysis, ratios were adapted from other locations. This approach is reasonable for comparison across the alternatives; it is not known if this approach would result in an overestimate or underestimate of recreation visitor days though there is uncertainty associated with the approach.

- To support the social welfare analysis, UDV estimates were obtained from the Corps Recreation Budget Evaluation System (RecBest). Since the Corps does not have UDV estimates for a few sites included in the analysis, UDV estimates were adapted from other nearby-by recreation areas (see Section 2.1.3 of this appendix for additional detail). This approach is reasonable for comparison across the alternatives; it is not known if this approach would result in an overestimate or underestimate of consumer surplus values though there is uncertainty associated with the approach.

- There is uncertainty regarding the magnitude of the consumer surplus value per day reflected in the UDV. 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. 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 UDV approach provides a consistent approach across all sites in the evaluation (Chang 2019). This approach would likely underestimate the consumer surplus value estimates.

- To support the regional economic effects analysis, a nationwide expenditure profile is applied at Corps reservoirs, along with Corps District-level data to describe trip characteristics (i.e., party size and trip length) (see Section 2.2 of this appendix for additional detail). This approach is reasonable for comparison across the alternatives; it is not known if this approach would result in an overestimate or underestimate of regional economic effects though there is uncertainty associated with the approach.
- Under MO3, there is uncertainty about the extent to which reservoir-based recreation on the lower Snake River would transition to river-based recreation over time (see Section 6.1 for additional detail). For example, 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). There is also uncertainty about how the environment might be managed to achieve 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. Finally, there is uncertainty in the information available to estimate recreational use levels that may occur in the long-term under MO3 in the lower Snake River area. As a result, the post dam breach visitation estimates in the lower Snake River in the long-term reflect a fairly large range in potential estimated use (see Table 6-4).

- During low water years under MO4, there could be major adverse impacts to recreation at local and/or private facilities on Lake Pend Oreille (see Section 7.1). While the analysis does not detect changes in boat ramp accessibility at Lake Pend Oreille using available data for Federal- and state-managed boat ramps, impacts are described qualitatively using information from local resource managers and stakeholders. Since effects could not be quantified due to gaps in the information applied for this EIS, there is uncertainty in the magnitude of the potential adverse effects.

- Potential effects to the visitation and the quality of recreation experience associated with changes in resource conditions (fish, wildlife, water quality, and others) were assessed qualitatively (and described in the CRSO EIS Section 3.11.3 and 7.5.10). These effects are based on the change in the resource condition, as described in the appropriate section of the EIS. However, there are uncertainties regarding the actual change in the resource condition and visitation would respond to or be affected by the change in the conditions. It is unknown if this approach would lead to an overestimation or underestimation of effects.

CHAPTER 3 - NO ACTION ALTERNATIVE

3.1 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED SOCIAL WELFARE EFFECTS

Under the No Action Alternative, social welfare effects are estimated for average annual recreational visitation at near-river sites across the basin, including water- and land-based use at reservoirs and river reaches. 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 and boat ramp accessibility. Using 2017-18 visitation in future years under the No Action Alternative is supported by recent visitation trends at Lake Roosevelt and communication with recreation managers.[11]

To support the analysis of the action alternatives (i.e., estimating changes in recreational visitation at reservoirs relative to the No Action Alternative due to changes in water surface elevations and boat ramp accessibility), monthly visitation in a typical water year at CRSO reservoirs in Table 2-1 is estimated and water-based visitation is identified by applying the estimated proportion of water-based activities at each reservoir (fishing, boating, and swimming).

3.1.1 Recreational Visitation

Visitation data for 2017 and 2018 is used to estimate annual visitation for the period of analysis under the No Action Alternative. Recreational visitation data for near-river sites across the basin were compiled with assistance from Federal and states agencies. Federal site managers include the Corps, the Bureau of Reclamation (Reclamation), the NPS, the Bureau of Land Management (BLM), the United States Fish and Wildlife Service (USFWS), and the United States Forest Service (USFS). State-managed facilities in Washington, Oregon, Idaho, and western Montana are operated by Washington State Parks and Recreation Commission (WSPRC) and Washington Department of Fish and Wildlife (WDFW); Oregon Parks and Recreation Department (OPRD) and Oregon Department of Fish and Wildlife (ODFW); Idaho Department of Parks and Recreation (IDPR) and Idaho Department of Fish and Game (IDFG), and Montana Fish, Wildlife, and Parks (MFWP), respectively.

Table 3-1 presents available annual visitation estimates for 2017 and 2018 and the distribution of monthly visitation for 2018. Figure 3-1 presents a map of the reservoirs/river reaches shown in Table 3-1, along with the CRSO Regions. Consistent visitation data for years prior to 2017 are not available from all Federal and state agencies. 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 around 13 million visits annually, with most visitation

[11] 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 the H&H Team and recreation managers that 2017 and 2018 represent relatively typical years in terms of water levels and recreational visitation, no adjustments were made to the average visitation numbers for future years.

occurring in summer months.[12] This estimate may underestimate river-based recreation as well as visitation at some state and local sites, as visitation sources for this analysis are most complete at Federal reservoir locations.

[12] Because regional visitation data from Federal and state agencies are more comprehensively collected for reservoirs and are limited for sections of river between reservoirs, total estimated visitation primarily reflects reservoir-based recreation.

Table 3-1. Available Recreational Visitation Data (Visits) for Columbia River Basin Reservoirs and River Reaches[1/]

CRSO Region, Reservoir/River Reach	2018 Monthly Recreational Visitation as a Percentage of Total Site Visitation[2/]												Annual Total Site Visits (Thousands of Visits)		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2017 Total	2018 Total	2017-2018 Average
Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	2%	2%	2%	4%	18%	17%	18%	16%	13%	6%	2%	1%	189	198	193
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 Lake Rufus Woods	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 Lake	2%	2%	6%	9%	12%	15%	17%	14%	12%	7%	3%	2%	322	331	327
Priest Rapids Dam and 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
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
Snake River below Hells Canyon Dam	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lower Granite Dam and 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

	2018 Monthly Recreational Visitation as a Percentage of Total Site Visitation[2/]												Annual Total Site Visits (Thousands of Visits)		
CRSO Region, Reservoir/River Reach	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**2017 Total**	**2018 Total**	**2017-2018 Average**
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	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**

Sources: MFWP 2017-2018 and email communication; NPS 2019; other visitation data provided through personal communication with BLM, Corps, USFWS, USFS, IDPR, OPRD, and WSPRC.

Notes:

ND = no data are available. Potential impacts to recreation at reservoirs/river reaches with no data are expected to be negligible (see Table 2-1).

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 are 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 are collected by partner agencies.

[1/] Totals and percentages presented in this table combine fiscal and calendar year data across agencies. Data from BLM, Corps, and USFWS reflect fiscal years while all other agencies provide data by calendar year.

[2/] Percentages are based on available monthly data from Federal and state agencies. Some agencies only report annual data.

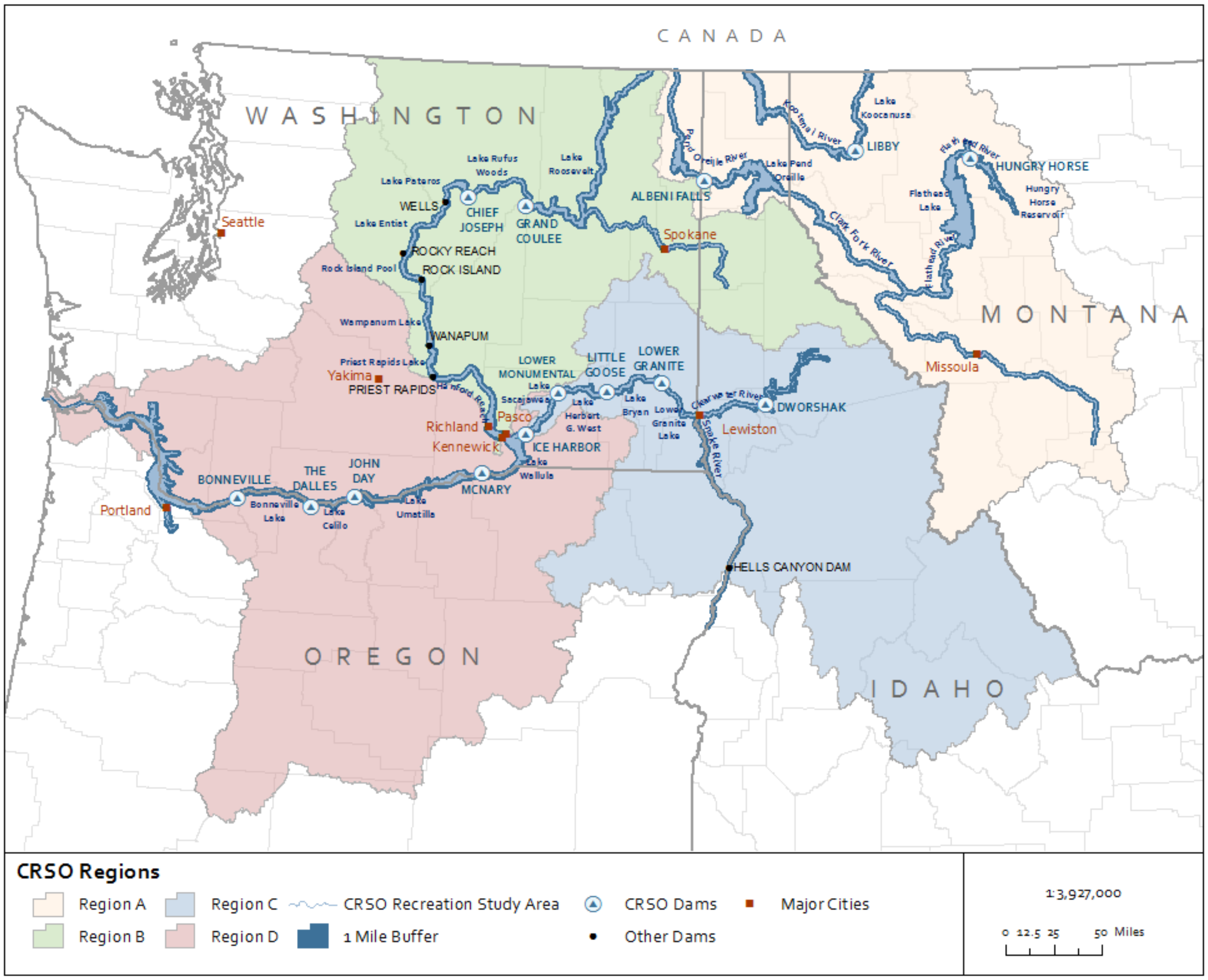

Figure 3-1. Area of Analysis for Recreation

Due to gaps in existing information, visitation estimates are not available for all sites across the basin managed by Federal and state agencies. 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 are not included in Table 3-1. It is expected that fluctuations in visitor use and activities would be mirrored at sites managed by local agencies and private land owners. Table 3-2 presents visitation estimates for the individual sites that underlie Table 3-1.

Table 3-2. Average Annual Visitation (Visits) by Site, 2017-2018

Sites	Managing Agency	2017-2018 Average
Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa		
Blackwell Flats	USACE	15,952
Dispersed Use	USACE	21,925
Downstream Area	USACE	29,268
Dunn Creek	USACE	8,748

Sites	Managing Agency	2017-2018 Average
Libby Dam Left Abutment	USACE	22,926
Libby Dam Visitor Center	USACE	16,232
Ripley	USACE	1,270
Souse Gulch	USACE	26,660
Vista Point	USACE	6,694
Kootenai NWR	USFWS	43,713
Total		**193,386**
Flathead River above Flathead Lake and Hungry Horse Dam and Reservoir		
Doris Creek Campground	USFS	2,573
Emery Bay Campground	USFS	860
Lid Creek	USFS	915
Lost Johnny Camp	USFS	510
Lost Johnny Point Campground	USFS	1,404
Murray Bay Campground	USFS	751
Riverside Campground	USFS	216
Total		**7,229**
Clark Fork River, Flathead River below Flathead Lake, and Flathead Lake		
Wayfarers	MFWP	163,673
Big Arm	MFWP	47,487
West Shore	MFWP	33,329
Yellow Bay	MFWP	24,534
Finley Point	MFWP	24,127
Wild Horse Island	MFWP	22,615
Total		**315,764**
Pend Oreille River and Lake Pend Oreille		
Albeni Cove	USACE	10,871
Albeni Falls Dam Visitor Center	USACE	12,724
Clark Fork Drift Yard	USACE	23,377
Dispersed Use	USACE	200,723
Hawkins Point	USACE	5,488
Johnson Creek	USACE	9,121
Morton Slough	USACE	17,102
Priest River	USACE	25,155
Riley Creek	USACE	49,386
Springy Point	USACE	21,048
Trestle Creek	USACE	20,767
Vista Area Lower	USACE	32,702
Vista Area Upper	USACE	46,446
Farragut	IDPR	522,540
Total		**997,447**
Grand Coulee Dam and Lake Roosevelt		
Barstow Flats	NPS	3,282
Bradbury Beach	NPS	35,846

Sites	Managing Agency	2017-2018 Average
China Bend	NPS	40,090
Cloverleaf	NPS	2,212
Colvile Flats	NPS	23,271
Crescent Bay	NPS	36,275
Daisy	NPS	19,204
Dispersed Use	NPS	2,884
Eden Harbor	NPS	11,211
Evans	NPS	31,229
Fort Spokane	NPS	98,365
Fort Spokane Swim Beach	NPS	40,627
Fort Spokane VC	NPS	8,795
French Rocks	NPS	14,512
Gifford	NPS	33,733
Haag Cove	NPS	7,094
Hanson Harbor	NPS	24,938
Hawk Creek	NPS	41,701
Hunters	NPS	96,653
Jones Bay	NPS	7,167
Kamloops Island	NPS	20,849
Keller Ferry	NPS	65,183
Kettle Falls	NPS	248,219
Kettle River	NPS	9,313
Lincoln Mill BL	NPS	42,946
Marcus Island	NPS	32,835
Napoleon	NPS	17,010
North Gorge	NPS	5,051
Porcupine Bay	NPS	9,166
Seven Bays Marina	NPS	119,118
Sherman Creek Hatchery	NPS	0
SnagCove	NPS	20,896
Spring Canyon	NPS	118,962
St Pauls Mission	NPS	1,926
Total		**1,290,563**
Chief Joseph Dam and Lake Rufus Woods		
Brandt's Landing	USACE	23,797
Bridgeport Marina Park Boat Ramp	USACE	19,389
Chief Joseph Dam Visitor Center	USACE	1,172
Commons	USACE	1,113
Debris Basin	USACE	50,203
Dispersed Use	USACE	32,149
Foster Creek	USACE	1,609
Information & Rest Area	USACE	58,024
Lower Spillway	USACE	10,929

Sites	Managing Agency	2017-2018 Average
North Shore Trail	USACE	921
North Viewpoint	USACE	14,556
Powerhouse Viewpoint	USACE	26,296
Rocky Flats	USACE	590
Spillway Viewpoint	USACE	2,786
Willow Flats	USACE	31,867
Bridgeport	WSPRC	100,578
Total		**375,975**
Wanapum Dam and Lake		
Ginkgo Petrified Forest	WSPRC	234,281
Wanapum	WSPRC	92,546
Total		**326,826**
Clearwater River and Dworshak Dam and Reservoir		
Big Eddy Marina	USACE	15,869
Big Eddy Recreation Area	USACE	59,959
Bruce's Eddy Recreation Area	USACE	25,118
Canyon Creek Recreation Area	USACE	8,291
Cold Springs Trail	USACE	335
Dam View Camping Area	USACE	20,427
Dent Acres Recreation Area	USACE	33,861
Dispersed Use	USACE	15,150
Dworshak Dam Viewpoint	USACE	8,573
Dworshak State Park- Three Meadows Group Camp	USACE	9,231
Dworshak State Park-Freeman Creek	USACE	70,331
Dworshak Visitor Center	USACE	20,427
Grandad Recreation Area	USACE	9,371
Lake-Based Recreation Facilities	USACE	29,595
Little Meadow Creek Campground	USACE	1,978
Merry's Bay Recreation Area	USACE	3,349
Powerhouse Road Fishing Access	USACE	56,827
Harpers Bend	BLM	13,336
McKays Bend Recreation Site	BLM	14,228
Pinkhouse Recreation Site	BLM	43,046
Total		**459,297**
Lower Granite Dam and Lake		
Asotin Slough	USACE	27,905
Blyton Landing	USACE	11,910
Chestnut Beach	USACE	164,597
Chief Looking Glass Park	USACE	67,713
Chief Timothy Park	USACE	77,672
Clearwater Park	USACE	20,039
Clearwater Ramp	USACE	40,594
Dispersed Use	USACE	199,700

Sites	Managing Agency	2017-2018 Average
Evans Pond	USACE	18,211
Gateway Park	USACE	5,732
Golf Course Pond	USACE	38,827
Granite Lake Park	USACE	91,409
Granite Lake RV Park	USACE	81,738
Greenbelt Ramp	USACE	65,308
Hells Canyon Resort	USACE	19,373
Hells Gate	USACE	18,747
Lewiston Levee Recreation Trail	USACE	261,646
Lower Granite Esplanade	USACE	19,448
Lower Granite North Shore Tailrace Area	USACE	5,433
Lower Granite South Shore Visitor Center	USACE	19,671
Nisqually John Landing	USACE	17,038
Offield Landing	USACE	3,859
Southway Park	USACE	8,343
Southway Ramp	USACE	83,817
Swallows Park	USACE	240,064
Wawawai County Park	USACE	14,021
Wawawai Landing	USACE	19,445
Hells Gate	IDPR	267,805
Total		**1,910,057**
Little Goose Dam and Lake Bryan		
Boyer Park And Marina	USACE	165,762
Central Ferry Park	USACE	8,888
Dispersed Use	USACE	3,050
Illia Dunes Recreation Area	USACE	14,603
Illia Landing	USACE	3,298
Lambi Creek Recreation Area	USACE	1,973
Little Goose Esplanade	USACE	29,176
Little Goose Landing	USACE	14,525
Little Goose North Shore Tailrace	USACE	4,214
Little Goose South Shore Area	USACE	3,890
Penawawa Bay Habitat Management Unit	USACE	1,825
Rice Bar Habitat Management Unit	USACE	6,042
Willow Landing	USACE	5,416
Total		**262,659**
Lower Monumental Dam and Lake Herbert G. West		
Ayer Boat Basin	USACE	8,405
Devils Bench Recreation Area	USACE	6,418
Dispersed Use	USACE	1,100
Lyons Ferry Marina	USACE	51,677
Lyons Ferry Natural Area	USACE	1,135
Riparia Park	USACE	5,421

Sites	Managing Agency	2017-2018 Average
Texas Rapids Park	USACE	13,535
Tucannon Habitat Management Unit	USACE	7,906
Lyons Ferry	WSPRC	79,350
Total		**174,945**
Ice Harbor Dam and Lake Sacajawea		
Big Flat Habitat Management Unit	USACE	7,423
Charbonneau Marina	USACE	12,934
Charbonneau Park	USACE	44,623
Dispersed Use	USACE	4,508
Fishhook Park	USACE	28,388
Hollebebek Habitat Management Unit	USACE	5,886
Ice Harbor - South Shore Recreation Area	USACE	26,043
Ice Harbor - South Shore Road Fishing Area	USACE	26,294
Ice Harbor Dam Boat Ramp	USACE	12,638
Ice Harbor Dam Visitor Center	USACE	5,834
Indian Memorial Viewing Area	USACE	1,504
Lake Emma Recreation Area	USACE	5,023
Levey Park	USACE	7,489
Matthews Boat Ramp	USACE	1,127
Snake River Junction	USACE	7,113
Walker Pit Habitat Management Unit	USACE	8,335
Windust Park	USACE	5,371
Total		**210,531**
McNary Dam and Lake Wallula		
Burbank Heights	USACE	5,732
Chiawana Park	USACE	121,455
Columbia Park	USACE	847,172
Dispersed Use	USACE	248,347
Hood Park	USACE	138,315
Howard Amon Park	USACE	202,336
Leslie Groves Park	USACE	318,175
Martindale	USACE	5,662
McNary Beach	USACE	78,035
McNary Wildlife Nature Area	USACE	178,667
McNary Yacht Club	USACE	19,383
Oregon Boat Ramp	USACE	27,244
Pacific Salmon Visitor Information Center	USACE	14,933
Pasco Boat Basin & Marina	USACE	20,890
Sand Station Recreation Area	USACE	21,434
Spillway Park	USACE	148,834
Two Rivers Park	USACE	83,522
Walla Walla Yacht Club	USACE	6,366
Warehouse Beach	USACE	24,855

Sites	Managing Agency	2017-2018 Average
Washington Boat Ramp	USACE	15,807
West Park	USACE	33,126
Wye Park	USACE	31,032
Yakima Delta	USACE	20,050
Hat Rock State Park	OPRD	291,804
Sacajawea	WSPRC	72,857
McNary NWR	USFWS	75,000
Total		**3,051,028**
John Day Dam and Lake Umatilla		
Boardman Park	USACE	85,889
Cliffs Park	USACE	17,691
Crow Butte Park	USACE	53,464
Dispersed Use	USACE	133,475
Giles French Park	USACE	44,550
Irrigon Park	USACE	57,778
Lepage Park	USACE	36,172
Paradise Park	USACE	12,207
Philippi Park	USACE	12,425
Plymouth Campground	USACE	12,646
Plymouth Day Use	USACE	50,374
Railroad Island	USACE	6,846
Rock Creek Park	USACE	7,885
Roosevelt Park	USACE	25,638
Sundale Park	USACE	7,558
Threemile Canyon Park	USACE	7,364
Umatilla Park	USACE	115,134
Total		**687,093**
The Dalles Dam and Lake Celilo		
Avery Park	USACE	36,658
Celilo Park	USACE	90,677
Dispersed Use	USACE	9,100
Heritage Landing	USACE	45,423
Hess Park	USACE	7,803
Rufus Landing	USACE	53,182
Seufert Park	USACE	68,420
Spearfish Park	USACE	16,278
The Dalles North Shore	USACE	27,639
The Dalles Visitor Center	USACE	12,932
The Wall	USACE	30,840
Columbia Hills	WSPRC	163,998
Maryhill	WSPRC	215,802
Deschutes River State Recreation Area	OPRD	297,652
Total		**1,076,402**

Sites	Managing Agency	2017-2018 Average
Bonneville Dam and Lake		
Bonneville Fish Hatchery	USACE	190,004
Bradford Island Recreation Area	USACE	35,839
Bradford Island Visitor Center	USACE	75,662
Dispersed Use	USACE	196,958
Fort Cascades National Historic Site	USACE	14,949
Hamilton Island Recreation Area	USACE	41,084
Home Valley Park	USACE	40,086
Navigation Lock Visitor Area	USACE	3,943
North Shore Recreation Area	USACE	32,633
Pacific Crest Trail Equestrian Trailhead	USACE	17,294
Robins Island Recreation Area	USACE	28,275
Tanner Creek Recreation Area	USACE	41,572
Washington Shore Visitor Center Complex	USACE	30,219
Doug's Beach	WSPRC	24,386
Spring Creek Hatchery	WSPRC	137,597
Koberg Beach State Recreation Site	OPRD	361,600
Mayer State Park	OPRD	206,145
Viento State Park	OPRD	112,873
Total		**1,591,114**
Below Bonneville Dam		
Beacon Rock	WSPRC	276,200
Total		**276,200**

Sources: MFWP 2017-2018 and email communication; NPS 2019; other visitation data provided through personal communication with BLM, Corps, USFWS, USFS, IDPR, OPRD, and WSPRC .

Notes:

This table displays available data from state and Federal agencies. Other agencies (e.g., counties, municipalities, etc.) are not included in this summary.

A significant amount of recreation occurs on managed lands and waters outside of developed recreation areas. This dispersed use includes visitors to wildlife management areas, low-density (undeveloped) recreation areas and visitors accessing the project from adjacent lands.

Some of the most commonly pursued activities in the region include fishing, sightseeing, boating, swimming, picnicking, and camping. Table 3-3 summarizes the distribution of recreation use at reservoirs/river reaches where such data are available. The most recent information is presented, which is from 2016. As discussed later in this Appendix, this information is used to identify land- and water-based visitation for this analysis.

Table 3-3. Distribution of Recreation Use by Activity for Columbia River Basin Reservoirs and River Reaches

CRSO Region, Reservoir/River Reach	Fishing	Camping	Boating	Swimming	Picnicking	Hunting	Sightseeing	Other	Water-Based Visitation[1/]
Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	26%	1%	0%	5%	19%	0%	17%	31%	31%
Flathead River above Flathead Lake and Hungry Horse Dam and Reservoir	ND	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	ND
Pend Oreille River and Lake Pend Oreille	9%	11%	6%	12%	12%	1%	14%	35%	27%
Region A Total	13%	8%	4%	10%	14%	1%	15%	34%	27%
Grand Coulee Dam and Lake Roosevelt	33%	27%	20%	7%	1%	ND	ND	12%	60%
Chief Joseph Dam and Lake Rufus Woods	34%	3%	4%	2%	7%	1%	36%	14%	40%
Wells Dam and Lake Pateros	ND	ND	ND	ND	ND	ND	ND	ND	ND
Rocky Reach Dam and Lake Entiat	ND	ND	ND	ND	ND	ND	ND	ND	ND
Rock Island Dam and Pool	ND	ND	ND	ND	ND	ND	ND	ND	ND
Wanapum Dam and Lake	ND	ND	ND	ND	ND	ND	ND	ND	ND
Priest Rapids Dam and Lake	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
Region B Total	33%	22%	17%	6%	2%	0%	7%	12%	56%
Clearwater River and Dworshak Dam and Reservoir	36%	13%	6%	5%	5%	1%	17%	17%	48%
Snake River below Hells Canyon Dam	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lower Granite Dam and Lake	13%	1%	7%	13%	9%	0%	11%	45%	32%

CRSO Region, Reservoir/River Reach	Fishing	Camping	Boating	Swimming	Picnicking	Hunting	Sightseeing	Other	Water-Based Visitation[1/]
Little Goose Dam and Lake Bryan	14%	4%	17%	15%	15%	1%	13%	20%	47%
Lower Monumental Dam and Lake Herbert G. West	19%	15%	14%	7%	10%	1%	8%	26%	40%
Ice Harbor Dam and Lake Sacajawea	27%	2%	13%	11%	14%	0%	13%	21%	50%
Region C Total	16%	3%	7%	12%	9%	1%	12%	40%	35%
McNary Dam and Lake Wallula	7%	0%	15%	4%	13%	0%	18%	43%	26%
John Day Dam and Lake Umatilla	27%	1%	21%	11%	17%	3%	10%	12%	58%
The Dalles Dam and Lake Celilo	25%	0%	14%	9%	17%	3%	15%	16%	49%
Bonneville Dam and Lake	19%	0%	2%	2%	7%	0%	52%	17%	23%
Below Bonneville Dam	ND	ND	ND	ND	ND	ND	ND	ND	ND
Region D Total	32%	20%	16%	7%	4%	0%	8%	14%	55%
Total	**23%**	**11%**	**11%**	**9%**	**7%**	**0%**	**10%**	**28%**	**43%**

Sources: Corps 2016; Le and Strawn 2017

Note: ND = no data are available. Potential impacts to recreation at reservoirs/river reaches with no data are expected to be negligible (see Table 2-1).

[1/] Water-based visitation is the sum of fishing, boating, and swimming visitation.

3.1.2 Boat Ramp Accessibility and Water-based Recreational Visitation

Four CRSO reservoirs were identified as exhibiting changes in boat ramp accessibility under one or more MOs or the PA using H&H modeling results (Table 2-1) in a typical water year: Lake Koocanusa (Libby Dam) and Hungry Horse Reservoir in Region A; Lake Roosevelt (Grand Coulee Dam) in Region B; and Dworshak Reservoir in Region C.[13] To support the analysis under the MOs and PA at these sites (i.e., estimating changes in water-based visitation at reservoirs relative to the No Action Alternative due to changes in water surface elevations and boat ramp accessibility), minimum usable boat ramp elevations were required for all boat ramps at these four reservoirs.[14]

Table 3-4 presents the boat ramps at each of these four reservoirs and their minimum usable elevations. The analysis approach assumes that changes in accessibility to ramps with minimum usable elevation data would be representative of other ramps for which elevation data are unavailable. Figure 3-2 through Figure 3-5 present the locations of these boat ramps. Table 3-4 also presents the annual elevation range across all days in a typical water year (50th Percentile) for each reservoir and the name of the H&H outputs used in the analysis for each boat ramp. The closest H&H output to each ramp was used.

Table 3-4. Minimum Usable Boat Launch Elevations for Four CRSO Reservoirs with Changes in Boat Ramp Accessibility using H&H Modeling Results

Boat Ramp	Minimum Usable Elevation (Feet)	Name of Closest H&H Output Used in Analysis
Libby Dam and Lake Koocanusa (Annual Elevation Range in a Typical Water Year: 2,384 to 2,453 feet)		
Barron Creek	2,282	Libby-Pool_Elev
Peck Gulch	2,310	Libby-Pool_Elev
Souse Gulch	2,310	Libby-Pool_Elev
Koocanusa Marina	2,334	Libby-Pool_Elev
Rexford Bench	2,341	Libby-Pool_Elev
Rocky Gorge	2,370	Libby-Pool_Elev
McGillivray	2,385	Libby-Pool_Elev
McGillivray 2	2,385	Libby-Pool_Elev
Tobacco Plains	2,433	Libby-Pool_Elev
Abayance Bay Marina	ND	N/A
Gateway Boat Camp	ND	N/A
Little North Fork Falls	ND	N/A
Tobacco River	ND	N/A
Hungry Horse Dam and Reservoir (Annual Elevation Range in a Typical Water Year: 3,519 to 3,560 feet)		
Abbot Bay Boating Site (Lion Hill Gorge)	3,430	Hungry Horse-Pool_Elev

[13] As described in Table 2-1, the lower Snake River Reservoirs and Lake Wallula were analyzed separately using information related to the lower Snake River dam breaches under MO3. Potential effects at Lake Pend Oreille would occur in low water years only. Analysis for these sites are discussed in subsequent sections.

[14] Minimum usable boat ramp elevations are not presented for other sites in the basin where the analysis did not detect changes in boat ramp accessibility using existing information.

Boat Ramp	Minimum Usable Elevation (Feet)	Name of Closest H&H Output Used in Analysis
Lost Johnny Point Campground	3,488	Hungry Horse-Pool_Elev
Riverside Boat	3,507	Hungry Horse-Pool_Elev
Devil's Corkscrew Campground	3,517	Hungry Horse-Pool_Elev
Emery Bay Campground	3,527	Hungry Horse-Pool_Elev
Lid Creek Campground	3,529	Hungry Horse-Pool_Elev
Crossover Boat	3,539	Hungry Horse-Pool_Elev
Murray Bay Campground	3,540	Hungry Horse-Pool_Elev
Canyon Creek Boating Site	3,542	Hungry Horse-Pool_Elev
Doris Point Boating Site	3,545	Hungry Horse-Pool_Elev
Goose Head	ND	N/A
Graves Creek	ND	N/A
Painted Turtle	ND	N/A
Grand Coulee Dam and Lake Roosevelt (Annual Elevation Range in a Typical Water Year: 1245 to 1,290 feet)		
Spring Canyon	1,222	Grand Coulee-Pool_Elev
Seven Bays	1,227	Columbia River Reach 21_River Mile_616.006_Stage
Keller Ferry	1,229	Columbia River Reach 21_River Mile_616.006_Stage
Hunters Camp	1,232	Columbia River Reach 21_River Mile_680.054_Stage
Kettle Falls	1,234	Columbia River Reach 21_River Mile_720.431_Stage
Porcupine Bay	1,243	Columbia River Reach 21_River Mile_616.006_Stage
Lincoln Mill	1,245	Columbia River Reach 21_River Mile_616.006_Stage
Fort Spokane	1,247	Columbia River Reach 21_River Mile_616.006_Stage
Gifford	1,249	Columbia River Reach 21_River Mile_680.054_Stage
Bradbury Beach	1,251	Columbia River Reach 21_River Mile_680.054_Stage
Hansen Harbor	1,253	Columbia River Reach 21_River Mile_616.006_Stage
Crescent Bay	1,265	Grand Coulee-Pool_Elev
Daisy	1,265	Columbia River Reach 21_River Mile_680.054_Stage
French Rocks	1,265	Columbia River Reach 21_River Mile_680.054_Stage
Jones Bay	1,268	Columbia River Reach 21_River Mile_616.006_Stage
China Bend	1,277	Columbia River Reach 21_River Mile_720.431_Stage

Boat Ramp	Minimum Usable Elevation (Feet)	Name of Closest H&H Output Used in Analysis
Snag Cove	1,277	Columbia River Reach 21_River Mile_720.431_Stage
Evans	1,280	Columbia River Reach 21_River Mile_720.431_Stage
Napoleon Bridge	1,280	Columbia River Reach 21_River Mile_720.431_Stage
North Gorge	1,280	Columbia River Reach 21_River Mile_720.431_Stage
Hawk Creek	1,281	Columbia River Reach 21_River Mile_616.006_Stage
Marcus Island	1,281	Columbia River Reach 21_River Mile_720.431_Stage
Northport Public Boat Ramp	ND	N/A
Dworshak Dam and Reservoir (Annual Elevation Range in a Typical Water Year: 1,517 to 1,600 feet)		
Big Eddy Recreation Area	1,445	Dworshak-Pool_Elev
Dent Acres Recreation Area	1,485	Dworshak-Pool_Elev
Bruce's Eddy Recreation Area	1,490	Dworshak-Pool_Elev
Dworshak State Park-Freeman Creek	1,515	Dworshak-Pool_Elev
Grandad Recreation Area	1,530	Dworshak-Pool_Elev
Bruce's Eddy #2	1,560	Dworshak-Pool_Elev
Canyon Creek Recreation Area	1,560	Dworshak-Pool_Elev
Dent Bridge	ND	N/A
Little North Fork	ND	N/A

Sources: NPS N.d.; LibbyMT.com 2012; Pence 2019; Crandall 2019.
Notes: ND = no data are available. N/A = not applicable.

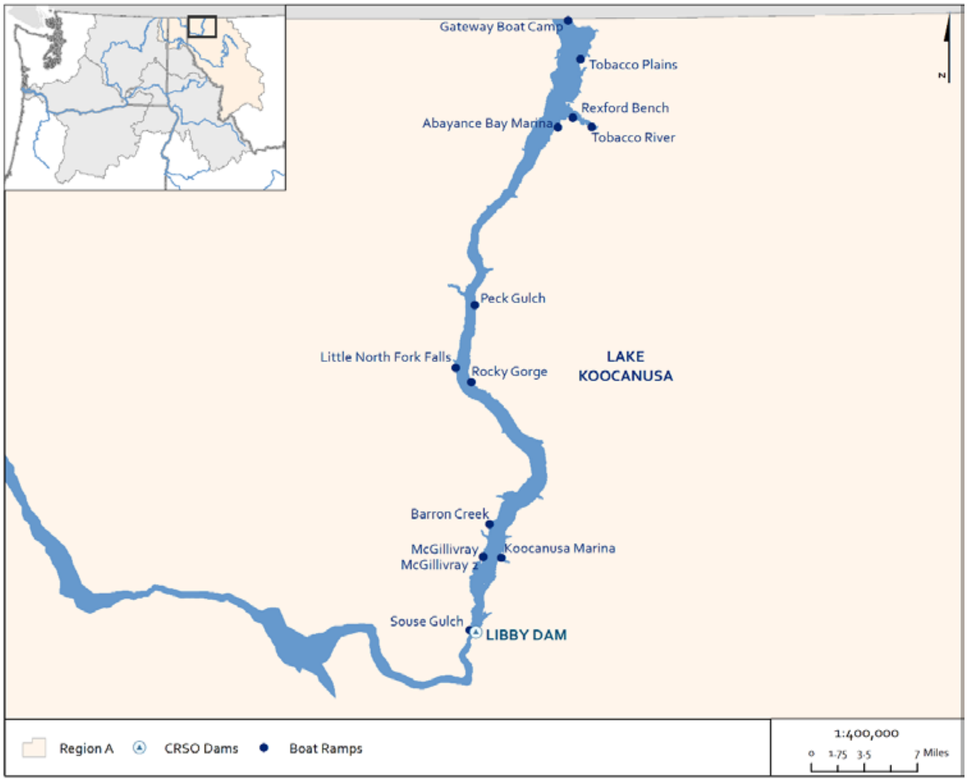

Figure 3-2. Lake Koocanusa Boat Ramps

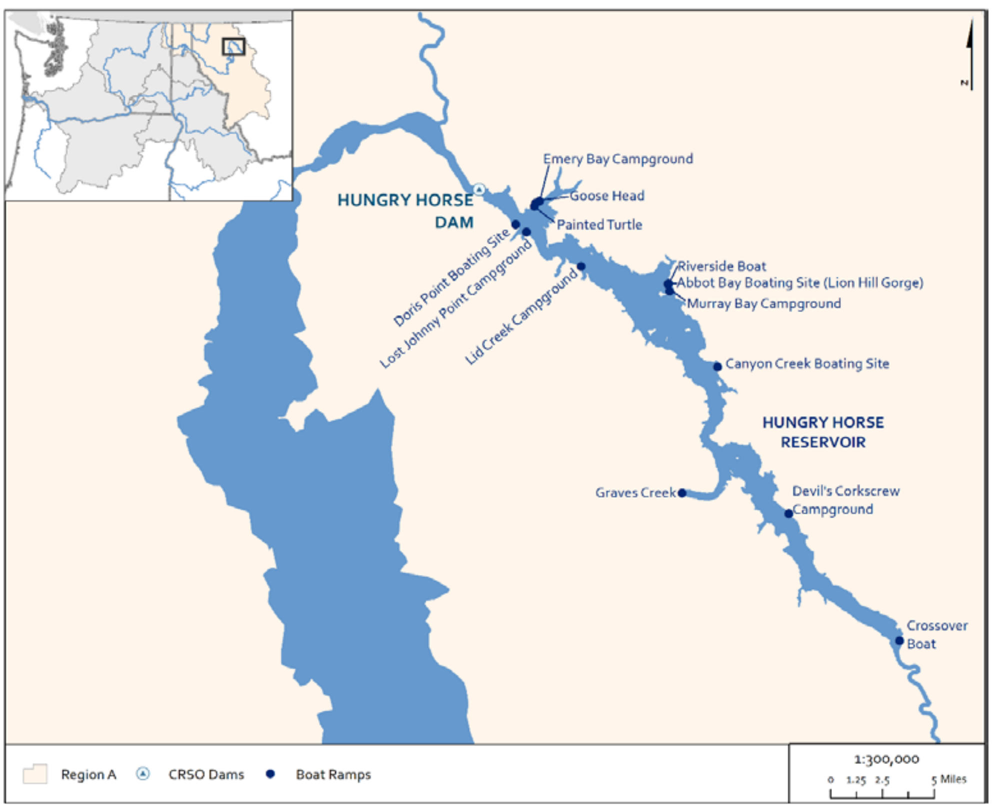

Figure 3-3. Hungry Horse Reservoir Boat Ramps

Figure 3-4. Lake Roosevelt Boat Ramps

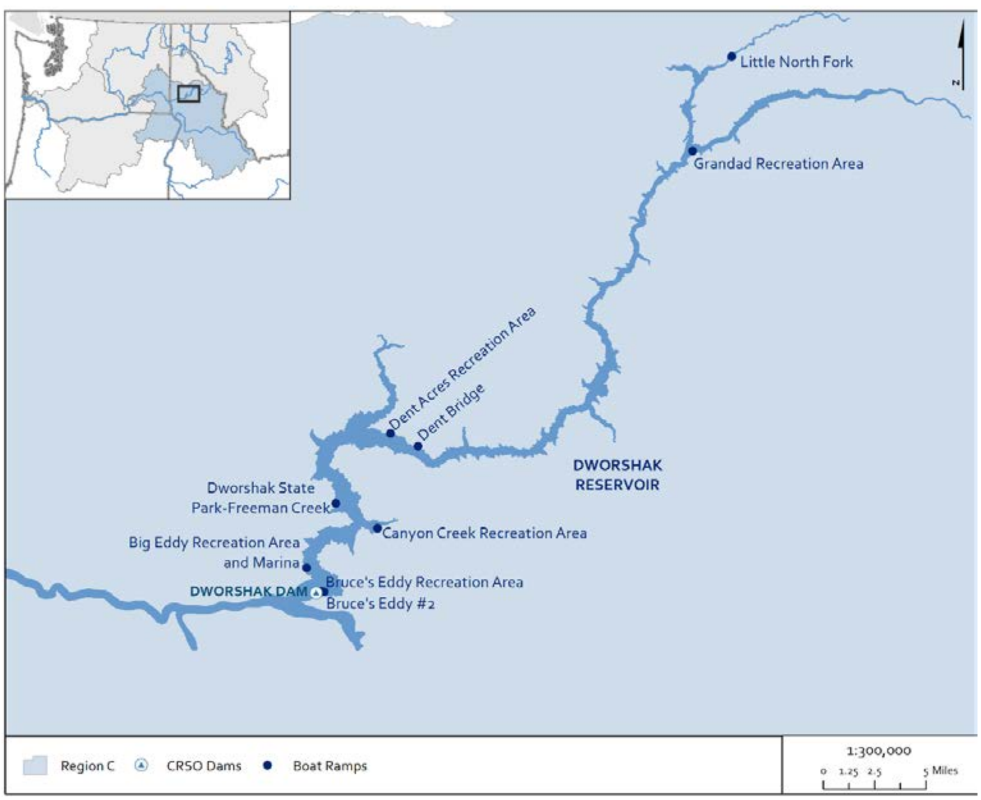

Figure 3-5. Dworshak Reservoir Boat Ramps

Water-based visitation, including fishing, boating, and swimming, is supported by the accessibility of the ramps shown above.[15] As described in Step 1 in Section 2.1.1, the minimum usable boat ramp elevations are compared with modeled H&H water surface elevations to evaluate boat ramp accessibility by day under the No Action Alternative. 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. The results of these calculations are presented in Table 3-5 for the No Action Alternative in the typical water year.

Table 3-5. No Action Alternative Boat Ramp Accessibility in a Typical Water Year (50th Percentile), by Month

	Libby Dam and Lake Koocanusa		Hungry Horse Dam and Reservoir		Grand Coulee Dam and Lake Roosevelt		Dworshak Dam and Reservoir	
Month	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible
Jan	248	89%	213	69%	682	100%	124	57%
Feb	224	89%	166	59%	508	82%	112	57%
Mar	248	89%	127	41%	350	51%	124	57%
Apr	206	76%	120	40%	272	41%	120	57%
May	248	89%	151	49%	285	42%	173	80%
Jun	247	91%	287	96%	526	80%	210	100%
Jul	279	100%	310	100%	682	100%	217	100%
Aug	279	100%	310	100%	638	94%	177	82%
Sep	270	100%	300	100%	615	93%	124	59%
Oct	279	100%	310	100%	642	94%	124	57%
Nov	270	100%	294	98%	660	100%	120	57%
Dec	251	90%	276	89%	682	100%	124	57%

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps. For example, two ramps with 100 percent accessibility in a 30-day month results in 60 accessible days.

For the recreation analysis, the results in Table 3-5 are assumed to represent boat ramp accessibility in a typical water year under the No Action Alternative. Estimates of corresponding monthly water-based visitation are developed using reported reservoir visitation data from 2017-2018 (Table 3-1) and applying the estimated proportion of water-based activities at each reservoir (the summation of fishing, boating, and swimming percentages in Table 3-3).[16] Table 3-6 presents average monthly water-based visitation for each reservoir.

[15] As described in Section 2.1.1, the analysis approach uses boat ramp accessibility as a proxy for water-based recreation activity on the reservoirs. However, 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).

[16] This approach is taken because visitation estimates and minimum usable boat ramp elevations are not comprehensively available for individual boat ramps across the basin.

Table 3-6. No Action Alternative Water-Based Visitation (Visits) in a Typical Water Year (50th Percentile), by Month

Month	Average Visitation 2017-2018	Percentage of Visitation that is Water Based	Estimated Total Water-Based Visitation (Visits)
Libby Dam and Lake Koocanusa			
Jan	1,409	31%	439
Feb	1,436	31%	447
Mar	1,805	31%	562
Apr	6,104	31%	1,900
May	19,766	31%	6,154
Jun	21,667	31%	6,746
Jul	30,117	31%	9,377
Aug	27,001	31%	8,407
Sep	20,349	31%	6,336
Oct	9,857	31%	3,069
Nov	8,007	31%	2,493
Dec	2,154	31%	671
Total	**149,673**	**31%**	**46,603**
Hungry Horse Dam and Reservoir			
Jan	0	31%	0
Feb	0	31%	0
Mar	0	31%	0
Apr	0	31%	0
May	435	31%	135
Jun	1,267	31%	394
Jul	3,703	31%	1,153
Aug	1,453	31%	452
Sep	371	31%	115
Oct	0	31%	0
Nov	0	31%	0
Dec	0	31%	0
Total	**7,229**	**31%**	**2,251**
Grand Coulee Dam and Lake Roosevelt			
Jan	40,390	60%	24,234
Feb	49,842	60%	29,905
Mar	65,191	60%	39,114
Apr	69,337	60%	41,602
May	105,161	60%	63,096
Jun	185,902	60%	111,541
Jul	319,751	60%	191,850
Aug	224,477	60%	134,686
Sep	114,846	60%	68,908
Oct	54,226	60%	32,535
Nov	31,269	60%	18,761

Month	Average Visitation 2017-2018	Percentage of Visitation that is Water Based	Estimated Total Water-Based Visitation (Visits)
Dec	30,174	60%	18,104
Total	**1,290,563**	**60%**	**774,338**
Dworshak Dam and Reservoir			
Jan	8,511	48%	4,058
Feb	13,214	48%	6,299
Mar	24,456	48%	11,659
Apr	40,229	48%	19,178
May	39,598	48%	18,877
Jun	58,992	48%	28,123
Jul	70,845	48%	33,774
Aug	48,303	48%	23,027
Sep	33,916	48%	16,169
Oct	21,837	48%	10,410
Nov	17,132	48%	8,167
Dec	11,596	48%	5,528
Total	**388,628**	**48%**	**185,269**

Note: This table includes the following sites from Table 3-2 that are on the reservoirs:
Lake Koocanusa: Blackwell Flats, Downstream Area, Dunn Creek, Libby Dam Left Abutment, Libby Dam Visitor Center, Ripley, Souse Gulch, Vista Point, and Dispersed Use;
Hungry Horse: all sites;
Lake Roosevelt: all sites; and
Dworshak: Big Eddy Marina, Big Eddy Recreation Area, Bruce's Eddy Recreation Area, Canyon Creek Recreation Area, Cold Springs Trail, Dam View Camping Area, Dent Acres Recreation Area, Dworshak Dam Viewpoint, Dworshak State Park- Three Meadows Group Camp, Dworshak State Park-Freeman Creek, Dworshak Visitor Center, Grandad Recreation Area, Lake-Based Recreation Facilities, Little Meadow Creek Campground, Merry's Bay Recreation Area, Powerhouse Road Fishing Access, and Dispersed Use.
At some recreation sites on these reservoirs, visitation data are only available at the annual level (rather than monthly). These annual data are allocated to months using the average distribution from monthly data available for other sites at the reservoirs.
Because the proportion of water-based activities is not available for Hungry Horse Reservoir, the proportion for Lake Koocanusa is applied, the closest site with this information.

Changes in boat ramp accessibility and water-based visitation were also evaluated in high and low water years under the No Action Alternative. As noted in section 2 of this appendix, analysts evaluated whether site access would be affected in any of the 25th, 50th, or 75th percentile water years. Four reservoir sites would experience water surface elevation changes of one foot or more in any of these water years, resulting in a change in boat ramp accessibility. Potential changes in recreational visitation resulting from smaller changes in water surface elevations were not evaluated because the effects, if any, are expected to be sufficiently small to not impede access. Table 3-7 and Table 3-8 present the number of accessible days across boat ramps by month for the low and high water years for the four affected reservoirs. [17]

[17] It should be noted that that the supplemental analysis under MO3 and MO4, for the lower Snake River and Pend Oreille, respectively, are presented in Sections 6 and 7 or this appendix.

Table 3-7. No Action Alternative Boat Ramp Accessibility in High Water Years (25th Percentile), by Month

Month	Libby Dam and Lake Koocanusa		Hungry Horse Dam and Reservoir		Grand Coulee Dam and Lake Roosevelt		Dworshak Dam and Reservoir	
	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible
Jan	248	89%	289	93%	682	100%	155	71%
Feb	224	89%	183	65%	616	100%	140	71%
Mar	248	89%	186	60%	655	96%	155	71%
Apr	240	89%	180	60%	403	61%	150	71%
May	248	89%	220	71%	386	57%	211	97%
Jun	259	96%	300	100%	601	91%	210	100%
Jul	279	100%	310	100%	682	100%	217	100%
Aug	279	100%	310	100%	663	97%	179	82%
Sep	270	100%	300	100%	635	96%	124	59%
Oct	279	100%	310	100%	642	94%	124	57%
Nov	270	100%	300	100%	660	100%	120	57%
Dec	254	91%	310	100%	682	100%	153	71%

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.

Table 3-8. No Action Alternative Boat Ramp Accessibility in Low Water Years (75th Percentile), by Month

Month	Libby Dam and Lake Koocanusa		Hungry Horse Dam and Reservoir		Grand Coulee Dam and Lake Roosevelt		Dworshak Dam and Reservoir	
	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible
Jan	248	89%	186	60%	682	100%	124	57%
Feb	156	62%	126	45%	449	73%	94	48%
Mar	129	46%	104	34%	340	50%	56	26%
Apr	90	33%	66	22%	184	28%	30	14%
May	151	54%	86	28%	181	27%	118	54%
Jun	230	85%	242	81%	480	73%	210	100%
Jul	277	99%	310	100%	682	100%	217	100%
Aug	279	100%	310	100%	618	91%	177	82%
Sep	270	100%	300	100%	591	90%	124	59%
Oct	279	100%	310	100%	642	94%	124	57%
Nov	270	100%	262	87%	660	100%	120	57%

Month	Libby Dam and Lake Koocanusa		Hungry Horse Dam and Reservoir		Grand Coulee Dam and Lake Roosevelt		Dworshak Dam and Reservoir	
	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible	NAA Accessible Days	Percent of Days that are Accessible
Dec	251	90%	204	66%	682	100%	124	57%

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.

Table 3-9 presents average monthly water-based visitation for each reservoir in high and low water years. Because consistent visitation data are not available for years prior to 2017, recent historical data are not available for high and low water years. Therefore, the estimates in Table 3-9 were constructed based on percentage changes in accessibility relative to a typical water year (50th percentile). Referring to Figure 3-1, more days of boat accessibility are supported during high water years (25th percentile), fewer are supported in typical water years (50th percentile), and the least are supported in low water years (75th percentile). Consistent with the basis for the analysis across alternatives (i.e., changes in boat ramp accessibility under an MO or the PA relative to the No Action Alternative lead to changes in water-based visitation), water-based visitation in the 25th and 75th percentiles under the No Action Alternative is estimated based on proportional differences in accessibility with the 50th percentile.

For example, the number of accessible days across ramps in June during a typical water year at Lake Roosevelt is 526 days (Table 3-5). There are 601 accessible days (14.3 percent more than a typical water year) during a high water year (Table 3-7) and 480 accessible days (8.7 percent less than a typical water year) during a low water year (Table 3-8). These percentage changes are applied to the estimated water-based visitation in June during a typical water year at Lake Roosevelt (111,541) to estimate water-based visitation during high and low water years for the same month (127,445 and 101,787, respectively). This approach is applied to all months across reservoirs to develop monthly water-based visitation estimates for high- and low water years under the No Action Alternative.

Table 3-9. No Action Alternative Water-Based Visitation (Visits) in High- (25th Percentile) and Low- (75th Percentile) Water-Level Years, by Month

Month	Estimated Total Water-Based Visitation (Visits)	
	High-water Year	Low-water Year
Libby Dam and Lake Koocanusa		
Jan	439	439
Feb	447	311
Mar	562	292
Apr	2,214	830
May	6,154	3,747
Jun	7,074	6,282

Month	Estimated Total Water-Based Visitation (Visits)	
	High-water Year	**Low-water Year**
Jul	9,377	9,310
Aug	8,407	8,407
Sep	6,336	6,336
Oct	3,069	3,069
Nov	2,493	2,493
Dec	679	671
Total	**47,252**	**42,188**
Hungry Horse Dam and Reservoir		
Jan	0	0
Feb	0	0
Mar	0	0
Apr	0	0
May	197	77
Jun	412	333
Jul	1,153	1,153
Aug	452	452
Sep	115	115
Oct	0	0
Nov	0	0
Dec	0	0
Total	**2,330**	**2,131**
Grand Coulee Dam and Lake Roosevelt		
Jan	24,234	24,234
Feb	36,263	26,432
Mar	73,200	37,997
Apr	61,638	28,142
May	85,457	40,072
Jun	127,445	101,787
Jul	191,850	191,850
Aug	139,964	130,464
Sep	71,148	66,219
Oct	32,535	32,535
Nov	18,761	18,761
Dec	18,104	18,104
Total	**880,600**	**716,597**
Dworshak Dam and Reservoir		
Jan	5,072	4,058
Feb	7,874	5,287
Mar	14,573	5,265
Apr	23,973	4,795
May	23,024	12,876
Jun	28,123	28,123

Month	Estimated Total Water-Based Visitation (Visits)	
	High-water Year	**Low-water Year**
Jul	33,774	33,774
Aug	23,288	23,027
Sep	16,169	16,169
Oct	10,410	10,410
Nov	8,167	8,167
Dec	6,821	5,528
Total	**201,267**	**157,478**

Note: This table includes the following sites from Table 3-2 that are on the reservoirs:
Lake Koocanusa: Blackwell Flats, Downstream Area, Dunn Creek, Libby Dam Left Abutment, Libby Dam Visitor Center, Ripley, Souse Gulch, Vista Point, and Dispersed Use;
Hungry Horse: all sites;
Lake Roosevelt: all sites; and
Dworshak: Big Eddy Marina, Big Eddy Recreation Area, Bruce's Eddy Recreation Area, Canyon Creek Recreation Area, Cold Springs Trail, Dam View Camping Area, Dent Acres Recreation Area, Dworshak Dam Viewpoint, Dworshak State Park- Three Meadows Group Camp, Dworshak State Park-Freeman Creek, Dworshak Visitor Center, Grandad Recreation Area, Lake-Based Recreation Facilities, Little Meadow Creek Campground, Merry's Bay Recreation Area, Powerhouse Road Fishing Access, and Dispersed Use.

3.1.3 Recreational Visitor Days and Consumer Surplus Values

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 around 13 million visits annually (Table 3-1) in a typical water year under the No Action Alternative. Accounting for overnight visitation yields an estimated 14.9 million recreational days.
As described above, this conversion of visits to recreation days is calculated using a ratio of recreation days to visits available for a limited number of sites to each area. The unit day values described in Section 2.1.3 are applied to these recreation days to estimate the social welfare effects. Recreational visitation is anticipated to support over $129 million in annual consumer surplus value (social welfare), primarily at CRS reservoirs. Table 3-10 presents the social welfare effects of these recreational days by reservoir/river reach, CRSO region, and in total.

Table 3-10. Summary of Average Annual Social Welfare Effects of Recreation under the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Recreational Visitor Days (Thousands)	Social Welfare Effects (Consumer Surplus)
Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	203	$1,947,000
Flathead River above Flathead Lake and Hungry Horse Dam and Reservoir	8	$73,000
Clark Fork River, Flathead River below Flathead Lake, and Flathead Lake	332	$3,181,000
Pend Oreille River and Lake Pend Oreille	1,086	$9,462,000
Region A Total	**1,629**	**$14,664,000**
Grand Coulee Dam and Lake Roosevelt	2,145	$18,852,000

CRSO Region, Reservoir/River Reach	Recreational Visitor Days (Thousands)	Social Welfare Effects (Consumer Surplus)
Chief Joseph Dam and Lake Rufus Woods	376	$2,901,000
Wells Dam and Lake Pateros	ND	ND
Rocky Reach Dam and Lake Entiat	ND	ND
Rock Island Dam and Pool	ND	ND
Wanapum Dam and Lake	339	$2,834,000
Priest Rapids Dam and Lake	ND	ND
Region B Total	**2,860**	**$24,588,000**
Clearwater River and Dworshak Dam and Reservoir	524	$5,023,000
Snake River below Hells Canyon Dam	ND	ND
Lower Granite Dam and Lake	1,939	$17,128,000
Little Goose Dam and Lake Bryan	280	$2,493,000
Lower Monumental Dam and Lake Herbert G. West	217	$2,078,000
Ice Harbor Dam and Lake Sacajawea	252	$2,120,000
Region C Total	**3,213**	**$28,843,000**
The Hanford Reach below Priest Rapids Dam	ND	ND
McNary Dam and Lake Wallula	3,164	$26,461,000
John Day Dam and Lake Umatilla	855	$7,058,000
The Dalles Dam and Lake Celilo	1,283	$11,129,000
Bonneville Dam and Lake	1,591	$14,117,000
Below Bonneville Dam	276	$2,450,000
Region D Total	**7,169**	**$61,215,000**
Total	**14,871**	**$129,310,000**

Notes: **1) THE SOCIAL WELFARE ANALYSIS IS CONDUCTED 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. SECOND, UDVS ARE APPLIED TO THE ESTIMATED RECREATIONAL VISITOR DAYS. 2) THERE IS NO VISITATION DATA FOR SITES MARKED AS ND. AS SUCH, CONSUMER SURPLUS VALUES MAY BE UNDERESTIMATED AT THESE SITES. HOWEVER, VISITATION AT RECREATION AT RESERVOIRS/RIVER REACHES WITH NO DATA ARE EXPECTED TO BE RELATIVELY LOW (SEE TABLE** 2-1**).**

3.2 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED REGIONAL ECONOMIC EFFECTS

Assuming that each visitor spends an average amount on recreation per day, non-local visitation at sites within 1 mile of the mainstem rivers, including water- and land-based use at reservoirs and river reaches, is anticipated to support $499 million in visitor expenditures annually in a typical water year under the No Action Alternative. Table 3-11 presents these expenditures by reservoir/river reach, CRSO region, and in total, as well as the percentage of expenditures associated with local and non-local visitors. Regional economic effects associated with non-local visitor expenditures would support approximately 6,480 annual jobs, $265 million in labor income, and $843 million in sales across the recreation study area annually under the No Action Alternative. Table 3-12 presents these regional economic effects by CRS region and in total. Regional effects associated with local, non-local, and total visitation are presented for completeness, but the focus of the regional economic effects evaluation was on non-local visitors since changes in their expenditures would result in impacts to the regional economy.

Table 3-11. Summary of Average Annual Visitor Expenditures under the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Local Visitor Expenditures	Non-Local Visitor Expenditures	Total Expenditures	Percentage Non-Local[1/]
Kootenai River between the US-Canada border and Libby Dam and Lake Koocanusa	$361,000	$8,589,000	$8,950,000	96%
Flathead River above Flathead Lake and Hungry Horse Dam and Reservoir	$14,000	$321,000	$335,000	96%
Clark Fork River, Flathead River below Flathead Lake, and Flathead Lake	$590,000	$14,034,000	$14,624,000	96%
Pend Oreille River and Lake Pend Oreille	$1,864,000	$44,299,000	$46,163,000	96%
Region A Total (weighted average)	$2,829,000	$67,243,000	$70,072,000	**96%**
Grand Coulee Dam and Lake Roosevelt	$6,265,000	$50,010,000	$56,275,000	89%
Chief Joseph Dam and Lake Rufus Woods	$2,379,000	$14,546,000	$16,925,000	86%
Wells Dam and Lake Pateros	ND	ND	ND	ND
Rocky Reach Dam and Lake Entiat	ND	ND	ND	ND
Rock Island Dam and Pool	ND	ND	ND	ND
Wanapum Dam and Lake	$3,031,000	$12,218,000	$15,249,000	80%
Priest Rapids Dam and Lake	ND	ND	ND	ND
The Hanford Reach below Priest Rapids Dam	ND	ND	ND	ND
Region B Total (weighted average)	$11,603,000	$76,846,000	$88,449,000	**87%**
Clearwater River and Dworshak Dam and Reservoir	$815,000	$21,100,000	$21,915,000	96%
Snake River below Hells Canyon Dam	ND	ND	ND	ND
Lower Granite Dam and Lake	$12,428,000	$73,543,000	$85,972,000	86%
Little Goose Dam and Lake Bryan	$301,000	$11,959,000	$12,260,000	98%
Lower Monumental Dam and Lake Herbert G. West	$188,000	$8,079,000	$8,267,000	98%
Ice Harbor Dam and Lake Sacajawea	$266,000	$9,483,000	$9,749,000	97%
Region C Total (weighted average)	$14,166,000	$123,997,000	$138,162,000	**90%**
McNary Dam and Lake Wallula	$28,298,000	$114,055,000	$142,353,000	80%
John Day Dam and Lake Umatilla	$8,201,000	$22,044,000	$30,246,000	73%

CRSO Region, Reservoir/River Reach	Local Visitor Expenditures	Non-Local Visitor Expenditures	Total Expenditures	Percentage Non-Local[1/]
The Dalles Dam and Lake Celilo	$12,848,000	$34,535,000	$47,383,000	73%
Bonneville Dam and Lake	$17,542,000	$51,823,000	$69,365,000	75%
Below Bonneville Dam	$3,045,000	$8,996,000	$12,041,000	75%
Region D Total (weighted average)	$70,226,000	$231,162,000	$301,388,000	**77%**
Total (weighted average)	**$99,126,000**	**$498,945,000**	**$598,071,000**	**83%**

Notes: There is no visitation data for sites marked as ND (Table 3-1 above). As such the contribution of visitor expenditures to the regional economy is likely underestimated for these sites. However, visitation at recreation at reservoirs/river reaches with no data are expected to be relatively low (see Table 2-1).

[1/] Information for Lake Koocanusa is applied to all reservoirs and river reaches in Region A, information for Lake Umatilla is applied to the reach containing Lake Celilo; and information for Lake Bonneville is applied to the stretch below Bonneville Dam.

Table 3-12. Summary of Average Annual Regional Economic Effects of Recreation under the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Local/Non-Local	Local/Non-Local Visitation (Thousands)	Jobs	Labor Income	Sales
Region A				
Local	61	36	$1,242,000	$3,720,000
Non-Local	1,453	858	$29,530,000	$88,423,000
Total	**1,514**	**894**	**$30,772,000**	**$92,143,000**
Region B				
Local	261	127	$3,896,000	$13,323,000
Non-Local	1,732	843	$25,803,000	$88,240,000
Total	**1,993**	**970**	**$29,699,000**	**$101,563,000**
Region C				
Local	309	170	$5,385,000	$20,163,000
Non-Local	2,708	1,488	$47,136,000	$176,495,000
Total	**3,017**	**1,658**	**$52,521,000**	**$196,658,000**
Region D				
Local	1,557	882	$38,437,000	$119,690,000
Non-Local	5,125	2,905	$126,522,000	$393,982,000
Total	**6,682**	**3,787**	**$164,959,000**	**$513,672,000**
Total				
Local	2,189	1,287	$52,637,000	$167,481,000
Non-Local	11,018	6,477	$264,945,000	$843,004,000
Total	**13,207**	**7,763**	**$317,582,000**	**$1,010,485,000**

Notes: The multiplier effect is larger for the entire Basin, so total regional economic effects are greater than the summation of effects across CRSO regions. There is no visitation data for sites marked as ND. As such the contribution of visitor expenditures to the regional economy is likely underestimated for these sites. However, visitation at recreation at reservoirs/river reaches with no data are expected to be relatively low (see Table 2-1).

3.3 SUMMARY OF EFFECTS

Consistent with the summary in Section 3.11 of the EIS, Table 3-13 summarizes the estimated social welfare effects, regional economic effects, and social welfare effects associated with recreational visitation under the No Action Alternative. A more detailed discussion of qualitative effects (e.g., other social effects and fishing conditions) that are described in the table are provided in section 3.11 of the EIS, Recreation.

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.[18] This recreational visitation is anticipated to support over $129 million in annual consumer surplus value (social welfare), primarily at CRS reservoirs.[19]

Visitor expenditures by non-local visitors are anticipated to be $499 million across the study area 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 support 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.

The No Action Alterative would continue to affect anadromous fish migration and survival in Region C, including the existence of project structures and dam passage modifications. These measures would have both adverse and beneficial effects on fish, and indirectly on angling, and would not change under the No Action Alternative.

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. Fishing closures and bag limits would continue to occur under the No Action Alternative, with adverse effects to rural river and tribal communities that rely on angler visitation to support their economies and communities.

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[18] 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.

[19] More information about boat ramp accessibility under the No Action Alternative, including boat ramp accessibility by month is provided in Appendix M.

Table 3-13. Summary of Average Annual Effects of Recreation Under the No Action Alternative (2019 Dollars)

<table>
<tr><th>Region</th><th>Social Welfare Effects</th><th>Regional Economic Effects</th><th>Other Social Effects</th></tr>
<tr><td>Region A</td><td>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.
Current conditions for fish, wildlife, and water quality would continue to support recreational experiences in the river and reservoirs.</td><td>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.</td><td rowspan="4">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. Fishing conditions and closures under the No Action Alternative would continue, with adverse effects to rural river and Tribal communities.</td></tr>
<tr><td>Region B</td><td>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 support annual welfare benefits of $25 million.</td><td>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.</td></tr>
<tr><td>Region C</td><td>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 $29 million. Anglers would continue to visit Region C, and fishing closures and bag limits would have adverse effects on social welfare.</td><td>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 related to recreation in areas within 1 mile of mainstem rivers (primarily reservoir recreation). Regional economic effects associated water-based recreation and angling would continue under the No Action Alternative. Fishing closures would reduce the regional economic effects associated with angler opportunities.</td></tr>
<tr><td>Region D</td><td>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 $61 million.</td><td>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.</td></tr>
</table>

Region	Social Welfare Effects	Regional Economic Effects	Other Social Effects
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 $129 million. Anglers would continue to visit Region C, and fishing closures and bag limits would have adverse effects on social welfare.	Non-local visitor expenditures of approximately $499 million annually would support for 6,480 jobs, $265 million in income, and $843 million in regional sales annually (primarily reservoir recreation). Fishing closures and limitations would continue to occur under the No Action Alternative, with adverse effects to jobs and income in rural river and tribal communities.	

CHAPTER 4 - MULTIPLE OBJECTIVE ALTERNATIVE 1

Anticipated changes in water surface elevations under MO1 would affect boat ramp accessibility and water-based visitation relative to the No Action Alternative at Lake Koocanusa (Libby Dam) and Hungry Horse Reservoir in Region A, Lake Roosevelt in Region B, and Dworshak Reservoir in Region C. Changes in water surface elevations at other reservoirs in the basin would not affect accessibility or visitation. Over time, visitors may adjust their behavior to adapt to changes in accessibility, such as utilizing different sites on the system, which could reduce the adverse effects to visitation described in this section. As discussed in Section 2.1.1, in this appendix the assumptions utilized in this analysis are conservative (i.e., they are more likely to overstate than understate effects of changes to water-based visitation), but the methodology is a reasonable approach given existing information.

4.1 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED SOCIAL WELFARE EFFECTS

The tables below present the changes in water-based visitation and social welfare effects under MO1 relative to the No Action Alternative. As discussed above, this appendix focuses on providing additional details to support the quantitative analysis that is described in Chapter 3. Additional qualitative analysis is not repeated in this Appendix; please refer to Section 3.11 of the EIS for a complete description of the effects of MO1 on recreation.

Table 4-1 presents the percentage change in the number of accessible days across boat ramps by month for the four reservoirs affected under MO1 relative to the No Action Alternative in a typical water year, as well as the associated change in water-based visitation. Table 4-2 and Table 4-3 present these results using the 25th percentile H&H results (high water year) and 75th percentile results (low water year). Table 4-4 presents the annual changes in recreation days and associated social welfare effects in a typical water year by reservoir, CRSO region, and in total. Note, the accessibility differences under high and low water years are similar to a typical water year (50th percentile), therefore just the social welfare effects in a typical water year are presented.

Table 4-1. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under MO1 Relative to the No Action Alternative in a Typical Water Year (50th Percentile), by Month

Month	NAA Accessible Days	MO1 Accessible Days	Percentage Change in Accessible Days	Estimated Change in Water-Based Visitation (Visits)[1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	224	224	0%	0
Mar	248	236	-5%	(27)
Apr	206	180	-13%	(240)
May	248	248	0%	0
Jun	247	248	0%	27
Jul	279	279	0%	0
Aug	279	279	0%	0

Month	NAA Accessible Days	MO1 Accessible Days	Percentage Change in Accessible Days	Estimated Change in Water-Based Visitation (Visits)1/
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	270	0%	0
Dec	251	253	1%	5
Total	**3,049**	**3,014**	**-1%**	**(234)**
Hungry Horse Dam and Reservoir				
Jan	213	186	-13%	0
Feb	166	129	-22%	0
Mar	127	113	-11%	0
Apr	120	90	-25%	0
May	151	137	-9%	(13)
Jun	287	277	-3%	(14)
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	282	-9%	0
Nov	294	209	-29%	0
Dec	276	186	-33%	0
Total	**2,864**	**2,529**	**-12%**	**(26)**
Grand Coulee Dam and Lake Roosevelt				
Jan	682	668	-2%	(497)
Feb	508	445	-12%	(3,709)
Mar	350	350	0%	0
Apr	272	269	-1%	(459)
May	285	284	0%	(221)
Jun	526	527	0%	212
Jul	682	682	0%	0
Aug	638	633	-1%	(1,056)
Sep	615	612	0%	(336)
Oct	642	642	0%	0
Nov	660	660	0%	0
Dec	682	682	0%	0
Total	**6,542**	**6,454**	**-1%**	**(6,066)**
Dworshak Dam and Reservoir				
Jan	124	124	0%	0
Feb	112	112	0%	0
Mar	124	124	0%	0
Apr	120	120	0%	0
May	173	173	0%	0
Jun	210	210	0%	0
Jul	217	217	0%	0
Aug	177	157	-11%	(2,602)

Month	NAA Accessible Days	MO1 Accessible Days	Percentage Change in Accessible Days	Estimated Change in Water-Based Visitation (Visits)[1/]
Sep	124	135	9%	1,434
Oct	124	124	0%	0
Nov	120	120	0%	0
Dec	124	124	0%	0
Total	**1,749**	**1,740**	**-1%**	**(1,168)**
Basin-Wide Total	**14,204**	**13,737**	**-3%**	**(7,494)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.
[1/] Change in water-based visitation is calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-5.

Table 4-2. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under MO1 Relative to the No Action Alternative in a High-water Year (25th Percentile), by Month

Month	NAA Accessible Days	MO1 Accessible Days	Percentage Change in Accessible Days	Estimated Change in Water-Based Visitation (Visits) [1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	224	224	0%	0
Mar	248	248	0%	0
Apr	240	240	0%	0
May	248	248	0%	0
Jun	259	262	1%	82
Jul	279	279	0%	0
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	270	0%	0
Dec	254	253	0%	(3)
Total	**3,098**	**3,100**	**0%**	**79**
Hungry Horse Dam and Reservoir				
Jan	289	247	-15%	0
Feb	183	168	-8%	0
Mar	186	160	-14%	0
Apr	180	120	-33%	0
May	220	199	-10%	(19)
Jun	300	300	0%	0
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	294	-5%	0
Nov	300	270	-10%	0

Month	NAA Accessible Days	MO1 Accessible Days	Percentage Change in Accessible Days	Estimated Change in Water-Based Visitation (Visits) 1/
Dec	310	279	-10%	0
Total	**3,198**	**2,957**	**-8%**	**(19)**
Grand Coulee Dam and Lake Roosevelt				
Jan	682	682	0%	0
Feb	616	521	-15%	(5,592)
Mar	655	507	-23%	(16,540)
Apr	403	381	-5%	(3,365)
May	386	388	1%	443
Jun	601	601	0%	0
Jul	682	682	0%	0
Aug	663	658	-1%	(1,056)
Sep	635	632	0%	(336)
Oct	642	642	0%	0
Nov	660	660	0%	0
Dec	682	682	0%	0
Total	**7,307**	**7,036**	**-4%**	**(26,446)**
Dworshak Dam and Reservoir				
Jan	155	155	0%	0
Feb	140	140	0%	0
Mar	155	155	0%	0
Apr	150	150	0%	0
May	211	211	0%	0
Jun	210	210	0%	0
Jul	217	217	0%	0
Aug	179	177	-1%	(260)
Sep	124	135	9%	1,434
Oct	124	124	0%	0
Nov	120	120	0%	0
Dec	153	153	0%	0
Total	**1,938**	**1,947**	**0%**	**1,174**
Basin-Wide Total	**15,541**	**15,040**	**-3%**	**(25,211)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.

1/ Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-7.

Table 4-3. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under MO1 Relative to the No Action Alternative in a Low-water Year (75th Percentile), by Month

Month	NAA Accessible Days	MO1 Accessible Days	Percentage Change in Accessible Days	Estimated Change in Water-Based Visitation (Visits) [1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	156	171	10%	30
Mar	129	145	12%	36
Apr	90	99	10%	83
May	151	152	1%	25
Jun	230	230	0%	0
Jul	277	278	0%	34
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	270	0%	0
Dec	251	252	0%	3
Total	**2,630**	**2,673**	**2%**	**210**
Hungry Horse Dam and Reservoir				
Jan	186	124	-33%	0
Feb	126	103	-18%	0
Mar	104	81	-22%	0
Apr	66	60	-9%	0
May	86	83	-3%	(3)
Jun	242	234	-3%	(11)
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	190	-39%	0
Nov	262	180	-31%	0
Dec	204	160	-22%	0
Total	**2,506**	**2,135**	**-15%**	**(14)**
Grand Coulee Dam and Lake Roosevelt				
Jan	682	559	-18%	(4,371)
Feb	449	415	-8%	(2,002)
Mar	340	336	-1%	(447)
Apr	184	177	-4%	(1,071)
May	181	175	-3%	(1,328)
Jun	480	480	0%	0
Jul	682	682	0%	0
Aug	618	610	-1%	(1,689)
Sep	591	591	0%	0
Oct	642	642	0%	0

Month	NAA Accessible Days	MO1 Accessible Days	Percentage Change in Accessible Days	Estimated Change in Water-Based Visitation (Visits) [1/]
Nov	660	660	0%	0
Dec	682	682	0%	0
Total	**6,191**	**6,009**	**-3%**	**(10,907)**
Dworshak Dam and Reservoir				
Jan	124	124	0%	0
Feb	94	94	0%	0
Mar	56	56	0%	0
Apr	30	30	0%	0
May	118	118	0%	0
Jun	210	210	0%	0
Jul	217	213	-2%	(623)
Aug	177	155	-12%	(2,862)
Sep	124	135	9%	1,434
Oct	124	124	0%	0
Nov	120	120	0%	0
Dec	124	124	0%	0
Total	**1,518**	**1,503**	**-1%**	**(2,050)**
Basin-Wide Total	**12,845**	**12,320**	**-4%**	**(12,761)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.

[1/] Change in water-based visitation is calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-8.

Table 4-4. Changes in Annual Social Welfare Effects of Water-Based Recreation under MO1 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Changes in Recreational Visitor Days	Social Welfare Effects (Consumer Surplus)
Region A Total (Lake Koocanusa and Hungry Horse Reservoir)	**(274)**	**($3,000)**
Lake Koocanusa	(246)	($2,000)
Hungry Horse Reservoir	(28)	($0)
Region B Total (Lake Roosevelt)	**(10,081)**	**($89,000)**
Region C Total (Dworshak Reservoir)	**(1,333)**	**($13,000)**
Region D Total	**0**	**$0**
Total	**(11,688)**	**($104,000)**

Notes: The social welfare analysis is conducted 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. Second, UDVs are applied to the estimated recreational visitor days. Impacts are estimated based on changes in water surface elevations at reservoirs. Changes in water surface elevations at other reservoirs in the basin not shown would not affect accessibility or visitation.

4.2 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED REGIONAL ECONOMIC EFFECTS

The tables below present the regional economic effects under MO1 relative to the No Action Alternative. Table 4-5 presents the average annual changes in visitor expenditures associated with effects to water-based recreation in a typical water year by reservoir, CRSO region, and in total, as well as the percentage of expenditures associated with non-local visitors. Table 4-6 presents the regional economic effects associated with these changes in expenditures by CRSO region and in total. Regional effects associated with local, non-local, and total visitation are presented for completeness, but the focus of the regional economic effects evaluation was on non-local visitors since changes in their expenditures would result in impacts to the regional economy.

Table 4-5. Changes in Visitor Expenditures under MO1 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Local Visitor Expenditures	Non-Local Visitor Expenditures	Total Expenditures	Percentage Non-Local
Region A Total (Lake Koocanusa and Hungry Horse Reservoir)	**($0)**	**($12,000)**	**($12,000)**	**96%**
Lake Koocanusa	($0)	($10,000)	($11,000)	96%
Hungry Horse Reservoir	($0)	($1,000)	($1,000)	96%
Region B Total (Lake Roosevelt)	**($29,000)**	**($235,000)**	**($265,000)**	**89%**
Region C Total (Dworshak Reservoir)	**($2,000)**	**($54,000)**	**($56,000)**	**96%**
Region D Total	**$0**	**$0**	**$0**	**77%**
Total (weighted average)	**($32,000)**	**($300,000)**	**($332,000)**	**90%**

Notes: Impacts are estimated based on changes in water surface elevations at reservoirs. Changes in water surface elevations at other reservoirs in the basin would not affect accessibility or visitation. Table does not reflect effects that are described qualitatively and may underestimate effects at some sites.

Table 4-6. Changes in Regional Economic Effects of Recreation under MO1 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Local/Non-Local	Local/Non-Local Visitation	Jobs	Labor Income	Sales
Region A				
Local	(11)	(0)	($0)	($0)
Non-Local	(250)	(0)	($5,000)	($15,000)
Total	**(261)**	**(0)**	**($5,000)**	**($16,000)**
Region B				
Local	(675)	(0)	($9,000)	($30,000)
Non-Local	(5,391)	(3)	($76,000)	($236,000)
Total	**(6,066)**	**(3)**	**($85,000)**	**($266,000)**
Region C				
Local	(43)	(0)	($1,000)	($3,000)
Non-Local	(1,124)	(1)	($21,000)	($76,000)
Total	**(1,168)**	**(1)**	**($21,000)**	**($79,000)**

CRSO Region, Local/Non-Local	Local/Non-Local Visitation	Jobs	Labor Income	Sales
Region D				
Local	0	0	$0	$0
Non-Local	0	0	$0	$0
Total	**0**	**0**	**$0**	**$0**
Total				
Local	(729)	(0)	($15,000)	($44,000)
Non-Local	(6,765)	(4)	($139,000)	($404,000)
Total	**(7,494)**	**(4)**	**($154,000)**	**($447,000)**

Notes: Regional economic effects of visitor expenditures are included for each study region, but some "leakage" effects occur in other areas from each region. As such, the total regional economic effects are larger for the total basin than the sum of the individual regions. Also, the table does not reflect effects that are described qualitatively, and may underestimate effects at some sites.

4.3 SUMMARY OF EFFECTS

Consistent with the summary in Section 3.11 of the EIS, Recreation, Table 4-7 summarizes social welfare effects, regional economic effects, and social welfare effects associated with changes in recreation conditions under MO1. Detailed discussion of qualitative effects (e.g., quality of the recreational experience, fishing conditions, other social effects) described in the table are provided in Section 3.11, of the EIS, Recreation.

Overall effects of MO1 on water-based recreational visitation are anticipated to be negligible to minor. There could be adverse impacts to angler opportunities at Hungry Horse, Lake Roosevelt, and in the Clearwater River below Dworshak Dam in August and September, with the potential for reduced angler spending and regional economic benefits in adjacent communities.

Across the basin, total recreational visitation and associated social welfare effects are anticipated to decrease by less than 1 percent annually (approximately 7,500 water-based visits and $104,000 in consumer surplus value) 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.

Table 4-7. 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 water 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 $3,000 in a typical water year. Adverse effects to anglers at Hungry Horse Reservoir could occur.	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. The regional economic effects of this change in expenditures would be negligible. Regional economic benefits could be reduced at Hungry Horse from changes in angler spending associated with impacts to some resident fish.	Negligible change from No Action in recreationist well-being due to potential reduction in visitor days and potential minor decreases in fishing.
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 water 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 $89,000 in a typical water year. Adverse effects to anglers at Lake Roosevelt could occur.	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. The regional economic effects of this change in expenditures would be negligible. Regional economic benefits could be reduced at Lake Roosevelt from changes in angler spending associated with impacts to some resident fish.	Negligible to minor decrease in recreationist well-being when compared No Action due to potential reduction in visitor days and potential minor decreases in fishing and 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 water 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 water 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. The regional economic effects of this change in expenditures would be negligible. Regional economic benefits could be reduced from changes in angler spending associated with impacts to angling on the Clearwater River.	Negligible change from No Action, with a localized exception along the Clearwater River in Region C where recreational anglers may be unable to fish due to increased turbidity.

Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
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 No Action.
Total	Negligible effects to reservoir visitation (7,500 fewer visits, representing approximately 0.1 percent of total visitation compared to the No Action Alternative) in a typical water year, with decreases in social welfare of approximately $104,000 annually associated with changes in boat ramp access. 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 adverse effects to recreational fishing at Hungry Horse, Lake Roosevelt, and along the Clearwater River.	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 water 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). Regional economic benefits could be reduced from changes in angler spending in some locations.	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 in water-based recreation from NAA in most locations. Adverse effects to fish under MO1 may have adverse social effects on anglers and communities that rely on angler activity.

CHAPTER 5 - MULTIPLE OBJECTIVE ALTERNATIVE 2

Anticipated changes in water surface elevations under MO2 would affect boat ramp accessibility and water-based visitation relative to the No Action Alternative at Lake Koocanusa (Libby Dam) and Hungry Horse Reservoir in Region A, Lake Roosevelt in Region B, and Dworshak Reservoir in Region C. Changes in water levels at other reservoirs in the basin would not affect accessibility or visitation. Over time, visitors may adjust their behavior to adapt to changes in accessibility, such as utilizing different sites on the system, which could reduce effects to visitation. As discussed in Section 2.1.1, the assumptions utilized in this analysis are conservative (i.e., they are more likely to overstate than understate effects of changes to water-based visitation), but the methodology is a reasonable approach given existing information.

5.1 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED SOCIAL WELFARE EFFECTS

The tables below present the changes in water-based visitation and social welfare effects under MO2 relative to the No Action Alternative. As discussed above, this appendix focuses on providing additional details to support the quantitative analysis that is described in Chapter 3. Additional qualitative analysis is not repeated in this appendix.

Table 5-1 presents the percentage change in the number of accessible days across boat ramps by month for the four reservoirs affected under MO2 relative to the No Action Alternative in a typical water year, as well as the associated change in water-based visitation. Table 5-2 and Table 5-3 present these results using the 25th percentile H&H results (high water year) and 75th percentile results (low water year). Table 5-4 presents the average annual changes in recreation days and associated social welfare effects in a typical water year by reservoir, CRSO region, and in total. Note, the accessibility differences under high and low water years are similar to a typical water year (50th percentile), therefore just the social welfare effects in a typical water year are presented.

Table 5-1. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under MO2 Relative to the No Action Alternative in a Typical Water Year (50th Percentile), by Month

Month	NAA Accessible Days	MO2 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	224	224	0%	0
Mar	248	238	-4%	(23)
Apr	206	184	-11%	(203)
May	248	248	0%	0
Jun	247	246	0%	(27)
Jul	279	279	0%	0
Aug	279	279	0%	0
Sep	270	270	0%	0

Month	NAA Accessible Days	MO2 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Oct	279	279	0%	0
Nov	270	264	-2%	(55)
Dec	251	248	-1%	(8)
Total	**3,049**	**3,007**	**-1%**	**(316)**
Hungry Horse Dam and Reservoir				
Jan	213	195	-8%	0
Feb	166	114	-31%	0
Mar	127	108	-15%	0
Apr	120	90	-25%	0
May	151	143	-5%	(7)
Jun	287	277	-3%	(14)
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	310	0%	0
Nov	294	298	1%	0
Dec	276	278	1%	0
Total	**2,864**	**2,733**	**-5%**	**(21)**
Grand Coulee Dam and Lake Roosevelt				
Jan	682	658	-4%	(853)
Feb	508	438	-14%	(4,121)
Mar	350	350	0%	0
Apr	272	266	-2%	(918)
May	285	286	0%	221
Jun	526	529	1%	636
Jul	682	682	0%	0
Aug	638	633	-1%	(1,056)
Sep	615	601	-2%	(1,569)
Oct	642	642	0%	0
Nov	660	660	0%	0
Dec	682	682	0%	0
Total	**6,542**	**6,427**	**-2%**	**(7,658)**
Dworshak Dam and Reservoir				
Jan	124	113	-9%	(360)
Feb	112	84	-25%	(1,575)
Mar	124	91	-27%	(3,103)
Apr	120	90	-25%	(4,795)
May	173	156	-10%	(1,855)
Jun	210	210	0%	0
Jul	217	217	0%	0
Aug	177	175	-1%	(260)
Sep	124	124	0%	0

Month	NAA Accessible Days	MO2 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) 1/
Oct	124	124	0%	0
Nov	120	120	0%	0
Dec	124	124	0%	0
Total	**1,749**	**1,628**	**-7%**	**(11,947)**
Basin-Wide Total	**14,204**	**13,795**	**-3%**	**(19,942)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.

1/ Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-5.

Table 5-2. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under MO2 Relative to the No Action Alternative in a High Water Year (25th Percentile), by Month

Month	NAA Accessible Days	MO2 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) 1/
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	224	224	0%	0
Mar	248	248	0%	0
Apr	240	240	0%	0
May	248	248	0%	0
Jun	259	255	-2%	(109)
Jul	279	279	0%	0
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	265	-2%	(46)
Dec	254	248	-2%	(16)
Total	**3,098**	**3,083**	**0%**	**(171)**
Hungry Horse Dam and Reservoir				
Jan	289	233	-19%	0
Feb	183	156	-15%	0
Mar	186	124	-33%	0
Apr	180	120	-33%	0
May	220	194	-12%	(23)
Jun	300	297	-1%	(4)
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	310	0%	0
Nov	300	300	0%	0
Dec	310	310	0%	0
Total	**3,198**	**2,964**	**-7%**	**(27)**

Month	NAA Accessible Days	MO2 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Grand Coulee Dam and Lake Roosevelt				
Jan	682	682	0%	0
Feb	616	560	-9%	(3,297)
Mar	655	524	-20%	(14,640)
Apr	403	404	0%	153
May	386	403	4%	3,764
Jun	601	610	1%	1,908
Jul	682	682	0%	0
Aug	663	658	-1%	(1,056)
Sep	635	630	-1%	(560)
Oct	642	642	0%	0
Nov	660	660	0%	0
Dec	682	682	0%	0
Total	**7,307**	**7,137**	**-2%**	**(13,727)**
Dworshak Dam and Reservoir				
Jan	155	140	-10%	(491)
Feb	140	112	-20%	(1,575)
Mar	155	124	-20%	(2,915)
Apr	150	141	-6%	(1,438)
May	211	195	-8%	(1,746)
Jun	210	210	0%	0
Jul	217	217	0%	0
Aug	179	177	-1%	(260)
Sep	124	124	0%	0
Oct	124	124	0%	0
Nov	120	120	0%	0
Dec	153	153	0%	0
Total	**1,938**	**1,837**	**-5%**	**(8,425)**
Basin-Wide Total	**15,541**	**15,021**	**-3%**	**(22,351)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.

[1/] Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-7.

Table 5-3. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under MO2 Relative to the No Action Alternative in a Low Water Year (75th Percentile), by Month

Month	NAA Accessible Days	MO2 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	156	161	3%	10
Mar	129	147	14%	41

Month	NAA Accessible Days	MO2 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) 1/
Apr	90	105	17%	138
May	151	154	2%	74
Jun	230	230	0%	0
Jul	277	277	0%	0
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	263	-3%	(65)
Dec	251	248	-1%	(8)
Total	**2,630**	**2,661**	**1%**	**191**
Hungry Horse Dam and Reservoir				
Jan	186	166	-11%	0
Feb	126	100	-21%	0
Mar	104	75	-28%	0
Apr	66	60	-9%	0
May	86	81	-6%	(4)
Jun	242	229	-5%	(18)
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	310	0%	0
Nov	262	265	1%	0
Dec	204	209	2%	0
Total	**2,506**	**2,415**	**-4%**	**(22)**
Grand Coulee Dam and Lake Roosevelt				
Jan	682	550	-19%	(4,690)
Feb	449	390	-13%	(3,473)
Mar	340	326	-4%	(1,565)
Apr	184	176	-4%	(1,224)
May	181	178	-2%	(664)
Jun	480	484	1%	848
Jul	682	682	0%	0
Aug	618	604	-2%	(2,955)
Sep	591	513	-13%	(8,740)
Oct	642	606	-6%	(1,824)
Nov	660	660	0%	0
Dec	682	682	0%	0
Total	**6,191**	**5,851**	**-5%**	**(24,287)**
Dworshak Dam and Reservoir				
Jan	124	99	-20%	(818)
Feb	94	36	-62%	(3,262)
Mar	56	31	-45%	(2,351)

Month	NAA Accessible Days	MO2 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Apr	30	30	0%	0
May	118	93	-21%	(2,728)
Jun	210	200	-5%	(1,339)
Jul	217	217	0%	0
Aug	177	173	-2%	(520)
Sep	124	124	0%	0
Oct	124	124	0%	0
Nov	120	120	0%	0
Dec	124	124	0%	0
Total	**1,518**	**1,371**	**-10%**	**(11,018)**
Basin-Wide Total	**12,845**	**12,298**	**-4%**	**(35,137)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.
[1/] Change in water-based visitation is calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-8.

Table 5-4. Changes in Average Annual Social Welfare Effects of Recreation under MO2 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Changes in Recreational Days	Social Welfare Effects (Consumer Surplus)
Region A Total (Lake Koocanusa and Hungry Horse Reservoir)	**(354)**	**($3,000)**
Lake Koocanusa	(332)	($3,000)
Hungry Horse Reservoir	(22)	($0)
Region B Total (Lake Roosevelt)	**(12,727)**	**($112,000)**
Region C Total (Dworshak Reservoir)	**(13,635)**	**($131,000)**
Region D Total	**0**	**$0**
Total	**(26,717)**	**($246,000)**

Notes: The social welfare analysis is conducted 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. Second, UDVs are applied to the estimated recreational visitor days. Impacts are estimated based on changes in water surface elevations at reservoirs. Changes in water surface elevations at other reservoirs in the basin not shown would not affect accessibility or visitation.

5.2 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED REGIONAL ECONOMIC EFFECTS

The tables below present the regional economic effects under MO2 relative to the No Action Alternative. Table 5-5 presents the average annual changes in expenditures associated with water-based recreation in a typical water year by reservoir, CRSO region, and in total, as well as the percentage of expenditures associated with non-local visitors. Table 5-6 presents the regional economic effects associated with these changes in expenditures by CRSO region and in total. Regional effects associated with local, non-local, and total visitation are presented for completeness, but the focus of the regional economic effects evaluation was on non-local visitors since changes in their expenditures would result in impacts to the regional economy.

Table 5-5. Changes in Visitor Expenditures under MO2 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Local Visitor Expenditures	Non-Local Visitor Expenditures	Total Expenditures	Percentage Non-Local
Region A Total (Lake Koocanusa and Hungry Horse Reservoir)	**($1,000)**	**($15,000)**	**($16,000)**	**96%**
Lake Koocanusa	($1,000)	($14,000)	($15,000)	96%
Hungry Horse Reservoir	($0)	($1000)	($1,000)	96%
Region B Total (Lake Roosevelt)	**($37,000)**	**($297,000)**	**($334,000)**	**89%**
Region C Total (Dworshak Reservoir)	**($21,000)**	**($549,000)**	**($570,000)**	**96%**
Region D Total	**$0**	**$0**	**$0**	**77%**
Total (weighted average)	**($59,000)**	**($861,000)**	**($920,000)**	**93%**

Notes: Impacts are estimated based on changes in water surface elevations at reservoirs. Changes in water surface elevations at other reservoirs in the basin would not affect accessibility or visitation. Table does not reflect effects that are described qualitatively, and may underestimate effects at some sites.

Table 5-6. Changes in Regional Economic Effects of Recreation under MO2 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Local/Non-Local	Local/Non-Local Visitation	Jobs	Labor Income	Sales
Region A				
Local	(14)	(0)	$0	($1,000)
Non-Local	(324)	(0)	($7,000)	($20,000)
Total	**(337)**	**(0)**	($7,000)	($21,000)
Region B				
Local	(853)	(0)	($12,000)	($37,000)
Non-Local	(6,805)	(3)	($95,000)	($298,000)
Total	**(7,658)**	**(4)**	($107,000)	($336,000)
Region C				
Local	(444)	(0)	($8,000)	($30,000)
Non-Local	(11,503)	(7)	($210,000)	($782,000)
Total	**(11,947)**	**(7)**	($218,000)	($813,000)
Region D				
Local	0	0	$0	$0
Non-Local	0	0	$0	$0
Total	**0**	**0**	$0	$0
Total				
Local	(1,310)	(1)	($31,000)	($94,000)
Non-Local	(18,632)	(11)	($434,000)	($1,336,000)
Total	**(19,942)**	**(12)**	($465,000)	($1,430,000)

Notes: Regional economic effects of recreational expenditures are included for each study region, but some "leakage" effects occur in other areas from each region. As such, the total regional economic effects are larger for the total basin than the sum of the individual regions. Also, the table does not reflect effects that are described qualitatively, and may underestimate effects at some sites.

5.3 SUMMARY OF EFFECTS

Consistent with the summary in Section 3.11 of the EIS, Recreation, Table 5-7 summarizes social welfare effects, regional economic effects, and social welfare effects associated with changes in recreation conditions under MO2. Detailed discussion of qualitative effects described in the table (e.g., quality of the recreational experience, fishing conditions, other social effects) are provided in Section 3.11, of the EIS, Recreation.

Across the basin, total water-based visitation and associated social welfare effects are anticipated to decrease by less than 1 percent (0.2 percent) annually in a typical water year (approximately 20,000 visits and $246,000 in consumer surplus value) associated with changes in boat ram access under MO2. Non-local visitor expenditures 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, decreased reservoir elevations, and higher reservoir releases would result in adverse effects to resident fish and habitat in Regions A and B. In addition, the potential for decreases in fish abundance for several anadromous fish species could occur under MO2 in Regions B, C, and D. These adverse effects to fish in reservoirs and rivers could result in adverse impacts to angler opportunities and visitation, with the potential for decreased regional economic impacts (jobs and income) in adjacent communities compared to the No Action Alternative. 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.

Table 5-7. 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 water 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 $3,000 in a typical water year. Resident fish species may be adversely impacted from higher winter flows anticipated under MO2. There would be minor adverse effects to waterbird populations, with the potential to affect the quality of the recreational experience.	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) (associated with boat-ramp access). The regional economic effects of this change in expenditures would be negligible. If anglers reduce trips to this region due to declines in fishing conditions and experiences, adverse impacts to regional economic conditions could occur.	Minor decrease in water-based recreation visitor days causing slight reduction in well-being of reservoir recreationist. Potential adverse impacts to fish species could decrease recreational fishing opportunity and reduce well-being of recreationists who value fishing, as well as.
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 water 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 $112,000 in a typical water year. Decreases in fish abundance for several anadromous fish species and adverse impacts to resident fish in Lake Roosevelt could adversely affect recreational fishing experiences and angler visitation.	Expenditures associated with non-local recreational visits would decrease by $297,000 across the region (0.4 percent changes from the No Action Alternative) (reservoir recreation). The regional economic effects of this change in expenditures would be minor. If anglers reduce trips to this region due to declines in fishing conditions and experiences, adverse impacts to regional economic conditions could occur.	Decreased water-based recreation access at Lake Roosevelt 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.

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 water 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 No Action water years. Annual social welfare benefits would decrease by approximately $131,000 in a typical water year. The potential for decreases in fish abundance for several anadromous fish species could adversely affect angler opportunities and visitation in Region C. Minor additional adverse effects to quality of hunting, wildlife viewing, swimming, and water sports associated with changes in 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 anglers reduce trips to this region due to declines in fishing conditions and experiences, adverse impacts to regional economic conditions could occur..	Decreased water-based recreational access at Doworshak Reservoir could have adverse effects on recreationists. Potential adverse impacts to fish species could decrease recreational fishing opportunity and reduce well-being of recreationists who value fishing, as well as tribes. Similarly adverse effects to hunting, wildlife viewing, swimming, and related activities would reduce the well-being of recreationists who value these activities, as well as tribes.
Region D	No changes in reservoir visitation would occur associated with changes to boat ramp access. The potential for decreases in fish abundance for several anadromous fish species could adversely affect angler opportunities and visitation in Region D. Negligible to minor adverse effects to quality of 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 anglers reduce trips to this region due to declines in fishing conditions and experiences, adverse impacts to regional economic conditions 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 associated with boat ramp access (20,000 fewer visits, representing approximately 0.2 percent of total visitation) in a typical water year, with consumer surplus value losses of approximately $246,000 annually. The potential for decreases in fish abundance for several anadromous and resident fish species could adversely affect angler opportunities and visitation in all regions. Minor adverse effects to quality of 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 water year associated with boat ramp access. Regional economic effects of this change in expenditures are likely to be minor (11 fewer jobs, and $434,000 less in labor income, and approximately $1.3 million less in sales). If anglers reduce trips to this region due to declines in fishing conditions and experiences, adverse impacts to regional economic conditions could occur.	Although changes in access to recreation sites would be minor under MO2, adverse effects to fish species may have adverse effects on angler opportunities under this alternative, which, in turn, could have adverse effects on the well-being of those recreationists who value these fish, communities who rely on angler spending, and area tribes.

CHAPTER 6 - MULTIPLE OBJECTIVE ALTERNATIVE 3

Anticipated changes in water surface elevations under MO3 would affect boat ramp accessibility and water-based visitation relative to the No Action Alternative at Lake Koocanusa (Libby Dam) and Hungry Horse Reservoir in Region A. The breaching of the four lower Snake River projects would have major adverse effects on current recreation in the short term at the four lower Snake River projects in Region C and Lake Wallula in Region D. 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. Changes in water levels at other reservoirs in the basin would not affect accessibility or visitation.

6.1 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED SOCIAL WELFARE EFFECTS

The sections below present the changes in visitation and social welfare effects by region under MO3 relative to the No Action Alternative. As discussed above, this appendix focuses on providing additional details to support the quantitative analysis on water-based visitation that is described in Chapter 3. In addition, the lower Snake River recreational evaluation under MO3 is also provided in this section.

Table 6-1 presents the percentage change in the number of accessible days across boat ramps by month for the two reservoirs in Region A affected under MO3 relative to the No Action Alternative in a typical water year, as well as the associated change in water-based visitation. Table 6-2 and Table 6-3 present these results using the 25th percentile H&H results (high water year) and 75th percentile results (low water year). The social welfare effects associated with these changes in water-based visitation are presented in Table 6-5 along with effects in other regions. Note, the accessibility differences under high and low water years are similar to a typical water year (50th percentile), therefore just the social welfare effects in a typical water year are presented.

Table 6-1. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under MO3 Relative to the No Action Alternative in a Typical Water Year (50th Percentile), by Month

Month	NAA Accessible Days	MO3 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits)[1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	224	224	0%	0
Mar	248	238	-4%	(23)
Apr	206	184	-11%	(203)
May	248	248	0%	0
Jun	247	246	0%	(27)
Jul	279	279	0%	0
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0

Month	NAA Accessible Days	MO3 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits)[1/]
Nov	270	264	-2%	(55)
Dec	251	248	-1%	(8)
Total	**3,049**	**3,007**	**-1%**	**(316)**
Hungry Horse Dam and Reservoir				
Jan	213	186	-13%	0
Feb	166	124	-25%	0
Mar	127	111	-13%	0
Apr	120	90	-25%	0
May	151	136	-10%	(13)
Jun	287	276	-4%	(15)
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	210	-32%	0
Nov	294	200	-32%	0
Dec	276	186	-33%	0
Total	**2,864**	**2,439**	**-15%**	**(29)**
Basin-Wide Total	**5,913**	**5,446**	**-8%**	**(345)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.

[1/] Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-5.

Table 6-2. Change in Boat Ramp Accessibility and Water-Based Visitation under MO3 Relative to the No Action Alternative in a High Water Year (25th Percentile), by Month

Month	NAA Accessible Days	MO3 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation[1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	224	224	0%	0
Mar	248	248	0%	0
Apr	240	240	0%	0
May	248	248	0%	0
Jun	259	255	-2%	(109)
Jul	279	279	0%	0
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	265	-2%	(46)
Dec	254	248	-2%	(16)

Month	NAA Accessible Days	MO3 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation[1/]
Total	**3,098**	**3,083**	**0%**	**(171)**
Hungry Horse Dam and Reservoir				
Jan	289	243	-16%	0
Feb	183	168	-8%	0
Mar	186	158	-15%	0
Apr	180	120	-33%	0
May	220	197	-10%	(21)
Jun	300	300	0%	0
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	293	-5%	0
Nov	300	270	-10%	0
Dec	310	279	-10%	0
Total	**3,198**	**2,948**	**-8%**	**(21)**
Basin-Wide Total	**6,296**	**6,031**	**-4%**	**(192)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.
[1/] Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-7.

Table 6-3. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under MO3 Relative to the No Action Alternative in a Low Water Year (75th Percentile), by Month

Month	NAA Accessible Days	MO3 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	156	161	3%	10
Mar	129	147	14%	41
Apr	90	105	17%	138
May	151	154	2%	74
Jun	230	230	0%	0
Jul	277	277	0%	0
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	263	-3%	(65)
Dec	251	248	-1%	(8)
Total	**2,630**	**2,661**	**1%**	**191**

Month	NAA Accessible Days	MO3 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Hungry Horse Dam and Reservoir				
Jan	186	124	-33%	0
Feb	126	99	-21%	0
Mar	104	78	-25%	0
Apr	66	60	-9%	0
May	86	83	-3%	(3)
Jun	242	234	-3%	(11)
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	190	-39%	0
Nov	262	172	-34%	0
Dec	204	136	-33%	0
Total	**2,506**	**2,096**	**-16%**	**(14)**
Basin-Wide Total	**5,136**	**4,757**	**-7%**	**177**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.
[1/] Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-8.

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 shorter-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 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 currently support 0.9 million annual water-based visits, 1.7 million land-based visits, with a total of 2.6 million annual visits overall (i.e., including water- and land-based visits; Table 3-1 and Table 3-3). This is converted to 2.7 million annual recreational visitor days using the methodology described in section 2.1.3 of this appendix. This visitation supports $8.6 million and $23.8 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 $23.8 million with major reductions in both land- and water-based visitors to the area (Table 6-5).

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 reservoirs would result in major adverse effects in the short-term post dam breach, a decrease in consumer surplus of $8.6 million (-36%), compared to $23.8 million under the No Action Alternative.

In the long term, both water-based and land-based river recreation would become re-established. 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. 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 and Environmental Impact Statement* (2002 EIS) and visitation estimates to other similar rivers in the region.

2002 Lower Snake River Juvenile Salmon Migration Feasibility Report / Environmental Impact Statement

For the 2002 Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Study (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 million to 2.7 million annual recreational visitor 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 2002a, p. I3-65 to I3-66).[20]

To provide an updated visitation level, the visitation was adjusted for changes in the target survey populations since the study was conducted. The following counties were used to assess the changes in population from 1998 to 2018. Rural Washington would include the following counties: Adams, Asotin, Benton, Columbia, Franklin, Garfield, Grant, Spokane, Walla, and Whitman. Rural Oregon would include the following counties: Union, Umatilla, and Wallowa. Rural Idaho would include the following counties: Adams, Idaho, Latah, Lewis, and Nez Perce. Based on population adjustments, the updated visitation would range from approximately 1.9 million to 3.4 million (Table 6-4).[21]

[20] The range reflects uncertainty about how to extrapolate the survey results, so two different methods were used (Corps 2002a, p. I3-61).
[21] 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 (White et al. 2016).

The Corps had a number of concerns about the survey methods and results from the contingent behavior survey from the 2002 EIS (Corps 2002a, Section 3.2.9). In 2002, the Corps' was concerned that the "potential recreation benefits associated with dam breaching may be significantly overstated." (Corps 2002a, p. I3-74), and these concerns remain. First, the result was much higher than visitation estimates to 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.[22]

Given the Corps' concerns, Table 6-4 also presents adjusted visitation estimates from the 2002 EIS without California visitors. Without California, visitation estimates would range from approximately 1.2 million 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.

Table 6-4. 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

[22] 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).

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
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**

Sources: 2002 EIS estimates from Table 3.2-7 (Corps 2002a, p. I3-61). Estimates 1 and 2 reflect uncertainty about how to extrapolate the survey results, so two different methods were used (Corps 2002a, p. I3-61). County-level population data for 1998, the year of the contingent behavior survey, from State and County Intercensal Tables: 1990-2000 (U.S. Census Bureau 2016); county-level population data for 2018, most recent data available, from American FactFinder (U.S. Census Bureau 2019).

Visitation to Other Similar Rivers in the Region

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 removal 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 of the 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 of the 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)[23] 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 are available from the BLM for sites they manage along the Clearwater River, but visitation data are 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 of the 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 removal under MO3 suggest a wide range of estimates of potential recreational visitation that may occur post dam breach.

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 contingent behavior survey in the 2002 EIS specifically focused on non-fishing visitation in the lower Snake River, it would underestimate that type of recreation. Recreational fishing visitation could be possible in the long-term although there is 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. 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, primarily angler visitation, which would be anticipated in the lower Snake River in the long term.

Combining the proxy site estimate of 140,000, which primarily captures fishing visitation, with the visitation estimates from the general recreation survey (contingent behavior survey) from the 2002 EIS, 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-based and land based visitation on the lower Snake River under the No Action Alternative of approximately 2.7 million recreational visitor days, the long-

[23] ODFW and WDFW (2018) and NMFS (2014).

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.

As described in Section 3.5.3.6 of the EIS, MO3 would result in major beneficial effects on upstream migration of Snake River anadromous fish, including steelhead and salmon, in the long term. With increases in salmon and steelhead migration to the Snake River, there is the potential for increased fish abundance that draws additional recreational anglers to Region C and tributaries relative to the No Action Alternative. Salmon and steelhead migration under MO3 would likely support the salmon and steelhead recreational fishery in Region C, supporting continued and increased angler visitation in the long-term.

Region D – McNary, John Day, The Dalles, and Bonneville Dams

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 effect and desired recreation conditions.

The seven affected sites in Lake Wallula support 163,000 water-based visits during a typical water year (5.6 percent of total Region D visitation) (Table 3-2 and Table 3-3), which support $1.4 million in annual consumer surplus value (social welfare) (Table 6-5). 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.

Summary

Table 6-5 presents the average annual changes in recreation days and associated social welfare effects in a typical water year by reservoir, CRSO region.

Table 6-5. Changes in Annual Social Welfare Effects of Recreation under MO3 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Changes in Recreational Visitor Days	Social Welfare Effects (Consumer Surplus)
Region A Total (Lake Koocanusa and Hungry Horse Reservoir)	**(<1,000)**	**($3,000)**
Lake Koocanusa	(<1,000)	($3,000)
Hungry Horse Reservoir	(0)	($0)
Region B Total (Lake Roosevelt)	**0**	**$0**
Region C Total in the Short-Term (Four Lower Snake River Reservoirs)[1/]	**(2.7 million)**	**($23,820,000)**
Region C Total in the Long-Term (Four Lower Snake River Reservoirs)	Uncertain - may range from reduction of 1.4 million to increase of 0.8 million recreational visitor days	not estimated
Region D Total (Lake Wallula) in the Short-Term[1/]	**(169,000)**	**($1,413,000)**
Region D Total (Lake Wallula) in the Long-Term	Uncertain; visitation would be return if sediment is removed and/or wetland and vegetation conditions are established and recreational access is re-established in Lake Wallula	

Notes: Changes in water levels at other reservoirs in the basin would not affect accessibility or visitation.

[1/] Social welfare effects presented for Regions C and D represent short-term effects. The long-term impacts to visitation is uncertain. Some adaptation is likely over time. To the extent that increases in anadromous fish populations draw additional fishing visits to the region, increases in social welfare and regional economic effects would increase in the long term.

6.2 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED REGIONAL ECONOMIC EFFECTS

The tables below present the regional economic effects under MO3 relative to the No Action Alternative. Table 6-6 presents the average annual changes in expenditures associated with recreation in a typical water year by reservoir, CRSO region, and in total, as well as the percentage of expenditures associated with non-local visitors. Table 6-7 presents the regional economic effects associated with these changes in expenditures by CRSO region and in total. Regional effects associated with local, non-local, and total visitation are presented for completeness, but the focus of the regional economic effects evaluation was on non-local visitors since changes in their expenditures would result in impacts to the regional economy.

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 (Table 6-6), 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 re-opened to some of the recreation areas, and it is likely that a portion of the land-based visitors, such as site-seers, 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.[24] 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 in the lower Snake River (i.e., rafting, kayaking, etc.) and anadromous recreational fishing in Region C would occur. These increases in visitation in the long-term may offset visitation losses in Region C associated with reservoir or flatwater-oriented recreation activities, and recreational opportunities and associated regional economic benefits 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 by private and public investments. 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. With increased visitation and visitor spending in the long-term, there is the potential for an increase in jobs and income for outfitters, boating companies, and other tourism businesses relative to the No Action Alternative.

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 (Table 6-6). 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

[24] Non-local water-based visitors are calculated as the average 2017-2018 visitation to the site multiplied by the percentage of visitation that is water based at the site and the percentage of non-local visitation at the site. The site-level results are then summed across sites. 820,000 non-local water-based visitors represent 36 percent of total non-local water- and land-based visitors. Thus, expenditures and associated regional economic effects would be 36 percent of the values reported for non-local visitors.

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 noted above, potential long term increases in anadromous fish populations could increase fishing activities in Region D, which may draw additional visitors.

As noted above in the social welfare analysis, potential long-term increases in anadromous fish populations could increase anadromous recreational fishing activities in Regions B and D, drawing additional visitors. Visitor expenditures associated with these increases in recreational fishing could also accrue, with benefits to tourism business, jobs, and income in the regions.

Table 6-6. Changes in Visitor Expenditures under MO3 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Local Visitor Expenditures	Non-Local Visitor Expenditures	Total Expenditures	Percentage Non-Local
Region A Total (Lake Koocanusa and Hungry Horse Reservoir)	**($1,000)**	**($15,000)**	**($16,000)**	**96%**
Lake Koocanusa	($1,000)	($14,000)	($15,000)	96%
Hungry Horse Reservoir	($0)	($1,000)	($1,000)	96%
Region B Total (Lake Roosevelt)	**$0**	**$0**	**$0**	**89%**
Region C Total (Four Lower Snake River Reservoirs) – Short-Term[1/]	**($13,282,000)**	**($102,965,000)**	**($116,248,000)**	**89%**
Region C Total (Four Lower Snake River Reservoirs) – Long-Term[1/]	The long-term impacts to visitation, visitor expenditures, and regional economic effects are uncertain. Post dam breach, river conditions and increases in anadromous fish populations would draw visitation to the region in the long-term, and the increased visitor expenditures and regional economic effects would partially or fully offset losses in the short-term, with the potential to increase in the long-term relative to the No Action Alternative.			
Region D Total (Lake Wallula)[1/]	**($1,511,000)**	**($6,091,000)**	**($7,603,000)**	**80%**

Notes: Changes in water levels at other reservoirs in the basin would not affect accessibility or visitation.
[1/] Changes in expenditures and regional economic effects presented for Regions C and D represent short-term effects associated with the reduction of all land- and water-based visitation at the four lower Snake River projects and some of the visitation at Lake Wallula.

Table 6-7. Changes in Regional Economic Effects of Recreation under MO3 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Local/Non-Local	Local/Non-Local Visitation	Jobs	Labor Income	Sales
Region A				
Local	(14)	(0)	($0)	($1000)
Non-Local	(331)	(0)	($7,000)	($20,000)
Total	**(345)**	**(0)**	**($7,000)**	**($21,000)**
Region B				
Local	0	0	$0	$0
Non-Local	0	0	$0	$0
Total	**0**	**0**	**$0**	**$0**
Region C[1/]				
Short-Term Effects				
Local	(292,298)	(159)	($5,044,000)	($18,901,000)
Non-Local	(2,265,893)	(1,233)	($39,101,000)	($146,519,000)
Total	**(2,558,191)**	**(1,392)**	**($44,145,000)**	**($165,420,000)**
Long-Term Effects	The long-term impacts to visitation, visitor expenditures, and regional economic effects are uncertain. Near-natural river conditions and increases in anadromous fish populations would draw visitation to the region in the long-term, and the increased visitor expenditures and regional economic effects would partially or fully offset losses in the short-term, with the potential to increase in the long-term relative to the No Action Alternative.			
Region D[1/]				
Local	(32,393)	(19)	($826,000)	($2,575,000)
Non-Local	(130,558)	(77)	($3,329,000)	($10,377,000)
Total	**(162,951)**	**(96)**	**($4,155,000)**	**($12,951,000)**

Notes: The multiplier effect is larger for the entire Basin, so total regional economic effects are greater than the summation of effects across CRSO regions.

[1/] Changes in expenditures and regional economic effects presented for Regions C and D represent short-term effects associated with the reduction of all land- and water-based visitation at the four lower Snake River projects and some of the visitation at Lake Wallula.

6.3 SUMMARY OF EFFECTS

Consistent with the summary table provided in Section 3.11 of the EIS, Table 6-8 summarizes social welfare effects, regional economic effects, and social welfare effects associated with changes in recreation conditions under MO3. Detailed discussion of qualitative effects (i.e., quality of the recreation experience, fishing condition, other social effects) described in the table are provided in Section 3.11, of the EIS, Recreation.

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 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.

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 in Regions B, C, and D could occur in the long-term, supporting continued and increased angler visitation. However, while Section 3.5 in the EIS, Aquatic Habitat, Aquatic Invertebrates, and Fish, describes increased abundance of these species under MO3, other factors may limit their long-term success (e.g., decreased hatchery operations on the lower Snake River).

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 $25.2 million across all locations).

Expenditures associated with the 2.4 million non-local recreational visits (an additional 0.3 million are 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 in 1,420 jobs, $59 million in labor income, and $189 million less in sales.[25] 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 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. River recreation in the lower Snake River and increased abundance of anadromous fish in Regions B, C, and D would bring social benefits to individuals, Tribes, and communities in the long-term. Restoration of riverine conditions and increases in anadromous fish species to the 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.

[25] The multiplier effect is larger for the entire Basin, so total regional economic effects are greater than the summation of effects across CRSO regions.

Table 6-8. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 3 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 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 water 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 $3,000 in a typical water year associated with access to boat ramps. Potential for adverse effects for anglers at Hungry Horse Reservoir.	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 at Hungry Horse Reservoir, 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. Increases in anadromous fish populations may draw additional fishing visits to the region, increasing regional economic expenditures and jobs and income in the long term.	Social benefits could accrue in Region B with the increased abundance of anadromous fish under MO3.
Region C	Overall, long-term beneficial (e.g., riverine-oriented recreation) and adverse (e.g., lake or flatwater-oriented recreation) effects are anticipated.	In the short-term, non-local visitor expenditures would decrease by $103 million during construction and breaching activities, resulting in major adverse effects to regional economic conditions (decrease in 1,230 jobs and $39 million in labor income). After the construction and breaching period is over, access would be re-opened to some of the recreation areas. A reduction in only the reservoir water-based visitors compared to No Action Alternative 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 individuals, Tribes, and communities with river-based recreation ties and values, including 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 4 lower Snake River projects. This could result in a decrease of 2.7 million annual recreational visitor days on average $24 million in social welfare in the short term. Some land-based visitation would return in the short term as access to lower Snake River areas is reopened. The reduction of only water-based reservoir recreation compared to No Action Alternative at the lower Snake River would result in a decrease of 0.9 million visitors and $8.6 million in social welfare. 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. The long-term river visitation estimates in the lower Snake River (land- and water-based) suggest that recreation values could range from 50 percent lower to 30 percent higher than under the No Action Alternative (1.3 million to 3.5 million visitor days). Anadromous fish migration would support recreational fisheries in Region C, supporting continued and increased angler visitation in the long-term.	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. Increased anadromous fish migration under MO3 would likely support continued and increased angler visitation in the long-term in Region C. With increased angler visitation and visitor spending in Region C, there would be an increase in jobs and income for outfitters, boating companies, and other tourism businesses relative to the No Action Alternative.	The restoration of the 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. Adverse effects to resident fish species would have adverse effects on fishing experiences in Region C, which, in turn, could have adverse effects on the well-being of those tribes in Region C who value the affected resident fish. 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. Recreationists who 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 $1.4 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. Increases in anadromous fish populations may draw additional fishing visits to the region, with increases in regional economic expenditures and jobs and income in the long term.	In the short run, there could be decrease 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 recreationist would improve. In addition, increased opportunity for recreational fishing for anadromous fish occur, bringing social benefits to communities and individuals.
Total	In Region A, a reduction of less than 1 percent in regional water-based visitation would occur at Lake Koocanusa and Hungry Horse Reservoirs in a typical water year. Negligible changes in water-based visitation in Region B and Region D. Overall in Region C, long-term beneficial (e.g., riverine-oriented recreation) and adverse (e.g., lake or flatwater-oriented recreation) effects are anticipated. A number of recreation areas on Lake Wallula would be adversely affected by sedimentation from breaching. Basin-wide visitation could decrease by up to 21 percent (approximately 2.7 million recreational visitor days and $25 million in annual social welfare benefits). 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). Increased catch rates and angler visitation could occur over time as anadromous fish populations increase in Regions B, C, and D.	Expenditures associated with non-local recreational visits could decrease by up to $109 million across the region (22 percent decrease compared to the No Action Alternative), 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 the No Action Alternative. Increases in anadromous fish populations could draw additional fishing visits to the region in the long term with benefits to jobs, income, and tourism businesses. These changes may be major in small rural river communities, particularly those in Region C. .	Negligible changes in other social effects in Region A compared to the No Action Alternative. In Region C major changes in other social effects would occur, which would be adverse in the short term and beneficial in the long term at the four lower Snake River projects and Lake Wallula. Long-term increases in anadromous fish abundance in Regions B, C, and D would result in increased social benefits compared to the No Action Alternative.

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In a typical water year, anticipated changes in water surface elevations under MO4 would affect boat ramp accessibility and water-based visitation relative to the No Action Alternative at Lake Koocanusa (Libby Dam), Hungry Horse Reservoir in Region A and Lake Roosevelt in Region B. Changes in water levels at other reservoirs in the basin in a typical water year would not affect accessibility or visitation. In low water years, changes in water surface elevations would also affect boat ramp accessibility and water-based visitation relative to the No Action Alternative at Lake Pend Oreille in Region A. Over time, visitors may adjust their behavior to adapt to changes in accessibility, such as utilizing different sites on the system, which could reduce effects to visitation. As discussed in Section 2.1.1, the assumptions utilized in this analysis are conservative (i.e., they are more likely to overstate than understate effects of changes to water-based visitation), but the methodology is a reasonable approach given existing information.

7.1 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED SOCIAL WELFARE EFFECTS

The tables in this section present the changes in water-based visitation and social welfare effects under MO4 relative to the No Action Alternative for Lake Koocanusa, Hungry Horse Reservoir, and Lake Roosevelt. As discussed above, this appendix focuses on providing additional details to support the quantitative analysis that is described in Chapter 3 (Section 3.11). In addition, a description of the potential effects at Lake Pend Oreille is included in this section.

While the analysis does not detect changes in boat ramp accessibility at Lake Pend Oreille using available data for Federal- and state-managed boat ramps, major adverse effects to recreation are possible under MO4 in low water years. 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.[26] 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 the River, many of whom are seasonal visitors (Lakes Commission 2019). The Lake Pend Oreille, Pend Oreille River, Priest Lake and Priest River Commission (Lakes

[26] 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).

Commission) reports that accessibility impacts can occur from just a one 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). As such, 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. As such, a one to three-foot decline in water surface elevations has the potential to have a major adverse effect on recreational visitation in low water level years. These effects would reduce the social welfare benefits associated with recreational visitation at Lake Pend Oreille.

Table 7-1 presents the percentage change in the number of accessible days across boat ramps by month for Lake Koocanusa, Hungry Horse Reservoir, and Lake Roosevelt under MO4 relative to the No Action Alternative in a typical water year, as well as the associated change in water-based visitation. As shown in Table 7-1, 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.. Table 7-2 and Table 7-3 present these results using the 25th percentile H&H results (high water year) and 75th percentile results (low water year). Table 7-4 presents the average annual changes in recreation days and associated social welfare effects in a typical water year by reservoir, CRSO region, and in total, and provides details about the change in recreation days and associated social welfare effects during low water years.

Table 7-1. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under MO4 Relative to the No Action Alternative in a Typical Water Year (50th Percentile), by Month

Month	NAA Accessible Days	MO4 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) 1/
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	224	224	0%	0
Mar	248	238	-4%	(23)
Apr	206	200	-3%	(55)
May	248	248	0%	0
Jun	247	249	1%	55
Jul	279	279	0%	0
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	270	0%	0

Month	NAA Accessible Days	MO4 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Dec	251	252	0%	3
Total	**3,049**	**3,036**	**0%**	**(21)**
Hungry Horse Dam and Reservoir				
Jan	213	186	-13%	0
Feb	166	124	-25%	0
Mar	127	111	-13%	0
Apr	120	90	-25%	0
May	151	135	-11%	(14)
Jun	287	275	-4%	(16)
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	210	-32%	0
Nov	294	200	-32%	0
Dec	276	186	-33%	0
Total	**2,864**	**2,437**	**-15%**	**(31)**
Grand Coulee Dam and Lake Roosevelt				
Jan	682	558	-18%	(4,406)
Feb	508	422	-17%	(5,063)
Mar	350	350	0%	0
Apr	272	269	-1%	(459)
May	285	241	-15%	(9,741)
Jun	526	466	-11%	(12,723)
Jul	682	682	0%	0
Aug	638	593	-7%	(9,500)
Sep	615	585	-5%	(3,361)
Oct	642	642	0%	0
Nov	660	660	0%	0
Dec	682	674	-1%	(212)
Total	**6,542**	**6,142**	**-6%**	**(45,466)**
Basin-Wide Total	**12,455**	**11,615**	**-7%**	**(45,517)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.

[1/] Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-5.

Table 7-2. Change in Boat Ramp Accessibility and Water-Based Visitation under MO4 Relative to the No Action Alternative in a High-water Year (25th Percentile), by Month

Month	NAA Accessible Days	MO4 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation[1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	224	224	0%	0
Mar	248	248	0%	0
Apr	240	240	0%	0
May	248	248	0%	0
Jun	259	261	1%	55
Jul	279	279	0%	0
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	270	0%	0
Dec	254	252	-1%	(5)
Total	**3,098**	**3,098**	**0%**	**49**
Hungry Horse Dam and Reservoir				
Jan	289	241	-17%	0
Feb	183	168	-8%	0
Mar	186	156	-16%	0
Apr	180	120	-33%	0
May	220	196	-11%	(22)
Jun	300	300	0%	0
Jul	310	310	0%	0
Aug	310	310	0%	0
Sep	300	300	0%	0
Oct	310	293	-5%	0
Nov	300	270	-10%	0
Dec	310	279	-10%	0
Total	**3,198**	**2,943**	**-8%**	**(22)**
Grand Coulee Dam and Lake Roosevelt				
Jan	682	678	-1%	(142)
Feb	616	454	-26%	(9,537)
Mar	655	493	-25%	(18,104)
Apr	403	394	-2%	(1,377)
May	386	344	-11%	(9,298)
Jun	601	529	-12%	(15,268)
Jul	682	682	0%	0
Aug	663	658	-1%	(1,056)
Sep	635	632	0%	(336)
Oct	642	642	0%	0
Nov	660	660	0%	0

Month	NAA Accessible Days	MO4 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation[1/]
Dec	682	682	0%	0
Total	**7,307**	**6,848**	**-6%**	**(55,118)**
Basin-Wide Total	**13,603**	**12,889**	**-5%**	**(55,090)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.
[1/] Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-7.

Table 7-3. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under MO4 Relative to the No Action Alternative in a Low-water Year (75th Percentile), by Month

Month	NAA Accessible Days	MO4 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/2/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	156	171	10%	30
Mar	129	145	12%	36
Apr	90	101	12%	101
May	151	155	3%	99
Jun	230	232	1%	55
Jul	277	278	0%	34
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	270	0%	0
Dec	251	249	-1%	(5)
Total	**2,630**	**2,677**	**2%**	**350**
Hungry Horse Dam and Reservoir				
Jan	186	124	-33%	0
Feb	126	100	-21%	0
Mar	104	79	-24%	0
Apr	66	60	-9%	0
May	86	82	-5%	(4)
Jun	242	230	-5%	(16)
Jul	310	310	0%	0
Aug	310	308	-1%	(3)
Sep	300	221	-26%	(30)
Oct	310	186	-40%	0
Nov	262	180	-31%	0
Dec	204	141	-31%	0

Month	NAA Accessible Days	MO4 Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/2/]
Total	**2,506**	**2,021**	**-19%**	**(53)**
Grand Coulee Dam and Lake Roosevelt				
Jan	682	497	-27%	(6,574)
Feb	449	411	-8%	(2,237)
Mar	340	337	-1%	(335)
Apr	184	177	-4%	(1,071)
May	181	147	-19%	(7,527)
Jun	480	374	-22%	(22,478)
Jul	682	446	-35%	(66,388)
Aug	618	394	-36%	(47,288)
Sep	591	433	-27%	(17,703)
Oct	642	593	-8%	(2,483)
Nov	660	660	0%	0
Dec	682	642	-6%	(1,062)
Total	**6,191**	**5,111**	**-17%**	**(175,146)**
Basin-Wide Total	**11,327**	**9,809**	**-13%**	**(174,849)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.

[1/] Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-8.

[2/] As described in this section, there could be major adverse effects to recreation at Lake Pend Oreille in Region A in low water years (Section 3.11.3.6 of the EIS).

Table 7-4. Changes in Annual Social Welfare Effects of Recreation under MO4 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Changes in Recreational Visitor Days	Social Welfare Effects (Consumer Surplus)
Region A Total (Lake Koocanusa and Hungry Horse Reservoir)[1/]	**(54)**	**($1,000)**
Lake Koocanusa	(22)	($0)
Hungry Horse Reservoir	(32)	($0)
Lake Pend Oreille[2/]	Potential for major adverse effects to visitation and social welfare at Lake Pend Oreille in low water years.	
Region B Total (Lake Roosevelt)[1/]	**(75,562)**	**($664,000)**
Region C Total (Dworshak Reservoir)	**0**	**$0**
Region D Total	**0**	**$0**

Notes: The social welfare analysis is conducted 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. Second, UDVs are applied to the estimated recreational visitor days. Impacts are estimated based on changes in water surface elevations at reservoirs. Changes in water surface elevations at other reservoirs in the basin not shown would not affect accessibility or visitation.

[1/] In low water years, water-based visitation at Lake Roosevelt would decrease by over 175,000 visits at Lake Roosevelt (Table 7-3). This would lead to an average annual decrease of $2.6 million in social welfare.
[2/] 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 could occur.

7.2 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED REGIONAL ECONOMIC EFFECTS

The tables below present the regional economic effects under MO4 relative to the No Action Alternative. Table 7-5 presents the average annual changes in expenditures associated with recreation in a typical water year by reservoir, CRSO region, and in total, as well as the percentage of expenditures associated with non-local visitors. Table 7-6 presents the regional economic effects associated with these changes in expenditures by CRSO region and in total. Regional effects associated with local, non-local, and total visitation are presented for completeness, but the focus of the regional economic effects evaluation was on non-local visitors since changes in their expenditures would result in impacts to the regional economy. low water year. 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.

As a result of changes in boat ramp accessibility in a typical water 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 associated with boat ramp access 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. 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.

No changes to visitation are anticipated in Region C or D under MO4 relative to the No Action Alternative associated with boat ramp access. Overall across all locations, the change in non-local visitor regional expenditures in a typical water 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.

Table 7-5. Changes in Visitor Expenditures under MO4 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Local Visitor Expenditures	Non-Local Visitor Expenditures	Total Expenditures	Percentage Non-Local
Region A Total (Lake Koocanusa and Hungry Horse Reservoir)	**($0)**	**($2,000)**	**($2,000)**	**96%**
Lake Koocanusa	($0)	($1,000)	($1,000)	96%
Hungry Horse Reservoir	($0)	($1,000)	($1,000)	96%
Lake Pend Oreille	Potential for major adverse effects to visitor expenditures and regional economic effects at Lake Pend Oreille in low water years			
Region B Total (Lake Roosevelt)	**($221,000)**	**($1,762,000)**	**($1,983,000)**	**89%**
Region C Total (Dworshak Reservoir)	**$0**	**$0**	**$0**	**96%**
Region D Total	**$0**	**$0**	**$0**	**77%**

Notes: Impacts are estimated based on changes in water surface elevations at reservoirs. Changes in water surface elevations at other reservoirs in the basin would not affect accessibility or visitation. Table does not reflect effects that are described qualitatively, and may underestimate visitation at some sites.

Table 7-6. Changes in Regional Economic Effects of Recreation under MO4 Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Local/Non-Local	Local/Non-Local Visitation	Jobs	Labor Income	Sales
Region A[1/]				
Local	(2)	(0)	$0	$0
Non-Local	(49)	(0)	($1,000)	($3,000)
Total	**(52)**	**(0)**	($1,000)	($3,000)
Potential for major adverse effects to visitor expenditures and regional economic effects at Lake Pend Oreille in low water years (these effects are not included in the regional economic effects in the rows above)				
Region B[1/]				
Local	(5,062)	(2)	($71,000)	($222,000)
Non-Local	(40,404)	(19)	($566,000)	($1,771,000)
Total	**(45,466)**	**(22)**	($637,000)	($1,993,000)
Region C				
Local	0	0	$0	$0
Non-Local	0	0	$0	$0
Total	**0**	**0**	$0	$0
Region D				
Local	0	0	$0	$0
Non-Local	0	0	$0	$0
Total	**0**	**0**	$0	$0

Notes: The multiplier effect is larger for the entire Basin, so total regional economic effects are greater than the summation of effects across CRSO regions.

[1/] In low water years, water-based visitation would decrease by over 175,000 visits at Lake Roosevelt (Table 7-3). Decreased expenditures associated with non-local visitors would lead to 74 fewer jobs, $2.2 million less in labor income, and $6.9 million less sales. Further, major adverse effects to recreation may occur at Lake Pend Oreille in Region A in low water years (Section 3.11.3.6 of the Draft EIS). Note: Table does not reflect effects that are described qualitatively, and may underestimate visitation at some sites.

7.3 SUMMARY OF EFFECTS

Consistent with the summary in Section 3.11 of the EIS, Recreation, Table 7-7 summarizes social welfare effects, regional economic effects, and social welfare effects associated with changes in recreation conditions under MO4. Detailed discussion of qualitative effects (fishing conditions, quality of recreational experience, other social effects) described in the table are provided in Section 3.11, of the EIS, Recreation.

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. Fishing opportunities and visitation would also be adversely affected at Lake Roosevelt and Lake Pend Oreille.

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 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.

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 water year. The change in non-local visitor regional expenditures in a typical water 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 sales. The largest adverse effects are anticipated at Lake Roosevelt in Region B and at Lake Pend Oreille in Region A in low water years.

In Regions B, C, and D, predicted changes to adult salmon and steelhead abundance vary by model and range from major decreases (NMFS LCM without latent mortality effects) to major increases (CSS). These effects (either adverse or beneficial) would likely be noticeable to anglers. Resident fish in Regions C and D would be adversely affected by increased spill and TDG concentrations, which could adversely affect fishing opportunities and visitation. 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.

Table 7-7. 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 water 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 these 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. Adverse effects to resident fish species at Hungry Horse Reservoir, Lake Pend Oreille, and the Kootenai River 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 anglers or other visitors reduce recreation trips to this region due to declines in angler opportunities or 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 visitor spending and tourism businesses, jobs and income.	During low water years only, social effects could occur to residents and communities at Lake Pend Oreille from decreased visitation and tourism activity. 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 $664,000 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. Adverse effects for some resident species (bull trout, kokanee, rainbow trout, burbot) could affect the destination fishery at Lake Roosevelt, decreasing angler opportunities and visitation. Adverse or beneficial effects could occur to anadromous fish, which would likely affect angler opportunities, although the directionality of effect is unclear.	Expenditures associated with non-local recreational visits would decrease by $1.8 million across the region (2.3 percent compared to the no Action Alternative) 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 sales; localized major adverse effects could occur at Lake Roosevelt. Decreases in fishing opportunities at Lake Roosevelt could contribute to further reductions in jobs and income. Changes in anadromous fish populations could affect jobs and income in adjacent communities.	Adverse social effects could occur residents and communities at Lake Roosevelt from decreased visitation and tourism activity, primarily during low water years. The Spokane Tribe and the Confederated Tribes of the Colville Reservation could experience adverse effects from change in water-based recreation visitation, and related decrease in tourism activity and expenditures. Likewise decreased well-being of water-based visitors could occur due to the sizable reduction in recreation days during a low water year. 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. Changes in anadromous fish abundance would have social effects, although the directionality of the effect is uncertain.
Region C	No changes to reservoir visitation related to changes in boat ramp access. Adverse or beneficial effects could occur to anadromous fish, which would likely affect angler opportunities, although the directionality of effect is unclear. Increased spill and TDG concentrations, and drawdown to MOP could adversely affect resident fish and associated angler opportunities.	No measurable changes in visitor expenditures or regional effects associated with boat ramp access. Decreases in resident fishing opportunities could lead to decreased visitor spending, and reductions in jobs and income. Changes in anadromous fish populations could affect jobs and income in adjacent communities.	No change from No Action for boat ramp access. 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. Changes in anadromous fish abundance would have social effects, although the directionality of the effect is uncertain.

Region	Social Welfare Effects	Regional Economic Effects (2019 dollars)	Other Social Effects
Region D	No changes to reservoir visitation related to changes in boat ramp access. Adverse or beneficial effects could occur to anadromous fish, which would likely affect angler opportunities, although the directionality of effect is unclear. Minor improvements in wildlife viewing may occur. Increased spill and TDG concentrations, and drawdown to MOP could adversely affect resident fish.	No measurable changes in visitor expenditures or regional effects associated with boat ramp access. Decreases in resident fishing opportunities could lead to decreased visitor spending, and reductions in jobs and income. Changes in anadromous fish populations could affect jobs and income in adjacent communities.	No change from No Action for boat ramp access. 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. Changes in anadromous fish abundance would have social effects, although the directionality of the effect is uncertain.
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 water year, with annual social welfare losses of approximately $665,000 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 the no Action Alternative. In addition, major adverse effects could occur in low water years at Lake Pend Oreille due to accessibility impacts to multiple facilities and infrastructure. Adverse or beneficial effects could occur to anadromous fish, which would likely affect angler opportunities, although the directionality of effect is unclear. However, adverse effects to resident fish may also occur in all regions. Minor improvements in wildlife viewing may 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 water year. Economic effects of this change in expenditures would be 22 fewer jobs, $780,000 less labor income, and $2.2 million less sales. In low water level 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 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. Decreases in resident fishing opportunities could lead to decreased visitor spending, and reductions in jobs and income. Changes in anadromous fish populations could affect jobs and income in adjacent communities.	Adverse social effects could occur to residents and communities at Lake Roosevelt and Lake Pend Oreille from decreased visitation and tourism activity during low water years. 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. Changes in anadromous fish abundance would have social effects, although the directionality of the effect is uncertain.

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In a typical water year, anticipated changes in water surface elevations under the PA would affect boat ramp accessibility and water-based visitation relative to the No Action Alternative at Lake Koocanusa (Libby Dam) in Region A and Lake Roosevelt in Region B. Changes in water levels at other reservoirs in the basin in a typical water year would not affect accessibility or visitation. In low water years, changes in water surface elevations would also affect boat ramp accessibility and water-based visitation relative to the No Action Alternative at Dworshak Reservoir in Region C. Over time, visitors may adjust their behavior to adapt to changes in accessibility, such as utilizing different sites on the system, which could reduce effects on visitation. As discussed in Section 2.1.1, the assumptions utilized in this analysis are conservative (i.e., they are more likely to overstate than understate effects of changes to water-based visitation), but the methodology is a reasonable approach given existing information.

8.1 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED SOCIAL WELFARE EFFECTS

The tables below present the changes in water-based visitation and social welfare effects under the PA relative to the No Action Alternative. Table 8-1 presents the percentage change in the number of accessible days across boat ramps by month for the two reservoirs affected under the PA relative to the No Action Alternative in a typical water year, as well as the associated change in water-based visitation. Table 8-2 and Table 8-3 present these results using the 25th percentile H&H results (high water year) and 75th percentile results (low water year), respectively. Table 8-4 presents the average annual changes in recreation days and associated social welfare effects in a typical water year by reservoir, CRSO region, and in total.

Table 8-1. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under the PA Relative to the No Action Alternative in a Typical Water Year (50th Percentile), by Month

Month	NAA Accessible Days	PA Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	224	224	0%	0
Mar	248	236	-5%	(27)
Apr	206	180	-13%	(240)
May	248	242	-2%	(149)
Jun	247	247	0%	0
Jul	279	279	0%	0
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	270	0%	0
Dec	251	251	0%	0
Total	**3,049**	**3,005**	**-1%**	**(416)**

Month	NAA Accessible Days	PA Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) 1/
Grand Coulee Dam and Lake Roosevelt				
Jan	682	682	0%	0
Feb	508	504	-1%	(235)
Mar	350	350	0%	0
Apr	272	272	0%	0
May	285	287	1%	443
Jun	526	529	1%	636
Jul	682	682	0%	0
Aug	638	638	0%	0
Sep	615	609	-1%	(672)
Oct	642	642	0%	0
Nov	660	660	0%	0
Dec	682	682	0%	0
Total	**6,542**	**6,437**	0%	**171**
Dworshak Dam and Reservoir (No change)				
Basin-Wide Total	**9,591**	**9,542**	**-1%**	**(245)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.
1/ Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-5.

Table 8-2. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under the PA Relative to the No Action Alternative in a High-water Year (25th Percentile), by Month

Month	NAA Accessible Days	PA Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) 1/
Libby Dam and Lake Koocanusa (No change)				
Grand Coulee Dam and Lake Roosevelt				
Jan	682	682	0%	0
Feb	616	616	0%	0
Mar	655	635	-3%	(2,235)
Apr	403	413	2%	1,529
May	386	411	6%	5,535
Jun	601	614	2%	2,757
Jul	682	682	0%	0
Aug	663	658	-1%	(1,056)
Sep	635	629	-1%	(672)
Oct	642	642	0%	0
Nov	660	660	0%	0
Dec	682	682	0%	0
Total	**7,307**	**7,324**	0%	**5,858**

Month	NAA Accessible Days	PA Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Dworshak Dam and Reservoir (No change)				
Basin-Wide Total	**7,307**	**7,324**	**0%**	**5,858**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.

[1/] Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-7.

Table 8-3. Change in Boat Ramp Accessibility and Water-Based Visitation (Visits) under the PA Relative to the No Action Alternative in a Low-water Year (75th Percentile), by Month

Month	NAA Accessible Days	PA Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Libby Dam and Lake Koocanusa				
Jan	248	248	0%	0
Feb	156	156	0%	0
Mar	129	130	1%	2
Apr	90	90	0%	0
May	151	139	-8%	(298)
Jun	230	226	-2%	(109)
Jul	277	276	0%	(34)
Aug	279	279	0%	0
Sep	270	270	0%	0
Oct	279	279	0%	0
Nov	270	270	0%	0
Dec	251	251	0%	0
Total	**2,630**	**2,614**	**-1%**	**(438)**
Grand Coulee Dam and Lake Roosevelt				
Jan	682	682	0%	0
Feb	449	445	-1%	(235)
Mar	340	339	0%	(112)
Apr	184	179	-3%	(765)
May	181	180	-1%	(221)
Jun	480	483	1%	636
Jul	682	682	0%	0
Aug	618	615	0%	(633)
Sep	591	580	-2%	(1,232)
Oct	642	642	0%	0
Nov	660	660	0%	0
Dec	682	682	0%	0
Total	**6,191**	**6,169**	0%	**(2,563)**
Dworshak Dam and Reservoir				
Jan	124	122	-2%	(65)

Month	NAA Accessible Days	PA Accessible Days	Percentage Change in Accessible Days	Change in Water-Based Visitation (Visits) [1/]
Feb	94	84	-11%	(562)
Mar	56	49	-13%	(658)
Apr	30	30	0%	0
May	118	118	0%	0
Jun	210	210	0%	0
Jul	217	217	0%	0
Aug	177	177	0%	0
Sep	124	124	0%	0
Oct	124	124	0%	0
Nov	120	120	0%	0
Dec	124	124	0%	0
Total	**1,518**	**1,499**	-1%	**(1,286)**
Basin-Wide Total	**10,339**	**10,282**	**-1%**	**(4,287)**

Note: The number of "accessible days" is a summation across boat across ramps within a month. Therefore, the number of accessible days reflects the number of days within a month and the number of boat ramps.
[1/] Change in water-based visitation calculated as the percentage change in accessible days multiplied by the NAA visitation presented in Table 3-8.

Table 8-4. Changes in Average Annual Social Welfare Effects of Recreation under the PA Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Changes in Recreational Visitor Days	Social Welfare Effects (Consumer Surplus)
Region A Total (Lake Koocanusa)	**(437)**	**($4,000)**
Region B Total (Lake Roosevelt)	**285**	**$3,000**
Region C Total	**0**	**$0**
Region D Total	**0**	**$0**
Total	**(152)**	**($2,000)**

Notes: The social welfare analysis is conducted 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. Second, UDVs are applied to the estimated recreational visitor days. Impacts are estimated based on changes in water surface elevations at reservoirs. Changes in water surface elevations at other reservoirs in the basin not shown would not affect accessibility or visitation.

8.2 SUPPLEMENTAL DETAIL DESCRIBING QUANTIFIED REGIONAL ECONOMIC EFFECTS

The tables below present the regional economic effects under the PA relative to the No Action Alternative. Table 8-5 presents the average annual changes in expenditures associated with recreation in a typical water year by reservoir, CRSO region, and in total, as well as the percentage of expenditures associated with non-local visitors. Table 8-6 presents the regional economic effects associated with these changes in expenditures by CRSO region and in total. Regional effects associated with local, non-local, and total visitation are presented for completeness, but the focus of the regional economic effects evaluation was on non-local visitors since changes in their expenditures would result in impacts to the regional economy.

Table 8-5. Changes in Visitor Expenditures under the PA Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Reservoir/River Reach	Local Visitor Expenditures	Non-Local Visitor Expenditures	Total Expenditures	Percentage Non-Local
Region A Total (Lake Koocanusa)-short term	**($1,000)**	**($18,000)**	**($19,000)**	**96%**
Region A Total (Lake Koocanusa)-long term				
Region B Total (Lake Roosevelt)	**$1,000**	**$7,000**	**$7,000**	**89%**
Region C Total	**$0**	**$0**	**$0**	**90%**
Region D Total	**$0**	**$0**	**$0**	**77%**
Total (weighted average)	**$0**	**($12,000)**	**($12,000)**	**100%**

Notes: Impacts are estimated based on changes in water surface elevations at reservoirs.Changes in water levels at other reservoirs in the basin would not affect accessibility or visitation. Table does not reflect effects that are described qualitatively, and may underestimate visitation at some sites.

Table 8-6. Changes in Regional Economic Effects of Recreation under the PA Relative to the No Action Alternative in a Typical Water Year (2019 Dollars)

CRSO Region, Local/Non-Local	Local/Non-Local Visitation	Jobs	Labor Income	Sales
Region A				
Local	(17)	(0)	$0	($1,000)
Non-Local	(399)	(0)	($8,000)	($24,000)
Total	**(416)**	**(0)**	($8,000)	($25,000)
Region B				
Local	19	0	$0	$1,000
Non-Local	152	0	$2,000	$6,000
Total	**171**	**0**	$2,000	$7,000
Region C				
Local	0	0	$0	$0
Non-Local	0	0	$0	$0
Total	**0**	**0**	$0	$0
Region D				
Local	0	0	$0	$0
Non-Local	0	0	$0	$0
Total	**0**	**0**	$0	$0
Total				
Local	2	0	$0	$0
Non-Local	(247)	(0)	($7,000)	($25,000)
Total	**(245)**	**(0)**	($7,000)	($25,000)

Notes: Regional economic effects of recreational expenditures are included for each study region, but some “leakage” effects occur in other areas from each region. As such, the total regional economic effects are larger for the total basin than the sum of the individual regions. Also, the table does not reflect effects that are described qualitatively, and may underestimate effects at some sites.

8.3 SUMMARY OF EFFECTS

Consistent with the summary in Section 7.7.13 of the EIS, Recreation, Table 8-7 summarizes social welfare effects, regional economic effects, and social welfare effects associated with changes in recreation conditions under the Preferred Alternative. Detailed discussion of qualitative effects described in the table (e.g., quality of recreational experience, fishing conditions, other social effects) are provided in Section 7.7.13, of the EIS, Recreation.

Overall effects of the Preferred Alternative on water-based recreation is anticipated to be negligible associated with changes in boat ramp access. Across the study area, total recreational visitation and associated social welfare effects are anticipated to decrease by less than 0.1 percent annually (approximately 250 visits and $2,000) in a typical year due to changes in boat ramp access. Expenditures associated with non-local water-based visitation would decrease by $12,000 annually across the study area, a change of less than 0.1 percent compared to the No Action Alternative. Regional economic effects of this change in expenditures associated with recreational access for water-based visitors would be negligible. Effects to the quality of hunting, wildlife viewing, swimming, and water sports at river recreation sites in the study area would be generally negligible to minor and adverse under the Preferred Alternative. In Regions C and D, adverse to beneficial effects to anglers and the quality of fishing experience may occur associated with the potential for major beneficial to moderate adverse effects to Snake River anadromous fish, although the directionally of the effect is uncertain.

Table 8-7. Changes in Economic Effects of Recreation Under the Preferred Alternative Relative to the No Action Alternative

Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region A	A decrease of approximately 400 water-based recreational visits would occur at Lake Koocanusa (less than 1.0 percent of water-based visitation at the site) in a typical year associated with changes in boat ramp access. In high-water-level years, water-based visitation would not change at Lake Koocanusa and would decrease by about 1.0 percent in low-water-level years. Annual social welfare benefits would decrease by $4,000 in a typical year. Negligible effects to the quality of recreation experiences would occur.	Expenditures associated with non-local recreational visits would decrease by $18,000 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 resulting in no noticeable effect to recreationist well-being when compared to the No Action Alternative.
Region B	Based on changes in boat ramp accessibility, an increase of approximately 200 water-based visits at Lake Roosevelt (less than 0.1 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 less than 1.0 percent. Annual social welfare benefits would increase by approximately $3,000 in a typical year. Potential adverse effects to angler visitation and the quality of the angler experience targeting Kokanee, burbot, and redband rainbow trout at Lake Roosevelt could occur.	Expenditures associated with non-local recreational visits would increase by $7,000 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. The potential for adverse regional effects could occur from decreased visitation at Lake Roosevelt from impacts to resident fish.	Negligible change resulting in no noticeable effect to recreationist well-being when compared to the No Action Alternative in most locations. There is the possibility of some adverse social effects associated with resident fish anglers on Lake Roosevelt.

Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region C	No changes in reservoir visitation associated with changes in boat ramp access in a typical year or high-water-level year. A reduction of approximately 1,300 water-based visits at Dworshak Reservoir (less than 1 percent of water-based visitation at the site) would occur in a low-water-level year. Annual social welfare benefits would not change in typical or high-water-level years, but would decrease by about $14,000 in a low-water-level year. Effects to hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions are likely to be negligible. Adverse to beneficial effects to anglers and the quality of fishing experience may occur associated with the potential for major beneficial and moderate adverse effects to Snake River anadromous fish, although the directionally of the effect is uncertain.	Changes in visitor expenditures or regional effects associated with changes in boat ramp access would be negligible. Changes in anadromous fish could affect angler visitor spending in tribal and river communities in Region C, affecting jobs and income for outfitters, boating companies, and other tourism businesses. However, the directionality of this regional economic effect is uncertain.	No change to visitor well-being associated with access to reservoir-based recreation. Changes in anadromous fish could range from major beneficial to moderate adverse, with the potential for adverse or beneficial social impacts to affected anglers and rural and tribal communities under the Preferred Alternative.
Region D	No changes in reservoir visitation associated with changes in boat ramp access. Effects to hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions are likely to be negligible. Adverse to beneficial effects to anglers and the quality of anadromous fishing experience associated with the potential for major beneficial to moderate adverse effects to Snake River anadromous fish, although the directionally of the effect is uncertain. .	No changes in visitor expenditures or regional effects associated with changes in boat ramp access. Changes in anadromous fish in the lower Columbia River could affect angler visitor spending in adjacent communities, affecting jobs and income for outfitters, boating companies, and other tourism businesses. However, the directionality of this regional economic effect is uncertain.	No change to visitor well-being associated with access to reservoir-based recreation. Changes in anadromous fish could range from major beneficial to moderate adverse in Region D, with the potential for adverse or beneficial social impacts to affected anglers and rural and tribal communities under the Preferred Alternative.

Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Total	Negligible effects to reservoir visitation (reduction of 250 visits, representing less than 0.1 percent of total visitation compared to the No Action Alternative) in a typical year, with decreases in social welfare of approximately $2,000 annually associated with changes in boat ramp access. Negligible to minor adverse effects in most areas to quality of fishing, hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions may occur. In Regions C and D, adverse to beneficial effects to anglers and the quality of fishing experience may occur associated with the potential for major beneficial and moderate adverse effects to Snake River anadromous fish, although the directionally of the effect is uncertain.	Expenditures associated with non-local recreational visits would decrease by $12,000 across the study area (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. In Region C and D, changes in anadromous fish could affect angler visitor spending in tribal and river communities, affecting jobs and income for outfitters, boating companies, and other tourism businesses. However, the directionality of this regional economic effect is uncertain.	Recreation would continue to provide other social effects associated with considerable recreational opportunities in the study area. Continued operation of the system would provide benefits to community well-being and identity. Negligible change from No Action in most locations, with the exception of potential for beneficial or adverse social effects to affected anglers, tribes, and communities from major beneficial to moderate adverse effects to anadromous fish in Regions C and D.

CHAPTER 9 - REFERENCES

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Columbia River System Operations
Final Environmental Impact Statement

Appendix N
Water Supply Physical and Socioeconomic Methods and Analysis

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Annexes

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Acronyms and Abbreviations

BPA	Bonneville Power Administration
bu	bushel
CDL	Cropland Data Layer
cfs	cubic feet per second
CRSO	Columbia River System Operations
CSKT	Confederated Salish and Kootenai Tribes
cwt	hundredweight (equal to 100 pounds)
EIS	environmental impact statement
H&H	hydrology and hydraulics
ID	Idaho State
IMPLAN	impact analysis for planning
lb	pound
MAF	million acre-feet
M&I	municipal and industrial
MO1	Multiple Objective Alternative 1
MO2	Multiple Objective Alternative 2
MO3	Multiple Objective Alternative 3
MO4	Multiple Objective Alternative 4
MT	Montana State
NAA	No Action Alternative
NASS	National Agricultural Statistics Service
NEPA	National Environmental Policy Act
NGVD29	National Geodetic Vertical Datum of 1929
OR	Oregon State
P&Gs	Principles and Guidelines
Reclamation	U.S. Bureau of Reclamation
ResSim	reservoir simulation model (power/flood model)
Corps	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WA	Washington State

CHAPTER 1 - INTRODUCTION

1.1 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 million acre-feet (MAF) of water is supplied for irrigation, drinking water, and other municipal and industrial (M&I) needs (U.S. Geological Survey [USGS] 2017).

This appendix describes both the physical and socioeconomic existing conditions relating to water supply. It also describes the environmental consequences resulting from the Alternatives in Chapter 2 of the main EIS document. 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 on the flow and stage in the rivers of diverting additional water.

1.1.1 Irrigation

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 five percent[2] of the Columbia Basin's Water is diverted for agriculture. Irrigation water is diverted directly from the rivers, from the pools behind the storage and run-of-river projects, and pumped from groundwater wells. Diversions can vary from year to year and month to month in response to varying weather and hydrologic conditions. A portion of the diverted water can travel back into the rivers and are known as irrigation return flows.

Though not all of these areas would be affected by potential changes to operations and maintenance of the Columbia River System, 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 133 million acre-feet (Northwest River Forecast Center 2018) and 7.1 million acre-feet of diversion for entire study area (Bonneville Power Administration [BPA] 2011).

1.1.1.1 Federal Irrigation Projects

Grand Coulee and Hungry Horse, operated by the U.S. Bureau of Reclamation (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 approximately 300 feet vertically 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 National Environmental Policy Act (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 are delivered to 28,800 Federal project acres.[6]

1.1.1.2 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 pools behind the four lower Columbia River dams (Bonneville, John Day, The Dalles, and McNary) and the pool behind Ice Harbor Dam on the lower Snake River. The dams are not authorized to store water for irrigation. Rather, they are run-of-river projects that maintain elevated pool levels primarily for power generation and navigation. The exception is John Day, which maintains a slightly higher pool 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 pools 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.

1.1.2 Municipal and Industrial

Use of water from the study area to meet municipal and industrial water supply needs is approximately 0.5 percent[7] of the annual flow in the Columbia River Basin, which is about 10 times smaller than 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 immeasurable when compared to the total flow in the system. Most of this water is diverted under flow rights issued by the States.

The largest municipal and industrial water withdrawals from the lower Snake and lower Columbia rivers are concentrated on or near the Lower Granite and McNary reservoirs. Water users withdrawing directly from the McNary Pool include the cities of Hermiston, Richland, Kennewick, and Pasco. Industrial water users, including the Port of Umatialla, also have intakes nearby. The City of Lewiston and Potlach Corporation have water supply intakes on the Clearwater above Lower Granite. The Columbia Basin Project has water rights to deliver 70,000 acre-feet of M&I water to its patrons.

1.2 ALTERNATIVES

The Environmental Impact Statement (EIS) evaluates possible effects from four Multiple Objective alternatives (MO1–MO4) and a No-Action alternative. Each Multiple Objective alternative was assessed relative to the No-Action following similar criteria. Each Multiple Objective alternative contained measures (or actions) that were analyzed to meet the objective of the alternative. For complete descriptions of operational changes associated with each alternative, see Chapter 2 of the main EIS document.

Table 1-1 highlights the potential actions that could affect physical water supply resources, which alternative measures these potential actions are associated with, the locations that could be potentially affected, the potential temporal scope of effects, and the metric or measure that will be used to assess the effect.

Table 1-1. Potential Cause-and-Effect Analysis for Physical Water Supply

Alternative Measure(s)	Potential Action	Potential Effect	Location of Potential Effect	Temporal Scope of Potential Effect	Metric Used to Assess Environmental Effect
MO1.O8, MO2.O9, MO3.O11, MO4.O13	Change to upstream Storage Correction Method as applied to Grand Coulee storage reservation diagram	Change in reservoir pool elevations	Grand Coulee/ Lake Roosevelt – Pump Generators	January through April	Pool elevations, operational range of the pump generators, pump capacity to pump water to Banks Lake.

[7] Calculated using 650,000 acre-feet (USGS 2017) from the counties using M&I water in the study area and 133 MAF from Northwest River Forecast Center (2018).

Alternative Measure(s)	Potential Action	Potential Effect	Location of Potential Effect	Temporal Scope of Potential Effect	Metric Used to Assess Environmental Effect
MO1.O9, MO2.O10, MO3.O12, MO4.O14	Change in the Grand Coulee Dam draft rate used in planning drawdown	Change in reservoir pool elevations	Grand Coulee/ Lake Roosevelt – Pump Generators	Winter to spring	Pool elevations, operational range of the pump generators, pump capacity to pump water to Banks Lake.
MO1.O10, MO2.O11, MO3.O13, MO4.O15	Change in operational constraints for ongoing Grand Coulee Maintenance of power plants and spillways.	Change in reservoir pool elevations	Grand Coulee/ Lake Roosevelt – Pump Generators	Winter to Spring	Pool elevations, operational range of the pump generators, pump capacity to pump water to Banks Lake.
MO1.O11, MO2.O12, MO4.O16	New draft requirements to protect against rain-induced flooding.	Change in reservoir pool elevations	Grand Coulee/ Lake Roosevelt – Pump Generators	Mid-December through March	Pool elevations, operational range of the pump generators, pump capacity to pump water to Banks Lake.
MO3.S1	Removal of earthen embankments and adjacent structures.	Change in reservoir pool elevations	Pumps at the following project pools: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite projects	Year round	Irrigation and M&I pumps elevations, pump capacity, reservoir pool water surface elevations.
MO3.S1	Removal of earthen embankments and adjacent structures	Change in groundwater elevations	Groundwater wells within 1 mile of the following project pools: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite projects	Year round	Well locations, well depths, operational range of wells, well pumping capacity.
MO4.O7	Maintenance of minimum 220/200 thousand cubic feet per second spring flow objective at McNary	Change in reservoir pool elevations	Grand Coulee	May 1 to June 15/ June 16 to July 31	Pool elevations, operational range of the pump generators, pump capacity to pump water to Banks Lake.

Alternative Measure(s)	Potential Action	Potential Effect	Location of Potential Effect	Temporal Scope of Potential Effect	Metric Used to Assess Environmental Effect
MO4.O8	Reservoir drawdown to Minimum Operating Pool	Change in reservoir pool elevations	John Day	Year round	Pool elevations
MO4.O8	Reservoir drawdown to Minimum Operating Pool	Change in groundwater elevations	John Day	Year round	Pool elevations

1.3 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 may potentially affect the ability to supply water for irrigation and municipal and industrial (M&I) purposes. Only the reaches where the analysis showed a physical change were further analyzed for socioeconomic effects.

The hydrology and hydraulics (H&H) models assume that current the diversion volume[8] of water for irrigation and M&I is delivered in all years and in all alternatives. So, the flow in the river in all years and 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 pool elevation such that water could not physically be diverted could affect the ability to deliver water. In addition, pool elevations could also affect efficiency, or the energy required to pump water both from surface and groundwater pumps.

The area of analysis for physical and socioeconomic water supply does not include Banks Lake or the Columbia Basin Project. Effects on the Columbia River from pumping water to Banks Lake are considered, but how water is managed in Banks Lake or delivered to the Columbia Basin Project is not considered. Additional information is provided in Chapter 5 of this appendix.

In addition, socioeconomic impacts were not evaluated for increased pumping from Grand Coulee or increased water supply from Hungry Horse or for the Chief Joseph Dam Project for the water supply measures. The details of how and where this water would be used is unknown and additional NEPA would be needed prior to implementation. Additional information is provided in Chapter 5 of this appendix.

[8] This includes all diversions for irrigation and M&I including both Federal and non-Federal obligations.

CHAPTER 2 - METHODS

2.1 OVERVIEW

This analysis primarily uses modeled or described[9] water surface elevation in the affected reaches to determine impacts. Both the ability to pump from the rivers or reservoirs behind the dams and groundwater wells can be affected by the water surface elevation in the rivers and reservoirs. John Day and Lower Snake reaches in this study are impounded behind dams that are considered run-of-river, which means that they do not store a lot of water and their water surface elevation does not change substantially. Grand Coulee elevations vary seasonally and annually due to varying flood, irrigation, and ecological operations.

2.2 PROCESS

A water supply study team was convened to develop evaluation criteria, collect data, and to review analysis results. The team consisted of at least one person from the co-lead agencies and representatives from about 15 of the cooperating agencies that had expressed interest in Water Supply in their Memorandum of Understanding.

During alternatives development, the team met regularly to discuss the scope of analysis and to develop an analysis plan. The team also met regularly as data was being collected, processed, and assessed for use in the analysis. Meetings were less frequent as the team waited for H&H modeling results and began documenting background information and early analysis. The team was given multiple opportunities to review written products as the analysis was developed and finalized through the spring and summer of 2019. Comments were tracked and responses were documented. Every effort was made to incorporate comments, but some comments could not addressed be due to data limitations or relevance to the NEPA process.

2.3 DATA COLLECTION AND PREPARATION

The study team collected a large amount of data for this analysis that included water use statistics for each state, diversion location and place of use, delivery efficiency estimates, and crop types. Because the study area covers many states and a large geographic area, it was necessary to use multiple data sets from a variety of sources. The data sets were compared and combined to ensure the most complete set of data could be used for analysis.

The analysis required data on the diversion point and lands associated with surface water delivery and data on the diversion point and lands associated with groundwater wells within one mile of the river. Data collection occurred concurrently with the development of EIS alternatives and measures. Additional information about the data collection and processing can be found in a technical memorandum that describes the development of this data (Reclamation 2019).

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[9] Not all proposed water surface elevations were modeled, so sometimes the descriptions in the measures themselves were used to analyze affects.

2.3.1 Surface Water Data

Both M&I and Agricultural water can be delivered from surface water. Most of the surface water from the study area rivers is delivered via pumps and intakes in the rivers or reservoirs. The states' geospatial water right datasets provided diversion locations that were used as surrogates for the surface water pumps. Each state collects and maintains their water right information differently. In cases where diversion type data were missing, water source data (e.g. surface vs. groundwater sources) were used to estimate diversion types and fill in missing data. Points of diversion classified by diversion type and/or water source were summarized from agricultural and municipal and industrial uses.

The points of diversion for each reach were linked to agricultural lands via place-of-use data (spatial data that indicates where the water can be used). Obvious data problems, such as a single county-sized place-of-use in Oregon, or places-of-use[10] far from their associated reach, were edited by removing them from the dataset to avoid mis-representing the place-of-use.

Many places-of-use are based upon property boundaries, and not all lands within the area are cultivated. In order to limit places-of-use to agricultural lands and determine the number of acres irrigated from each reach, the places-of-use were clipped to the extent of mapped crops, called crop-delimited (in other words, place of use areas that did not overlay crops were excluded). The places-of-use were spatially overlain on the CropLand Data Layers (CDLs) for 2013 to 2017 (U.S. Department of Agriculture [USDA] National Agricultural Statistics Service Cropland Data Layer, 2013–2017). The CDLs are pixel-based spatial datasets where each 30 m^2 pixel was classified as a different crop type based upon the light reflectance signatures of different crops. The USDA releases a new layer each year that is based upon satellite measurements of surface reflectance throughout the year. Any pixels within the places-of-use that supported crops in at least one of the five years were classified as irrigated lands. The crop-delimited places-of-use were then totaled to estimate the total acres of land irrigated from each reach and classified by combined water sources and diversion types.

Additionally, by overlaying the place-of-use dataset and the CDLs, the number of acres of individual crops that were grown in each irrigated area were determined for each year and averaged over the five years. Linking the place-of-use back to the point of diversion allowed the crop types to be summarized by each socioeconomic region.

States' water rights databases are often not a reliable method for obtaining the amount of water delivered because often only the maximum delivery rate is reported, which would overestimate the amount of water actually delivered. The following two methods were used to define water diverted for irrigation and M&I.

Irrigation depletion (diversion minus return flow) was summarized from the 2010 Modified Flows Study (Bonneville Power Administration [BPA] 2011) for the reaches that were within the

[10] Place-of-use are the lands where diverted water can be applied. These are defined by the States under water rights.

study area. Modified Flows is a process where unregulated streamflow is adjusted by removing irrigation diversion and adding in return flows. The diversions and return flows that are used in the 2010 dataset are representative of average conditions from 2000 to 2008. These diversions are summarized for the study area in the No Action alternative section.

M&I use was summarized from the USGS water use study data (USGS 2018). The team obtained the county-level water use dataset, which was the finest resolution dataset from the USGS, and used it to summarize the amount of surface water used for both M&I and irrigation within counties overlapping the study area.

2.3.2 Groundwater Data

The study area included groundwater points of diversion (wells) that were up to one mile away from the study rivers. These data points were identified using the points of diversion and water use datasets. Information on well pumping rates were incomplete, so the volume of groundwater withdrawals potentially affected was not assessed.

2.4 ALTERNATIVE ANALYSIS

Four Multiple Objective alternatives were analyzed for this EIS, compared to a No-Action alternative, to understand the effect to water delivery and associated lands.

2.4.1 Physical Analysis

Water supply in the affected reaches is largely driven by a threshold surface water elevation, where the reservoir pool elevation has historically been high enough for the pumps to be able to operate. If the pool or river stage elevations drop below the historical operational minimum, they may still be able to operate, but may be less efficient, or they may not be able to operate at all. This analysis only considers negative effects to efficiencies in reaches where pool elevations drop below historical operating elevations but are still able to operate.

Modeled water surface elevation in the affected reaches using ResSim (see Appendix B: Hydrology and Hydraulics Data Analysis) is used as a key indicator to assess environmental consequences of the measures. Where the models did not explicitly simulate proposed changes in measures, the description of elevation changes in the measures was used. For example, in the Ice Harbor pool, the minimum operating elevation is 437 feet based on National Geodetic Vertical Datum of 1929 (NGVD29). Pumps in this pool were designed to work with this minimum operating pool. If the pool is lowered because the dam is removed (as is proposed in MO3), these pumps will no longer be able to operate.

The models assume that the same amount of water will be diverted from the river reaches in each year. The amount that is diverted is representative of current diversions as defined in the 2010 Modified Flows study (BPA 2011). This results in the same amount of water being diverted in each year, regardless of conditions, and therefore generally indicates no impact to water supply deliveries since that water is in fact delivered in each year in the models. The model results then reflect the flow and stage that would result from diverting that water in all years.

Another step in the analysis was considered to take in to account possible changes in water surface elevation that could impact the ability for a pump to operate. In many cases within in the study area, irrigation developed in places where other operations (navigation and power generation) required stable pool elevations. So, the pumps in these regions rely on operating ranges that have not historically changed. The analysis used the information in the measures that stated if a pool elevation would be decreased to determine if the pumps may no longer be able to operate or could be less efficient. Similar assessments were conducted for areas where water is diverted from rivers.

For pumping from Lake Roosevelt to Banks Lake, a monthly pumping rate (Figure 2-1) representative of current water rights (Table 2-1) and environmental compliance is used.

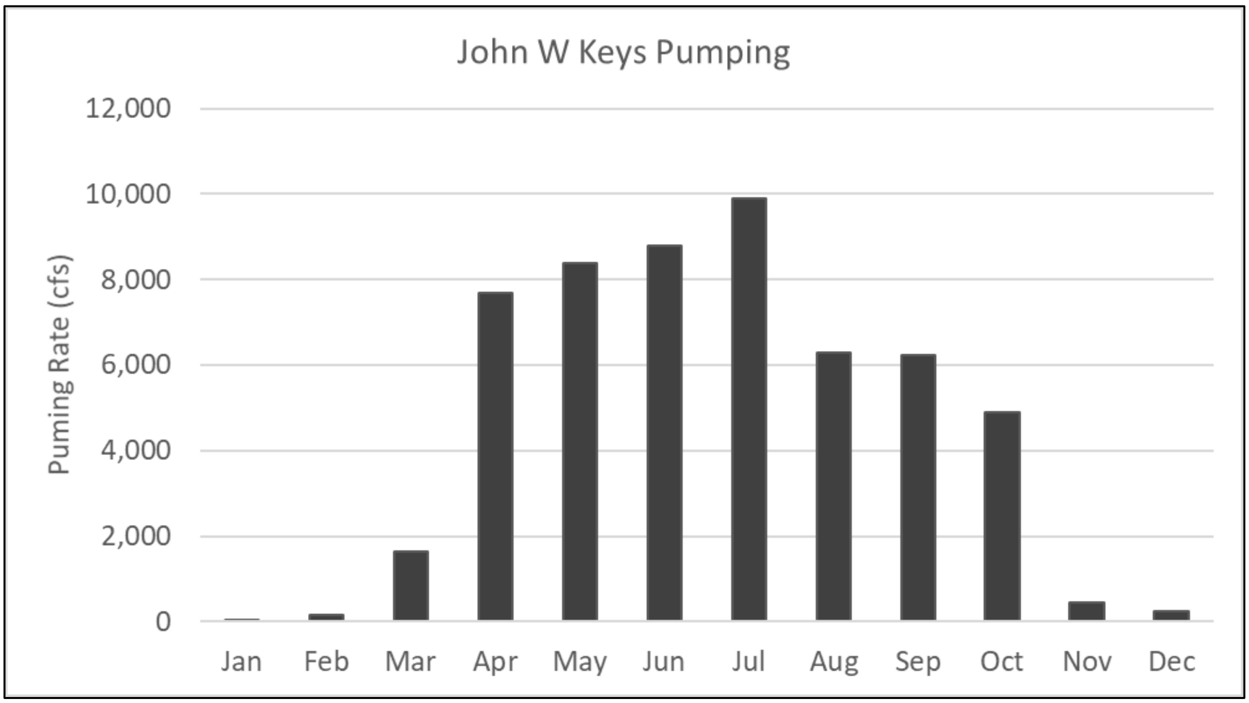

Figure 2-1. Monthly Pumping Rate Used in No Action Models and for Comparison in Analysis

Table 2-1. Water Rights to Pump Water from Lake Roosevelt to Banks Lake for Columbia Basin Project

Certificate Number	Acres	Duty (acre-feet/acre)	Volume (acre-feet)	Additional Information
S3-01622C	590,000	4.83	2,910,000	60,000 acre-feet is used for M&I
S3-28586	50,000	4.08	214,000	10,000 acre-feet is used for M&I
S4-33091P	70,000	2.34	164,000	–
S3-30486	10,000	3.00	30,000	–
Total	***772,525***	**–**	***3,318,000***	**–**

Potential effects to groundwater were analyzed qualitatively using the assumption that groundwater wells within one mile of the rivers and reservoirs could be hydraulically connected to the local aquifers. Wells close to the surface feature will experience more of an effect than those further away; however, the aquifer would need to be hydraulically connected for there to be any effect. Though there was not sufficient data to quantitively asses the degree of connectivity or the effect it would have on wells, qualitative statements were made if it was possible that wells could be effected given changes in surface water elevations from the No Action.

2.4.2 Socioeconomic Analysis

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 crop production values for those lands. The irrigated lands receiving water from these pumps were estimated using the USDA Cropland Data Layer as discussed above. These acreage estimates were the basis for cropland land acreages and cropping patterns in the socioeconomic analysis. The potential socioeconomic effects related to M&I water deliveries were also analyzed based on the changes to physical water diversions.

The proposed alternatives were analyzed using two economic measures: 1) the social welfare effects, or direct impacts; and 2) the regional economic impacts. A regional impact 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 alternatives for other social effects.

The results of the social welfare analysis and the regional 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 impacts, which are flows of money (or employment) into or out of a defined region. The regional impacts 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 which are not translated into actual money flows.

The regional effects analysis includes not only the initial or direct impact on the primary affected industries, but also the secondary impacts resulting from those industries providing inputs to the directly affected industries as well. This analysis also includes the changes in economic activity stemming from household spending of income earned by those employed in the sectors of the economy that are impacted either directly or indirectly. These secondary impacts are often referred to as "multiplier effects."

The modeling package used to assess the regional economic impacts stemming from the expenditures associated with each alternative was IMPLAN (IMpact analysis for PLANning). IMPLAN is an economic input-output modeling system that estimates the effects of economic changes in a defined analysis area. The regional effects include employment, output (sales), and labor income. Employment measures the number of jobs (full time and part time) related to each industry sector of the regional economy. Labor income is the sum of employee compensation[11] and proprietor income[12]. 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 (annual model) when the impacts are expected to occur, based on the makeup of the economy at the time of the underlying IMPLAN data (this analysis used 2017 data, the most current at the time of the analysis). 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 relative changes between the No Action Alternative and the action alternatives and cannot be used to predict or forecast future employment, labor income, or output (sales).

Input-output models measure commodity flows from producers to intermediate and final consumers. Purchases for final use (final demand) drive the model. Industries produce goods and services for final demand and purchase goods and services from other producers. These other producers, in turn, purchase goods and services. This buying of goods and services (indirect purchases) continues until leakages from the analysis area (imports and value added) stop the cycle. These indirect and induced effects (the effects of household spending) can be mathematically derived using a set of multipliers. The multipliers describe the change in output for each regional industry caused by a 1-dollar change in final demand.

This analysis used 2017 IMPLAN data for the counties which encompass the Study Areas. IMPLAN data files for the analysis area are compiled from a variety of sources including the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor Statistics, and the U.S. Census Bureau.

2.4.2.1 Acres Affected by Socioeconomic Region

The socioeconomic analysis for water supply is based on the acres shown in Table 2-2. These data were summarized by reach and county to estimate the number of acres by crop using surface water or groundwater from each reach to more accurately estimate the water supply socioeconomic impacts for each alternative.

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[11] IMPLAN defines employee compensation as "the total payroll cost of wage and salary employees to the employer. This includes wages and salaries, all benefits (e.g., health, retirement) and payroll taxes (both sides of social security, unemployment insurance taxes, etc.).

[12] IMPLAN definition of proprietor income: proprietor income consists of payments received by self-employed individuals and unincorporated business owners. This includes current-production income of sole proprietorships, partnerships, and tax-exempt cooperatives

Table 2-2. CDL Estimated Crop Acres by County and Water Supply Socioeconomic Region (annual averages, 2013–2017)

Water Supply Socioeconomic Region	County and State	Alfalfa	Other Hay	Small Grains	Irrigated Vegetables	Fruit Crops	Grapes	Total
Lower Granite	Nez Perce, ID	6	11	5	2	0	0	24
Little Goose	Garfield, WA	0	1	11	4	0	0	17
Little Goose	Whitman, WA	20	9	16	1	0	0	46
Total	–	***25***	***21***	***32***	***7***	***0***	***0***	***86***
Lower Monumental	Columbia, WA	9	20	159	0	0	0	189
Lower Monumental	Franklin, WA	3	0	5	0	2	0	11
Lower Monumental	Walla Walla, WA	72	10	361	28	0	2	474
Ice Harbor	Franklin, WA	450	25	3,874	4,140	1,628	209	10,326
Ice Harbor	Walla Walla, WA	1,355	188	10,359	7,963	14,170	2,801	36,836
Total	–	***1,889***	***244***	***14,758***	***12,131***	***15,801***	***3,013***	***47,835***

2.4.2.2 Analysis Area

The river reaches and associated counties were combined into 5 analysis regions for describing water supply related socioeconomic effects; 1) Ice Harbor and Lower Monumental, 2) Lower Granite and Little Goose, and 3) John Day. The socioeconomic regions were determined based on the economic relationships which are shared among counties and the types of farm operations. Table 2-3 summarizes the river reaches, counties, and analysis regions.

Table 2-3. Water Supply Socioeconomic Analysis Areas

<table>
<tr><th>Reach Name</th><th>Region Name</th><th>County</th><th>State</th><th>County and State Included in the Socioeconomic Analysis Region</th><th>Modeled Socioeconomic Region Name</th></tr>
<tr><td>Libby, Hungry Horse and Albeni Falls</td><td>Region A</td><td>Bonner</td><td>ID</td><td>Bonner, ID</td><td>Bonner</td></tr>
<tr><td>Grand Coulee</td><td>Region B</td><td>Adams
Franklin
Grant
Lincoln</td><td>WA
WA
WA
WA</td><td>Adam, WA
Franklin, WA
Grant, WA
Lincoln, WA</td><td>Columbia Basin</td></tr>
<tr><td>Lower Granite</td><td>Region C</td><td>Nez Perce
Asotin</td><td>ID
WA</td><td rowspan="2">Nez Perce, ID
Garfield, WA
Whitman, WA
Asotin, WA</td><td rowspan="2">Lower Granite and Little Goose</td></tr>
<tr><td>Little Goose</td><td>Region C</td><td>Garfield
Whitman</td><td>WA
WA</td></tr>
<tr><td>Ice Harbor</td><td>Region C</td><td>Franklin
Walla Walla</td><td>WA
WA</td><td rowspan="2">Columbia, WA
Franklin, WA
Walla Walla, WA</td><td rowspan="2">Ice Harbor and Lower Monumental</td></tr>
<tr><td>Lower Monumental</td><td>Region C</td><td>Columbia
Franklin
Walla Walla</td><td>WA
WA
WA</td></tr>
<tr><td>John Day</td><td>Region D</td><td>Benton
Klickitat
Morrow
Umatilla</td><td>WA
WA
OR
OR</td><td>Benton, WA
Klickitat, WA
Morrow, OR
Umatilla, OR</td><td>John Day</td></tr>
</table>

CHAPTER 3 - PHYSICAL EFFECTS ANALYSIS

3.1 NO-ACTION ANALYSIS

The No-Action Alternative simulates the state of the system in 25 years if current operations were not changed. The No-Action Alternative serves as a point of comparison, or baseline, for the other alternatives. As such, it is processed and analyzed following the same consistent methodology as the other alternatives. The No Action Alternative represents a continued supply of water to existing users as it has in the recent past. It is assumed in the model that an average diversion every year is representative of current conditions. Regardless of conditions, water supply from surface water resources is not impacted in the No Action.

Aquifers typically have some hydrogeologic connectivity to nearby lakes and streams, and depending on the degree of connectivity, changes in the surface feature may cause changes in the aquifer. 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, it is not anticipated that the elevations in any of the streams or reservoirs will affect nearby groundwater wells because the operation is representative of the historical range.

3.1.1 Region A – Libby, Hungry Horse, Albeni Falls

In Region A, approximately 675,000 acre-feet of water is diverted on average annual basis for irrigation with a portion of that water returning to the rivers as return flows (BPA 2011). 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 2018; Table 3-1). Figure 3-1 shows the areas irrigated from water diverted from study area H&H reaches in Region A (Reclamation 2019). The numbers on the reaches correspond to ResSim model reaches. There are approximately 1,390 diversions in these reaches and 4,430 wells within 1 mile of the river, as counted from the point of diversion files described in Chapter 2 of this appendix.

Table 3-1. Summary of M&I Use by County for Surface and Groundwater in Counties that Border the CRSO Reaches in Region A

County	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***

Source: USGS (2018)
Note: Kootenai County was not included because most of the M&I use was near Coeur d'Alene in that county, which is not within the study area.

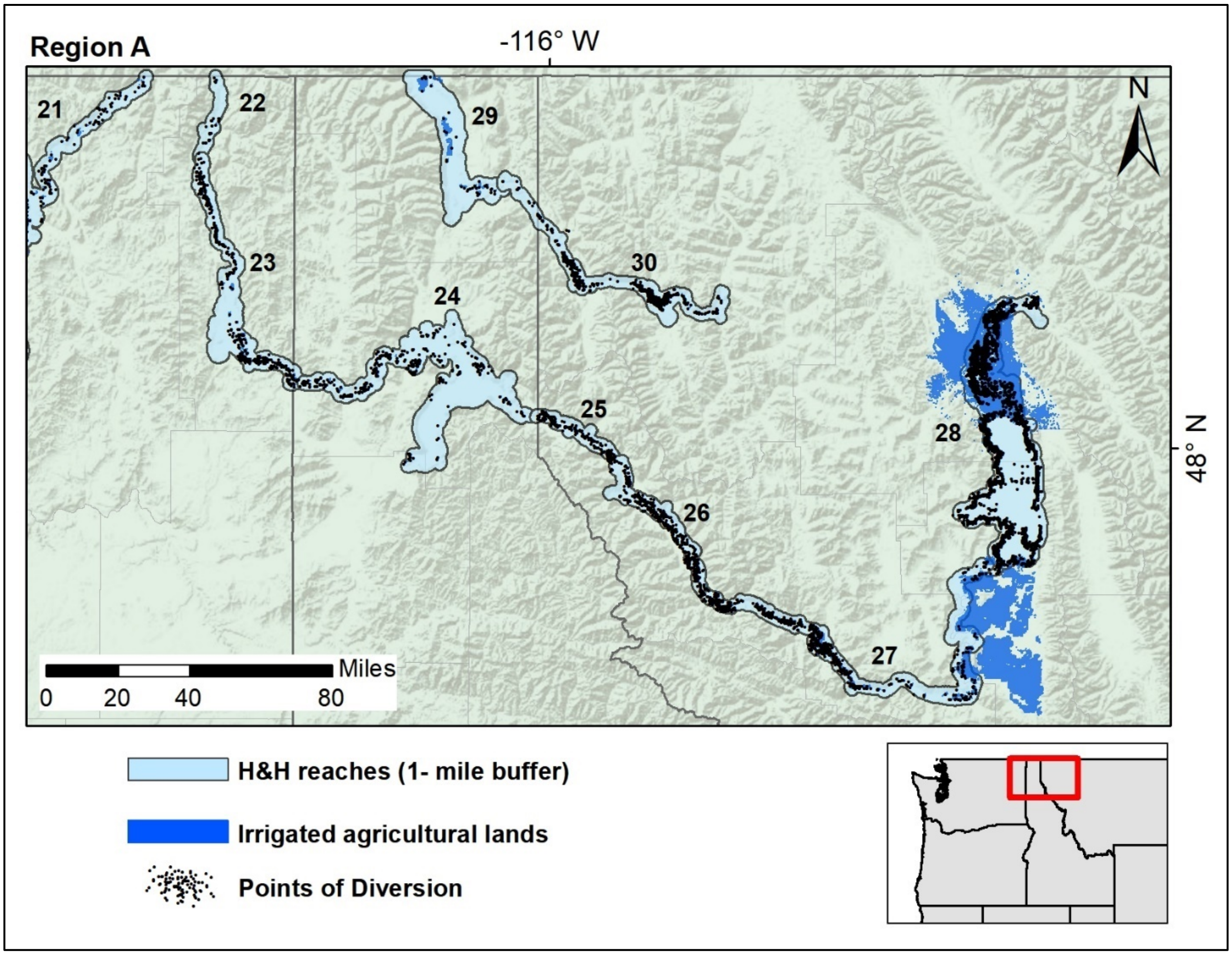

Figure 3-1. Points of Diversion and Land Irrigated from Water Diverted from Study Area H&H Reaches in Region A

3.1.2 Region B – Grand Coulee, Chief Joseph

In Region B, a volume of 3.318[13] million acre-feet is pumped annually from Lake Roosevelt for irrigation and M&I purposes on the Columbia Basin Project. An additional 16,860 acre-feet is diverted on average annual basis from the countries surrounding Region B for M&I purposes from both surface and groundwater (USGS 2018; Table 3-2). Figure 3-2 shows the areas irrigated from water diverted from study area H&H reaches in Region B (Reclamation 2019). The numbers on the reaches correspond to ResSim model reaches. There are approximately 200 diversions in these reaches and 370 wells within 1 mile of the river, as counted from the point of diversion files described in Chapter 2 of this appendix.

[13] The full water right value is used in the No Action even though portions are still under development since they are reasonably certain to occur within the EIS project horizon.

Table 3-2. Summary of M&I Use by County for Surface and Groundwater in Counties that Border the CRSO Reaches 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***

Source: USGS (2018)

Note: Douglas County, WA, was not included because most of the M&I use was near Wenatchee in that county, which is not within the study area. Okanagan County, WA, was also removed because only a very small corner of the county bordered the Columbia River and there did not appear to be any M&I activity in the area.

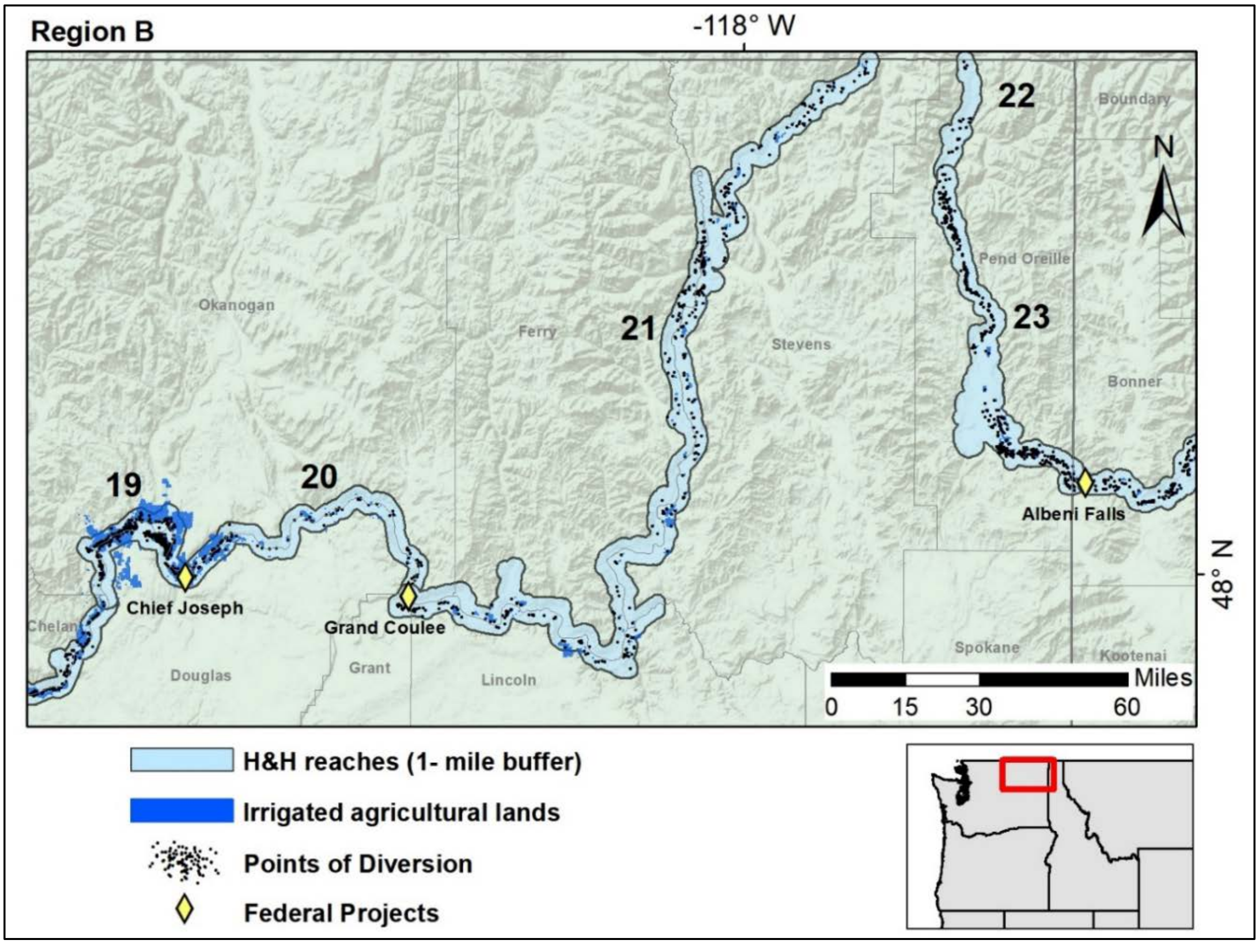

Figure 3-2. Points of Diversion and Land Irrigated from Water Diverted from Study Area H&H Reaches in Region B

3.1.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

In Region C, approximately 316,000 acre-feet of water is diverted on average annual basis for irrigation with a portion of that water returning to the river as return flows (BPA 2011). In the counties surrounding Region C, approximately 21,330 acre-feet is diverted for M&I purposes (USGS 2018; Table 3-3). Figure 3-3 shows the areas irrigated from water diverted from study area H&H reaches in Region C (Reclamation 2019). The numbers on the reaches correspond to ResSim model reaches. There are approximately 80 diversions in these reaches and 200 wells within 1 mile of the river, as counted from the point of diversion file described in Chapter 2 of this appendix.

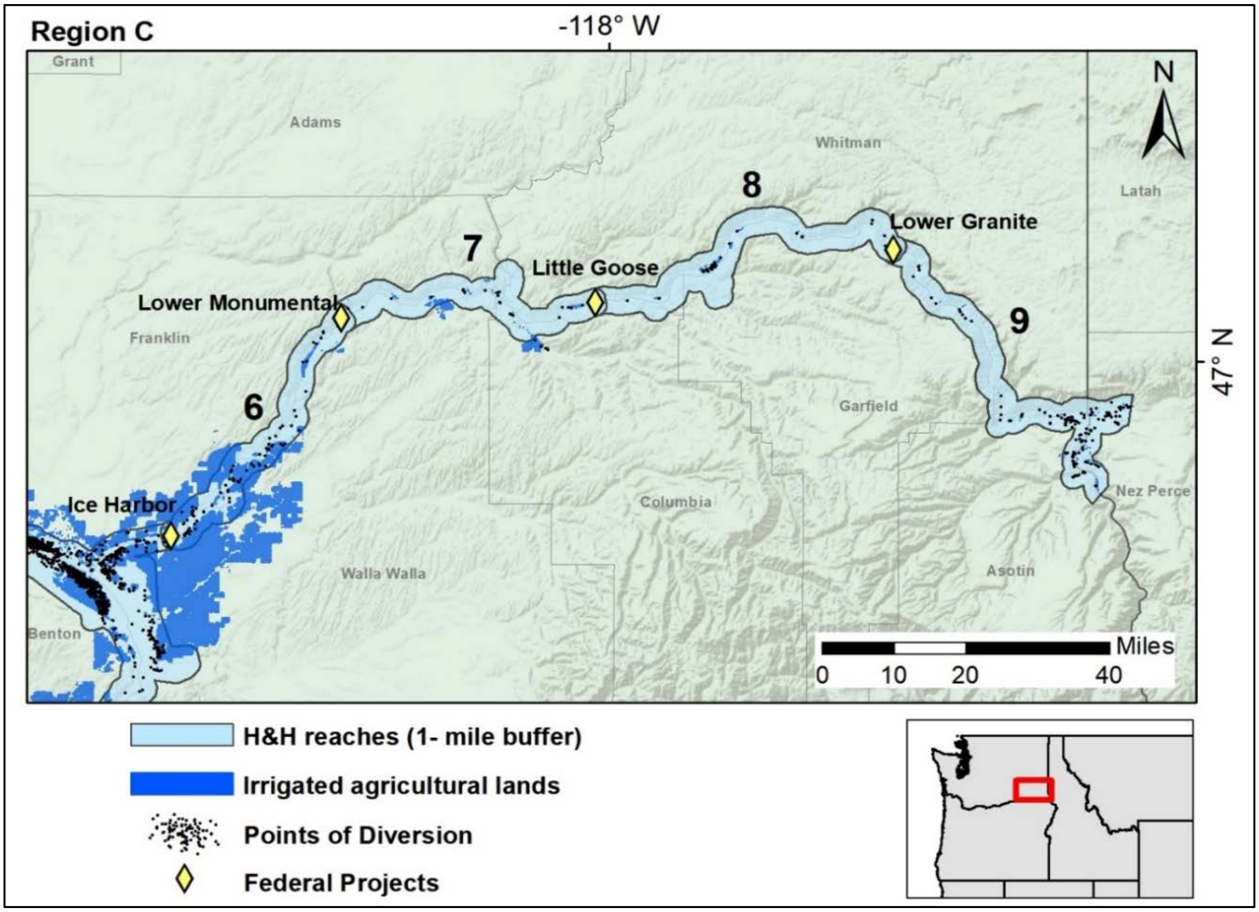

Figure 3-3. Points of Diversion and Land Irrigated from Water Diverted from Study Area H&H Reaches in Region C

Table 3-3. Summary of M&I Use by County for Surface and Groundwater in Counties that Border the CRSO Reaches in Region C

County	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***

Source: USGS (2018)

Note: Did not include Columbia County, WA, Whitman County, WA, and Franklin County, WA because there did not appear to be any M&I activity along the Lower Snake. Removed Walla Walla County, WA, because most of the M&I activity was in the city of Walla Walla, which is not in the study area.

3.1.4 Region D – McNary, John Day, The Dalles, Bonneville

In Region D, approximately 530,000 acre-feet of water is diverted on average annual basis for irrigation with a portion of water returning to the river as return flows (BPA 2011). In the counties surrounding Region D, about 34,400 acre-feet are diverted for M&I purposes (USGS 2018; Table 3-4). Figure 3-4 shows the areas irrigated from water diverted from study area H&H reaches in Region D (Reclamation 2019). The numbers on the reaches correspond to ResSim model reaches. There are approximately 240 diversions in these reaches and 1,850 wells within 1 mile of the river, as counted from the point of diversion file described in Chapter 2 of this appendix.

Table 3-4. Summary of M&I Use by County for Surface and Groundwater in Counties that Border the CRSO Reaches in Region D

County	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***

Source: USGS (2018)

Note: 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).

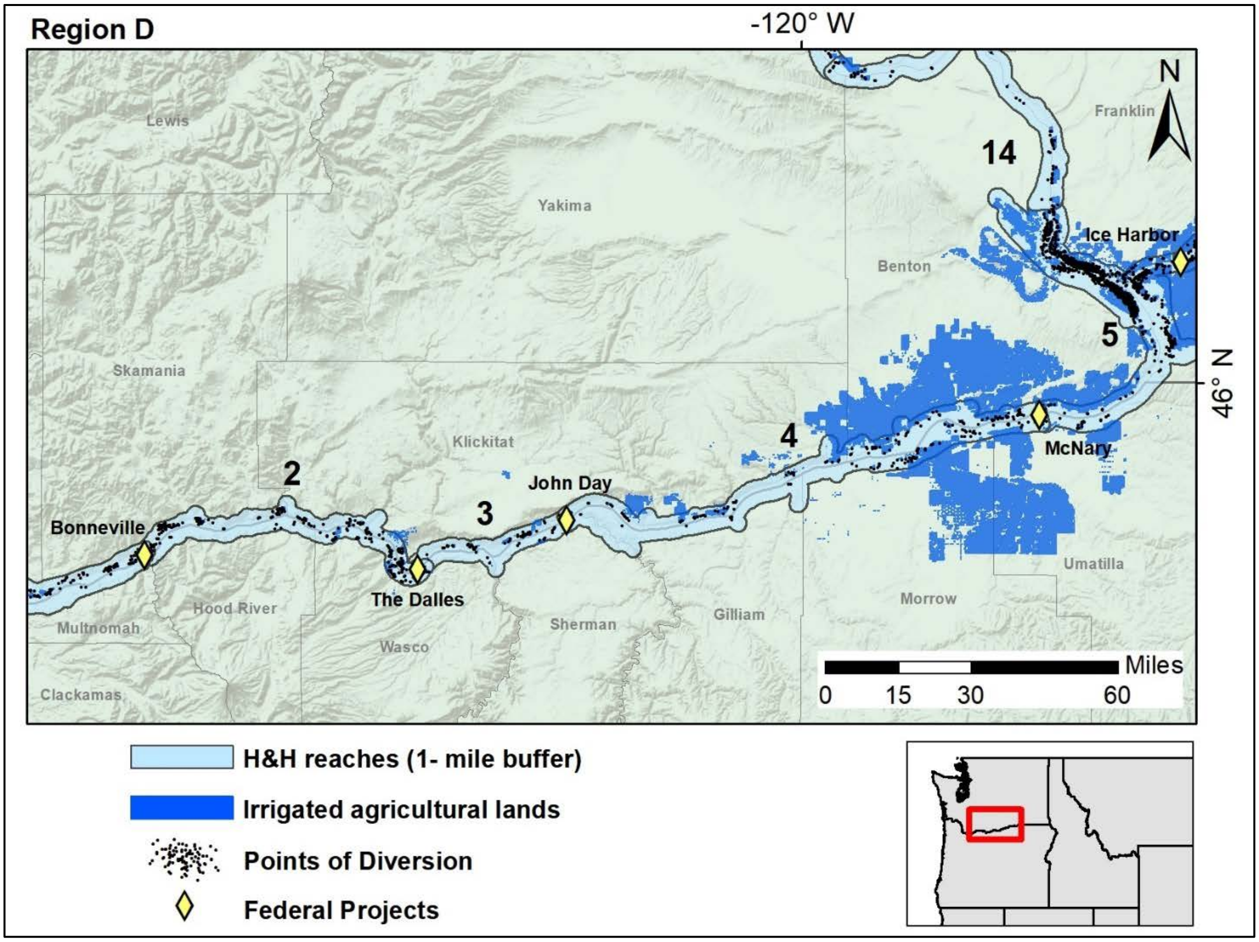

Figure 3-4. Points of Diversion and Land Irrigated from Water Diverted from Study Area H&H Reaches in Region D

3.2 MULTIPLE OBJECTIVE ALTERNATIVE 1

The H&H models assumed that current level diversions will be diverted in all years, which indicates that the volume of water needed for water supply will be available for diversion in all years. Because of is assumption, the flow and stage in the MO1 model results reflect meeting those diversions in all years, and the effect of diverting the water is included in the analysis for the resources including H&H, water quality, and fish that use those model results. There are possible negligible effects to pumping costs for MO1 if pool elevations or river stages drop below current pump configurations. Those locations are identified in this section, but are effects are not quantified because of limited data.

3.2.1 Region A – Libby, Hungry Horse, Albeni Falls

The H&H model results for MO1 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-5 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-5. Summary of H&H and Water Supply Effects for MO1 in Region A

Indicator	H&H effect	Water Supply effect
Lake Koocanusa (Libby Dam reservoir)	Lake levels higher than No Action Alternative (NAA) year-round	No effect
Libby Dam outflow	Lower Dec flows in some years, but not lower than lowest winter flows in NAA. Higher than NAA in Nov, Jan, and Feb.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Elevation is controlled by downstream lake, so likely no change to pumping costs.
Hungry Horse reservoir	Lower lake levels than NAA.	No effect because there are no water supply diversions for irrigation or M&I directly from the pool.
Hungry Horse Dam (outflow)	Lower outflow than NAA in April, May, and June, but not lower than summer lowest. Higher than NAA in July, Aug, and Sep.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Change in flow translates to immeasurable difference in head, so no impact to pumping costs.
Lake Pend Oreille	No change	No effect

3.2.2 Region B – Grand Coulee, Chief Joseph

The H&H model results for MO1 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-6 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-6. Summary of H&H and Water Supply Effects for MO1 in Region B

Indicator	H&H effect	Water Supply effect
Lake Roosevelt (Grand Coulee Dam Reservoir)	Lower lake elevations than NAA in Dec, Jan, and April 10.	No effect to the ability to deliver water because it assumed that pumps can operate given that lake levels are not lower than lowest NAA elevation. Possible minor effect to pumping costs in some years in the spring. These are quantified for John W Keys pumping plant, but not for other small surface or groundwater users on the Lake because there is not enough information about the pumps.
Grand Coulee Dam outflow	Lower Feb, Mar, Apr, May, Jun, Jul, Aug flows than NAA. Higher than NAA in Dec.	No effect to the ability to deliver water because the pool at Chief Joseph is not changing from NAA, so water surface and groundwater elevations are not affected regardless of outflow from Grand Coulee.
Rufus Woods Lake (Chief Joseph Dam reservoir)	No change from NAA	No effect

3.2.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

The H&H model results for MO1 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see

Chapter 3 – Table 3-4). Table 3-7 describes the H&H effects that could affect the physical ability to divert water and whether there is a possible effect to water supply.

Table 3-7. Summary of H&H and Water Supply Effects for MO1 in Region C

Indicator	H&H effect	Water Supply effect
Dworshak Reservoir	Lower lake elevations than NAA in Jun, Jul, Aug and higher than NAA in Sep.	No effect because there is not irrigation or M&I diverting from the pool.
Dworshak Dam outflow	Higher outflows than NAA in Jun, Jul, and Sep; lower than NAA in Aug. Lowest outflow is not lower than NAA in the summer.	No irrigation or M&I above Lewiston, so no effect.
Lower Granite Dam Reservoir	Higher pool elevations than NAA	No effect
Little Goose Dam Reservoir	Higher pool elevations than NAA	No effect
Lower Monumental Dam Reservoir	Higher pool elevations than NAA	No effect
Ice Harbor Dam Reservoir	Higher pool elevations than NAA	No effect

3.2.4 Region D – McNary, John Day, The Dalles, Bonneville

The H&H model results for MO1 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 – Table 3-4). Table 3-8 describes the H&H effects that could affect the physical ability to divert water and whether there is a possible effect to water supply.

Table 3-8. Summary of H&H and Water Supply Effects from MO1 in Region D

Indicator	H&H effect	Water Supply effect
McNary Dam outflow	Lower than NAA in May and June	No effect to the ability to deliver water because the pool at John Day is higher from NAA, so water surface and groundwater elevations are not affected regardless of outflow from McNary.
Lake Umatilla (John Day Dam Reservoir)	Higher pool elevations than NAA	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels.
The Dalles Reservoir	No change from NAA	No effect
Bonneville Reservoir	No change from NAA	No effect

3.3 MULTIPLE OBJECTIVE ALTERNATIVE 2

The H&H models assumed that current level diversions will be diverted in all years, which indicates that the volume of water needed for water supply will be available for diversion in all years. Because of is assumption, the flow and stage in the MO2 model results reflect meeting those diversions in all years, and the effect of diverting the water is analyzed for the resources including H&H, water quality, and fish that use those model results. There are possible negligible effects of changes to pumping costs for MO2 if pool elevation or river stages drop below current pump configurations. Those locations are identified in this section, but are impacts are not quantified because of limited data.

3.3.1 Region A – Libby, Hungry Horse, Albeni Falls

The H&H model results for MO2 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-9 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-9. Summary of H&H and Water Supply Effects for MO2 in Region A

Indicator	H&H effect	Water Supply effect
Lake Koocanusa (Libby Dam reservoir)	Lake levels lower than NAA in winter (about 20 feet) and higher than NAA in summer (about 1 foot). However, lower elevations are not lower than lowest elevation in NAA.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Possible negligible effect to winter pumping costs; these effects are not quantified in this analysis because there is not enough information about these pumps
Libby Dam outflow	Lower Jan and Feb flows than NAA. Higher than NAA in Nov and Dec. Lower flows than NAA in Jul, Aug, and Sep, but not lower than lowest outflow in NAA.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Elevation is controlled by downstream lake, so likely no change to pumping costs.
Hungry Horse reservoir	Lower lake levels than NAA.	No effect because there are no water supply diversions for irrigation or M&I directly from the reservoir.
Hungry Horse Dam (outflow)	Lower outflow than NAA in April, May, June, Jul, Aug, and Sep, lower than NAA in many years; lowest flow 100 cfs lower than lowest NAA summer flow but not lower than lowest annual flow. Higher than NAA in Jan and Feb.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Change in flow translates to immeasurable difference in head, so no impact to pumping costs.
Lake Pend Oreille	No change	No effect

3.3.2 Region B – Grand Coulee, Chief Joseph

The H&H model results for MO2 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-10 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-10. Summary of H&H and Water Supply Effects for MO2 in Region B

Indicator	H&H effect	Water Supply effect
Lake Roosevelt (Grand Coulee Dam Reservoir)	Lower lake elevations than NAA in Dec, Jan, April 10, and Sep.	No effect to the ability to deliver water because it assumed that pumps can operate given that lake levels are not lower than lowest NAA elevation. Possible negligible effect to pumping costs. These are quantified for John W Keys pumping plant, but not for other small surface or groundwater users on the Lake because there is not enough information about the pumps.
Grand Coulee Dam outflow	Lower Feb, Mar, Apr, May, Jun, Jul, Aug flows than NAA. Higher than NAA in Dec.	No effect to the ability to deliver water because the pool at Chief Joseph is not changing from NAA, so water surface and groundwater elevations are not affected regardless of outflow from Grand Coulee.
Rufus Woods Lake (Chief Joseph Dam reservoir)	No change from NAA	No effect

3.3.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

The H&H model results for MO2 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 – Table 3-4). Table 3-11 describes the H&H effects that could affect the physical ability to divert water and whether there is a possible effect to water supply.

Table 3-11. Summary of H&H and Water Supply Effects for MO2 in Region C

Indicator	H&H effect	Water Supply effect
Dworshak Reservoir	Lower lake elevations than NAA in Jan, Feb, Mar, Apr, Jun, Jul, Aug.	No effect because there is not irrigation or M&I diverting from the pool.
Dworshak Dam outflow	Higher outflows than NAA in Jan, Feb, and May; lower than NAA in Mar, Apr, Jun, Jul, and Aug. Lowest outflow is not lower than NAA in the summer.	No irrigation or M&I above Lewiston, so no effect.
Lower Granite Dam Reservoir	Higher pool elevations than NAA	No effect
Little Goose Dam Reservoir	Higher pool elevations than NAA	No effect
Lower Monumental Dam Reservoir	Higher pool elevations than NAA	No effect
Ice Harbor Dam Reservoir	Higher pool elevations than NAA	No effect

3.3.4 Region D – McNary, John Day, The Dalles, Bonneville

The H&H model results for MO2 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 – Table 3-4). Table 3-12 describes the H&H effects that could affect the physical ability to divert water and whether there is a possible effect to water supply.

Table 3-12. Summary of H&H and Water Supply Effects from MO2 in Region D

Indicator	H&H effect	Water Supply effect
McNary Dam outflow	Lower than NAA in May and Jun.	No effect to the ability to deliver water because the pool at John Day is higher from NAA, so water surface and groundwater elevations are not affected regardless of outflow from McNary.
Lake Umatilla (John Day Dam Reservoir)	Broader range of pool elevations than NAA	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels.
The Dalles Reservoir	No change from NAA	No effect
Bonneville Reservoir	No change from NAA	No effect

3.4 MULTIPLE OBJECTIVE ALTERNATIVE 3

MO3 included measures that could impact delivery of current water supply in Region C. This alternative included measures to remove dams in the region of the Lower Snake river, where water is diverted for irrigation of lands in Washington and is anticipated to have a major effect on water supply.

The H&H models assumed that current level diversions will be diverted in all years, which indicates that the volume of water needed for water supply will be available for diversion in all years. Because of is assumption, the flow and stage in the MO3 model results reflect meeting those diversions in all years, and the effect of diverting the water is carried forward to the resources including H&H, water quality, and fish that use those model results. There are possible negligible effects of changes to pumping costs for MO3 if pool elevation or river stages drop below current pump configurations. Those locations are identified in this section, but are impacts are not quantified because of limited data.

3.4.1 Region A – Libby, Hungry Horse, Albeni Falls

The H&H model results for MO3 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-13 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-13. Summary of H&H and Water Supply Effects for MO3 in Region A

Indicator	H&H effect	Water Supply effect
Lake Koocanusa (Libby Dam reservoir)	Lake levels lower than NAA in winter (about 20 feet) and higher than NAA in summer (about 1 foot). However, lower elevations are not lower than lowest elevation in NAA.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Possible negligible effect to winter pumping costs; these effects are not quantified in this analysis because there is not enough information about these pumps

Indicator	H&H effect	Water Supply effect
Libby Dam outflow	Higher than NAA in Nov and Dec. Lower flows than NAA in Jan, Feb, Jul, Aug, and Sep, but not lower than lowest outflow in NAA.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Elevation is controlled by downstream lake, so likely no change to pumping costs.
Hungry Horse reservoir	Lower lake levels than NAA.	No effect because there are no water supply diversion for irrigation or M&I directly from the reservoir.
Hungry Horse Dam (outflow)	Lower outflow than NAA in April, May, and June, but not lower than summer lowest. Higher than NAA in Jul. Aug, and Sep.	Possible negligible effect to the ability to deliver water in the summer months due to lower stage as a result of lower outflows; since pump elevations are unknown, this effect is not quantified. Change in flow translates to immeasurable difference in head, so no impact to pumping costs.
Lake Pend Oreille	No change	No effect

3.4.2 Region B – Grand Coulee, Chief Joseph

The H&H model results for MO3 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-14 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-14. Summary of H&H and Water Supply Effects for MO3 in Region B

Indicator	H&H effect	Water Supply effect
Lake Roosevelt (Grand Coulee Dam Reservoir)	Similar lake elevations to NAA.	No effect to the ability to deliver water because it assumed that pumps can operate given that lake levels are not lower than lowest NAA elevation. Estimated changes to pumping costs are quantified for John W Keys pumping plant.
Grand Coulee Dam outflow	Lower Feb, Mar, Apr, May, Jun, Jul, Aug flows than NAA. Higher than NAA in Dec.	No effect to the ability to deliver water because the pool at Chief Joseph is not changing from NAA, so water surface and groundwater elevations are not affected regardless of outflow from Grand Coulee.
Rufus Woods Lake (Chief Joseph Dam reservoir)	No change from NAA	No effect

3.4.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

MO3 included a structural measure (S1) that could impact water supply in this region by removing the lower four Snake River Dams. Currently and in the NAA, water is provided out of the pools of these facilities and groundwater that results from the pools. The pumps that supply this water would no longer be operational once the dams are removed and the nearby groundwater elevations could be significantly impacted. Chapter 4 of this appendix analyzes the socioeconomic effects of these impacts. Table 3-15 summarized the impacts in Region C.

Table 3-15. Summary of H&H and Water Supply Effects for MO3 in Region C

Indicator	H&H effect	Water Supply effect
Dworshak Reservoir	No change from NAA	No effect
Dworshak Dam outflow	No change from NAA	No effect
Lower Granite Dam Reservoir	Dam breached	Major effect
Little Goose Dam Reservoir	Dam breached	Major effect
Lower Monumental Dam Reservoir	Dam breached	Major effect
Ice Harbor Dam Reservoir	Dam breached	Major effect

3.4.3.1 Irrigation

There are approximately 48,000 acres currently being 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, so are likely a high estimate of diversion for the possibly affected acres). Currently and in the NAA, water provided out of the pools of these facilities and by nearby groundwater, and the pumps and wells that supply this water would no longer be operational once these dams are removed. [Add Corps analysis to here]

3.4.3.2 Municipal and Industrial

There are M&I pumps in the Lewiston area that will 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 whose water rights purpose was indicated to be M&I. These points may use up to 9,230 acre-feet per year (USGS 2018).

The Corps of Engineers evaluated 15 pumps on Lower Granite Reservoir and indicated that they used approximately 40,000 acre-feet per year in 1996 (Corps 2002), with the largest user being the Potlatch Corporation (now Clearwater Paper). It is unclear if this number is total consumptive use or just 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.

3.4.3.3 Groundwater

Groundwater will likely be impacted by this measure with groundwater elevations having the potential to drop the entire height of previous water levels, up to 100 feet. This would impact well users in the region. The co-lead agencies identified approximately 200 groundwater points of diversion that could be used for M&I or irrigation.

The Corps of Engineers evaluated wells in this region for the 2004 EIS. They found a similar number of wells, 228, that were recorded in the region. Of the 228, they found that 180 were functioning and within the study area, which is 79 percent. They analyzed 38 of the 180 wells using well log data combined with topographic features, well depth, stratigraphy, surface elevation to determine the wells that could be affected by changes in the river water surface elevation (Corps 2002). They found that 15 of them would need to be modified to continue operation under the dam breaching condition, which is 40 percent of those evaluated (38 wells). 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.

3.4.4 Region D – McNary, John Day, The Dalles, Bonneville

The H&H model results for MO3 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-16 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-16. Summary of H&H and Water Supply Effects for MO3 in Region D

Indicator	H&H effect	Water Supply effect
McNary Dam outflow	Lower than NAA in May and Jun	No effect to the ability to deliver water because the pool at John Day is higher from NAA, so water surface and groundwater elevations are not affected regardless of outflow from McNary
Lake Umatilla (John Day Dam Reservoir)	Broader range of pool elevations than NAA	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels.
The Dalles Reservoir	No change from NAA	No effect
Bonneville Reservoir	No change from NAA	No effect

Following the removal of the Lower Snake Dams, there will likely be sediment that is transported through the McNary and John Day pools (see the River Mechanics section in Chapter 3 for more information). The river mechanics modeling showed that at the location of the large pumps used for the Umatilla lands near river mile 295, there would be fine-grained material that would reach the pumps. However, it should not impact that pumps 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 require more frequent maintenance.[14]

3.5 MULTIPLE OBJECTIVE ALTERNATIVE 4

The H&H models assumed that current level diversions will be diverted in all years, which indicates that the volume of water needed for water supply will be available for diversion in all years. Because of is assumption, the flow and stage in the MO4 model results reflect meeting those diversions in all years, and the effect of diverting the water is carried forward to the resources including H&H, water quality, and fish that use those model results. There are possible negligible effects of changes to pumping costs, particularly in Region D at John Day, for MO4 as pool elevation or river stages drop below current pump configurations. There are possible negligible effects of changes to pumping costs if pool elevation or river stages drop

[14] Based on conversations with Reclamation's Umatilla Field Office Manager.

below current pump configurations. Those locations are identified in this section, but are impacts are not quantified because of limited data.

3.5.1 Region A – Libby, Hungry Horse, Albeni Falls

The H&H model results for MO4 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-17 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-17. Summary of H&H and Water Supply Effects for MO4 in Region A

Indicator	H&H effect	Water Supply effect
Lake Koocanusa (Libby Dam reservoir)	Lake levels higher than NAA in winter and lower than NAA in Jul, Aug, Sep.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Possible negligible effect to winter pumping costs; these effects are not quantified in this analysis because there is not enough information about these pumps
Libby Dam outflow	Lower Nov and Dec flows in some years, but not lower than lowest winter flows in NAA. Higher than NAA in Jan, Feb, and Jul.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels Elevation is controlled by downstream lake, so likely no change to pumping costs.
Hungry Horse reservoir	Lower lake levels than NAA.	No effect because there is not irrigation or M&I diverting from the pool.
Hungry Horse Dam (outflow)	Lower outflow than NAA in April, May, and June, but not lower than summer lowest. Higher than NAA in Jul, Aug, and Sep.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Change in flow translates to immeasurable difference in head, so no impact to pumping costs.
Lake Pend Oreille	Lower summer lake levels than NAA.	Possible effect to the ability to deliver summer water supplies if pumps are configured to operate at historical elevations; not enough information is available to analyze this effect. If pumps are configured to operate year-round, there should be no impact to the ability to pump but pumping costs may increase.

3.5.2 Region B – Grand Coulee, Chief Joseph

The H&H model results for MO4 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-18 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-18. Summary of H&H and Water Supply Effects for MO4 in Region B

Indicator	H&H effect	Water Supply effect
Lake Roosevelt (Grand Coulee Dam Reservoir)	Lower lake elevations than NAA in Dec, Jan, April 10, Jul, Aug, and Sep.	No effect to the ability to deliver water because it assumed that pumps can operate given that lake levels are not lower than lowest NAA elevation. Possible negligible effect to pumping costs. These are quantified for John W Keys pumping plant, but not for other small surface or groundwater users on the Lake because there is not enough information about the pumps.
Grand Coulee Dam outflow	Lower Feb, Mar, Apr, May, Jun, Jul, Aug flows than NAA. Higher than NAA in Dec and Jan.	No effect to the ability to deliver water because the pool at Chief Joseph is not changing from NAA, so water surface and groundwater elevations are not affected regardless of outflow from Grand Coulee.
Rufus Woods Lake (Chief Joseph Dam reservoir)	No change from NAA	No effect

3.5.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

The H&H model results for MO4 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-19 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-19. Summary of H&H and Water Supply Effects for MO4 in Region C

Indicator	H&H effect	Water Supply effect
Dworshak Reservoir	No change from NAA	No effect
Dworshak Dam outflow	No change from NAA	No effect
Lower Granite Dam Reservoir	Higher pool elevations than NAA	No effect
Little Goose Dam Reservoir	Higher pool elevations than NAA	No effect
Lower Monumental Dam Reservoir	Higher pool elevations than NAA	No effect
Ice Harbor Dam Reservoir	Higher pool elevations than NAA	No effect

3.5.4 Region D – McNary, John Day, The Dalles, Bonneville

The H&H model results for MO4 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see Chapter 3 - Table 3-4). Table 3-20 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-20. Summary of H&H and Water Supply Effects for MO4 in Region D

Indicator	H&H effect	Water Supply effect
McNary Dam outflow	Higher than NAA	No effect
Lake Umatilla (John Day Dam Reservoir)	Summer pool elevations 1.5 feet lower than NAA	No effect to the ability to deliver irrigation and M&I water from surface and groundwater. Increased pumping costs due to lower pool elevations.
The Dalles Reservoir	No change from NAA	No effect
Bonneville Reservoir	No change from NAA	No effect

MO4 included an operational measure that could impact water supply from the John Day pool (08) by lowering the minimum pool during the irrigation season by 1.5 to 261.0 feet (NGVD29). 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 there are some pumps that might need modification to continue operation. Data is not available to analyze the number of pumps requiring modification or the degree of modification required, so the cost of this modification is 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, which was analyzed.

This measure could also impact groundwater because the head would be lower for the irrigation season than NAA operations. The 1.5 feet of head difference could lower groundwater levels up to 1.5 feet, but the effect may be less.

3.6 PREFERRED ALTERNATIVE

The H&H models assumed that current level diversions will be diverted in all years, which indicates that the volume of water needed for water supply will be available for diversion in all years. Because of is assumption, the flow and stage in the Preferred Alternative model results reflect meeting those diversions in all years, and the effect of diverting the water is carried forward to the resources including H&H, water quality, and fish that use those model results. There are possible negligible effects of changes to pumping costs if pool elevation or river stages drop below current pump configurations. Those locations are identified in this section, but are impacts are not quantified because of limited data.

3.6.1 Region A – Libby, Hungry Horse, Albeni Falls

The H&H model results for the Preferred Alternative were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see section 7.5.1). Table 3-21 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-21. Summary of H&H and Water Supply Effects for Preferred Alternative in Region A

Indicator	H&H effect	Water Supply effect
Lake Koocanusa (Libby Dam reservoir)	Lake levels higher than NAA in summer and lower in spring	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Possible negligible effect to spring pumping costs; these effects are not quantified in this analysis because there is not enough information about these pumps
Libby Dam outflow	Outflows are generally higher than NAA	No effect to the ability to deliver water.
Hungry Horse reservoir	Lower lake levels than NAA in fall and higher in summer.	No effect because there is not irrigation or M&I diverting from the pool.

Indicator	H&H effect	Water Supply effect
Hungry Horse Dam (outflow)	In Jul, Aug, and Sep, monthly average outflow would be lower than NAA by less than 1,000 cfs	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Change in flow translates to immeasurable difference in head, so no impact to pumping costs.
Lake Pend Oreille	No change from NAA	No effect

3.6.2 Region B – Grand Coulee, Chief Joseph

The H&H model results for the Preferred Alternative were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see section 7.5.1). Table 3-22 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-22. Summary of H&H and Water Supply Effects for Preferred Alternative in Region B

Indicator	H&H effect	Water Supply effect
Lake Roosevelt (Grand Coulee Dam Reservoir)	Lower lake elevations than NAA in Feb through May	No effect to the ability to deliver water because it assumed that pumps can operate given that lake levels are not lower than lowest NAA elevation. Possible negligible effect to pumping costs. These are quantified for John W Keys pumping plant, but not for other small surface or groundwater users on the Lake because there is not enough information about the pumps.
Grand Coulee Dam outflow	Lower Apr, May, Jun, Jul, Aug outflows than NAA. Higher than NAA in Dec and Jan.	No effect to the ability to deliver water because the pool at Chief Joseph is not changing from NAA, so water surface and groundwater elevations are not affected regardless of outflow from Grand Coulee.
Rufus Woods Lake (Chief Joseph Dam reservoir)	No change from NAA	No effect

3.6.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

The H&H model results for the preferred were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see section 7.5.1). Table 3-23 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-23. Summary of H&H and Water Supply Effects for Preferred Alternative in Region C

Indicator	H&H effect	Water Supply effect
Dworshak Reservoir	Lower pool elevations than NAA in Jan, Feb, Mar in driest years	No effect because there is not irrigation or M&I diverting from the pool.
Dworshak Dam outflow	Lower outflows than NAA in Feb and Mar.	No effect to the ability to deliver water because it is assumed that pumps can operate given that outflows are not lower than lowest NAA levels. Change in flow translates to immeasurable change in head, so no change to pumping costs.

Indicator	H&H effect	Water Supply effect
Lower Granite Dam Reservoir	Higher pool elevations than NAA	No effect
Little Goose Dam Reservoir	Higher pool elevations than NAA	No effect
Lower Monumental Dam Reservoir	Higher pool elevations than NAA	No effect
Ice Harbor Dam Reservoir	Higher pool elevations than NAA	No effect

3.6.4 Region D – McNary, John Day, The Dalles, Bonneville

The H&H model results for MO4 were used to determine if there could be an impact to the ability to deliver water based on physical limitations for surface or groundwater pumps (see section 3.5.1). Table 3-24 describes the H&H effects that could affect the physical ability to divert water and whether there a possible effect to water supply.

Table 3-24. Summary of H&H and Water Supply Effects for Preferred Alternative in Region D

Indicator	H&H effect	Water Supply effect
McNary Dam outflow	Higher than NAA.	No effect.
Lake Umatilla (John Day Dam Reservoir)	Higher than NAA	No effect.
The Dalles Reservoir	Higher than NAA	No effect
Bonneville Reservoir	Higher than NAA	No effect

CHAPTER 4 - SOCIOECONOMIC EFFECTS ANALYSIS

This section presents estimates of the social welfare effects and the regional economic impacts resulting from physical water supply impacts to irrigation and M&I water supply. Based on the physical analysis, only Region C and D were analyzed for the No Action because those are the only regions with expected changes. The social welfare effects for each alternative are described below followed by the details related to the Regional Economic Impacts for each alternative.

4.1 SOCIAL WELFARE ANALYSIS

The following section describes the social welfare effects for each alternative. The social welfare effects measure the economic benefits resulting from an alternative from a societal or national perspective.

4.1.1 No Action Alternative

4.1.1.1 Region A – Libby, Hungry Horse, Albeni Falls

Water supply effects related to socioeconomics are not expected in this area because no physical water supply effects were measured or expected.

4.1.1.2 Region B – Grand Coulee, Chief Joseph

The effects for the Multiple Objective alternatives conditions were estimated as the increment between the No Action Alternative and the Multiple Objective alternatives conditions. Therefore, effects were not estimated for the No Action Alternative.

4.1.1.3 Region C - Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

SOCIAL WELFARE EFFECTS - IRRIGATION

The U.S. Army Corps of Engineers (Corps) 2002 report analyzed dam removal and the impact on water supply. Several system modifications were considered 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 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 and the replacement water would be used to irrigate some of the fruit orchards and vineyards. The development cost for the replacement water would need to be included as part of the alternative to assess the net benefits of irrigation under this scenario.

The current analysis also assumed that all irrigated acres (approximately 47,926 acres) receiving water from the current pumps would no longer be irrigated (with condition) and would convert to dryland pasture (without condition). This assumption was based on conversations with several extension agents in Washington and Oregon. It was assumed that there isn't a suitable substitute water source and the annual rainfall is not sufficient to support a dryland crop rotation such as a wheat/fallow operation. There was also concern that soil acidity may impact a dryland wheat/fallow operation on lands that were previously supporting fruit orchards and vineyards.

The Principles and Guidelines (P&Gs) describe two methods for evaluating the social welfare effects associated with irrigation, farm budget analysis and land value analysis. The land value method is based on the use of land values as a measure of the land's income-producing capability from farm production. The P&Gs land value method call 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 only on the land's income-producing capability from crop production so other factors not related to irrigation water supply are excluded from the social welfare effects.

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). This guidance is supported in the discipline and is documented in the Commodity Cost and Returns Handbook (American Agricultural Economics Association, 2000) which was written to provide uniform best practices for university farm budget analyses.

Farmland market values, which are generally based on sales data, are often greater than the value in use due to the expectation or potential for the land to be used for non-agricultural purposes either currently or at some point in the future (American Agricultural Economics Association, 2000). Therefore, the social welfare effects may be overstated if market values are used without making adjustments to remove potential values associated with non-agricultural influences.

Young and Loomis (2014) describe the comprehensive treatment of the methods employed to value water used in irrigated crop production including the 'land value method'. Young and Loomis (2014) caution that when using this approach that

> "if any of the market value is attributable to potential real appreciation from nonagricultural (residential, industrial, or recreational) demands for the land, this factor should be accounted for by deducting the premium attributable to potential nonagricultural demand from the imputed irrigation gains. Because of the difficulty in estimating such a premium without formal econometric techniques, the land value method must be used with caution whenever this factor is judged to be significant."

The market value of land often differs from the agricultural use value and includes premiums unrelated to irrigation water. The differences may occur when market values are influenced by non-agricultural activities such as urban development. Because of these differences extensive data collection and rigorous statistical modeling is often required to estimate the economic value of irrigation water using the market land values.

Without statistical modeling to isolate the various factors, such as the value of farm production, from USDA published farmland values may not correctly reflect the social welfare effect of irrigation water supply. It's also not clear if the USDA values include the value of irrigation systems or permanent plantings. The USDA data are available on a statewide level so these data do not reflect local conditions. Farmland values are greatly influenced by soil types and other local conditions.

Greenbelt laws encourage the retention of farmland by limiting property taxes to the land's agricultural use value rather than the market value which may include a speculative component. In Washington State assessors follow the requirements set out in the Open Space Taxation Act enacted in 1970 when determining the land values for taxation purposes. In this act it stipulates that agricultural land must be valued based on "current use" rather than at their "highest and best use." As described in the Washington State Department of Revenue's manual entitled "Current Use and Designated Forestland Administration (Washington Department of Revenue, 2018), the assessed value of agricultural land is determined using an income approach based on the earning or productivity of the land. A net cash rental or lease is the preferred method for estimating the earning or productive capacity of the land. Therefore, the productive capacity measure is equivalent to a land value analysis as defined in the P&Gs.

Almost 80 percent of the lands in the study are in Walla Walla, County. The Walla Walla County assessor's office maintains an extensive public dataset related to assessed values along with GIS mapping. Based on these available data and the location of the lands Walla Walla county assessor data was considered representative for the area.

The analysis used two datasets to estimate the benefit values. The first estimate relied on Walla Walla County assessor estimates of current use values (based on cash rental rates) for Class 1 land. The second estimate used USDA farmland value survey estimates for Washington.

The approach to estimate a per acre benefit value involved two steps. First the difference between land value with irrigated land and without irrigated was determined. Second the per acre value was converted to annual equivalent value.

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).

The County of Walla Walla assessor's office provided the estimates used to derive their land values. These estimates were based on a current use value based on a 10-year average. The county estimates assumed a 40 percent owner's share of income and expenses. This analysis estimates NED benefits by adjusting the data to reflect a 100 percent owner's share to account for 100 percent of the revenues and expenses attributed to the land. The County of Walla Walla assumed a 0.0379 percent capitalization factor to adjust the current use value. These calculations are shown in Table 4-1.

Table 4-1. Irrigated Land Value Using Assessor Data

Assessor Data Category	Irrigated Land Value
Owner's share of Income (100%)	$575.00
Depreciation of equipment	$123.94
Owner's share of the Expenses (100%)	$123.94
Estimated net Income attributable to the land	$327.13
Net Income/state cap. rate (0.0379%)	$8,631.39
Plus Irrigation System value (depreciated)	$702.00
Current Use Value	$9,333
Annualized value	$353.74

Note the estimated per acre cash rental rate for dryland pasture based on the Walla Walla assessor data was less than $2 per acre, therefore this analysis assumed zero dollars per acre for dryland. Also, the USDA[15] farm land values were $7,690 and $766 per acre for irrigated and dryland respectively. These values were assumed to be present value numbers and were therefore annualized assuming 50-year project life and 2.875 percent discount rate.

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 per acre value was multiplied by the total number of acres (47,926 acres) under the No Action conditions. The present value of this annual amount was discounted over the 50-year period using the discount rate of 2.875 (2019 Federal planning rate). The present value equals $447,174,000 (annual equivalent value is $16,953,343). By contrast using the USDA farmland values the present value equals $331,773,000 (annual equivalent value is $12,577,000). These calculations are shown in Table 4-3.

Table 4-2. Benefit Values Assuming a Dryland Pasture is the Without Condition

Data Source	Price Level	With Condition (irrigated crops)	Without Condition (dryland pasture)	Benefit Value (With minus Without)
Assessor data	2019	$353.74/acre	$0.00/acre	$353.74/acre
USDA farmland data	2019	$291.45/acre	$29.03/acre	$262.42/acre

Table 4-3. Irrigation Water Supply Social Welfare Effects Under the No Action Conditions

Data Source	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	$4447,174,000
USDA data	47,926	2019	$262.42	$12,577,000	$331,733,000

SOCIAL WELFARE EFFECTS – MUNICIPAL AND INDUSTRIAL

In Region C, approximately 21,330 acre-feet of M&I water diversions were estimated in the physical water supply affected environment section of this EIS. Two approaches were used to

[15] USDA, National Agricultural Statistics Service, Census of Agriculture.

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 the willingness to pay or the dollar amount that an entity is willing to pay to obtain an acre foot water.

First the observed market transaction values were analyzed to derive the value of the M&I water supply. The observed data were obtained from the Water Transfer Data Base presented by the Bren School. 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 between 1987 and 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 affects 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 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, found in the 2002 Corps report, were utilized.

The effects were estimated as the increment between the No Action and the Action conditions, therefore pumping costs were not estimated under the No Action condition.

4.1.1.4 Region D – McNary, John Day, The Dalles, Bonneville

The effects were estimated as the increment between the No Action and the Action conditions, therefore pumping costs were not estimated under the No Action condition.

4.1.2 Multiple Objective Alternative 1

MO1 did not affect the ability to deliver water in Regions A, C, or D therefore there were not estimated changes as compared to No-Action.

4.1.2.1 Region B – Grand Coulee, Chief Joseph

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 2019 Federal planning rate (2.875 percent). The annual equivalent value equals $7,000 ($185,000). This value represents a decrease in net farm income across the region under MO1.

4.1.3 Multiple Objective Alternative 2

MO2 did not affect the ability to deliver water in Regions A, C, or D therefore there were not estimated changes as compared to No-Action.

4.1.3.1 Region B – Grand Coulee, Chief Joseph

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 2019 Federal planning rate (2.875 percent). The annual equivalent value equals $10,000 ($264,000). This value represents a decrease in net farm income across the region under MO2.

4.1.4 Multiple Objective Alternative 3

MO3 did not affect the ability to deliver water in Regions A or D therefore there were not estimated changes as compared to No-Action.

4.1.4.1 Region B – Grand Coulee, Chief Joseph

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 $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 2019 Federal planning rate (2.875 percent). The annual equivalent value equals $3,000 ($79,000). This value represents a decrease in net farm income across the region under MO3.

4.1.4.2 Region C - Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

SOCIAL WELFARE EFFECTS - IRRIGATION

Assuming the entire 47,926 acres were no longer irrigated, the present value of the lost social welfare benefit under MO3 is $447,174,000 (annual equivalent value is $16,953,343). This calculation is described in the No Action alternative section. By contrast using the USDA farmland values the present value of the lost social welfare benefit equals 331,773,000 (annual equivalent value is $12,576,741). These estimates are in 2019 dollars.

SOCIAL WELFARE EFFECTS – MUNICIPAL AND INDUSTRIAL

The M&I social welfare effects were first estimated using observed market data. Urban water use transfers were taken from the Water Transfer database, these observations are shown in Table 4-4. These values were indexed to 2019 dollars using the Consumer Price Index.

Table 4-4. Urban (M&I water supply) Transfers in Various Years for Washington and Idaho

Year	State	Average Annual Water Transfer (acre-feet)	Total Price	Price per acre-foot	Consumer Price Index	Indexed (2019 dollars) $/acre-foot
1993	ID	39	$273	$7.00	1.761146	12.33
1998	ID	3000	$1,575,000	$525.00	1.560731	819.38
1999	ID	3000	$19,500	$6.50	1.477423	9.6
1999	ID	300	$15,000	$50.00	1.527313	76.37
2001	WA	2597	$101,263	$38.99	1.436816	56.02
2002	WA	137	$5,343	$39.00	1.414383	55.16
2004	WA	920	$236,860	$257.46	1.346928	346.78
1992	WA	2000	$340,000	$170.00	1.813129	308.23
1995	WA	4592.58	$1,082,380	$235.68	1.669554	393.48
2004	WA	63.45	$31,725	$500.00	1.346928	673.46
2005	WA	1.5	$834	$556.00	1.302729	724.32

Source: Obtained from https://www.bren.ucsb.edu/news/water_transfers.htm

As shown in Table 4-5, a weighted average M&I per acre water value was derived. The M&I water values were weighted using the estimated surface water and groundwater M&I diversions discussed in the physical water supply affected environment section of this EIS.

Table 4-5. Weighted Average Per Acre-Foot M&I Value

State	Estimated M&I diversions (acre-feet)	Percent	State Average Value ($/acre-foot)	Weighted Average Value ($/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 taken from the 2002 Corps report. This analysis assumes that these modifications were 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. A summary of these costs are shown in Table 4-6.

Table 4-6. Summary of M&I Water Supply Modification Construction Costs

Supply	Low	High
Original Costs (1998 dollars)		
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
Indexed (2019 dollars)		
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 (2.875% discount rate and 50-year period of analysis)	$5,014,660.45 ($235.10 per acre-foot)	$7,804,271.23 ($365.88 per acre-foot)

To estimate the social welfare effects the cost estimates were annualized assuming a 50-year period of analysis and a 2.875 percent discount rate (2019 Federal planning rate). As shown in Table 4-6, the annualized social welfare effects range from $5,014,660.45 and $7,804,271.23. On a per acre foot basis the social welfare effects range from $235.10 and $365.88.

It should be recognized that the physical quantities of water are based on the water right. This may lead to an overestimated of the actual water used. The estimates of social welfare effects of M&I water may be overstated.

4.1.5 Multiple Objective Alternative 4

MO4 did not affect the ability to deliver water in Regions A or C therefore there were not estimated changes as compared to No-Action.

4.1.5.1 Region B – Grand Coulee, Chief Joseph

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 2019 Federal planning rate (2.875 percent). The annual equivalent value equals $72,000 ($1,899,000). This value represents a decrease in net farm income across the region under MO4.

4.1.5.2 Region D – McNary, John Day, The Dalles, Bonneville

SOCIAL WELFARE EFFECT - IRRIGATION

This analysis assumes that the currently irrigated lands (approximately 212,225 acres) would remain in production. This level of production will require increased pumping costs. Due to the drawdown, pump efficiencies were assumed to change which required 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 as described in [reference}. Available pump information and use rates were used to the estimate energy requirement to maintain the operability post drawdown.

The cost of the additional power requirement was valued using power prices for pumping which were obtained from the Power and Transmission analyses. These prices are forecasted by county for a 20-year period under the MO4 conditions (shown in Table 4-7 and Table 4-8). A weighted average pumping rate for each state (Washington and Oregon) was estimated using the estimated acres for each county (Table 4-9). Table 4-5 shows these weights.

Table 4-7. Estimated Pumping Rates for Washington Counties Under MO4

County	Klickitat, WA Min	Benton, WA Min	Weighted WA State Price Min	Klickitat, WA Max	Benton, WA Max	Weighted WA State Price Max
Year	$/kilowatt-hour (2019 dollars)					
1	0.0661	0.0594	0.0601	0.0707	0.0636	0.0644
2	0.066	0.0591	0.0598	0.070	0.0633	0.0641
3	0.065	0.0588	0.0595	0.070	0.0630	0.0638
4	0.065	0.0585	0.0592	0.069	0.0627	0.0634
5	0.064	0.0582	0.0589	0.069	0.0624	0.0631
6	0.064	0.0579	0.0586	0.069	0.0621	0.0628
7	0.064	0.0576	0.0583	0.068	0.0618	0.0625
8	0.063	0.0572	0.0579	0.068	0.0614	0.0621
9	0.063	0.0568	0.0575	0.067	0.0610	0.0617
10	0.062	0.0564	0.0571	0.067	0.0606	0.0612
11	0.062	0.0561	0.0567	0.066	0.0601	0.0608
12	0.062	0.0557	0.0563	0.066	0.0597	0.0604
13	0.061	0.0553	0.0559	0.065	0.0593	0.0600
14	0.061	0.0549	0.0556	0.065	0.0589	0.0596
15	0.060	0.0545	0.0552	0.064	0.0585	0.0592
16	0.060	0.0542	0.0548	0.064	0.0581	0.0588

County	Klickitat, WA Min	Benton, WA Min	Weighted WA State Price Min	Klickitat, WA Max	Benton, WA Max	Weighted WA State Price Max
Year	$/kilowatt-hour (2019 dollars)					
17	0.059	0.0538	0.0544	0.064	0.0577	0.0584
18	0.059	0.0534	0.0540	0.063	0.0573	0.0580
19	0.059	0.0531	0.0537	0.063	0.0569	0.0576
20	0.058	0.0527	0.0533	0.062	0.0565	0.0572
Annual Rate of Change			-0.63%	Annual Rate of Change		-0.62%

Table 4-8. Estimated Pumping Rates for Oregon Counties Under MO4

County	Morrow, OR Min	Umatilla, OR Min	Weighted OR State Price Min	Morrow, OR Max	Umatilla, OR Max	Weighted OR State Price Max
Year	$/kilowatt-hour (2019 dollars)					
1	0.0598	0.0685	0.0648	0.0637	0.0710	0.0679
2	0.0594	0.0681	0.0644	0.0634	0.0706	0.0675
3	0.0590	0.0677	0.0640	0.0630	0.0702	0.0671
4	0.0587	0.0674	0.0637	0.0626	0.0698	0.0667
5	0.0583	0.0670	0.0633	0.0622	0.0694	0.0663
6	0.0579	0.0666	0.0629	0.0618	0.0690	0.0659
7	0.0576	0.0662	0.0625	0.0614	0.0686	0.0655
8	0.0572	0.0657	0.0621	0.0610	0.0681	0.0651
9	0.0568	0.0653	0.0617	0.0606	0.0676	0.0647
10	0.0564	0.0648	0.0613	0.0602	0.0672	0.0642
11	0.0560	0.0644	0.0608	0.0598	0.0667	0.0638
12	0.0556	0.0639	0.0604	0.0594	0.0663	0.0633
13	0.0553	0.0635	0.0600	0.0590	0.0658	0.0629
14	0.0549	0.0631	0.0596	0.0586	0.0654	0.0625
15	0.0545	0.0626	0.0592	0.0582	0.0649	0.0620
16	0.0541	0.0622	0.0588	0.0578	0.0645	0.0616
17	0.0538	0.0618	0.0584	0.0574	0.0640	0.0612
18	0.0534	0.0614	0.0580	0.0570	0.0636	0.0608
19	0.0530	0.0609	0.0576	0.0566	0.0631	0.0604
20	0.0527	0.0605	0.0572	0.0562	0.0627	0.0599
	Annual Rate of Change		-0.65%	Annual Rate of Change		-0.66%

Table 4-9. Average Acres by County

County, State	Acres	Percent
Klickitat, WA	13,561	11.05%
Benton, WA	109,144	88.95%
WA Total	122,705	100.00%
Morrow, OR	38,010	42.46%
Umatilla, OR	51,509	57.54%
OR State Total	89,519	100.00%

A range of pumping rates (minimum and maximum estimates) were 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 was calculated for the pumping rates provided by the Power and Transmission analysis. 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 4-10.
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 4-10. Estimated Power Rate and Additional Pumping Costs for Year 1, and Average Annual Rate Increase of the 20-year Period

Rate	WA		OR	
	Min	Max	Min	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 increase	-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 2019 Federal planning rate (2.875 percent). The present values are shown in Table 4-11 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 is equal to these estimated differences in pumping costs between the alternatives across the 50-year period of analysis.

Table 4-11. Estimated Social Welfare Effects Under MO4

Value	Total (WA and OR)	Acres	$/acre
Min Present Value	$6,852,000	–	–
Min Annual Equivalent	$260,0	212,226	$1.23
Max Present Value	$7,322,000	–	–
Max Annual Equivalent	$277,900	212,226	$1.31

SOCIAL WELFARE EFFECTS - MUNICIPAL AND INDUSTRIAL

The physical effects to M&I were not estimated under the MO4 conditions.

4.1.6 Preferred Alternative

4.1.6.1 Region A – Libby, Hungry Horse, Albeni Falls

Preferred Alternative did not affect the ability to deliver water therefore there were not estimated changes as compared to No-Action.

4.1.6.2 Region B – Grand Coulee, Chief Joseph

Effects to Lake Roosevelt pool elevation could result increased pumping costs.

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 $1,000 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 $1,000 ($27,000). This value represents a decrease in net farm income across the region under the Preferred Alternative. This is considered a negligible effect as compared to No Action.

4.1.6.3 Region C - Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

Preferred Alternative did not affect the ability to deliver water therefore there were not estimated changes as compared to No-Action.

4.1.6.4 Region D – McNary, John Day, The Dalles, Bonneville

Preferred Alternative did not affect the ability to deliver water therefore there were not estimated changes as compared to No-Action.

4.2 REGIONAL ECONOMIC IMPACTS

The results of the social welfare analysis and the regional impact analysis are not directly comparable because they do not measure the same effects. The regional economic effects are a measure of regional activity as a result of the action. Regional economic effects are distinctly different than then the social welfare effects which measure economic benefits from a national perspective.

4.2.1 No Action Alternative

4.2.1.1 Region A – Libby, Hungry Horse, Albeni Falls

Water supply effects related to socioeconomics are not expected in this area.

4.2.1.2 Region B – Grand Coulee, Chief Joseph

The effects for the Multiple Objective alternatives conditions were estimated as the increment between the No Action Alternative and the Multiple Objective alternatives conditions. Therefore effects were not estimated for the No Action Alternative.

4.2.1.3 Region C - Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

REGIONAL ECONOMIC IMPACTS - IRRIGATION

The regional impact analysis estimated impacts in two separate analysis areas within Region C. The Ice Harbor and Lower Monumental socioeconomic region included the following counties located in Washington State; Columbia County, Franklin County, and Walla Walla County. The Lower Granite and Little Goose socioeconomic region included Nez Perce County in Idaho and Asotin, Garfield, and Whitman counties in Washington.

The available water rights place of use and point of diversion data was used to identify the lands that receive water from these reaches as discussed in the affected environment section of this EIS. In this analysis the changes in gross value of agriculture production based on potential changes to cropping patterns or the additional cost required to continue using the existing pumps to maintain baseline acres and cropping patterns were estimated based on the physical water assumptions. These potential regional effects were inputs to the IMPLAN model.

Data was not available to estimate the gross value for all the crops grown in the regions. If certain crops are grown only on a small percentage of total acres, they can be represented by a more extensively grown crop in the same general category of crops (i.e., hay, small grains, orchard, vegetables, etc.). Crop aggregation is the process by which the crops grown in the study area are grouped into representative crops. The aggregation is based on the availability of data on crop acres, prices, and yields. The representative crops chosen for the Ice Harbor and Lower Monumental region were alfalfa, winter wheat, corn, potatoes, apples, and wine grapes.

In the Lower Granite and Little Goose region alfalfa and wheat are the primary crops. Less than 90 acres were identified as receiving deliveries and therefore potentially impacted by the alternatives.

The CDLs were used to determine the number of acres for each crop. Table 4-12 shows these crops and the representative crop modeled for each socioeconomic area.

Table 4-12. Crops and Representative Crop Modeled for Each Socioeconomic Area in Region C

Crop		Socioeconomic Area: Ice Harbor and Lower Monumental		Socioeconomic Area: Lower Granite and Little Goose
Crop Category	**Crop**	**Acres**	**Percent of Category**	**Acres**
Hay	–	2,134	–	46
	Alfalfa	1,889	88.52%	25
	Other Hay	245	11.48%	21
Small Grains	–	14,761	–	32
	Winter Wheat	9,747	66.03%	–
	Corn	4,014	27.19%	–
	Spring Wheat	–	–	–
	All Other	1,000	6.77%	–

Crop		Socioeconomic Area		
		Ice Harbor and Lower Monumental		Lower Granite and Little Goose
Crop Category	**Crop**	**Acres**	**Percent of Category**	**Acres**
Irrigated Vegetables	–	12,131	–	7
	Potatoes	8,238	67.91%	–
	Sweet Corn	1,785	14.71%	–
	All Other	2,108	17.38%	–
Fruit Crops	–	15,801	–	0
	Apples	11,454	72.49%	–
	Other Tree Crops	3,734	23.63%	–
	All Other	613	3.88%	–
Grapes	*Grapes*	3,013	100.00%	0
Total		**47,840**	**–**	**86**

Source: USDA CDL, 2013–2017.

The crop yields, shown in Table 4-13, were obtained from USDA National Agricultural Statistics Service (NASS) and the USDA Farm and Ranch Survey. In the Ice Harbor and Lower Monumental socioeconomic region alfalfa yields for Walla Walla county were used to derive an average yield (2013-2017) to represent the area. Walla Walla county was used because the majority alfalfa is grown in Walla Walla county and data was not available for the other counties. In this region average yields for potatoes, apples, and grapes were derived using Washington state yields because county level data were not published for these crops. The irrigated winter wheat and corn yields were taken from the Farm and Ranch Survey (2008 and 2013) because irrigated yields are not collected on an annual basis by NASS.

Published yields were not available for the Lower Granite and Little Goose socioeconomic region.

Table 4-13. Crop Yields for Ice Harbor and Lower Monumental Socioeconomic Area

Year	Alfalfa[1] (tons)	Winter Wheat[3] (Bu)	Corn[3] (Bu)	Pototoes[2] (cwt)	Apples[2] (lbs)	Grapes[2] (tons)
2008	–	94	185	–	–	–
2013	7.60	111	209	600	38,600	4.67
2014	6.00	–	–	615	48,400	4.73
2015	7.35	–	–	590	36,800	4.53
2016	6.20	–	–	625	44,400	5.19
2017	7.30	–	–	605	45,500	4.32
Average	**6.89**	**102.5**	**197**	**607**	**42,740**	**4.69**

Sources:
1 Walla Walla county (USDA NASS, Quick Stats Database)
2 Washington State (USDA NASS, Quick Stats Database.)
3 Washington state irrigated winter wheat yield (Farm and Ranch Survey, 2013 and 2008)
bu = bushel; cwt = hundredweight (equal to 100 pounds); lb = pound

State prices were obtained from USDA NASS for each representative crop as shown in Table 4-14. Because county level prices are not published state level prices were used in this analysis.

Table 4-14. Crop Prices for Washington State

Crop	Unit	2013	2014	2015	2016	2017	2013–2017 Average
Hay, Alfalfa	$/ton	200	213	171	135	157	**175.20**
Wheat, Winter	$/bu	6.87	6.42	5.31	4.1	4.72	**5.48**
Corn	$/bu	5.29	4.9	4.3	4.7	4.05	**4.65**
Potatoes	$/cwt	8.25	7.6	7.7	7.7	6.92	**7.63**
Apples	$/lb	0.362	0.268	0.394	0.341	0.338	**0.341**
Grapes	$/ton	1,110	1,110	1,150	1,160	1,210	**1,148**

Data source: USDA NASS, Quick Stats Database.

bu = bushel; cwt = hundredweight (equal to 100 pounds); lb = pound

Results – Ice Harbor and Lower Monumental

The gross value of production was calculated for each representative crop and was run through IMPLAN to estimate the regional impacts for the alternative. The regional impacts include estimated employment, labor income, and output (sales) stemming from the gross value of production. Table 4-15 shows the estimated gross value of production for the crops grown in the Ice Harbor and Lower Monumental socioeconomic region and the corresponding IMPLAN region.

The No Action Alternative would result in approximately 4,800 jobs (full time and part time jobs) within the Ice Harbor and Lower Monumental study area as shown in Table 4-16. These jobs are the result of gross farm income generated from crop production on approximately 47,840 acres of farmland. Labor income resulting from the implementation of the No Action Alternative would equal $232,000,000. Output would equal $460,000,000.

Table 4-15. Irrigated Cropping Pattern, Estimated Gross Farm Income, and Associated IMPLAN Sector for Ice Harbor and Lower Monumental Socioeconomic Area–No Action Alternative

Representative Crops	Acres	Yield	Price	Gross Value	IMPLAN Sector
Irrigated Alfalfa	2,134	6.89 tons	$175.20/ton	$2,575,947	All other crops
Irrigated Winter Wheat	10,747	102.5 bu	$5.48/bu	$6,041,015	Grain farming
Corn	4,014	197 bu	$4.65/by	$3,677,383	Grain farming
Potatoes	12,131	607 cwt	$7.63/cwt	$56,213,352	All other crops
Apples	15,801	42,740 lbs	$0.34/lb	$230,013,500	Fruit farming
Grapes	3,013	4.688 tons	$1,148.00/ton	$16,212,745	All other crops
Total	47,840	–	–	$314,733,944	–

bu = bushel; cwt = hundredweight (equal to 100 pounds); lb = pound

Table 4-16. Estimated Regional Impacts for Ice Harbor and Lower Monumental Socioeconomic Area–No Action Alternative

Impact Type	Employment	Labor Income	Output
Direct Effect	3,300	170,169,000	314,734,000
Indirect Effect	900	34,563,000	58,117,000
Induced Effect	700	26,892,000	87,116,000
Total Effect	4,800	231,624,000	459,968,000

SUBREGION - LOWER GRANITE AND LITTLE GOOSE

Effects in this region were not modeled due to the small number of acres, (less than 90 acres) 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.

REGIONAL ECONOMIC IMPACTS - MUNICIPAL AND INDUSTRIAL

The effects were estimated as the increment between the No Action and the Action conditions, therefore pumping costs were not estimated under the No Action condition

4.2.1.4 Region D – McNary, John Day, The Dalles, Bonneville

REGIONAL ECONOMIC IMPACTS

The physical effects to M&I were not shown in this region.

4.2.2 Multiple Objective Alternative 1

MO1 did not affect the ability to deliver water in Regions A, C, or D therefore there were not estimated changes as compared to No-Action.

4.2.2.1 Region B – Grand Coulee, Chief Joseph

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 $7,000 (annual equivalent), as described in Section 4.1 Social Welfare Analysis above. The average annual employment impact was estimated to be a decrease in employment (less than one 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.

4.2.3 Multiple Objective Alternative 2

MO2 did not affect the ability to deliver water in Regions A, C, or D therefore there were not estimated changes as compared to No-Action.

4.2.3.1 Region B – Grand Coulee, Chief Joseph

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 range from $10,000 (annual equivalent), as described in Section 4.1 Social Welfare Analysis above. The average annual employment impact was estimated to be a decrease in employment (less than one 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.

4.2.4 Multiple Objective Alternative 3

MO3 did not affect the ability to deliver water in Regions A or D therefore there were not estimated changes as compared to No-Action.

4.2.4.1 Region B – Grand Coulee, Chief Joseph

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 range from $3,000 (annual equivalent), as described in Section 4.1 Social Welfare Analysis above. The average annual employment impact was estimated to be a decrease in employment (less than one 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.

4.2.4.2 Region C - Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

REGIONAL ECONOMIC IMPACTS - IRRIGATION

The 2002 Corps report analyzed dam removal and the impact 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 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 isn't 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 impact a dryland wheat/fallow operation on lands that were previously supporting fruit orchards and vineyards. A decrease in agricultural production would result in less local expenditures related to farm inputs, wages, and household income.

Results - Ice Harbor and Lower Monumental

Assuming the entire 47,840 acres were no longer irrigated gross value of production would decline by approximately $314,733,944 as described in 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 and part time jobs) within the Ice Harbor and Lower Monumental were estimated be lost. The implementation of MO3 would decrease labor income by $232,000,000. Output would decline by $460,000,000.

Results - Lower Granite and Little Goose

Assuming the entire 90 acres, shown in the No Action alternative, was no longer irrigated gross value of production would decline. Published yields and prices were not available in this area to measure the gross value of 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.

REGIONAL ECONOMIC IMPACTS – MUNICIPAL AND INDUSTRIAL

The physical water supply analysis estimated that 21,330 acre-feet of water is diverted for M&I purposes. These impacts were estimated to occur in the Lower Granite and Little Goose region.

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 change. This decrease in household income has a negative impact on the regional economy in terms of jobs, labor income, and output (sales). These impacts were estimated as a loss of 55 jobs, $2,261,000 of labor income, and $7,518,000 of output (sales) annually.

4.2.5 Multiple Objective Alternative 4

MO4 did not affect the ability to deliver water in Regions A or C therefore there were not estimated changes as compared to No-Action.

4.2.5.1 Region B – Grand Coulee, Chief Joseph

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 range from $72,000 (annual equivalent), as described in Section 4.1 Social Welfare Analysis above. The average annual employment impact was estimated to be a decrease in employment (less than one 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.

4.2.5.2 Region D – McNary, John Day, The Dalles, Bonneville

REGIONAL ECONOMIC IMPACTS - 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 were required to maintain irrigation needs. This additional power requirement results in additional estimated annual energy costs ranging from $260,000-277,000 (annual equivalent) for the entire study area as described in Section 4.1 Social Welfare Analysis above. In this analysis the additional cost required to continue using the existing pumps to maintain baseline acres and cropping patterns were inputs to the IMPLAN model.

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 impacts (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.

Table 4-17 shows the lost employment, labor income, and output resulting from an increase in pumping costs ranging from $260,000 to $277,860 (annual equivalent) as described in Section 4.1 Social Welfare Analysis above. The average annual employment impact was estimated to be a decrease in employment (less than 5 jobs), labor income ($55,000-$59,000), and output ($176,000-$188,000). 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.

Table 4-17. Estimated Regional Impacts for John Day Socioeconomic Area – MO4

Impact Type	Decrease in Employment	Labor Income	Output
Direct Effect	0	0	0
Indirect Effect	0	0	0
Induced Effect	Less than 5	$55,000-$59,000	$176,000-$188,000
Total Effect	Less than 5	$55,000-$59,000	$176,000-$188,000

REGIONAL ECONOMIC IMPACTS – MUNICIPAL AND INDUSTRIAL

The physical effects to M&I were not shown in this region.

4.2.6 Preferred Alternative

4.2.6.1 Region A – Libby, Hungry Horse, Albeni Falls

Preferred Alternative did not affect the ability to deliver water therefore there were not estimated changes as compared to No-Action.

4.2.6.2 Region B – Grand Coulee, Chief Joseph

Effects to Lake Roosevelt pool elevation could result increased pumping costs.

REGIONAL ECONOMIC EFFECTS ANALYSIS

Increased pumping costs would of $1,000 annual would result no measurable regional economic effects compared to the No Action alternative.

4.2.6.3 Region C - Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor

Preferred Alternative did not affect the ability to deliver water therefore there were not estimated changes as compared to No-Action.

4.2.6.4 Region D – McNary, John Day, The Dalles, Bonneville

Preferred Alternative did not affect the ability to deliver water therefore there were not estimated changes as compared to No-Action.

CHAPTER 5 - DISCUSSION OF OTHER WATER SUPPLY RELATED TOPICS

5.1 WATER SUPPLY MEASURES

The future water supply measures were added to MO1, MO3, and MO4 to evaluate the effects of diverting that water on the flow and stage in the river and reservoirs associated with the 14 Federal Projects (see Chapter 2 of the main EIS document for a complete description). The scope of the future water supply measure analysis is limited to effects on the water surface elevation and river flows in the study area and reservoirs, not the physical or socioeconomic effects of delivering that water. In other words, the effects of these measures are analyzed in the resources that are affected by water surface elevation and river flows in the study area, not in the water supply sections of this EIS.

Hungry Horse Additional Water Supply – In 2015, the Montana State Legislature ratified the Confederated Salish and Kootenai Tribes (CSKT)- Montana Compact that allows the CSKT to divert up to 229,383 acre-feet per year with 128,158 acre-feet per year allowed for consumptive use or depletion (Montana 2019). The Compact allocated up to 90,000 acre-feet of water stored in Hungry Horse to meet this need. Prior to this agreement, there had been other requests for water by the State and other interested parties, but the parties have agreed to the terms in the Compact and no other requests are currently pending.

The Compact must be approved by Congress and the Montana Water Court before it can become effective. Because approvals for the Compact are still being implemented, it is not known exactly when or what amounts of water from Hungry Horse will be used and how much will be consumptively used. To analyze the most extreme effects of using this water, MO1, MO3, and MO4 included an operational future water supply measure to release 90,000 acre-feet of water from Hungry Horse in July, August, and September and divert all of it downstream where it would be consumptively used (O13, O15, and O20, respectively).

The modeling of the Compact for this EIS was designed to capture the maximum impacts to Hungry Horse. Previous modeling work conducted by Reclamation (2012) shows possible methods of implementation, but by covering the extremes in this EIS, flexibility is provided for the actual implementation.

The modeling showed how release of this stored water from Hungry Horse would affect the reservoir and downstream reaches. It generally resulted in Hungry Horse being approximately four feet lower than the No Action on September 30 and flows being 500 cubic feet per second (cfs) higher in July, August, and September downstream of the dam. The impacts on other resources are discussed in their respective sections of this EIS.

Lake Roosevelt Additional Water Supply - Reclamation's Columbia Basin Project was originally authorized by Congress for 1,095,000 acres of irrigated land but has developed or has current plans to develop 772,525 acres. To serve the 254,475 additional acres with an estimated 4.5 acre-feet per acre, 1.154 million acre-feet of additional water would need to be pumped from the Columbia River.

MO1, MO3, and MO4 included an operational future water supply measure to pump an additional 1.154 MAF from Lake Roosevelt for additional water supply to the Columbia Basin Project (O12, O14, and O17, respectively). Figure 5-1 shows the total pumped monthly volume that was modeled to simulate delivering that water. This amount of water was delivered in each model year to analyze the downstream effects of the delivery. Additional NEPA would be required prior to delivering this water to the Columbia Basin Project, further analysis would need to be done to determine the impacts and the methods that would be used to deliver this water.

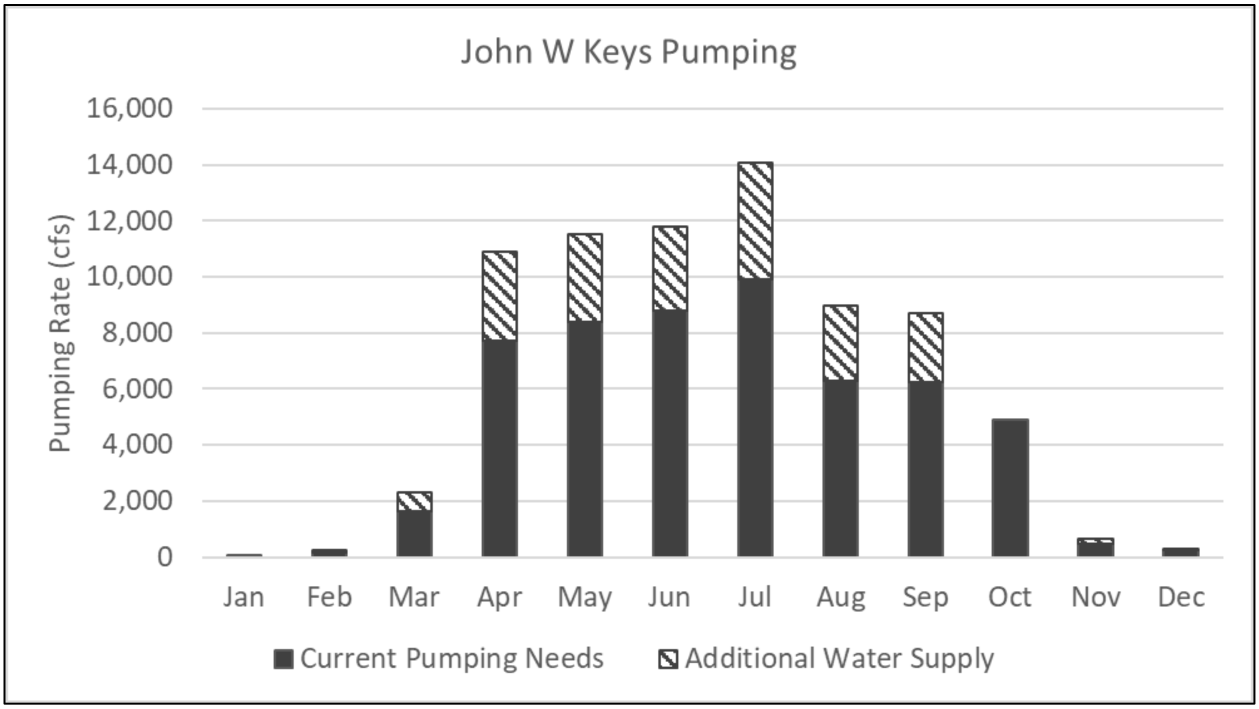

Figure 5-1. Monthly Pumping Requirement from Lake Roosevelt for Current Water Supply (solid bars) and Additional Water Supply (dashed bars)

The modeling showed how delivery of this water from Lake Roosevelt would affect the downstream reaches. Diverting this additional water did not have an effect on Lake Roosevelt elevations; however, it did result in outflows being slightly lower during the irrigation season. The impacts on other resources are discussed in their respective sections of this EIS.

Chief Joseph Dam Project Additional Water Supply - Reclamation's Chief Joseph Dam Project is an irrigation project that was authorized with the construction of the Corps' Chief Joseph Dam. Although they share the same name, they are separate projects. The irrigation project was authorized in phases over many years with authorizations totaling 33,050 acres. To date, 2,821 acres were authorized but have not been developed. To serve the additional acres with an estimated 3.4 acre-feet per acre, approximately 9,600 acre-feet of water would need to be diverted from the Columbia River.

MO1, MO3, and MO4 included an operational future water supply measure to deliver an additional 9,600 acre-feet of water to the Chief Joseph Dam Project for irrigation (O14, O16, and O21, respectively). It is outside the scope of this EIS to determine the exact method and timing of delivery of this water.

The modeling intended to show how diverting this water would impact downstream flows. However, at most, this diversion would result in 50 cfs less flow in the river, which is within the noise of the model. The impacts on other resources are discussed in their respective sections of this EIS.

5.2 WASHINGTON INTERRUPTIBLE WATER RIGHTS

The State of Washington defines “interruptible water rights” that are curtailed when the March 1, April to September Dalles forecast drops below 60 million acre-feet. The models use the same set of modified inflows for all the alternatives, including the same forecasts. Because The Dalles forecast does not change from alternative to alternative, the frequency of triggering the “interruptible water rights” occurring does not change from alternative to alternative. From the ResSim No Action model, there is a 2.4 percent probability of the 5,000-year simulations where the Dalles forecast would drop below 60 million acre-feet.

5.3 COLUMBIA BASIN PROJECT DELIVERIES

Water for the Columbia Basin Project is pumped from Lake Roosevelt to Banks Lake via six pumps and six pump-generators who’s pump capacities vary with the elevations in both lakes. The pump-generators cannot operate when Lake Roosevelt is below elevation 1,240 feet (NGVD29), which reduces the overall pumping plant capacity.

Project water is delivered from Banks Lake, which can draw down if project deliveries exceed the amount pumped from Lake Roosevelt. Generally, Banks Lake is allowed to fluctuate within the top five feet of space, although it has NEPA compliance to draw down as low as 11 feet in order to ensure deliveries to the Columbia Basin Project (Odessa 2013).

For this NEPA study, Banks Lake was outside the scope of evaluation. However, an analysis was conducted to ensure that current water supply obligations could be met without drawing Banks below existing NEPA compliance. The analysis found that even in the most extreme years when Lake Roosevelt was drawn down for spring flood control operations, the necessary water could be delivered without drawing Banks Lake more than 11 feet down as long as all six pumps were operational in April, May, and June. Grand Coulee maintenance plan activities will not be conducted during April through June so that all six pumps are operational in wet years to meet this criteria.

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Columbia River System Operations
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Appendix O
Environmental Justice

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CHAPTER 1 - ENVIRONMENTAL JUSTICE

The tables in this appendix supplement the Environmental Justice Affected Environment section of this EIS (Section 3.15.2). According to the Council on Environmental Quality (CEQ) guidance for implementing Executive Order 12898 under the National Environmental Policy Act (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; Clinton 1994). This supplemental material is intended to show the details of how the populations for environmental justice analysis were identified using demographic data. It also illuminates the socioeconomic and cultural vulnerabilities that necessitate these populations be studied to address the potential for disproportionately adverse effects. Specifically, this appendix includes the following tables to provide additional detailed breakdown:

- Table 1-1 provides a breakdown of low-income population, illustrating the number of census block groups and associated population that are considered low-income in each county in the study area.
- Table 1-2 provides a breakdown of minority population, illustrating the number of census block groups and associated population that are considered minority in each county in the study area.
- Table 1-3 provides additional information on minority populations and race and ethnicity for each county in the study area.
- Table 1-4 provides other socioeconomic indicators that evaluate income and employment, age distribution, and education for counties in the study area.
- Table 1-5 provides socioeconomic indicators for Indian tribes in the study area that evaluate income and employment, age distribution, and education.

Demographic information for Indian tribes in the study area has been collected from the U.S. Census Bureau (U.S. Census). These data include metrics typically used by researchers and in EPA's EJ screening tools to represent the "social vulnerability" characteristics of a disadvantaged population (EPA 2017). However, these data do not capture a complete picture of the current economic, social, and health conditions in these communities. For example, U.S. Census may not fully capture tribal members that are transient during the year as it relies on those with permanent addresses.

Note, the demographic data included in Table 5 represent statistics for the population residing within the geographic boundaries of the reservation, and includes off-reservation trust lands as well, where data was included in the U.S. Census data.

Table 1-1. Low-Income Populations in the Study Area, by County

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Low-Income Criteria[1/]	Percent Low-Income	Total	Meet Low-Income Criteria[1/]	Percent Low-Income
California	Modoc County, CA	12	4	33%	9,033	2,629	29%
	California Total	**12**	**4**	**33%**	**9,033**	**2,629**	**29%**
Idaho	Ada County, ID	169	39	23%	425,798	63,935	15%
	Adams County, ID	3	1	33%	3,865	1,573	41%
	Bannock County, ID	60	28	47%	83,815	36,593	44%
	Bear Lake County, ID	7	2	29%	5,928	1,359	23%
	Benewah County, ID	9	3	33%	9,068	2,925	32%
	Bingham County, ID	30	6	20%	45,261	9,048	20%
	Blaine County, ID	13	2	15%	21,427	2,804	13%
	Boise County, ID	4	2	50%	6,891	3,008	44%
	Bonner County, ID	35	8	23%	41,389	10,459	25%
	Bonneville County, ID	68	22	32%	108,989	25,687	24%
	Boundary County, ID	9	2	22%	11,141	2,451	22%
	Butte County, ID	3	1	33%	2,592	1,013	39%
	Camas County, ID	1	0	0%	968	0	0%
	Canyon County, ID	84	36	43%	202,782	60,788	30%
	Caribou County, ID	7	0	0%	6,813	0	0%
	Cassia County, ID	19	5	26%	23,441	4,927	21%
	Clark County, ID	1	1	100%	960	960	100%
	Clearwater County, ID	13	0	0%	8,528	0	0%
	Custer County, ID	4	2	50%	4,185	2,318	55%
	Elmore County, ID	16	9	56%	26,103	12,559	48%
	Franklin County, ID	10	0	0%	13,013	0	0%
	Fremont County, ID	12	2	17%	12,896	1,544	12%
	Gem County, ID	12	6	50%	16,853	9,402	56%
	Gooding County, ID	13	3	23%	15,157	3,579	24%
	Idaho County, ID	15	5	33%	16,251	3,532	22%

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Low-Income Criteria1/	Percent Low-Income	Total	Meet Low-Income Criteria1/	Percent Low-Income
	Jefferson County, ID	14	2	14%	27,096	1,876	7%
	Jerome County, ID	15	6	40%	22,694	5,664	25%
	Kootenai County, ID	66	12	18%	147,716	20,039	14%
	Latah County, ID	31	11	35%	38,593	18,007	47%
	Lemhi County, ID	8	3	38%	7,743	3,312	43%
	Lewis County, ID	6	1	17%	3,826	878	23%
	Lincoln County, ID	4	0	0%	5,292	0	0%
	Madison County, ID	22	12	55%	38,114	23,870	63%
	Minidoka County, ID	16	5	31%	20,331	7,190	35%
	Nez Perce County, ID	36	8	22%	39,995	10,494	26%
	Oneida County, ID	3	0	0%	4,269	0	0%
	Owyhee County, ID	10	5	50%	11,356	5,195	46%
	Payette County, ID	15	5	33%	22,773	5,346	23%
	Power County, ID	7	1	14%	7,696	1,252	16%
	Shoshone County, ID	18	7	39%	12,551	5,715	46%
	Teton County, ID	4	1	25%	10,437	2,477	24%
	Twin Falls County, ID	53	18	34%	80,955	22,437	28%
	Valley County, ID	7	2	29%	9,897	2,636	27%
	Washington County, ID	10	2	20%	10,035	1,668	17%
	Idaho Total	**962**	**286**	**30%**	**1,635,483**	**398,520**	**24%**
Montana	Beaverhead County, MT	8	3	38%	9,317	3,477	37%
	Broadwater County, MT	4	0	0%	5,692	0	0%
	Deer Lodge County, MT	11	5	45%	9,176	4,377	48%
	Flathead County, MT	70	16	23%	94,696	22,447	24%
	Glacier County, MT	15	11	73%	13,695	11,012	80%
	Granite County, MT	3	1	33%	3,212	1,189	37%
	Jefferson County, MT	10	2	20%	11,601	1,454	13%
	Lake County, MT	25	10	40%	29,311	12,405	42%

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Low-Income Criteria[1/]	Percent Low-Income	Total	Meet Low-Income Criteria[1/]	Percent Low-Income
	Lincoln County, MT	17	7	41%	19,268	6,685	35%
	Madison County, MT	7	1	14%	7,810	1,398	18%
	Mineral County, MT	4	1	25%	4,223	899	21%
	Missoula County, MT	76	25	33%	113,101	32,496	29%
	Powell County, MT	8	0	0%	6,928	0	0%
	Ravalli County, MT	31	13	42%	41,130	17,585	43%
	Sanders County, MT	10	6	60%	11,375	7,047	62%
	Silver Bow County, MT	37	16	43%	34,560	15,354	44%
	Montana Total	**336**	**117**	**35%**	**415,095**	**137,825**	**33%**
Nevada	Elko County, NV	37	7	19%	52,029	8,991	17%
	Humboldt County, NV	14	3	21%	17,091	4,458	26%
	Nevada Total	**51**	**10**	**20%**	**69,120**	**13,449**	**19%**
Oregon	Baker County, OR	17	5	29%	16,030	4,253	27%
	Benton County, OR	61	30	49%	87,455	40,084	46%
	Clackamas County, OR	217	26	12%	394,967	42,653	11%
	Clatsop County, OR	37	10	27%	37,660	9,025	24%
	Columbia County, OR	36	5	14%	49,645	6,354	13%
	Coos County, OR	63	21	33%	62,944	18,779	30%
	Crook County, OR	16	6	38%	21,334	5,786	27%
	Curry County, OR	16	5	31%	22,364	6,080	27%
	Deschutes County, OR	85	21	25%	170,813	35,293	21%
	Douglas County, OR	84	36	43%	107,375	46,771	44%
	Gilliam County, OR	3	0	0%	1,913	0	0%
	Grant County, OR	8	3	38%	7,227	2,745	38%
	Harney County, OR	7	2	29%	7,214	1,372	19%
	Hood River County, OR	19	2	11%	22,842	3,236	14%
	Jackson County, OR	127	44	35%	210,916	78,884	37%
	Jefferson County, OR	16	5	31%	22,305	8,865	40%

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Low-Income Criteria[1/]	Percent Low-Income	Total	Meet Low-Income Criteria[1/]	Percent Low-Income
	Josephine County, OR	54	21	39%	84,063	32,979	39%
	Klamath County, OR	67	28	42%	65,946	24,372	37%
	Lake County, OR	9	3	33%	7,799	2,097	27%
	Lane County, OR	257	96	37%	360,273	131,839	37%
	Lincoln County, OR	39	15	38%	46,685	18,368	39%
	Linn County, OR	85	28	33%	119,862	40,092	33%
	Malheur County, OR	30	17	57%	30,474	19,032	62%
	Marion County, OR	192	64	33%	326,527	111,381	34%
	Morrow County, OR	11	3	27%	11,207	3,230	29%
	Multnomah County, OR	520	158	30%	778,193	273,499	35%
	Polk County, OR	41	12	29%	78,470	20,562	26%
	Sherman County, OR	2	1	50%	1,705	764	45%
	Tillamook County, OR	28	9	32%	25,552	8,046	31%
	Umatilla County, OR	64	21	33%	76,582	28,661	37%
	Union County, OR	26	10	38%	25,758	10,023	39%
	Wallowa County, OR	7	1	14%	6,836	1,507	22%
	Wasco County, OR	22	2	9%	25,657	2,034	8%
	Washington County, OR	303	52	17%	564,088	93,206	17%
	Wheeler County, OR	2	1	50%	1,369	760	56%
	Yamhill County, OR	54	15	28%	102,217	29,041	28%
	Oregon Total	**2,625**	**778**	**30%**	**3,982,267**	**1,161,673**	**29%**
Washington	Adams County, WA	15	6	40%	19,100	10,209	53%
	Asotin County, WA	21	7	33%	22,113	6,808	31%
	Benton County, WA	134	35	26%	187,519	48,815	26%
	Chelan County, WA	55	10	18%	74,761	13,232	18%
	Clallam County, WA	54	14	26%	72,969	17,136	23%
	Clark County, WA	280	34	12%	450,893	53,567	12%
	Columbia County, WA	5	1	20%	3,971	1,196	30%

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Low-Income Criteria[1/]	Percent Low-Income	Total	Meet Low-Income Criteria[1/]	Percent Low-Income
	Cowlitz County, WA	89	26	29%	102,854	24,366	24%
	Douglas County, WA	29	8	28%	40,101	11,318	28%
	Ferry County, WA	7	5	71%	7,639	5,172	68%
	Franklin County, WA	48	14	29%	87,810	30,329	35%
	Garfield County, WA	3	1	33%	2,231	606	27%
	Grant County, WA	46	16	35%	92,530	35,039	38%
	Grays Harbor County, WA	61	21	34%	71,233	20,520	29%
	Island County, WA	56	4	7%	80,113	4,770	6%
	Jefferson County, WA	26	6	23%	30,333	5,798	19%
	King County, WA	1,420	218	15%	2,079,550	342,063	16%
	Kitsap County, WA	162	14	9%	257,488	20,640	8%
	Kittitas County, WA	25	7	28%	42,785	12,197	29%
	Klickitat County, WA	19	4	21%	20,930	4,088	20%
	Lewis County, WA	62	18	29%	75,724	22,037	29%
	Lincoln County, WA	11	2	18%	10,326	2,056	20%
	Mason County, WA	49	17	35%	61,060	22,695	37%
	Okanogan County, WA	44	23	52%	41,299	19,734	48%
	Pacific County, WA	19	11	58%	20,743	9,903	48%
	Pend Oreille County, WA	14	3	21%	13,001	3,157	24%
	Pierce County, WA	558	132	24%	832,896	172,644	21%
	San Juan County, WA	13	0	0%	16,056	0	0%
	Skagit County, WA	81	23	28%	120,475	34,943	29%
	Skamania County, WA	10	3	30%	11,316	3,459	31%
	Snohomish County, WA	499	59	12%	758,649	85,359	11%
	Spokane County, WA	322	110	34%	485,859	147,823	30%
	Stevens County, WA	34	13	38%	43,744	13,611	31%
	Thurston County, WA	160	32	20%	266,311	49,594	19%
	Wahkiakum County, WA	5	1	20%	4,051	888	22%

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Low-Income Criteria[1/]	Percent Low-Income	Total	Meet Low-Income Criteria[1/]	Percent Low-Income
	Walla Walla County, WA	43	19	44%	59,809	24,627	41%
	Whatcom County, WA	102	29	28%	209,729	63,651	30%
	Whitman County, WA	33	12	36%	47,494	22,520	47%
	Yakima County, WA	149	71	48%	247,681	123,507	50%
	Washington Total	**4,763**	**1,029**	**22%**	**7,073,146**	**1,490,077**	**21%**
Wyoming	Teton County, WY	14	2	14%	22,623	2,521	11%
	Wyoming Total	**14**	**2**	**14%**	**22,623**	**2,521**	**11%**

Source: U.S. Census Bureau 2017
Notes:
1/ For this analysis, census block groups for which the U.S. Census reports that 20 percent or more of the population is living below the poverty level are categorized as low-income populations.

Table 1-2. Minority Populations in the Study Area, by County

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Minority Criteria[1/]	Percent Minority	Total	Meet Minority Criteria[1/]	Percent Minority
California	Modoc County, CA	12	0	0%	9,033	0	0%
	California Total	**12**	**0**	**0%**	**9,033**	**0**	**0%**
Idaho	Ada County, ID	169	59	35%	425,798	136,851	32%
	Adams County, ID	3	0	0%	3,865	0	0%
	Bannock County, ID	60	21	35%	83,815	26,584	32%
	Bear Lake County, ID	7	0	0%	5,928	0	0%
	Benewah County, ID	9	3	33%	9,068	2,925	32%
	Bingham County, ID	30	14	47%	45,261	19,307	43%
	Blaine County, ID	13	6	46%	21,427	11,399	53%
	Boise County, ID	4	0	0%	6,891	0	0%
	Bonner County, ID	35	0	0%	41,389	0	0%
	Bonneville County, ID	68	26	38%	108,989	32,632	30%
	Boundary County, ID	9	0	0%	11,141	0	0%

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Minority Criteria[1/]	Percent Minority	Total	Meet Minority Criteria[1/]	Percent Minority
	Butte County, ID	3	0	0%	2,592	0	0%
	Camas County, ID	1	0	0%	968	0	0%
	Canyon County, ID	84	66	79%	202,782	162,380	80%
	Caribou County, ID	7	0	0%	6,813	0	0%
	Cassia County, ID	19	14	74%	23,441	16,710	71%
	Clark County, ID	1	1	100%	960	960	100%
	Clearwater County, ID	13	2	15%	8,528	2,149	25%
	Custer County, ID	4	0	0%	4,185	0	0%
	Elmore County, ID	16	10	63%	26,103	18,073	69%
	Franklin County, ID	10	1	10%	13,013	1,326	10%
	Fremont County, ID	12	4	33%	12,896	4,755	37%
	Gem County, ID	12	2	17%	16,853	3,213	19%
	Gooding County, ID	13	12	92%	15,157	13,850	91%
	Idaho County, ID	15	1	7%	16,251	867	5%
	Jefferson County, ID	14	4	29%	27,096	8,376	31%
	Jerome County, ID	15	13	87%	22,694	20,561	91%
	Kootenai County, ID	66	2	3%	147,716	2,061	1%
	Latah County, ID	31	4	13%	38,593	6,793	18%
	Lemhi County, ID	8	0	0%	7,743	0	0%
	Lewis County, ID	6	2	33%	3,826	1,801	47%
	Lincoln County, ID	4	4	100%	5,292	5,292	100%
	Madison County, ID	22	6	27%	38,114	5,655	15%
	Minidoka County, ID	16	15	94%	20,331	19,535	96%
	Nez Perce County, ID	36	6	17%	39,995	5,661	14%
	Oneida County, ID	3	0	0%	4,269	0	0%
	Owyhee County, ID	10	8	80%	11,356	9,004	79%
	Payette County, ID	15	9	60%	22,773	14,423	63%
	Power County, ID	7	5	71%	7,696	6,144	80%

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Minority Criteria[1/]	Percent Minority	Total	Meet Minority Criteria[1/]	Percent Minority
	Shoshone County, ID	18	1	6%	12,551	625	5%
	Teton County, ID	4	2	50%	10,437	4,586	44%
	Twin Falls County, ID	53	25	47%	80,955	39,971	49%
	Valley County, ID	7	0	0%	9,897	0	0%
	Washington County, ID	10	3	30%	10,035	3,539	35%
	Idaho Total	**962**	**351**	**36%**	**1,635,483**	**608,008**	**37%**
Montana	Beaverhead County, MT	8	2	25%	9,317	3,114	33%
	Broadwater County, MT	4	0	0%	5,692	0	0%
	Deer Lodge County, MT	11	3	27%	9,176	3,032	33%
	Flathead County, MT	70	11	16%	94,696	11,082	12%
	Glacier County, MT	15	14	93%	13,695	13,112	96%
	Granite County, MT	3	0	0%	3,212	0	0%
	Jefferson County, MT	10	0	0%	11,601	0	0%
	Lake County, MT	25	19	76%	29,311	23,901	82%
	Lincoln County, MT	17	1	6%	19,268	507	3%
	Madison County, MT	7	0	0%	7,810	0	0%
	Mineral County, MT	4	0	0%	4,223	0	0%
	Missoula County, MT	76	19	25%	113,101	31,023	27%
	Powell County, MT	8	1	13%	6,928	1,453	21%
	Ravalli County, MT	31	5	16%	41,130	6,326	15%
	Sanders County, MT	10	2	20%	11,375	1,867	16%
	Silver Bow County, MT	37	10	27%	34,560	12,314	36%
	Montana Total	**336**	**87**	**26%**	**415,095**	**107,731**	**26%**
Nevada	Elko County, NV	37	10	27%	52,029	12,879	25%
	Humboldt County, NV	14	2	14%	17,091	2,787	16%
	Nevada Total	**51**	**12**	**24%**	**69,120**	**15,666**	**23%**
Oregon	Baker County, OR	17	0	0%	16,030	0	0%
	Benton County, OR	61	15	25%	87,455	22,346	26%

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Minority Criteria[1/]	Percent Minority	Total	Meet Minority Criteria[1/]	Percent Minority
	Clackamas County, OR	217	57	26%	394,967	115,424	29%
	Clatsop County, OR	37	6	16%	37,660	5,636	15%
	Columbia County, OR	36	1	3%	49,645	1,102	2%
	Coos County, OR	63	12	19%	62,944	12,332	20%
	Crook County, OR	16	1	6%	21,334	677	3%
	Curry County, OR	16	1	6%	22,364	2,534	11%
	Deschutes County, OR	85	10	12%	170,813	18,047	11%
	Douglas County, OR	84	5	6%	107,375	6,156	6%
	Gilliam County, OR	3	1	33%	1,913	470	25%
	Grant County, OR	8	0	0%	7,227	0	0%
	Harney County, OR	7	0	0%	7,214	0	0%
	Hood River County, OR	19	11	58%	22,842	15,039	66%
	Jackson County, OR	127	34	27%	210,916	64,887	31%
	Jefferson County, OR	16	8	50%	22,305	13,854	62%
	Josephine County, OR	54	6	11%	84,063	7,179	9%
	Klamath County, OR	67	23	34%	65,946	22,706	34%
	Lake County, OR	9	2	22%	7,799	1,925	25%
	Lane County, OR	257	50	19%	360,273	80,954	22%
	Lincoln County, OR	39	10	26%	46,685	11,994	26%
	Linn County, OR	85	14	16%	119,862	21,479	18%
	Malheur County, OR	30	21	70%	30,474	23,012	76%
	Marion County, OR	192	106	55%	326,527	190,456	58%
	Morrow County, OR	11	5	45%	11,207	8,262	74%
	Multnomah County, OR	520	267	51%	778,193	450,750	58%
	Polk County, OR	41	10	24%	78,470	21,143	27%
	Sherman County, OR	2	0	0%	1,705	0	0%
	Tillamook County, OR	28	4	14%	25,552	2,951	12%
	Umatilla County, OR	64	35	55%	76,582	50,431	66%

State	County	Number of Block Groups			Population of Block Groups		
		Total	Meet Minority Criteria[1/]	Percent Minority	Total	Meet Minority Criteria[1/]	Percent Minority
	Union County, OR	26	1	4%	25,758	1,021	4%
	Wallowa County, OR	7	0	0%	6,836	0	0%
	Wasco County, OR	22	9	41%	25,657	10,107	39%
	Washington County, OR	303	176	58%	564,088	363,459	64%
	Wheeler County, OR	2	0	0%	1,369	0	0%
	Yamhill County, OR	54	20	37%	102,217	41,553	41%
	Oregon Total	**2,625**	**921**	**35%**	**3,982,267**	**1,587,886**	**40%**
Washington	Adams County, WA	15	9	60%	19,100	15,019	79%
	Asotin County, WA	21	0	0%	22,113	0	0%
	Benton County, WA	134	46	34%	187,519	64,576	34%
	Chelan County, WA	55	23	42%	74,761	32,180	43%
	Clallam County, WA	54	8	15%	72,969	9,583	13%
	Clark County, WA	280	62	22%	450,893	102,784	23%
	Columbia County, WA	5	0	0%	3,971	0	0%
	Cowlitz County, WA	89	13	15%	102,854	14,652	14%
	Douglas County, WA	29	17	59%	40,101	21,624	54%
	Ferry County, WA	7	1	14%	7,639	1,700	22%
	Franklin County, WA	48	40	83%	87,810	79,260	90%
	Garfield County, WA	3	0	0%	2,231	0	0%
	Grant County, WA	46	28	61%	92,530	61,263	66%
	Grays Harbor County, WA	61	12	20%	71,233	14,601	20%
	Island County, WA	56	13	23%	80,113	19,850	25%
	Jefferson County, WA	26	1	4%	30,333	1,025	3%
	King County, WA	1,420	780	55%	2,079,550	1,225,129	59%
	Kitsap County, WA	162	29	18%	257,488	48,043	19%
	Kittitas County, WA	25	2	8%	42,785	6,048	14%
	Klickitat County, WA	19	2	11%	20,930	3,067	15%
	Lewis County, WA	62	6	10%	75,724	9,499	13%

State	County	Number of Block Groups: Total	Number of Block Groups: Meet Minority Criteria[1/]	Number of Block Groups: Percent Minority	Population of Block Groups: Total	Population of Block Groups: Meet Minority Criteria[1/]	Population of Block Groups: Percent Minority
	Lincoln County, WA	11	0	0%	10,326	0	0%
	Mason County, WA	49	7	14%	61,060	10,621	17%
	Okanogan County, WA	44	20	45%	41,299	20,788	50%
	Pacific County, WA	19	3	16%	20,743	2,959	14%
	Pend Oreille County, WA	14	1	7%	13,001	708	5%
	Pierce County, WA	558	262	47%	832,896	415,806	50%
	San Juan County, WA	13	0	0%	16,056	0	0%
	Skagit County, WA	81	21	26%	120,475	32,795	27%
	Skamania County, WA	10	0	0%	11,316	0	0%
	Snohomish County, WA	499	183	37%	758,649	313,589	41%
	Spokane County, WA	322	24	7%	485,859	32,989	7%
	Stevens County, WA	34	2	6%	43,744	2,064	5%
	Thurston County, WA	160	43	27%	266,311	87,200	33%
	Wahkiakum County, WA	5	0	0%	4,051	0	0%
	Walla Walla County, WA	43	16	37%	59,809	20,510	34%
	Whatcom County, WA	102	12	12%	209,729	27,363	13%
	Whitman County, WA	33	5	15%	47,494	12,271	26%
	Yakima County, WA	149	106	71%	247,681	178,814	72%
	Washington Total	**4,763**	**1,797**	**38%**	**7,073,146**	**2,888,380**	**41%**
Wyoming	Teton County, WY	14	6	43%	22,623	8,096	36%
	Wyoming Total	**14**	**6**	**43%**	**22,623**	**8,096**	**36%**

Source: U.S. Census Bureau 2017

Note:

1/ For purposes of this 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). Minority population reflects all populations not identified as "Not Hispanic or Latino: White alone" in the U.S. Census Bureau's American Community Survey.

Table 1-3. Breakdown of Race and Ethnicity in the Study Area, by County

State	County	Total Population	White Alone	Minority Population[2/]	Breakdown of Minority Populations[1/]					
					American Indian or Alaskan Native	Asian or Pacific Islander	Black or African American	Hispanic or Latino	Some Other Race	Two or More Races
California	Modoc County, CA	9,033	7,014	2,019	367	118	82	1,335	5	112
	California Total	**9,033**	**7,014**	**2,019**	**367**	**118**	**82**	**1,335**	**5**	**112**
	California Percent of Total Population	**100%**	**78%**	**22%**	**4%**	**1%**	**1%**	**15%**	**0%**	**1%**
Idaho	Ada County, ID	425,798	364,242	61,556	1,913	10,912	4,999	32,905	370	10,457
	Adams County, ID	3,865	3,597	268	73	8	8	122	11	46
	Bannock County, ID	83,815	71,181	12,634	2,194	1,104	506	6,678	135	2,017
	Bear Lake County, ID	5,928	5,559	369	17	35	46	243	0	28
	Benewah County, ID	9,068	7,682	1,386	750	127	20	300	0	189
	Bingham County, ID	45,261	33,606	11,655	2,239	488	132	8,037	40	719
	Blaine County, ID	21,427	16,481	4,946	9	260	25	4,444	0	208
	Boise County, ID	6,891	6,340	551	101	35	30	260	0	125
	Bonner County, ID	41,389	38,799	2,590	225	282	43	1,143	0	897
	Bonneville County, ID	108,989	91,505	17,484	331	967	466	13,517	50	2,153
	Boundary County, ID	11,141	10,138	1,003	174	16	17	493	0	303
	Butte County, ID	2,592	2,450	142	4	0	31	101	0	6
	Camas County, ID	968	881	87	3	0	0	82	0	2
	Canyon County, ID	202,782	144,636	58,146	1,288	1,958	743	49,941	65	4,151
	Caribou County, ID	6,813	6,283	530	13	0	13	363	4	137
	Cassia County, ID	23,441	16,585	6,856	118	109	44	6,248	27	310
	Clark County, ID	960	496	464	0	0	1	454	0	9
	Clearwater County, ID	8,528	7,778	750	166	87	18	329	0	150
	Custer County, ID	4,185	4,007	178	17	1	0	132	0	28
	Elmore County, ID	26,103	19,326	6,777	354	852	658	4,204	12	697
	Franklin County, ID	13,013	11,889	1,124	24	20	37	871	0	172

State	County	Total Population	White Alone	Minority Population[2/]	Breakdown of Minority Populations[1/]					
					American Indian or Alaskan Native	Asian or Pacific Islander	Black or African American	Hispanic or Latino	Some Other Race	Two or More Races
	Fremont County, ID	12,896	10,995	1,901	46	56	41	1,589	13	156
	Gem County, ID	16,853	14,864	1,989	165	131	0	1,362	0	331
	Gooding County, ID	15,157	10,328	4,829	202	105	12	4,388	23	99
	Idaho County, ID	16,251	14,877	1,374	401	58	20	507	0	388
	Jefferson County, ID	27,096	23,622	3,474	120	92	18	2,810	0	434
	Jerome County, ID	22,694	14,525	8,169	137	117	20	7,622	6	267
	Kootenai County, ID	147,716	134,752	12,964	1,867	1,074	470	6,219	3	3,331
	Latah County, ID	38,593	34,617	3,976	248	914	274	1,559	52	929
	Lemhi County, ID	7,743	7,241	502	59	34	16	231	9	153
	Lewis County, ID	3,826	3,309	517	187	29	3	160	0	138
	Lincoln County, ID	5,292	3,572	1,720	97	9	0	1,577	0	37
	Madison County, ID	38,114	34,110	4,004	2	459	225	2,639	9	670
	Minidoka County, ID	20,331	12,937	7,394	140	89	45	6,869	0	251
	Nez Perce County, ID	39,995	34,963	5,032	2,203	359	146	1,429	0	895
	Oneida County, ID	4,269	4,017	252	20	0	0	162	0	70
	Owyhee County, ID	11,356	7,739	3,617	340	14	14	3,001	0	248
	Payette County, ID	22,773	18,030	4,743	197	286	87	3,796	46	331
	Power County, ID	7,696	4,856	2,840	286	2	17	2,487	19	29
	Shoshone County, ID	12,551	11,572	979	223	54	43	412	2	245
	Teton County, ID	10,437	8,439	1,998	22	11	18	1,814	0	133
	Twin Falls County, ID	80,955	65,504	15,451	589	1,149	511	12,235	12	955
	Valley County, ID	9,897	9,670	227	11	11	1	111	0	93
	Washington County, ID	10,035	7,896	2,139	60	61	0	1,743	40	235
	Idaho Total	**1,635,483**	**1,355,896**	**279,587**	**17,635**	**22,375**	**9,818**	**195,589**	**948**	**33,222**

State	County	Total Population	White Alone	Minority Population[2/]	Breakdown of Minority Populations[1/] American Indian or Alaskan Native	Asian or Pacific Islander	Black or African American	Hispanic or Latino	Some Other Race	Two or More Races
	Idaho Percent of Total Population	**100%**	**83%**	**17%**	**1%**	**1%**	**1%**	**12%**	**0%**	**2%**
Montana	Beaverhead County, MT	9,317	8,534	783	209	154	8	358	0	54
	Broadwater County, MT	5,692	5,336	356	86	80	10	70	0	110
	Deer Lodge County, MT	9,176	8,327	849	128	218	32	282	0	189
	Flathead County, MT	94,696	88,370	6,326	1,295	536	234	2,417	41	1,803
	Glacier County, MT	13,695	4,290	9,405	8,716	68	36	386	0	199
	Granite County, MT	3,212	3,042	170	19	2	2	64	0	83
	Jefferson County, MT	11,601	10,813	788	190	31	8	254	1	304
	Lake County, MT	29,311	19,304	10,007	7,164	131	72	1,197	0	1,443
	Lincoln County, MT	19,268	17,987	1,281	197	114	11	516	0	443
	Madison County, MT	7,810	7,361	449	39	14	13	235	0	148
	Mineral County, MT	4,223	4,108	115	14	32	2	56	4	7
	Missoula County, MT	113,101	101,865	11,236	2,646	1,557	470	3,413	0	3,150
	Powell County, MT	6,928	6,260	668	274	68	29	170	0	127
	Ravalli County, MT	41,130	38,374	2,756	219	231	32	1,322	24	928
	Sanders County, MT	11,375	10,266	1,109	421	55	18	299	0	316
	Silver Bow County, MT	34,560	31,512	3,048	711	305	202	1,411	0	419
	Montana Total	**415,095**	**365,749**	**49,346**	**22,328**	**3,596**	**1,179**	**12,450**	**70**	**9,723**
	Montana Percent of Total Population	**100%**	**88%**	**12%**	**5%**	**1%**	**0%**	**3%**	**0%**	**2%**
Nevada	Elko County, NV	52,029	35,044	16,985	2,689	683	552	12,522	6	533
	Humboldt County, NV	17,091	11,192	5,899	778	84	82	4,419	198	338

State	County	Total Population	White Alone	Minority Population[2/]	Breakdown of Minority Populations[1/]					
					American Indian or Alaskan Native	Asian or Pacific Islander	Black or African American	Hispanic or Latino	Some Other Race	Two or More Races
	Nevada Total	**69,120**	**46,236**	**22,884**	**3,467**	**767**	**634**	**16,941**	**204**	**871**
	Nevada Percent of Total Population	**100%**	**67%**	**33%**	**5%**	**1%**	**1%**	**25%**	**0%**	**1%**
Oregon	Baker County, OR	16,030	14,657	1,373	213	167	65	615	14	299
	Benton County, OR	87,455	71,510	15,945	483	5,789	851	6,100	119	2,603
	Clackamas County, OR	394,967	328,760	66,207	2,031	16,764	3,163	32,503	169	11,577
	Clatsop County, OR	37,660	32,445	5,215	139	497	267	3,074	0	1,238
	Columbia County, OR	49,645	44,362	5,283	573	672	303	2,301	0	1,434
	Coos County, OR	62,944	53,888	9,056	1,320	815	403	3,910	72	2,536
	Crook County, OR	21,334	18,903	2,431	217	48	39	1,588	0	539
	Curry County, OR	22,364	19,513	2,851	402	133	87	1,457	25	747
	Deschutes County, OR	170,813	150,077	20,736	769	1,848	797	13,029	80	4,213
	Douglas County, OR	107,375	95,301	12,074	1,042	1,063	380	5,649	16	3,924
	Gilliam County, OR	1,913	1,657	256	54	10	6	186	0	0
	Grant County, OR	7,227	6,650	577	46	17	30	253	1	230
	Harney County, OR	7,214	6,294	920	241	42	46	356	42	193
	Hood River County, OR	22,842	14,741	8,101	202	398	111	7,046	0	344
	Jackson County, OR	210,916	173,329	37,587	1,280	2,862	1,321	25,058	285	6,781
	Jefferson County, OR	22,305	13,410	8,895	3,614	242	226	4,421	0	392
	Josephine County, OR	84,063	73,736	10,327	1,022	651	297	5,850	30	2,477
	Klamath County, OR	65,946	52,273	13,673	2,118	718	394	7,823	65	2,555
	Lake County, OR	7,799	6,679	1,120	90	70	44	592	10	314
	Lane County, OR	360,273	299,530	60,743	3,155	9,911	3,442	29,403	574	14,258
	Lincoln County, OR	46,685	38,725	7,960	1,334	648	205	4,028	80	1,665
	Linn County, OR	119,862	103,248	16,614	1,623	1,479	591	10,054	69	2,798

State	County	Total Population	White Alone	Minority Population[2/]	Breakdown of Minority Populations[1/]					
					American Indian or Alaskan Native	Asian or Pacific Islander	Black or African American	Hispanic or Latino	Some Other Race	Two or More Races
	Malheur County, OR	30,474	18,902	11,572	167	492	306	10,015	39	553
	Marion County, OR	326,527	218,448	108,079	1,952	8,798	3,547	83,659	249	9,874
	Morrow County, OR	11,207	6,857	4,350	44	54	15	3,886	0	351
	Multnomah County, OR	778,193	553,241	224,952	4,389	57,730	41,100	86,579	1,899	33,255
	Polk County, OR	78,470	62,253	16,217	849	1,733	621	10,232	54	2,728
	Sherman County, OR	1,705	1,506	199	42	2	8	87	0	60
	Tillamook County, OR	25,552	21,733	3,819	199	289	79	2,573	4	675
	Umatilla County, OR	76,582	51,612	24,970	1,641	624	519	19,596	41	2,549
	Union County, OR	25,758	23,106	2,652	202	567	170	1,131	13	569
	Wallowa County, OR	6,836	6,407	429	29	16	27	174	7	176
	Wasco County, OR	25,657	19,499	6,158	921	389	109	4,289	0	450
	Washington County, OR	564,088	382,165	181,923	1,865	55,148	10,013	91,495	894	22,508
	Wheeler County, OR	1,369	1,291	78	15	9	0	26	0	28
	Yamhill County, OR	102,217	79,759	22,458	791	1,759	777	15,768	54	3,309
	Oregon Total	**3,982,267**	**3,066,467**	**915,800**	**35,074**	**172,454**	**70,359**	**494,806**	**4,905**	**138,202**
	Oregon Percent of Total Population	**100%**	**77%**	**23%**	**1%**	**4%**	**2%**	**12%**	**0%**	**3%**
Washington	Adams County, WA	19,100	6,813	12,287	34	185	59	11,820	0	189
	Asotin County, WA	22,113	20,230	1,883	228	205	56	791	0	603
	Benton County, WA	187,519	135,362	52,157	1,104	4,530	2,589	38,146	459	5,329
	Chelan County, WA	74,761	51,466	23,295	738	700	303	20,307	10	1,237
	Clallam County, WA	72,969	61,008	11,961	3,281	1,174	687	4,274	223	2,322
	Clark County, WA	450,893	360,807	90,086	2,407	22,278	8,084	39,042	695	17,580
	Columbia County, WA	3,971	3,491	480	18	76	15	270	15	86

State	County	Total Population	White Alone	Minority Population[2/]	Breakdown of Minority Populations[1/]					
					American Indian or Alaskan Native	Asian or Pacific Islander	Black or African American	Hispanic or Latino	Some Other Race	Two or More Races
	Cowlitz County, WA	102,854	87,013	15,841	1,002	1,557	600	8,640	73	3,969
	Douglas County, WA	40,101	26,177	13,924	282	345	90	12,247	26	934
	Ferry County, WA	7,639	5,636	2,003	1,150	111	13	316	0	413
	Franklin County, WA	87,810	36,534	51,276	337	1,835	1,752	45,685	54	1,613
	Garfield County, WA	2,231	2,058	173	7	19	0	74	0	73
	Grant County, WA	92,530	51,364	41,166	744	947	604	37,124	38	1,709
	Grays Harbor County, WA	71,233	56,988	14,245	2,918	1,379	744	6,864	18	2,322
	Island County, WA	80,113	64,659	15,454	844	3,968	2,385	5,402	142	2,713
	Jefferson County, WA	30,333	26,912	3,421	574	526	267	1,045	2	1,007
	King County, WA	2,079,550	1,294,359	785,191	11,354	346,392	124,303	194,189	3,929	105,024
	Kitsap County, WA	257,488	200,165	57,323	2,557	13,600	6,159	18,375	354	16,278
	Kittitas County, WA	42,785	36,177	6,608	324	881	474	3,653	8	1,268
	Klickitat County, WA	20,930	17,217	3,713	560	186	138	2,520	0	309
	Lewis County, WA	75,724	63,979	11,745	491	910	502	7,292	42	2,508
	Lincoln County, WA	10,326	9,506	820	121	72	32	308	0	287
	Mason County, WA	61,060	49,879	11,181	1,639	1,027	578	5,465	24	2,448
	Okanogan County, WA	41,299	27,387	13,912	3,873	425	246	7,869	22	1,477
	Pacific County, WA	20,743	17,167	3,576	368	415	59	1,855	11	868
	Pend Oreille County, WA	13,001	11,566	1,435	455	121	30	455	11	363
	Pierce County, WA	832,896	571,006	261,890	8,466	60,203	53,881	84,021	1,093	54,226
	San Juan County, WA	16,056	14,308	1,748	128	262	97	937	47	277
	Skagit County, WA	120,475	90,922	29,553	1,774	2,431	839	21,310	71	3,128
	Skamania County, WA	11,316	9,989	1,327	261	111	104	668	13	170

State	County	Total Population	White Alone	Minority Population[2/]	Breakdown of Minority Populations[1/] American Indian or Alaskan Native	Asian or Pacific Islander	Black or African American	Hispanic or Latino	Some Other Race	Two or More Races
	Snohomish County, WA	758,649	546,155	212,494	6,061	76,313	19,427	72,859	952	36,882
	Spokane County, WA	485,859	415,979	69,880	5,823	13,328	8,346	25,143	212	17,028
	Stevens County, WA	43,744	38,114	5,630	1,903	326	200	1,468	8	1,725
	Thurston County, WA	266,311	203,511	62,800	3,573	17,390	7,611	21,856	404	11,966
	Wahkiakum County, WA	4,051	3,633	418	85	79	5	188	0	61
	Walla Walla County, WA	59,809	43,428	16,381	269	997	887	12,508	104	1,616
	Whatcom County, WA	209,729	168,060	41,669	5,754	8,944	1,958	18,517	170	6,326
	Whitman County, WA	47,494	37,902	9,592	164	3,774	950	2,681	54	1,969
	Yakima County, WA	247,681	111,448	136,233	9,026	2,519	1,835	118,091	120	4,642
	Washington Total	**7,073,146**	**4,978,375**	**2,094,771**	**80,697**	**590,541**	**246,909**	**854,275**	**9,404**	**312,945**
	Washington Percent of Total Population	**100%**	**70%**	**30%**	**1%**	**8%**	**3%**	**12%**	**0%**	**4%**
Wyoming	Teton County, WY	22,623	18,370	4,253	66	410	139	3,433	8	197
	Wyoming Total	**22,623**	**18,370**	**4,253**	**66**	**410**	**139**	**3,433**	**8**	**197**
	Wyoming Percent of Total Population	**100%**	**81%**	**19%**	**0%**	**2%**	**1%**	**15%**	**0%**	**1%**

Source: U.S. Census Bureau 2017

Notes:

1/ The U.S. Census distinguishes between two ethnic groups: Not Hispanic or Latino and Hispanic or Latino. Within these two groups, the Census reports racial identification. For the purpose of this analysis, all peoples 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.

2/ For purposes of this analysis, minority population reflects all populations not identified as "Not Hispanic or Latino: White alone" in the U.S. Census Bureau's American Community Survey.

Table 1-4. Other Socioeconomic Indicators in the Study Area, by County

State	Geographic Region	Median Household Income[1/]	Per Capita Income[1/]	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education[2/]	Percent Households in Linguistic Isolation[3/]
N/A	**United States**	**$55,322**	**$29,829**	**7%**	**14%**	**6%**	**13%**	**4%**
California	Modoc County, CA	$44,567	$22,755	7%	23%	4%	14%	2%
	California	**$63,783**	**$31,458**	**9%**	**13%**	**6%**	**18%**	**9%**
Idaho	Ada County, ID	$58,264	$30,589	5%	13%	6%	5%	2%
	Adams County, ID	$42,468	$22,707	11%	25%	4%	10%	1%
	Bannock County, ID	$48,197	$21,938	7%	13%	8%	8%	1%
	Bear Lake County, ID	$46,063	$22,297	3%	20%	7%	6%	1%
	Benewah County, ID	$42,880	$22,347	10%	21%	6%	13%	0%
	Bingham County, ID	$49,015	$20,028	7%	13%	8%	14%	3%
	Blaine County, ID	$58,556	$36,780	4%	16%	6%	10%	3%
	Boise County, ID	$46,901	$26,844	8%	22%	3%	6%	0%
	Bonner County, ID	$43,063	$24,601	6%	21%	5%	10%	0%
	Bonneville County, ID	$53,481	$23,874	5%	12%	9%	9%	2%
	Boundary County, ID	$38,676	$22,688	4%	20%	6%	11%	0%
	Butte County, ID	$40,762	$25,313	7%	20%	4%	10%	1%
	Camas County, ID	$42,708	$26,544	4%	17%	7%	12%	2%
	Canyon County, ID	$41,799	$18,211	8%	13%	8%	16%	3%
	Caribou County, ID	$58,653	$24,614	2%	17%	7%	8%	1%
	Cassia County, ID	$45,647	$18,537	5%	13%	9%	18%	8%
	Clark County, ID	$32,422	$14,622	5%	11%	11%	30%	20%
	Clearwater County, ID	$40,603	$22,546	7%	25%	3%	12%	0%
	Custer County, ID	$40,498	$24,225	4%	25%	4%	7%	2%
	Elmore County, ID	$45,950	$22,380	6%	12%	8%	14%	4%
	Franklin County, ID	$51,828	$19,982	4%	14%	8%	10%	2%
	Fremont County, ID	$49,707	$21,014	5%	16%	7%	13%	3%
	Gem County, ID	$41,848	$19,004	9%	21%	5%	13%	1%
	Gooding County, ID	$45,068	$20,082	4%	17%	7%	24%	6%

State	Geographic Region	Median Household Income[1/]	Per Capita Income[1/]	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education[2/]	Percent Households in Linguistic Isolation[3/]
	Idaho County, ID	$39,386	$19,250	6%	24%	5%	12%	0%
	Jefferson County, ID	$51,825	$20,396	5%	10%	9%	13%	2%
	Jerome County, ID	$43,461	$17,776	5%	12%	9%	25%	11%
	Kootenai County, ID	$52,151	$27,166	7%	17%	6%	8%	0%
	Latah County, ID	$49,669	$24,779	8%	12%	6%	4%	1%
	Lemhi County, ID	$34,980	$22,791	6%	27%	4%	8%	1%
	Lewis County, ID	$35,963	$23,287	6%	24%	5%	11%	0%
	Lincoln County, ID	$45,924	$18,600	5%	13%	7%	22%	7%
	Madison County, ID	$40,892	$14,785	9%	6%	10%	4%	1%
	Minidoka County, ID	$48,021	$22,468	5%	15%	8%	22%	9%
	Nez Perce County, ID	$51,206	$25,193	6%	19%	6%	8%	0%
	Oneida County, ID	$40,796	$18,990	7%	19%	6%	6%	1%
	Owyhee County, ID	$33,248	$17,439	9%	16%	7%	25%	7%
	Payette County, ID	$43,686	$22,451	8%	17%	7%	13%	1%
	Power County, ID	$53,079	$22,080	7%	15%	10%	21%	6%
	Shoshone County, ID	$39,083	$22,490	11%	21%	5%	14%	0%
	Teton County, ID	$57,864	$31,476	6%	8%	8%	9%	6%
	Twin Falls County, ID	$46,810	$21,450	4%	15%	8%	13%	3%
	Valley County, ID	$52,502	$28,514	5%	21%	5%	4%	1%
	Washington County, ID	$36,809	$20,235	9%	23%	5%	16%	3%
	Idaho	**$49,174**	**$24,280**	**6%**	**14%**	**7%**	**10%**	**2%**
Montana	Beaverhead County, MT	$44,028	$26,173	7%	20%	5%	6%	1%
	Broadwater County, MT	$47,801	$28,056	6%	21%	4%	6%	0%
	Deer Lodge County, MT	$42,005	$23,822	4%	21%	3%	11%	0%
	Flathead County, MT	$50,464	$27,306	7%	17%	6%	5%	0%
	Glacier County, MT	$35,028	$17,464	11%	11%	9%	10%	0%
	Granite County, MT	$47,324	$25,914	7%	28%	4%	11%	0%
	Jefferson County, MT	$60,114	$28,654	6%	19%	4%	5%	0%

State	Geographic Region	Median Household Income[1/]	Per Capita Income[1/]	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education[2/]	Percent Households in Linguistic Isolation[3/]
	Lake County, MT	$42,723	$24,741	9%	20%	6%	9%	0%
	Lincoln County, MT	$36,370	$22,512	12%	25%	4%	12%	0%
	Madison County, MT	$46,684	$29,505	4%	26%	4%	5%	0%
	Mineral County, MT	$35,305	$21,600	7%	27%	5%	13%	0%
	Missoula County, MT	$50,723	$28,339	7%	14%	5%	5%	1%
	Powell County, MT	$45,188	$25,850	1%	19%	4%	11%	0%
	Ravalli County, MT	$43,557	$23,651	8%	23%	5%	9%	0%
	Sanders County, MT	$33,663	$19,985	9%	26%	5%	12%	0%
	Silver Bow County, MT	$44,198	$25,645	7%	17%	5%	9%	0%
	Montana	**$48,380**	**$27,309**	**6%**	**17%**	**6%**	**7%**	**0%**
Nevada	Elko County, NV	$69,725	$29,998	5%	9%	7%	17%	2%
	Humboldt County, NV	$66,138	$28,729	8%	11%	8%	18%	4%
	Nevada	**$53,094**	**$27,253**	**9%**	**14%**	**6%**	**15%**	**6%**
Oregon	Baker County, OR	$42,174	$25,183	9%	25%	5%	10%	1%
	Benton County, OR	$56,271	$28,175	8%	14%	4%	5%	2%
	Clackamas County, OR	$73,266	$35,759	7%	16%	5%	7%	2%
	Clatsop County, OR	$49,015	$26,526	7%	19%	5%	8%	2%
	Columbia County, OR	$54,804	$26,795	9%	17%	5%	10%	0%
	Coos County, OR	$41,573	$25,089	11%	24%	5%	11%	1%
	Crook County, OR	$40,478	$21,276	11%	24%	5%	12%	0%
	Curry County, OR	$40,078	$25,015	11%	32%	4%	10%	1%
	Deschutes County, OR	$55,499	$29,918	7%	18%	5%	7%	1%
	Douglas County, OR	$44,780	$23,621	11%	24%	5%	11%	0%
	Gilliam County, OR	$42,727	$22,711	11%	24%	6%	10%	1%
	Grant County, OR	$40,370	$23,516	7%	27%	4%	10%	1%
	Harney County, OR	$40,761	$22,519	14%	22%	5%	10%	2%
	Hood River County, OR	$57,084	$28,518	5%	15%	7%	20%	4%
	Jackson County, OR	$48,724	$26,445	9%	20%	6%	11%	2%

State	Geographic Region	Median Household Income1/	Per Capita Income1/	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education2/	Percent Households in Linguistic Isolation3/
	Jefferson County, OR	$50,785	$23,346	13%	18%	7%	16%	1%
	Josephine County, OR	$40,034	$22,908	11%	25%	5%	11%	0%
	Klamath County, OR	$42,503	$21,885	11%	19%	6%	12%	1%
	Lake County, OR	$36,274	$20,613	9%	23%	5%	16%	0%
	Lane County, OR	$49,390	$25,915	9%	17%	5%	9%	2%
	Lincoln County, OR	$43,528	$25,254	7%	25%	5%	11%	1%
	Linn County, OR	$48,768	$23,213	10%	17%	6%	10%	1%
	Malheur County, OR	$38,230	$18,441	10%	16%	7%	20%	5%
	Marion County, OR	$52,487	$23,806	9%	14%	7%	15%	5%
	Morrow County, OR	$52,167	$22,514	6%	14%	7%	25%	9%
	Multnomah County, OR	$65,493	$35,097	8%	12%	6%	9%	4%
	Polk County, OR	$54,313	$24,530	10%	17%	6%	9%	2%
	Sherman County, OR	$42,471	$32,170	7%	24%	5%	7%	0%
	Tillamook County, OR	$46,692	$24,351	7%	23%	5%	10%	0%
	Umatilla County, OR	$49,820	$22,742	9%	14%	7%	17%	4%
	Union County, OR	$47,897	$25,352	7%	18%	6%	7%	0%
	Wallowa County, OR	$44,521	$25,965	8%	27%	5%	7%	0%
	Wasco County, OR	$49,049	$23,005	7%	20%	6%	14%	2%
	Washington County, OR	$72,019	$33,275	7%	12%	7%	9%	4%
	Wheeler County, OR	$33,304	$22,849	10%	36%	2%	8%	0%
	Yamhill County, OR	$58,760	$26,259	8%	16%	6%	12%	3%
	Oregon	**$53,270**	**$28,822**	**8%**	**16%**	**6%**	**10%**	**3%**
Washington	Adams County, WA	$48,443	$20,074	6%	10%	11%	34%	19%
	Asotin County, WA	$46,803	$24,517	8%	21%	6%	10%	0%
	Benton County, WA	$66,628	$29,563	7%	13%	7%	10%	4%
	Chelan County, WA	$53,850	$26,286	7%	17%	7%	17%	4%
	Clallam County, WA	$47,274	$26,508	9%	27%	5%	8%	2%
	Clark County, WA	$67,468	$30,511	7%	14%	6%	8%	3%

State	Geographic Region	Median Household Income[1/]	Per Capita Income[1/]	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education[2/]	Percent Households in Linguistic Isolation[3/]
	Columbia County, WA	$43,098	$28,282	9%	27%	5%	10%	1%
	Cowlitz County, WA	$48,928	$24,317	10%	18%	6%	12%	1%
	Douglas County, WA	$53,421	$23,911	5%	16%	7%	19%	7%
	Ferry County, WA	$38,829	$21,595	10%	22%	4%	13%	0%
	Franklin County, WA	$59,422	$22,621	7%	8%	10%	26%	13%
	Garfield County, WA	$49,938	$23,022	4%	22%	7%	4%	0%
	Grant County, WA	$50,353	$21,070	9%	13%	8%	25%	9%
	Grays Harbor County, WA	$46,595	$24,561	12%	19%	6%	12%	2%
	Island County, WA	$62,599	$32,832	7%	22%	6%	5%	1%
	Jefferson County, WA	$49,896	$30,621	7%	32%	4%	5%	0%
	King County, WA	$88,238	$44,165	6%	12%	6%	8%	6%
	Kitsap County, WA	$69,142	$32,857	6%	16%	6%	6%	1%
	Kittitas County, WA	$50,415	$26,332	7%	15%	5%	9%	1%
	Klickitat County, WA	$48,222	$22,786	5%	21%	5%	13%	1%
	Lewis County, WA	$45,991	$22,984	10%	20%	6%	13%	2%
	Lincoln County, WA	$49,632	$25,381	4%	24%	5%	9%	1%
	Mason County, WA	$53,866	$27,516	11%	21%	5%	13%	2%
	Okanogan County, WA	$43,161	$23,086	8%	20%	7%	18%	3%
	Pacific County, WA	$38,388	$21,342	8%	28%	4%	12%	2%
	Pend Oreille County, WA	$44,553	$24,597	9%	24%	5%	11%	0%
	Pierce County, WA	$64,655	$29,862	8%	13%	7%	9%	3%
	San Juan County, WA	$58,233	$40,716	5%	30%	3%	5%	1%
	Skagit County, WA	$55,952	$28,330	7%	19%	6%	11%	3%
	Skamania County, WA	$50,862	$28,326	8%	17%	5%	10%	0%
	Snohomish County, WA	$78,327	$34,503	6%	12%	6%	8%	4%
	Spokane County, WA	$52,422	$26,253	7%	15%	6%	7%	2%
	Stevens County, WA	$43,469	$22,049	9%	21%	5%	10%	0%
	Thurston County, WA	$65,131	$30,975	8%	15%	6%	6%	2%

State	Geographic Region	Median Household Income[1/]	Per Capita Income[1/]	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education[2/]	Percent Households in Linguistic Isolation[3/]
	Wahkiakum County, WA	$49,898	$27,336	7%	31%	3%	7%	0%
	Walla Walla County, WA	$50,243	$25,965	6%	16%	6%	11%	4%
	Whatcom County, WA	$57,279	$29,195	8%	15%	6%	9%	2%
	Whitman County, WA	$45,149	$23,694	9%	10%	4%	4%	4%
	Yakima County, WA	$48,033	$21,528	8%	13%	8%	28%	9%
	Washington	**$62,848**	**$32,999**	**7%**	**14%**	**6%**	**9%**	**4%**
Wyoming	Teton County, WY	$77,343	$45,186	2%	12%	5%	5%	3%
	Wyoming	**$59,143**	**$30,139**	**5%**	**14%**	**7%**	**8%**	**1%**

Source: U.S. Census Bureau 2017

Notes:

1/ In the past 12 months using 2016 inflation-adjusted dollars.

2/ Percent of population 25 years and older.

3/ A linguistically isolated household is one in which no member 14 years old and over (1) speaks only English or (2) speaks a non-English language and speaks English "very well."

Table 1-5. Demographic Information for Indian Reservations in the Study Area[1/]

Tribe[2/]	Total Population	Percent Below Poverty Level[3/]	Median Household Income[4/]	Per Capita Income[4/]	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education
Alturas Indian Rancheria, California[5/]	No data	No data	No data	No data	No data	No data	No data	No data
Blackfeet Tribe of the Blackfeet Indian Reservation of Montana	10,842	38%	$25,641	$14,249	14%	9%	8%	10%
Burns Paiute Tribe	138	26%	$30,625	$13,799	29%	18%	9%	13%
Cedarville Rancheria, California	21	30%	No data	$24,552	0%	5%	5%	0%
Coeur D'Alene Tribe[5/]	7,064	19%	$45,375	$24,666	9%	22%	5%	11%

Tribe[2/]	Total Population	Percent Below Poverty Level[3/]	Median Household Income[4/]	Per Capita Income[4/]	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education
Confederated Salish and Kootenai Tribes of the Flathead Reservation[5/]	28,938	23%	$37,540	$21,685	10%	18%	7%	10%
Confederated Tribes and Bands of the Yakama Nation	31,283	30%	$40,958	$14,916	10%	10%	10%	38%
Confederated Tribes of Siletz Indians of Oregon	412	33%	$31,250	$13,164	18%	9%	9%	18%
Confederated Tribes of the Chehalis Reservation	828	30%	$40,729	$16,533	22%	8%	13%	17%
Confederated Tribes of the Colville Reservation	7,460	29%	$34,457	$18,047	17%	15%	8%	17%
Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians[6/]	95	No data	No data	No data	No data	9%	16%	No data
Confederated Tribes of the Grand Ronde Community of Oregon	130	15%	$33,125	$21,155	11%	55%	2%	18%
Confederated Tribes of the Umatilla Indian Reservation	2,782	21%	$47,679	$21,444	10%	18%	7%	10%
Confederated Tribes of the Warm Springs Reservation of Oregon	4,548	30%	$42,390	$13,020	25%	8%	7%	20%
Coquille Indian Tribe[5/]	388	23%	$25,000	$20,456	13%	35%	10%	24%
Cow Creek Band of Umpqua Tribe of Indians	152	35%	$41,667	$12,729	14%	14%	8%	12%
Cowlitz Indian Tribe[5/]	No data	No data	No data	No data	No data	No data	No data	No data
Elko Band (Constituent band of the Te-Moak Tribe of Western Shoshone Indians of Nevada) [5/]	932	27%	$35,250	$20,532	12%	10%	4%	17%
Fort Bidwell Indian Community of the Fort	190	51%	$21,875	$9,590	28%	4%	8%	40%

Tribe[2/]	Total Population	Percent Below Poverty Level[3/]	Median Household Income[4/]	Per Capita Income[4/]	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education
Bidwell Reservation of California								
Fort McDermitt Paiute and Shoshone Tribes of the Fort McDermitt Indian Reservation, Nevada and Oregon[5/]	482	44%	$16,250	$7,579	46%	14%	11%	28%
Hoh Indian Tribe	153	55%	$34,583	$9,084	14%	4%	8%	35%
Jamestown S'Klallam Tribe[6/]	27	No data	No data	No data	No data	0%	0%	No data
Kalispel Indian Community of the Kalispel Reservation	280	27%	$39,500	$17,209	3%	9%	3%	19%
Klamath Tribes[5/]	43	72%	$9,722	$7,660	77%	28%	0%	34%
Kootenai Tribe of Idaho	41	15%	$61,250	$28,871	0%	0%	0%	17%
Likely (Pit River Tribe, California) [5/]	No data	No data	No data	No data	No data	No data	No data	No data
Lookout (Pit River Tribe, California) [5/]	16	25%	$34,375	$14,363	0%	13%	0%	18%
Lower Elwha Tribal Community	379	36%	$30,938	$14,453	24%	8%	7%	23%
Lummi Tribe of the Lummi Reservation[5/]	5,428	25%	$50,397	$20,977	11%	14%	8%	13%
Makah Indian Tribe of the Makah Indian Reservation[5/]	1,590	21%	$35,114	$15,667	19%	8%	10%	17%
Muckleshoot Indian Tribe	3,991	22%	$47,039	$20,607	15%	14%	8%	19%
Nez Perce Tribe[5/, 7/]	3,554	30%	$40,278	$13,735	27%	No data	No data	29%
Nisqually Indian Tribe[5/]	735	23%	$51,250	$17,769	16%	10%	7%	23%
Nooksack Indian Tribe[6/]	1,132	No data	No data	No data	No data	11%	11%	No data
Port Gamble S'Klallam Tribe	560	31%	$37,500	$14,749	12%	7%	5%	18%
Puyallup Tribe of the Puyallup Reservation	49,416	14%	$66,668	$30,629	7%	12%	7%	10%

Tribe[2/]	Total Population	Percent Below Poverty Level[3/]	Median Household Income[4/]	Per Capita Income[4/]	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education
Quileute Tribe of the Quileute Reservation[5/]	433	33%	$36,750	$16,984	22%	3%	12%	18%
Quinault Indian Nation[5/]	1,159	33%	$33,906	$14,447	23%	15%	7%	19%
Samish Indian Nation[5/]	37,397	10%	$61,160	$38,538	5%	28%	4%	5%
Sauk-Suiattle Indian Tribe[5/]	69	13%	$62,500	$25,632	16%	9%	7%	3%
Shoalwater Bay Indian Tribe of the Shoalwater Bay Indian Reservation	88	22%	$47,813	$20,526	21%	17%	7%	12%
Shoshone-Bannock Tribes of the Fort Hall Reservation	6,061	22%	$42,365	$16,558	21%	13%	7%	20%
Shoshone-Paiute Tribes of the Duck Valley Reservation, Nevada[5/ 6/]	1,450	27%	$34,792	$17,526	21%	12%	8%	13%
Skokomish Indian Tribe[5/]	934	33%	$37,917	$14,376	15%	13%	4%	18%
Snoqualmie Indian Tribe[5/]	No data	No data	No data	No data	No data	No data	No data	No data
South Fork Band (Constituent band of Te-Moak Tribe of Western Shoshone Indians of Nevada)	70	13%		$28,317	6%	24%	0%	13%
Spokane Tribe of the Spokane Reservation[8/]	2,085	33%	$34,150	$15,733	26%	13%	10%	15%
Squaxin Island Tribe of the Squaxin Island Reservation	352	22%	$40,938	$17,059	20%	7%	5%	26%
Stillaguamish Tribe of Indians of Washington[6/]	11	No data	No data	No data	No data	18%	0%	No data
Summit Lake Paiute Tribe of Nevada	No data	No data	No data	No data	No data	No data	No data	No data
Suquamish Indian Tribe of the Port Madison Reservation[5/]	7,832	11%	$62,012	$33,207	6%	16%	5%	5%

Tribe[2/]	Total Population	Percent Below Poverty Level[3/]	Median Household Income[4/]	Per Capita Income[4/]	Unemployment Rate	Percent Over Age 64	Percent Under Age 5	Percent Population with less than High School Education
Swinomish Indian Tribal Community	2,843	11%	$58,167	$33,384	5%	35%	3%	7%
Tulalip Tribes of Washington	10,064	13%	$68,498	$31,004	11%	15%	5%	13%
Upper Skagit Indian Tribe[5/]	259	44%	$31,250	$10,651	35%	7%	12%	37%
Wells Band (Constituent band of Te-Moak Tribe of Western Shoshone Indians of Nevada) [5/]	106	21%	$46,875	$14,252	6%	6%	8%	10%
Winnemucca Indian Colony of Nevada[5/]	35	54%	$11,458	$16,254	17%	40%	6%	50%
XL Ranch (Pit River Tribe, California)[5/]	97	8%	$39,125	$12,839	7%	7%	8%	4%

Sources: Manson et al. 2018; U.S. Census Bureau 2018; Nez Perce Tribe 2019; USDA 2016

Notes:

1/ The demographic indicators presented in this table include metrics typically used by researchers and in EPA's EJ screening tools to represent the "social vulnerability" characteristics of a disadvantaged population (EPA 2017).

2/ Unless otherwise noted, these data represent statistics for the population residing within the geographic boundaries of the reservation (including tribal member and non-tribal member households) as well as off-reservation trust lands.

3/ Defined as percentage of all people whose income in the past 12 months is below poverty level.

4/ In the past 12 months using 2016 inflation-adjusted dollars.

5/ Includes reservation only; off-reservation trust land not included.

6/ 2013-2017 estimates from U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates (U.S. Census Bureau 2018).

7/ These data are from the Nez Perce Tribe Demographics Database (Nez Perce Tribe 2019).

8/ Data on population, poverty rate, and unemployment rate are from the HUD Promise Zone factsheet on the Spokane Indian Reservation (USDA 2016).

CHAPTER 2 - REFERENCES

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Columbia River System Operations
Final Environmental Impact Statement

Appendix P, Tribal Perspectives

Note: The Section 508 amendment of the Rehabilitation Act of 1973 requires that the information in federal documents be accessible to individuals with disabilities. The Agency has made every effort to ensure that the information in *Appendix P: Tribal Perspectives* is accessible. However, if readers have any issues accessing the information in this appendix, please contact the *U.S. Army Corps of Engineers* at (800) 290-5033 or info@crso.info so additional accommodations may be provided.

Table of Contents for Appendix P

As described in Section 3.17.2 of the main body of the EIS, the federally recognized tribes potentially affected by the operations and maintenance of the Columbia River System (CRS) were invited 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. This appendix contains the tribal perspective documents that were received from ten of the participating tribes. The lower Columbia River treaty tribes, submitted a joint perspective document. The lower Columbia River treaty tribes consists of the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of Warm Springs, and the Nez Perce Tribe.

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RE: Supplement Information on Tribal Perspective for the CRSO EIS

Dear Administrator Mainzer, Brigadier General Helmlinger, Regional Director Gray:

This letter is sent on behalf of the Coeur d'Alene Tribe ("Tribe") as supplemental information to the Tribe's December 10, 2018 letter regarding the Tribe's perspective on the impacts of the Columbia River Systems Operations ("CRSO") to tribal resources. We appreciate the opportunity to provide additional detail on the impacts of the CRSO to the Coeur d'Alene Tribal community.

First, the Tribe must express its disappointment in the approach taken by your agencies in collecting this information. In previous NEPA processes, the action agencies have hired experts agreed upon by affected tribes to assess and document the impacts in a detailed manner. The attached 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") was prepared by Meyer Resources, Inc. on behalf of the Columbia River Inter-Tribal Fish Commission with funding from the Army Corps of Engineers ("Corps") for the NEPA process for the Lower Snake River dams.

This report involved a significant amount of tribal coordination, was funded by the Corps, and was then utilized by the agencies as part of the NEPA process, including the environmental justice section. To date there have been no overtures by the action agencies to fund a tribal impact assessment within the CRSO NEPA process. As the tribes have been left to provide their own internal resources for an impact assessment, any information gathered will not meet acceptable milestones due to a lack of funding. We urge the action agencies to consider building an internal process that encompasses the tribes concerns regarding a thorough and well-funded impact assessment to properly assess impacts of CRSO to tribal communities.

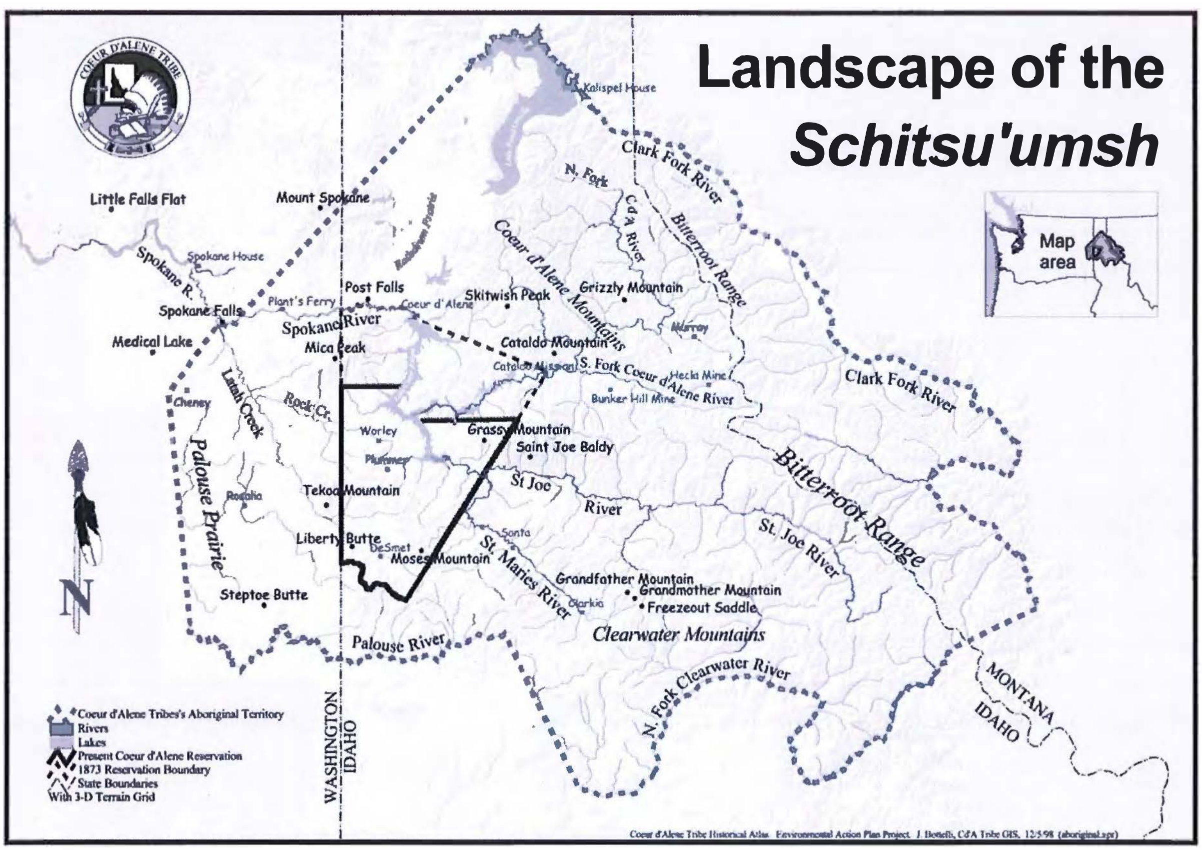
The Tribal Circumstances Report identifies impacts to tribal income/health, life-support resources, and economic base from the status quo operations of the Snake River dams (see summary in chart below).

Summary of Environmental Justice Effects for the Tribes from Lower Snake River Project Alternatives	
EJ Factors	**Relative Effects on the Tribes**
Alternative A1 (Status Quo)/ Alternative A2 (Status Quo + Transportation):	
Income Level/ Health.	• Tribal families are impoverished and unemployed at 3-4 times levels ofe Washington/Oregon/Idaho residents as a whole (Table 41). Winter-time tribale unemployment reaches as high as 80 percent.e • Tribal members are dying at from 20 percent to 130 percent higher rates than non-Indian residents.e • Recent analyses describe tribal health and health care access as "poor". • Implementation of A1 or A2 would have no discernible effect in remedying thesee cumulative adverse conditions.e
Life-support Resources.	• Extensive information in this report places salmon at the center of the study tribes'e cultural, spiritual and material world. Table 43 identifies that salmon guaranteed toe the tribes by Treaty has almost entirely been lost. Tribal spokespersons and healthe experts cited throughout this report have identified the devastating effect thesee losses have had on tribal culture, health and material wellbeing. • Beaty, et.al (1999) identify lower Snake River dams have contributed substantiallye to destruction of these life-support resources • Selection of A1 or A2 would not significantly change these cumulative conditions-and the pain, suffering and premature deaths of tribal peoples would continue fore decades.e
Economic base.	• The cumulative effects of dam construction have transferred potential wealthe produced in the river basin from the salmon on which the tribes depend toe electricity production, irrigation of agriculture, water transport services and wastee disposal, these latter primarily benefiting non-Indians. These transfers have been ae significant contributor to gross poverty, income and health disparities between thee tribes and non-Indian neighbors.e • Selection of A1 or A2 would continue these conditions and disparities.e
Inconsistent Standards.	• Historically, agencies asserted confidence that they could manage uncertaintye concerning adverse impacts on salmon during construction of the dams thate facilitated wealth transfers from the tribes to non-Indians. Some of the samee agencies now claim to be risk adverse, when considering more substantial remediale action which would recover salmon and result in some measure of rebalancing ofe wealth to improve the circumstances of tribal peoples.e

Many of these issues, including disproportionate impacts to the economic base, community health and loss of culture, are relevant to the Coeur d'Alene Tribe. These are impacts that must be considered in the NEPA process. To the extent possible, given all the constraints that are embedded in the CRSO NEPA process, we discuss the importance of salmon and impacts to Tribal health and resources below:

1. **Landscape of the Schitsu'umsh.**

The traditional aboriginal territory of the Schitsu'umsh, (Coeur d'Alene) depicted below, spans more than 5 million acres encompassing much of what is today known as the "Idaho Panhandle" as well as portions of eastern Washington and western Montana. Their overall territory extended north to Lake Pend Oreille and the Clark Fork River. On the south the territory extended into the drainages of the Palouse and North Fork of the Clearwater Rivers and the Clearwater Mountains. The eastern boundary extended across the Bitterroot Range into Montana. To the west, the territory was marked by a place called "Plante's Ferry" on the Spokane River, and then ran south from Spokane Falls to encompass the entire Hangman Creek drainage (also known as Latah Creek) and Steptoe Butte, near the present Rosalia, Washington. Importantly, the aboriginal landscape of the Tribe included many important rivers that reinforced the cultural connections of Tribal members to the anadromous fishery and fostered a considerable reliance on those resources.



Over time, changes to the Coeur d'Alene Reservation boundaries has influenced the patterns of land use affecting the Tribe. The area within each negotiated Reservation boundary was reserved for the Tribe's use and exclusive management. Prior to the changes brought about by allotment, the Tribe's land use had developed into a combination of agricultural and traditional subsistence activities on the Reservation. Large farms of 1,000 acres and more were successfully managed and notions of property ownership were handled within the Tribe's own organizational entities. In the year 1906, the Federal Government unilaterally violated the Coeur d'Alene Treaty of 1887, forcing Tribal members onto individual land allotments and opening the rest of the Reservation to settlement. This "subdivision" created a market for land parcels on the Reservation. Many allotments passed into non-Indian use and ownership within a short period of time. By 1934 when the Allotment era ended with passage of the Indian Reorganization Act, Tribal land ownership had declined to less than one fifth of their 334,471-acre Reservation.

2. Traditional Harvest and Fishing.

For the Schitsu'umsh people, traditional culture is seasonally-based. For generations, food-gathering activities and physical activity aligned with the seasons. In the spring, tribal families would travel to the outskirts of their territory to gather camas and bitterroot. In the summer, families traveled to higher elevation to gather berries, such as huckleberry and service berry. Fall was generally the time for hunting game such as deer and elk. Winter saw families return to the lowlands around Coeur d'Alene Lake to take advantage of milder weather. Fishing for trout, salmon, and whitefish took place throughout the year.

The Coeur d'Alene Tribe fishing territory extended from the North Fork of the Clearwater River on the southern margin to Lake Pend Oreille and the Clark Fork River on the north, the upper portion of the Spokane River to Spokane Falls, Hangman Creek and the headwaters of the Palouse River. The Coeur d'Alene routinely visited Kettle Falls during the fishing season and occasionally fished for salmon on the Snake and Lower Columbia at sites such as Celilo Falls. This practice continued until Celilo Falls was inundated by The Dalles Dam in 1957. The Celilo Falls site became especially important to the Coeur d'Alene after the Spokane River dams and Grand Coulee Dam blocked the runs into the upper basin, because it was one of few places left where they were able to obtain salmon for religious rituals. The construction of Dworshak Dam on the North Fork of the Clearwater River during the late 1960s – early 1970s signaled the complete extirpation of anadromous salmon and steelhead from the cultural territories of the Coeur d'Alene Tribe. Hence, 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.

3. Loss of Fishing Areas Due to Dams.

All drainages relied upon by the Tribe for anadromous fish harvest have been adversely impacted by dam construction and operation. Chief Joseph and Grand Coulee dams block access for anadromous salmon and steelhead to significant amounts of habitat, totaling 711 miles for spring Chinook and 1,610 miles for summer steelhead for spawning, rearing and migration. Much of these habitats fall within the Coeur d'Alene Tribe's usual and accustomed fishing areas. In addition, construction of Dworshak Dam eliminated 54 miles of riverine habitat and blocked access to a much greater, but unquantified amount of habitat on the North Fork of the Clearwater

River, which accounted for sixty percent of the average annual count of steelhead which passed into Idaho via the Snake River.[1] 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.

4. Historic Harvest and Consumption Rates.

Tribal members are estimated to have consumed about 124,000 salmon and steelhead annually (1.3 million to 2.3 million pounds). This included the shared fishery on the Spokane River where Indians caught about 1000 salmon a day at five weirs for a period of 30 days each year for a total harvest of 150,000 salmon. Estimates of fish consumption, including anadromous and resident fish, puts historic Tribal consumption per capita at between 300-1000 lbs per year.[2] Current fish consumption rates are a tiny fraction of historic levels due largely to the loss of fisheries from dam construction.

5. Loss of Salmon and Tribal Health.

As addressed above, the Tribal Circumstance Report documented impacts to tribal health that corresponds to impacts to salmon harvest.

Recent public health research has demonstrated that dominant culture-based approaches to community health that focus primarily on biophysical and socioeconomic indicators, such as disease incidence and poverty rates, ignore the broader determinants of Indigenous health. Impacts of historic trauma, including loss of language, land base and culture, contribute 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 chronic psychological stresses associated with this collective trauma have been recognized as an established risk factor for cardiovascular disease. 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."

Nationwide, disparities of American Indian/Alaska Native (AIAN) populations are well-documented, such as disproportional amounts of death attributed to cerebrovascular disease and diabetes when compared with the general population. AIAN mortality rates for these two diseases are 2.7 times that of the general population. High poverty rates contribute to these disparities. Though the AIAN population makes up approximately 1% of the U.S. population, it represents approximately 2% of recipients of the Supplemental Nutrition Assessment Program

[1] *See* UCUT. 2019. Fish passage and reintroduction Phase 1 Report: Investigation upstream of Chief Joseph and Grand Coulee dams. Upper Columbia United Tribes, Spokane, WA and U.S. Army Corps of Engineers. 1974. Dworshak Dam and Reservoir, North Fork Clearwater River, Idaho, Draft Environmental Impact Statement. U.S. Army Engineer District, Walla Walla, WA (available at https://babel.hathitrust.org/cgi/pt?id=ien.35556030997696;view=1up;seq=181).

[2] *See* Scholz, A. (and 9 others). 1985. Compilation of information on salmon and steelhead total run size, catch and hydropower related losses in the Upper Columbia River basin, above Grand Coulee Dam. Upper Columbia United Tribes, Fisheries Technical Report No 2. Eastern Washington University, Cheney, WA and Ridolfi, Inc. 2016. Heritage fish consumption rates of the Coeur d'Alene Tribe. Prepared for the U.S. EPA, Contract EP-W-14-020. Both of these reports are attached to these comments.

(SNAP). In addition to poverty, cultural challenges are barriers to health. Less than 0.2% of health providers in the U.S. are AIAN (National Stakeholder Strategy for Achieving Healthy Equity, 2011). Lack of familiarity with the historical and societal issues that may impact AIAN communities' participation in prevention programs is a barrier for providers working in Indian Country. Additionally, community-level health assessments have typically neglected many of the aspects of well-being considered critical to Indigenous communities, particularly the interconnectedness of physiological health with cultural, environmental, and community connections. As a result, physical health indicators alone are insufficient in providing a full assessment of Indigenous community health.

Recent community-level health assessments on the Coeur d'Alene Reservation have attempted to broaden their approach by taking a multi-dimensional approach that includes physical environmental and community design. A 2013 Community Health Assessment completed by the Coeur d'Alene Tribe's Marimn Health (formerly Benewah Medical and Wellness Center) included attention to environmental safety and water quality, as well as access to healthy foods and physical activity. The assessment found significant disparities in rates of obesity, diabetes, and hypertension between the Native and non-Native population. According to the 2013 Uniform Data Service Data, Marimn's Native population included 2,325 Native Americans, or approximately 55% of its service population, yet this population accounted for 61.8% of clients with diabetes.[3]

At the regional level, University of Idaho researchers reported in a Body Mass Index study conducted in 2009 that AIAN children had the highest levels of being overweight and obesity in the state. Overall, 50% of all AIAN children evaluated in grades 1,3,5,7,9 and 11 were overweight or obese, compared to 30% of all Idaho children. The highest rates of obesity are among older males and children receiving free and reduced lunch (an estimate of Social Economic Status) and residing in northern Idaho regions. Access to health supports exacerbates health and wellness issues; at the state level, Idaho ranks 48th out of the 50 states in access to physicians.[4] In the 2018 Panhandle Health District Community Health Assessment, 22.6% of the Benewah County population was reported as having low food access.

Within the Marimn Health service area, a high proportion of Native clientele are burdened with chronic diseases issues, with obesity rates much greater than Benewah County (reported at 30% in 2018[5]), as well as higher rates of diabetes (11% for the Native Marimn population v. 9% for Benewah County).

Disease incidence in Marimn Health Native Population (source: Marimn Health)

	2015	% of Native patients	2016	% of Native patients	2017	% of Native patients
Native Client Population	2986		3207		3328	
Heart Disease	299	10%	303	9%	284	8%

[3] Benewah Medical and Wellness Center, Community Health Assessment, 2013.
[4] "Get Healthy Idaho 2018," Idaho Health and Welfare.
[5] Panhandle Health, Community Health Assessment, 2018.

Disease incidence in Marimn Health Native Population (source: Marimn Health)						
	2015	**% of Native patients**	**2016**	**% of Native patients**	**2017**	**% of Native patients**
Stroke	27	1%	27	1%	26	1%
Cancer	49	2%	46	1%	49	1%
Obesity	1189	40%	1242	39%	1258	38%
Diabetes	339	11%	365	11%	360	11%
Suicidal ideation*	3		16		31	

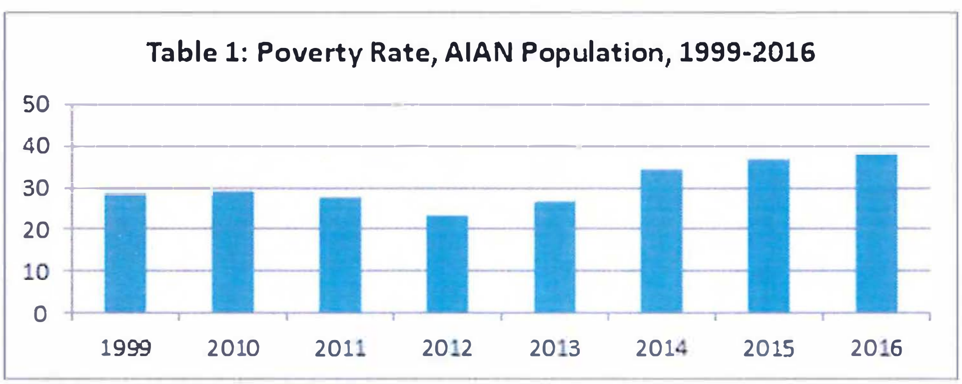
*improvements in coding practice may be related to the significant increase in diagnosis.

6. Loss of Salmon and Tribal Poverty Rates.

A major contributing factor to these health disparities are issues of poverty and joblessness. The Tribal Circumstances Report describes the intersection of dam construction and poverty:

> *"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."*
>
> Tribal Circumstances Report at 21.

As of April 2018, the Benewah County unemployment rate was 5.8%, while state unemployment rate was 2.9% (Idaho Department of Labor, July 2018). Based on data from the American Community Survey, the 2016 poverty rate for the Coeur d'Alene Reservation was 18.7%, while the poverty rate for the American Indian population was a staggering 38% (Table 1).[6]



[6] *See* www.indicatorsidaho.org .

Furthermore, thirty-six percent of Native youth live in poverty, compared to 21 percent of their non-Native counterparts on the Reservation.[7] Mental health issues are persistent. Since 2015, four Tribal members died as a result of suicide, all under the age of 30 and two under the age of 17.

7. Wildlife Habitat Impacts

Currently there are more than sixty dams that were constructed in the Columbia River watershed system that inundated millions of acres of critical habitat important to the Tribal cultures that subsisted in these traditional areas. Subsequent to the inundation of wildlife habitat, operational impacts in the form of water level manipulation and wave action further diminished any available habitat left through magnified erosional processes.

Other impacts that grew from the construction of dams were habitat conversions to agricultural farms, namely center pivot irrigation as well as mining, logging, and increased open water habitat in favor of riverine systems and wetlands.

Secondary impacts while not easily quantified are no less important than quantifiable resource impacts. Without a dependent and once abundant resource (salmon) the shift to a commensurate wildlife resource for subsistence placed undue stresses on resident fish and wildlife populations causing cyclic population fluctuations to a marked degree. Historic migration routes of ungulate wildlife species were disrupted and subsequently affected population structures whether by seasonal starvation (blocked wintering areas) or increased disease vectors.

We appreciate this opportunity to provide additional information regarding the impacts of the CRSO to the Coeur d'Alene Tribe. We reiterate our request that the action agencies will provide resources necessary to better quantify these impacts in the NEPA process, including environmental justice and tribal impacts.

If you have any questions about this letter, please contact me at (208)686-1800.

Sincerely,

Caj Matheson
Director, Natural Resources

[7] Benewah Medical and Wellness Center Community Health Assessment, 2013.

DRAFT 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)

Draft v. 4.26.2019

I. Background and Issue Statement

In 2016, the U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and U.S. Bureau of Reclamation (USBR) (collectively, the Coleads) announced the initiation of a 5-year process under NEPA for developing the CRSO-EIS, a document that would analyze the impacts of continued and modified operations of 14 federal dams in the Columbia River system, pursuant to federal judicial order.

Within a year, several scoping meetings with leaders of the 19 federally recognized tribes of the Columbia Basin had been hosted by the Coleads in Spokane, Boise, The Dalles, and Portland. In the same timeframe, several interagency working groups were formed to focus on the various affected resources and began meeting regularly. As expected, the degree of tribal involvement in the CRSO-EIS has varied between individual tribes. However, certain themes began to be expressed among the tribes who were members of the working groups, particularly the Cultural Resources group. One such theme centered around a concern regarding the narrowness of the "Traditional Cultural Properties (TCPs)" and "Sacred Sites" policies making it difficult to fully capture, describe, and analyze tribally important resources that would potentially be affected by CRSO-EIS alternatives, if limited only to those two policies.

Soon after this, in Fall 2018, a Presidential Memorandum was released providing for a revised understanding of NEPA process regarding the CRSO-EIS, with a Record of Decision (ROD) being signed in September 2020, one year sooner than originally scheduled. The Coleads announced they would be seeking tribal input and proposals on a "Tribal Perspectives" section to be authored by tribes, around the same time they announced the revised EIS schedule.

In light of (1) the accelerated schedule and (2) the need to identify and analyze impacts to tribally important resources beyond "TCPs" and "Sacred Sites", the issue is that a stepwise and documentable (but also protectable) system is needed to describe protocols for resource identification, prioritization and analysis in the CRSO-EIS APE. In this way, the protocols themselves may be followed both before and after the issuance of the ROD, and their outcomes and products may inform CRSO operations even if not written into the EIS.

II. Proposal Statement—the Blueprint

Project staff from the Confederated Tribes of Grand Ronde propose, as part of the Tribal Perspectives section of the CRSO-EIS, a blueprint for developing the protocols for resource identification and analysis of tribally important resources ("Blueprint"), as described above. Tribes would develop and write the protocols, Coleads and tribes would follow them, and the outcomes and products would be used only as determined/allowed by the contributing tribes.

The Blueprint is based heavily upon the Bureau of Ocean Energy Management (BOEM) documents *A Guidance Document for Characterizing Tribal Cultural Landscapes*,[1] and *Characterizing Tribal Cultural Landscapes, Volumes I* and *II*.[2] All of the above documents were prepared under BOEM-NOAA Interagency Agreement M12PG00035 by the National Oceanic and Atmospheric Administration (NOAA) Office of National Marine Sanctuaries, the Makah Tribe, the Confederated Tribes of the Grand Ronde Community of Oregon, the Yurok Tribe, the National Marine Sanctuary Foundation, and the BOEM Pacific OCS Region, and were first published in 2015-2017.

III. Description of Blueprint Methodologies and Parameters

A. Concepts

1. Tribal Cultural Landscape (TCL): 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. A tribal cultural landscape is determined by and known to a culturally related group of indigenous people with relationships to that place.[3]
2. TCLs are defined as significant by tribes and indigenous communities, rather than by exterior criteria. This is a fundamental difference between TCLs and Section 106 TCPs.[4]
3. 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.
4. 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.
5. While TCL identification by a tribe does not by itself mandate any special action or consideration from government agencies or others, a government agency acting in good faith should at least attempt to adaptively incorporate such values into its relevant management practices and policies.
6. The tribe(s) identifying a TCL should determine the level of sensitivity of tribal information associated with the TCL or resource, and this determination should be

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[1] Ball, David, R. Clayburn, R. Cordero, B. Edwards, V. Grussing, J. Ledford, R. McConnell, R. Monette, R. Steelquist, E. Thorsgard, and J. Townsend. OCS Study BOEM 2015-047, November 30, 2015. Online at http://www.boem.gov/Pacific-Completed-Studies.

[2] Same authors as above. OCS Study BOEM 2017-001, December 31, 2017. Online at http://www.boem.gov/Pacific-Completed-Studies.

[3] Ball *et al.* (2015).

[4] *Id.*

respected by all partners. Often such information is not meant to be shared outside of the tribal group or subgroup. Where multiple tribes identify the same identical TCL or resource information, the most restrictive tribe's policies and practices should govern.

7. As much as possible, information about a tribe should come from that tribe.[5]
8. TCL and tribally important resource identification and/or analysis (a "TCL study") should be utilized as part of ongoing conversations and adaptive decision-making processes in the course of project planning, design, implementation, monitoring, and evaluation. They should not be treated as "check the box" steps to be completed and then forgotten.

B. Protocols[6]

The protocols listed here are intended only to enhance the government-to-government consultation process, not to replace it. Each tribe as a sovereign has the right to engage in consultation with the Coleads within or outside of this process.

1. Conceptualization
    - Tribe(s) identify appropriate geographic scope of study, with CRSO-EIS alternatives in mind
    - Tribe(s) determines types of information to be collected and analyzed
    - Tribe(s) determines formats for recording and processing
    - Tribe(s) may identify format for presentation, if applicable
    - Tribe(s) may identify desired use of information in CRSO processes
    - Conversation between Coleads and tribe(s) regarding capacity needs, organizational needs, and other needs as applicable, given the above
2. Data Acquisition—this can be an ongoing process
    - Tribe(s) determines data standards and attributes
    - Tribe(s) gathers and stores information according to tribal access policy
3. Geo-reference
    - Locating of boundaries, if applicable
    - Data layer development, including metadata
    - Data linkage and cleaning
    - Document verification
4. Synthesis
    - Analyze information on, and illuminate linkages between, the following:
        - Places
        - Activities
        - Traditional knowledge (TK)
        - Context
        - Cultural understanding
5. Presentation—this step is at sole discretion of each tribe, and may include:
    - Public presentations, in person or written, of non-sensitive data
    - Maps (redacted if necessary)

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[5] *Id.*
[6] *See id.* for a thorough description of this process and the associated "Figure 1" attachment.

- GIS data layers (redacted if necessary)
- Field visits
- Written (redacted if necessary) and oral reports.

C. Participants and mode of participation

For purposes of this Blueprint, each of the 19 federally recognized tribes of the U.S. portion of the Columbia Basin is a potential participant. Participation is completely voluntary. Each tribe will determine whether, and to what extent, it will participate in a TCL study. A tribe may complete all of the protocols as described above, or it may wish only to participate in one or some of the protocols. A number of tribes may wish to group together for the purposes of the TCL study, but this would not have the effect of "outweighing" or excluding an individually participating tribe's TCL study.

IV. Outcomes and Products

While outcomes and products would differ from tribe to tribe, the Coleads would have the ability to consolidate and synthesize the non-sensitive information shared by all participating tribes. Such products may take the form of maps, GIS data layers, reports, presentations, or other information to be utilized adaptively in CRSO management.

While it is understood that final products would likely not be complete until after the issuance of the ROD for the CRSO-EIS, the reasoning is that the information gathered and shared through the TCL study process would be used to inform best practices and adaptive strategies for avoidance, minimization, and mitigation of impacts moving forward.

V. Treatment of Sensitive TCL Information

Any and all sensitive information a tribe chooses to share with the Coleads, and describes as sensitive, should be treated respectfully and as Confidential. This holds true whether or not the same information is publicly available elsewhere. Where possible, and when acceptable to the contributing tribe(s), the sensitive information should be redacted and/or made more general for the development of public products. Examples of this include large-scale circles on maps rather than points, and GIS data layers with sensitive fields removed from the attribute tables.

VI. Conclusion and Attachments

This Blueprint is offered 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.

Attachments: "Figure 1" Template for Indigenous Data Collection and Retention[7]
"Figure 2" Process for Application of TCL Approach[8]

[7] *Id.*
[8] *Id.*

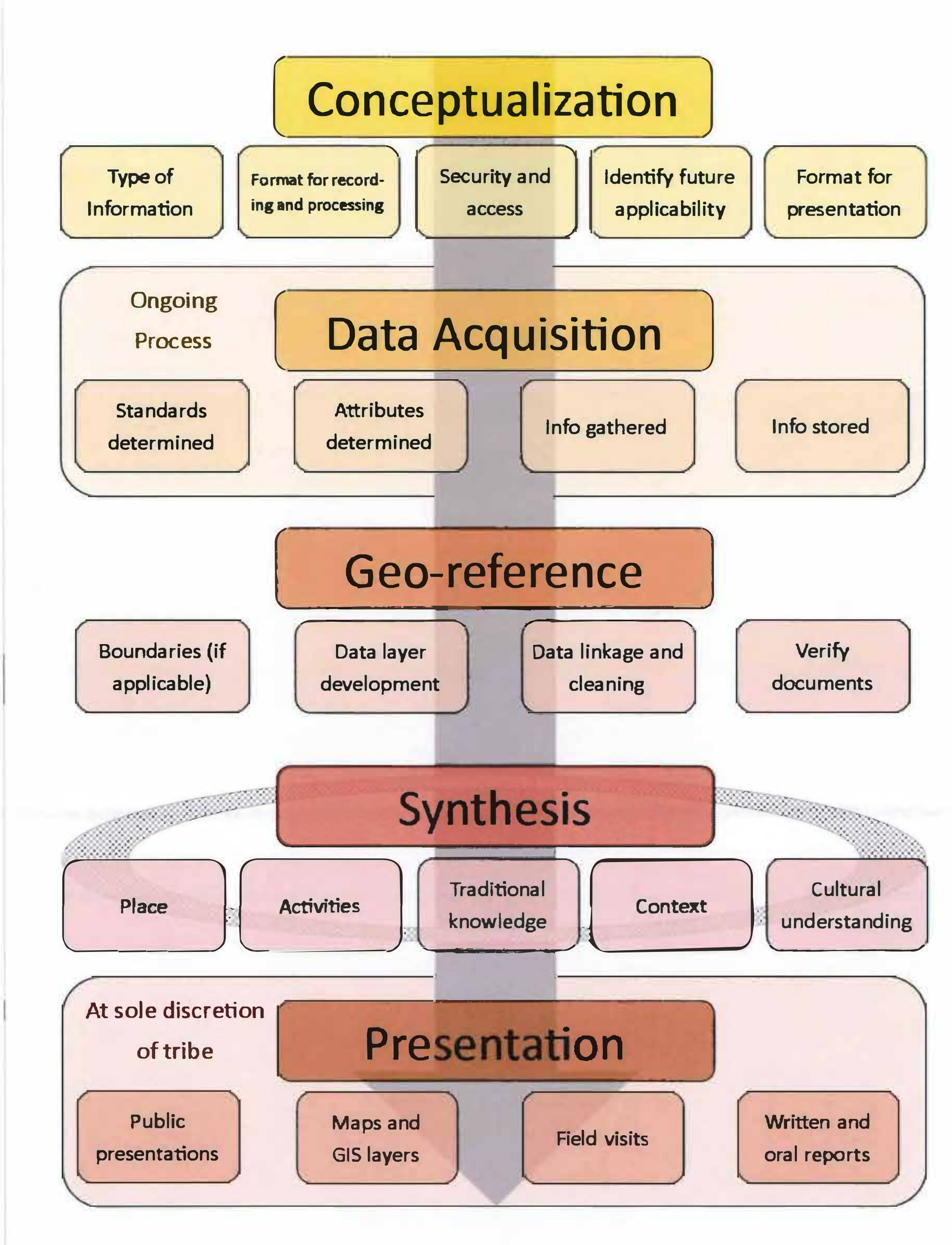

Figure 1. Template for Indigenous Data Collection and Retention. This process provides a method for tribes to collect and hold information that can be queried internally, with the ability to provide summary results to external parties.

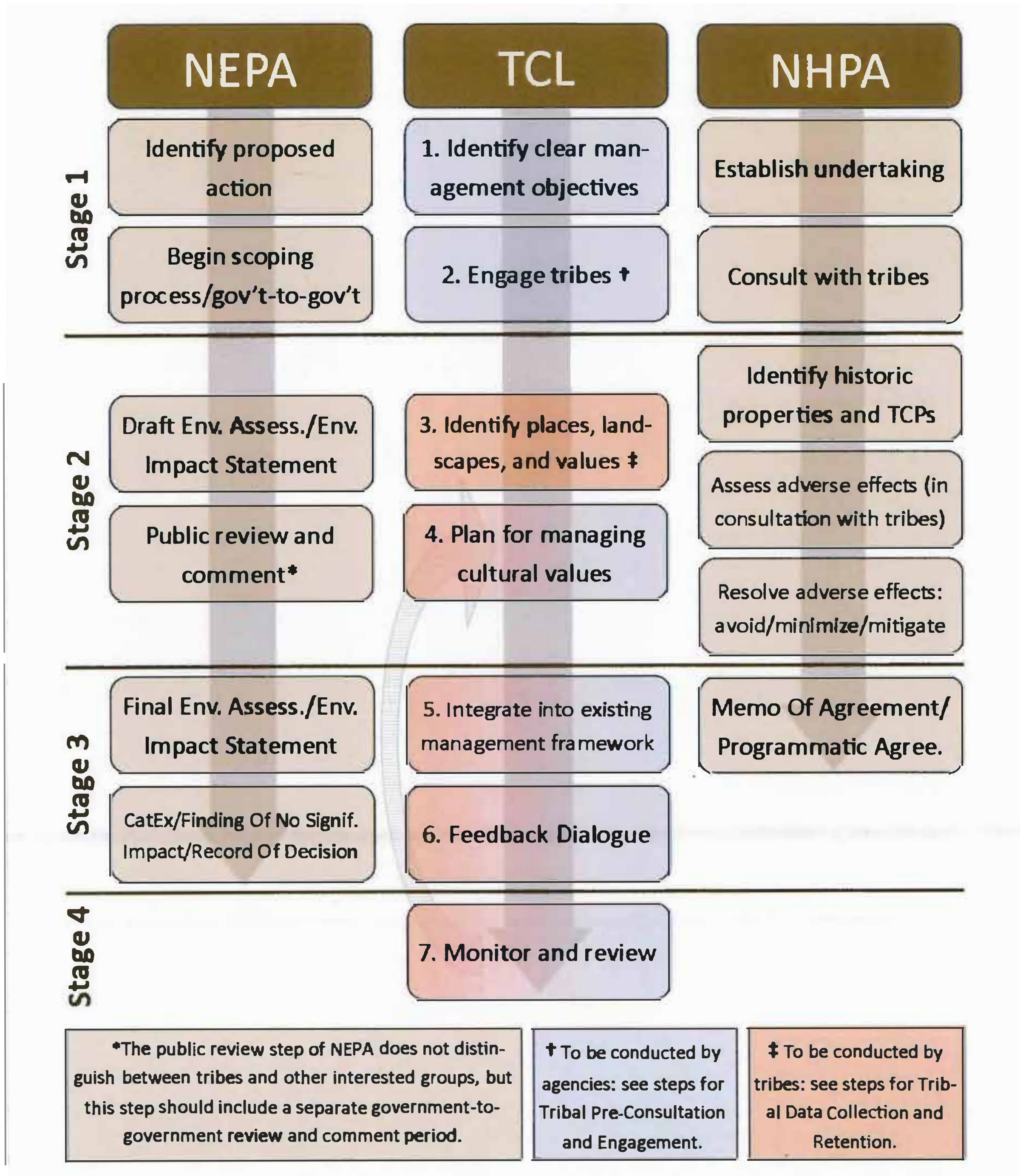

Figure 2. Process for application of TCL approach, showing how it can be feasibly implemented under existing federal policy and regulatory framework. The steps for conducting NEPA and NHPA Section 106 analyses are also included for comparison, to illustrate how the steps in the TCL approach align, and at what points they could be implemented.

Columbia River System Operations EIS
Tribal Cultural Resource Perspective Assessment

Tribal Perspectives, Traditional Places, and the Federal Columbia River System

CTCR Elder, Agatha Bart, at Harry Jim's inundated home site and fishing station, north bank of Snake River, 2007

Jon Meyer and Guy Moura, 2015
Revised Guy Moura and Crystal Miller 2018
History/Archaeology Program
Confederated Tribes of the Colville Reservation

February 28, 2019

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Introduction

Prior to presenting detailed information on tribal perspectives related to the effects of the Federal Columbia River Power System (FCRPS) on tribal culture and cultural resources, it is important to convey the totality of the impacts on tribal members. The focus of this assessment is on Grand Coulee Dam, but also applies to Chief Joseph Dam and all other dams in the Basin. Detrimental effects of dams may be the single most devastating factor in the loss of traditional lifeways among the affected tribes. Settlement patterns centered on the rivers' shores were disrupted as Indian towns (like Inchelium), individual homes, archaeological villages, and ancestral cemeteries were inundated. Salmon, the staple food and trade item for Columbia River tribes, were abruptly blocked from many areas, while in other areas, the annual runs were decimated. Gathering areas for traditional cultural plants have been compromised by the effects of irrigation, inundation, and agriculture. Traditional transportation routes across the Columbia and Snake Rivers became impassable without seasonal low water conducive to fording the rivers. Productive riparian habitat was drowned. Tribal members who successfully transitioned to a commercial agricultural-based economy lost their fields beneath the rising waters of reservoirs, as well as the family gardens used to augment the yearly food supply and supplement traditional hunting, gathering, and fishing. Religious, ceremonial, ritual, sacred, and burial sites were lost. Indian cemeteries were flooded.

Population displacement was compounded when many tribal members moved to dam construction sites and associated boom towns. Almost everything about life in boom towns was detrimental to traditional ways (Ortolano and Cushing 2000; Ray 1977). Native language was lost, a cash economy upset traditional social roles, and alcoholism and prostitution were prevalent in these non-native communities. Gone were many of the traditional familial and leadership roles. Increasing civil authority and abandonment of Indian villages undermined the influence of tribal elders and leadership families. Key cultural roles, like that of the Salmon Chief, which was once a powerful and prestigious position, were no longer needed where the salmon no longer ran.

On June 12, 2018, at the Environmental Impact Statement (EIS) Deputy-Level Regional Meeting in Spokane, Dr. Michael Marchand, Chairman of the Colville Business Council at the time, summarized the enormity of the dams' impacts. He stated that a once powerful and independent people, rich in heritage, culture, and the natural resources to sustain themselves, became a Fourth World Nation as the resources upon which they relied were destroyed.

Cultural Resources: Definition

For the purposes of the Columbia River System Operations (CRSO) EIS, the Confederated Tribes of the Colville Reservation (Tribes or CTCR) take a broad view of cultural resources.[1]

[1] CTCR's Cultural Resource Management Plan explains that "Cultural resources can be generally defined as sites, structures, landforms, objects and locations of importance to a culture or community for historic, educational, traditional, religious, ceremonial, scientific or other reasons. Given this broad definition, the number and kinds of cultural resources is indeed vast. Cultural resources extend from whole rivers and mountain ranges down to individual items. Overall, cultural resources reflect, nourish, and reinforce our communities." Confederated Tribes of the Colville Reservation, Cultural Resource Management Plan (March 6, 2006) at 5. *Available at https://static1.squarespace.com/static/56a24f7f841aba12ab7ecfa9/t/57bf56cdb3db2bdb891e63d1/1472157400402/Cultural+Resource+Management+Plan.pdf.*

These include, but are not limited to, cultural resources defined in applicable laws directed toward tangible resources. They also include cultural heritage that is not necessarily site-specific such as ritual, ceremony, language, traditional teachings, etc., and they include resources such as the land, water, air, and animals. These resources consist of individual artifacts, sites, natural resources, and ecosystems. A vast literature on effects to cultural resources exists.

Laws, Regulations, and Guidelines

What follows is a summary of definitions of 'cultural resources' as provided in various federal and state laws. Much of the language is taken directly from the laws or their implementing regulations.

National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4231 et seq.)

NEPA expands the definition of cultural resources beyond objects and bounded properties. NEPA states the need to preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice. Under the Scoping clause (1508.25), project components cannot be reviewed independently as unconnected actions. This means irrigation projects, recreation, hydroelectric power generation, power transmission, off-channel storage, etc., are ancillary components of the primary undertaking that is the power system itself.

Archaeological Resources Protection Act (ARPA) of 1979 (16 U.S.C. 470aa-mm)

The term "archaeological resource" means any material remains of past human life or activities which are of archaeological interest, as determined under uniform regulations promulgated pursuant to this chapter. Such regulations containing such determination shall include, but not be limited to: pottery, basketry, bottles, weapons, weapon projectiles, tools, structures or portions of structures, pit houses, rock paintings, rock carvings, intaglios, graves, human skeletal materials, or any portion or piece of any of the foregoing items. No item shall be treated as an archaeological resource under these regulations unless such item is at least 100 years of age.

National Historic Preservation Act (NHPA) of 1966 (54 U.S.C. 300101 et seq.)

"Historic property" or "historic resource" means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion on the National Register, including artifacts, records, and material remains related to such a property or resource.

Protection of Historic Properties (36 CFR 800.16)

Historic property means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization that meet the National Register criteria.

Native American Graves Protection and Repatriation Act (NAGPRA) of 1990 (25 U.S.C. 3001-3013)

These regulations apply to human remains, funerary objects, sacred objects, or objects of cultural patrimony.

Guidelines for Evaluating and Documenting Traditional Cultural Properties (National Register Bulletin 38)

A traditional cultural property (TCP) is a property eligible for inclusion in the National Register because of its association with cultural practices or beliefs of a living community that are rooted in that community's history, and are important in maintaining the continuing cultural identity of the community. In practice, CTCR TCPs include, but are not limited to: religious areas, resource gathering areas (plant, animal, fish, and mineral), places associated with stories and legends, archaeological and ethnographic sites, habitation sites, campsites, rock images, special use sites, trails, tribal allotments and homesteads, and locations named in Native languages.

American Indian Religious Freedom Act (AIRFA) of 1978 (42 U.S.C. 1996)

Religious practices of the American Indian are an integral part of their culture, tradition, and heritage – such practices form the basis of Indian identity and value systems. Traditional American Indian religions, as an integral part of Indian life, are indispensable and irreplaceable. It shall be the policy of the United States to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise the traditional religions of the American Indian, Eskimo, Aleut, and Native Hawaiians, including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites.

Indian Graves and Records (RCW 27.44)

Includes any glyptic or painted records, cairns, graves, and any associated archaeological material from any such cairn or grave.

Archaeological Sites and Resources (RCW 27.53)

All sites, objects, structures, artifacts, implements, and locations of prehistorical or archaeological interest, whether previously recorded or still unrecognized, including, but not limited to, those pertaining to prehistoric and historic American Indian or aboriginal burials, campsites, dwellings, and habitation sites, including rock shelters and caves, their artifacts and implements of culture such as projectile points, arrowheads, skeletal remains, grave goods, basketry, pestles, mauls and grinding stones, knives, scrapers, rock carvings and paintings, and other implements and artifacts of any material that are located in, on, or under the surface of any lands or waters owned by or under the possession, custody, or control of the state of Washington or any county, city, or political subdivision of the state are hereby declared to be archaeological resources. Any object that comprises the physical evidence of an indigenous and subsequent culture including material remains of past human life including monuments, symbols, tools, facilities, and technological by-products or any geographic locality, including but not limited to, submerged and submersible lands and the bed of the sea within the state's jurisdiction, that contains archaeological objects.

When added together, tangible cultural resources span the wide range from an isolated fire-cracked rock to entire ecosystems, such as those supporting anadromous fish runs.

Cultural Traditions

Language, ceremonies, rituals, traditional teachings, religion, legends, settlement and subsistence patterns, and many other intangible things are a product, and shape the beliefs, of a living community and the history of that community. They 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. For example, in 1956, the Canadian government issued an extinction declaration for the Lakes (Sinixt) people that led to the erroneous and damaging concept that the Sinixt people no longer exist. This notion of Sinixt extinction has no basis in fact, as they moved to the southern reach of their territory (including the Colville Reservation) after the establishment of the Colville Reservation, bringing their traditions with them. The untiring efforts of Sinixt tribal members and the CTCR to assert, exercise, and uphold the traditional subsistence rights and rights to territory of the Sinixt people are clear evidence of the centrality of these practices to the maintenance of cultural continuity.

It is critical to keep in mind, however, that the cause of an impact can rarely be ascribed to a single action, event, entity, or moment, and also that impacts are cumulative. We understand there is difficulty documenting the causal relationship between the loss of language, ceremonies, legends, and other non-property-based aspects of culture to specific undertakings. We offer the following statement in support of the connection.

Sylvia Peasley (personal communication, 2012), a former member of the Colville Business Council, stated that “culture” is lost when the Indian language is lost and when spiritual ceremonies are no longer conducted. Sylvia grew up on Keller Butte, above the Sanpoil River, a tributary of the Columbia that passes through the Colville Reservation. Sylvia’s grandfather and great grandparents lived along the Sanpoil River by the town of Keller. She learned her traditional ways from her grandfather. Her family ritually practiced daily sweat baths. During the ceremonies, they spoke in their language, discussed family history, and told legends. Elders relayed details of the sweat bath ceremony through teaching and practice. As an adult, Sylvia moved to Keller. 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.

Many of her traditions are compromised. Indian people are aware of the contamination and they fear it. Salmon are not present on most of the Colville Reservation, including Keller, above Chief Joseph Dam and there are health alerts limiting the intake of resident fish in the Grand Coulee Dam reservoir. [Similar fears are connected with most dams; for example, tribal members fear the radioactivity in the water and sediment related to the operation of the Hanford Nuclear Facility.] Sylvia sees youth, elders, and other community members overcome with various health issues tied to the transformation of the river and all that the Columbia River encompasses in Indian culture and subsistence. The dams’ effect on tribal culture is far-reaching. Youth in Keller are losing their traditional ways, the tainted river and loss of salmon damaged the CTCR way of life. Parents do not have the same opportunities to pass down their customs and traditions. Few know all the words to the different ceremonies anymore. No one person still remembers the names of all the fish. No one person remembers all the different names used for some species of fish, as they are called by different names as they move through the stages of their life. Sylvia contends that when sweats are not conducted, the 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.

However, more than just polluted waters caused such loss. Examples of comparable Columbia River losses relate to preventing the migration of salmon and lamprey runs, the destruction of the sturgeon fishery, inundation of the Indian towns, the move to a cash economy in the construction boomtowns, and the breaking up of families who moved to earn money. The examples provided by Sylvia Peasley are the experiences of one tribal member. Many more among the over nine thousand CTCR members have had (and continue to have) similar experiences.

Reservoirs of Concern

The Confederated Tribes of the Colville Reservation are comprised of twelve constituent tribes (Okanogan, Lakes, Colville, Sanpoil, Nespelem, Moses-Columbia, Methow, Chelan, Entiat, Wenatchi, Palus, and Chief Joseph Band of Nez Perce). Altogether, CTCR's traditional territory spans more than 37 million acres across Washington, Oregon, Idaho, and British Columbia (Figure 1).

No less than nineteen dams and their corresponding reservoirs affect traditional use areas of the CTCR constituent tribes:

McNary Dam – Lake Wallula (Palus)
Ice Harbor Dam – Lake Sacajawea (Palus)
Lower Monumental Dam – Lake Herbert G. West (Palus)
Little Goose Dam – Lake Bryan (Palus and Chief Joseph Band of Nez Perce)
Lower Granite Dam – Lower Granite Lake (Palus and Chief Joseph Band of Nez Perce)
Priest Rapids Dam – Priest Rapids Lake (Moses-Columbia)
Wanapum Dam – Lake Wanapum (Moses-Columbia)
Rock Island Dam – Rock Island Pool (Moses-Columbia and Wenatchi)
Rocky Reach Dam – Lake Entiat (Wenatchi, Entiat, Chelan, and Moses-Columbia)
Wells Dam – Lake Pateros (Chelan, Methow, Okanogan, and Moses-Columbia)
Chief Joseph Dam – Rufus Woods Lake (Okanogan, Moses-Columbia, Nespelem, and Sanpoil)
Grand Coulee Dam – Lake Roosevelt (Nespelem, Moses-Columbia, Sanpoil, Colville, and Lakes)
Keenleyside Dam – Arrow Lakes (Lakes)
Revelstoke Dam – Lake Revelstoke (Lakes)
Mica Dam – Kinbasket Lake (Lakes)
Waneta Dam - Waneta Reservoir (Lakes)
Seven Mile Dam – Seven Mile Reservoir (Lakes)
Boundary Dam – Boundary Reservoir (Lakes)
Hells Canyon Dam – Hells Canyon Reservoir (Chief Joseph Band of Nez Perce)
Enloe Dam – Similkameen River (Okanogan)

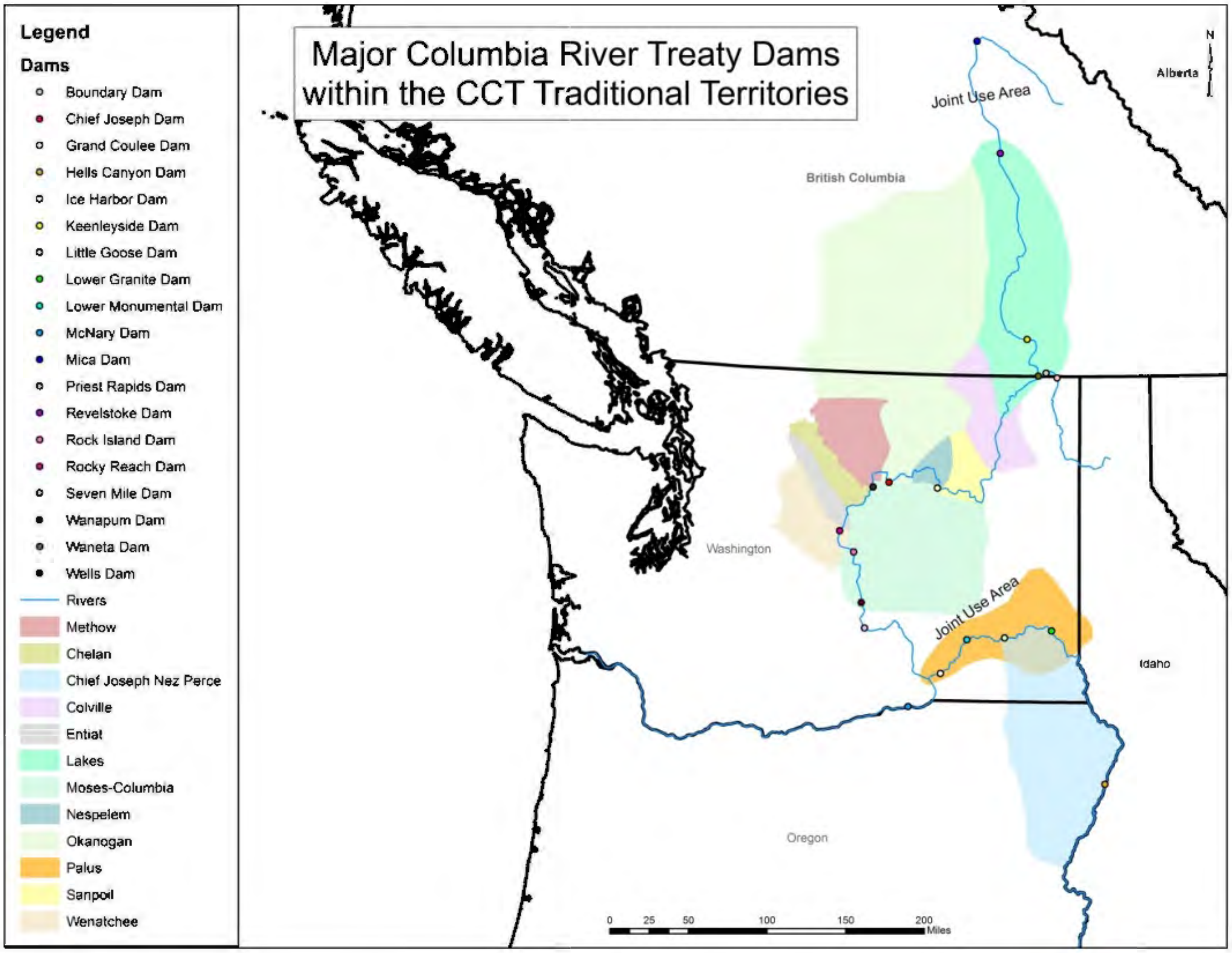

Figure 1: Major Columbia River Dams and Traditional Territories of the Confederated Tribes of the Colville Reservation

The existence, operation and management of these dams and their associated reservoirs have played a major role in some of the CTCR's most pressing contemporary cultural resource concerns, including:

- The destruction of the salmon fishery at Kettle Falls and traditional fishing locations on much of the Colville Reservation was directly caused by the construction of Grand Coulee Dam and Chief Joseph Dam and the continuing failure to include fish passage in the management of these dams. Tribal salmon fisheries below Chief Joseph Dam have been severely depleted by the construction, operation and management of nine dams on the mainstem Columbia below the Reservation. This devastation of the Tribes' ancestral fisheries caused (and continues to cause) irreparable harm to the culture, subsistence, religion, and economy of the 12 constituent tribes. While salmon are a focal point of any impacts discussion from the Tribes' perspective, the dams have also severely limited tribal access to lamprey, sturgeon, and other native fish species while creating an environment where non-native predator species are increasing in abundance and posing grave risks to these native fauna.

- Current CTCR fisheries, such as the summer/fall Chinook fishery on the Reservation at the tailrace of Chief Joseph Dam, are affected by CRS operations. The ability of tribal members to harvest salmon directly from the Columbia River in one of the few places it is still available to them is severely impacted by power, flood risk and other operations that result in high levels of spill from Chief Joseph Dam.

- The exposure of the ancestral remains of the Ancient One, also known as Kennewick Man, in 1996, caused by the operations of the McNary Dam and the fluctuating waters of Lake Wallula Reservoir. The exposure and recovery of his remains led to decades of legal battles pertaining to their repatriation to his descendants. CTCR considers the monitoring of known and likely ancestral cemetery locations impacted by reservoir operations to be of paramount importance;

- The crack in Wanapum Dam discovered in 2014 necessitated a substantial drawdown of the Wanapum Reservoir. Staff members of CTCR's History/Archaeology Program were tasked with monitoring ancestral cemeteries and gravesites that were either exposed or impacted by erosion due to the drawdown. A number of the Columbia River Treaty dams are aging structures that are not without flaws, and we expect that similar emergent situations will arise; and

- The excessive flow rates on the Columbia, Snake, and Palouse Rivers in May 2018 caused a marked increase in the inundation of, and erosive activity at, previously documented archaeological sites including villages, camps, rock image locations, rock feature sites, and other places of cultural and archaeological significance.

Resources Impacted

The Columbia River and its tributaries are central to the cultural traditions of the Confederated Tribes of the Colville Reservation. Each of the twelve constituent tribes of the Colville Reservation utilized the Columbia River, and their traditional territories had boundaries encompassing and lying adjacent to portions of the Columbia and Snake Rivers. To this day, only two federally recognized tribes retain reservation lands on the Columbia and Snake Rivers – the CTCR is one of those tribes. Tribes utilized riverine resources continually throughout the year (Ray 1933). Beyond subsistence, the Columbia River occupies a central role in CTCR culture, spirituality, and history. The Columbia River, or some aspect of the river, is central to the identity of each of the tribes of the Colville Reservation.

The Columbia and Okanogan Rivers border the current Colville Reservation for approximately 150 miles starting from a point around Malott on the Okanogan, past Chief Joseph Dam, and extending to an arbitrary line at the division of cadastral markers Township 34 North and Township 35 North. The boundaries of the Colville Reservation recognized the importance of fishing to tribes and were originally defined with the intent to include fisheries important to the tribes assigned to the Reservation (Hart 2002). The completion of the Grand Coulee Dam, and later the Chief Joseph Dam, inundated these fisheries and 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 1898, to which CTCR members retain federally protected reserved hunting, fishing and gathering rights. The effects have been devastating. The subsistence fishing economy has been destroyed and many of the cultural traditions associated with it are now diminished. The subsistence harvesting economy – particularly the gathering of traditional cultural plant foods, medicines, and materials – has been dramatically impacted by the Columbia Basin-wide effects of irrigation projects, and the agricultural industry they sustain, which have dramatically altered entire ecological systems. Furthermore, the waters behind the dams inundated hundreds of culturally important sites such as villages, hunting and gathering areas, and ceremonial grounds. Today, the erosional effects of dam operations continue to damage cultural sites. Impacts to cultural resources also result from recreation and the federal taking of lands. Decisions regarding the management of the Columbia River System affect CTCR tribal members directly and constantly.

Legends pertaining to the Columbia River highlight the importance of the river to tribes. KwElkwElta'xEn, a Nespelem tribal member, told the story of the Origin of the Columbia River to James Teit (1917:65-66).

> *Coyote was travelling, and heard water dropping. He said, "I will go and beat it." He sat down near it, and cried, "Hox-hox-hox-hox!" in imitation of water dripping. He tried four times, but the noise never ceased. He became angry, arose, and kicked the place where the water dropped. The noise ceased. He thought he had beaten it, and laughed, saying, "I beat you. No more shall water drip thus and make a noise." Shortly after he had gone, the water began to drip as before. He became angry, and said, "Did I not say water shall not run and make a noise?" The water was coming after him, and increased in volume as it flowed. He kept on running; but still he heard the noise of water, and was much annoyed. Now he travelled along the edge of a plateau. There was no water there, nor trees. He looked down into the coulee, bet everywhere it was dry. It was warm, and he became very thirsty. He heard the noise of water, but saw none. Then he looked again down into the coulee, and saw a small creek flowing along the bottom. It seemed a long distance away. He went down, and drank his fill. And ascended again, but had not reached the top when he was thirsty, as before. He thought, "Where can I drink?" The water was following him. He went to the edge of a bench and looked down. A small river was now running below. He descended and drank. He wondered that much water was running where there had been none before. The more he drank, the sooner he became thirsty again. The fourth time he became thirsty he was only a little way from the water. He was angry, and turned back to drink. The water had now risen to a good-sized river, so that he had not far to go. He said, "What may be the matter? I am always thirsty now. There is no use of my going away. I will walk along the edge of the water." He did son; but as he was still thirsty, he said, "I will walk in the water." The water reached up to his knew. This did not satisfy him; and every time after drinking, he walked deeper, first up to the waist, then up to the arms. Then he said, "I will swim, so that my mouth will be close to the water, and I can drink all the time." Finally he had drunk so much that he lost consciousness. Thus the water got even with Coyote for kicking it; and thus from a few drops of water originated the Columbia River.*

Among other messages, this story reminds the listener to respect the Columbia River, suggesting that it is foolish to think that nature can be controlled.

The second story details the creation of Kettle Falls as told by Lakes Indian Eneas Seymour to Mrs. Goldie Putnam (Lakin 1976:V-VI):

> *I am Coyote, the Transformer, and have been sent by Great Mystery, the creator and arranger of the world. Great Mystery has said that all people should have an equal right in everything and that all should share alike. As long as the sun sets in the west this will be a land of peace. This is the commandment I gave to my people, and they have obeyed me.*
>
> *My people are the Skoyelpi and Snaitceskt Indians, who lived near the Kettle Falls on the Columbia River. I gave them that Falls to provide them with fish all their days. It was called Ilthkoyape, which means "falls of boiling baskets," but the name was shortened to Skoyelpi. The Falls was surrounded by potholes which resembled the boiling baskets in which my people cooked their food…*
>
> *Many generations ago my people were hungry and starving. They did not have a good place to catch their fish. One day while I was out walking I came upon a poor man and his three daughters. They were thin from hunger because they could not get salmon. I promised the old man I would make him a dam across the river to enable him to catch fish, if he would give me his youngest daughter as my wife. The old man agreed to this and I built him a fine falls where he could fish at low water. But when I went to claim the daughter the old man explained that it was customary to give away the eldest daughter first. So I took the oldest daughter and once again promised the man I would build him a medium dam so he could fish at medium water if I could have the youngest daughter. The old man explained again that the middle daughter must be married before the youngest, so I claimed his middle daughter and built him a fine falls where he could fish at medium water.*
>
> *Shortly after the father came to me and said he was in need of a high dam where he could fish at high water. He promised me his youngest daughter if I would build this. So I built him a third and highest dam where he could fish at high water. And then I claimed the long-awaited youngest daughter as my wife.*
>
> *And now, because I had built the Falls in three levels, my people could fish at low, medium and high water. I had become responsible for my people, and I saw that the fish must jump up the falls in one certain area where the water flowed over a deep depression. I appointed the old man as Salmon Chief, and he and his descendants were to rule over the Falls and see that all people shared in the fish caught there. All people must live there in peace, and no one should leave there unprovided. Indians and white men from hundreds of miles away have gathered during the salmon runs at my falls, and they have all lived in peace sharing together.*

The construction of the Grand Coulee Dam destroyed the Kettle Falls Fishery. The falls were submerged beneath the waters of Lake Roosevelt and the salmon were stopped at the base of the Grand Coulee Dam and, later, the Chief Joseph Dam. Now those who visit Kettle Falls will not be able to catch salmon and will leave "unprovided." Not only has the Kettle Falls economy been ruined, but the moral lessons embedded in the site have been debased.

The two legends above are among many told over the centuries by members of CTCR. They demonstrate that the Columbia River is not simply a tool for subsistence and travel, but an integral part of the cosmology of Columbia Plateau tribes.

Figure 2: Kettle Falls before inundation.

Figure 3: Kettle Falls today.

Within the Grand Coulee Project Area, from the Grand Coulee Dam upriver to the Canadian border, 408 traditional cultural properties had been identified up through 2017 (George 2008), and another 54 are being added in 2018. Hundreds of other TCPs have been recorded along the Columbia River system within the traditional territories of the Confederated Tribes of the Colville Reservation (e.g. Finley 2006, 2008; Finley, Wazaney and Moura 2008; Kennedy and Bouchard 1998; Mattina 1987; Ray 1932, 1933, and 1936; Shannon 2007; Shannon and Moura 2007a, 2007b, and 2010; Spier 1938; Turner, et al. 1979; Wazaney and Moura 2008).

Given the immense number of cultural sites that are affected under the current Columbia River System Operations (and which are being analyzed in the CRSO EIS), we will limit our discussion to traditional non-archaeological cultural resources under ten categories. These are vision quest sites, ceremonial locations, traditional sites, named places, legendary locations, fishing stations, mineral procurement areas, plant gathering areas, hunting areas, and burials. Descriptions of each of these categories are provided below. These descriptions should not be considered hard definitions, as many of these categories have overlapping elements, and an individual site can often be described under several categories. Additionally, these categories should not be considered all-inclusive. Some cultural sites important to CTCR may not fit any of the categories provided here.

Vision Quest Sites

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.

Ceremonial Locations

Ceremonial locations include, but are not limited to, 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. Many of these places are located alongside rivers. In the case of the cairn formation representing a prayer site in Figure 55, access to the site is dependent on the reservoir level behind Grand Coulee Dam. During full pool, the site is mostly inundated and cannot be reached without traversing the water. Other ceremonial locations have been found to be completely inundated during full pool. Significant drafting of the reservoirs pursuant to Columbia River System Operations may also adversely affect such locations through erosion and other impacts.

Figure 4: Rock cairn on the Colville Reservation, looking south over the Columbia River

Figure 5: Cairn formation located adjacent to Columbia River.

Named Places

Figure 6: Location of *nsʔátqʷəɬp*.

Named places are locations that have been given a Native language name. Usually, these are locations found in the ethnographic record with names provided in the native language.

Named places are often important for identifying geographic or environmental features, resources, or stories associated with the place.

Reservoir effects have damaged many of these sites, either through erosion or inundation. In some cases, the dams have caused irreparable harm to named places by preventing a resource from being present at the site. For example, the site called *snc'əm'túmstn*, translated as "sturgeon place," was an important fishing location for sturgeon (George 2008). Since the construction of the Grand Coulee Dam, however, sturgeon have been unable to return to this location. The ponderosa pines at another site, *nsʔátqʷəɬp*, translated as "in pine groves," were traditionally used for canoe construction. During the drawdown period, this site can be revisited, but pine trees can no longer grow here. Examples such as these also demonstrate the negative indirect impacts that may occur when a site is damaged. Since sturgeon and ponderosa pine are no longer present at these sites, there is no incentive to return to these areas. Consequently, the transmission of teachings by older generations to younger ones does not occur here. Moreover, the native words to describe these places are not passed on to the younger generation. Both language and culture are lost.

Legendary Locations

Legendary locations are places associated with traditional legends or stories. Many of these places, such as the Owl Sisters' Site (Figure 7), sit along the Columbia River or one of its tributaries. While the legends persist, if associated places are eroded or inundated, the re-telling of the legend dwindles over time. Some of these sites, such as Kettle Falls, lie in or adjacent to these rivers and can be directly impacted by river management activities.

Fishing Stations

Fishing stations are places that were repeatedly revisited for fishing. Often fishing stations included rock and stick weirs, net locations, traps, and places with platforms for the use of hoop nets or spears. Many of the fishing stations used prior to the arrival of Europeans are now inundated. Contemporary fishing requires that desired fish are actually present in the rivers and streams. Obviously, the Chief Joseph and Grand Coulee dams prevent some of these fish from reaching traditional fishing areas and being harvested by CTCR members. Additionally, flow rates, spill (and associated turbidity, flow and dissolved gas), temperature, and fluctuating reservoir pool levels may have negative impacts on traditional fishing conducted today.

Mineral Procurement Areas

Mineral procurement areas include those areas where naturally occurring inorganic materials are obtained. Most commonly, these areas refer to locations where rocks or minerals used for stone tool production are found. However, these places also include sites that produce minerals, such as ochre, that may be used for ceremonial purposes or as pigments in paints.

Figure 7. Owl Sisters' Site along the Columbia River

Figure 8: Petrified wood found at Ginkgo Petrified Forest State Park (USGS 2013).

Mineral procurement areas are often found in quarries where the desired stone is extracted. At some sites, such as the Ginkgo Petrified Forest, the resource is easily accessible. Here, petrified wood is found on the ground surface next to the Columbia River (Figure 8). Some minerals, such as agate, chalcedony, jasper and other cryptocrystallines, are collected in nodules found among the gravels in the Columbia River and its tributaries (Beste 1996). Where the natural river channels are inundated, retrieval of these cobbles becomes infeasible.

Alternatives Analysis and Tribal Impacts

The Confederated Tribes of the Colville Reservation are in the unique position of representing tribes that have an interest in cultural resources in both the United States and Canada, and in several states on both the Columbia River and Snake River drainages. Under any proposed alternative for the Columbia River System Operations EIS, the management of these rivers will result in negative impacts to CTCR cultural resources. In all of the alternatives to be evaluated by the Columbia River System Operations EIS, especially the No Action Alternative, there is there is room for vast improvements to System operations, resource management, traditional non-archaeological cultural resource treatments, and the application of creative mitigation. Therefore, with regard to potential Columbia River System Operations effects, CTCR has no preferred alternative for 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 of the Colville Reservation and other areas in the Tribes' traditional territory that are vitally important to the CTCR.

The tribal and family histories obtained from informants suggest that throughout the project area, tribal members continue to practice subsistence and ceremonial activities related to hunting, gathering, and fishing. Such places have traditional cultural value. Places, practices, stories and legends also serve as a means of perpetuating tribal tradition. As the ethnographic interviews emphasize, these activities cease only when access is prohibited, or in areas permanently altered by environmental change caused by farming, ranching, recreation, land tenure policies, inundation, or impoundment. CTCR considers all of the preceding impacts as direct or indirect effects of dams, especially those projects including in the CRS.

Parker and King, in ***Guidelines for Evaluating and Documenting Traditional Cultural Properties***: (1998:1), state that: "A traditional cultural property […] can be defined generally as one that is eligible for inclusion in the National Register because of its association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community." Even within the restricted guidance under the National Historic Preservation Act, such places are considered to be significant. Parker and King (1998:3) further explain that these guidelines are "meant to supplement, not substitute for, more specific guidelines, such as those used by…Indian tribes with respect to their own lands and programs." Additionally, the effects of ethnocentrism must be avoided: "It is vital to evaluate properties thought to have traditional cultural significance from the standpoint of those who may ascribe such significance to them, whatever one's own perception of them, based on one's own cultural values, may be" (Parker and King 1998:4). This is because, "The existence and significance of such locations often can be ascertained only through interviews with knowledgeable users of the area" (Parker and King 1998:2).

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KOOTENAI TRIBE OF IDAHO

PERSPECTIVES ON THE COLUMBIA RIVER SYSTEM OPERATIONS

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:

> "It's just like in your Bible. There is a Creator who made the world. You call the Creator God; He told us to call Him Nupika.
>
> The Creator-Spirit was in everything, and there were no people. Then He decided to make human beings. He made different people for different places. He made the Kootenai People for this place.
>
> When He was ready to put us on the earth, He told all the spirit-creatures they would have to move above, because the people were coming. Only their forms and their songs could stay behind, to help the people.
>
> And then, the same as with Moses in your Bible, He told us Kootenais our rules, our Commandments. Here is part of what He said:
>
> '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.
>
> Then He told us the ceremonies and prayers we could use to get help when we need it. You have your angels and your saints, who help you. We Kootenai People have our Nupikas, who help us.
>
> Finally, Quilxka Nupika told us His most important commandment. He said:
>
> '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?'

And those first Kootenai People promised to keep the Covenant with the Creator, just the way the Jews did in the Old Testament. So He put us here, in our Kootenai Aboriginal Territory.

And that's how time began."

Century of Survival, A Brief History of the Kootenai Tribe of Idaho, By the Elders of the Kootenai Nation and the Members of the Tribe (2nd Ed. 2010).

The Ktunaxa (Kootenai) Nation consists of several modern communities in the United States and Canada. The Kootenai Tribe of Idaho (ʔaq̓anqmi) (KTOI) is located near Bonners Ferry, Idaho. The other bands are:

- yaqan nuʔkiy (Lower Kootenay Band), located near Creston, B.C.
- ʔaq̓am (St. Mary's Band) located near Cranbrook, B.C.
- ʔakink̓umǂasnuqǂiʔit (Tobacco Plains Band) located near Tobacco Plains, B.C.
- ʔakisq̓nuk (Columbia Lake Band) located near Windermere, B.C.
- k̓upawi¢q̓nuk (Ksanka Band) located in Elmo, Montana

The KTOI is governed by the Kootenai Tribal Council. The Ksanka Band is part of the Confederated Salish and Kootenai Tribes of the Flathead Reservation (CSKT) and is governed by CSKT Tribal Council. The four communities in British Columbia are governed by their individual Band Councils and the Ktunaxa Nation Council. The Ktunaxa Nation comes together as one to discuss and address issues affecting the Nation and the Territory under a Protocol signed in 2009.

Ktunaxa Territory consists of portions of Idaho, Montana, Washington, British Columbia and Alberta. The KTOI inhabited the area along the Kootenai River from above Kootenai Falls, Montana in the east, Priest Lake, Idaho in the west, Lake Pend Oreille, Idaho in the south and Kootenay Lake, British Columbia in the north.

The heart of Ktunaxa Territory is the Kootenai/y River and its tributaries. The Kootenai Subbasin Plan provides a useful overview (found at https://www.nwcouncil.org/sites/default/files/Assessment_01IntroOverview.pdf):

> The Kootenai River Subbasin is situated between 48° and 51° north latitude and 115° and 118° west longitude and includes within its boundaries parts of southeastern British Columbia, northern Idaho, and northwestern Montana. It measures 238 miles by 153 miles and has an area 16,180 sq miles. Nearly two-thirds of the Kootenai River's 485-mile-long channel and almost 70 percent of its watershed area, is located within the province of British Columbia. The Montana part of the subbasin makes up about 23 percent of the watershed, while the Idaho portion is about 6.5 percent (Knudson 1994). The primary focus of this assessment

is on that part of the subbasin that falls within the U.S.; those parts of the subbasin upstream and downstream in British Columbia are covered in less detail. ***

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The headwaters of the Kootenai River, which is spelled Kootenay in Canada, originate in Kootenay National Park, B.C. The river flows south into the Rocky Mountain Trench, and then enters Koocanusa Reservoir (also known as Lake Koocanusa) created by Libby Dam and located near Libby, Montana. After leaving the reservoir, the Kootenai River flows west, passes through a gap between the Purcell and Cabinet Mountains and enters Idaho. From Bonners Ferry, it enters the Purcell Trench and flows northward through flat agricultural land (formerly a floodplain/wetland complex) toward the Idaho-Canada border. North of the border, it runs past the city of Creston, B.C. and into the south arm of Kootenay Lake. Kootenay Lake's west arm is the outlet, and from there, the Kootenai River flows south again to join the Columbia River at Castlegar, B.C. At its mouth, the Kootenai has an average annual discharge of 30,650 cfs (KRN 2003). The Continental Divide forms much of the eastern boundary of the subbasin, the Selkirk Mountains the western boundary, and the Cabinet Range the southern. The Purcell Mountains fill the center of the river's J-shaped course to where it joins Kootenay Lake.

In its first 70 miles (from the source to Canal Flats), five rivers—the Vermillion, Simpson, Cross, Palliser and White—empty into the Kootenai. Together those streams drain an area of approximately 2,080 square miles. At Canal Flats, the Kootenai enters the Rocky Mountain Trench, and from there to where it crosses the border into Montana, a distance of some 83 miles, it is joined by several more tributaries (Skookumchuck, Lussier, St. Mary, Elk, and Bull Rivers and Gold Creek). Collectively, they drain another 4,280 square miles. After entering Montana, the Tobacco River and numerous small tributaries flow into Koocanusa Reservoir. Between Libby Dam and the Montana-Idaho border, the major tributaries are the Fisher and Yaak Rivers. In Idaho, the major tributary is the Moyie River, which joins the Kootenai from the north between the Montana-Idaho border and Bonners Ferry, Idaho. The Goat River enters the river in Canada, near Creston, B.C.

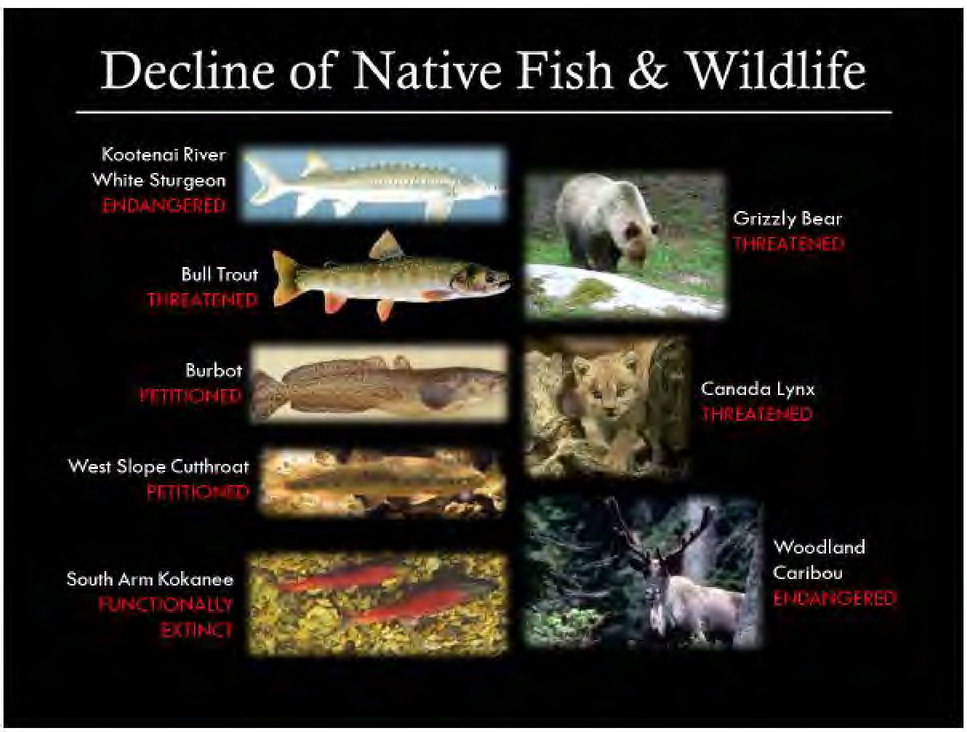
Almost all of the major tributaries to the river—including the Elk, Bull, White, Lussier, and Vermillion Rivers—have a very high channel gradient, particularly in their headwaters. The highest headwater areas lie almost 10,000 vertical feet above the point at which the Kootenai River enters Kootenai Lake. Much of the mainstem, however, has a low gradient; from near Canal Flats to where the river enters Kootenay Lake, a distance of 300 miles, the river drops less than 1000 feet. Still, even there valley-bottom widths are generally under two miles and are characterized by tree-covered rolling hills with few grassland openings. Only in the Bonners Ferry-to-Creston area and the Tobacco Plains are there slightly wider floodplains.

In terms of runoff volume, the Kootenai River is the second largest Columbia River tributary. In terms of watershed area (10.4 million acres), the subbasin ranks third in the Columbia (Knudson 1994).

Libby Dam became operational in 1974 and is part of the Columbia River System Operations. 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.

Ktunaxa people also inhabited and used the Arrow Lakes, Priest Lake and Lake Pend Oreille for subsistence gathering and cultural activities. Ktunaxa participated in the Kettle Falls fishery, traveling from Ktunaxa Territory to the location annually to obtain salmon.

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.



Thus, the ability of Ktunaxa people to practice their religion and culture is impeded by the Columbia River System Operations. Especially for the KTOI and Yaqan Nukiy, the main source of subsistence was fishing rather than hunting due to the location. The Kootenai/y River itself became part of KTOI identity and historically there were a number of camp locations along the River such as at Jennings, Montana.

The construction, inundation and continued operation of Libby Dam interrupted the lifeways of the River and its ecosystems, which had a cascading effect from the fish, to the riparian areas, and to the mountaintop ridges, including berries. This in turn had a cascading effect on KTOI culture.

For example, the Kootenai Sturgeon Nose Canoe was an integral part of KTOI identity and was unique to the Kootenai. The Kootenai would travel throughout the Kootenai Valley during the spring floods to different areas for different purposes, as well as between villages to visit other Ktunaxa. The CRSO eliminated the ability to do so and the Kootenai Sturgeon Nose Canoe was nearly lost.

One significant site along the River for the KTOI specifically and Ktunaxa generally is the Kootenai Falls located in present-day Montana. There have been attempts to dam the Falls, but Ktunaxa people from all communities gathered together to fight the attempts and won. CRSO operations have changed the Falls somewhat, but thankfully Ktunaxa People are still able to utilize Kootenai Falls as their modern church. Every June, the Ktunaxa Nation gather at Kootenai Falls for ceremony and social interaction.

Ktunaxa Territory generally and the Kootenai River Subbasin specifically is transboundary and impacted by Columbia River System Operations. The KTOI works diligently to mitigate the impacts of the CRSO operations through ecosystem restoration. The Tribe works in close coordination with its sister communities in the Ktunaxa Nation as well as the United States, Canada, British Columbia, Idaho and Montana governments, along with local governments, individuals and organizations to address those impacts and restore Ktunaxa resources.

Unfortunately, the CRSO EIS analysis focuses solely on resources in the United States. It is impossible to fully analyze impacts to Ktunaxa resources with this artificial limitation. Libby Dam operations affect both upstream resources in British Columbia, as well as downstream resources in Montana, Idaho and British Columbia. Columbia River System Operations are also closely coordinated with Columbia River Treaty operations, which have an impact on Ktunaxa resources on both sides of the international boundary. The alternatives analysis will not show those impacts unless the EIS is expanded to address all impacts to Ktunaxa resources.

10 June 2019

Tribal Perspectives Report

Prepared by the Columbia River Treaty Tribes

Introduction and Purpose

This Tribal Perspective is provided to the Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration [hereinafter “Co-Lead Agencies” or “Agencies”] in response to the Agencies’ email dated February 14, 2019, requesting submissions of Tribal Perspectives for the Columbia River System Operation Draft Environmental Impact Statement [CRSO DEIS]. This Tribal Perspective was prepared by the Nez Perce Tribe [NPT], Confederated Tribes of the Umatilla Indian Reservation [CTUIR], Confederated Tribes of the Warm Springs Reservation of Oregon [CTWRSO] and the Confederated Tribes and Bands of the Yakama Nation [YN] with assistance by the Columbia River Inter-Tribal Fish Commission [CRITFC][collectively the “Columbia River Treaty Tribes”].

The Columbia River Treaty Tribes expect that this Tribal Perspectives Report, incorporating by reference the entirety of the 1999 Meyer Report that serves as its foundation, will be incorporated in the CRSO EIS as submitted.[1] The Meyer Report provides a useful framework for outlining and introducing tribal concerns and perspectives with the effects of the federal Columbia and Snake river dams on tribal resources, interests and culture. This Tribal Perspective draws highlights from the Meyer Report and supplements it with updated and new information. For instance, since the 1999 Meyer Report, each of the Columbia River Treaty Tribes have published plans and reports reconfirming two of the major premises of the Meyer Report:

- The baseline for tribal salmon restoration and harvest is 1855; and
- There is a large gap between current conditions and the baseline.

[1] Meyer Resources, Inc., Tribal Circumstances and Impacts of the Lower Snake River Project on Nez Perce, Yakama, Umatilla, Warm Springs and Shoshone Bannock Tribes (April 1999) <https://www.critfc.org/wp-content/uploads/2014/11/circum.pdf> [hereinafter Meyer Report].

After an overview of the Tribes' treaty fishing rights, the following sections of the document consider updated plans for rebuilding salmon and other species adopted by the tribes themselves as well as other institutions. These planning commitments are then discussed in the context of preliminary analyses now available from the Co-Lead Agencies for the CRSO DEIS.

A. Background on the Treaty Rights to Take Fish of the Columbia River Treaty Tribes

Since time immemorial the Columbia River and its tributaries were viewed by the Columbia River Basin tribes as "a great table where all the Indians came to partake."[2] More than a century after the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes and Bands of the Yakima Indian Nation, and the Nez Perce Tribe signed the treaties which reserved their fishing rights and created their reservations, the tribes' place at the table has been subordinated to energy production and other non-Indian water development. Today, the Columbia River treaty tribes struggle to fulfill even a small fraction of their reserved fishing rights. The treaties – the supreme law of the land under the United States Constitution – promised more.

> "The right to resort to the fishing places in controversy was a part of larger rights possessed by the Indians, upon the exercise of which there was not a shadow of impediment, and which were not much less necessary to the existence of the Indians than the atmosphere they breathed."

United States v. Winans, 198 U.S. 371, 381 (1905) (*Winans* is a seminal case in Indian law. It upheld the Yakama Nation's treaty-reserved fishing rights on the Columbia River and established that treaties are "not a grant of rights to the Indians, but a grant of right from them – a reservation of those not granted.").

In the last twelve months two decisions from the U.S. Supreme Court have reaffirmed the permanence of the treaty commitments considered in the 1999 Tribal Circumstance report. These cases specifically addressed United States' treaty commitments made at the Walla Walla treaty grounds in 1855 as the tribal negotiators understood them.

In the *U.S. v. Washington* "Culverts Case", the United States Supreme Court affirmed a decision by the Ninth Circuit Court of Appeals which determined that the Columbia River Tribes' Treaties guaranteed the right to have fish to take, not just the right for the tribes to dip their nets into empty waters devoid of salmon. The language of the appeals court confirms the perspective of the Columbia River Treaty Tribes in the CRSO DEIS.

> The Indians did not understand the Treaties to promise that they would have access to their usual and accustomed fishing places, but with a qualification that would allow the government to diminish or destroy the fish runs. Governor Stevens did not make, and the Indians did not understand him to make, such a cynical and disingenuous promise.

[2] *Seufert Brothers Co. v. United States*, 249 U.S. 194, 197 (1919).

> The Indians reasonably understood Governor Stevens to promise not only that they would have access to their usual and accustomed fishing places, but also that there would be fish sufficient to sustain them. They reasonably understood that they would have, in Stevens' words, "food and drink ... forever." As the Supreme Court wrote in *Fishing Vessel*:
>
>> Governor Stevens and his associates were well aware of the "sense" in which the Indians were likely to view assurances regarding their fishing rights. During the negotiations, the vital importance of the fish to the Indians was repeatedly emphasized by both sides, and the Governor's promises that the treaties would protect that source of food and commerce were crucial in obtaining the Indians' assent. It is absolutely clear, as Governor Stevens himself said, that neither he nor the Indians intended that the latter should be excluded from their ancient fisheries, and it is accordingly inconceivable that either party deliberately agreed to authorize future settlers to crowd the Indians out of any meaningful use of their accustomed places to fish.

United States v. Washington, 827 F.3d 836, 851–52 (9th Cir. 2016), opinion amended and superseded, 853 F.3d 946 (9th Cir. 2017) (citations omitted).

The Ninth Circuit upheld the district court's order directing the State of Washington to remove culverts underneath state roads that blocked salmon access to over 1,000 miles of spawning habitat. The State of Washington had vigorously opposed the positions of the United States and the tribes, at one point claiming that the treaties would not prevent the state from blocking every salmon bearing stream entering Puget Sound. *Id.* at 849-50. The State argued that the principal purpose of the treaties was to open land for settlement. "But it was most certainly not the principal purpose of the Indians. Their principal purpose was to secure a means of supporting themselves once the Treaties took effect." *Id*. at 851. Like the dams on the Columbia and Snake rivers, the culverts in Puget Sound transferred the productive function of salmon bearing streams into transportation systems benefiting the public while sacrificing tribal cultural and economic resources. The United States Supreme Court did not accept Washington's arguments for ignoring the treaty commitments.

More recently, the United States Supreme Court spoke at length to the nature of the of the Treaty agreements made by the United States and the Yakama Nation in the 1855 Treaties. It upheld the agreement as understood by the tribal negotiators: in short, "a deal is a deal."

> [T]his Court has considered this [Yakama] treaty four times previously; each time it has considered language very similar to the language before us; and each time it has stressed that the language of the treaty should be understood as bearing the meaning that the Yakamas understood it to have in 1855. *See Winans*, 198 U.S. at 380–381, 25 S.Ct. 662; *Seufert Brothers Co. v. United States*, 249 U.S. 194, 196–198, 39 S.Ct. 203, 63 L.Ed. 555 (1919); Tulee, 315 U.S. at 683–685, 62 S.Ct. 862; *Washington v. Washington*

> *State Commercial Passenger Fishing Vessel Assn*., 443 U.S. 658, 677–678, 99 S.Ct. 3055, 61 L.Ed.2d 823 (1979).

Washington State Dep't of Licensing v. Cougar Den, Inc., 139 S. Ct. 1000, 1011 (2019).

> Really, this case just tells an old and familiar story. The State of Washington includes millions of acres that the Yakamas ceded to the United States under significant pressure. In return, the government supplied a handful of modest promises. The State is now dissatisfied with the consequences of one of those promises. It is a new day, and now it wants more. But today and to its credit, the Court holds the parties to the terms of their deal. It is the least we can do.

Id. at 1021 (Gorsuch and Ginsberg, concurring).

This year and last, the United States Supreme Court has upheld key treaty rights commitments. If there was a question in 1999 about the significance of the tribes' treaty fishing rights it has been resolved in favor of the tribes' understanding.

B. Tribal Circumstances Framework

These comments offer a perspective on the Columbia River System Operation Draft Environmental Impact Statement, including its background information, alternatives and evaluations. Because the CRSO DEIS is constantly evolving and incompletely drafted at the time these comments were prepared, the Columbia River Treaty Tribes will prepare further comments on the CRSO DEIS as it progresses. Each of the Co-Lead Agencies has adopted policies respecting the tribes' sovereignty, treaty secured interests, the Co-Leads' government-to-government relationships and their trust responsibilities to the tribes. It is important that the CRSO DEIS clearly inform the public that the tribes are not merely stakeholders, but that the tribes' interests are guaranteed by the United States.

In April 1999, the CRITFC published a report entitled "Tribal Circumstances and Impacts of the Lower Snake River Project on the Nez Perce, Yakama, Umatilla, Warm Springs and Shoshone Bannock Tribes" prepared by Meyer Resources, Inc. [hereinafter "Meyer Report]. The Meyer Report was prepared under a contract between Foster-Wheeler and CRITFC with funding provided by the Corps of Engineers. The principle author of the Meyer Report was Phil Meyer, an economist with years of experience working with native communities. The Meyer Report was submitted to the administrative record for the Corps' Lower Snake River Juvenile Salmon Migration Feasibility Study and Draft Environmental Impact Statement.[3] Since 1999, the Meyer Report has maintained its relevancy and is particularly pertinent to the CRSO DEIS.

[3] Army Corps of Engineers, Lower Snake River Juvenile Salmon Migration Feasibility Study and Draft Environmental Impact Statement (Dec. 1999)<http://docs.streamnetlibrary.org/USACE/LSR-FR-EIS/coemain.pdf>; Army Corps of

One of the most salient features of the Meyer Report is the many contemporary statements by leaders of the Columbia River Treaty Tribes that it ties to the socio-economic analytical framework. The tribal leaders' quotations in the Meyer Report are all still relevant and particularly to the CRSO DEIS. Moreover, the tribes' views have been consistently expressed since treaty times.

> God created this Indian country and it was like He spread out a big blanket. He put the Indians on it... Then God created the fish in this river and put deer in these mountains and made laws through which has come the increase of fish and game. ...For the women, God made roots and berries to gather, and the Indians grew and multiplied as a people. When we were created we were given our ground to live on, and from that time these were our rights. This is all true. We had the fish before the missionaries came. ...This was the food on which we lived. ...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. ...We never thought we would be troubled about these things, and I tell my people, and I believe it, it is not wrong for us to get this food. Whenever the seasons open, I raise my heart in thanks to the Creator for his bounty that this food has come. [4]

George Meninock's statement reinforces the tribal understanding at treaty times that the United States was securing the tribes' food, particularly fish. The testimony of Jim Wallahe, a co-defendant of Meninock, is also particularly pertinent to the CRSO EIS. He expresses his understanding that his treaty fishing rights were not subordinated by dam building. He stated, "I do not think I do any wrong when I fish at this place my father saved for me and which the great spirit made for the Indians [Top-tut Falls where Prosser Dam now exists]. Is it right for the white man to build a dam at the falls and then say that the Indians destroy the bounty of the Creator?"[5]

A more contemporary explanation of a similar point is made in the Nez Perce Tribe's Department of Fisheries Resources Management 2013-2028 Management Plan. "Tribal harvest is not to be viewed as a "new" action that incrementally increases the survival gap of diminished Columbia and Snake River runs, but rather as a baseline that the fish runs have always encountered and that the United States secured by treaty."[6] For decades, the tribes

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Engineers, Final Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement (Feb. 2002).

[4] Testimony of George Meninock before the Washington Supreme Court in 1913 in Meyer Report, *supra* note 1 at 146. An excellent description of the events leading up to and following this testimony is provided in the book, "Si'lailo Way" (see note 5).

[5] Dupris, Joseph C. et al., The Si'lailo Way: Indians, Salmon and the Law on the Columbia River at 229 (Caroline Academic Press 2006).

have shouldered the conservation burden created by dams which they eloquently opposed in formal testimony.[7]

The Meyer Report reinforces the vision of George Meninock who urged non-Indians to respect the commitments of Isaac Stevens, the United States' 1855 treaty negotiator and Governor of Washington Territory.[8] The Meyer Report describes the baseline from which to consider the effects of the Lower Snake River Dams:

> At treaty times, the salmon resource reserved by the tribes was the harvest from river systems that were biologically functional and fully productive. If the tribal treaty negotiators had perceived that they were bargaining to reserve "only a small fraction" of the salmon available to harvest in the mid-1800's, the treaty negotiations would have been much different – if they had occurred at all.
>
> The treaty signers, both tribal and non-tribal, were also clear that the Treaties were designed to take care of the needs of tribal peoples into the future without limit. Successive tribal leaders have reminded us of this intent. Consequently, there is no date in time, subsequent to 1855, that cuts off tribal Treaty entitlements.
>
> In conclusion, the Treaty tribes are entitled to a fair share of the salmon harvest from all streams in their ceded area(s) – measured at the fully functioning production levels observed in the mid-1800's. This was the tribal entitlement at Treaty times. It is still so today, and into the future. Declines in the salmon productivity of the river due to subsequent human action have not changed this entitlement.[9]

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[6] Nez Perce Tribe Department of Fisheries Management, Management Plan 2013-2028 at 45 (July 17, 2013), < http://www.nptfisheries.org/portals/0/images/dfrm/home/MgmntPlan.pdf >.

[7] *E.g.,* Comments of William Minthorn in US Army Corps of Engineers, Review Report on John Day Dam, 22-3:

> this dam [John Day] will do a lot of people some good in this community - however, our primary concern has always been fishing, that is the Indians' concern has been fishing and ancient fishing sites. Therefore, we oppose the construction of the John Day Dam. For these reasons, the main reason is that it will flood out the last remaining fishing sites that was guaranteed us by our treaty of June 9, 1855. Already through the other constructions of the developments to date, we have lost some of our best fishing sites, such as Celilo Falls. Practically the last remaining fishing sites that we have left is between the mouth of the John Day River and the McNary Dam; so by building the John Day Dam, these last remaining sites will be flooded.

Allen, Cain, *Replacing Salmon: Columbia River Indian Fishing Rights and the Geography of Fisheries Mitigation* in Oregon Historical Quarterly*,* Vol. 104 No. 2, pp. 196-227 at 215 (Summer 2003) <www.jstor.org/stable/20615319> [hereinafter *Replacing Salmon*].

[8] Isaac Stevens' military career included service with the Corps of Engineers the during the Mexican-American War.

[9] Meyer Report, *supra* note 1 at 15.

As described by a Warm Springs tribal leader in the Meyer Report:

> So there's no question that the people hold you responsible forever to manage the salmon and all of the foods that they reserved. And that's a simple answer to the concern of how long do you manage. I understand that now some people say, 'Why the fisheries resources getting small, it's so minor now. It isn't worth planning for any longer.' The industrial and economic people saying, 'Let's go another direction. To heck with the good rivers, clean rivers and the salmon. Let's go another way.' That's a question coming pretty close I understand. And that is not the case. We're going to be there to say you're going to keep your promise. Forever! [10]

No intervening circumstances have changed this important perspective, which the tribes have held prior to and since their treaty negotiations. As discussed below, events since 1999 have not diminished, but rather have reinforced, the point of view that the United States' treaty commitments are forever.

C. An updated discussion of tribal poverty and income levels of the Columbia River Treaty Tribes with reference to the Meyer Report.

The 1999 Meyer Report tied multiple expressions of tribal values to an understanding of tribal well-being measured by several different economic indicators. These economic indicators were framed in terms of a hierarchy of needs:[11]

Self Esteem
|
Belongingness and Love
|
Safety Needs
|
Food and Shelter

The Meyer Report observed linkage between the availability of traditional foods, including especially salmon, and tribal health as measured by mortality rates associated with the loss of

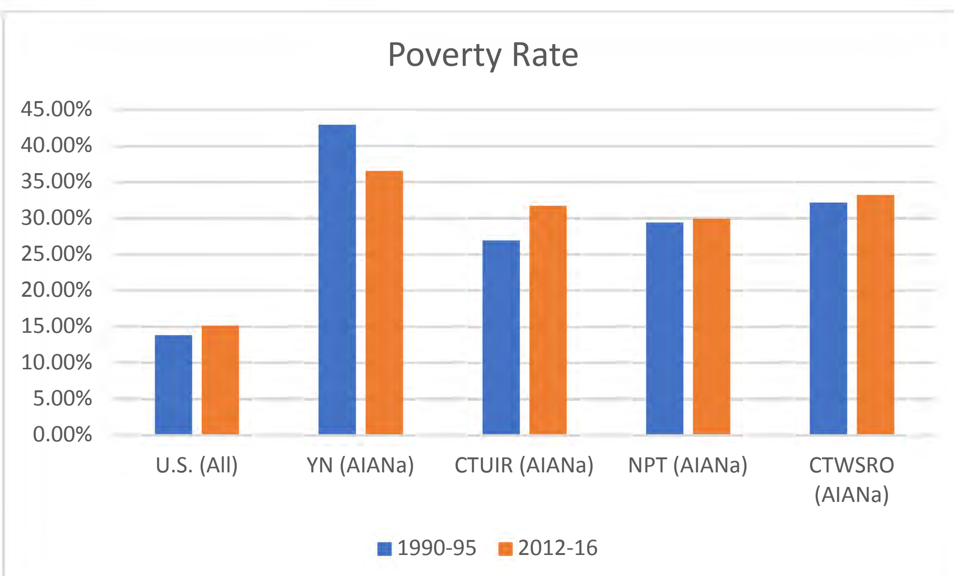
[10] Statement of Delbert Frank, Meyer Report, *supra* note 1 at 34.

[11] These needs underlie human kind's goal for "an increasing trend toward unity, integration, or synergy, within the person". For instance, someone who is absorbed totally in fulfilling ongoing hunger needs will attend less to safety needs; and, a person whose security is constantly threatened will be less able to develop intimacy with others. See Meyer Report, *supra* note 1 at 46, discussing and quoting Bachtold, L.M., Destruction of Indian Fisheries and Impacts on Indian Peoples in Meyer-Zangri Associates, The Historic and Economic Value of Salmon and Steelhead to Treaty Fisheries in 14 River Systems in Washington, Oregon and Idaho. Vol. 1. A Report to the US Bureau of Indian Affairs. Davis, CA., pp. 17-21 (1982).

healthy/traditional foods. 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.[12]

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.[13] The Report provided relevant data for each of these indicators. In the end, the Meyer Report concluded that the impacts of the Snake River dams to the productivity of the Snake River Basin's salmon and steelhead had severely impacted the tribes' well-being.

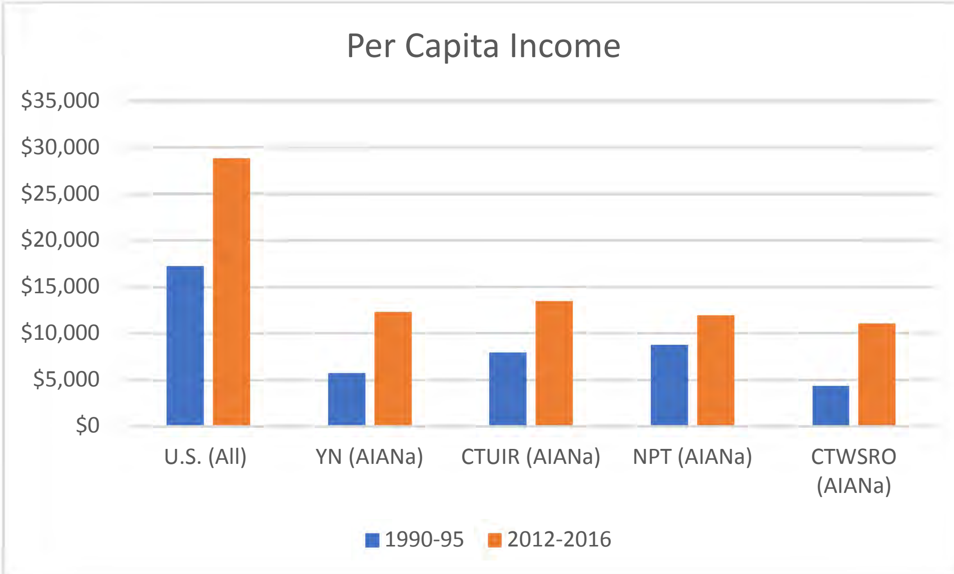
One of the ways this Tribal Perspectives Report updates the continuing relevance of those portions of the Meyer Report concerning tribal well-being is to compare the tribal poverty levels and income information from the Meyer Report with more current data. The data for this comparison were obtained from the Federal Reserve Bank of Minneapolis, which maintains a comprehensive data base through its Center for Indian Country Development.[14] The more recent data from the American Community Survey reflects the pattern observed in the Meyer Report; Tribal poverty rates for the Columbia River Treaty Tribes are still two to three times the national average and per capita income is less than half the national average.



[12] Meyer Report, *supra* note 1 at 45.

[13] *Id.* at 49.

[14] Available at https://www.minneapolisfed.org/indiancountry.



The 1990-95 data (blue) were obtained from the 1999 Meyer Report, which presented information from the 1990 Special Tribal Run U.S. Census. The source and nature of these data are described in section 2.1.5.2. of the Meyer Report. The 2012-2016 data (orange) were obtained from the Center for Indian Country Development, which is a project of the Federal Reserve Bank of Minneapolis. The Center aggregates data from the American Community Survey (ACS), which is conducted every year to provide up-to-date information about the social and economic conditions within the United States. The long form decennial Census and the ACS forms are very similar and responses to both are required by law. The ACS data are aggregated into five-year periods, which is considered best practice for small communities.[15]

Current poverty and income levels among the four Columbia River Treaty Tribes present very challenging circumstances from which tribal members can develop improved well-being. The absence of salmon underlies and compounds these challenges. Tribal members often prefer fishing-related economic means of support, which preserve their cultural ties to prior generations, the tribes' traditions and the fisheries resources themselves.

The eight 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,

[15] Personal communication (email), April 19, 2019, from Donna Feil, PhD. Research Economist CICD <https://www.minneapolisfed.org/indiancountry >.

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. As discussed below, the burdens of the dams and failed mitigation policies fell disproportionately on tribal fisheries.[16]

D. Discriminatory Effects of Mitigation and the Importance of "In-Place, In-Kind"

The Meyer Report briefly describes the history of hatchery development in the Columbia Basin.[17] This history deserves expansion in this Perspective on the CRSO DEIS. Failures to implement "in-place, in-kind" mitigation illustrate the cumulative effects the tribes have experienced resulting from the development of the Columbia River System dams and past inappropriate mitigation efforts.

Since 1938, the U.S. Army Corps of Engineers conducted two separate programs to mitigate for the loss of salmon spawning grounds due to the construction of the Bonneville, The Dalles, John Day and McNary dams. Between 1946 and 1980, the Columbia River Fisheries Development Program (CRFDP), also referred to as the Mitchell Act, funded the construction and expansion of twenty-six hatcheries to mitigate for mid-Columbia River dams, twenty-four of them below the Long Narrows and Celilo Falls where the tribes had fished for millennia. Like the CRFDP, John Day Fishery Mitigation for the construction of The Dalles and John Day dams exhibited a spatial discontinuity between impact and mitigation, with all of the proposed hatchery sites located well below the dam.[18]

For the Columbia River Treaty Tribes whose fishing places were inundated by the dams (along with their primary homes and important sites to tribal culture and religion), the location of hatchery mitigation added further injury to their losses. The hatchery mitigation implementation was clearly intended to benefit non-Indian fisheries in the lower Columbia River and the coastal locations where non-Indian fisheries predominated. "In other words, fish that had been returning to the Indians' usual and accustomed fishing places for generations

[16] The US Environmental Protection Agency (EPA) defines Environmental Justice (EJ) 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. Fair treatment means no group of people, including racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences from industrial, municipal and commercial operations or the execution of federal, state, local, and tribal programs and policies.

US EPA, Environmental Justice (visited June 7, 2019) <https://www.epa.gov/environmentaljustice>. Relevant tribal information is presented below and will be added to the record for the CRSO DEIS in the future.

[17] Meyer Report, *supra* note 1 at 147.

[18] Allen, *Replacing Salmon,* supra note 7 at 199.

were destroyed by the dam, but only a fraction of those fish that were produced as mitigation returned to an area where Indians are allowed to fish commercially."[19]

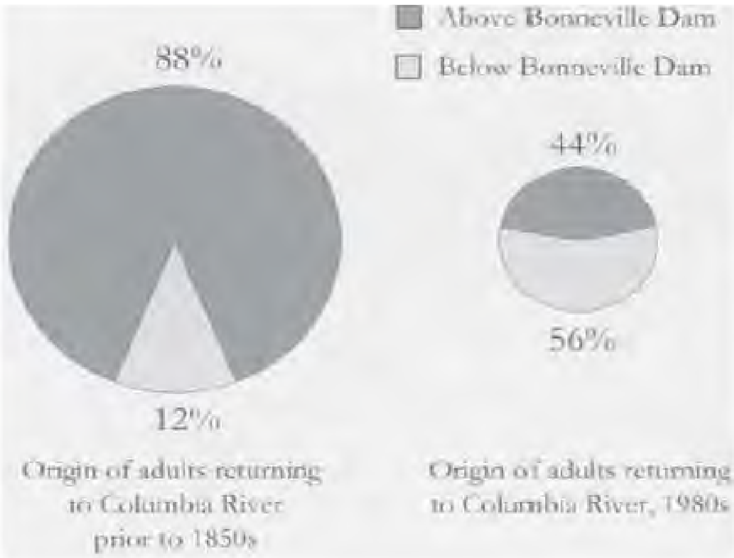


Figure 1: Changes in the distribution of salmon production in the Columbia River Basin (Northwest Power Planning Council, Columbia River Basin Fish and Wildlife Program, *Portland, Ore., 1987, app. E, table 6)*

For decades, the Treaty Tribes have vigorously objected to the injustice of this situation. In recent years the parties to the *U.S. v. Oregon* proceedings and the Corps of Engineers have agreed to implement a portion of the mitigation requirements for John Day and The Dalles dams at locations above McNary Dam. That work is pending approval by the Assistant Secretary of the Army for Civil Works, appropriations necessary to carry out the work, regulatory compliance, and construction.[20] It has taken the Corps of Engineers more than 40 years to address the Tribes concerns that salmon production mitigate impacts to their fisheries.

E. Tribal Restoration Initiatives Published Since 1999

Since 1999, the Columbia River Treaty Tribes have published multiple plans, documents and reports that add important context to the tribes' perspectives. Several of these publications are highlighted below. They should all be carefully considered in the CRSO DEIS and each are herein fully incorporated by reference.

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[19] *Id.* at 221.

[20] *See,* Letter to Col. Eisenhauer, USACE Portland District, and Steve Wright, Administrator Bonneville Power Administration, from Guy Norman, vice chair *U.S. v. Oregon* Policy Committee dated September 7, 2011 (describing in-kind mitigation commitments); Letter to BG Funkhouser, USACE Northwestern Division, from Guy Norman, vice chair *U.S. v. Oregon* Policy Committee, dated March 7, 2013 (escribing agreement on total adult production goal).

1. In 2014, CRITFC and its member tribes updated Wy-Kan-Ush-Mi Wa-Kish-Wit, the Columbia River Treaty Tribes' Spirit of the Salmon Plan. The tribes originally published Wy-Kan-Ush-Mi Wa-Kish-Wit in 1995.[21] This tribal salmon restoration plan outlined the cultural, biological, legal, institutional and economic context within which the region's salmon restoration efforts are taking place. This long-term plan addresses virtually all causes of salmon decline and roadblocks to salmon restoration for all anadromous fish stocks: Chinook, coho, sockeye, steelhead, chum, eels (Pacific lamprey)[22] and sturgeon, above Bonneville Dam.

   The 2014 Update did not alter the tribal goals and objectives for restoring anadromous fishes to the rivers and streams that support the historical, cultural and economic practices of the tribes. The objectives are to:

   - Within 7 years, halt the declining trends in salmon, sturgeon and lamprey populations originating upstream of Bonneville Dam.
   - Within 25 years, increase the total adult salmon returns above Bonneville Dam to 4 million annually and in a manner that sustains natural production to support tribal commercial as well as ceremonial and subsistence harvests.
   - Within 25 years, increase sturgeon and lamprey populations to naturally sustainable levels that also support tribal harvest opportunities.
   - Restore anadromous fishes to historical abundance in perpetuity.

The EIS must consider the technical recommendations presented in Wy-Kan-Ush-Mi Wa-Kish-Wit, which address twenty different subject matter areas, framed in terms of the salmon life cycle, including watershed restoration, juvenile fish migration, estuary protection and restoration, adult fish migration, climate change and more.[23] These recommendations relate directly to the CRSO operations and mitigation measures for those operations.

2. Pacific lamprey are just as important to tribal peoples as salmon. For over 10,000 years the people of the Nez Perce, Umatilla, Yakama and Warm Springs tribes depended on lamprey (commonly referred to as "eels") alongside of the salmon, roots and berries. The tribal people used the eel for food and medicine, and many stories and legends surrounding the eel were passed down from generation to generation. Before the

[21] Columbia River Inter-Tribal Fish Commission [Columbia River Treaty Tribes], Wy-Kan-Ush-Mi Wa-Kish-Wit, the Spirit of the Salmon, 1995 Tribal Restoration Plan and 2014 Update, available at https://plan.critfc.org/ [hereinafter Wy-Kan-Ush-Mi Wa-Kish-Wit].

[22] Wy-Kan-Ush-Mi Wa-Kish-Wit also addresses Pacific lamprey in the Willamette Basin.

[23] Summary and link to Wy-Kan-Ush-Mi Wa-Kish-Wit Technical Recommendations available at https://plan.critfc.org/2013/spirit-of-the-salmon-plan/technical-recommendations/.

construction of The Dalles Dam in 1957, the river at Celilo Falls was often black with eels. Tribal members took just what their families needed for a year. Eels were plentiful in many Columbia basin waters including the Walla Walla River, Asotin Creek, Clearwater River tributaries, the South Fork of the Salmon River, Swan Falls, the upper portions of the Yakima River and the tributaries of the upper Columbia. Now many of these great rivers have no eels or at best remnant numbers. "The Creator told the people that the eels would always return as long as the people took care of them, but if the people failed to take care of them, they would disappear."[24]

The Tribal Pacific Lamprey Restoration Plan is the most inclusive plan for Pacific lamprey to date. Published in 2011, the plan looks to halt the significant decline of lamprey and reestablish lamprey populations throughout the mainstem Columbia River and its tributaries.[25] The plan seeks to improve mainstem and tributary passage for juvenile and adult lamprey, restore and protect mainstem and tributary habitat, reduce toxic contaminants, and consider supplementation programs to aid re-colonization throughout the basin. The Tribal Lamprey Plan, including all of its recommendations, must be carefully addressed in the CRSO DEIS.

3. No mitigation has occurred benefitting either the abundance or productivity of sturgeon populations affected by the construction and operation of the eight lower Columbia and Snake river federal dams. In 2015, CRITFC published a 360-page master plan for development of a hatchery to supplement sturgeon populations in the mainstem lower Snake and Columbia rivers.[26] The master plan describes the current conditions of sturgeon with particular relevance to the Columbia River Treaty Tribes. While sturgeons occur throughout most of their historical range, current production is far below the historical levels. Unlike salmon and lamprey, passage of sturgeon upstream is no longer possible and the dams have taken anadromy away from some of these fish. Low numbers severely limit sturgeon harvest opportunities throughout the basin, particularly for impounded populations upstream from Bonneville Dam. Small tribal subsistence, tribal commercial fisheries, and non-tribal recreational fisheries occur upstream from Bonneville Dam. Current fisheries are highly regulated in order to maintain small levels of harvest consistent with current productivity. In addition, because they are no longer anadromous, many sturgeon are now more contaminated by pollution than they were previously. The master plan is designed to help mitigate impacts of development and operation of the Federal Columbia River Power System on

[24] Remarks of Ron Suppah, Vice Chair, Warm Springs Tribes in CRITFC, Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin, (December 19, 2011) <https://critfc.org/wp-content/uploads/2012/12/lamprey_plan.pdf>.

[25] *Id.*

[26] CRITFC, White Sturgeon Hatchery Master Plan: Lower Columbia and Snake River Impoundments, Step 1 Revised (December 15, 2015), available at https://www.critfc.org/blog/documents/white-sturgeon-hatchery-master-plan/

sturgeon population productivity and fishery opportunities in lower mid-Columbia River and lower Snake River reservoirs. The master plan's information and mitigation proposals should be carefully considered in the CRSO DEIS.

4. The Yakama Nation publishes a Status and Trends Annual Report (STAR) that describes the progress it is making in restoring anadromous fish in its reservation lands and ceded territories. [27] The STAR reports confirm that the Yakama Nation's expectations are grounded in its 1855 treaty reserved rights.

> "In the Treaty of June 9, 1855, the Yakama Nation reserved the right to maintain its culture and the natural resources on which its culture depends, including rights to water, land, and natural foods and medicines at all usual and accustomed places. Subsequent federal court rulings assured the Yakama Nation the right to self-regulation of their own fish management and take, a fair share of all allowable harvest, and the restoration of fish historically present and/or mitigation for losses."[28]

The STAR reports are not so much a mitigation plan, per se, as they are a reflection of the mitigation actions that are occurring pursuant to the Tribe's inherent sovereignty exercised in planning coordination with various federal authorities such as the Northwest Power Act, Endangered Species Act, Yakima Basin Water Enhancement legislation and multiple others.[29] The mitigation actions specified in the Yakama STAR reports will continue for decades to come. These mitigation measures must be addressed in the CRSO EIS as ongoing mitigation for the CRSO.

5. In 2013, the Nez Perce Tribe adopted a Fisheries Management Plan, 2013-2028. [30] The Plan is intended to formally establish and describe the desired fishery resource conditions and the management framework that will be applied by the Nez Perce Tribes'

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[27] Yakama Nation Fisheries, Status and Trends Annual Report (2017) available at http://yakamafish-nsn.gov/restore/projects/star [hereinafter 2017 STAR Report].

[28] *Id.* at 52.

[29] For example, fish passage improvements in the Yakima Basin have been funded in significant part by the Bonneville Power Administration (> $500 M) as offsite mitigation for the FCRPS and were implemented by the Bureau of Reclamation. Section 109 of the Hoover Power Plant Act of 1984 (P.L. 98-381, 98 Stat. 1333) gave Reclamation authority to design, construct, operate, and maintain fish passage facilities within the Yakima River Basin and to accept funds from BPA. The relationship of Bonneville's funding and the Reclamation's authorizations has been described in multiple publications, including the Council's Fish and Wildlife Program. A good summary is contained in the Bureau of Reclamation's 2009 Summary of the Fish Passage Program in the Yakima Basin <https://www.usbr.gov/pn/programs/yrbwep/reports/fishscreen/completionreport.pdf>.

[30] Nez Perce Tribe Department of Fisheries Resources Management, 2013-2028 Management Plan (July 17, 2013) <http://www.nptfisheries.org/portals/0/images/dfrm/home/fisheries-management-plan-final-sm.pdf>.

Fishery Management Department to achieve those conditions. Communicating this fundamental mission to co-managers and the public is a key object of the Management Plan. The Management Plan must be addressed in the CRSO DEIS. "Eventually, the goal would be to achieve a harvest consistent with pre-Treaty harvest levels." The plan sets forth salmon and steelhead abundance goals for individual tributaries throughout the Nez Perce's ceded lands and its' usual and accustomed fishing places.

6. The 2008 Umatilla River Vision sets forth a First Foods management context for the Umatilla River Basin.[31] Its innovation and important cultural context has been recognized by other co-managers, including tribes, states and federal agencies. The First Foods are considered by the CTUIR Department of Natural Resources to constitute the minimum ecological products necessary to sustain CTUIR culture. The CTUIR DNR has a mission to protect First Foods and a long-term goal of restoring related foods in the order to provide a diverse table setting of native foods for the Tribal community. The mission was developed in response to long-standing and continuing community expressions of First Foods traditions, and community member requests that all First Foods be protected and restored for their respectful use now and in the future.[32]

7. The Warm Springs Fisheries Department is dedicated to the research, management, and enhancement of fisheries and fishery resources on the reservation, ceded lands and usual and accustomed stations of the Confederated Tribes of the Warm Springs. The Department actively maintains a website describing its monitoring and research, fish habitat, production and harvest management.[33] Through the Warm Springs, John Day, and Parkdale offices the Fisheries Department employed over 70 professional, technical, and temporary staff. The Warm Springs Fisheries Department has implemented over 200 projects for management and enhancement of spring and fall Chinook, summer and winter steelhead, sockeye/kokanee, bull trout, and Pacific lamprey populations and their habitat.

F. Non-Tribal Plans Affirming the goals of the Tribes.

Multiple plans have been published by governments in the Northwest that are consistent with or otherwise support the visions set forth in the tribal plans. Three of them are highlighted below.

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[31] Jones et al., Umatilla River Vision (2008) <http://www.ykfp.org/par10/html/CTUIR%20DNR%20Umatilla%20River%20Vision%20100108.pdf >.

[32] Webster, James, CTUIR River Vision for Floodplain Management (Powerpoint Presentation) (June 1, 2001) <http://www.salmonforall.org/wp-content/uploads/2013/02/webster_rivervision.pdf >.

[33] Warm Spring Fisheries Department website <https://fisheries.warmsprings-nsn.gov/about-the-fisheries-department/ >.

1. Columbia Basin Partnership (CBP) 2019 Provisional Goals

Over the past two years, the 28 members of the Columbia Basin Partnership Task Force (Task Force), representing a diversity of managers and stakeholders across the Columbia Basin, have worked to develop a shared vision and goals for Columbia Basin salmon and steelhead. The Task Force forwarded recommendations on these goals, in the form of a Phase 1 Report,[34] to the Marine Fisheries Advisory Committee (MAFAC) for their consideration and that of the NOAA Fisheries Administrator.

The recommendations include qualitative and quantitative goals. The quantitative goals translate into a total increase of naturally produced salmon and steelhead from the current average of 400,000 to as high as 3.6 million adults. This represents an eightfold improvement from current levels but is considerably less than the number of salmon and steelhead that the basin produced historically. The goals also reflect available information on habitat production potential. The corresponding average total Columbia River run (natural-plus hatchery-origin fish) would be projected to increase from 2.3 million to approximately 11.4 million fish.

Importantly, the Task Force acknowledged that "[t]he tribal nations are not willing to accept the normalization of the status quo and do not concede our long-term tribal goals for salmon and steelhead restoration, including restoring passage to blocked regions of the Columbia River basin that historically supported anadromous fish."[35]

2. Northwest Power and Conservation Council, 2014 Columbia Basin Fish and Wildlife Program (F&WP)

The Northwest Power Act requires the Northwest Power and Conservation Council (NPCC) to adopt and renew at least once every five years a Fish and Wildlife Program "to protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries."[36] The Council is currently in a one-year cycle to consider modifications to the Program, based on its statutory requirements to base the Program on the recommendations of tribes and other fish and wildlife co-managers.[37] Bonneville, Reclamation and the Corps must take the Program adopted by the Council "into account at each relevant

[34] 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) [hereinafter Phase 1 Report].

[35] *Id.* at 25.

[36] 16 U.S.C. 839b (h)(1).

[37] *NRIC and Yakama Nation v. NPPC*, 35 F.3d 1371, 1385 (9th Cir. 1994).

stage of decision making processes to the fullest extent practicable."[38] The 2014 Columbia River Basin Fish and Wildlife Program includes the following objectives:

> As an interim objective, increase total adult salmon and steelhead runs to an average of 5 million annually by 2025 in a manner that emphasizes the populations that originate above Bonneville Dam and supports tribal and non-tribal harvest.
>
> As an interim objective, achieve smolt-to-adult return rates in the 2-6 percent range (minimum 2 percent; average 4 percent) for listed Snake River and upper Columbia salmon and steelhead. Within 100 years, achieve population characteristics that, while fluctuating due to natural variability, represent full mitigation for losses of fish.[39]

The Independent Scientific Advisory Board (ISAB) has consistently recognized the importance of the 2-6% SAR goal and recommended that the Comparative Survival Study (CSS) conduct analyses to verify and validate the 2-6% SAR goal in terms of population rebuilding.[40] The 2014 CSS Annual Report is the first which included analyses of 2-6% SAR regional goal. SARs versus productivity for major population groups has been analyzed in each CSS Annual Report since 2014, adding additional population groups each year. The results of these analyses confirm the validity of the 2-6% SAR goal for Chinook and steelhead as necessary to rebuild major population groups.[41]

3. **The Accords Extension signed by the Co-Lead Agencies, CTUIR, CTWSRO, YN and CRITFC broadly affirms the Parties support for the Columbia River Basin Fish and Wildlife Program.**

The Accords Agreement was initially negotiated in 2007-2008 and signed by the Co-Lead Agencies, three of the Columbia River Treaty Tribes and CRITFC. After several more years of negotiation, this landmark agreement was renewed in 2019. This Extension affirms support for the Columbia River Basin Fish and Wildlife Program and continues to address direct and indirect effects of construction, inundation, operation, and maintenance of the fourteen federal multiple-purpose dam and reservoir projects in the Federal Columbia River Power System that

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[38] 16 U.S.C. 839b (h)(11)(A)(ii).

[39] Northwest Power and Conservation Council, 2014 Columbia River Basin Fish and Wildlife Program at 157.

[40] Independent Scientific Advisory Board, Review of the Comparative Survival Study's Draft 2013 Annual Report, ISAB 2013-4 at 1 (October 14, 2013) <https://www.nwcouncil.org/sites/default/files/ISAB2013-4_0.pdf >.

[41] McCann, J., et al., Comparative Survival Study (CSS) of PIT tagged Spring/Summer Chinook and Summer Steelhead. 2018 Annual Report. Project No. 199602000 (December 2018) <http://www.fpc.org/documents/CSS/2018_Final_CSS.pdf > [hereinafter 2018 CSS Annual Report].

are operated by the Co-Lead Agencies as a coordinated water management system for multiple congressionally authorized public purposes and referred to as the Columbia River System, as well as Reclamation's Upper Snake River Projects on fish and some wildlife resources of the Columbia River Basin.

G. Comparing Aspects of Affected Environment in the Meyer Report 1999 versus the CRSO DEIS Analyses

This section of the Tribal Perspectives Report addresses 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. Juvenile salmonid reach survival in the mainstem sections of the Snake and Columbia rivers impounded by the FCRPS dams is still similar to and sometimes less than the reach survival levels that occurred in the 1990s.

1. Salmon Abundance

During the intervening years between 1999 and 2019, salmon abundance improved somewhat. Based on ten-year averages, the most recent ten-year average returns of salmon to Bonneville Dam from 2008 to 2018 are greater than the ten-year average from 1990 to 1999 that were considered in the Meyer Report. As noted below, the most recent two years of adult returns from 2017 and 2018 however have declined to run sizes similar to those that occurred in the 1980s.

To place recent adult salmon abundance in perspective, however, data for selected tributaries from the Columbia Basin Partnership Phase 1 Report (CBP Report) provide a synopsis of current context. Appendix A of the CBP Report is particularly useful in this regard. It displays recent and historic salmon abundance in tributaries throughout the Columbia Basin. The data show that the reductions in salmon abundance in these subbasins are still very significant, one to three orders of magnitude less than historic conditions that would have existed in 1855 at the time of the treaty negotiations.

The following abundance comparisons for naturally spawning populations of salmon and steelhead from Appendix A of the CBP Report are shown below for regions within the Columbia Basin. Naturally spawning populations in the Upper Columbia[42] and Snake[43] River regions have been often two orders of magnitude less than the historic naturally spawning abundance levels.

[42] The Upper Columbia Region comprises the Columbia mainstem and its tributaries above the confluence of the Yakima and Columbia Rivers, including Canadian portions of the Basin.

[43] The Snake River stocks are those located with the Snake River Basin from the headwaters to the confluence of the Snake River with the Columbia River.

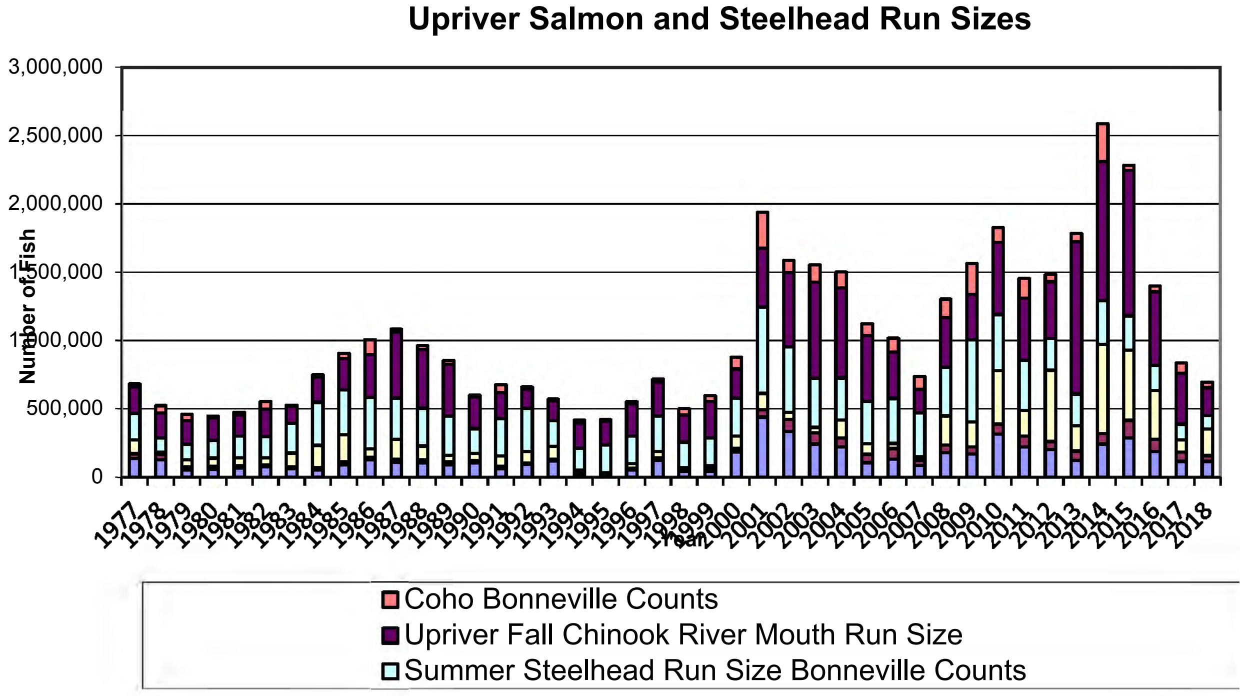
In the Mid-Columbia[44] region, current naturally spawning populations are roughly an order of magnitude less than the historic naturally spawning abundance levels.

Tributary Abundance	Recent	Historical
Upper Columbia Sockeye	80,750	2,000,000
Upper Columbia Steelhead	1,480	1,121,400
Upper Columbia Spring Chinook	1,430	259,432
Upper Columbia Summer Chinook	16,290	694,000
Upper Columbia Fall Chinook	92,400	680,000
Snake River Sockeye	100	84,000
Snake River Steehead	28,000	114,800
Snake River Spring/Summer Chinook	6,988	1,000,000
Snake River Fall Chinook	8,360	500,000
Mid-Columbia Sockeye		
Mid-Columbia Spring Chinook	9,600	103,700
Mid-Columbia Summer/Fall Chinook	11,500	17,000
Mid-Columbia Steelhead	18,155	132,800
Total naturally spawning populations	275,053	6,707,132

The following graph depicts recent adult salmon returns of both natural and hatchery spawned fish observed since 1977. The graph is consistent with the foregoing table comprised of naturally spawning fish. While there was a period of improved returns from 2001 through 2016, returns in 2017 and 2018 were similar to returns from 1984 to 2000.[45]

[44] The Mid-Columbia region is the area from Bonneville Dam upstream to and including the Yakima River Basin.

[45] Graph compiled by Stuart Ellis, CRITFC, using data available from the Fish Passage Center at http://www.fpc.org/adults/adult_queries/Q_adultcoequeries_adultrunsum_queryv2.php .



These run sizes are far short of the interim goals set forth in Wy-Kan-Ush-Mi Wa-Kish-Wit, the Columbia Basin Fish and Wildlife Program and the provisional goals of the Columbia Basin Partnership. For instance, the Council adopted a goal in 2000 to increase returning salmon and steelhead to an average of five million adults returning above Bonneville Dam by 2025 in a manner that supports tribal and non-tribal harvest. In 2018, less than one million salmon and steelhead returned above Bonneville Dam.

2. Smolt to Adult Survival Rates, PITPH, Reach Survival and the CRSO DEIS Alternatives

Smolt-to-Adult return ratio (SAR) is measured as the survival from a beginning point as a smolt to an ending point as an adult. This metric has been reported in hundreds of scientific studies in the Columbia Basin. Observed differences in SARs at the population level by year have been attributed to differences in river conditions, hydroelectric dam operational strategies and ocean conditions. Individual-level variables related to fish condition also play an important role in survivorship.

The success of any hydro system mitigation strategy will require achievement of SAR survival rates sufficient to meet recovery and rebuilding objectives, in combination with a program to maintain or achieve adequate survival in other life stages.[46] By 1994, an independent peer

[46] Throughout the 1980s, "TIRs", the ratio of adult returns for transported juvenile fish compared to in-river migrating juvenile fish, was a metric typically reported by the Corps of Engineers as a measure of the success of

review of the Corps' juvenile fish transportation program concluded: "[u]nless a minimum level of survival is maintained for listed species sufficient for them to at least persist, the issue of the effect of transportation is moot."[47] As Mundy et al. and others observed, transportation did not remove 100% of the effects of hydro system passage. [48] As one of its major outcomes, Mundy et al. recommended establishing a minimum survival standard for juvenile salmon in the hydroelectric system tied to biological recovery of the affected species.

By 1998, expert scientists through the Plan for Analyzing and Testing Hypotheses (PATH) found that median SARs of 4% were necessary to meet the NMFS interim 48-year recovery standard for Snake River spring/summer Chinook; meeting the interim 100-year survival standard required a median SAR of at least 2%.[49] The Northwest Power and Conservation Council (NPCC 2003, 2009, 2014) subsequently adopted a goal of achieving overall SARs (including jacks) in the 2%–6% range (4% average; 2% minimum) for federal ESA-listed Snake River and upper Columbia River salmon and steelhead. Notably, life cycle analyses have compared John Day River and Yakima River population SARs to Snake River SARs.[50] The data time series show that middle Columbia Stocks that pass 4 or less dams, such as John Day River, Deschutes River, Yakima River, and Umatilla River, consistently meet the 2-6% SAR goal, but Snake River populations passing five to eight dams generally do not meet this SAR goal. In the 20 years since 1997, SARs have significantly exceeded the 2% minimum in only two years for Snake River wild Chinook and four years for wild steelhead.[51]

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hydro system mitigation measures. While the metric considered survival to adulthood, it only *compared* the efficacy mitigation measures, it did not consider what survival was needed as a biological matter.

[47] Mundy, P.R., D. Neeley, C.R. Steward, T. Quinn, B.A. Barton, R.N. Williams, D. Goodman, R.R. Whitney, M.W. Erho, and L.W. Botsford. 1994. Transportation of juvenile salmonids from hydroelectric projects in the Columbia River Basin; an independent peer review. Final Report. U.S. Fish and Wildlife Service, 911 N.E. 11th Ave., Portland, OR. 97232-4181 [hereinafter Mundy, et al.].

[48] *Id.* The report raised the possibility that latent mortalities associated with hydro system passage, including the effects of bypass system collection and transportation, were being experienced by the fish.

[49] Marmorek, D.R., C.N. Peters and I. Parnell (eds.). 1998. PATH final report for fiscal year 1998. Compiled and edited by ESSA Technologies, Ltd., Vancouver, B.C. Available from Bonneville Power Administration, Portland, Oregon < http://www.efw.bpa.gov/ Environment/PATH/reports/ISRP1999CD/PATH%20Reports/WOE_Report >.

[50] *Which juvenile survival values (if any) achieve 4% average SARs?*, Comparative Survival Study (CSS), 2013 Workshop Report at 79-80 (March 7th and 8th, 2013) <http://www.fpc.org/documents/CSS/CSS_2013_Workshop_Report_-_FINAL_w_presentations.pdf >.

[51] McCann et. al, 2018 CSS Annual Report, *supra* note 41. The conclusion from Chapter 4 of the 2018 CSS Annual Report is:

> Neither Snake River wild spring/summer Chinook nor wild steelhead populations appear to consistently meet the NPCC 2%–6% SAR objective. Geometric mean SARs (LGR-to-GRA) were 0.8% and 1.4% for PIT-tagged wild spring/summer Chinook and steelhead, respectively. In the 20 years since 1997, SARs have

The Mundy et al. report also recommended using PIT tag technology "to design and implement a program to measure the contribution of hydroelectric survival by route of passage in population numbers by major river system (e.g. Clearwater, Salmon, Imnaha, Grand Ronde) for listed species…"[52] Such a program using PIT tags was initiated in 1997 with funding from the Bonneville Power Administration.

By 2015, scientists participating in the Comparative Survival Studies (CSS) observed that survival to adulthood varied by route of juvenile passage through the hydro system, in particular survival of PIT-tagged salmon as returning adults differed depending on whether as juveniles the fish had encountered a powerhouse, either a bypass or turbine, or did not (PITPH).[53] Juvenile salmon survived at higher rates in years where PIT tag detections indicated lower encounter rates with powerhouses (low PITPH). The PITPH index has been developed in subsequent annual CSS reports and has been used to forecast SARs for Snake River spring/summer Chinook and steelhead resulting from alternative hydro system configurations and operations.[54]

The 2017 CSS Annual Report, at the suggestion of the Independent Science Advisory Board, considered alternative spill and breach scenarios at the eight dams from Lower Granite to Bonneville. The analysis forecasted SARs that would be likely to result from four different spill levels under two alternative dam configurations; first with the current configuration of the eight federal dams from Lower Granite to Bonneville and second assuming that the four lower Snake River dams were breached and the four lower Columbia River dams remained in their current physical configuration. [55] PITPH values were the lowest in the breach and highest spill scenario. For SARs the results were similar in that higher spill levels and breach scenarios result in higher SARs. The Report concludes: "In a fully impounded river, we predict a 2-2.5 fold increase in return abundance above BiOp spill levels when spill is increased to 125% TDG. If the lower four Snake River dams are breached and the remaining four lower Columbia dams operate at BiOP spill levels, we predict approximately a 2-3 fold increase in abundance above

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significantly exceeded the 2% minimum in only two years for Snake River wild Chinook and four years for wild steelhead. SARs of both species have been well short of the NPCC objective of an average 4% SAR.

[52] Mundy, et al. *supra* note 47, Introduction at p. X.

[53] All transported fish encounter a minimum of one powerhouse at the point where they are collected for barge or truck transportation and release below Bonneville Dam.

[54] McCann et. al, 2017. Comparative Survival Study of PIT-Tagged Spring/Summer/Fall Chinook, Summer Steelhead and Sockeye, 2017 Annual Report at Chapter 2 (December 2017) <http://www.fpc.org/documents/CSS/CSS_2017_Final_ver1-1.pdf > [hereinafter CSS 2017 Annual Report].

[55] *Id.* at 25.

that predicted at BiOp spill levels in an impounded system, and up to a 4 fold increase if spill is increased to the 125% TDG limit."[56]

For purposes of the CRSO DEIS, the Co-Lead Agencies requested that the CSS models be used to predict the effects on Snake River yearling Chinook and steelhead resulting from the no action alternative and four alternatives labeled MO1 through MO4. While the alternatives contain many different features, in terms of dam operations and configurations the major differences can be described in terms of breach and spill levels.

	Estimated Smolt to Adult Survival (LGR to LGR)		
	Yearling Chinook	Steelhead	Breach/Spill Level
MO3	.042	.050	Yes/120%
MO4	.035	.031	No/125%
MO1	.021	.019	No/120%
MO2	.012	.012	No/110%
NAA	.018	.020	No/BiOp

Table 12. Predicted SARs with 20% surface passage efficiency using the CSS Life-Cycle Model.

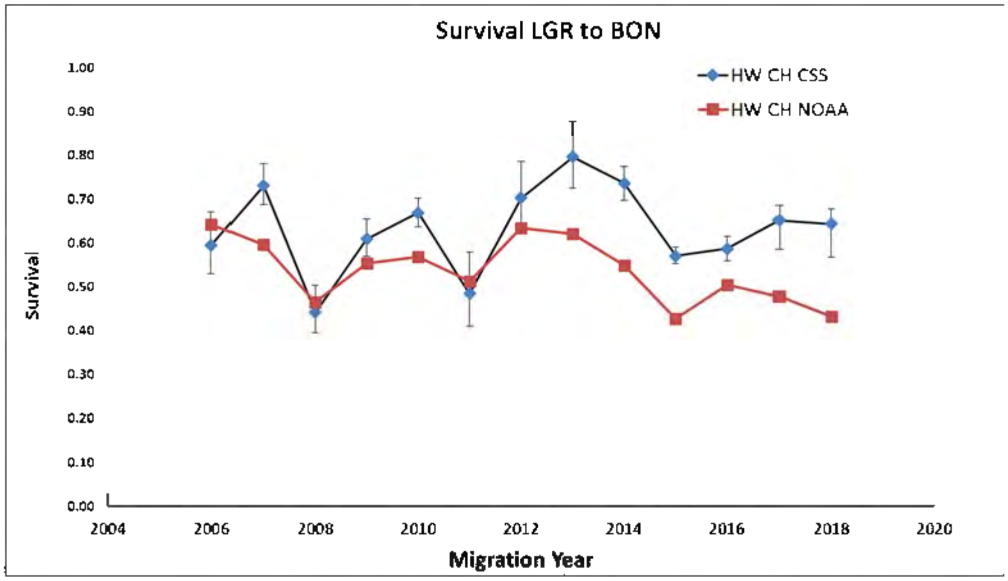
SARs for two of the Alternatives, MO3 and MO4, fell within the 2% to 6% range identified by the NPCC and multiple other authors.

3. Juvenile Salmon Reach Survival

Juvenile salmon and steelhead survival through the hydro system is also an important indicator of the mortality burden of the dams and their affected environment. Survival data have been collected from Lower Granite Dam on the Snake River through Bonneville Dam on the Columbia from 2001 to present. The information is annually reported by NOAA's Northwest Fish Science Center and the reports of the CSS, and available on the NPCC's website. From 2001 through 2013 reach survival improved, and then began a steady decline over the past five years.[57]

[56] *Id.* at 62.

[57] NPCC, High Level Indicators, Indicator 2a <https://app.nwcouncil.org/ext/hli/level1.php?q=hydrosystem >.



Current reach survivals do not correspond to SAR survival rates associated with the goals adopted by the Tribes, ISAB, CSS or the NPCC for rebuilding salmon populations. Analyses from the CSS showed that juvenile survival to below Bonneville Dam needs to be approximately 80% or greater in order to consistently meet the NPCC regional SAR goals. Reach survivals for upper Columbia or Snake River Basin spring Chinook or steelhead in the last 15 years have failed to meet this goal.

The reach survivals annually reported by NOAA are troubling. During their migration through the federal hydro system, juvenile spring Chinook, steelhead and sockeye experience levels of mortality roughly equal to or greater than the observed mortality from more than two decades ago and survived at a rate less than the long-term average:[58]

> Estimated survival for wild steelhead from Lower Granite to Bonneville Dam was 0.299 (0.211-0.387) in 2017, which was below the long-term average of 0.417.
>
> For wild yearling Chinook salmon in 2017, the estimated survival from Lower Granite to Bonneville Dam of 0.309 (0.221-0.397) was below the long-term average of 0.476 and was among the lowest of our time series.
>
> For pooled groups of wild and hatchery Snake River sockeye salmon, survival from Lower Granite to Bonneville Dam was 0.176 (0.097-0.320) in 2017. This estimate was

[58] CSS 2017 Annual Report, *supra,* note 54. The reach survival observed in the CSS results differs somewhat from NOAA's reported information. As reported by NOAA, the tagged populations it assessed would encounter more powerhouses than the run-at-large group of tagged fish assessed in the CSS work. This difference may explain why the NOAA estimates are on average lower than the CSS estimates, since powerhouse encounters are known to cause delayed mortality in juvenile migrants that can be measured in reach survivals.

the fourth lowest of our time series through this reach and was well below the 1996-2017 average of 0.392.

The recent CSS Analysis of CRSO Operation Alternatives estimates reach survival from Lower Granite Dam to the tailrace of Bonneville Dam under the CRSO DEIS scenarios (assuming 20% SPE for surface bypass routes).

	Estimated Reach Survival	
	Yearling Chinook	Steelhead
MO3	.682	.831
MO4	.634	.737
MO1	.582	.585
MO2	.531	.427
NAA	.576	.571

Table 14. Predicted juvenile survival (LGR-BON) with 20%, surface passage efficiency using the CSS cohort-specific model.

None of the CRSO Alternatives, analysis of which were constrained by the data sets provided by the Co-Lead Agencies and other information limits, meet the 85% reach survival metric. While reach survivals did not meet the reach survival goal, SARs for two of the CRSO Alternatives fell within the 2% to 6% range identified by the NPCC and multiple other authors – MO3 and MO4.[59]

The results from COMPASS, the other modeling system being used to analyze the CRSO Alternatives, describe different results. Analyzed with the COMPASS modeling system, there is no contrast in the predictions regardless of the CRSO Alternatives that include the current dam configurations. Only MO3 showed an increase in survival.[60]

The CSS and COMPASS modeling systems make different assumptions and apply empirical data differently, which may explain the differences in their predictions. The CSS life cycle results are based on actual (empirical) adult returns. The COMPASS modeling system is a deterministic model of individual juvenile survival parameters measured dam by dam and ultimately

[59] *See supra,* discussion accompanying note 54-56. The 2017 CSS Annual Report, *supra* note 54, considered alternative spill and breach scenarios which differ slightly from those that are being considered in the CRSO DEIS. The results are similar in that higher spill levels and breach scenarios result in higher SARs (*see e.g. id.* at figure 2.10). As discussed above, the 2017 CSS Annual Report, at 62, found 2-4 fold increase in return abundance under the different spill and breach scenarios.

[60] Independent Scientific Advisory Board, Review of NOAA Fisheries' Interior Columbia Basin Life-Cycle Modeling (May 27, 2017). https://www.nwcouncil.org/sites/default/files/isab-2017-1-noaalifecyclemodelreview22sep.pdf The 2017 ISAB report commented that COMPASS did not appear to be sensitive to alternative spill operations. The ISAB could not discern from the information presented by the COMPASS authors why the analysis produced these results. Pp. 54-55.

calibrated to fit adult return data.[61] The COMPASS model also explains variability in survival with variability in arrival timing of juveniles, whereas the CSS model explains variability in survival with route of passage, which can be controlled with spill. The tribes have been critical of the COMPASS modeling systems over the years and further information will be submitted to the Co-Lead Agencies in this regard through the draft EIS process.

CONCLUSION

The Meyer Report forms the foundation to this report on the Columbia River Treaty Tribes' perspectives on the CRSO DEIS. The Tribes' perspectives are fundamentally informed by their place on the land and the foods provided by the Creator and the reciprocal commitments made by the Indian people to these foods. The foods are named explicitly in the Tribes' 1855 treaties with the United States. It is an expression of tribal law, sometimes called *Tamanwit.*

> There is so much to this word or this way, this *Tamanwit.* It's how we live. It's our lifestyle. There is so much that we as Indian people are governed by, through our traditions, our culture, our religion, and most of all, by this land that we live on. We know through our oral histories, our religion, and our traditions how time began. We know the order of the food, when this world was created, and when those foods were created for us. We know of a time when the animals and foods could speak. Each of those foods spoke a promise. They spoke a law – how they would take care of the Indian people and the time of year when they would come. All of those foods got themselves ready for us – our Indian people who lived by the land. It was the land that made our lifestyle. The foods first directed our life. Today, we all have these traditions and customs that recognize our food: our first kill, first fish, first digging, the first picking of berries. All of those things are dictated to us because it was shown and it directed our ancestors before us.
>
> The songs we sing with our religion are derived from how we live on this land. Our cultural way of life and the land cannot be separated. Even though we recognize that our life is short, it all goes back to that promise that was made when this land was created for us as Indian people, the promise that this land would take care of us from the day we are born until the day that we die.[62]

The DEIS must respect the Columbia River Treaty Tribes' culture, food, and ways of life. The draft purposes section recognizes this obligation. It contains three particularly relevant provisions that form the basis for the analyses contained in the document.

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[61] Sometimes called a mechanistic model. Regarding COMPASS, the ISAB observed that its statistical models are very complex with each having from 13 to 23 explanatory variables. And then asked, "Is collinearity or over-parameterization an issue?" *Id.*

[62] CTUIR, Comprehensive Plan, 2010 <https://ctuir.org/system/files/FinalCompPlan.pdf > (quoting Armand Minthorn, *As Days Go By,* 2006).

- Provide for fish and wildlife conservation, including protection of threatened, endangered, and sensitive species, and provide for equitable treatment with other project purposes
- Comply with environmental laws and regulations and all other applicable federal statutory and regulatory requirements
- Address Native American treaty rights and trust obligations for natural and cultural resources

Fish and wildlife conservation, compliance with environmental laws and addressing Tribes' treaty rights go hand in hand. This Tribal Perspective broadly describes what achieving these purposes means in terms of the federal treaty commitments to the Columbia River Treaty Tribes. For the tribes, these will be measured in terms of the treaty commitments made by the United States to the Columbia River Treaty Tribes in 1855. The salmon, steelhead, lamprey, sturgeon and other fish and wildlife populations that existed at the time of the 1855 treaty negotiations represent levels of species viability at which there would be no question about the need for ESA listings. Nor, at these levels, would there be questions about the discriminatory effects of mitigation programs on four tribes' cultures and economies that depend on salmon.

Of the alternatives presented to date in the CRSO DEIS, as measured by the CSS modeling systems, only two come close to meeting rebuilding requirements for Snake River yearling Chinook and steelhead that flow from the treaties and other laws. These are MO3 (breaching the Snake River dams) and MO4 (spill to 125% TDG levels). Using the NOAA modeling systems (COMPASS), only the Snake River dam breaching alternative (MO3) shows any substantial improvement over the status quo.

At this point, the CRSO DEIS analysis is limited and has not quantitatively addressed:

Other Stocks: The CSS and COMPASS systems have not addressed upper Columbia yearling Chinook and steelhead stocks that are particularly at risk as well as other salmon and steelhead stocks in the Basin that have been impacted by the federal and are also listed under the ESA. Whether the CRSO DEIS will quantify the biological requirement of these stocks remains unclear.

Mitigation: The CRSO DEIS mitigation analysis is still in beginning information-gathering phases. The Co-Lead Agencies have not presented any of their own mitigation proposals. What has been provided to date is a collection of mitigation ideas collected during CRSO DEIS scoping stages. The collection did not relate the mitigation measures to existing obligations such as consistency with the NPCC's Fish and Wildlife Program or ongoing contractual commitments. The extensive history and ongoing commitments to mitigation for the development and operation of the federal Columbia River System of dams are important to understanding current conditions and has not been present in the CRSO DEIS to date.

All four of the Columbia River Treaty Tribes are vitally interested in the analyses and outcomes related to the CRSO DEIS.[63] Three of the Columbia River Treaty Tribes are Cooperating Agencies in the process for development of the CRSO DEIS. With the assistance of CRITFC, their technical services organization, the tribes have attempted to engage the federal Co-Lead Agencies. We have been hampered in this effort by extraordinarily limited periods for review and comment, lack of a composite framework for the affected environment and analysis, significant factual errors in the draft text, and the absence of historical context, particularly with regard to federal mitigation obligations.

We look forward to continuing to assist the Co-Lead Agencies to assure that the tribes' treaty secured interests are protected. All the documents cited in this paper will be made available to the Co-Lead Agencies in electronic format.

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[63] The Columbia River Treaty Tribes supported the 2019-2021 Flex Spill Agreement that established spill operations for the eight federal dams. Four additional examples serve to highlight the tribes' consistent concerns with the operations of the federal Columbia River system:

- In 1973, the Confederated Tribes of the Umatilla Indian Reservation and numerous individual tribal plaintiffs received a final judgment from Judge Robert Belloni in *Confederated Tribes v. Callaway* that limited federal power peaking operations and required reporting the status of the federal research studies. *Confederated Tribes v. Callaway,* Civ. No. 72-211 (Final Judgment, August 17, 1973)

- In 1979 and 1980, the Columbia River Treaty Tribes sought obtained numerous amendments to the draft Northwest Power Act that eventually became law. These amendments are found throughout the Act, but particularly in section 4(h) of the Act, 16 U.S.C. 839b (h), which among other things requires that the Council's Fish and Wildlife Program only include measures that are consistent with the tribes' rights.

- In 2003, CRITFC published an "Energy Vision for the Columbia River". https://www.critfc.org/wp-content/uploads/2012/11/tev.pdf. In 2013, CRITFC solicited Bonneville's comments on a draft update to the Tribal Energy Vision. The Energy Vision sought to reduce the burden of the region's energy needs on the ecosystem of the Columbia River.

- In 2017, with other tribes in the Basin, the tribes supported the publication of a research report on "The Value of Natural Capital in the Columbia River Basin". https://www.eartheconomics.org/crb Anticipating changes in the Columbia River Treaty, the authors analyzed the broad economic context of the Columbia River Basin's ecosystem values.

We request that each of these documents be included in the CRSO DEIS record and be carefully considered in the development of the co-lead agencies decisions.

Shoshone-Bannock Tribes
CRSO Tribal Perspectives Document

Summary/Abstract: *The Shoshone-Bannock Tribes (Tribes) of the Fort Hall Indian Reservation, located in Southeast Idaho, appreciate the co-lead agencies providing this opportunity to hear our perspective on the Columbia River System Operations (CRSO) and the Environmental Impact Statement (EIS) currently being developed for the Columbia River System (System). As a cooperating agency, federally recognized Tribe, and Fish Accord partner, the Tribes have a unique view of the issues surrounding anadromous fish management in the context of the operations of the System. Given the limiting factors affecting the recovery of anadromous fish throughout the System, the Tribes believe it is time to select an alternative that restores the systems and affected unoccupied lands to a natural condition. This includes the restoration of component resources to conditions which most closely represents the ecological features associated with a natural riverine ecosystem. Based on the range of feasible alternatives, the nearest alternative to this perspective would be for the co-lead agencies to select and implement Multiple Objective - 3 (MO3).*

The Tribes perspectives are based upon our reliance on the natural riverine ecosystem of the Columbia River Basin (Basin) for subsistence since time immemorial. This reliance was recognized and guaranteed through the Treaty reserved right to hunt on unoccupied lands of the United States. Our rights and interests are directly impacted by the operation, maintenance, and configuration of the System. To protect our rights and interests we are participating in the development of the EIS as a cooperating agency. Since our perspective can be broader than the boxes of National Environmental Policy Act (NEPA) allows for 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.

As is the fate of the Salmon, the continued existence of our culture is at risk of extinction because of the environmental inequities that have been forced upon our people. Over the last 200 years we have endured brutal atrocities against our people, the taking of our lands, the depletion of our food and medicinal resources, the political interests of the majority, and the legal conclusions that now govern how our culture can exist. The equitable distribution of environmental risk and benefits has not been afforded to the Shoshone and Bannock peoples, and as it has been done throughout history, we are forced to shoulder the burdens of conservation. Because what is at stake now is our Treaty reserved subsistence lifestyle.

Populations of salmon, including those in the Snake River subbasin, decreased substantially coincident with the construction of hydroelectric dams on the Lower Snake and Columbia rivers and other anthropogenic impacts across the landscape. Currently, salmon occupy 40% of their historic habitat in the Basin. Salmon in the Snake River subbasin have been completely eliminated above the Hells Canyon Complex and abundance in the Salmon River is estimated at 0.5% of its historical runs size. Snake River chinook and steelhead smolt to adult returns (SARs) are generally less than 1% — far below the necessary standard for population replacement or to meet the Northwest Power and Conservation Council goals of 2-6%. Reducing current annual Tribal member consumption to 1.2 pounds of salmon compared to historical use of about 700 *pounds per person. The loss of salmon threatens traditional cultural practices that are a vital part of our Tribal identity.*

I. Shoshone and Bannock Peoples' Culture of Stewardship

The Tribes' desired future condition for the System 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 lands and resources within the Basin are an important part of the Tribes' history, contemporary subsistence, and traditional cultural practices. The management direction taken by this environmental evaluation will have a significant impact on our people and our cultural resources. The resulting decisions must ensure future generations of Tribal members will have the same unique opportunities to enjoy the landscape, gather resources and continue traditional cultural practices.

Knowledge and stewardship of traditional fisheries is a privilege and a responsibility of the present generation to continue the unique heritage of the Shoshone and Bannock people. Continuation of traditional cultural practices in modern day requires the use of technical innovation combined with essentials of tradition. Persistent today is an instinct to return to the fisheries, resource patches, and lands to continue the heritage of the Shoshone and Bannock peoples. Tribal identity continues to be defined by practicing traditional cultural lifeways. Hunting and gathering in the same location as our ancestors and continuing to practice the same traditions is a powerful realization that these lifeways have been unchanged for millennia. Tribal identification is found by practicing traditional principles that mirror the images of our ancestors hunting anadromous fish and gathering and giving thanks for the blessings.

During the nineteenth century, increasing numbers of emigrant fur trappers, miners, ranchers, and non-Indian settlers occupied the lands within the Columbia River basin. These early contacts with the Shoshone and Bannock peoples identified settlements with large concentrations of our people noted throughout the Snake River drainages. "By the time Euro-Americans began to write about the Upper Snake Region in 1811, most of the Shoshone-Bannock populations in the area were fully equestrian peoples who traveled a wide territorial range." (Albers, 1998) Although the *Agai Deka* (Shoshone Salmon Eaters) were fully equestrian, the *Tuku Deka* (Sheepeater Shoshone) never adopted the horse and had permanent residence in Central Idaho until the late 1800's when conflict forced this last band to the reservation lifestyle. The fierce competition for resources by a growing population required the Shoshone and Bannock peoples to travel further for wildlife resources now absent from the Snake River subbasin; increasing the importance of anadromous fisheries for basic survival.

The Shoshone and Bannock peoples endured decades of conflict with encroaching settlers onto traditional gathering areas and witnessed the once sustainable resources disappearing from the landscape. At the height of the Civil War, troops led by General Connor massacred over 300 Shoshone people at the Bear River and a new era of forced removal began for our people. The federal government and territorial officials negotiated numerous treaties with Shoshone and Bannock peoples but never ratified. During the summer of 1863 treaties were proposed to Shoshone and Bannock peoples at Fort Bridger, Box Elder, and Soda Springs; all three were unratified. In 1864 a treaty was offered to Shoshone and Bannock peoples in the Boise Valley to force them to make way for settlement, the treaty was signed but, never ratified and our people were removed. In 1866, 1867 and 1868, the Bruneau, the Long Tom Creek, and Virginia City treaties were offered to Shoshone, Paiute and Bannock peoples and then the Virginia City; but none were ratified. Finally, on July 3, 1868 the Fort Bridger Treaty was negotiated and ratified by Congress in 1869, which reaffirmed the permanent home and reserved off-reservation rights.

In June 1867, an Executive Order established the Fort Hall Indian Reservation in Southeastern Idaho, as a collective place to consolidate the various bands of Shoshones and Bannocks, from their aboriginal lands, clearing the way for European-American settlements, such as ranchers and miners who desired rich resources present on aboriginal lands. Following the ratification of the Fort Bridger Treaty of 1868, an Executive Order in 1869 confirmed Fort Hall as the permanent home of the Tribes. The Tribes acted in good faith to protect our subsistence rights to harvest foods, medicine, and materials from our homelands, while promoting a safe, secure permanent homeland on the Fort Hall Reservation. Article IV of the Fort Bridger Treaty secured the off-reservation right to procure subsistence resources:

> *The Indians herein named agree, when the agency-house and other buildings shall be constructed on their reservations named, they will make said reservations their permanent home, and they will make no permanent settlement elsewhere; but 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.*

In the Lemhi River Valley, the *Agai Deka* (Salmon Eater) Shoshone, Bannock and mixed *Tuku Deka* (Sheepeater) bands occupied a small reservation reserved near present day Salmon, Idaho through the Virginia City Treaty of 1868. By 1900, the Lemhi Bands of Shoshone, mixed bands of Bannock, and Sheepeater Shoshone were forcibly removed from the Lemhi Reservation to Fort Hall to join the Shoshone-Bannock Tribes. With the termination of the Lemhi Reservation our people were forced to travel long distances to procure anadromous fish resources from our homelands.

Cultural resources, as narrowly defined by most federal and state agencies, are "historic and archeological sites, historic structures and buildings". The Tribes expand this definition of cultural resources and include all elements of mind, spirit, and physical being; all are inextricably tied to the physical landscape. Examples include 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. Cultural resources located in the Basin and associated drainages are highly significant because they directly contribute to the Shoshone and Bannock peoples' unique cultural heritage. Simply stated, a cultural resource is any resource of cultural character. The Tribes policy for Cultural Resource states:

> *The Tribes retain, assert, and exercise our inherent and ongoing rights as a sovereign government, pertaining to cultural resources and cultural properties. Where federal laws are non-existent or inconsistent, the Tribes will continue to exercise our inherent*

> *rights and unwritten traditional practices, in regards to the management of cultural properties and natural resources.*
>
> *It is the Tribes' right and responsibility to interpret and perpetuate cultural and heritage resources for future generations of Tribal members and the Tribal community. The Tribes continue to practice our unique subsistence lifestyle that maintains Tribal traditions and ceremonies, improves health, and utilizes ancestral territories. In addition, the Tribes will continue to work diligently to ensure the protection, preservation, and enhancement of our rights for future generations.*

Archeological records indicate that the Shoshone and Bannock cultures are at least 10,000 years old in their aboriginal range, while our oral histories are centered around creation in our homelands. Research shows salmon is a significant primary resource along with terrestrial wildlife, resident fish, roots, berries and other botanical resources. A renowned ethnographer and linguist for the Tribes described our connection to anadromous fish in the mid-1900's by noting, "A culture existence is dependent on the continuity of interconnected knowledge, beliefs, conventional behavior and technical practices" (Lilljeblad 1972:79). The traditional cultural practices, including the use of riverine resources, are the foundation on which the Shoshone and Bannock peoples built sustainable communities across our homelands for millennia.

It is well established that the United States has a solemn trust obligation to the Tribes. Under this obligation, the United States has a trust responsibility to consider the best interests of the Tribes pursuant to federal law, including the Native American Graves Protection and Repatriation Act (NAGPRA) and other federal heritage laws. The Tribes policy for NAGRPA states:

> *The Shoshone and Bannock people continue to advocate for protection of the human remains of our ancestral people because we consider that to be a basic human right. Although we were forcibly removed to the Fort Hall Reservation, our innate connections with the off-reservation lands are strong and viable. It is not our wish to see the forcible removal of our people who have already left this world, and move them to the Fort Hall Reservation, but it is the Tribes desire to retain the ancestral links to the lands in which they lived. These Newenne people demonstrate the proof of our existence on our aboriginal lands, therefore we do not want them removed from these lands. It is the policy of the Tribes to repatriate the human remains of our people as close as reasonably possible to the original burial location or with the original discovery site.*
> *Recognizing the timely need to collaborate with federal land owners, museums and other curation facilities, it is the policy of the Shoshone-Bannock Tribes to develop agreements on repatriation, to ensure confidential protection of burial locations and original discovery location. It is the policy of the Shoshone-Bannock Tribes that any commercialization of any aspect of the NAGPRA process is expressly prohibited.*
> *It is the policy of the Shoshone-Bannock Tribes that all of our past people's human remains, and funerary items, associated and unassociated items, shall not be subject to destructive testing, handling or scientific research inquires by academia. Any photography, use of social media or video of such items by reporters, academics, federal agencies, and private individuals is expressly prohibited, unless a Tribally-designated representative is present with written approval from the Tribes.*

It is the intent of this perspectives section to include more than the basic archeological issues identified in the DEIS and discuss all aspects of the cultural resources present in the Basin. From the Tribes' perspective, the empirical data in ethnographic and archaeological records documenting Tribal occupancy, oral history regarding the importance of the riverine ecosystem, and the cultural aspects of procuring subsistence foods cannot be effectively separated. In essence the entire Basin is a connected cultural resource for our people, as well as many other tribes residing in the Basin. It is only when you view this complex system as a whole that you realize the cascading effect of management actions for every living being that relies on it. The construction, inundation, operations, and current configuration of the System have impacted cultural resources by contributing to the decline in anadromous fish abundance.

II. Tribal Subsistence in an Era of Depletion

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. Using simple subtraction results in a deficit of ~699 pounds of salmon consumed per Tribal member annually when comparing traditional and current harvest estimates by the Tribes. As a people, we have gone from relying on anadromous fish runs that provided year-long subsistence resources for our communities to ingesting merely ceremonial amounts of salmon during a short window each fishing season. While abundantly cheap hydropower has benefitted the Basin, it has come at the expense of our community's health and well-being. While every reasonable person recognizes that we cannot return to pristine, pre-contact conditions, the Tribes will continue to advocate for our members because we are currently shouldering the burden of conservation in our homelands, and losing an important part of our culture along the way.

Throughout the 20th Century, anadromous fish runs began to diminish in both total abundance and in their range. Although commercial over-harvest was one of the earliest issues, the development of the contemporary System from 1927-1978 severely limited the ability of salmon, steelhead, and Pacific lamprey to access their historic range; in some instances this development completely blocked entire watersheds. The challenges associated with managing ever limited anadromous fish resources inevitably led to structural conflict across the Basin.

The Tribes were not immune to the challenges surrounding off-reservation treaty rights and the often limited access to anadromous fish resources in the Basin. Gerald Cleo Tinno, an enrolled member of the Tribes and permanent resident of the Fort Hall Indian Reservation, was charged by the State of Idaho for spearing a Chinook salmon on the Yankee Fork Salmon River on July 16, 1968. Both spear fishing and taking salmon at that particular time and location were violations of state fishing regulations. The runs of anadromous fish were low and the state had curtailed all fishing in an attempt to preserve the species.[1]

The record specifically shows that historically Indians took salmon by spear at the spawning beds; likewise, there is evidence that after the treaty signing Fort Hall Reservation Indians customarily hunted and fished in the region encompassing the Yankee Fork locale. Salmon and steelhead have always been a key resource for the Shoshone and Bannock peoples throughout

[1] State v. Tinno, 94 Idaho 759 (Supreme Court of Idaho, June 8, 1972)

our homeland. The Supreme Court of Idaho concluded that this area was within the meaning of the Treaty for fishing by Tribal members.

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."[2]

Article IV of the Fort Bridger Treaty extended the right to take salmon, although the reasonable and necessary conservation regulations enacted by the State of Idaho may apply in certain circumstances. It was becoming very clear that anadromous fish would no longer be found in the same abundance as were necessary to sustain our people with subsistence resources unless intensive management objectives were implemented by all parties. It became essential that the Tribes continue to actively support restoration, supplementation and cooperative efforts with interested parties so that those anadromous fish species continue to be 'found thereon' in harvestable abundance. 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 determined it was necessary to adopt reasonable regulations to protect the Treaty right to 'hunt' free of interference from outside entities. As such, the Tribes adopted ordinances to govern the conduct of hunting activities both on and off the reservation by our membership. The basic tenets of these ordinances are then refined into regulations and guidelines for the harvest of anadromous fish and are coordinated, as necessary, with appropriate co-managers to alleviate conflicts during annual management seasons.

The shift in focus by the Tribes to become an active co-manager of anadromous fish resources led to new policy that would guide future Tribal actions. The Tribes offered a policy statement that would stress the importance of initiating efforts to restore the Snake River and affected unoccupied lands to a natural condition. The Tribes Policy for Management of the Snake River Basin Resources states:

> *The Shoshone Bannock Tribes (Tribes) will pursue, promote, and where necessary, initiate efforts to restore the Snake River systems and affected unoccupied lands to a natural condition. This includes the restoration of component resources to conditions which most closely represents the ecological features associated with a natural riverine ecosystem. In addition, the Tribes will work to ensure the protection, preservation, and*

[2] *Id.* See generally.

> *where appropriate-the enhancement of Rights reserved by the Tribes under the Fort Bridger Treaty of 1868 (Treaty) and any inherent aboriginal rights.*

The Tribes then followed the policy statement by committing significant resources to developing a comprehensive Fish and Wildlife Department to manage resources across our homelands; one arm of that Department is solely focused on managing anadromous fish species. Consistent with the Tribes' Snake River policy, the Tribes' Fish and Wildlife Department are guided by the following mission statement:

> *The mission of the Shoshone-Bannock Tribes Fish & Wildlife Department is to protect, restore, and enhance, fish and wildlife related resources in accordance with the Tribes' unique interests and vested rights in such resources and their habitats, including the inherent, aboriginal and treaty protected rights of Tribes members to fair process and the priority rights to harvest pursuant to the Fort Bridger Treaty of July 3, 1868 (15 Stat . 673).*

The Department uses the language from our Treaty, policy statements, and mission statement to implement a collective Tribal vision for management. The Tribes still have a significant interest in developing sustainable hunting and fishing opportunities in the Basin because without broad consensus on goals and mitigation measures, it is likely anadromous fisheries will remain below sustainable and harvestable quantities. A quintessential component of the Tribal perspective is blending our traditional ecological knowledge with the tenets of western science to develop projects that will holistically benefit numerous native species and provide sustainable opportunities for subsistence harvest of those resources.

Populations of salmon, including those in the Salmon River subbasin, decreased substantially coincident with the construction of hydroelectric dams on the Lower Snake and Columbia rivers and other anthropogenic impacts across the landscape. Anadromous fish populations have been reduced to the point that Chinook salmon are listed under the Endangered Species Act (ESA) as a threatened species; this listing occurred on April 22, 1992 (57 FR 14653). Prior to 1992, the Tribes implemented Chinook salmon fisheries throughout the Salmon River, but in 1992 the dynamics of these fisheries were drastically altered. The annual harvest guidelines changed on a yearly basis and were dependent upon escapement estimates. Once the ESA protections were established, the Tribes were forced to adapt their fishing practices to hatchery influenced areas, which resulted in a diminishment of fishing practices in traditional fishing areas. After the listing of Snake River Sockeye the Tribes were precluded from harvesting these fish in any meaningful manner. Our perspective at that time was that ESA listing would help these anadromous fish populations recover over the next few decades to sustainable, harvestable levels again. Unfortunately, populations remain roughly in the same condition as they were during the listing decisions almost thirty years ago.

Historically, the Shoshone and Bannock peoples harvested salmon and trout throughout the Basin for subsistence across an almost year-round timeline. Annual salmon and steelhead runs in what are now Oregon, Washington, Idaho and Nevada provided harvest opportunities throughout the year for our people. Anthropogenic impacts to the Basin severely constrained runs of anadromous fish over the next century, in particular System development and operations.

Current salmon abundance in the Upper Salmon River subbasin is estimated at about 0.5% of historical runs and the Hells Canyon Complex completely eliminated upstream migration into the Middle Snake Province in Idaho, Nevada, and Oregon. **Recent harvest opportunities for Tribal members have only provided 1.2 pounds of salmon per Tribal member compared to historical use of about 700 pounds per person annually.** The following excerpt demonstrates how this estimate is derived.

Shoshone-Bannock Reliance on Anadromous Fish Resources – taken from Walker 1993[3].

Several methods have been employed by scholars and scientists to estimate both the amount of fish traditionally available and the amounts traditionally harvested by the tribes of Idaho including the Shoshone-Bannock Tribes. It has been estimated by Rostlund, Hewes and Walker, the Shoshone and Bannock people's average annual fish harvest for the Salmon River region was 233,555 fish (range 36,500-604,166). This is based on several methods of estimating historical catch information and assumes 15 pounds per fish.

One of the earliest and most enduring studies of fish populations and harvests in Native North America was completed by Erhard Rostlund in 1952 and published as "Freshwater Fish and Fishing in Native North America." Assuming Rostlund's method is correct, the home territory of the Tribes which includes 10 million square acres or about 15,625 square miles, the Tribal catch derived by Rostland would be 9,062,500 pounds. At an average weight of 15 pounds per fish, this equates to 604,166 total fish.

A different method was used by Hewes in his 1947 "Aboriginal Use of Fishery Resources in Northwestern North America." By this method, a tribal population of 1,000 would consume 1,000 pounds per day or 365,000 pounds per year. The Shoshone and Bannock population of southern and central Idaho probably exceeded 5,000 which would produce an average annual catch of 1,825,000 pounds. By apportioning 1,500 of this 5,000 total Shoshone and Bannock peoples to central-Idaho (Salmon River region), the Hewes method would yield an average annual catch of 547,500 pounds, a figure close to the estimate made by Walker. At an average weight of 15 pounds per fish, this equates to 36,500 total fish.

Another method used for estimating Shoshone and Bannock subsistence harvest, typical of central Idaho during the mid-19th century is the direct comparison of harvest of fish and game in Alaska. The Alaskan research indicates that contemporary hunting and gathering ranged as high as 1,498 pounds of fish and game per person per year with an estimated annual average throughout Alaska of 250 pounds (dressed weight). About 65% of the harvest was found to be fish with such species at salmon, halibut, herring, whitefish, cod, and artic char. Also resembling the Columbia system during the latter nineteenth century, ninety-five percent of the total fish harvest in Alaska is now taken by the commercial harvest.

[3] Walker, D. E. 1993. Lemhi Shoshone-Bannock reliance on anadromous and other fish resources. Northwest Anthropological Research Notes Vol. 27, pp. 215–250.

> *Although we cannot compare specific Alaska communities with the Shoshone-Bannock, we can use the Alaskan survey data to help validate ranges of historic Shoshone-Bannock fish consumption. For example, 65% of the Alaskan high estimate is 973.7 pounds of fish per person per year, a figure within the range of estimates for tribal groups of the Columbia River system.*
>
> *Walker (1993) further improved fish consumption estimates for the Shoshone-Bannock. Walker used more empirical methods as a first step in estimating Shoshone-Bannock reliance on fish resources in the Salmon River country. Walker (1993) grouped the Shoshone-Bannock fishing sites into three broad types: fishing sites at natural falls, cascades, or rapids; those constructed as weirs, traps, and fish walls, and the simple fishing site commonly utilized without any such distinguishing features. The first two types are by far the most productive sites and are capable of daily harvests in the hundreds and even thousands of fish during certain peak days of the fish runs. Walker (1993) located about 50 such sites. The third type is not usually employed during peak days of the anadromous fish runs and is used in an opportunistic manner for both anadromous and resident species. Walker estimates Shoshone-Bannock harvest in the Lemhi/Salmon River region to be 200 fish per day, per weir, averaging 15 pounds each. This yields a potential average annual harvest of 900,000 pounds, or about 60,000 fish*

Several methods have been employed to estimate the amounts traditionally harvested by the Tribes in the Salmon River subbasin. Rostlund (1952), Hewes (1947), and Walker (1993) used different methods for estimating annual harvest, but the average annual salmon harvest for the Salmon River was 233,555 salmon (range 36,500 – 604,166). Assuming an average of 15 pounds per salmon, the annual average harvest in pounds of salmon was 3,503,325 (range 547,500 – 9,062,500). Hewes (1947) also apportioned 1,500 of the 5,000 total Shoshone and Bannock peoples to traditionally inhabit central Idaho (Salmon River subbasin) to hunt salmon. Using the annual average harvest in pounds of salmon (3,503,325) and dividing by the approximately 1,500 Tribal members traditionally in the Salmon River region, equates to 2,336 pounds of salmon consumed per tribal member annually. (Denny et al. 2010)

Current estimates (1981 – 2018) of average salmon harvested by the Tribes in the Salmon River are approximately 470 salmon annually (range 0 – 1,678). After applying an average of 15 pounds per salmon, the current annual average harvest in pounds of salmon is 7,050. Using the current annual harvest in pounds per salmon (7,050) and dividing by the current approximately 6,000 Tribal members, equates to an *average* of 1.2 pounds of salmon consumed per tribal member annually. On years of particularly low abundance, it is common for many Tribal members to consider themselves fortunate to procure enough fish for a single family meal or ceremony. To make up for some of this loss the Tribes conduct traditional trades for salmon with other Northwest tribes or receive surplus hatchery salmon from collection racks in Idaho, Oregon, and Washington. Without a doubt, the loss of this food source has had impacts on our community's health and well-being, with anadromous fish resources contributing healthy sources of protein for our people in an age of processed foods and rising rates of diabetes[4].

[4] Estimates for diabetes rates among Native American populations is generally twice as high as the national average (2018 CDC.gov Diabetes Quick Facts).

Regardless of the decision from this environmental evaluation, the Tribes remain focused on the sustainability of anadromous fish resources in the Basin. Over the past three years, abundance of Snake River Sockeye, Snake River Steelhead, and Snake River Chinook have all decreased to their lowest levels since they were listed under the ESA. This environmental evaluation is coming at a critical time for the Basin and could have long-reaching effects for these iconic anadromous fish species and the Tribal members who rely upon them. Our obligation as managers and stewards of these resources from time immemorial has shaped our perspective on the best manner to operate the System and ultimately, recover anadromous fish species to sustainable and harvestable levels.

III. Salmon and Ecosystems

The Tribes perspective on meaningful recovery includes the restoration of component resources to conditions that most closely represent the ecological characteristics and processes associated with a natural riverine ecosystem. We agree with Williams et al. (1999) who concluded "that management of the Columbia River and its salmonid populations has been based on the belief that natural ecological processes comprising a healthy salmonid ecosystem can, to a large degree, be replaced, circumvented, simplified, and controlled by humans while production is maintained or even enhanced." If one conclusion can be effectively drawn, it is that with the current system configuration we will be unable to meet our collective goals of species conservation and sustaining Tribal treaty rights. The Tribes endorse a more holistic perspective where humans work to restore the natural processes that support healthy ecosystems, healthy economies, and healthy cultures.

Based on our unique Traditional Ecological Knowledge gathered over generations as stewards of the Snake River, is a desire to move toward more normative river conditions. In the Basin an estimated 5-9 million anadromous fishes returned annually (Alldredge et al., Northwest Power and Conservation Council ISAB Report 2015).[5] Watersheds across the Basin were filled with an abundance we can scarcely comprehend in our current management paradigm. The anthropogenic impacts of industrialized development in the Basin have dramatically reduced anadromous fish abundance to near-extinction and as co-managers the Tribes are seeing a growing acceptance of the new levels of abundance.

Salmon and steelhead are crucial components of the landscape of the Basin. Abundant populations of anadromous salmonids (*Oncorhynchus* spp.) historically contributed large amounts of marine-derived nutrients (MDN) to aquatic and terrestrial ecosystems in the Pacific Northwest (PNW) of the United States of America (California, Oregon, Washington, and Idaho) (Kline et al. 1990; Larkin & Slaney 1997; Cederholm et al. 1999; Gresh et al. 2000; Bilby et al. 2003). Nitrogen, phosphorous, and carbon sequestered in the marine environment, where approximately 95% of the body mass of salmon accumulates, are subsequently delivered to inland watersheds via upstream migrations (Groot & Margolis 1991). These migrations represent a major nutrient and energy vector from the marine environment to freshwater and terrestrial ecosystems (Cederholm et al. 1999).

After returning to natal spawning habitat, salmon complete their life cycle and in turn deliver ecologically significant amounts of MDN to inland habitats (Gende et al. 2002; Thomas et al.

[5] Alldredge et al., Northwest Power and Conservation Council ISAB Report, 2015.

2003). Anadromous fishes deliver MDN to freshwater ecosystems through excretion, gametes, and their own nutrient-rich carcasses. Primary nutrient pathways from salmon carcasses to stream biota include: 1) uptake of inorganic nutrients (provided by excretion during spawning events) by primary producers; 2) uptake of mineralized inorganic nutrients by primary producers and subsequent food web transfer; 3) uptake of dissolved organic matter by microfauna in the streambed and subsequent food web transfer; and 4) direct consumption of eggs and carcass materials by secondary consumers and fishes (Cederholm et al. 1999; Kiernan et al. 2010). Energy and nutrients delivered to freshwater ecosystems also benefit a myriad of aquatic and terrestrial wildlife species and acts to sustain the ecological integrity and proper functioning condition of whole ecosystems. In the PNW, Cederholm et al. (1989) documented 22 species of mammals and birds that were observed or known to directly consume salmon carcasses. And Bilby et al. (1996) estimated that 18% of nutrients in riparian area vegetation along a salmon bearing stream were derived from salmon themselves.

Spawning salmon contribute an estimated 5 to 95% of the P and N loading in salmon-bearing watersheds (Gresh et al. 2000), and even small input of nutrients and C may be important to the maintenance of trophic productivity (Larkin & Slaney 1997). This process has been described as a positive feedback loop functioning to enhance freshwater productivity for future generations of anadromous and resident stream biota (Wipfli et al. 1998; Hicks et al. 2005). The presence and availability of marine-derived nutrients has been shown to increase the growth rate, lipid level, and condition factor of juvenile fishes (Bilby et al. 1996; Wipfli et al. 2004); and higher growth rates appear to increase freshwater and marine survival (Beckman et al. 1999; Bilton et al. 1982; Ward and Slaney 1988). It is now clear that spawning salmon serve numerous ecological functions and should be an important component of ecosystem recovery plans (Cederholm et al. 1999).

Following periods of intense commercial harvest, hydrosystem development, hatchery production, and habitat loss, significant declines in Pacific salmon abundance have occurred throughout the region (Lichatowich 1999). Returning anadromous adults in the Basin, once estimated at 5-9 million fish annually, now return at an average of less than 2-3 million fish per year (Alldredge et al. (ISAB) 2015). Healthy populations of salmon that once provided annual nutrient subsidies to otherwise nutrient-impoverished environments largely remain depressed or have been extirpated (Levy 1997). Currently, salmon occupy approximately 40% of their historic range (Nehlsen et al. 1991) and contribute just 6-7% of the MDN historically delivered to PNW rivers and streams (Gresh et al. 2000). Consequently, many forested streams of the region are now characterized as ultra-oligotrophic (Welsh et al. 1998), a condition of low nutrient concentrations suggested to result from a combination of parent geology and low numbers of returning anadromous fishes (Ambrose et al. 2004).

The upper Salmon River subbasin of central Idaho is an example of this process, where we have seen evidence that the paucity of returning anadromous fishes, coupled with low watershed scale nutrient inputs, act synergistically to limit freshwater productivity and associated habitat carrying capacities. Effectively, the loss of ecological functions associated with abundant salmon returns will constrain efforts to recover salmon and steelhead populations. Thomas et al. (2003) estimated that 25-50% of Idaho streams are nutrient-limited and Alldredge et al. (ISAB 2015) and Achord et al. (2003) found evidence of density-dependent mortality at population sizes well below historical levels, suggesting nutrient deficits as a limiting factor capable of reducing stream rearing carrying capacities. In a recent analysis, Scheuerell et al. (2005) examined phosphorous-transport dynamics by spring/summer Chinook salmon (*Oncoryhnchus tshawytscha*) in the Snake River subbasin and estimated that over the past 40 years less than 2% of historical marine-derived phosphorous is currently delivered to natal spawning and rearing streams.

Interestingly enough, these same central Idaho streams and lakes found in wilderness or roadless areas are reported by Idaho Department of Environmental Quality as presumed to be fully supporting all beneficial uses (IDEQ 2016). However, the 'new normal' abundance levels do not adequately support harvest, species conservation, or the ecosystems these populations of anadromous fish influenced over thousands of years. The simple truth is that we need returning adults to feed the next generation of anadromous fish and to support the ecological functions necessary for their survival.

IV. Salmon in a Changing Climate

Climate change impacts have the potential to affect the entire Basin and resources the Tribes stewarded from time immemorial. The change has the potential to impact both aquatic systems across the Basin and the generation of electricity from the System. Planning for these changes will require a focused shift in attention towards building resilience, supporting ecosystem services and habitat health, decreasing non-climate stressors, and improving watershed retentive capabilities to help buffer these climate changes. Climate change presents a threat to critical cultural resources, thereby also threatening the lifeways and wellbeing of the Tribes. This creates an urgent need to build climate resilience to protect and preserve these resources for future generations. The Tribes policy on Climate Change states:

> *Global temperatures very likely exceed anything observed in the last 1,400 years and current levels of carbon dioxide are at concentrations unseen in the last three million years. Projected changes in temperature, precipitation, hydrology, and ocean chemistry threaten not only the lands, resources, and economies of the Shoshone-Bannock Tribes (Tribes), but also tribal homelands, ceremonial sites, burial sites, tribal traditions, and cultural practices that have relied on native plants, fish, and animal species since time immemorial. Therefore, the Tribes recognizes that action must be taken to reduce greenhouse gas emissions, positive radiative forces, and observed warming. The Tribes also recognizes a need for additional information to assess and convey uncertainties, identify actions to implement, develop decision support tools and climate projections, maintain and enhance healthy and resilient ecosystems, conserve water, and understand how climate change will impact the health and wellbeing of the Tribes. Therefore the Tribes will make efforts to mitigate the effects of human caused climate change through planning, consultation, education, and enforcement of Treaty Rights.*

The Tribes, in cooperation with the Upper Snake River Tribes Foundation, received funding from the Bureau of Indian Affairs in 2016 to prepare a Climate Change Vulnerability Assessment and Adaptation Plan for the Snake River Basin. The Tribes used an interdisciplinary approach where technical staff worked collectively with outside consultants to assess climate vulnerability and identify adaptation actions for critical plant and animal species and their habitats. While the primary focus of the adaptation plan was to determine impacts to the Fort Hall Reservation, one of the assessment areas included the Salmon River subbasin to the importance of anadromous fish to the Tribes. This report included downscaled future climate projections for the project area and a description of the vulnerability assessment process and outcomes for species evaluated (Snake River Spring/Summer Chinook salmon).

The impacts of climate change will likely be severe throughout the Basin and that some of those impacts are occurring right now. Anadromous fish require relatively cold water habitats and favorable ocean conditions to thrive; unfortunately, future conditions are unlikely to support the ecosystem services that anadromous fishes depend upon without planning to mitigate the effects of reduced snowpack, elevated summer air temperatures, extreme precipitation events, and the overall effects of greenhouse gases to the biosphere. While a specious argument could be made that hydropower does not generate carbon dioxide, the more immediate concerns lie with the impacts from the facilities that create slack-water reservoirs and a loss of riverine ecosystem structure and function.

Across the entire project area, average annual temperatures are projected to increase under both future climate scenarios and for all time periods. Warmer ambient air temperatures are expected to have important impacts on water availability and seasonal stream flows in the Snake River subbasin. Even with precipitation patterns staying relatively consistent (though still highly variable from year to year), the warmer temperatures are likely to increase evaporation and evapotranspiration. Mountainous regions, like the Salmon River subbasin, are projected to have less overall soil moisture available and receive less precipitation in the form of snowpack.

A change in ambient air temperatures and a shift from snowpack based systems to warmer, rain based systems may have cascading effects throughout the Salmon River subbasin. Reductions in snowpack due to a greater proportion of winter precipitation falling as rain instead of snow, will shift peak streamflow earlier in the year, increase winter streamflow, and decrease base summer stream flows. In basins where winter precipitation historically falls largely as snow, year-to-year variability in winter monthly flows is relatively small because the precipitation accumulates as snow instead of making its way to streams. This creates a winter flow regime that is relatively stable year-to-year. For aquatic species adapted to a relatively stable winter flow regime, changes in flow regimes will affect migration and refugia for anadromous and resident fish at all life stages.

More alarming than a change in flow regimes for anadromous fishes is the projection that stream temperatures are projected to rise as air temperatures rise. This will result in summer temperatures reaching thresholds above which the aquatic environment ceases to provide suitable habitat for some species. During the Tribes' planning process we viewed modelling results showing river segments throughout the Salmon River subbasin and Snake River migratory corridor in which the August mean water temperature is projected to exceed 63.5°F by the 2040s. This temperature threshold was chosen for illustrative purposes as temperatures exceeding 63.5°F extremely harmful for many salmonid species like Chinook salmon, Snake River sockeye salmon, Steelhead, and Bull Trout. For example, in 2015, greater than 98% of adult Snake River sockeye salmon perished attempting to migrate through the System during extreme July temperatures and low flow conditions. The compounding effect of warmer stream temperatures, warmer reservoirs, and altered flow regimes would negatively affect many native salmonid populations beyond their innate adaptive capability.[6]

V. Managing for Sustainability

In a contemporary setting, the Tribes exercise their right to hunt for Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*) under inherent rights and the Fort Bridger Treaty. Under the ESA Section 4(d) Rule (50 CFR 223) allows a tribal government to submit a Tribal Resource Management Plan (TRMP) with the intent of exempting the tribes' harvest of protected species from the ESA. The purpose and scope of the Tribes' TRMP is to provide the Tribes an exemption under the ESA to harvest listed Chinook salmon in the Salmon River and Grande Ronde/Imnaha subbasins, while the species is listed as threatened. This approach is a responsible way to manage listed stocks and provides opportunities to pursue anadromous fish across our cultural landscape. The severe limitation of these conservation frameworks often restricts a ceremonial take of several fish in wild watersheds due to the extremely low abundance of wild fish returning in the past three decades. From our perspective, we have done everything possible to preserve our presence through traditional fishing in our homelands; it is time to implement an action that will provide for meaningful harvest opportunities for our future generations.

The current management paradigm, now almost two decades old, is that minor modifications to hydropower facilities and improvements in natal habitat and hatchery management will provide a vehicle for populations to 'trend toward recovery'. The Tribes continue to believe that conservation work has resulted in significant benefits to ecological processes and that hatchery reform will pay dividends for any program in the Basin; however, those benefits are not significant enough to overcome impacts from highly modified mainstem river habitats. The Northwest Power and Conservation Council has set goals of 2-6% (4% average) smolt to adult returns (SAR) so populations are at replacement even in low-abundance years, while on higher productivity years we see population growth.

McElhany et al. (2000[7]) developed a science-based framework to better understand and recover salmon populations. Within that framework, viable salmonid populations (VSP's) are defined as having a negligible risk of extinction resulting from demographic variation, local environmental variation, and loss of genetic diversity for a period of 100 years. McElhany et al. (2000) identified four broad categories for VSP parameters: diversity, spatial structure, abundance, and productivity. These factors have been identified as a means to assess populations, establish de-listing goals, and provide guidelines for relating viability at the population level to larger ecologically significant unit's (McElhany et al. 2000).
Currently (2012 to 2018), 84% of natural origin spring/summer Chinook salmon populations are below abundance levels needed to sustain themselves (viable population threshold abundance criteria) (SBT *unpublished data*). During the same period, 50% of these Chinook populations where Tribal members harvest salmon are at imminent risk of extinction (critical population threshold) (SBT *unpublished data*). The Snake River spring/summer Chinook ESU remains

[6] *See generally*, https://eprints.qut.edu.au/103728/1/Isaak_et_al-2010-Ecological_Applications.pdf
[7] McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 156 p.

likely to become endangered (NWFSC 2015[8]). In more recent years, adverse ocean conditions and System management acted synergistically to yield some of the lowest adult Chinook salmon returns to the upper Salmon River subbasin since these populations were listed under the ESA.

Snake River Chinook salmon and steelhead smolt to adult return rates (SARs) from Lower Granite Dam to Lower Granite Dam are generally less than 1% — far below the necessary standard for population replacement. According to the Comparative Survival Study modeling conducted by the Fish Passage Center (FPC 2018), major population declines of Snake River wild spring/summer Chinook salmon were associated with SARs less than 1%. Only with SARs greater than 2% were populations at or above replacement. The Tribes support actions that will help achieve the Northwest Power and Conservation Council's Fish and Wildlife Program goal of SARs in the 2% to 6% range (average 4%) for federally ESA-listed Snake and Columbia River salmon and steelhead populations.

The Lower Snake River Compensation Plan (LSRCP) was authorized in 1976 explicitly to mitigate for lost commercial and recreational harvest opportunities associated with the construction and completion of the four dams on the Lower Snake River (Corps of Engineers 1975[9]). LSRCP included a significant hatchery program aimed at compensating for the estimated loss of 48% of juveniles migrating through the system and set production goals at 11 hatcheries to offset that loss (ISRP 2002[10]). Throughout the program's history up to present, LSRCP programs have not met their compensation goals in most years despite decades of hatchery reform and expensive changes to System infrastructure to increase the viability of hatchery reared juveniles and decrease System related losses, respectively (Marshall 2010[11], Marshall 2012[12]). For example, the LSRCP hatchery in the Upper Salmon River (i.e. Sawtooth Fish Hatchery), which produces Chinook salmon available for tribal members to harvest, are now not meeting the production goals to provide salmon for future generations (IDFG 2018[13]). The failure of the LSRCP to meet its congressionally authorized goals parallels continued declines in wild anadromous fishes above the four Lower Snake River dams and demonstrates that the losses associated with the current configuration of the System may be too great, and its effects too strong, to adequately mitigate.

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[8] Northwest Fisheries Science Center. 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest.

[9] Corps of Engineers. 2975. Special Report, Lower Snake River Fish and Wildlife Compensation Plan. Lower Snake river Washing and Idaho. U.S. Army Engineer District, Walla Walla, Washington. 96pp plus appendices.

[10] ISRP. 2002. Lower Snake River Compensation Plan — Final Proposal Review for the Columbia Plateau, Blue Mountain, and Mountain Snake Provinces, April 23, 2002. ISRP 2002-6.

[11] Marshall, S. L. 2010. A brief history of the Lower Snake River Compensation Plan Hatchery Program for spring and summer Chinook salmon. In: Lower Snake River Compensation Plan spring/summer Chinook program review, November 30-December 02, 2010. Boise, ID.

[12] Marshall, S. L. 2012. A brief history of the Lower Snake River Compensation Plan Hatchery Program for summer steelhead. In: Lower Snake River Compensation Plan Summer Steelhead Program Review, June 20-21, 2012. Clarkston, WA.

[13] IDFG. 2018. Sawtooth FH Operations and Maintenance 2018 Annual Report. https://www.fws.gov/lsnakecomplan/Reports/IDFGreports.html.

VI. Economics of Energy - Why Restoring the Snake River Makes Fiscal Sense

One of the most contentious issues to face our region has been the mitigation measures associated with the Snake River facilities for listed stocks and the continued use of the facilities for hydropower and transportation. In 2002, the US Army Corps of Engineers performed a feasibility report that concluded the presence of these facilities outweighed alternatives in favor of removing the earthen portions of the dams; a practice commonly referred to as breaching.[14] Almost twenty years later it is time to revisit the issue in an objective manner and determine if the underlying assumptions associated with those facilities have shifted away from the status quo; the Tribes believe they have.

The following three perspectives from 2002 represent a spectrum of the discussion at that time, from how we value rivers and transport to the actual costs of maintaining them in place for the foreseeable future.

Loomis, John. "Quantifying recreation use values from removing dams and restoring free-flowing rivers: A contingent behavior travel cost demand model for the Lower Snake River." Water Resources Research 38.6 (2002): 2-1.

> The river recreation use value estimates of $192–310 million are 6–10 times larger than current reservoir recreation benefits ($31.6 million). However, the annual hydro-power losses associated with dam removal are estimated to be $271million annually [USACOE, 1999]. Including the dam removal cost and foregone barge transportation, the costs rise to $360 million [USACOE, 1999]. River recreation would cover a large portion of these costs but not all of it. Owing to the need to recover the fish stocks, recreational, commercial, and tribal fishing benefits are limited as well. Thus in a traditional national economic development (NED) analysis that does not incorporate passive use values of recovering of threatened and endangered species, a strict benefit cost criterion would suggest it is economically efficient to allow the dams to remain.

Whitelaw, E., & MacMullan, E. (2002). A Framework for Estimating the Costs and Benefits of Dam Removal: Sound cost–benefit analyses of removing dams account for subsidies and externalities, for both the short and long run, and place the estimated costs and benefits in the appropriate economic context. BioScience, 52(8), 724-730.

> In estimating the benefits from breaching the dams, the Corps excluded a number of relevant values, including tribe related benefits and the benefits that all of us gain from the existence of both the increased salmon runs and a free-flowing lower Snake River. First, the Corps' estimate of tribe related benefits included the number of acres of sacred and traditional sites that the tribes would regain access to, as well as the number of pounds of fish from treaty-protected subsistence and ceremonial fisheries, but it did not include the economic benefits that tribal members and other Northwesterners and

[14] USACE Walla Walla District. 2002. Lower Snake Feasibility Report/Environmental Impact Statement Economic Appendix (I))

> *Americans would gain from these changes (USACE 1999b). In not doing so, it overlooked economic benefits to tribal members that constitute real increases in the value of national goods and services. As a result, the Corps underestimated how breaching the dams would benefit the tribes, and how that, in turn, would benefit all of us.*

Babbitt, B. (2002). What goes up, may come down: Learning from our experiences with dam construction in the past can guide and improve dam removal in the future. *BioScience*, *52*(8), 656-658.

> *And lest there be any misunderstanding, my own stand on consensus-based dam removal is on the record. It became increasingly pronounced over the past half-decade as I graduated from one level to the next, embracing sledgehammer, jackhammer, wrecking ball, sky crane, and even C-4 plastic explosives to help dismantle dozens of obsolete structures, structures that had either outlived their function or outweighed their benefits with costs that society was no longer willing to pay. The change has come. The heyday of dams has come and gone. From my perspective, there is no turning back…. Dam removal, like dam construction, is not an end unto itself, only a means to an end. It is a means by which humans can live more responsible lives in harmony with creation, a means that requires the illumination of science, ensuring that we look clearly back, and down, before we can truly move forward on solid ground together.*

While these differing perspectives dominated the conversation at the time, the underlying assumptions should be critically evaluated. In 2016, a group, Earth Economics[15], reviewed the 2002 Economic Appendix to the Lower Snake Feasibility report and concluded that circumstances have changed enough to warrant a new evaluation of these facilities.[16] This particular evaluation concluded that the "benefits created by the four dams are outweighed by the costs of keeping them." The basis for this conclusion included several aspects that were assumed to maintain a positive benefit over the 2002-2021 evaluation period, including: annual power production from the region, the cost and assumed benefit of mitigation programs aimed at recovering listed anadromous fishes, and, the maintenance of these facilities for transport programs.

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. In 2019, the Basin is producing more electricity than we use and the growing renewable energy sector is changing the market at a rapid pace.[17] In the 2017 Pacific Northwest Loads and Resources Study (commonly referred to as the 2017 BPA White Book) the analysis shows significant surplus electricity generation through 2028. As noted in the

[15] Earth Economics is a non-partisan, non-profit, science based group that develops value estimates for ecological services. General information may be found at their website: https://www.eartheconomics.org/ .

[16] (Mojica, J., Cousins, K., Briceno, T., 2016. National Economic Analysis of the Four Lower Snake River Dams: A Review of the 2002 Lower Snake Feasibility Report/Environmental Impact Statement. Economic Appendix (I). Earth Economics, Tacoma, WA.)

[17] See generally, *Power Shift*, Jim Norton, January 11, 2019. Available online at: https://columbiarediviva.org/power-shift/

BPA's evaluation of the issue, "This annual surplus has seasonal variability, spiking from April through June as Columbia River Basin flows increase through the spring, and dropping to net demand during low water from December to March. This variability has implications for specific hydro assets managed by BPA, which must curtail and/or sell surplus power some of the year while procuring power from regional markets other times of the year." It is critical to note that this projected surplus also coincides with the new contract period for large-scale customers of energy produced in the System.

While profits from the sale of electricity have remained static or declined over the past ten years, the regional appetite for renewable energy in the form of solar and wind has fundamentally changed the market. Carbon-free policies and decentralized sources of renewable energy have led to hundreds of new large and small scale sources of electricity in the Basin. Previously reliable customers of Columbia River power (e.g., California) may see an overall reduction in need for large-scale hydropower facilities as solar and wind generators assume space on the grid. During a 2018 NPCC meeting, BPA acknowledged that this changing market has led BPA to institute rates that are now significantly higher than the current market prices and that may have long term effects on overall profitability for the System; these sentiments are echoed in BPA's 2018 Strategic Plan.[18]

> *Bonneville is committed to remaining a cost-effective power supplier, but its cost advantage has eroded. A substantial challenge is low wholesale power prices caused by persistently low natural gas prices and ever-increasing renewable energy expansion during a time when electric loads remain flat. Supply is outpacing demand. Low wholesale power prices entice customers to consider other power suppliers while also reducing BPA's net secondary revenues, which BPA uses to help keep rates low.*
>
> *Bonneville also faces cost pressure from maintaining aging generation infrastructure, increasing costs to meet fish and wildlife obligations, the cost of the Residential Exchange Program settlement, and flat-to-declining firm power sales.*

In particular, the current mitigation program for fish and wildlife in the Basin is often described as one of the most expensive and rigorous conservation programs in the country. The Tribes remain proud of the countless hours each co-manager and action agency commits on an annual basis to ensure the survival of these species. The basis for these mitigation measures is to return to stasis on non-listed stocks and recover listed stocks to prevent extinction. The region has avoided extinction of listed stocks, but recovery has been an elusive goal for the fish and wildlife program. At the time of the current evaluation, the region is experiencing an annual return that puts virtually every wild stock in Idaho at critical levels and is inherently increasing the risk of near-term extinction for some of these stocks. A potentially dwindling pool of resources to mitigate impacts from the operations of the System has the Tribes concerned that future efforts may not include comprehensive, watershed level efforts to conserve and recover listed wild stocks in our homelands.[19] Based on the current program priorities, the listed stocks in our

[18] 2018 BPA Strategic Plan, Strategic Goal 3, page 34.
[19] From the 2018 BPA Strategic Plan, Page 41. *Fish and wildlife costs account for a sizable portion, about 25 percent, of BPA's direct power costs; combined with the financial impacts of spill, these costs account for about one-third of BPA's power rates. BPA and its partners have made great strides in improving fish survival, fish*

homelands in most need of conservation generally receive a small portion of the overall allocation from the current Fish and Wildlife Program.

The 'Lower Four' Snake River dams comprise a massive 140-mile corridor along the Snake River with each facility in desperate need of significant capital investments for turbine generators, channel dredging, spillway modifications, adult and juvenile fish passage modifications, cold-water ladder modifications for late run anadromous fish like Sockeye, etc. Unlike the new wave of decentralized renewable power sources becoming available across the basin, this entire facility requires constant structural and operational maintenance. Even though barging has reached an effective rate of zero in Idaho for most products, and Portland has shifted away from container shipping up the Columbia to Idaho, the facility still needs to be maintained for navigation whether it is used or not. Ironically, one of the most expensive barged 'products' through this corridor are juvenile salmonids that are currently a component of mitigation programs.

The maintenance expense for these facilities has reached over a billion dollars, although estimates vary so widely it is difficult to define exactly how expensive this renovation would actually cost. While the Lower Snake River facilities have known impacts to listed stocks and are no longer being used for barging traffic at any economically significant level, the conversation should now focus on the actual benefit of effectively divesting this asset from the System. The restoration of the Snake River would replace an expensive mitigation program, an unused navigation channel, and alleviate the need to replace turbines generating surplus power that cannot be effectively sold at a profit on the open market. 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. The alternative is a direct reflection of the past twenty years: spill regimes that cost exorbitant amounts of money, stocks at perilously low abundance, and significant capital investments in facilities that have a net zero, or lower, rate of return for BPA.

VII. Restoring the Snake River

The Tribes have actively participated in the development of the CRSO Draft EIS and recognize the difficult task of balancing project configuration between anadromous fish needs and the desire to generate hydroelectric power. The co-lead agencies have identified objectives that would improve salmonid passage and survival throughout the project, as well as objectives to maximize power production at each of the facilities in the Basin. Although these objectives are not necessarily diametrically opposed, it is difficult to reconcile both of these concepts without favoring one issue over another; the same is true with the Tribal perspective.

During the development of the Fish Accords, the Tribes advocated for an approach that would place an emphasis on efforts to build system resiliency and efficacy in lieu of participating in

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abundance and providing habitat restoration, and have used BPA's funding to leverage additional resources from others. But going forward, we must continue to be deliberate about controlling Fish and Wildlife Program costs, consistent with sound business principles and in the context of BPA's competitive position, while assuring that fish and wildlife receives equitable treatment with the other purposes of the system, as required by the Northwest Power Act.

litigation. The outcome of this environmental review for operations also has objectives for integrating adaptive management techniques and measures to mitigate the effects of power generation on mainstem Columbia River habitat attributes. The effect of any management scheme will depend on the consensus of co-managers and action agencies on those measures with the most potential to re-build an ecosystem impacted by a century of over-development.

Mitigation measures will be critical to resolve long-standing issues with the operational aspects of the system (i.e., spill, juvenile survival, adult passage, etc.). As with previous comments and position statements, the Tribes continue to advocate for a more comprehensive approach to resolve issues with ESA-listed populations in Idaho. The populations most at risk are those populations occupying the furthest extent of anadromy in the Basin and should be the highest priority for mitigation measures. While the Tribes recognize that there are significant issues in the mainstem reaches and associated tributaries throughout Oregon and Washington, the fact remains that the majority of listed anadromous fish species in the Basin occur in Idaho. Thankfully, central Idaho has large areas of high quality spawning and rearing habitat available to anadromous fishes. These habitats, such as the Middle Fork Salmon River, are intact and functioning in a manner that best exemplifies the ecological integrity of natural riverine ecosystems; except for the absence of abundant runs of anadromous fishes and marine derived nutrients.

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. Selecting this alternative would require additional work within the project on the ground and by action agency policy makers through coordination with affected stakeholders, Congress, Tribes, and the States. While the undertaking is undoubtedly the largest single action for the conservation of listed species in the Basin, it is also appropriate given the challenges we face collectively and the needs of our Tribe noted in the preceding discussion.

Through this evaluation, each agency, tribe, and State agency is offered an opportunity to develop a measure that fundamentally re-prioritizes our current paradigm into one that balances sustainable utilization of water resources for power generation and anadromous fish resources. In the next century we will face an unprecedented shift in how water resources are allocated at each project and how species reliant on those resources adapt to changing thermal regimes. By selecting an alternative to remove obsolete and unnecessary projects today, we will have an opportunity to support conditions suitable for anadromous fish species throughout the mainstem migratory corridor. It is unrealistic to assume that hydroelectric features constructed for climatic conditions during the mid-twentieth century will remain effective in the next. In fact, we are already seeing the limitations of current conditions for species like Snake River sockeye salmon. In addition, the nature of decentralized renewable energy projects in the Basin will provide new opportunities for communities to access sustainable energy resources from the market. Anadromous fish populations in the Snake River subbasin are experiencing average annual smolt to adult returns of less than one-half of one-percent (e.g. Snake River sockeye salmon averages 0.1-0.3%). There simply is no easy way to improve anadromous fish productivity and ecological health, maintain harvest and hydroelectric production, and support tribal lifeways without a change in how we view the system. Confrontation, particularly in the context of Basin litigation, is typically a debate over deeply ingrained views on the best way to manage our special riverine resource; those involved come to the table with a philosophy constructed over decades of litigious confrontation. There is no way to debate our way out of an inescapable truth facing the Basin, that the resources we all rely on are going to continue to change regardless of who prevails in a courtroom; it is up to each manager and action agency to adapt to that change.

Adaptation is the process of changing habits and perspectives to meet a new reality that challenges our ability to thrive in the environment we all call home. Adaptation is not an easy process; it is painfully slow and requires a fundamental shift in behavior. In a similar fashion, meeting the coming challenges will not be an easy task, but the Tribes remain optimistic that collectively we can make the necessary decisions about our environment. This begins with re-imagining how the System could operate more efficiently with new attributes, and by leaving antiquated solutions in the past. The current environmental evaluation is not going to be a 'silver bullet' solution for every issue facing anadromous fish, hydroelectric project operators, or stakeholders tied to the riverine ecosystem; but it is a start. Bold decisions are borne of necessity; wise decisions are made in context of both time and place, while the worst decisions are made by holding onto past solutions that did not deliver the promised results. The Tribes view the selection of an alternative to breach the lower four Snake River dams as a decision that meets the necessity of conserving wild fish and offers a new paradigm for our posterity.

Spokane Tribe of Indians

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June 3, 2019

Subject: Columbia River System Operation: Tribal Perspective

Brigadier General D. Peter Helmlinger,

The Spokane Tribe of Indians traces a deep and rich history that is tied to inland northwest waterways, especially the Spokane River. The lower stretch of the river is known today as the Spokane Arm of Lake Roosevelt, which stretches 30 miles from Little Falls Dam to its confluence with the Columbia 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.

Throughout history, the Spokane River has been a center of Spokane ancestral culture with a documented time depth of at least 8000 years. 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. Many of these sites have been recommended as eligible for listing on the National Register of Historic Places (NRHP), and two archaeological/traditional cultural place (TCP) districts containing a combined 33 sites are in the process of being recommended as eligible for NRHP listing.

The Spokane Tribe is inextricably tied to the Spokane River, resulting in a close association with this place that began thousands of years ago and continues into the present day. As a result, the Spokane Tribe considers the entire Spokane Arm a traditional cultural place.

Sincerely,

Carol Evans, Chairwoman
Spokane Tribe Business Council

Columbia River System Operations
Final Environmental Impact Statement

Appendix Q
Cost Analysis

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ACRONYMS AND ABBREVIATIONS

CEFMS	Corps of Engineers Financial Management System
O&M	Operations and maintenance
No Action Alternative	No Action Alternative
MOs	Multiple objective alternatives
CRSO	Columbia River System Operations
CRFM	Columbia River Fish Mitigation
ESA	Endangered Species Act
ROD	Record of Decision
NREX	Non-routine Extraordinary Expense
NEPA	National Environmental Policy Act
MCACES	Micro-Computer Aided Cost Engineering System
MII	Second Generation (MCACES)
BOR	U.S. Bureau of Reclamation

CHAPTER 1 - INTRODUCTION

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 CRSO alternatives. The emphasis of the cost analysis is to understand the cost difference between alternative, particularly between the proposed CRSO action alternatives, including the multi-objective alternatives (MOs) and the Preferred Alternatives (PA) and the No Action Alternative (No Action Alternative). Implementation costs include the costs of constructing proposed structural measures under the action alternatives. All alternatives including the No Action Alternative 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 action alternative. These on-going future costs include capital investments, routine and non-routine operations costs (including extraordinary maintenance (NREX), and mitigation costs including fish & wildlife mitigation 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. 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 (2019), EGM 20-1, Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2020). Construction of structural measures and associated operations is assumed to begin in 2021.

The details of the methodology and results of the cost analysis are presented in this appendix. An overview of the approach is presented in Chapter 2. In addition, the methods to estimate the costs of the structural measures are described in Annex A. The approach to develop the costs for each of the additional mitigation measures as well as the cost estimate for each measure is provided in Annex B. Finally, Annex C of this appendix provides the methods and results of a regional economic analysis, which estimates the jobs and income supported by the CRS system costs under the No Action and action alternatives.

CHAPTER 2 - OVERVIEW OF APPROACH

USACE, Bonneville, and BOR technical specialists, including hydrology and hydraulics engineering, operations, cost engineering, budget, asset management, project-specific specialists, fish, navigation, and hydropower provided input to the cost analysis. An extensive effort was undertaken to obtain a comprehensive perspective of the costs to operate the CRS under the No Action Alternative and how these costs would change under the multiple objective alternatives.

This section provides a brief overview of the methodology to conduct the cost analysis. Table 2-1 provides a short description of the cost categories, organized by the four general categories described above: construction costs of structural measures; capital costs; operations and maintenance (O&M) costs; and mitigation costs. There is additional detail on the methodology employed to estimate costs for each category in Chapters 3, 4, and 5 of this appendix.

The costs to operate the system are funded through multiple mechanisms including federal tax dollars appropriated to cover system costs, as well as revenue generated through the marketing and sale of hydropower. The Corps and Reclamation receive annual Congressional appropriations to fund system capital, and operations and maintenance activities. Bonneville funds the power-share of these costs to the Corps, Reclamation and USFWS. In addition, Bonneville is responsible for repaying the US Treasury for a share of the appropriations if it is determined that the costs are appropriately allocable to power. The cost team has made every effort to not double count the costs included in the cost analysis. For example, if the Corps receives both appropriations and Bonneville direct funding for a capital investment, each portion of those costs go into separate categories, the sum of which is the total spent on the investment.

Table 2-1. Cost Components and Descriptions

Cost Category		Description	Source
Construction of Structural Measures	Structural Measure Costs of the Action Alternatives	Includes 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 administration costs (Bonneville, Corps, and Reclamation).	USACE Cost Engineering Center of Expertise
Capital Costs	Capital Costs (Power Specific and Joint)	Includes 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 USACE and BOR 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); USACE District and Bureau of Reclamation resource and budget specialists
O&M Costs	Non-routine Extraordinary Maintenance (NREX) Costs (Power Specific and Joint)	Includes Bonneville's power specific and joint costs for non-routine extraordinary maintenance, such as costs for repair of a failed units. Includes the USACE 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; USACE 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 one of the 14 Columbia River Projects (Bonneville).	Corps of Engineers Financial Management System, queried by AMSCO code, Category Class Subclass (CCS) code, for past five fiscal years
	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
	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
	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
	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 BOR cultural resource specialists; Federal Columbia River Power System Fiscal Year 2018 Annual Report.

Cost Category		Description	Source
	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
	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 activities required to maintain the federal deep draft and shallow draft navigation channel (mouth of the Columbia, lower Columbia Deep Draft, Columbia Shallow, and lower Snake River Shallow Draft) (Corps).	Corps operations technical specialists and asset managers
Mitigation Costs[1]	Bonneville Fish and Wildlife (F&W) Program[2]	Bonneville provides funding to multiple local, state, tribal, and federal entities as part of its F&W Program to implement off-site mitigation actions[3] listed in various Biological Opinions for ESA-listed species as well as off-site mitigation actions for non-listed species. The Bonneville F&W Program also supports efforts to protect, mitigate, and enhance fish and wildlife affected by the development and operation of the Federal Columbia River Power System (FCRPS), which includes the CRS under the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act) (16 U.S.C. § 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	Bonneville and Corps operations and budget specialists

[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] This category only includes non-capital expenses; Bonneville F&W program capital costs, such as hatchery construction, are evaluated as part of the Power and Transmission analysis (see Power Revenue Requirement under Section 3.7.2.7).
[3] Over the last decade, the Co-lead Agencies have worked to improve the quantity and quality of fish habitat in the estuary and tributaries as “off-site 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 implemented 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.

Cost Category		Description	Source
		funds USFWS for the annual operation and maintenance of these LSRCP facilities.[4]	
	Columbia River Endangered Species Act (ESA) Mitigation	These funds are used to meet the BOR ESA requirements, including mitigation commitments in coordination and administration; hydrosystem management; hatcheries; research monitoring and evaluation; tributary habitat improvement projects; and predation management (Reclamation)	BOR 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).[5]	Corps Construction Account, obtained from Corps Northwestern Division Program Managers
	Costs of Additional Mitigation Measures under the CRSO alternatives	Mitigation measures were developed that would mitigate adverse impacts of the multiple objective alternatives. Construction or annual costs as well as any relevant O&M and non-routine costs were developed for the additional mitigation measures from input from Bonneville, Corps, and Reclamation specialists.	USACE cost engineers from the Cost Engineering Center of Expertise

[4] 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.
[5] Bonneville is required to repay the power-share of the CRFM appropriations, with interest.

2.1 NO ACTION ALTERNATIVE

The No Action Alternative provides a baseline for understanding the costs associated with operating and maintaining the CRS. These costs include all the cost categories summarized in Table 2-1 above, except for structural measures construction costs. The No Action Alternative also provides a starting point for determining how costs will change as various structural or operational changes or both are made under action alternatives. Under the No Action Alternative, it was assumed the CRS would continue to be operated in a similar manner to current operations, balancing operations for congressionally authorized purposes across the CRS. Under the No Action Alternative, co-lead agencies will continue to maintain system infrastructure, while making 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.

The No Action Alternative was developed with extensive input from Bonneville, Reclamation, and the Corps to provide a comprehensive accounting of all costs to operate and maintain the CRS. A team from the three agencies met regularly to discuss cost data needs, review the costs, and verify and validate the cost analysis. Experts from the three agencies provided input on current, historic, and, if possible forecasted, large and small capital costs; non-routine extraordinary maintenance (NREX); routine operations and maintenance costs; mitigation costs including F&W costs and costs of mitigation measures specific to the CRSO alternatives; and others. These current, historic, and forecasted costs were used to estimate the total costs to operate and maintain the CRS.

2.2 CONSTRUCTION COSTS OF THE STRUCTURAL MEASURES

Cost estimates for each of the structural measures included in the action alternatives were developed by the cost engineers at the Corps Mandatory Cost Center of Expertise at the Walla Walla District. Given the uncertainty associated with the planning level design for structural measures, a contingency of 50 percent was added to all construction estimates. Based on historic Corps cost engineering estimates, 30 percent of the construction and contingency cost was included to account for supervision, administration, and engineering during construction. The total project first costs for the structural measures are assumed to be implemented over the first two years after the signing of the Record of Decision (ROD), consistent with co-lead agency guidance.[6] The RODs are scheduled to be signed in 2020; construction is assumed to occur in 2021 and 2022.

[6] Project first costs include construction costs, as well as contingency, supervision and administration, planning engineering and design, and engineering during construction. They do not include any annual O&M costs (including NREX) that may be necessary once the structural measures are constructed. See Annex A: Cost engineering for further details.

The structural measures only include measures that are unique additions under an action alternative. For example, as described under the No Action Alternative, the co-lead agencies will continue to invest in power-related capital improvements, additions, replacements and fund O&M (including NREX), as needed (described in Capital and O&M costs). Based on a review of structural measures relative to these system costs it was determined that some structural measures are planned under No Action Alternative and all action alternatives, and therefore these costs are included under the system costs for capital and O&M only. For example, the fish turbines at John Day are currently planned to be constructed and the capital costs for their implementation are included in the Strategic Asset Management Plan. Therefore, this measure and associated cost is included as a capital cost under No Action Alternative and the multiple objective alternatives and not included under the structural measures to avoid double counting.

Additional details on the cost estimates for the structural measures under the multiple objective alternatives are provided in Section 3.19, Implementation and System Cost Analysis of the EIS and in Annex A, Costs of the Structural Measures.

2.3 CAPITAL AND OPERATIONS AND MAINTENANCE COSTS

Costs to operate the CRS were organized into two categories: 1) capital costs; and 2) routine and non-routine O&M costs. If possible, costs were categorized by project. The capital costs include power-specific and joint large and small capital costs. The O&M costs include routine costs to operate and maintain the projects, non-routine extraordinary maintenance (NREX) costs, and non-routine navigation maintenance, such as dredging and lock and dam costs.

Capital and O&M costs, including NREX costs, have been estimated for each action alternative based upon the specific structural and operational measures included. An estimate of capital and O&M costs were developed by operations and programs staff based upon their knowledge of similar structural measures, and costs associated with system operations. In general, the estimated changes are relatively small compared to the No Action Alternative, with the exception of MO3 for the lower Snake River projects.

2.4 MITIGATION COSTS

The federal agencies are required to protect, mitigate, and enhance fish and wildlife affected by the operation of the CRS projects. In addition, NEPA requires that mitigation measures be identified to avoid significant impacts of proposed alternatives. This section describes fish and wildlife mitigation activities, including the Endangered Species Act (ESA) compliance across the CRS, as well as additional mitigation measures that were identified for each action alternative to mitigate adverse impacts.

2.4.1 Fish and Wildlife

The Bonneville Fish and Wildlife (F&W) Program funds hundreds of projects each year to mitigate the impacts of the federal hydropower system on fish and wildlife. Bonneville began this program to fulfill mandates established by Congress in the Pacific Northwest Electric Power Planning and Conservation Act of 1980[7] to protect, mitigate, and enhance fish and wildlife affected by the development and operation of the FCRPS. Each year Bonneville funds projects with local, state, tribal, and federal entities to fulfill its Northwest Power Act fish and wildlife responsibilities and to implement offsite mitigation actions listed in various Biological Opinions for ESA-listed species, including direct funding of Corps and Reclamation fish and wildlife projects.

In addition to its F&W Program, Bonneville also directly funds the annual operations and maintenance of the Lower Snake River Compensation Plan (LSRCP) facilities. A major component of the authorized Plan was the design and construction of fish hatcheries and satellite 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 dams. Current and anticipated future annual costs for Bonneville's F&W program and LSRCP, were developed by Bonneville F&W Program experts for the No Action and action alternatives

The Corps has recently completed construction and implementation activities associated with its LSRCP authorization, including habitat development and game bird production, throughout the lower Snake River basin. The Corps would continue to manage fish and wildlife resources through its O&M funding.

The Corps and Reclamation also provide funding for fish and wildlife conservation measures and activities under obligations to the Endangered Species Act. The Corps has a construction program for fish and wildlife mitigation activities, titled the Columbia River Fish Mitigation (CRFM). Reclamation's mitigation costs include ESA compliance measures for habitat improvement, hatcheries, and monitoring activities. The No Action Alternative cost estimates were provided by program specialists at the Corps and Reclamation, along with estimates of how costs would likely change under the action alternatives.

2.4.2 Additional Mitigation Measures for the CRSO Alternatives

Mitigation measures were developed that would mitigate adverse impacts related to the implementation of action alternatives (see Chapter 5 of the DEIS). The measures were identified during the resource evaluations and include reasonably foreseeable activities that could be undertaken to avoid, minimize or mitigate adverse impacts from occurring under the action alternatives. These activities may include protecting cultural resources, improving or mitigating fish and wildlife or water quality impacts under the breach scenario, among others.

The associated costs for these mitigation measures were estimated by the cost engineers at the Mandatory Cost Center for Expertise with input from the Corps, Reclamation, and Bonneville

[7] Section 4(h)(10)(A), 16 U.S.C. § 839b(h)(10)(A).

specialists. Bonneville is obligated to repay the power share of these costs. Additional details on the mitigation measures are provided in Annex B, Costs for Additional Mitigation Measures.

2.5 RISK AND UNCERTAINTY

There are multiple areas of risk and uncertainty related to the development of the cost analysis. In fact, risk and uncertainty are inherent with any model that is developed and used for water resource planning. Much of the risk and uncertainty associated with modeling the costs stem from the assumptions that historic activities and costs would reflect cost estimates in the future. There are uncertainties in terms of the needs and timing of O&M, capital requirements, fish and wildlife mitigation, and construction costs of the structural measures; the cost estimates associated with those needs or requirements; and execution risk associated with timing and the ability to obtain authorizations and appropriations to implement the alternatives, and others. Future costs can also be affected by technological advancements and cost efficiencies although any future changes in technologies are speculative. Additional descriptions of the uncertainties surrounding the implementation and system cost categories are described in relevant methodology sub-sections in this Appendix. In some cases, uncertainty ranges have been estimated, if possible, with historic data (i.e., for routine operations and maintenance, Portland dredging costs).

Due to a complex federal study approval and project appropriation process, the actual implementation timeframe for each alternative is uncertain. The effect of assuming a shorter timeframe is that it reduces the effect of discounting for costs that may not actually occur for several years, therefore increasing the annualized costs of structural measures associated with the alternatives. As described above, the cost analysis presents annual-equivalent costs over the 50-year period of analysis in 2019 dollars, and construction of structural measures and associated operations is assumed to begin in 2021. For consistency across alternatives, construction of the structural measures under each action alternative is assumed to occur over a two-year period. However, there is uncertainty around the potential implementation timing for a complex alternative such as the dam breaching alternative (MO3). As a result, a sensitivity analysis was completed to determine the effect of construction timing on costs, which is described in Section 3.1.2. Given the unknowns surrounding implementation, there is no simple solution to reduce this uncertainty. However, further detailed evaluation would occur on planning, design, and engineering, after the CRSO FEIS is completed.

CHAPTER 3 - COSTS OF THE STRUCTURAL MEASURES

3.1 DATA COLLECTION AND METHODS FOR STRUCTURAL MEASURES

This section describes how the cost estimates of the structural measures were developed and summarizes these costs by alternative. The detailed cost estimates for each structural measure are provided in Annex A, Costs of the Structural Measures. This section also describes the approach and cost estimates for real estate administration costs associated with MO3.

3.1.1 No Action Alternative

Generally, the structural measures under the multi-objective alternatives would not occur under the No Action Alternative. As described previously, there is one structural measure that would be implemented under the No Action Alternative and all of the multi-objective alternatives, including the preferred alternative -- the fish passage turbines at the John Day project. This measure is currently included in the three-agency Strategic Asset Management Plan (SAMP). As a result, in order to avoid double counting it is not treated as a "new" structural measure, but rather associated construction and implementation costs for this measure are included in the capital costs under the No Action Alternative and all of the multi-objective alternatives (see Chapter 4). The implementation of this structural measure would occur over multiple years, consistent with assumptions in the SAMP.

3.1.2 Multiple Objective Alternatives

This section describes the approach to estimate the construction costs of the structural measures and the real estate administrative costs under MO3.

3.1.2.1 Construction Costs of the Structural Measures

Construction cost estimates for each of the structural measures were developed by the cost engineers at the Corps Mandatory Cost Center of Expertise at the Walla Walla District. The construction costs were developed based on the Corps Micro-computer Aided Cost Estimating System (MCASES) Second Generation (MII) with the conceptual designs of the structural measures, and also using construction requirements and design from similar projects and studies (e.g., Lower Snake River Juvenile Salmon Migration Final Feasibility Report and Environmental Impact Statement (2002a). Where designs were not available, an escalation factor was applied to the costs developed in the 2002 Lower Snake River Juvenile Salmon Migration Final Feasibility Report and EIS utilizing the Civil Works Construction Cost Index System (CWCCIS) tables for the type of construction anticipated. For a number of measures that were escalated from the *Lower Snake River Juvenile Salmon Migration Final Feasibility Report and EIS* (2002), additional efforts were undertaken to validate the costs; cost estimates were developed with the MCACES MII based on the same scope as in the 2002 Report. These newly developed estimates were very similar to the escalated costs from the 2002 Report.

For the dam breaching measures, preliminary designs were used from the 2002 Lower Snake River Juvenile Salmon Migration Final Feasibility Report and EIS along with the MCACES MII system to provide the cost estimates. A contingency of 50 percent was added to all construction estimates based on preliminary designs, scope, and uncertainty surrounding the construction estimates and in consultation with Bonneville. A 50 percent contingency is typical for this level of scope and cost engineering estimate development. Thirty percent of the construction and contingency cost was included to account for supervision, administration, planning, engineering, design, and engineering during construction costs based on historic Corps cost engineering experience with these types of costs. All costs were developed at a 2019 price level. The costs for construction, contingency, supervision, administration, and engineering during construction in total are referred to as the "project first costs" or "first costs." The cost estimates for the structural measures are provided in Annex A of this document.

The construction costs for the structural measures were assumed to be implemented over the first two years of the project (2021 and 2022), consistent with guidance provided by the co-lead agencies. Although some of these measures, especially the dam breaching measures, may take a number of years to implement or may not start for a number of years (pending further studies), it was necessary to provide a consistent time-frame for implementation in the evaluation to compare across the alternatives. A sensitivity analysis was conducted on the timing of the construction in terms of its impact on annualized costs under MO3. A scenario was conducted to estimate the annual-equivalent cost if the construction costs for the lower Snake River dams, including demolition, supervision, administration, and engineering during construction, occurred over 10 years, as compared to the two-year construction implementation assumption. Because of the large system costs, delaying and spreading out costs for breaching the lower Snake River dams would result in a change in annual-equivalent costs for the construction activity of $3.8 million (from $46.7 million with a two-year implementation to $42.9 million with a 10-year implementation schedule). This difference in cost ($3.8 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 evaluation.

Any needed operations and maintenance or capital costs associated with the structural measures under the multiple objective alternatives (or operational measures) are assessed as changes in capital and O&M costs in Chapters 4 and 5.

3.1.2.2 Real Estate Administrative Costs under MO3

Real estate administrative costs were captured as first costs under MO3. It is anticipated that the Corps would retain jurisdiction over the land holdings throughout the implementation period and biological evaluation process and that public control of a portion of public lands would be necessary to protect the environmental and natural benefits to salmon associated with dam breaching. Post dam breaching, the Corps may choose to transfer the lands to another federal or state agency.

Under the dam breaching measures of MO3, it could be necessary to negotiate agreements with affected parties and property owners and enter into relocation contracts for the alteration or replacement of affected structures. Under MO1, MO2, and MO4, there would be no additional real estate costs compared to the No Action Alternative and therefore no further evaluation was necessary.

Real estate administrative costs were developed for renegotiating contracts, leases, agreements, rights-of entry, etc. Given the uncertainty in the design and specifics of MO3 at this point, the real estate evaluation used the approach from the *Lower Snake River Juvenile Salmon Migration Final Feasibility Report and Environmental Impact Statement* (2002) and updated the data and costs as needed (Corps Walla Walla District Real Estate Division, 2019). Further detailed evaluation would occur on planning, design, engineering, real estate, costs, etc., in subsequent studies, if MO3 were chosen for implementation.

The Walla Walla District Real Estate Division reviewed the evaluation that was conducted under the *Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement, Appendix K* (2002b). The Corps Real Estate experts updated the 2002 figures to reflect current numbers of contracts and agreements, where possible. Real estate administration costs for modifying a number of the contract components used the 2002 study costs and updated the costs to current price levels with the West All Urban Consumer Price Index (CPI) (U.S. Bureau of Labor Statistics, 2019). The present value of the real estate administration costs was estimated to be $1.9 million, and the annual-equivalent cost over the 50-year period was estimated to be $70,000.

3.2 STRUCTURAL MEASURE COST ESTIMATES

The costs estimated for structural measures by alternative are provided below.

3.2.1 No Action Alternative

The structural measures under the action alternatives would not occur under the No Action Alternative and therefore there are no cost estimates for new structural measures. Please note that the No Action Alternative includes activities to operate the system, including capital investments and operations and maintenance costs, which are described in Chapters 4 and 5, respectively.

3.2.2 Multi-Objective Alternative 1

The present value of the costs for the structural measures for MO1 are estimated to be $532 million, which includes construction and associated contingency costs, supervisions and administration costs, and planning and engineering during construction costs. When amortized over the 50-year period of analysis, the annual-equivalent cost is approximately $20.2 million.

Almost half of the cost associated with structural measures would occur at the McNary project ($243 million in present value costs), where a number of structural measures would be constructed. These measures include construction of additional surface passage (modifications to the juvenile fish facility and to the floor elevation of the project; adding telescoping weirs); upgrading spillway weirs to adjustable spillway weirs; constructing lamprey passage structures; modifying the turbine cooling water strainer systems to exclude lamprey; modifying the turbine intake bypass screens to reduce impingement; and modifying existing fish ladders. The most costly measure at McNary is the additional surface passage ($152 million in present value costs).

The costs of the structural measures at Ice Harbor are second highest under MO1 after those at McNary, with a present value cost of $109 million. Many of the same measures would occur at Ice Harbor as planned at McNary. Although additional surface passage would be constructed at Ice Harbor, it is almost half as costly as McNary because many of the modifications to the fish facility at McNary would not be needed at Ice Harbor. New pumping systems would be installed for the fish ladders at Ice Harbor and Lower Monumental dams.

A number of weirs would be upgraded to adjustable spillway weirs under MO1, with a cost between $19 to $38 million per project (present value costs), including at Lower Granite, Lower Monumental, Ice Harbor, McNary, and John Day projects. Modifying the intake bypass screens that cause juvenile lamprey impingement and entanglement would be constructed at McNary, Little Goose, and Lower Granite, and would cost between $21 million and $50 million per project in costs (present value) at each project.[8]

3.2.3 Multi-Objective Alternative 2

The costs associated with the structural measures for MO2 are estimated to be $1.4 billion (present value), which includes construction and associated contingency costs, supervisions and administration cost, and planning and engineering during construction costs. When amortized over the 50-year period of analysis, the annual-equivalent cost is approximately $53.5 million.

Much of the cost increase under MO2 compared to MO1 occurs at McNary ($894 million under MO2 versus $243 million under MO1 in project costs). Additional surface passage would be constructed at McNary including construction of a collection channel for surface passage, a dewatering facility, demolition of the fish facility, and repurposing water through replacing fish pumps. In addition, under MO2, additional surface passage would be constructed at John Day, which also does not occur under MO1, with a project present value cost of $239 million.

Similar to MO1, MO2 includes updates to the adjustable spillway weirs at Lower Granite, Lower Monumental, Ice Harbor, McNary, and John Day projects; modifying the intake bypass screens that cause juvenile lamprey impingement and entanglement at Little Goose and Lower Granite (this would not occur at McNary as under MO1); modifying the turbine cooling water strainer systems to exclude lamprey at all of the lower Snake River and Lower Columbia river projects;

[8] The current intake bypass screens would likely be replaced when needed (and not necessarily within the first two years of the period of analysis).

and modifying existing fish ladders at the lower Snake River projects and The Dalles, Bonneville, and McNary projects.

3.2.4 Multi-Objective Alternative 3

The total cost of the structural measures for MO3 is estimated to be $1.2 billion (net present value), which includes construction and associated contingency costs, supervision and administration costs, and planning and engineering during construction costs. Of the $1.2 billion, $953 million (or approximately 77%) would costs associated with breaching the lower Snake River dams. When amortized over the 50-year period of analysis, the annual-equivalent cost is approximately $46.7 million ($36.2 million for the costs for breaching the lower Snake River dams). Breaching of the dams includes constructing water control structures such as cofferdams and levees at breach locations to direct and control flows, and removal of earthen and adjacent structures at the dams to facilitate reservoir drawdown.

Similar to MO1, MO3 includes constructing additional powerhouse surface passage at McNary Dam; updating to adjustable spillway weirs at McNary and John Day projects; modifying the turbine cooling water strainer systems to exclude lamprey at all of the Lower Columbia river projects; and modifying existing fish ladders at The Dalles, Bonneville, and McNary projects.

3.2.5 Multi-Objective Alternative 4

The total present value of the costs associated with the structural measures for MO4 are estimated to be $1.2 billion, which includes construction and associated contingency costs, supervision and administration costs, and planning and engineering during construction costs. When amortized over the 50-year period of analysis, the annual-equivalent cost is approximately $45.4 million. The structural measures that differ from the other alternatives under MO4 include spillway weir notch inserts at the lower Snake River projects, McNary and John Day projects. MO4 would not include upgrading to adjustable spillway weirs at any of the projects.

Similar to MO1, MO4 includes modifying the intake bypass screens that cause juvenile lamprey impingement and entanglement at Little Goose, Lower Granite, and McNary projects; modifying the turbine cooling water strainer systems to exclude lamprey at all of the lower Snake River and Lower Columbia river projects; and modifying existing fish ladders at the lower Snake River projects and The Dalles, Bonneville, and McNary projects.

3.2.6 Preferred Alternative

The total present value of the structural measure costs for the preferred alternative are estimated to be $104 million, and when amortized over the 50-year period, the annual-equivalent cost is estimated to be approximately $3.9 million, considerably lower than the other MOs. Structural measures would be constructed at Bonneville, The Dalles, John Day, McNary, and the four lower Snake River projects. The projects that would incur the largest costs under the preferred alternative are at Bonneville for the Lamprey passage structures and the ladder serpentine weir; and at Lower Granite and Little Goose projects associated with the bypass screen modifications for Lamprey.

CHAPTER 4 - CAPITAL COSTS

4.1 DATA COLLECTION AND METHODS

This section describes the cost components included in the capital costs under the No Action Alternative and the methods to estimate the changes in capital costs under the action alternatives. Section 4.2 summarizes the capital costs for all of the alternatives.

4.1.1 No Action Alternative

Under the No Action Alternative, there are several items under the category of capital costs, including the Bonneville direct-funded power-specific and joint capital costs as well as the Corps and Reclamation joint capital costs. The large and small capital investments needed to maintain the projects were obtained from the SAMP. The 2018 SAMP forecasts capital requirements for assets based on their estimated economic end-of-life between the years 2019 to 2068. The large capital requirements include rehabilitation and replacement costs for hydropower equipment as well as the Bonneville funded portion of "joint" features that serve or mitigate for multiple purposes at the facilities. The SAMP outlines strategies for both the FCRPS Asset Management System and FCRPS hydro system assets. Asset management maturity is assessed and specific gaps are described with plans for improvement. For asset strategies, optimal levels of investment are identified based on the condition, criticality and risk of FCRPS assets. These results are intended to drive investment identification and, in combination with input from the 31 hydropower facilities, form the basis for the FCRPS System Asset Plan. The SAMP is developed by experts at the three Co-lead Agencies.

There are multiple areas of uncertainty related to these future capital costs, including equipment replacement and repair needs and timing, cost estimates of the capital requirements, and execution risk (i.e., planning timing, authorizations, and appropriations). Bonneville has begun a process to evaluate how well the individual investments in the short-term (one year out) align with the cost estimates; however, any evaluation of the magnitude of this uncertainty related to capital cost estimates would be speculative and is beyond the scope of this evaluation. To reflect a 50-year period of analysis, these capital costs were extended to the year 2070 by averaging the previous 5 years. The SAMP investments are adjusted for inflation every year; so they were deflated to 2019 dollars using the rates of inflation provided by Bonneville (2.08% annually for the SAMP costs).[9] Then the total present value for inflation adjusted capital costs was estimated based on the 2019 federal water resources discount rate of 2.785%, and then amortized over the 50-year period for an annual-equivalent value. For all projects, SAMP large and small capital costs are estimated to be $233 million annually.

The capital costs also include the Corps and Reclamation share of joint costs (often referred to as joint tail) for large and small capital costs for the 14 federal CRS projects. District and project experts relied on past years joint costs as a percentage of the SAMP to project future joint costs

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[99] For the purposes of Bonneville cost recovery, the costs of capital assets are recovered over the useful life of the asset. The NREX costs are recovered in the year they are incurred.

based on the future SAMP costs. Annual joint capital costs for Corps and Reclamation projects were estimated to be $12.0 million for large and small capital costs.

4.1.2 Action Alternatives

The structural measures under the action alternatives were reviewed by Corps and Reclamation engineers, operations support, and budget experts to assess how the new infrastructure and structures under the alternatives would affect needed capital investments in the future (Corps Walla Walla District, 2019a; Corps Portland District, 2019a; Corps Seattle District, 2019a). In many cases, a structural measure would require replacement or major rehabilitation over the 50-year period.[10] A one-time cost for these replacements or rehabilitations was assumed to occur in year 25. These costs were assessed by project, discounted to reflect the present value in in 2019$, and then amortized over the 50-year period to provide an annual-equivalent cost.

Under MO3, the capital costs reflected by the SAMP as well as the Corps and Reclamation joint capital cost for the four lower Snake River projects would be assumed to no longer be incurred. With the selection of MO3, Bonneville budgets and expenses and the associated cost shares associated with the four lower Snake projects would no longer be budgeted or expended, starting at the beginning of the period in year 2021 for the 50-year period of analysis.

4.2 CAPITAL COST ESTIMATES

This section provides estimates of the capital costs under the No Action Alternative and multi-objective alternatives.

4.2.1 No Action Alternative

Table 4-1 summarizes the capital costs for the No Action Alternative, which include power-specific capital investments (from SAMP) and joint capital costs. Grand Coulee and McNary have the highest capital costs under the No Action Alternative, with an annual cost of $70.9 million and $29.8 million, respectively.

Table 4-1. Capital Cost Estimates for the No Action Alternative (2019$)

Project	Annual-equivalent Cost	Percent of Total Cost
Bonneville	$18,653,000	7.6%
The Dalles	$26,203,000	10.7%
John Day	$24,326,000	9.9%
Chief Joseph	$18,980,000	7.7%
Grand Coulee	$70,921,000	28.9%
Albeni Falls	$2,783,000	1.1%
Libby	$7,168,000	2.9%
Hungry Horse	$8,530,000	3.5%
McNary	$29,763,000	12.1%

[10] The non-routine costs associated with the rehabilitation or major repair of the structures were captured as capital costs, although sometimes activities are funded through NREX.

Project	Annual-equivalent Cost	Percent of Total Cost
Ice Harbor	$8,237,000	3.4%
Lower Monumental	$8,607,000	3.5%
Little Goose	$8,740,000	3.6%
Lower Granite	$6,605,000	2.7%
Dworshak	$5,681,000	2.3%
Total	**$245,199,000**	**100.0%**

4.2.2 Multiple Objective Alternative 1

Under MO1, there would be very little change in the capital costs compared to the No Action Alternative, a change of approximately 0.02 percent annually over the period of analysis (Table 4-2). The costs would change only slightly under MO1 associated with the upgraded spillway weirs, Lower Granite trap modifications, lower Snake river ladder pumps, and the modifications to the turbine strainer systems to safely exclude lamprey when compared with the capital expenses that would continue to be required to operate the CRS under the No Action Alternative.

Table 4-2. Capital Cost Estimates for MO1 and Change from the No Action Alternative (2019$)

Project	Annual-equivalent Cost	Change in Annual-equivalent Cost from No Action Alternative	Percent Change from No Action Alternative
Bonneville	$18,661,000	$8,000	0.0%
The Dalles	$26,211,000	$8,000	0.0%
John Day	$24,337,000	$11,000	0.0%
Chief Joseph	$18,980,000	$0	0.0%
Grand Coulee	$70,921,000	$0	0.0%
Albeni Falls	$2,783,000	$0	0.0%
Libby	$7,168,000	$0	0.0%
Hungry Horse	$8,530,000	$0	0.0%
McNary	$29,772,000	$9,000	0.0%
Ice Harbor	$8,242,000	$5,000	0.1%
Lower Monumental	$8,612,000	$5,000	0.1%
Little Goose	$8,743,000	$2,000	0.0%
Lower Granite	$6,613,000	$9,000	0.1%
Dworshak	$5,681,000	$0	0.0%
Total	**$245,256,000**	**$57,000**	**0.02%**

4.2.3 Multiple Objective Alternative 2

Under MO2, there would be very little change in the capital costs compared to the No Action Alternative, an increase of approximately 0.02 percent annually over the period of analysis (Table 4-3). When compared to MO1, there are two structural measures under MO2 that would result in a slight change in costs under MO2. Additional powerhouse surface passage would occur at John Day under MO2 and not under MO1, and Lower Granite trap modifications would occur under MO1 but not under MO2. When these capital costs associated with these structural measures are annualized over the 50-year period of analysis, there is very little change in these costs compared to the No Action Alternative.

Table 4-3. Capital Cost Estimates for MO2 and Change from the No Action Alternative (2019$)

Project	Annual-equivalent Cost	Change in Annual-equivalent Cost from No Action Alternative	Percent Change from No Action Alternative
Bonneville	$18,661,000	$8,000	0.0%
The Dalles	$26,211,000	$8,000	0.0%
John Day	$24,338,000	$12,000	0.0%
Chief Joseph	$18,980,000	$0	0.0%
Grand Coulee	$70,921,000	$0	0.0%
Albeni Falls	$2,783,000	$0	0.0%
Libby	$7,168,000	$0	0.0%
Hungry Horse	$8,530,000	$0	0.0%
McNary	$29,772,000	$9,000	0.0%
Ice Harbor	$8,242,000	$5,000	0.1%
Lower Monumental	$8,612,000	$5,000	0.1%
Little Goose	$8,743,000	$2,000	0.0%
Lower Granite	$6,608,000	$4,000	0.1%
Dworshak	$5,681,000	$0	0.0%
Total	**$245,252,000**	**$53,000**	**0.02%**

4.2.4 Multiple Objective Alternative 3

Under MO3, the breaching of the four lower Snake dams would result in large decreases in annual-equivalent costs compared to the No Action Alternative. A decrease of $32.1 million (-13.1%) in annual-equivalent capital costs would occur under MO3 (Table 4-4). All large and small capital investments incurred for power, fish, dredging, and other dam infrastructure would no longer be required at the four lower Snake River dams, an annual decrease between $6.6 and $8.7 million for each of these projects. However, at the other projects on the Columbia River, there would be very little change in capital costs compared to the No Action Alternative.

Table 4-4. Capital Cost Estimates for MO3 and Change from the No Action Alternative (2019$)

Project	Annual-equivalent Cost	Change in Annual-equivalent Cost from No Action Alternative	Percent Change from No Action Alternative
Bonneville	$18,661,000	$8,000	0.0%
The Dalles	$26,211,000	$8,000	0.0%
John Day	$24,337,000	$11,000	0.0%
Chief Joseph	$18,980,000	$0	0.0%
Grand Coulee	$70,921,000	$0	0.0%
Albeni Falls	$2,783,000	$0	0.0%
Libby	$7,168,000	$0	0.0%
Hungry Horse	$8,530,000	$0	0.0%
McNary	$29,772,000	$9,000	0.0%
Ice Harbor	$0	-$8,237,000	-100.0%

Project	Annual-equivalent Cost	Change in Annual-equivalent Cost from No Action Alternative	Percent Change from No Action Alternative
Lower Monumental	$0	-$8,607,000	-100.0%
Little Goose	$0	-$8,740,000	-100.0%
Lower Granite	$0	-$6,605,000	-100.0%
Dworshak	$5,681,000	$0	0.0%
Total	**$213,044,000**	**-$32,154,000**	**-13.1%**

4.2.5 Multiple Objective Alternative 4

Under MO4, there would be a small change in the capital costs compared to the No Action Alternative, a change of approximately 0.02 percent annually over the period of analysis (Table 4-5). Under MO4 there would not be costs associated with the upgraded adjustable spillway weirs (as under MO1 and MO2), although there would be some costs associated with the spillway weir notch inserts at John Day, McNary, and the lower Snake River projects. The changes in the anticipated capital costs under MO4 are negligible in comparison to the capital costs to operate the CRS under the No Action Alternative.

Table 4-5. Capital Cost Estimates for MO4 and Change from the No Action Alternative (2019$)

Project	Annual-equivalent Cost	Change in Annual-equivalent Cost from No Action Alternative	Percent Change from No Action Alternative
Bonneville	$18,661,000	$8,000	0.0%
The Dalles	$26,211,000	$8,000	0.0%
John Day	$24,336,000	$10,000	0.0%
Chief Joseph	$18,980,000	$0	0.0%
Grand Coulee	$70,921,000	$0	0.0%
Albeni Falls	$2,783,000	$0	0.0%
Libby	$7,168,000	$0	0.0%
Hungry Horse	$8,530,000	$0	0.0%
McNary	$29,767,000	$4,000	0.0%
Ice Harbor	$8,242,000	$5,000	0.1%
Lower Monumental	$8,615,000	$8,000	0.1%
Little Goose	$8,744,000	$4,000	0.0%
Lower Granite	$6,614,000	$9,000	0.1%
Dworshak	$5,681,000	$0	0.0%
Total	**$245,255,000**	**$56,000**	**0.02%**

4.2.6 Preferred Alternative

Under the Preferred Alternative, there would be a small change in the capital costs compared to the No Action Alternative, a change of approximately 0.02 percent annually over the period of analysis (Table 4-6). There would be some very small changes in capital costs associated with the Lower Granite trap modification and the turbine strainer Lamprey exclusion over the period of analysis. The changes in the anticipated capital costs under the preferred alternative are negligible in comparison to the capital costs to operate the CRS under the No Action Alternative.

Table 4-6. Capital Cost Estimates for the Preferred Alternative and Change from the No Action Alternative (2019$)

Project	Annual-equivalent Cost	Change in Annual-equivalent Cost from No Action Alternative	Percent Change from No Action Alternative
Bonneville	$18,661,000	$8,000	0.0%
The Dalles	$26,211,000	$8,000	0.0%
John Day	$24,334,000	$8,000	0.0%
Chief Joseph	$18,980,000	$0	0.0%
Grand Coulee	$70,921,000	$0	0.0%
Albeni Falls	$2,783,000	$0	0.0%
Libby	$7,168,000	$0	0.0%
Hungry Horse	$8,530,000	$0	0.0%
McNary	$29,769,000	$6,000	0.0%
Ice Harbor	$8,240,000	$3,000	0.0%
Lower Monumental	$8,609,000	$2,000	0.0%
Little Goose	$8,743,000	$3,000	0.0%
Lower Granite	$6,612,000	$7,000	0.1%
Dworshak	$5,681,000	$0	0.0%
Total	**$245,243,000**	**$44,000**	**0.02%**

CHAPTER 5 - OPERATIONS AND MAINTENANCE COSTS

5.1 DATA COLLECTION AND METHODS

The data collection and methods for estimating O&M costs for the No Action Alternative and action alternatives are summarized in this section. The O&M cost estimates are provided in Section 5.2.

5.1.1 No Action Alternative

The O&M costs include routine O&M, non-routine extraordinary expenses, and non-routine navigation-related maintenance expenses.

5.1.1.1 Routine O&M

The routine O&M costs for the 12 Corps Federal Columbia River Basin Projects were obtained from the Corps of Engineers Financial Management System (CFEMS). CFEMS is the Corps of Engineer's financial database system and contains detailed costs for all of the Corps projects. The CEFMS is accessed through the Enterprise Data Warehouse. Routine O&M costs were obtained for the past 5 years (2013-2017) organized by business lines/categories: hydropower, fish and wildlife, cultural resources, navigation (dredging expenditures are covered under non-routine costs), recreation, and other operations and maintenance. The O&M costs include both the appropriated and power share of the costs. The Corps Walla Walla, Portland, and Seattle District and Northwestern Division project managers, operations personnel, as well as cost and budget experts from the Corps, Bonneville, and Reclamation provided input and review of the estimated O&M costs to ensure the represented current and anticipated future O&M needs under No Action Alternative.

Routine O&M costs for Hungry Horse and Grand Coulee projects were obtained from Reclamation from 2013 to 2018 for the water users and appropriated accounts. The costs were reviewed with the Reclamation budget experts, and the costs for 2018 were selected as representative of current and future annual routine O&M costs and activities under the No Action Alternative at the two projects. The costs were inflated to 2019 dollars with the CWCCIS for the dam category.

For the Corp's data, the Corps Civil Works category class subclass code (CCS) for Corps business lines and projects were queried in CEFMS to obtain the routine O&M costs for each project. Relevant CCS codes are as follows: fish and wildlife – 394; hydropower (routine) – 381; navigation – 300; recreation – 300; and other – 396. Routine O&M costs include appropriated and joint costs. Operations experts at the Corps Districts reviewed the O&M costs in detail to ensure the estimated O&M costs were reasonable and to ensure that costs were not double-counted among the categories.

The "other routine O&M" category includes costs associated with regular activities such as facilities upkeep, security equipment, salaries for security guards, general grounds maintenance, and office upgrades and maintenance. Hydropower O&M costs include routine costs associated with generating power at the respective projects, such as turbine upkeep, tailrace maintenance, and support salaries. Routine fish and wildlife O&M costs include hatchery operations, trap and transport activities for fish, and biologist salaries. Navigation costs include costs such as routine lock maintenance; however, the non-routine navigation costs, such as dredging, are described in Section 5.1.1.3 of this appendix. Recreation costs include O&M of recreation areas provided by the Corps as well as park ranger salaries.

Routine O&M costs for cultural resource were obtained from Bonneville, Corps, and Reclamation cultural resource specialists and are consistent with the Federal Columbia River Power System Fiscal Year 2018 Annual Report (Bonneville, Reclamation, and Corps 2019a). These costs include activities to preserve and maintain historic cultural sites or practices, as well as salaries and operations for cultural resource specialists. Based upon this annual report, O&M costs for cultural resources are assumed to be $10 million annually over the period of analysis for all projects.

Routine O&M costs for all projects (including all business line expenses) were estimated to be $353 million annually. More details regarding routine O&M by alternative and project are provided in Section 5.2 below.

To better understand the variation and uncertainty regarding routine O&M costs, an evaluation was completed on the standard deviation and 95 percent confidence interval for the O&M costs that used 5 years of historic data (12 Corps projects). Average routine O&M costs for all of the Corps projects (updated to 2019 price level and not including cultural resource O&M) were estimated to be $237.1 million annually based on 5 years of cost data from 2013 to 2017. From these five years of data, the standard deviation was estimated to be $9.2 million with a 95 percent confidence interval that ranges from $229.0 million to $245.2 million.

5.1.1.2 Non-routine Extraordinary Expenses

Bonneville operations experts provided the NREX cost estimated by project for 2020 to 2065. NREX costs include specific hydropower related items such as repair of failed units. Large and small capital (see Chapter 4) and non-routine navigation costs (see section 5.1.1.3) were provided separately. The Bonneville NREX costs were extended to the year 2070 by averaging the previous 5 years. The NREX investments included 2 percent inflation added every year; therefore, the NREX costs were deflated to 2019 dollars using the rates of inflation provided by Bonneville. Bonneville NREX costs were estimated to be $38.4 million, annually.

The Corps and Reclamation provided estimates of their share of joint NREX costs. The joint cost assumptions were based on historic estimates of these costs as a percentage of the SAMP costs, which were then projected of the 50-year period. The joint NREX costs were estimated to be $2.5 million for all projects.

NREX cost estimates are based on long-range forecasts of these non-routine requirements to 2068. There are multiple areas of uncertainty related to these future costs, including equipment replacement and repair needs and timing, cost estimates of the non-routine requirements, and execution risk (i.e., planning timing, authorizations, and appropriations). An estimate of the uncertainty surrounding the magnitude of these costs would be speculative and is beyond the scope of this evaluation.

5.1.1.3 Navigation

The non-routine navigation costs, including costs for dredging activities, were obtained from operations experts at the Corps Walla Walla and Portland Districts. For the Corps Walla Walla District, non-routine navigation and dredging costs were estimated based upon historic and current CEFMS data and projected over a 50-year period of analysis based on existing conditions and future anticipated needs (Corps Walla Walla District, 2019a). The bulk of dredging activities under the No Action Alternative would occur at Lower Granite. Navigation costs for the Walla Walla projects and McNary pool are estimated to be $14.2 million annually, of which, dredging costs for Ice Harbor and Lower Granite were estimated to cost $2.7 million annually over the 50-year period.

The Portland District provided dredging quantities and costs for five locations between 2011 and 2018: the mouth of the Columbia River; the Columbia and lower Willamette River; the Portland and Vancouver Anchorages; Vancouver to The Dalles; and The Dalles Lock and Dam (Corps Portland District, 2019b). Based on expert judgement, these 2016 to 2018 costs were inflated to 2019 price levels and averaged to provide an annual estimate of the anticipated dredging requirements in the Portland District under the No Action Alternative. The total cost of the dredging activities within the Portland District were estimated to be $67.1 million annually over the 50-year period.

The Technical Operations Branch at the Portland District also provided cost estimates to maintain the locks for the three Portland projects. All locks have had recent major rehabilitation. The District specialists estimated the non-routine costs that would likely need to occur over the next 10 to 30 years. Since recent rehabilitation has recently occurred, it was assumed that the non-routine lock costs would occur at year 20; these costs were then discounted to 2019 dollars and amortized over the 50-year period of analysis (Corps Portland District, 2019c). The navigation non-routine costs (not including dredging) were estimated to be $2.9 million annually for the three lower Columbia River projects.

To better understand the variation and uncertainty regarding navigation costs, an evaluation was completed on the standard deviation and 95 percent confidence interval for the Portland District dredging costs, which was based on 3 years of historic data. Average Portland District dredging costs were estimated to be $67.1 million annually, with a standard deviation of $4.1 million and a 95 percent confidence interval that ranges from $62.5 million to $71.7 million.

5.1.2 Multiple Objective Alternatives

For the multi-objective alternatives, the Corps District operations, engineering, and budgeting personnel reviewed each of the structural and operational measures to evaluate how these measures would affect or change the estimates of O&M activities and costs under the multiple objective alternatives. For the multi-objective alternatives, the District personnel expressed each cost as a change from the current O&M activities and costs. Additional details on this approach are provided in this section.

5.1.2.1 Routine O&M

The structural and operational measures under the multiple objectives alternatives were evaluated by all of the Corps districts and Reclamation engineers, operations support, and budget experts to assess how the new infrastructure and structures and operations under the alternatives would increase or decrease the current routine O&M activities and costs (Corps Walla Walla District, 2019a; Corps Portland District, 2019b; Corps Seattle District, 2019b). These costs were assessed by project, structural or operational measure, and by alternative, discounted to reflect 2019 dollars and then amortized over the 50-year period of analysis to provide an annual-equivalent cost.

For the four lower Snake River projects that would be breached under MO3, multiple interviews and communications with Bonneville experts and Walla Walla District operations and budget experts were conducted to assess the levels of Corps operations and maintenance support and costs that would be needed after the breaching of the four lower Snake River dams (Corps Walla Walla District, 2019c). Each of the business line routine operations and maintenance activities were evaluated for these projects. The following assumptions were used in the cost analysis for the changes in the operations and maintenance costs under MO3. The O&M activities and associated costs for recreation, cultural resources, navigation, hydropower, and fish and wildlife would not be required or wouldn't be funded under current authorities. Other operations and maintenance activities in the lower Snake River area would be considerably reduced compared to the No Action Alternative, but would include maintenance of Clarkston and Lewiston Levees, law enforcement, and engineering/safety inspections. Additional costs would be incurred as MO3-specific mitigation costs (for example, for public safety, transportation and navigation, and cultural resources, etc.) (see Sections 6.1.2 and 6.2.4 and Annex B for details on additional mitigation measures).

5.1.2.2 Non-routine Extraordinary Maintenance

Under MO3, the NREX as well as the Corps and Reclamation NREX cost shares for the four lower Snake River projects would be assumed to no longer be incurred. With the selection of MO3, NREX budgets and expenses and the associated cost shares associated with the four lower Snake projects would no longer be budgeted or expended, starting at the beginning of the period of analysis in year 2021. The estimates of NREX would not change under MO1, MO2, MO4, and the preferred alternative.

5.1.2.3 Navigation

All changes in the need for dredging or navigation-related activities were considered relative to the current estimates under the No Action Alternative. There would be no anticipated changes in non-routine non-dredging-related navigation costs under MO1, MO2, MO4, and the preferred alternative. There would be additional dredging needed under MO3, MO4, and the preferred alternative; these costs are not included as non-routine maintenance costs, but are captured as additional mitigation costs in Section 6.2 and Annex B.

All non-routine navigation and dredging costs associated with the four lower Snake Locks and Dams would no longer be incurred under MO3. Annual navigation costs of approximately $10.5 million, including $2.7 million in dredging costs, would no longer be authorized at the 4 lower Snake River projects under MO3.

5.2 OPERATIONS AND MAINTENANCE COST ESTIMATES

5.2.1 No Action Alternative

Table 5-1 summarizes the annual-equivalent O&M costs for each of the projects, which includes routine O&M costs, navigation non-routine costs, and NREX. Grand Coulee and Bonneville represent the projects with the highest O&M costs, with $117 million and $39.6 million, respectively. Note that the Portland District dredging is provided as a separate line item as it is not readily categorized into project-specific expenses. Of the O&M costs categories, routine O&M is the highest annualized cost, accounting for $353 million, while NREX accounts for $40.9 million, and non-routine navigation costs (including dredging) account for $84.2 million.

Table 5-1. No Action Alternative Annual Operations and Maintenance Costs by Project

Dam	Routine O&M Costs	NREX	Non-routine Navigation Costs	Total Annual-equivalent O&M Cost (2019$)	Percent of Total
Bonneville	$33,344,000	$4,596,000	$1,655,000	$39,595,000	8.3%
The Dalles	$25,479,000	$3,017,000	$439,000	$28,936,000	6.0%
John Day	$33,837,000	$2,991,000	$805,000	$37,634,000	7.9%
Chief Joseph	$27,509,000	$4,906,000	NA	$32,416,000	6.8%
Grand Coulee	$104,049,000	$12,942,000	NA	$116,992,000	24.5%
Albeni Falls	$9,705,000	$277,000	NA	$9,982,000	2.1%
Libby	$12,213,000	$1,002,000	NA	$13,215,000	2.8%
Hungry Horse	$6,369,000	$855,000	NA	$7,224,000	1.5%
McNary	$27,449,000	$2,907,000	$3,738,000	$34,095,000	7.1%
Ice Harbor	$14,945,000	$1,303,000	$1,959,000	$18,207,000	3.8%
Lower Monumental	$12,281,000	$1,614,000	$1,670,000	$15,566,000	3.3%
Little Goose	$11,670,000	$1,104,000	$2,283,000	$15,056,000	3.1%
Lower Granite	$19,560,000	$2,550,000	$4,587,000	$26,696,000	5.6%
Dworshak	$14,902,000	$825,000	NA	$15,726,000	3.3%
Portland Dredging	-	-	$67,072,000	$67,072,000	14.0%
TOTAL	$353,312,000	$40,889,000	$84,208,000	$478,412,000	100.0%

Note: Totals may not add exactly due to rounding.

5.2.2 Multiple Objective Alternative 1

MO1 includes structural and operational measures that would lead to a very small change in the overall cost of operating and maintaining the CRS. Although annual costs would increase and decrease depending on the measure, total O&M costs across all projects would decrease slightly under MO1 when compared to the No Action Alternative, resulting in annual-equivalent O&M cost decrease of -$15,000 or -0.003 percent. Table 5-2 presents the O&M costs associated with MO1.

Increased O&M costs would occur from some of the structural measures as well as additional fish transport associated with the operational measure. During spring juvenile fish passage spill operations juvenile fish transportation would begin earlier in the spring. Some small increases in O&M costs compared to the No Action Alternative would occur due to additional staffing levels for fish transportation at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, Dworshak, John Day, The Dalles, and Bonneville. In addition, small increases in O&M would occur from some of the structural measures: adjustable spillway weirs at John Day, Ice Harbor, Lower Granite, Lower Monumental, and McNary dams; Lower Granite trap modifications; lower Snake Ladder pumps at Ice Harbor and Lower Monumental; turbine strainer modifications to exclude lamprey at the lower Snake River projects, McNary, Bonneville, The Dalles, and John Day projects; and turbine bypass screen modifications at McNary, Lower Granite, and Little Goose.

Under MO1, the juvenile fish facilities at Ice Harbor and McNary would no longer be needed due to the construction of additional fish surface passage. Reductions in costs compared to the No Action Alternative would occur from reduced levels of staffing for the juvenile fish facility at Ice Harbor and McNary. NREX and navigation costs would not be anticipated to change under MO1.

Table 5-2. Operations and Maintenance Costs for MO1 and Change from the No Action Alternative

Dam/Project/Project	Annual-equivalent Cost (2019$)	Change in Annual-equivalent Costs from No Action	Percent Change in Annual-equivalent Costs
Bonneville	$39,695,000	$100,000	0.3%
The Dalles	$29,035,000	$99,000	0.3%
John Day	$37,738,000	$104,000	0.3%
Chief Joseph	$32,416,000	$0	0.0%
Grand Coulee	$116,992,000	$0	0.0%
Albeni Falls	$9,982,000	$0	0.0%
Libby	$13,215,000	$0	0.0%
Hungry Horse	$7,224,000	$0	0.0%
McNary	$33,560,000	-$535,000	-1.6%
Ice Harbor	$18,036,000	-$171,000	-0.9%
Lower Monumental	$15,663,000	$97,000	0.6%
Little Goose	$15,148,000	$92,000	0.6%
Lower Granite	$26,816,000	$120,000	0.4%
Dworshak	$15,805,000	$79,000	0.5%
Portland Dredging	$67,072,000	$0	0.0%
TOTAL	$478,397,000	-$15,000	-0.003%

5.2.3 Multiple Objective Alternative 2

MO2 includes structural and operational measures that would affect the cost of operating and maintaining the CRS. Total O&M costs across all projects would result in a decrease in annual-equivalent O&M costs of $1.5 million or -0.3 percent when compared to the No Action Alternative. Table 5-3 presents the O&M costs associated with MO2.

Decreased O&M costs would occur at McNary, Ice Harbor, and John Day projects. Under MO2, with the additional fish surface passage at Ice Harbor, the juvenile fish facility would no longer be required. There would not be the need for fish transportation (i.e., trap and transport) at McNary, reducing O&M activities compared to the No Action Alternative. In addition, MO2 would cease installation of fish screens at Ice Harbor, McNary, and John Day projects, which would require fewer resources for routine O&M activities at these projects. NREX and navigation costs would not be anticipated to change under MO2.

Table 5-3. Operations and Maintenance Costs for MO2 and Change from the No Action Alternative

Dam/Project	Annual-equivalent Cost (2019$)	Change in Annual-equivalent Costs from No Action	Percent Change in Annual-equivalent Costs
Bonneville	$39,625,000	$30,000	0.1%
The Dalles	$28,965,000	$29,000	0.1%
John Day	$37,322,000	-$312,000	-0.8%
Chief Joseph	$32,416,000	$0	0.0%
Grand Coulee	$116,992,000	$0	0.0%
Albeni Falls	$9,982,000	$0	0.0%
Libby	$13,215,000	$0	0.0%
Hungry Horse	$7,224,000	$0	0.0%
McNary	$33,228,000	-$867,000	-2.5%
Ice Harbor	$17,830,000	-$377,000	-2.1%
Lower Monumental	$15,577,000	$11,000	0.1%
Little Goose	$15,051,000	-$5,000	0.0%
Lower Granite	$26,695,000	-$1,000	0.0%
Dworshak	$15,726,000	$0	0.0%
Portland Dredging	$67,072,000	$0	0.0%
TOTAL	**$476,920,000**	**-$1,492,000**	**-0.3%**

5.2.4 Multiple Objective Alternative 3

MO3 includes structural and operational measures including breaching of the four lower Snake River projects, that would affect the cost of operating and maintaining the CRS. Changes in costs across all projects would result in a decrease in annual-equivalent O&M costs of -$79.0 million or -16.5 percent. Table 5-4 presents the O&M costs associated with MO3.

The largest change in O&M costs would occur as reductions in costs, or cost savings compared to the No Action Alternative at Ice Harbor, Little Goose, Lower Granite, and Lower Monumental projects. Most of the O&M costs would no longer be required with the breaching of the four lower Snake River dams, including routine O&M costs to support navigation, recreation, hydropower, cultural resources, and fish and wildlife. Other O&M would be considerably reduced compared to No Action (Corps Walla Walla District, 2019c). However, mitigation costs to address the adverse effects to fish, cultural resources, and other resources during the breaching activity and transitional period would be anticipated to occur and are captured in the costs as described in Section 6.1.2 and 6.2.4 and Annex B. The NREX costs and non-routine dredging and lock and dam costs at the lower Snake River projects would also no longer be incurred under MO3.

Bonneville, The Dalles, John Day, and Dworshak projects would experience a decrease in routine O&M costs from the elimination of the fish trap and transport program under MO3. There would be decreased O&M costs at McNary relative to the No Action Alternative from the elimination of fish screens and considerable reduction in staffing levels from the elimination of the juvenile fish facility. Additional dredging costs at McNary would be needed to maintain the federal navigation channel, which are further described under Mitigation Costs, Section 6.2.4. There are no anticipated changes in dredging required in the Portland District (at the projects, at the mouth of the Columbia, or in the Columbia and Lower Willamette River).

Table 5-4. Operations and Maintenance Costs for MO3 and Change from the No Action Alternative

Dam /Project	Annual-equivalent Cost (2019$)	Change in Annual Costs from No Action	Percent Change in Annual Costs
Bonneville	$38,949,000	-$646,000	-1.6%
The Dalles	$28,290,000	-$646,000	-2.2%
John Day	$36,940,000	-$694,000	-1.8%
Chief Joseph	$32,416,000	$0	0.0%
Grand Coulee	$116,992,000	$0	0.0%
Albeni Falls	$9,982,000	$0	0.0%
Libby	$13,215,000	$0	0.0%
Hungry Horse	$7,224,000	$0	0.0%
McNary	$32,399,000	-$1,696,000	-5.0%
Ice Harbor	$62,000	-$18,145,000	-99.7%
Lower Monumental	$62,000	-$15,504,000	-99.6%
Little Goose	$62,000	-$14,994,000	-99.6%
Lower Granite	$687,000	-$26,009,000	-97.4%
Dworshak	$15,059,000	-$667,000	-4.2%
Portland Dredging	$67,072,000	$0	0.0%
TOTAL	**$399,411,000**	**-$79,001,000**	**-16.5%**

5.2.5 Multiple Objective Alternative 4

MO4 includes structural and operational measures that would affect the cost of operating and maintaining the CRS. Changes in O&M activities across all projects would result in an increase in annual-equivalent O&M costs of $80,000 or 0.02 percent. Table 5-5 presents the O&M costs associated with MO4.

Similar to MO1, the juvenile fish facilities at Ice Harbor and McNary would no longer be required with the construction of additional fish surface passage under MO4. Reductions in costs compared to the No Action Alternative would occur from reduced levels of staffing for the juvenile fish facility at Ice Harbor and McNary. O&M activities for fish trap and transportation would shift in terms of the locations to more fish transportation activities required at Lower Monumental, Little Goose, ad Lower Granite, and fewer fish transportation requirements at McNary, Ice Harbor, Dworshak, John Day, The Dalles, and Bonneville.

Increased costs compared to the No Action Alternative would occur from a number of the structural and operational measures under MO4, including additional fish transport needs under MO4 at Lower Granite, Little Goose, and Lower Monumental projects; increased cavitation repair from operating the turbines within and above 1% peak efficiency in juvenile fish passage season; and additional O&M activities associated with the lower Snake Ladder pumps, intake bypass screens, and spillway weir notch gate inserts.

The NREX costs would not change under MO4 compared to No Action Alternative. There would be some additional dredging needed associated with the 125 Gas Cap spill operation, although these activities and costs are captured under Mitigation Costs, Section 6.2.5. Aside from increases in dredging at John Day and Walla Walla projects (captured under mitigation), there are no additional anticipated changes in dredging required in the Portland District (at the projects, at the mouth of the Columbia, or in the Columbia and Lower Willamette River).[11]

Table 5-5. Operations and Maintenance Costs for MO4 and Change from the No Action Alternative

Dam/Project	Annual-equivalent Cost (2019$)	Change in Annual-equivalent Costs from No Action	Percent Change in Annual-equivalent Costs
Bonneville	$39,639,000	$44,000	0.1%
The Dalles	$28,879,000	-$57,000	-0.2%
John Day	$37,679,000	$45,000	0.1%
Chief Joseph	$32,416,000	$0	0.0%
Grand Coulee	$116,992,000	$0	0.0%
Albeni Falls	$9,982,000	$0	0.0%
Libby	$13,215,000	$0	0.0%
Hungry Horse	$7,224,000	$0	0.0%
McNary	$33,535,000	-$560,000	-1.6%
Ice Harbor	$17,997,000	-$210,000	-1.2%
Lower Monumental	$15,792,000	$226,000	1.5%
Little Goose	$15,281,000	$225,000	1.5%
Lower Granite	$27,063,000	$367,000	1.4%
Dworshak	$15,726,000	$0	0.0%
Portland Dredging	$67,072,000	$0	0.0%
TOTAL	**$478,492,000**	**$80,000**	**0.02%**

[11] Private and/or and municipal dredging of ports would likely be needed under MO4, which is described in the Navigation section .

5.2.6 Preferred Alternative

The preferred alternative includes structural and operational measures that would affect the cost of operating and maintaining the CRS. Changes in O&M costs for all projects would result in a slight decrease in annual-equivalent O&M costs of $729,000 or -0.15 percent. Table 5-6 presents the O&M costs associated with the preferred alternative.

Small increases O&M costs would occur at Bonneville, The Dalles, Lower Monumental, Little Goose, Lower Granite, and Dworshak associated with the earlier start time for fish transportation (all Portland and Walla Walla District projects), and the turbine bypass screen Lamprey exclusions and trap modifications at Lower Granite.

Under the preferred alternative, there would be decreases in O&M costs at McNary, Ice Harbor, and John Day projects compared to the No Action Alternative with the potential to cease installation of fish screens to increase efficiency of new hydropower turbines. As a result, there would be reduced routine O&M costs from fewer staffing requirements at these projects compared to the No Action Alternative.

Table 5-6. Operations and Maintenance Costs for the Preferred Alternative and Change from the No Action Alternative

Dam/Project/Project	Annual-equivalent Cost (2019$)	Change in Annual-equivalent Costs from No Action	Percent Change in Annual-equivalent Costs
Bonneville	$39,700,000	$105,000	0.3%
The Dalles	$29,035,000	$99,000	0.3%
John Day	$37,392,000	-$242,000	-0.6%
Chief Joseph	$32,416,000	$0	0.0%
Grand Coulee	$116,992,000	$0	0.0%
Albeni Falls	$9,982,000	$0	0.0%
Libby	$13,215,000	$0	0.0%
Hungry Horse	$7,224,000	$0	0.0%
McNary	$33,348,000	-$747,000	-2.2%
Ice Harbor	$17,819,000	-$388,000	-2.1%
Lower Monumental	$15,671,000	$105,000	0.7%
Little Goose	$15,174,000	$118,000	0.8%
Lower Granite	$26,838,000	$142,000	0.5%
Dworshak	$15,805,000	$79,000	0.5%
Portland Dredging	$67,072,000	$0	0.0%
TOTAL	**$477,683,000**	**-$729,000**	**-0.15%**

CHAPTER 6 - MITIGATION COSTS

Mitigation includes fish and wildlife-related expenses required to mitigate the operation of the Federal Columbia River Power System (FCRPS), as well as separate, ESA-related mitigation requirements. Additional mitigation measures have also been proposed under each of the alternatives to mitigate adverse impacts of the alternatives; these measures include fish and wildlife-related measures as well as other measures, such as, protecting fish, cultural resources, and others. This section describes these mitigation measures and costs.

6.1 DATA COLLECTION AND METHODS

6.1.1 Fish and Wildlife Costs

Bonneville's F&W Program funds hundreds of projects each year to mitigate the impacts of the federal hydropower system on fish and wildlife. Bonneville began this program to fulfill mandates established by Congress in the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act), 16 USC § 839b(h)(10)(A), 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 fulfill its Northwest Power Act fish and wildlife responsibilities and 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, 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. The Bonneville F&W Program also includes capital projects, such as hatchery construction projects, but those costs are analyzed as part of the Power and Transmission chapter.

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 are included to inform the broader cost analysis for each alternative in the EIS. To make the most of available funds, investments in fish and wildlife mitigation would be prioritized based on biological and cost effectiveness and their connection to mitigating for impacts to the FCRPS. 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.

Congress authorized the Lower Snake River Compensation Plan (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. Bonneville also directly funds the annual operations and maintenance of the Lower Snake River

Compensation Plan (LSRCP) facilities; this program is administered through the USFWS. The LSRCP hatcheries and satellite facilities produce and release more than 19 million salmon, steelhead and resident rainbow trout as part of the program's mitigation responsibility. The 26 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). Current and anticipated future annual costs for both Bonneville's F&W program and LSRCP were obtained from experts at Bonneville; any potential changes in funding and anticipated costs under the multiple objective alternatives were estimated by Bonneville. Costs for the F&W Program and LSRCP were obtained for 2016 (BP16 Rate Case) and inflated to reflect costs/funding in 2019 dollars.

The Corps has recently completed construction and implementation activities associated with its LSRCP authorization, including habitat development and game bird production, throughout the lower Snake River basin. The Corps would continue to manage fish and wildlife resources through its O&M funding. No costs were included for the LSRCP program under the No Action Alternative or under the action alternatives.

The Corps and Reclamation also provide funding for fish and wildlife conservation measures and activities under obligations including the Endangered Species Act. The Corps Columbia River Fish Mitigation (CRFM) Program includes construction-focused conservation and fish and wildlife mitigation measures. In recent years, funding for this program has decreased and is anticipated to continue decreasing in the near team, and will no longer be required in approximately 10 years (Corps Northwestern Division, 2019). Any structural measures that would occur under the action alternatives were removed from these estimates to avoid double counting. Funding under the CRFM included the Four-year plan (FY21-FY24) estimates as well as one additional project that was not included in plan estimates, debris management at McNary and the four lower Snake River projects. The debris management project was assumed to be implemented over ten years. The Four-year plan estimates and the debris management projects were discounted to reflect a present value of the CRFM Program in 2020. When amortized over 50 years, the CRFM program was estimated to cost approximately $2.0 million annually (50% associated with the lower Snake River projects). Bonneville is obligated to repay the power share of these costs.

Reclamation has a fish and wildlife program to meet its ESA obligations at its two projects, Grand Coulee and Hungry Horse. The program funds activities such as improving tributary habitat, avian predation management, and it also includes funding for ESA consultation and litigation support. Program experts at BOR estimated that annual costs to meet these obligations under the No Action Alternative would be approximately $14.3 million. This estimate excludes measures and activities for the Upper Snake Flow Augmentation Biological Opinion, which is outside of the scope of this EIS.

In addition to the fish and wildlife mitigation costs described in this section, there are also fish and wildlife costs that are, in part, directly funded by Bonneville to the Corps and Reclamation for mitigation activities, such as hatchery operations, fish stocking, elk habitat maintenance, and others. In addition, Bonneville directly funds the power share of O&M costs for Corps operated fish passage facilities. These costs were captured under the fish and wildlife routine O&M costs (Sections 5.1.1.1 and 5.1.2.1).

The Preferred Alternative is being coordinated for consultation with the USFWS and NMFS. Chapter 7 of the EIS, Preferred Alternative, 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 6-1. 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).

6.1.2 Costs for Additional Mitigation Measures

Additional mitigation measures for the action alternatives are activities that have been identified during the resource evaluation process that include reasonably foreseeable activities undertaken to avoid, minimize, or mitigate impacts from occurring under the action alternatives. These activities may include protecting cultural resources, planting and re-vegetating areas, and extending boat and ferry ramps. MO3 has a number of additional mitigation measures to help to offset certain adverse impacts from breaching the four lower Snake River projects. Chapter 5 in the main body of the EIS provides additional details on the mitigation measures. In addition, Annex B in this Appendix, Costs for Additional Mitigation Measures, provides additional details on how the costs were developed and an estimate of the costs for each measure.

Resource specialists along with agency policy and technical leads developed mitigation measures based upon likely effects under each alternative. Similar to the process for developing action alternative cost estimates, the mitigation measure costs were developed utilizing cost engineering as well as related historic, current or estimated future costs, depending upon the proposed measure. Structural mitigation measures were estimated by the cost engineers at the Mandatory Cost Center for Expertise, while on-going system annual system costs were developed with input from programs, operations and cost engineering. A contingency of 50 percent was added to all construction estimates based on preliminary designs, scope, and uncertainty surrounding the construction estimates and in consultation with Bonneville. A 50 percent contingency is typical for this level of scope and cost engineering estimate development. Thirty percent of the construction and contingency cost was included to account for supervision, administration, planning, engineering, design, and engineering during construction costs based on historic Corps cost engineering experience with these types of costs. All costs were developed at a 2019 price level. Similar to action alternative cost estimates, O&M costs for routine and non-routine activities were estimated for mitigation measures, if applicable.

Bonneville F&W Program experts reviewed the fish and wildlife mitigation measures to identify specific measures that would be funded under Bonneville's F&W Program, and to ensure double-counting between cost categories did not occur. These measures include wetland, riparian, and tributary habitat improvements; planting vegetation and cottonwoods; and creating back channel habitat. Because these specific measures are currently being implemented or would be prioritized for funding under Bonneville's F&W Program, the mitigation measures are recognized under the appropriate MO, but costs are captured in the Bonneville F&W Program costs.

6.2 MITIGATION COST ESTIMATES

This section presents the mitigation costs under the alternatives. Additional details on the costs of the additional mitigation measures are provided in Annex B. Table 6-1 summarizes the Bonneville F&W Program costs, LSRCP costs, the CRFM costs, the BOR ESA-related costs, and the MO-specific mitigation costs.

Table 6-1. Annual Mitigation Costs under the No Action Alternative and the Action Alternatives

Alternative	Fish and Wildlife Mitigation					Additional Mitigation Costs[b]	Total Mitigation Costs (Low F&W Program Cost)	Total Mitigation Costs (High F&W Program Cost)
	Bonneville's F&W Program[a] (Low Estimate)	Bonneville's F&W Program[a] (High Estimate)	LSRCP	BOR ESA Funding Obligations	CRFM			
No Action Alternative	$282,000,000	$282,000,000	$34,000,000	$14,300,000	$2,000,000	NA	$332,300,000	$332,300,000
MO1	$282,000,000	$282,000,000	$34,000,000	$14,300,000	$2,000,000	$1,200,000	$333,500,000	$333,500,000
MO2	$282,000,000	$335,000,000	$34,000,000	$14,300,000	$2,000,000	$1,800,000	$334,100,000	$387,100,000
MO3	$177,000,000	$282,000,000	$0	$14,300,000	$900,000	$45,400,000	$237,600,000	$342,600,000
MO4	$177,000,000	$282,000,000	$34,000,000	$14,300,000	$2,000,000	$6,200,000	$233,500,000	$338,500,000
Preferred Alternative	$235,000,000	$282,000,000	$34,000,000	$14,300,000	$2,000,000	$2,600,000	$287,900,000	$334,900,000

[a]The F&W Program also includes capital projects, such as hatchery construction projects; those costs are analyzed as part of the Power and Transmission chapter of the Draft EIS (Section 3.7).
[b] Note that the additional mitigation measures include some fish and wildlife-related measures that would not be implemented or funded through the F&W Program, LSRCP, CRFM, or the BOR ESA measures. Please see Annex B for additional details.

6.2.1 No Action Alternative

The No Action Alternative would include approximately $316 million in annual funding for Bonneville's F&W Program and LSRCP.[12] BOR ESA funding obligations are estimated to be $14.3

[12] In 2016, the Bonneville Fish and Wildlife Program budget was $267,000,000, and the LSRCP budget was $32,303,000. When these budgets are adjusted to represent 2019 dollars, they become $281,536,000 and $34,062,000, respectively. It should be noted that in fiscal year 2020, Bonneville adjusted the F&W Program budget to $249 million and the LSRCP budget to $30.5 million (BP-18 Rate Case).

million annually under the No Action Alternative and would not change under the multiple objective alternatives. The CRFM Program would cost approximately $2.0 million in annual-equivalent costs under the No Action Alternative. There are no additional mitigation costs under the No Action Alternative.

6.2.2 Multiple Objective Alternative 1

System operations under MO1 is similar to the No Action Alternative; therefore, fish and wildlife mitigation costs associated with existing co-lead agency programs, are estimated to be the same as those estimated under the No Action Alternative. MO1 would result in additional mitigation measures of $1.2 million annually, which would occur at Grand Coulee, Hungry Horse, Libby, and the lower Snake River projects. Additional fish and wildlife mitigation measures ($530,000 annually) under MO1 are currently being implemented and/or would be prioritized for funding under Bonneville's F&W Program (these costs are captured under the F&W Program costs in Table 6-1).

6.2.3 Multiple Objective Alternative 2

Under MO2, power generation would increase, and juvenile fish passage spill would be reduced. If the changes to system operations under MO2 impact fish as anticipated, there may be an increased need for off-site mitigation funded through Bonneville's F&W Program (Bonneville 2019), with the potential for increases in funding for Bonneville's F&W Program. As a result, Bonneville's F&W Program costs were provided as a range under MO2: from $282 million to $335 million (an increase of $53 million annually compared to the No Action Alternative). Future budget adjustments will be made with the region through Bonneville's budget-making processes and other appropriate forums and consistent with existing agreements. Under MO2, Bonneville would continue funding O&M of the LSRCP, estimated at $34 million annually (Bonneville, 2019). CRFM and BOR ESA funding would also remain the same as estimated under the No Action Alternative.

MO2 would result in additional mitigation measures, which would occur at Grand Coulee, Libby, Hungry Horse, and Dworshak, with an annual cost of $1.8 million. Additional fish and wildlife mitigation measures ($530,000 annually) proposed under MO2 are currently being implemented and/or would be prioritized for funding under Bonneville's F&W Program (these costs are captured under the F&W Program costs in Table 6-1).

6.2.4 Multiple Objective Alternative 3

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, because 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 by Bonneville and other funding sources. 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 were provided as a range under MO3: from $282 million annually (the same estimate of Bonneville's F&W Program cost as under the No Action Alternative) to $177 million annually (a decrease of $105 million annually compared to the No Action Alternative). By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related to managing its F&W 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.

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. Proposed project modifications would be coordinated with project sponsors and regional stakeholders to determine appropriate funding levels. Future budget adjustments will be made with the region through Bonneville's budget-making processes and other appropriate forums and consistent with existing agreements. BOR ESA funding obligations are estimated to be $14.3 million annually under the No Action Alternative and would not change under MO3. The CRFM Program annual funding is estimated to be reduced by about half of the current funding of $1.5 million under MO3.

Additional mitigation measures under MO3 are anticipated to cost $45.4 million annually, most of which would occur to mitigate the adverse effects of the breach at McNary and the lower Snake River projects. The additional mitigation measures include: planting and restoration activities ($7.6 million annually); actions to protect and enhance fish habitat ($5.1 million annually); navigation and transportation ($30.7 million annually); public safety ($1.7 million annually); and protecting cultural resources ($1.5 million annually). Additional fish and wildlife mitigation measures ($530,000 annually) proposed under MO3 are currently being implemented and/or would be prioritized for funding under Bonneville's F&W Program (these costs are captured under the F&W Program costs in Table 6-1).

6.2.5 Multiple Objective Alternative 4

Operational changes at the Lower Columbia and lower Snake projects that benefit fish under MO4 would decrease power generation.[13] 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. By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related to managing its F&W 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. Therefore, Bonneville's F&W Program costs were provided as a range under MO4: from $282 million annually (the same estimate as provided for the No Action Alternative) to $177 million annually (a decrease of $105 million annually

[13]Please see the Power and Transmission Technical Appendix for additional details.

compared to the No Action Alternative). 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. Bonneville would continue to fund O&M of the LSRCP, estimated at $34 million annually. CRFM and BOR ESA funding would remain the same as estimated under the No Action Alternative.

Additional measures to mitigate the adverse effects of MO4 were estimated to be $2.6 million annually at Albeni Falls, Hungry Horse, Grand Coulee, Lower Monumental, Little Goose, Lower Granite, McNary, and John Day. Included are measures to protect water quality, fish habitat, cultural resources, and to navigation and transportation. One additional fish and wildlife mitigation measure ($250,000 annually) proposed under MO4 is currently being implemented and/or would be prioritized for funding under Bonneville's F&W Program (this cost is captured under the F&W Program costs in Table 6-1).

6.2.6 Preferred Alternative

Under the preferred alternative, Bonneville included a range of potential F&W Program costs to acknowledge the possibility that the preferred alternative could provide biological benefits to anadromous fish species (see Chapter 7 of the EIS) and that this could, in turn, reduce the need for some offsite mitigation funded through the Bonneville F&W Program. By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related to managing its 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. Bonneville's F&W Program costs were provided as a range under the preferred alternative: from $282 million annually (the same estimate as provided for the No Action Alternative) to $235 million annually (a decrease of $47 million annually compared to the No Action Alternative or 17 percent). Proposed project modifications would be coordinated with project sponsors and regional stakeholders to determine appropriate funding levels. [14] Bonneville would continue to fund the operations and maintenance of the LSRCP, estimated at $34 million annually. CRFM and Reclamation ESA funding would remain the same as estimated under the No Action Alternative.

Additional measures to mitigate the adverse effects of preferred alternative were estimated to be $2.6 million in annual costs at Grand Coulee, Libby, Lower Monumental, Lower Granite, Ice Harbor, and McNary. These measures include measures to protect water quality, fish habitat, cultural resources, and to maintain navigation and transportation. One additional fish and wildlife mitigation measure ($280,000 annually) proposed under MO4 is currently being implemented and/or would be prioritized for funding under Bonneville's F&W Program (this cost is captured under the F&W Program costs in Table 6-1).

[14] In 2016, Bonneville's F&W Program budget was $267,000,000, and the LSRCP budget was $32,303,000. When these budgets are adjusted to represent 2019 dollars, they become $281,536,000 and $34,062,000, respectively, which are the budgets used under the No Action Alternative. Bonneville's fiscal year 2020 decisions to adjust the F&W Program budget to $249 million and the LSRCP budget to $30.5 million (BP-18 Rate Case) are consistent with the range of costs analyzed for the Preferred Alternative.

CHAPTER 7 - SUMMARY OF ALL COSTS

This chapter presents a summary of the annual-equivalent costs for all alternatives, including the change and percent change from the No Action Alternative. Table 7-1 summarizes the annual-equivalent costs by alternatives; Table 7-2 summarizes the changes in annual-equivalent costs compared to the No Action Alternative; and Table 7-3 summarizes the percent change in annual-equivalent costs compared to the No Action Alternative.

As shown in Table 6-1, the estimated total cost for operating and maintaining the CRS under the No Action Alternative is approximately $1.06 billion annually. As described in Chapters 4, 5, and 6, the No Action Alternative costs include capital, O&M and mitigation costs. Mitigation costs include Bonneville's F&W Program and the LSRCP; the Corps CRFM costs; Reclamation ESA-related costs as well as additional measures to mitigate adverse effects under the action alternative (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 45 percent of total annual system costs, and mitigation 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 2.0 percent compared to No Action Alternative. This cost increase is driven primarily by construction of structural measures. Present value of the structural measure costs for MO1 are estimated to be $532 million. When amortized over the 50-year period of analysis, the annual-equivalent cost is approximately $20.2 million (or 95 percent of the annual cost increase). Almost half of this cost would occur at 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). 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 BOR ESA-related mitigation would continue). MO1 would also include additional mitigation measures as described in Section 6.2 and Annex B.

As shown in Table 7-1, MO2 is estimated to cost between $54 to $107 million more annually than the No Action Alternative (5.1 to 10.1 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 up to $53 million above the No Action Alternative budget of $281 million. Future budget adjustments would be made 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 6.2.2 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 7-2 and Table 7-3). The present value of the construction of the structural measures for MO3 are estimated to be $1.2 billion. Of the $1.2 billion, $953 million (or 77%) are costs associated with breaching the lower Snake River projects. When amortized over the 50-year period of analysis, the annual-equivalent cost is approximately $47 million ($36 million for the costs for breaching the lower Snake River projects).

As described in Section 3.1.2, a sensitivity analysis was conducted on the timing of the construction of the 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 projects would represent a difference in annualized costs of $3.8 million, which represents approximately 8 percent of the construction costs of the structural measures and 0.4 percent of total annual-equivalent costs under MO3. Therefore, 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 -13.1%) 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 7-2). Upon the breaching of the LSR dams, Bonneville would no longer have an obligation to fund USFWS for the operations and maintenance of the LSRCP facilities, estimated at $34 million. Bonneville's funding authority is directly tied to the operation of the lower Snake River projects. 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 competed to the No Action Alternative. Proposed project modifications would be coordinated with project sponsors and regional stakeholders to determine appropriate funding levels. Future budget adjustments would be made 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 $45.4 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 6.2.2 and Annex B.

Estimated MO4 costs range from a decrease in annual costs of $54 million to an increase in annual costs of $51 million, or a -5.1% decrease to 4.8% increase compared to the No Action Alternative (Table 7-2 and Table 7-3). MO4 includes $1.2 billion (present value) for the construction of structural measures, or $45 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. Proposed project modifications would be coordinated with project sponsors and regional stakeholders to determine appropriate funding levels. Future budget adjustments would be made 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. MO4 would include additional mitigation measures, estimated to cost approximately $6.2 million, annually (see Section 6.2.2 and Annex B for additional details).

The Preferred Alternative is estimated to cost from $6 million more annually (+0.6%) to $41 million (-3.9%) less than the No Action Alternative (Table 7-2 and Table 7-3). Present value of the structural measure costs for the Preferred Alternative are estimated to be $104 million, and when amortized over the 50-year period of analysis, the annual-equivalent cost is approximately $3.9 million. Most of the costs of the structural measures would occur at Bonneville project for the Lamprey passage structures and the ladder serpentine weir and at Lower Granite and Little Goose projects associated with the bypass screen modifications for Lamprey. Additionally, there could be slight decreases in capital and O&M costs under the Preferred Alternative driven by ceasing installation of fish screens at Ice Harbor, McNary and

John Day. The timing for ceasing the installation of these screens would be coordinated with the Corps and NMFS. However, the changes in capital and O&M costs compared to the No Action Alternative would be minimal.

As previously discussed, 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 are included to inform the broader cost analysis for each alternative in the EIS. 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 the Preferred Alternative, Bonneville included a range of potential Fish and Wildlife Program costs to acknowledge the possibility that the Preferred Alternative could provide biological benefits to anadromous fish species (see Chapter 7 of the EIS, Preferred Alternative) and that this could, in turn, reduce the need for some offsite mitigation funded through the Bonneville F&W Program. By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related to managing its 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. In 2016, Bonneville's F&W Program budget was $267,000,000, and the LSRCP budget was $32,303,000. When these budgets are adjusted to represent 2019 dollars, they become $281,536,000 and $34,062,000, respectively, which are the budgets used under the No Action Alternative. For the Preferred Alternative, Bonneville would continue funding the operations and maintenance of the LSRCP facilities, consistent with the No Action Alternative. Bonneville's F&W Program costs under the Preferred Alternative are estimated to range from no change from the No Action Alternative to a decrease of approximately 17 percent, or approximately $47 million, annually. Bonneville's fiscal year 2020 decisions to adjust the F&W Program budget to $249 million and the LSRCP budget to $30.5 million (BP-18 Rate Case) are consistent with the range of costs analyzed for the Preferred Alternative.

Under the Preferred Alternative, the CRFM, F&W O&M, and the Reclamation ESA-related mitigation would remain the same as under the No Action Alternative. The Preferred Alternative would include additional mitigation measures, estimated to cost approximately $2.6 million, annually (see Section 6.2.2 and Annex B for additional details).

Table 7-1. Annual-equivalent Costs for 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)	Total Annual-Equivalent Costs (Low)	Total Annual-Equivalent Costs (High)
No Action Alternative		NA	$245,000,000	$478,000,000	$332,000,000	$332,000,000	$1,055,000,000	$1,055,000,000
MO1	$532,000,000	$20,000,000	$245,000,000	$478,000,000	$333,000,000	$333,000,000	$1,076,000,000	$1,076,000,000
MO2	$1,410,000,000	$53,000,000	$245,000,000	$477,000,000	$334,000,000	$387,000,000	$1,109,000,000	$1,162,000,000
MO3	$1,231,000,000	$47,000,000	$213,000,000	$399,000,000	$237,000,000	$342,000,000	$896,000,000	$1,001,000,000
MO4	$1,198,000,000	$45,000,000	$245,000,000	$478,000,000	$233,000,000	$338,000,000	$1,001,000,000	$1,106,000,000
Preferred Alternative	$104,000,000	$4,000,000	$245,000,000	$478,000,000	$288,000,000	$335,000,000	$1,015,000,000	$1,062,000,000

Table 7-2. Change in Annual-equivalent Costs from the No Action Alternative for the Alternatives ($2019)

Alternative	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 Annual-Equivalent Costs (Low F&W costs)	Change in Annual-Equivalent Costs (High F&W costs)
MO1	$20,000,000	$0	$0	$1,000,000	$1,000,000	$21,000,000	$21,000,000
MO2	$53,000,000	$0	-$1,000,000	$2,000,000	$55,000,000	$54,000,000	$107,000,000
MO3	$47,000,000	-$32,000,000	-$79,000,000	-$95,000,000	$10,000,000	-$159,000,000	-$54,000,000
MO4	$45,000,000	$0	$0	-$99,000,000	$6,000,000	-$54,000,000	$51,000,000
Preferred Alternative	$4,000,000	$0	$0	-$44,000,000	$3,000,000	-$40,000,000	$7,000,000

Table 7-3. Percent Change in Annual-equivalent Costs from the No Action Alternative for the Alternatives ($2019)

Alternative	Construction Costs of Structural Measures (annual)	Percent Change in Capital Costs (annual)	Percent Change in O&M Costs (annual)	Percent Change in Annual Mitigation (Low F&W Costs)	Percent Change in Annual Mitigation (High F&W Costs)	Percent Change in Annual-Equivalent Costs (Low F&W costs)	Percent Change in Annual- Equivalent Costs (High F&W costs)
MO1	NA	0.0%	0.0%	0.3%	0.3%	2.0%	2.0%
MO2	NA	0.0%	-0.2%	0.6%	16.6%	5.1%	10.1%
MO3	NA	-13.1%	-16.5%	-28.6%	3.0%	-15.1%	-5.1%
MO4	NA	0.0%	0.0%	-29.8%	1.8%	-5.1%	4.8%
Preferred Alternative	NA	0.0%	0.0%	-13.3%	0.9%	-3.8%	0.7%

CHAPTER 8 - REFERENCES

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ANNEX A: COSTS OF THE STRUCTURAL MEASURES

Approach to Develop Costs for Structural Measures

Cost estimates for each of the structural measures were developed by the cost engineers at the USACE Mandatory Cost Center of Expertise at the Walla Walla District. The construction costs were developed based on the USACE Micro-computer Aided Cost Estimating System (MCASES) Second Generation (MII) with the conceptual designs of the structural measures, and also using construction requirements and design from similar projects and assessing previous estimates from the Lower Snake River Juvenile Salmon Migration Final Feasibility Report and Environmental Impact Statement (2002). Where designs were not available, an escalation factor was applied to the costs developed in the *Lower Snake River Juvenile Salmon Migration Final Feasibility Report and Environmental Impact Statement* (2002) utilizing the Civil Works Construction Cost Index System (CWCCIS) tables for the type of construction anticipated. When possible, the items that were escalated from the *Lower Snake River Juvenile Salmon Migration Final Feasibility Report and Environmental Impact Statement* (2002) were validated by developing an additional cost estimate in 2019 based on the same scope (as described in the 2002 Report). The newly developed estimates were within similar ranges to the escalated cost values from the 2002 Report.

The construction costs for the dam breaching measures used preliminary designs from the *Lower Snake River Juvenile Salmon Migration Final Feasibility Report and Environmental Impact Statement* along with the MCACES MII system to provide the cost estimates. A contingency of 50 percent was added to all construction estimates based on preliminary designs and uncertainty surrounding the construction estimates and in consultation with BPA. An additional 30 percent was added to the construction cost to account for supervision, administration, and engineering during construction costs based on historic Corps cost engineering experience with these types of costs. All costs were developed at a 2019 price level.

The structural measures were all assumed to occur over two years; the costs for these two years (assumed to be divided evenly) were discounted to present value and amortized over the 50-year period of analysis to present an annual-equivalent cost (see Section 3.1.2.1 for a description of a sensitivity analysis on the timing of the construction of the structural measures). The federal water resources discount rate of 2.785 was used in the discounting to provide average annualized costs for the structural measures (Corps, EGM 19-1, Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2019). Additional details on the approach to develop the costs of the structural measures are presented in this section.

Additional Powerhouse Surface Passage

Location and Features included:

- Applied at Ice Harbor in M01, MO2, and MO4; at McNary in MO1, MO3, and MO4
- Includes demolition of six concrete bulkheads at each of the projects, which would be replaced with telescoping weirs

- Existing collection channel and dewatering systems for juvenile fish facility operations would be demolished within the sluices
- McNary would require additional modification with the lowering of the sluiceway floor
- Downwell geometry would be modified at each project with the addition of flow control and increased radiuses of curvature
- Tailrace flow entry would include the construction of a transition chute and flow deflector for each of the two projects.
- Additional surface passage at McNary in MO2 paired with an operational measure (alter juvenile fish transportation program) requires the collection and transportation of all juveniles entering the McNary additional surface passage. Assumes flow capacity of 8000 cfs and the capability of collecting and transporting fish.

Key features:

- Surface Passage/Collection Channel - $75 million
  - The complete removal of existing fish collection channel.
  - Demolition and reshaping historic ice/trash channel floor.
  - Demolition of 6 concrete bulkheads to be replaced by telescoping weirs.
  - Construction of bulkhead for north ice trash chute for use in emergency release
- Dewatering Facility - $247 million
  - Demolition and reconstruction of south powerhouse downwell
  - Construction of overhead transportation flume
  - Construction of overhead vertical screen dewatering facility with capability to dewater 8,000 cfs at 0.4 feet per second thru screen velocity criteria
- Juvenile Fish Facility - $86 M
  - Water surfaces too low for existing facility operation
  - Demo Juvenile fish facility site except for Lab building, fish lift system to keep lab building operational (hopper)
  - Rebuild separator, sampling, raceways.
- Repurpose Water (replace fish pumps) - $48 M
  - Construction of conveyance to supplement/replace adult fish pumps
  - Incorporates turbine to reduce amount of energy entering system
  - Bypass flow could reenter tailrace via adult fish pump intakes
- Additional surface passage at John Day for MO2 and MO4 would include a floating steel structure attached to the powerhouse face designed to mimic the hydraulics of an ice/trash

chute with the capacity of 8kcfs and conveyance of the flow through the powerhouse would be made possible by modifying a skeleton unit.

- Additional surface passage at Lower Granite, Little Goose, and Lower Monumental in MO4 would include a floating steel structure attached to the powerhouse face designed to mimic the hydraulics of an ice/trash chute with the capacity of 4kcfs
  - Conveyance of the flow through the powerhouse would be made possible by modifying non-overflow sections of the powerhouse
  - tailrace flow entry would include the construction of a transition chute and flow deflector for each project
- Scope similar to past project costs developed from the McNary configuration and operations plan (COP). The cost estimate was developed utilizing the cost estimates from the McNary COP study conducted in 2009. The costs were updated to reflect current pricing levels and scaled accordingly for Ice Harbor.

Upgrade to Adjustable Spillway Weirs

- Applied at Lower Granite, Lower Monumental, and Ice Harbor for MO1 and MO2
- Applied at McNary and John Day projects for MO1, MO2, and MO3
- Includes upgrading the existing spillway weirs that are not adjustable to adjustable spillway weirs at McNary, Lower Granite, Lower Monumental, Ice Harbor, and John Day projects
- Two dams, McNary and John Day, would receive two weirs each, while Lower Granite, Lower Monumental, and Ice Harbor would each receive a single weir
- Scope replicates adjustable spillway weirs found at Little Goose. Cost estimate based on historical prices from similar projects constructed in 2016. The 2016 estimate was updated to reflect current pricing levels and scaled accordingly for each of the applicable projects.

Lower Granite Trap Modifications

- Applied at Lower Granite in MO1 and MO4
- Replace the existing trap gate with a drop gate actuated by a dedicated hoist.
- The new gate will feature a gap on the bottom to allow lamprey passage.
- Used a similar scope to a past design/build project at Ice Harbor and scaled to the current application. Prices were updated to 2019 price levels.

Modify Bonneville Ladder Serpentine Weir

- Applied at Bonneville project in MO1, MO3, and PA
- Include modifying the upper serpentine flow control fish ladder sections at Bonneville project and converting them to a vertical slot style fishway

- the existing baffles at the project's Bradford Island and Washington Shore fish ladders would be replaced with baffles that have vertical slot orifices for fish passage
- Scope similar to past project within John Day ladder. The 2009 cost for the ladder at John Day was $3.2 million, which was reduced by half to meet the appropriate scope of Bonneville serpentine weir and updated to 2019 price level.

Lower Snake Ladder Pumps

- Applied at Lower Monumental and Ice Harbor in MO1, MO2, and MO4
- Installing new pumping and pipe systems for the fish ladders at Lower Monumental and Ice Harbor projects
- Pumps and pipes would pull water from elevations deep in the reservoir to provide cooling water to fish ladders and at fish ladder exits to potentially reduce thermal barriers to fish passage for adult salmon migrating upstream.
- Scope uses recent similar projects at Lower Granite and Little Goose that were constructed in 2015. The 2015 costs were escalated to current price levels.

Spillway Weir Notch Inserts

- Applied at all lower Snake projects, McNary and John Day for MO4
- Provide a notch gate to be installed in one spillway weir at each dam to create a smaller opening in the weir and enable reduced spill.
- Assumes a steel structure allowing for 2kcfs flow with a 12 foot wide opening.
- Used a scope similar to the adjustable spillway weir that was installed at Little Goose. The 2016 cost estimate was reduced in scale for each of the applicable project and updated to reflect current pricing levels.

Lamprey Passage Structures

- Applied at John Day, The Dalles, and Bonneville in MO1, MO2, MO3, MO4, and PA.
- Modifying existing fish ladders at John Day, Bonneville, and The Dalles projects with additional structures to make upstream passage easier for Lamprey
- The structures may be an aluminum slot or tunnel that Lamprey would use to travel an alternate, but parallel route along the existing fish ladder
- The lamprey structure would use an independent water source and employ flow velocities that attract lamprey to the alternative route.

- These structures would be constructed as follows:
    - at Bonneville project, additional Lamprey passage structures would be installed in two locations -- on the Bradford Island ladder (south ladder) and at the Washington Shore fish ladder (north ladder)
    - at John Day project, an Lamprey passage structure would be constructed on the south fish ladder and the existing Lamprey passage structure on the north ladder would be extended from the tailrace deck to the forebay.
    - At The Dalles project, a diffuser grating plating would be added to the diffuser on the north ladder
    - Used a scope similar to past project effort at Bonneville. Costs based on historical pricing from the 2018 project. The 2018 costs were escalated to current levels and modified to align with the appropriate scope for each project.

Turbine Strainer Lamprey Exclusion

- Applied at all Lower Columbia projects for all multi objective alternatives and PA
- Applied at all lower Snake projects for MO1, MO2, MO4, and PA
- Installation of exclusion structure to prevent juvenile lamprey and all other fish from being entrained into the turbine unit cooling water source at the Bonneville, the Dalles, and John Day projects
- These structures provide a hood over the existing intake grating and allow sweeping flows to move fish past the opening, making entrainment unlikely.
- Used a scope for a similar project at Ice Harbor for cooling water lamprey exclusion cover. This estimate was scaled appropriately to each of the projects. Pricing levels were also updated to FY2019 levels.

Bypass Screen Modifications for Lamprey

- Applied at McNary for all multi objective alternatives
- Applied and Lower Granite and Little Goose for MO1, MO2, MO4, and PA
- Includes replacing existing fish screens used to divert fish into the collection channel of the juvenile bypass system
- Includes replacing existing extended length bar screens with submerged traveling screens to reduce juvenile lamprey entanglement
- Pricing was based on Corps Walla Walla District fish screen replacement budgetary data in FY2014. Pricing was escalated to FY2019 and scaled to the appropriate level for this project.

Lamprey Passage Ladder Modifications

- Applied at all Lower Columbia projects for all Mos and PA
- Applied at all lower Snake projects for MO1, MO2, MO4, and PA
- Includes modifying existing fish ladders at the lower Snake and Lower Columbia River projects
- Install ramps to salmon orifices at Bonneville dam; install concrete or aluminum ramps in the fish ladder to make salmon orifices elevated above the fish ladder floor more accessible to lamprey; a ramp would enable adult lamprey to more easily and directly access the salmon passage openings by removing right angles at the approach.
- Install diffuser grating plating at Bonneville (south and Cascade Island ladders), The Dalles (north ladder), and Lower Monumental (north and south ladders); install a solid stainless steel plate over the floor diffuser grating within the existing fish ladder
- Install additional refuge boxes at Bonneville Dam; construct metal refuge boxes on the floor of the fish ladder to provide a protected resting environment for lamprey migrating upstream; additional refuge boxes would be installed in the Washington shore and Bradford Island fish ladders.
- Install a wetted wall in the fish ladder at Bonneville Dam; install a metal wall in the serpentine section of the Washington shore fish ladder at Bonneville (similar to that already installed in the Bradford Island ladder)
- Install entrance weir caps at McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Round edges at fish ladder entrance weirs to eliminate 90 degree surfaces which hinder lamprey from entering fish ladders on the lower Snake projects and at McNary.
- Used a scope similar to past project effort at Ice Harbor in 2017. The 2017 costs were escalated to current levels and modified to align with the scope for each project.

Breach Lower Snake River Embankments

- Applied at all lower Snake projects for MO3
- Includes removal of the earthen embankments, abutments, and structures at each dam as needed to provide a 140-mile stretch of river without impoundment
- To control sediment inputs and maintain safe conditions at downstream dams, breaching would be accomplished in phases, starting with Lower Granite and Little Goose dams, followed by Lower Monumental and Ice Harbor dams
- Includes installing water control structures such as cofferdams and levees at breach locations to direct and control flows near the powerhouse, spillways, and navigation locks to facilitate safe drawdown of the reservoirs and provide fish passage

- A cost estimate was developed based on the scope and quantities listed in both the Lower Snake River Juvenile Salmon Migration Final Feasibility Report and Environmental Impact Statement (2002). Where information was limited, the costs were escalated from the Lower Snake River Juvenile Salmon Migration Final Feasibility Report and Environmental Impact Statement.

Lower Snake Infrastructure Drawdown

- Applied at all lower Snake projects for MO3
- Includes modifying existing equipment and dam infrastructure to adjust to drawdown conditions so that both spillways and powerhouse outlets may be used to evacuate the reservoir at various elevations
- Existing equipment and dam would not be used for hydropower generation, but would instead be used as outlets for drawdown below spillway elevations
- Costs were escalated from Lower Snake River Juvenile Salmon Migration Final Feasibility Report and Environmental Impact Statement (2002) cost estimate to 2019 price levels.

Improved Fish Passage Turbines[15]

This structural measure is include under the No Action Alternative, all of the multiple objective alternatives, and the preferred alternative. These costs for this measure are included in the capital costs estimates, as provided in the Strategic Asset Management Plan (2018).

Cost Estimates of the Structural Measures

No Action Alternative

The structural measures under the multi-objective alternatives are separate from the ongoing structural measures occurring under the No Action Alternative and therefore there are no cost estimates for structural measures under the No Action Alternative.

Summary of Structural Costs for Multi-Objective Alternatives

Table A-1 summarizes the costs for the structural measures for all of the multi-objective alternatives.

[15] Note that this structural measure is being implemented under the No Action Alternative, and is also included under all of the MO alternatives.

Table A-1. Cost Estimates for the Structural Measures under the Multi-objective Alternatives (2019$)

MO1	MO2	MO3	MO4	Preferred Alternative	Description	Location	Construction Cost (A)	Contingency Cost (B)	Supervision and Administration, Engineering During Construction Cost (C)	Total Project First Cost (A+B+C)	Present Value of First Cost	Annual-equivalent Costs (Amortized over 50 years)
	X		X		Additional Powerhouse Surface Passage	John Day	$128,086,714	$64,043,357	$57,639,021	$249,769,092	$239,396,356	$9,084,634
	X					McNary	$455,911,470	$227,955,735	$205,160,162	$889,027,367	$852,106,681	$32,335,818
X		X	X			McNary	$81,064,553	$40,532,277	$36,479,049	$158,075,878	$151,511,098	$5,749,556
X	X		X			Ice Harbor	$43,988,065	$21,994,033	$19,794,629	$85,776,727	$82,214,479	$3,119,882
			X			Lower Monumental	$82,604,902	$41,302,451	$37,172,206	$161,079,559	$154,390,037	$5,858,806
			X			Little Goose	$84,750,099	$42,375,050	$38,137,545	$165,262,693	$158,399,449	$6,010,956
			X			Lower Granite	$86,895,297	$43,447,649	$39,102,884	$169,445,829	$162,408,862	$6,163,105
X	X				Upgrade to Adjustable Spillway Weirs	Lower Granite	$10,159,658	$5,079,829	$4,571,846	$19,811,333	$18,988,582	$720,580
X	X					Lower Monumental	$10,159,658	$5,079,829	$4,571,846	$19,811,333	$18,988,582	$720,580
X	X					Ice Harbor	$10,159,658	$5,079,829	$4,571,846	$19,811,333	$18,988,582	$720,580
X	X	X				McNary	$20,319,317	$10,159,659	$9,143,693	$39,622,668	$37,977,166	$1,441,161
X	X	X				John Day	$20,319,317	$10,159,659	$9,143,693	$39,622,668	$37,977,166	$1,441,161
X			X	X	Lower Granite Trap Modification	Lower Granite	$214,519	$107,260	$96,534	$418,312	$400,940	$15,215
X		X		X	Modify Bonneville Ladder Serpentine Weir	Bonneville	$6,503,891	$3,251,946	$2,926,751	$12,682,587	$12,155,888	$461,293
X	X		X		Lower Snake Ladder Pumps	Lower Monumental	$3,079,761	$1,539,881	$1,385,892	$6,005,534	$5,756,128	$218,434
X	X		X			Ice Harbor	$3,079,761	$1,539,881	$1,385,892	$6,005,534	$5,756,128	$218,434
			X		Spillway Weir Notch Inserts	Lower Granite	$8,548,997	$4,274,499	$3,847,049	$16,670,544	$15,978,228	$606,343
			X			Little Goose	$8,548,997	$4,274,499	$3,847,049	$16,670,544	$15,978,228	$606,343
			X			Lower Monumental	$8,548,997	$4,274,499	$3,847,049	$16,670,544	$15,978,228	$606,343
			X			Ice Harbor	$8,548,997	$4,274,499	$3,847,049	$16,670,544	$15,978,228	$606,343
			X			McNary	$8,548,997	$4,274,499	$3,847,049	$16,670,544	$15,978,228	$606,343
			X			John Day	$8,548,997	$4,274,499	$3,847,049	$16,670,544	$15,978,228	$606,343

MO1	MO2	MO3	MO4	Preferred Alternative	Description	Location	Construction Cost (A)	Contingency Cost (B)	Supervision and Administration, Engineering During Construction Cost (C)	Total Project First Cost (A+B+C)	Present Value of First Cost	Annual-equivalent Costs (Amortized over 50 years)
X	X	X	X	X	Lamprey Passage Structures	Bonneville	$4,116,858	$2,058,429	$1,852,586	$8,027,873	$7,694,481	$291,991
X	X	X	X	X		The Dalles	$2,058,429	$1,029,215	$926,293	$4,013,937	$3,847,241	$145,995
X	X	X	X	X		John Day	$4,116,858	$2,058,429	$1,852,586	$8,027,873	$7,694,481	$291,991
X	X		X	X	Turbine Strainer Lamprey Exclusion	Lower Granite	$527,433	$263,717	$237,345	$1,028,494	$985,782	$37,409
X	X		X	X		Lower Monumental	$527,433	$263,717	$237,345	$1,028,494	$985,782	$37,409
X	X		X	X		Little Goose	$527,433	$263,717	$237,345	$1,028,494	$985,782	$37,409
X	X		X	X		Ice Harbor	$527,433	$263,717	$237,345	$1,028,494	$985,782	$37,409
X	X	X	X	X		McNary	$1,193,858	$596,929	$537,236	$2,328,023	$2,231,342	$84,675
X	X	X	X	X		John Day	$1,360,464	$680,232	$612,209	$2,652,905	$2,542,732	$96,492
X	X	X	X	X		Bonneville	$1,693,677	$846,839	$762,155	$3,302,670	$3,165,513	$120,125
X	X	X	X	X		The Dalles	$1,860,283	$930,142	$837,127	$3,627,552	$3,476,902	$131,942
X	X	X	X		Bypass Screen Modifications for Lamprey	McNary	$26,754,000	$13,377,000	$12,039,300	$52,170,300	$50,003,704	$1,897,545
X	X		X	X		Little Goose	$11,466,000	$5,733,000	$5,159,700	$22,358,700	$21,430,159	$813,234
X	X		X	X		Lower Granite	$11,466,000	$5,733,000	$5,159,700	$22,358,700	$21,430,159	$813,234
X	X	X	X	X	Lamprey Passage Ladder Modifications	Bonneville	$1,670,776	$835,388	$751,849	$3,258,013	$3,122,710	$118,501
X	X	X	X	X		The Dalles	$1,670,776	$835,388	$751,849	$3,258,013	$3,122,710	$118,501
X	X	X	X	X		McNary	$804,479	$402,240	$362,016	$1,568,734	$1,503,586	$57,058
X	X		X	X		Ice Harbor	$804,479	$402,240	$362,016	$1,568,734	$1,503,586	$57,058
X	X		X	X		Lower Monumental	$1,569,606	$784,803	$706,323	$3,060,732	$2,933,622	$111,325
X	X		X	X		Little Goose	$485,694	$242,847	$218,562	$947,103	$907,771	$34,448
X	X		X	X		Lower Granite	$485,694	$242,847	$218,562	$947,103	$907,771	$34,448
		X			Breach Snake Embankments	Lower Granite	$52,404,972	$26,202,486	$23,582,237	$102,189,695	$97,945,829	$3,716,857
		X				Little Goose	$108,359,485	$54,179,743	$48,761,768	$211,300,996	$202,525,814	$7,685,467
		X				Lower Monumental	$112,565,563	$56,282,781	$50,654,503	$219,502,847	$210,387,047	$7,983,786
		X				Ice Harbor	$176,583,663	$88,291,831	$79,462,648	$344,338,142	$330,038,020	$12,524,311

MO1	MO2	MO3	MO4	Preferred Alternative	Description	Location	Construction Cost (A)	Contingency Cost (B)	Supervision and Administration, Engineering During Construction Cost (C)	Total Project First Cost (A+B+C)	Present Value of First Cost	Annual-equivalent Costs (Amortized over 50 years)
		X			Lower Snake Infrastructure Drawdown	Lower Granite	$15,405,537	$7,702,769	$6,932,492	$30,040,797	$28,793,224	$1,092,648
		X				Little Goose	$14,899,599	$7,449,799	$6,704,819	$29,054,217	$27,847,616	$1,056,764
		X				Lower Monumental	$14,888,229	$7,444,115	$6,699,703	$29,032,047	$27,826,367	$1,055,957
		X				Ice Harbor	$14,888,229	$7,444,115	$6,699,703	$29,032,047	$27,826,367	$1,055,957
X	X	X	X	X	Improved Fish Passage Turbines	John Day	Included under the capital costs for the No Action Alternative and all of the MOs					

Note that the cost estimates include items that were escalated from the *Lower Snake River Juvenile Salmon Migration Feasibility Report and EIS* (2002). To validate these escalated costs, several cost estimates were developed in 2019 based on the same scope as in the 2002 Report. These newly developed estimates were within similar ranges to the escalated cost values from the 2002 Report.

ANNEX B: COST OF ADDITIONAL MITIGATION MEASURES

As described in Chapter 6, mitigation includes the fish and wildlife mitigation as well as additional mitigation measures associated with mitigating the adverse effects under the MOs. The costs of the additional mitigation measures are provided for each MO in this Annex; the last column in the tables note if the measure is being implemented or would be prioritized for implementation under the Bonneville Fish and Wildlife (F&W) Program. The costs of the additional mitigation measures that are currently being implemented or would be prioritized for funding under the Bonneville F&W Program (as part of the fish and wildlife mitigation costs) are included in Bonneville's F&W Program costs and not as additional mitigation to avoid double counting (see Table 6-1 in Section 6.2).

The mitigation measures were estimated as on-going annual costs or as construction costs by the cost engineers. The Corps, Reclamation, and Bonneville provided input on mitigation measures and associated costs. Similar to the estimates developed for the structural measures under the MO alternatives, the mitigation construction cost estimates were developed utilizing planning level designs (when available), available documents, or best professional judgment based upon historic operations and/or knowledge of system costs. Cost engineers at the Corps Mandatory Cost Center of Expertise at the Walla Walla District estimated the costs using MCACES MII software and proposed design. A contingency of 50 percent was added to all construction estimates based on preliminary designs and uncertainty surrounding the construction estimates and in consultation with Bonneville. Thirty percent of the construction and contingency cost was included to account for supervision, administration, and engineering during construction costs to represent project first costs based on historic Corps cost engineering experience with these types of costs.

The project first costs were assumed to occur over two years (for MO3, measures that would occur post breach were assumed to occur in years 3 and 4, consistent with the alternative implementation guidance), discounted to present value, and amortized over the 50-year period of analysis. For applicable structural mitigation measures, Corps project, operations, and engineers estimated the changes in O&M and capital investments and/or non-routine costs, if relevant, that would occur with these structural mitigation measures. These additional costs were discounted to reflect 2019 dollars and amortized over the 50-year period of analysis and aggregated with the annual-equivalent of the project first costs to estimate the annual-equivalent costs (provided in the last column in Tables B-1 to B-5).

Table B-1. Mitigation Costs for Multiple Objective 1

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Water Quality	Region C: Moderate adverse effects from water temperatures can create increased algal growth due to high August water temperatures in the lower Snake River Projects. This can be a public safety issue for water recreation.	Region C: On the lower Snake River Increased harmful algal bloom monitoring at recreational areas; if algal blooms produce toxins, post public advisories at recreational areas with to protect the public	Cost estimates were provided by water quality specialists in the Corps Portland District, and were based on current monitoring costs.	NA	$200,000
Vegetation, Wildlife, Wetlands, and Floodplains	In Region A & B exposure of mudflats and barren lands during the spring months could result in minor effects to native habitats by establishment of non-native, invasive plant species.	In Region A, update and implement Invasive Plant Management Plan for the shoreline at Libby. Region B will have habitat for fish mitigation	The estimate of 24 acres was based on information from fish and wildlife GIS mapping. The Corps Natural Resource Specialist estimated that in-water invasive plant treatments average about $1,000 per acre.	NA	$24,000
Vegetation, Wildlife, Wetlands, and Floodplains	In Region A, Conversion of wetland to upland habitat in May through summer (off-channel habitat). Effects on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Effects are minor and would occur seasonally.	In Region A, on Kootenai River downstream of Libby: Plant native wetland and riparian vegetation up to ~100 acres along river.	Fish and Wildlife teams used GIS mapping to establish acreage needed for planting. Previous estimates were obtained from MCACES MII of plant prices from the Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with Corps Walla Walla District wildlife biologists. Unit costs assumed: $40 per plant for cottonwood; $30.70 per willow; 10 pounds per acre at $9 per pound for grass seeding.	$3.5 million	$144,000 (covered under F&W Program)

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Anadromous Fish	Regions C and D: Moderate adverse effect from increased spill levels, which create turbulence and eddies below the dams resulting in delays to adult passage.	Temporary extension of performance standard spill levels in coordination with the Regional Forum	NA	NA	No cost-
Resident Fish - ESA Kootenai River White Sturgeon	Region A: The current flow regime at Libby has made establishment of riparian vegetation difficult to sustain young stands of cottonwoods - major contributors to foodweb for Sturgeon, which results in moderate localized effects. While this MO would not exacerbated these effects in the No Action, it is an ongoing problem.	Plant 1-2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon (KWRS) by providing a food source. This would complement ongoing habitat actions already being taken in the region.	Fish and Wildlife teams used GIS mapping to establish acreage needed for planting. Previous estimates were obtained from MCACES MII of plant prices from the Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with Walla Walla District wildlife biologists. Unit costs assumed: $40 per plant for cottonwood; $30.70 per willow; 10 pounds per acre at $9 per pound for grass seeding.	$3.1 million	$132,000 (covered under F&W Program)
Resident Fish - Burbot, Kokanee, and Redband Rainbow Trout	In Region B changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. (a) Determine where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. (b) Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	Information was used from previous cost estimates. The cost estimate assumes approximately one foot of gravel would be needed for 100 acres, approximately 160,000 cubic yards, at $35 per cubic yard.	$10.9 million	$397,000

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Resident Fish – ESA Bull Trout	Region A: Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make Bull Trout more susceptible to angling/predation. Negligible to Moderate adverse effect.	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.	Estimate assumes 15 sites, with 3 acres per site. Based on recent costs from the Skokomish River GI in Seattle, an approximate per acre cost for major in-stream restoration is $12k per acre. Additional cost for berm construction is based on 9,200 yards of material, with a major berm at each site and the unit cost of $45 per yard.	$6.76 million	$255,000 (covered under F&W Program)
Navigation & Transportation	Region B: Inchelium-Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members. This would be a moderate adverse effect that results in public safety and environmental justice concerns.	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it's available at lower water elevations.	Cost engineers at the Corps Mandatory Cost Center of Expertise at the Walla Walla District estimated the costs using MCACES MII software and proposed design. Assumes the use of 2 drilled shafts, heavy steel structure, and aluminum decking 50 feet long	$2.4 million	$97,000
Cultural Resources	Region A and B: Major adverse effects from increase in number of acre-days that archaeological resources would be exposed.	Region A and B: Use the Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other mitigation to address impacts to TCPs.	Costs were estimated by Cultural Resource specialists from the three agencies, based on operational changes under MO1.	NA	$500,000

Note: Some of the mitigation measures would require annual operations and maintenance activities and/or non-routine major repair or rehabilitation once over the 50-years; the present value of these costs were added to the project first costs and amortized to provide the annual-equivalent cost.

Table B-2. Mitigation Costs for Multiple Objective 2

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Water Quality	Region A: At Hungry Horse the drawdown in summer impacts primary and secondary biological productivity that result from reservoir drawdowns and higher flushing rates.	Initiate a nutrient supplementation program at Hungry Horse.	Estimates from the current nutrient supplementation program at Dworshak were used, including $20,000 in monitoring.	NA	$220,000
Recreation	Region C: Changes in water levels would make the Dworshak State Park (Freeman Creek) boat ramp inaccessible for 30 days in the month of April, the start of turkey hunting season and early bass fishing season. Because of the steep terrain and limited road access at Dworshak, this boat ramp is heavily used by recreators, especially hunters and fishermen, outside of the traditional recreation season. The alternative results in minor impacts to recreation.	Extend the boat ramp at Dworshak State Park (Freeman Creek) to make it accessible in April, when it is used by hunters and fishermen.	Costs were estimated based on previous estimates for Robie Creek Boat Ramp extensions project produced by the cost engineers at the Corps Walla Walla District Mandatory Cost Center for Expertise. Assumes 220 feet ramp extension at 14% slope for 30 foot water surface elevation drop and $1,000 per linear foot.	$429,000	$19,000

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Vegetation, Wildlife, Wetlands, & Floodplains	In Region A, Conversion of wetland to upland habitat in May through summer (off-channel habitat). Impacts on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Impacts are minor and would occur seasonally.	In Region A, on Kootenai River downstream of Libby: Plant native wetland and riparian vegetation up to ~100 acres along river.	Fish and Wildlife teams used GIS mapping to establish acreage needed for planting. Previous estimates were obtained from MCACES MII of plant prices from the Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with the Corps Walla Walla District wildlife biologists. Unit costs assumed: $40 per plant for cottonwood; $30.70 per willow; 10 pounds per acre at $9 per pound for grass seeding.	$3.5 million	$144,000 (covered under F&W Program)
Vegetation, Wildlife, Wetlands & Floodplains	In Region A & B exposure of mudflats and barren lands during the spring months could result in minor effects to native habitats by establishment of non-native, invasive plant species.	In Region A, update and implement Invasive Plant Management Plan for the shoreline at Libby. Region B will have habitat for fish mitigation (see below)	The estimate of 24 acres were based on information from fish and wildlife GIS mapping. Corps specialists estimated that in-water invasive plant treatments average about $1,000 per acre.	NA	$24,000

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Resident Fish - ESA Kootenai River White Sturgeon	Region A: The current flow regime at Libby has made establishment of riparian vegetation difficult to sustain young stands of cottonwoods - major contributors to food web for Sturgeon, which results in moderate localized effects. While this MO would not exacerbated these impact in the No Action, it is an ongoing problem.	Plant 1-2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon (KWRS) by providing a food source. This would complement ongoing habitat actions already being taken in the region	Fish and Wildlife teams used GIS mapping to establish acreage needed for planting. Previous estimates were obtained from MCACES MII of plant prices from the Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with Corps Walla Walla District wildlife biologists. Unit costs assumed: $40 per plant for cottonwood; $30.70 per willow; 10 pounds per acre at $9 per pound for grass seeding.	$3.1 million	$132,000 (covered under F&W Program)
Resident Fish – ESA Bull Trout	Region A: Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make Bull Trout more susceptible to angling/predation. Negligible to Moderate adverse impact.	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.	Estimate assumes 15 sites, with 3 acres per site. Based on recent costs from the Skokomish River GI in Seattle, an approximate per acre cost for major in-stream restoration is $12,000 per acre. Additional cost for berm construction is based on 9,200 yards of material, with a major berm at each site and the unit cost of $45 per yard.	$6.76 million	$255,000 (covered under F&W Program)

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Resident Fish - Burbot, Kokanee, and Redband Rainbow Trout	In Region B changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. (a) Determine where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. (b) Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	Information was used from previous cost estimates. Cost estimate assumes approximately one foot of gravel would be needed for 100 acres, approximately 160,000 cubic yards, at $35 per cubic yard.	$10.9 million	$397,000
Anadromous Fish, Resident Fish, and Wildlife	All regions: Since power generation would increase, and juvenile fish passage spill would be reduced, potential impacts to fish and wildlife are anticipated above the impacts discussed for the No Action Alternative.	Increase the Bonneville Fish and Wildlife Program to mitigate additional impacts to fish and wildlife.	Costs captured under fish and wildlife mitigation costs (Sections 6.1.1 and 6.2.3).	NA	NA
Navigation & Transportation	Region B: Inchelium-Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members. This would be a moderate adverse effect that results in public safety and environmental justice concerns.	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it's available at lower water elevations.	Cost engineers at the Corps Mandatory Cost Center of Expertise at the Walla Walla District estimated the costs using MCACES MII software and proposed design. Assumes the use of 2 drilled shafts, heavy steel structure, and aluminum decking 50 feet long.	$2.4 million	$97,000

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Cultural Resources	Region A, B, and C: Major adverse effects from increase in number of acre-days that archaeological resources would be exposed.	Region A, B, and C: Use Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other mitigation to address impacts to TCPs.	Costs were estimated by Cultural Resource specialists from the three agencies, based on operational changes under MO2.	NA	$1.0 million

Note: Some of the mitigation measures would require annual operations and maintenance activities and/or non-routine major repair or rehabilitation once over the 50-years; the present value of these costs were added to the project first costs and amortized to provide the annual-equivalent cost.

Table B-3. Mitigation Costs for Multiple Objective 3

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Vegetation, Wildlife, Wetlands, &Floodplains	Region A: Operations at Libby Dam impact wetland vegetation along the Kootenai River and could cause conversion of wetland habitat to upland habitat. This could cause impact to wildlife. Adverse, moderate impacts would occur seasonally.	In Region A, on Kootenai River downstream of Libby: Plant native wetland and riparian vegetation up to ~100 acres along river.	Fish and Wildlife teams used GIS mapping to establish acreage needed for planting. Previous estimates were obtained from MCACES MII of plant prices from the Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with Corps Walla Walla District wildlife biologists. Unit costs assumed: $40 per plant for cottonwood; $30.70 per willow; 10 pounds per acre at $9 per pound for grass seeding. O&M costs were assumed to be $250 per acre.	$3.5 million	$144,000 (covered under F&W Program)

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Vegetation, Wildlife, Wetlands, a& Floodplains	Region C: Lowering of the water table associated with breaching could have a major adverse effect by conversion of plant communities to non-native, invasive plant communities.	Develop and implement a planting plan to restore arid, native plant communities on approximately 13,000 acres of arid lands along the lower Snake River.	Fish and Wildlife teams used GIS mapping to establish acreage needed for planting. The cost estimate assumed unit prices based on previous project MCACES MII for plant prices from the Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with Corps Walla Walla District wildlife biologists. Unit prices assumed were: hydroseed ($90 per acre, for 10lbs per acre at $9 pound); and shrubbery ($25 per planting, 80 stems per acre at $2,000 per acre). Annual O&M costs were assumed to be $250 per acre.	$53.0 million	$5.0 million

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Vegetation, Wildlife, Wetlands, a& Floodplains	Region C: Breaching the lower Snake River dams would expose approximately 13,000 acres of shoreline, creating major negative effects to wetland and riparian plant communities.	Develop and implement a planting plan for approximately 1500 acres of wetland and riparian species along the exposed shorelines.	Fish and Wildlife teams used GIS mapping to establish acreage needed for planting. Per acre costs were obtained from previous project cost estimates of plant prices from Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with Corps Walla Walla wildlife biologists. The cost estimate assumed cottonwoods at 400 stems per acre (1-2 gallon) interspersed with willow, with half willow and half cottonwood. Unit costs were $17,674 per acre for cottonwoods and willows and $90 per acre for the seed mix. O&M costs were assumed to be $250 per acre.	$52.0 million	$2.2 million
Vegetation, Wildlife, Wetlands, a& Floodplains	Region C: Breaching the lower Snake River dams would result in sediment deposition, causing major adverse impacts for wetlands downstream of Ice Harbor dam.	Develop and implement a restoration plan for approximately 155 acres of wetlands downstream of Ice Harbor. The plan may include excavation of sediments deposited after breaching.	Unit prices were from previous project MCACES MII estimates for plant prices from the Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with Corps Walla Walla District wildlife biologists. Unit costs were 400 stems per acre for willow whip at a per acre cost of $15,348 and $90 per acre for seed mix. Fish and Wildlife teams used GIS mapping to establish acreage needed for planting.	$4.7 million	$199,000

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Vegetation, Wildlife, Wetlands, a& Floodplains	Region A: Exposure of mudflats and barren lands could result in establishment of non-native, invasive plant species, a moderate, adverse effect.	Update and implement the existing Invasive Plant Management Plan at Libby to prevent establishment of invasive plant species	The estimate of 24 acres were based on information from fish and wildlife GIS mapping. The Corps Natural Resource Specialist at Albeni Dam estimated that in-water invasive plant treatments average about $1,000 per acre.	NA	$24,000
Anadromous Fish	Regions D: Moderate adverse effect from increased spill levels, which create turbulence and eddies below the dams resulting in delays to adult passage.	Temporary extension of performance standard spill levels in coordination with the Regional Forum	NA	NA	No Cost
Anadromous Fish	Region C: Breaching the lower Snake River dams would have major short-term adverse effects. Breaching would create lethal river conditions (turbidity and suspended sediment, low dissolved oxygen) which would cause major effects to Snake River anadromous fish populations in the short-term.	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.	Cost estimate was based on the Cost Appendix from the Lower Snake River Feasibility Report and EIS (2002) for the. Temporary Fish Handling Facilities for Ice Harbor ($19.6 million), updated FY19 costs was $36.6 million	$36.6 million	$1.6 million

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Anadromous Fish	Region C: Breaching the lower Snake River dams would create major adverse short-term effects from high levels of turbidity/suspended sediment from Lower Granite Dam to Ice Harbor Dam during fall fish migration. This could result in mortality of 20-40% of the populations. Very low dissolved oxygen levels caused by dam breaching would result in fish mortality in the lower Snake River, with considerable impacts to year class of fall migrating fish.	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.	Produce up to 21 million salmon, steelhead, and resident rainbow trout at existing facilities, and work with facility operators to determine how best to support required production levels. This action would require new authority since Bonneville's authority for LSRCP is tied to the operation of the dams.	$78.1 million	$2.9 million
Anadromous Fish	In Region D, concentrations of total dissolved gas (TDG) could increase as a result of spill measures implemented as part of MO3. This could delay adult migration or cause health effects to fish.	Real time monitoring of fish. If it is observed that conditions in the tailrace are impeding upstream passage of adult salmon and steelhead or actionable TDG impacts to fish are observed, the co-lead agencies would implement performance standard spill operations until the situation is remedied.	NA	NA	No costs

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Resident Fish – White Sturgeon	Region C: Breaching the lower Snake River dams would create major adverse short-term effects from high levels of turbidity/suspended and very low dissolved oxygen levels in the river. This could result in mortality for sturgeon and the forage fish they feed on. Although sturgeon are not ESA-listed, they are important to regional tribes and sport fishers.	On the Snake River, trap –and-haul White Sturgeon from impacted areas prior to dam breaching. Relocate trapped sturgeon to locations in Hells Canyon on the Snake River, and downstream of McNary project on the Columbia River.	Used current costs of the trap and haul program. Assumes an operational cost of $105,000 per week for two week duration; 10 and boat crews consisting of 3 individuals per boat	NA	$29,000 ($784,000 in year 1)
Resident Fish - ESA Kootenai River White Sturgeon	Region A: The current flow regime at Libby has made establishment of riparian vegetation difficult to sustain young stands of cottonwoods - major contributors to food web for Sturgeon, which results in moderate localized effects. While this MO would not exacerbated these impact in the No Action, it is an ongoing problem.	Plant 1-2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon (KWRS) by providing a food source. This would complement ongoing habitat actions already being taken in the region.	Fish and Wildlife teams used GIS mapping to establish acreage needed for planting. Previous estimates were obtained from MCACES MII plant prices from the Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with Corps Walla Walla District wildlife biologists. Unit costs assumed: $40 per plant for cottonwoods, and 10 pounds per acre at $9 per pound for grass seeding.	$3.1 million	$132,000 (covered under F&W Program)

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Resident Fish – ESA Bull Trout	Region A: Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make Bull Trout more susceptible to angling/predation. Negligible to Moderate adverse impact.	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.	Estimate assumes 15 sites, with 3 acres per site. Based on recent costs from the Skokomish River GI in Seattle, an approximate per acre cost for major in-stream restoration is $12,000 per acre, $36,000 per site with 15 sites. Additional cost for berm construction is based on 9,200 yards of material, with a major berm at each site and a unit cost of $45 per yard.	$6.76 million	$255,000 (covered under F&W Program)
Resident and Anadromous Fish	Region C: Breaching the lower Snake River Dams would result in major short-term adverse effects from reservoir drawdown. These conditions could make the Tucannon River (a tributary of the Snake River) delta inaccessible to Bull Trout, salmon and steelhead, inhibiting their access to spawning habitat.	In Region C: Modify the Tucannon River channel at the delta to allow Bull Trout, salmon, and steelhead passage after Snake River water elevations decrease from breaching.	Corps experts assumed 1 river mile of instream restoration would be required, including 1 week of work pre-breaching to clear the streambed. Stream restoration pricing is based on the most recent large scale in-stream restoration project in the region, Skokomish River Ecosystem Restoration.	$7.6 million	$276,000
Navigation & Transportation	Region B: Inchelium-Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members. This would be a moderate adverse effect that results in public safety and environmental justice concerns.	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it's available at lower water elevations.	Assumes the use of 2 drilled shafts, heavy steel structure, and aluminum decking 50 feet long .Cost engineers at the Corps Mandatory Cost Center of Expertise at the Walla Walla District estimated the costs using MCACES MII software and proposed design.	$2.4 million	$97,000

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Navigation/Transportation	Region C: Breaching the lower Snake River Dams would result in higher water velocities, increasing scour around bridge piers and creating a major adverse effect to transportation and public safety.	Armor approximately 80 miles of railroad and highway embankments previously designed or constructed by the Corps to protect them from erosion caused by the breaching measure	This estimate was based on the 2002 LSR Final Feasibility Report and EIS estimates of bridge pier and abutment protection costs for Ice Harbor, Lower Monumental, Lower Granite, and Little Goose. Costs were updated to FY19 price levels.	$203 million	$7.4 million
Navigation & Transportation	Breaching the LSR dams will result in higher water velocities in the river, increasing erosion and higher flows through drainage structures/culverts.	More than 80 miles of railroad and highway embankments would need to be armored to protect from erosion.	This estimate was based on the 2002 LSR Final Feasibility Report and EIS estimates of the railroad and roadway damage repair costs for Ice Harbor, Lower Monumental, Lower Granite, and Little Goose. Costs were updated to FY19 price levels.	$472 million	$17.2 million
Navigation & Transportation	In Region D, breaching of the lower Snake River dams would cause sediment to deposit in the federal navigation channel in the lower Snake River near the confluence with the Columbia River in the upper part of McNary Reservoir.	At the confluence of the lower Snake River in Region D the Corps would dredge the Federal navigation channel post breaching and until the river equilibrium is achieved, as needed, to maintain the federal channel.	Sediment and hydraulic engineers at the Corps Walla Walla District estimated the amount of sediment that would be required to be removed from the lower Snake River approximately at the confluence with the Columbia River. Unit dredging costs were estimated based on a mid-point between lower Snake River and lower Columbia River costs.	$108.7 million (short-term dredging cost)	$6.1 million

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Public Safety	Region C: Breaching the lower Snake River dams would create high water velocities that could increase scour conditions that would damage existing gas pipelines that cross the lower Snake River near Lyons Ferry. This would cause a major adverse effect to utilities and could contribute an interruption in service or public safety issues.	After breaching the lower Snake River dams, the gas lines would need to be modified to withstand the velocities due to breach.	This estimate was based on the 2002 LSR Juvenile Salmon Migration Final Feasibility Report and EIS estimates of replacing gas lines. Costs were updated to FY19 price levels.	$46 million	$1.7 million
Cultural Resources	Region A and B: Major adverse effects from increase in number of acre-days that archaeological resources would be exposed.	Region A and B: use Cultural Resources Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other mitigation to address impacts to TCPs.	Costs were estimated by Cultural Resource specialists from the three agencies, based on operational changes under MO3 at non-lower Snake River reservoirs.	NA	$500,000

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual-Equivalent Costs
Cultural Resources	Region C: Drawdown of the reservoirs on the lower Snake River caused by dam breaching would result in the exposure of over 350 known cultural resources.	Develop a new Programmatic Agreement under the existing FCRPS Cultural Resource Program for cultural resources exposed in the four reservoir areas.	Costs were estimated by Cultural Resource specialists from the three agencies, based on structural changes under MO3. Includes cultural resource protection in the short-term during and following breaching activities; and annual maintenance costs for cultural resources for 10 years as management of the LSR lands transitions.:.	$20 million (short-term protection measures at LSR)	$1.0 million

Note: Some of the mitigation measures would require annual operations and maintenance activities and/or non-routine major repair or rehabilitation once over the 50-years; the present value of these costs were added to the project first costs and amortized to provide the annual-equivalent cost.
The cost estimates include items that were escalated from the *Lower Snake River Juvenile Salmon Migration Feasibility Report and EIS* (2002). To validate these escalated costs, several cost estimates were developed in 2019 based on the same scope *as in the 2002 Report. These newly developed estimates were within similar ranges to the escalated cost values from the 2002 Report.

Table B-4. Mitigation Costs for Multiple Objective 4

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual Costs
Water Quality	Region A: Lower lake levels at Albeni Falls could make near shore areas more difficult to access due to greater macrophyte and periphyon growth (e.g. Eurasian water milfoil). This is estimated to be a negligible to minor effect.	Implement and expand the existing Invasive Aquatic Plant Removal program at Albeni Falls	The estimate of 1,200 acres was based on information from fish and wildlife GIS mapping. The Corps specialists at Albeni Dam estimated that in-water invasive plant treatments average about $1,000 per acre, annually.	NA	$1.2 million
Water Quality	In Region A, at Hungry Horse the drawdown in summer impacts primary and secondary biological productivity that result from reservoir drawdowns and higher flushing rates.	In Region A, initiate a nutrient supplementation program at Hungry Horse	Estimates from the current nutrient supplementation program at Dworshak were used, including $20,000 in monitoring.	NA	$220,000
Resident Fish – ESA Bull Trout	Region A: Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make Bull Trout more susceptible to angling/predation. Negligible to Moderate adverse impact.	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.	Estimate assumes 15 sites, with 3 acres per site. Based on recent costs from the Skokomish River GI in Seattle, an approximate per acre cost for major in-stream restoration is $12,000 per acre. $36,000 per site. Additional cost for berm construction is based on 9,200 yards of material, with a major berm at each site and the unit cost of $45 per yard.	$6.76 million	$255,000 (covered under F&W Program)

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual Costs
Resident Fish - Burbot, Kokanee, and Redband Rainbow Trout	In Region B changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. (a) Determine where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. (b) Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	Information was used from previous cost estimates. Estimate uses approximately one foot of gravel would be needed for 100 acres, approximately 160,000 cubic yards, at $35 per cubic yard.	$10.9 million	$397,000
Navigation & Transportation	Region B: Inchelium-Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members. This would be a moderate adverse effect that results in public safety and environmental justice concerns.	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it's available at lower water elevations.	Assumes the use of 2 drilled shafts, heavy steel structure, and aluminum decking 50 feet long .Cost engineers at the Corps Mandatory Cost Center of Expertise at the Walla Walla District estimated the costs using MCACES MII software and proposed design.	$2.4 million	$97,000
Navigation & Transportation	In Region C & D, high spill volumes and lower tail water increase scour, creating sediments and filling of the navigation channel. This is a moderate adverse impact to navigation.	Monitoring of scour and infill at John Day, McNary, Ice Harbor, Lower Monumental, and Lower Granite projects and increase dredging maintenance, as needed to maintain navigation channel. This is predicted to be needed every 4-7 years.	Sediment and hydraulic engineers at the Corps Walla Walla District estimated the localized dredging required with the 125 TDG spill operation at Lower Monumental, John Day, Lower Granite, McNary, and Ice Harbor. Unit dredging and placement costs were estimated based on a mid-point between lower Snake River and lower Columbia River costs.	NA	$1.0 million

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual Costs
Navigation & Transportation	Regions C and D: High spill, combined with tailrace conditions could result in infrastructure damage and more frequent O&M of navigation channel at project.	Regular monitoring of tailrace conditions will be conducted. If discovery of negative impacts, install coffer cells at Lower Monumental, Lower Granite, McNary, and John Day to dissipate energy from higher spill levels.	Based on similar levels of effort and information in the Corps Walla Walla District; Assumes 4 cells per project at $2 million per cell and two projects would be affected.	$31.2 million	$1.2 million
Anadromous Fish	Regions C and D: Moderate adverse effect from increased spill levels, which create turbulence and eddies below the dams resulting in delays to adult passage.	Temporary extension of performance standard spill levels in coordination with the Regional Forum	NA	NA	No cost
Anadromous Fish	Region C: Water in the Little Goose raceway is expected to have high TDG due to higher spill levels. This could have major adverse effects to transported fish.	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.	Used MCACES MII software to develop a parametric cost estimate based on scope provided by PDT.	$1.9 million	$69,000
Cultural Resources	Region A, B, C: Major adverse effects from increase in number of acre-days that archaeological resources would be exposed.	Region A, B and C: use Cultural Resources Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other mitigation to address impacts to TCPs.	Costs were estimated by Cultural Resource specialists from the three agencies, based on operational changes under MO4.	NA	$2,000,000

Note: Some of the mitigation measures would require annual operations and maintenance activities and/or non-routine major repair or rehabilitation once over the 50-years; the present value of these costs were added to the project first costs and amortized to provide the annual-equivalent cost.

Table B-5. Mitigation Costs for the Preferred Alternative

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual Costs
Vegetation, Wildlife, Wetlands, and Floodplains	In Region A, Conversion of wetland to upland habitat in May through summer (off-channel habitat). Effects on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Effects are minor and would occur seasonally.	In Region A, on Kootenai River downstream of Libby: Plant native wetland and riparian vegetation up to ~100 acres along river.	Fish and Wildlife teams used GIS mapping to establish acreage needed for planting. Previous estimates were obtained from MCACES MII of plant prices from the Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with Corps Walla Walla District wildlife biologists. Unit costs assumed: $40 per plant for cottonwood; $30.70 per willow; 10 pounds per acre at $9 per pound for grass seeding.	$3.5 million	$144,000 (covered under F&W Program)
Resident Fish - ESA Kootenai River White Sturgeon	Region A: The current flow regime at Libby has made establishment of riparian vegetation difficult to sustain young stands of cottonwoods - major contributors to foodweb for Sturgeon, which results in moderate localized effects. While this MO would not exacerbated these effects in the No Action, it is an ongoing problem.	Plant 1-2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon (KWRS) by providing a food source. This would complement ongoing habitat actions already being taken in the region.	Fish and Wildlife teams used GIS mapping to establish acreage needed for planting. Previous estimates were obtained from MCACES MII of plant prices from the Inland Avian Predation Management Plan at Crescent Island San Francisco, and verified with Corps Walla Walla District wildlife biologists. Unit costs assumed: $40 per plant for cottonwood; $30.70 per willow; 10 pounds per acre at $9 per pound for grass seeding.	$3.1 million	$132,000 (covered under F&W Program)

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual Costs
Resident Fish - Burbot, Kokanee, and Redband Rainbow Trout	In Region B changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. (a) Determine where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. (b) Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	Information was used from previous cost estimates. Estimate uses approximately one foot of gravel would be needed for 100 acres, approximately 160,000 cubic years, at $35 per cubic yard.	$10.9 million	$397,000
Navigation & Transportation	Region B: Inchelium-Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members. This would be a moderate adverse effect that results in public safety and environmental justice concerns.	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it's available at lower water elevations.	Assumes the use of 2 drilled shafts, heavy steel structure, and aluminum decking 50 feet long .Cost engineers at the Corps Mandatory Cost Center of Expertise at the Walla Walla District estimated the costs using MCACES MII software and proposed design.	$2.4 million	$97,000
Navigation & Transportation	Regions C and D: High spill, combined with tailrace conditions could result in infrastructure damage and more frequent O&M of navigation channel at project.	Regular monitoring of tailrace conditions will be conducted. If discovery of negative impacts, install coffer cells at Lower Monumental, Lower Granite, McNary, and John Day to dissipate energy from higher spill levels.	Based on similar levels of effort and information provided by the Corps Walla Walla District; assumes 4 cells per project at $2 million per cell and 2 projects would be affected.	$31.2 million	$1.2 million

Resource	Impact	Potential Mitigation Action	Approach to Develop Costs	Project First Costs (Construction)	Annual Costs
Navigation & Transportation	In Region C & D, high spill volumes and lower tail water increase scour, creating sediments and filling of the navigation channel. This is a moderate adverse impact to navigation.	Monitoring of scour and infill at John Day, McNary, Ice Harbor, Lower Monumental, and Lower Granite projects and increase dredging maintenance, as needed to maintain navigation channel. This is predicted to be needed every 4-7 years.	Sediment and hydraulic engineers at the Corps Walla Walla District estimated the localized dredging required with the 125 TDG spill operation at Lower Monumental, Lower Granite, McNary, and Ice Harbor. Unit dredging and placement costs were estimated based on a mid-point between lower Snake River and lower Columbia River costs.	NA	$909,000
Anadromous Fish	Regions C and D: Moderate adverse effect from increased spill levels, which create turbulence and eddies below the dams resulting in delays to adult passage.	Temporary extension of performance standard spill levels in coordination with the Regional Forum	NA	NA	No cost-

Note: Some of the mitigation measures would require annual operations and maintenance activities and/or non-routine major repair or rehabilitation once over the 50-years; the present value of these costs were added to the project first costs and amortized to provide the annual-equivalent cost.

ANNEX C: REGIONAL ECONOMIC EFFECTS

Regional economic effects are measures of economic activity (jobs, labor income, and sales) that are supported by CRS expenditures. This section evaluates the regional economic effects of changes in expenditures associated with implementing, operating, and maintaining the CRS across alternatives. For each alternative, regional economic effects are evaluated by estimating the economic activity resulting from anticipated system and implementation expenditures that are described in the Implementation and System Costs section of the EIS (Section 3.19) and in this appendix.

METHODOLOGY

Effects of changes in CRS expenditures on regional economic activity are estimated in terms of jobs, labor income, and sales by tracing expenditures by sector through the economy using the input-output model, IMPLAN.[16] 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 federal sources, including the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the U.S. Census Bureau.

CRS expenditures were categorized by industry sectors based on Corps' Regional ECONomic System (RECONS) spending profiles. RECONS provides specific expenditure or spending profiles for Corps work activities, using IMPLAN industry sectors. For some of the Corps work activities, RECONS uses the cost factors from Micro-Computer Aided Cost Estimating System (MCACES), which incorporates hundreds of construction project cost estimates, along with additional data and information from Corps "business line" experts (Corps 2019). In addition, based on the Corps budget line item data, RECONS also rolls up the work activities by business line to provide spending profile by business line (i.e., recreation, flood risk management, navigation, hydropower) and appropriation accounts (i.e., construction, operations and maintenance, and investigations). For example, the RECONS spending profile associated with the work activity of operations and maintenance of locks and dams includes (Corps 2019):

- 86 percent of expenditures are spent on the industry: repair and maintenance of industrial machinery and equipment;
- 9 percent is spent on USACE construction management and planning;
- 4 percent is spent on USACE overhead costs; and
- 1 percent is spent on environmental compliance activities undertaken by the USACE and contractors.

[16] For more information on the IMPLAN® system, visit http://www.implan.com/.

Each of these expenditure categories is associated with one of 536 IMPLAN industry sectors.[17] In this manner, the expenditures were identified with RECONS spending profiles to assist in estimating how the government expenditures would be allocated to both government sectors and industries in IMPLAN. Expenditures were also identified as being short-term (i.e., expenditures generally taking place in the construction phase of the alternatives occurring within the first 1 to 3 years of the period of analysis) or long-term (i.e. on-going expenditures occurring annually over the entire study period). Table C-1 provides a summary of how CRS costs from the No Action Alternative and each action alternative were assigned to specific RECONS spending profiles, and duration category, to estimate the regional economic effects.

Table C-1. Distribution of Cost Expenditures by RECONS Spending Profiles

Costs Analysis Spending Category	Spending Subcategory	RECONS Spending Profile(s)	Type of Effect
Construction Costs of Structural Measures	Structural Measures & MO3 Real Estate	• Hydropower Construction for the Civil Works Budget • Construction or Major Rehabilitation—Other Water Resources Infrastructure • Lock Construction of Onsite Features • Construction of Fish Facilities at Dams • Federal Government, Non-Military[1]	Short-term
Capital Costs	Large Capital Costs	• Hydropower Construction for Civil Works Budget	Long-term
Operations and Maintenance	Non-routine Extraordinary Maintenance (NREX) Costs	• Hydropower Construction for Civil Works Budget	Long Term
	Navigation and Dredging Non-Routine O&M Costs	• Navigation Construction for Civil Works Budget	Long Term
	Routine O&M Costs, including Recreation, Fish and Wildlife, Navigation, Cultural Resource, and Other	• Environment Operations and Maintenance for Civil Works Budget (fish and wildlife)[2] • Recreation Operations and Maintenance for Civil Works Budget (recreation)[2] • Navigation Operations and Maintenance for Civil Works Budget (navigation)[2] • Hydropower Operations and Maintenance for Civil Works Budget (other)[2]	Long Term

[17] Some of the spending profiles were developed using IMPLAN's previous sectoring scheme, which had 440 industry sectors. In these cases, the sector numbers were updated to correspond to the relevant 536 sector scheme for purposes of this analysis.

Costs Analysis Spending Category	Spending Subcategory	RECONS Spending Profile(s)	Type of Effect
Mitigation	Additional Mitigation Costs	• Environment Construction for Civil Works Budget • Hydropower Construction for Civil Works Budget • Construction or Major Rehabilitation of Utilities and Power Structures[3] • Navigation Construction for Civil Works Budget	Short Term
	On-Going Fish & Wildlife Mitigation	• Construction Activities for Ecosystem and Habitat Restoration or Improvements • Ecosystem and Habitat Restoration or Improvements, Non-Construction Activities • Construction of Fish Facilities at Dams	Long Term

[1] Modeling utilizes Federal Government (Non-Military spending) as a single sector. This sector was applied to legal/real estate fees.
[2] Routine O&M costs were mapped to the appropriate activity type for all dams other than Grand Coulee and Hungry Horse. Grand Coulee and Hungry Horse O&M costs are modeled using the average spending profile for all O&M activities (environment, hydropower, recreation, and navigation).
[3] Construction or Major Rehabilitation of Utilities and Power Structures is a single sector that was applied to gas line repairs under MO3 mitigation costs.
[4] Fish and wildlife mitigation costs were assigned the average of the three spending profiles listed. Because this mitigation involves funding for a wide range of ongoing activities, these expenditures are assumed to take place over the study period.
Sources: U.S. Army Corps of Engineers Institute for Water Resources, RECONS 2.0 Methods Manual, Appendix A, April 2019.

The IMPLAN model estimates economic impacts for four metrics: employment, labor income, value added, and output.

- **Employment** reflects a mix of full-time and part-time job-years[18] that result from additional employment demand created by a project.
- **Labor Income** captures all employment income received as part of the project-related employment demand, including wages, benefits, and proprietor income.
- **Value Added** reflects the total value of all output or production minus the costs of intermediate outputs (value added is analogous to gross domestic product); Value Added includes payroll taxes, sales taxes, excise taxes, and property taxes.
- **Output** reflects the total value of all output or production, including the costs of intermediate and final outputs.

[18] IMPLAN defines a "job" as a full-time job lasting 12 months, which is equivalent to two jobs lasting six months each. A job can be either full-time or part time. The IMPLAN job-year results were converted to full-time equivalents (FTEs) using sector-specific conversion factors developed by IMPLAN.

For each of these metrics, IMPLAN categorizes the impacts into direct, indirect, and induced effects:

- **Direct effects** are the production changes or expenditures that directly result from an activity or policy. In this analysis, the direct effects are equal to the expenditures on structural measures, capital costs, operation and maintenance, and mitigation costs (including fish and wildlife), which we assign to appropriate economic sectors.
- **Indirect effects are** "ripple" impacts that result from changes in the output of industries that supply goods and services to industries that are directly affected.
- **Induced effects** are changes in household consumption arising from changes in employment and associated income that result from direct and indirect effects.

The potential area of economic effect associated with changes to the CRS expenditures includes the CRS multi-county region[19]; this is the region in which most of the expenditures are likely to be captured, and where the associated direct, indirect, and induced effects would be likely to occur. Although a relatively broad study area was used for the evaluation, in general the jobs and income would be supported in the locations where the spending occurs (for example, at the project location). A qualitative assessment was undertaken to describe where the bulk of the change in regional economic effects would be experienced, based on the anticipated changes in expenditures.

SUMMARY OF REGIONAL ECONOMIC EFFECTS OF ALTERNATIVES

Table C-2 presents the regional economic effects of short-term spending associated with construction expenditures on the CRSO system of the action alternatives, both total and relative to the No Action Alternative. These include construction costs of various alternative measures, encompassing construction of the structural measures and additional mitigation measures. Short-term expenditures are not anticipated to occur under the No Action Alternative. Regional economic impacts of these short-term expenditures are based on the present value of the cost estimates. Short-term expenditures are anticipated to occur over a period of approximately one to three years, although the exact timing of the construction activity is uncertain. For the purposes of this evaluation, it is assumed that the effects presented in Table C-2 would occur over a 2-year period.

All action alternatives are expected to lead to short-term increases in CRS spending and regional economic effects compared to the No Action Alternative. These short-term effects would be highest under MO3, supporting over 12,000 job-years and $774 million in labor income over a two-year period. Under MO3, a majority of the regional economic benefits

[19] There were 139 counties identified where these expenditures may occur, resulting in a study area that included counties across eight states: Washington (39 counties), Oregon (36 counties), Idaho (44 counties), Montana (16 counties), Nevada (2 counties), Wyoming (1 county), and California (1 county).

would occur as a result of the dam breaching activity in the lower Snake River region as 77 and 85 percent of the construction expenditures for the structural measures and additional mitigation measures, respectively, would occur at these four projects. Therefore, local communities such as Lewiston and the tri-cities are likely to benefit from this construction activity.

MO2 and MO4 would support employment between 6,500 to 6,800 job-years and labor income of $417 to $438 million per year over the 2-year period. The vast majority of the construction spending under MO2 would occur at McNary for the additional powerhouse surface passage; John Day would incur the second highest amount of construction spending, also associated with additional surface passage. Under MO4, the construction spending would be spread out among a number of projects, with the bulk of the expenditures occurring at John Day, McNary, and the four lower Snake River projects.

MO1 and the Preferred Alternative would support a smaller number of jobs and income over the 2-year period. McNary and Ice Harbor would have the largest construction expenditures under MO1, while Bonneville, Lower Monumental, Lower Granite, and Little Goose would have the largest construction expenditures under the Preferred Alternative.

Adjacent communities to the projects most affected by the structural and mitigation measures would benefit from this construction spending. However, specialized equipment, services, and materials associated with this construction may need to be sourced from outside of the region, leaking some of this regional economic activity outside the study area.

Table C-2. Regional Economic Effects of Construction and Short-Term Expenditures under the Alternatives (2019 dollars)

Alternative	Employment	Labor Income	Value Added	Economic Output
No Action Alternative	0	0	0	0
MO1	2,779	$177 million	$266 million	$464 million
MO2	6,788	$438 million	$673 million	$1,175 million
MO3	12,166	$774 million	$1,142 million	$2,010 million
MO4	6,501	$417 million	$635 million	$1,107 million
Preferred Alternative	906	$57 million	$83 million	$146 million

Note: The construction or short-term regional economic effects are not additive with the long-term annual-equivalent effects. Assumes the construction expenditures would be incurred over a 2-year period.

Regional economic effects associated with on-going or long-term expenditures to support system operations and implementation of the alternatives would occur under the No Action Alternative and action alternatives. Long-term expenditures include capital investments, non-routine extraordinary expenses, operating and maintenance costs, fish and wildlife mitigation, and non-routine navigation expenses. These expenditures and regional economic effects would occur throughout the period of analysis; the regional economic effects are estimated based on annualized estimates over the 50-year period of analysis.

Table C-3 presents the regional economic effects associated with the long-term expenditures (presented as annual effects) compared to the No Action Alternative. Table C-4 presents the change in annual effects compared to the No Action Alternative, and Table C-5 presents the percent change in the annual effects compared to the No Action Alternative.

There would be negligible changes in regional economic effects under MO1. MO2 would support from 20 fewer jobs to 920 more jobs per year (up to 7 percent fewer jobs) compared to the No Action Alternative; annual labor income could range from $1.4 million less to $48.7 million more than labor income estimated under the No Action Alternative. The relatively larger beneficial regional economic effects under MO2 would occur from the possibility that MO2 could have an adverse effect on fish and wildlife, and there could be an increased need for off-site mitigation funded through the Bonneville F&W Program. The potential for increases in expenditures associated with Bonneville's F&W Program could provide beneficial regional economic effects in locations across the Basin.

In general, MO3 and MO4 would support fewer regional jobs and income associated with on-going long-term CRS expenditures. MO3 would support 1,800 to 3,800 fewer jobs per year (14 to 27 percent fewer jobs) and $117 to $217 million less labor income than estimated under the No Action Alternative. Decreases in lower Snake River project expenditures for capital investments, navigation, operations and maintenance, and the Lower Snake River Compensation Plan would be associated with the smaller effects under MO3. The potential for decreases in offsite mitigation requirements and associated Bonneville's F&W Program spending under MO3 could contribute to further decreases in regional economic benefits. Much of the adverse regional economic effects associated with federal and state project spending under MO3 would be experienced in Region C[20].

MO4 would support 40 to 2,000 fewer jobs per year (up to 14 percent fewer jobs) and $8 to $108 million less labor income than estimated under the No Action Alternative. The relatively larger adverse regional economic effects could occur from the possibility that MO4 could provide biological benefits to fish and wildlife and that, in turn, could reduce the need for some offsite mitigation funded by the Bonneville F&W Program. The potential for decreased expenditures associated with Bonneville's F&W Program could adversely affect regional economic conditions in locations across the Basin.

The Preferred Alternative would support 10 to 850 fewer jobs per year (up to 6 percent fewer jobs) and $0.7 to $45.1 million less labor income than estimated under the No Action Alternative. The relatively larger adverse regional economic effects under the Preferred Alternative could occur from the possibility that the Preferred Alternative could provide biological benefits to fish and wildlife and that, in turn, could reduce the need for some offsite

[20] There could be an increase in fish and wildlife expenditures from other entities (outside of Bonneville's F&W program) such as science and research institutes with a dam breach scenario, which are not accounted for in this analysis.

mitigation funded by the Bonneville F&W Program. The potential for decreased expenditures associated with Bonneville's F&W Program could adversely affect regional economic conditions in locations across the Basin.

Table C-3. Regional Economic Effects of Long-Term Recurring Average Annual CRS Expenditures under the Alternatives (2019 dollars)

Alternative		Employment	Labor Income	Value Added	Output
No Action Alternative		13,765	$843.6 million	$1,175.1 million	$1,839.9 million
MO1		13,766	$843.6 million	$1,175.1 million	$1,840.0 million
MO2	Low F&W	13,744	$842.2 million	$1,173.2 million	$1,837.3 million
	High F&W	14,683	$892.2 million	$1,239.1 million	$1,936.9 million
MO3	Low F&W	10,020	$626.7 million	$880.6 million	$1,388.4 million
	High F&W	11,881	$725.8 million	$1,011.1 million	$1,585.5 million
MO4	Low F&W	11,858	$736.2 million	$1,034.9 million	$1,650.9 million
	High F&W	13,719	$835.3 million	$1,165.5 million	$1,848.1 million
Preferred Alternative	Low F&W	12,921	$798.5 million	$1,115.7 million	$1,750.4 million
	High F&W	13,754	$842.8 million	$1,174.1 million	$1,838.6 million

Table C-4. Regional Economic Effects of Long-Term Recurring Average Annual CRS Expenditures, Compared to the No Action Alternative (2019 dollars)

Alternative		Employment	Labor Income	Value Added	Output
MO1		1	$0.1 million	$0.1 million	$0.1 million
MO2	Low F&W	(21)	($1.4 million)	($1.9 million)	($2.6 million)
	High F&W	919	$48.7 million	$64.0 million	$96.9 million
MO3	Low F&W	(3,745)	($216.9 million)	($294.5 million)	($451.5 million)
	High F&W	(1,884)	($117.7 million)	($163.9 million)	($254.4 million)
MO4	Low F&W	(1,907)	($107.4 million)	($140.1 million)	($189.0 million)
	High F&W	(46)	($8.2 million)	($9.6 million)	$8.2 million
Preferred Alternative	Low F&W	(844)	($45.1 million)	($59.4 million)	($89.6 million)
	High F&W	(11)	($0.7 million)	$(0.9 million)	($1.3 million)

Table C-5. Regional Economic Effects of Long-Term Recurring Average Annual CRS Expenditures, Compared to the No Action Alternative, percent change

Alternative		Employment	Labor Income	Value Added	Output
MO1		0%	0%	0%	0%
MO2	Low F&W	0%	0%	0%	0%
	High F&W	7%	6%	5%	5%
MO3	Low F&W	-27%	-26%	-25%	-25%
	High F&W	-14%	-14%	-14%	-14%
MO4	Low F&W	-14%	-13%	-12%	-10%
	High F&W	0%	-1%	-1%	0%
Preferred Alternative	Low F&W	-6%	-5%	-5%	-5%
	High F&W	0%	0%	0%	0%

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Appendix R, Mitigation, Monitoring, and Adaptive Management

Part 1, Monitoring and Adaptive Management Plan

Table of Contents

CHAPTER 1 - INTRODUCTION

This appendix presents the conceptual level monitoring and adaptive management plan (MAMP) for the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS). This plan identifies and describes the monitoring and adaptive management activities proposed for the EIS and duration. This plan will be further developed during implementation.

1.1 AUTHORITY AND PURPOSE

The following legal requirements for monitoring and adaptive management actions apply to U.S. Army Corps of Engineers (Corps) projects[1]:[2]

- Section 906(d) of the Water Resources Development Act (WRDA) of 1986 Fish and Wildlife Mitigation Plans as Part of Project Proposals.
- Section 2036 of the Water Resources Development Act (WRDA) of 2007. Mitigation for fish and wildlife and wetlands losses.
- Section 2039 of the Water Resources Development Act (WRDA) of 2007. Monitoring ecosystem restoration.
- Section 1040 of the Water Resources Development Act (WRDA) of 2014. Fish and wildlife mitigation.
- Sections 1161 and 1162 of the Water Infrastructure Improvements for the Nation Act or the WIIN Act, Completion of ecosystem restoration projects and Fish and wildlife mitigation, respectively.

ER 1105-2-100 (Planning Guidance Notebook) states that a plan for monitoring ecological success must be included in the decision document, must include the rationale for monitoring, and must identify key project-specific parameters and how they relate to achieving the desired outcomes for making a decision about the next phase of the project. The guidance states that the monitoring and adaptive management costs will be included in the project cost estimate. The monitoring plan should also identify the criteria for success and when adaptive management is needed.

The co-lead agencies have proposed measures as part of the Preferred Alternative that are intended to benefit fish and wildlife. Those measures include structural and operational

[1] Bonneville will follow the requirements for mitigation measures included in the U.S. Department of Energy's National Environmental Policy Act Implementing Procedures. Specifically, Bonneville will develop a Mitigation Action Plan that will be included with its Record of Decision, which explains the mitigation measures and how they will be planned and implemented. (see 10 C.F.R. § 1021.331 Mitigation action plans).

[2] This Monitoring and Adaptive Management Plan is compliant with Bureau of Reclamation's adaptive management guidance (Williams and Brown 2012).

measure at the projects to benefit fish, mitigation measures to minimize effects to fish and wildlife, and measures identified during Endangered Species Act consultation.

According to WRDA 2007, "monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits."

This document lays out the monitoring and adaptive management requirements for the CRSO, and established success criteria and associated adaptive management triggers.

1.2 MONITORING AND ADAPTIVE MANAGEMENT PLAN DEVELOPMENT

The purpose of this MAMP is to establish the required components and approach of the MAMP. This success is determined by monitoring metrics that are specifically tied to project objectives and setting performance targets. In addition, the plan identifies what adaptive management is proposed if the performance targets are not met. The MAMP identifies how adaptive management would be conducted for the project and who would be responsible for this project specific adaptive management. This MAMP outlines how the results of the monitoring program would be used to adaptively manage the project, including specification of conditions that will define project success. This MAMP provides the basis for the monitoring and adaptive management methodology and implementation, which will be refined in collaboration with the other Federal and non-Federal agencies, cooperating agencies, and tribes, as well as other stakeholders who may take responsibility for monitoring ecological variables in the CRSO EIS study area.

The level of detail in this plan is based on currently available data and information developed during the NEPA process as part of the CRSO. Uncertainties remain concerning the exact project features, monitoring elements, and adaptive management opportunities. Components of the monitoring and adaptive management plan were similarly estimated using currently available information.

1.2.1 Project Uncertainty and Risk

Scientific uncertainties and technological challenges are inherent with operations of the CRSO because available data and information about any project is never perfect or complete. Adaptive management provides a coherent process for making decisions in the face of uncertainty. Scientific uncertainties and technological challenges are inherent with CRSO.

Risk is defined as the probability of an undesirable consequence. In the context of CRSO, risk exists because there is uncertainty about realizing positive net benefits from implementing a project. The dominant risks associated with the Preferred Alternative are the potential for undesirable ecological outcomes that could result from natural hazards or human actions. Potential risks include:

- Inadequate riparian vegetation cover and abundance of invasive and non-native species which inhibit native vegetation growth.
- Unpredictable changes to the riparian or the shallow water habitat could create favorable conditions for predatory species such as smallmouth bass in the aquatic habitat, and piscivorous birds in the riparian and upland habitat.
- Unpredictable flow regimes associated with stochastic events may alter restored aquatic habitat, wetlands or erode the shoreline.
- Effects of climate change on river temperatures and seasonal flows;
- Unintended consequences on non-target fish species as a result of passage improvements for salmon and steelhead; and
- Latent effects on fish survival that cannot be directly measured.

1.2.2 Objectives Monitored

Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project goals. The following factors will be monitored, as well as plant survival and percent non-native plants.

1.3 PREFERRED ALTERNATIVE MEASURES IN THE MAMP

The Preferred Alternative includes a combination of measures that meet the Purpose and Need and objectives of the Columbia River System Operations (CRSO) EIS, while balancing the authorized purposes of the 14 Federal dam and reservoir projects that make up the Columbia River System (CRS). An effective MAMP will determine if the project outcomes are consistent with the project objectives as described in Chapter 2 of the EIS.

There are many measures in the Preferred Alternative that have secondary beneficial effects to fish and wildlife resources. As the purposes of those measures are for other objectives not related to fish and wildlife, and because the effects are not adverse and resulting in mitigation, they are not proposed for monitoring in this document. The Preferred Alternative includes the following measures to be included in this MAMP:

1.3.1 Structural Measures

- Bonneville Ladder Serpentine Weir Modifications
- Lower Granite Trap Modifications
- Closeable Floating Gates for Lamprey (Bonneville)
- Bypass Screen Modifications for Lamprey
- Lamprey Passage Ladder Modifications

- Turbine Strainer Lamprey Exclusion

1.3.2 Operational Measures

- Juvenile Fish Passage Spill Operations
- Early Start Transport (Lower Columbia and Lower Snake)
- Predator Disruption Operations (John Day)

1.3.3 Mitigation Measures

- Temporary extension of performance standard Spill Operations
- Spawning Habitat Augmentation at Lake Roosevelt
- Plant Cottonwood Trees (Up to 100 acres) near Bonners Ferry
- Plant Native Wetland and Riparian Vegetation (Up to 100 acres) on the Kootenai River Downstream of Libby Dam

1.3.4 ESA Measures

- Bull Trout Access to Perched Tributaries in Kootenai River
- Surface Spill to Reduce Take of Overshooting Adult Steelhead

CHAPTER 2 - MONITORING AND ADAPTIVE MANAGEMENT OF PREFERRED ALTERNATIVE

2.1 STRUCTURAL MEASURES FOR FISH PASSAGE

2.1.1 Bonneville Ladder Serpentine Weir Modifications

The Corps would modify the serpentine-style flow control sections of Bonneville Dam's Washington Shore and Bradford Island fish ladders converting them to an Ice Harbor-style vertical slot with submerged orifice configurations. This would improve passage conditions for adult lamprey and likely reduce stress and delay for adult salmon, steelhead, and bull trout. This action has the potential to increase adult salmon and steelhead survival by reducing upstream passage time at the dam.

2.1.1.1 Measure Monitoring Objectives

This measure is intended to:

- Increase passage success of adult lamprey past Bonneville Dam by improving passage through the control sections of the Bradford Island and Washington Shore fish ladders.
- Reduce adult salmon and steelhead upstream passage time at the dam.

All lamprey and adult salmonid study objectives and study designs would be coordinated with the Studies Review Work Group (SRWG). Any changes to normal fishway operations would be coordinated with regional fish managers via the Fish Passage Operations and Maintenance Work Group (FPOM). Lamprey passage designs would be coordinated through the Fish Facility Design Review Work Group (FFDRWG). All work would be coordinated with the Corps-Tribal Lamprey Work Group, per the 2018 extension of the Columbia Basin Fish Accords.

2.1.1.2 Monitoring Metrics, Targets, and Adaptive Management Measures

MONITORING METRIC 1: EVALUATE ADULT LAMPREY PASSAGE BEHAVIOR IN RESPONSE TO FISHWAY MODIFICATIONS.

Methods and Timing

Use active telemetry tools (radio or acoustic) and PIT tags to compare standard pre- and post-modification adult lamprey passage metrics at three scales: (1) Control sections (serpentine weirs) of Bonneville Washington Shore Fish Ladder and Bonneville Bradford Island Fish Ladder; (2) Bonneville Washington Shore and Bradford Island fish ladders; (3) Bonneville Dam. Adult lamprey would be collected at the dam, tagged with a combination of radio-telemetry (RT), acoustic telemetry (AT) or Passive Integrated Transponder (PIT) tags, and released downstream of the dam, consistent with past methodologies (Keefer et al. 2012). Telemetry and PIT arrays fixed in locations previously monitored would be used to monitor tagged lamprey as they approach and re-ascend Bonneville Dam fishways. Tagging and monitoring would occur during the spring/summer adult lamprey migration. The primary metrics of interest will include passage efficiency through the control section of the ladder, fishway passage efficiency for the ladders modified, and total dam passage efficiency. An increase in total dam passage efficiency (i.e., getting more lamprey past the dam) is the ultimate goal of these modifications but evaluation at multiple scales allows for meaningful pre- and post-modification comparisons of passage performance. Other metrics, such as passage times (at the three scales noted above), fallback past the dam, etc. will also be reported. Study results will be compared with historic data (i.e., a pre-modification study is not needed). Tagged fish would be monitored as they pass upstream dams as well.

Due to inter-annual variability in passage metrics, this evaluation would require a minimum of two years of study. Because modifications to ladders would be made in different years (Bonneville fishway maintenance occurs in alternating years), two separate 2-year studies may be required. To reduce cost and handling and tagging of lamprey, the Corps – in coordination with regional fish managers through the SRWG and the Corps-Tribal Lamprey Work Group – may elect to wait until *both* ladders are modified before implementing study. In the interim, fish counts (window counts) and Lamprey Passage Structure (LPS) counts would be used to monitor passage.

Performance Target

Success would be defined as an increase in passage efficiency through vertical slot fishway section (treatment sections of the ladders) compared to control sections (serpentine weir sections) of the fishways.

Adaptive Management

Due to the extent of modifications proposed, adaptive management options are limited. There is a very low risk that lamprey passage performance would decrease following modification of the fishways, as the proposed modifications involve standard passage design features that have performed well elsewhere (e.g., John Day Dam).

Should study results suggest poor passage performance (relative to prior studies) in the treatment section of the ladders, adaptive management actions may include: (1) Use video, acoustic imaging and other tools to evaluate lamprey passage behavior at a smaller scale in the area of interest; (2) Based on results of this follow-up evaluation, implement small-scale follow-on modifications to correct deficiencies.

MONITORING METRIC 2: EVALUATE ADULT SALMON AND STEELHEAD BEHAVIOR IN RESPONSE TO FISHWAY MODIFICATIONS.

Methods and Timing

There are two basic approaches that could be used to compare adult salmonid passage performance at the Washington Shore and Bradford Island fish ladders:

a) Use adult fish counts (window counts) and PIT monitoring in the control sections of these ladders to compare pre- and post-construction passage performance. This approach would avoid the need to handle and tag fish and would be cost neutral. However, without active telemetry data, managers would have a limited ability to diagnose any problems with the new configuration or compare key passage metrics such as passage times and passage efficiency through the modified fishway sections.

b) Use active telemetry tools (radio or acoustic) to compare standard pre- and post-modification adult salmonid passage metrics (in addition to fish counts and PIT monitoring).

The Corps would determine, in close coordination with National Marine Fisheries Service (NMFS) and other fish managers through the SRWG the most appropriate approach.

If an active (radio or acoustic) telemetry study is required, the Corps would evaluate passage performance at multiple scales: (1) Control sections (serpentine weirs) of Bonneville Washington Shore Fish Ladder and Bonneville Bradford Island Fish Ladder; (2) Bonneville Washington Shore and Bradford Island fish ladders; (3) Bonneville Dam. For each study year, adult Chinook salmon, steelhead and (if necessary) sockeye salmon would be collected at the dam, tagged with a combination of radio tags, acoustic tags or PIT tags, and released downstream of the dam, consistent with past methodologies (Keefer et al. 2017). Telemetry and PIT arrays fixed in locations previously monitored would be used to monitor tagged salmonids as they approach and re-ascend Bonneville Dam fishways. For salmonids, the primary metrics of interest will include passage efficiency and passage timing through the control section of the ladder, fishway passage efficiency, and total dam passage efficiency. Other metrics, such as fallback past the dam, etc. will also be reported. Study results will be compared with historic data (i.e., a pre-modification study is not needed). Due to inter-annual variability in passage metrics, this evaluation would require a minimum of two years of study for each fish ladder. Tagged fish would be monitored as they pass upstream dams as well. As with the lamprey study, the Corps may elect to – in coordination with SRWG – conduct a single study following modification to both fish ladders.

Performance Target

Success would be defined as neutral to beneficial changes in adult salmon and steelhead passage metrics relative to historic data.

Adaptive Management

Due to the extent of modifications proposed, adaptive management options are limited. There is a very low risk that adult salmon or steelhead passage performance would decrease following modification of the fishways, as the proposed modifications involve standard passage design features that have performed well elsewhere (e.g., John Day Dam).

If the Corps (in coordination with SRWG) uses fish counts and PIT monitoring to evaluate passage and results suggest that modifications may be causing salmonid passage delays or other issues, the Corps would initiate a telemetry study and/or video or acoustic imagining evaluation (as described above) to identify potential design deficiencies. Based on results of this follow-up evaluation, implement small-scale follow-on modifications to correct deficiencies.

Contingency Planning and Implementation

Portland District, U.S. Army Corps of Engineers, in coordination with appropriate Regional Forum work groups and the Corps-Tribal Lamprey Work Group.

Timing of implementation is dependent on funding availability. The lamprey passage evaluation would take up to two years following construction for each of the fish ladders. Final study results would be reported in June of the year following the final study year (for each fish ladder). The adult salmon and steelhead evaluation(s) would be completed in a similar timeframe. If fish counts and PIT monitoring are used to evaluate salmon and steelhead passage, results would be available in real time.

2.1.2 Lower Granite Trap Modifications

The current trap gate limits the ability to start and stop trap operations mid-season. The existing trap gate would be replaced with a gate operated by a dedicated hoist to reduce fish passage delays during times the trap is not in operation and improve debris management, while retaining anticipated benefits to fish. The trap would be designed and implemented to reduce delay and stress for adult salmonids and other species such as Pacific lamprey. The new gate would be designed to more efficiently shed debris and would include a gap in the bottom to allow upstream passage of lamprey.

2.1.2.1 Measure Monitoring Objectives

This measure is intended to:

- Increase adult salmon and steelhead survival by reducing upstream travel times.
- Reduce delay and stress for adult salmonids and other species such as Pacific lamprey

2.1.2.2 Monitoring Metrics, Targets, and Adaptive Management Measures

MONITORING METRIC 1: DEBRIS MANAGEMENT

Methods and Timing

Number of days spent managing and removing debris from March to September each year.

Performance Target

Reduction in days spent manually removing debris.

Adaptive Management

If a significant reduction in debris management is not achieve, potential design or operation changes will be evaluated.

MONITORING METRIC 2: LAMPREY PASSAGE

Methods and Timing

Daily visual inspection of the gate during operation to check for impinged lamprey coordinate with FFDRWG from March to September each year.

Performance Target

Decreases in lamprey blockages at the trap gate.

Adaptive Management

After the first year of observations for blockage, design review and discussion would occur to improve gate design and operation.

MONITORING METRIC 3: SALMON DELAY

Methods and Timing

Daily visual inspection of the gate during operation to check for impinged salmon from March to September each year.

Performance Target

Decreases in delay at the trap gate.

Adaptive Management

After the first year of observations for delay, design review and discussion with FFDRWG would occur to improve gate design and operation.

Contingency Planning and Implementation

USACE NWW Lower Granite employees and contractors who operate the trap would implement the monitoring and would document inadequacies.

Monitoring would begin as soon as the trap gate is re-installed and put into operation

Budget Estimate

$100,000

2.1.3 Closeable Floating Gates for Lamprey (Bonneville)

This measure was developed for inclusion in the Preferred Alternative to meet the lamprey objective to provide a benefit to Pacific lamprey passage at Bonneville Dam. It installs closeable gates on Bonneville Powerhouse 2 floating orifice gates to reduce incidences of lamprey falling out of the Washington Shore Fish Ladder. Closeable gates would allow seasonal closure during the lamprey passage season.

2.1.3.1 Measure Monitoring Objectives

This measure is intended to:

- Increase adult lamprey upstream passage success at Bonneville Dam by increasing retention of lamprey in the Bonneville Washington Shore / Powerhouse 2 collection channel.
- Have a neutral to beneficial effect on adult salmon (i.e., Chinook and sockeye) passage.

All lamprey study objectives and study designs would be coordinated with the SRWG. Any changes to normal fishway operations would be coordinated with regional fish managers via the FPOM. Lamprey passage designs would be coordinated through the FFDRWG. All work would be coordinated with the Corps-Tribal Lamprey Work Group.

Monitoring and evaluation would be designed to inform a proposed change to the annual Fish Passage Plan, to be coordinated with the FPOM. Though details are to be determined, the Corps would design studies to evaluate effects of seasonal (approximately June 1 through August) closure of the FOGs. The evaluation would include use of existing closure structures that would be installed and removed as needed by Bonneville Dam staff.

2.1.3.2 Monitoring Metrics, Targets, and Adaptive Management Measures

MONITORING METRIC 1: EVALUATE ADULT LAMPREY PASSAGE BEHAVIOR IN RESPONSE TO CLOSURE OF BONNEVILLE POWERHOUSE 2 COLLECTION CHANNEL FLOATING ORIFICE GATES (FOGS)

Methods and Timing

Use active telemetry tools (radio or acoustic) and PIT tags to compare standard pre- and post-modification adult lamprey passage metrics at three scales: (1) Powerhouse 2 Collection Channel (between south main fishway entrances and junction pool) of Bonneville Washington Shore Fish Ladder; (2) Bonneville Washington Shore Ladder; (3) Bonneville Dam. Adult lamprey would be collected at the dam, tagged with a combination of RT, AT or PIT tags, and released downstream of the dam, consistent with past methodologies (Keefer et al. 2012). Telemetry and PIT arrays fixed in locations previously monitored would be used to monitor tagged lamprey as they approach and re-ascend Bonneville Dam fishways. Tagging and monitoring would occur during the spring/summer adult lamprey migration. The primary metrics of interest will include passage efficiency through the collection channel (i.e., proportion of tagged lamprey that enter through main entrances on the south end of the powerhouse and successfully pass to the junction pool near the north end of the powerhouse), fishway passage efficiency for Washington Shore Fish Ladder, and total dam passage efficiency. An increase in total dam passage efficiency (i.e., getting more lamprey past the dam) is the ultimate goal of this measure but evaluation at multiple scales allows for meaningful pre- and post-modification comparisons of passage performance. Other metrics, such as passage times (at the three scales noted above) will also be reported. Study results will be compared with historic data (i.e., a pre-modification study is not needed). Tagged fish would be monitored as they pass upstream dams as well.

Due to inter-annual variability in passage metrics, this evaluation would require a minimum of two years of study. To reduce cost and handling and tagging of lamprey, the Corps – in coordination with regional fish managers through the Studies Review Work Group (SRWG) – may elect to wait until other fishway modifications are made (e.g., serpentine weir modifications) before implementing the study.

Performance Target

Success would be defined as an increase in lamprey passage efficiency.

Adaptive Management

If study results from two years of study suggest a *decrease* in lamprey passage performance, the Corps would, in coordination with the Corps-Tribal Lamprey Work Group and FPOM, recommend eliminating this measure from further consideration.

If study results suggest an improvement in lamprey passage performance and salmon study results (below) suggest a neutral to beneficial effect on salmon passage, the Corps would draft a Fish Passage Plan change form recommending seasonal closure of FOGs at Powerhouse 2. This change form would be reviewed by the FPOM.

MONITORING METRIC 2: EVALUATE ADULT SALMON AND STEELHEAD BEHAVIOR IN RESPONSE TO FISHWAY MODIFICATIONS.

Methods and Timing

The Corps assumes that an active (radio or acoustic) telemetry study would be required to determine whether the proposed configuration change would have a negative impact on salmon and steelhead passage. The Corps would evaluate passage performance at multiple scales: (1) Powerhouse 2 / Bonneville Washington Shore Fish Ladder collection channel; (2) Bonneville Washington Shore Fish Ladder, and; (3) Bonneville Dam. For each study year, adult Chinook salmon, steelhead and (if necessary) sockeye salmon would be collected at the dam, tagged with a combination of RT, AT or PIT tags, and released downstream of the dam, consistent with past methodologies (Keefer et al. 2017). Telemetry and PIT arrays fixed in locations previously monitored would be used to monitor tagged salmonids as they approach and re-ascend Bonneville Dam fishways. For salmonids, the primary metrics of interest will include passage efficiency and passage timing through the collection channel, fishway passage efficiency, and total dam passage efficiency. Other metrics, such as fallback past the dam, etc. will also be reported. Study results will be compared with historic data (i.e., a pre-modification study is not needed). Due to inter-annual variability in passage metrics, this evaluation would require a minimum of two years of study for each fish ladder. Tagged fish would be monitored as they pass upstream dams as well. As with the lamprey study, the Corps may elect to – in coordination with SRWG – conduct a single study following modification to both fish ladders.

Performance Target

Success would be defined as neutral to beneficial changes in adult salmon and steelhead passage efficiency and timing relative to historic data.

Adaptive Management

If study results suggest a negative impact on adult salmon and steelhead passage performance as compared to historic studies, the Corps would, in coordination with regional fish managers via the FPOM and the Corps-Tribal Lamprey Work Group, determine if other options are feasible (e.g., closure of some but not all of the eight remaining FOGs). If no feasible options are available, the Corps would recommend eliminating this measure from further consideration.

Contingency Planning and Implementation

Portland District, U.S. Army Corps of Engineers, in coordination with appropriate Regional Forum work groups and the Corps-Tribal Lamprey Work Group.

Timing of implementation is dependent on funding availability. The lamprey passage evaluation would involve monitoring of passage performance for up to two years. Final study results would be reported in June of the year following the final study year (for each fish ladder). The adult salmon study would be completed in a similar timeframe.

2.1.4 Bypass Screen Modifications for Lamprey

This measure is to provide a benefit to lamprey passage at Little Goose, Lower Granite, and McNary projects. It has been modified to only be implemented at Lower Granite and Little Goose. Turbine intake bypass screens used to divert fish into the collection channel of the juvenile bypass system would be replaced at little Goose and Lower Granite projects (screens for one LWG turbine have already been replaced with 1.75 mm bar mesh). The Corps would replace the existing extended length bar screens with screens designed to reduce juvenile lamprey entanglement. The reason that it would not be implemented at McNary is because it may conflict with other measure, Fewer Fish Screens under consideration for this location. These upgrades would occur when the existing screens need replacement.

2.1.4.1 Measure Monitoring Objectives

This measure has the potential to:

- Reduce lamprey mortality from impingement on the fish screens.

2.1.4.2 Monitoring Metrics, Targets, and Adaptive Management Measures

MONITORING METRIC 1: PROPORTION OF LAMPREY CONTACTING THE SCREEN BECOMING ENTANGLED

Methods and Timing

Visual recording with a camera on the screen brush (Moursund 2003).

Performance Target

A statistically significant lower rate of entanglement between the two bar spacings.

Adaptive Management

If the smaller spacing leads to a lower entanglement rate, the Corps in coordination with the FFEDRWG and the Corps-Tribal Lamprey Work Group would consider the magnitude of the benefit relative to the cost of replacing the bar screen material on the rest of the screens.

Contingency Planning and Implementation

The Corps would implement this through the Columbia River Fish Mitigation program, and the study design would be developed and reviewed through both the SRWG and the Corps-Tribal Lamprey Work Group.

The evaluation data could be collected in a couple months. It would take at least two years to fully implement once a decision is made to change all bar screens at these projects.

2.1.5 Lamprey Passage Ladder Modifications

This measure is to provide Pacific lamprey passage. Existing fish ladders at the lower Snake River and lower Columbia River projects would be modified as described:

- **Install ramps to salmon orifices at Bonneville Dam.** Install concrete or aluminum ramps in the Bradford Island Fish Ladder to make salmon orifices elevated above fish ladder floors more accessible to lamprey. Ramps would enable adult lamprey to more easily and directly access the salmon passage openings by removing right angles at the approach.
- **Install diffuser grating plating at Bonneville (south and Cascade Island ladders), The Dalles (north ladder), and Lower Monumental (north and south ladders).** Where feasible, install steel plating over floor diffuser grating immediately adjacent to submerged weir orifices

within the existing fish ladders. Floor diffusers add water to the fish ladder to provide attraction flows for fish, but the grating makes it difficult for lamprey to attach as they attempt to pass through submerged weir orifices. Steel plating would provide an attachment surface for lamprey to attach and rest as they swim upstream through the fish ladder.

- **Install additional refuge boxes at Bonneville Dam.** At Washington Shore and Bradford Island fish ladders, install metal refuge boxes or similar structures on the floors or walls of fish ladders to provide a protected resting environment for lamprey migrating upstream.
- **Install a wetted wall in the fish ladder at Bonneville Dam.** At the Bonneville Dam Washington Shore Fish Ladder, install a metal wall in the control section of the fishway (like the structure already installed in the Bradford Island Fish Ladder). This would provide an alternative upstream passage route for migrating adult lamprey and allow the lamprey to escape the higher water velocities and turbulence in the adjacent control section of the fish ladder.
- **Lamprey Passage Structures (LPS).** Ramp-like flume structures would be installed or modified in fish ladders at Bonneville, The Dalles, and John Day dams to guide adult lamprey out of fish ladders and into parallel systems for volitional passage or collection for upstream transport or passage studies. The LPSs would use independent water sources (pumps or gravity-flow systems) and may be placed in various locations within fish ladders, such as collection channels, junction pools, or auxiliary water supply channels. New structures would be installed at Bonneville Dam's Bradford Island and Washington Shore fish ladders, The Dalles Dam's east fish ladder, or John Day Dam's south fish ladder. At John Day Dam, the existing LPS on the north fish ladder may be extended from the tailrace deck to the forebay. This measure is intended to increase adult lamprey passage at the dams.

2.1.5.1 Measure Monitoring Objectives

The actions described in this measure are intended to increase adult lamprey passage performance at lower Columbia and lower Snake River dams without impacting adult salmon and steelhead passage success. The measure will:

- Provide alternate upstream passage routes (for volitional passage or upstream transport) for migrating adult lamprey;
- Provide protected resting environments for lamprey migrating upstream;
- Provide additional attachment surfaces for lamprey to attach and rest as they attempt to enter and ascend conventional fish ladders;

All lamprey study objectives and study designs would be coordinated with the SRWG. Any changes to normal fishway operations would be coordinated with regional fish managers via the FPOM. Lamprey passage designs would be coordinated through the FFDRWG. All work would be coordinated with the Corps-Tribal Lamprey Work Group.

Many elements of this measure would *not* require monitoring or adaptive management considerations. Minor fishway modifications such as installation of small ramps, diffuser plating and rounded corners on entrance weirs or other surfaces would be implemented without formal monitoring, as these design features are intended to address known fishway design deficiencies and present negligible risks (and may benefit, in some cases) salmon passage and normal operation and maintenance of fish ladders. Elements that require monitoring include:

- **Install additional refuge boxes.** While providing resting areas and cover for lamprey is needed and past evaluations and observations have demonstrated that lamprey readily use these structures (Moser et al., in press), qualitative monitoring with respect to operations and maintenance considerations is required. Refuge boxes need to be easily opened, removed and/or maneuvered around during fish ladder dewatering operations to ensure fish health and safety. For planning purposes, it is assumed that monitoring for salmon interaction with the refuge boxes is not required.
- **Install a wetted wall.** Wetted walls are a relatively new technology designed to guide lamprey out of dead end areas or conventional fishways and into an alternate route or collection box. For planning purposes, it is assumed that a new wetted wall would terminate in a collection box rather than function as a volitional structure. Monitoring will be required to inform any necessary follow-on modifications. For planning purposes, it is assumed that monitoring for salmon interaction with the structure is not required.
- **Lamprey Passage Structures (LPSs).** While LPSs are not a new design concept, monitoring is required to evaluate passage success and inform any necessary follow-on modifications. New structures would either: (1) terminate in a collection box located on a deck and would require Corps staff or others (i.e., tribal biologists) to collect lamprey for upstream release, or; (2) function as volitional passage structures, though retaining capability of collection if needed. Volitional passage structures would either connect to existing LPSs or deliver lamprey to the forebay of the dam(s). While exact designs and configurations will be determined in coordination with the FFDRWG and the Corps-Tribal Lamprey Work group, it is assumed here that new LPSs at Bonneville Dam's Bradford Island and Washington Shore fish ladders, The Dalles East Fish Ladder and John Day South Fish Ladder would terminate in collection boxes and that the John Day North Fish Ladder LPS would be extended to the dam forebay or to the overflow weir section of the ladder. For planning purposes, it is assumed that monitoring for salmon interaction with structures would not be required.

2.1.5.2 Monitoring Metrics, Targets, and Adaptive Management Measures

MONITORING METRIC 1: QUALITATIVE EVALUATION OF OPERATION AND MAINTENANCE OF REFUGE BOXES.

Methods and Timing

Corps staff would qualitatively assess performance of lamprey refuge boxes at the Washington Shore and Bradford Island ladders during dewatering operations. Dewatering operations typically occur sometime during the first two weeks of December, as the winter maintenance period is December 1 – end of February). Winter maintenance (and construction) at these fish ladders occurs in alternating years. Staff would assess ease of handling the new refuge boxes during dewatering operations (opening, removing, maneuvering around, ease of collecting lamprey that may be resting in the boxes) and determine whether new refuge boxes need to be moved (sediment can build up in certain areas of the fishway) or potentially modified. Biologists and/or maintenance staff would identify any structural or mechanical issues with the boxes (e.g., moving parts work and the boxes are securely fastened to fishway surfaces) and make recommendations, if necessary, on modifications. Results would be documented in a memorandum and reported to the FPOM and the Corps-Tribal Lamprey Work Group.

Performance Target

This is a qualitative assessment. Refuge box performance would be considered successful if Bonneville Dam project biologists determine that the boxes are easy to operate (open, remove, maneuver around, collect lamprey from) during dewatering operations. Inspections by biologists and/or maintenance staff should verify that structural and mechanical features of the boxes are working as designed.

Adaptive Management

If the Corps determines that the refuge boxes are not performing as anticipated, the boxes will be moved, modified or (if necessary due to fish health/safety concerns) removed. Any follow-on modifications would be coordinated with the FFDRWG and FPOM working groups, as appropriate, and the Corps-Tribal Lamprey Work Group.

MONITORING METRIC 2: QUALITATIVE EVALUATION OF BONNEVILLE WASHINGTON SHORE FISH LADDER WETTED WALL PERFORMANCE.

Methods and Timing

For planning purposes, it is assumed that this structure would terminate in a collection box located on a deck and would require Corps staff or others (i.e., tribal biologists) to collect lamprey for upstream release. Although exact operation dates of the structure would be dependent on FPOM coordination and coordination with those who will be collecting lamprey from the structure, the wetted wall would likely be operated between May and August each year. Corps staff would visually inspect the structure during daily fishway inspections when the structure is being operated to look for operational issues (e.g., water supply) or other problems. Users of the structure would monitor for operational issues and immediately report them to Bonneville Dam project biologists to determine whether problems need to be addressed immediately. Any in-season disruption to normal operation of the structure would be reported to the FPOM via a coordination memorandum or in the Project's weekly report to FPOM, as appropriate. Users of the structure would record the number of lamprey collected each day and report on a regular basis (likely weekly and annually, but to be determined through further coordination with structure users and FPOM). At the conclusion of the first season of operation, Corps biologists and users of the structure would produce a memorandum reporting on the number of lamprey collected and performance of the structure. The memorandum would include recommendations for modification of the structure.

Performance Target

This would be a qualitative assessment. The structure would be determined to be successful if it successfully attracts and collects lamprey (as the analogous Bradford Island Fish Ladder structure does), operates reliably (i.e., minimal disruptions due to pump failures or similar operational issues), and does not require modification.

Adaptive Management

If the Corps determines that the new wetted wall structure is not performing as anticipated, the structure would be modified and qualitative evaluation would continue as described above. Any follow-on modifications would be coordinated with the FFDRWG and FPOM working groups, as appropriate, and the Corps-Tribal Lamprey Work Group.

MONITORING METRIC 3: QUALITATIVE EVALUATION OF PERFORMANCE OF LAMPREY PASSAGE STRUCTURES (LPS) THAT TERMINATE IN COLLECTION BOXES (BONNEVILLE WASHINGTON SHORE, BONNEVILLE BRADFORD ISLAND, THE DALLES EAST, AND JOHN DAY SOUTH FISH LADDERS).

Methods and Timing

Although exact operation dates of the new structures would be dependent on FPOM coordination and (for structures terminating in a collection box) coordination with those who will be collecting lamprey from the structures, LPSs would likely be operated sometime between April and October each year. Peak lamprey passage activity is expected to occur from June through August. Corps staff would visually inspect the new structures during daily fishway inspections when the structure is being operated to look for operational issues (e.g., water supply, lamprey mortalities) or other problems. Users of structures that terminate in collection boxes would also be required to monitor for operational issues and immediately report them to Corps project biologists to determine whether problems need to be addressed immediately. Any in-season disruption to normal operation of these structures would be reported to the FPOM via a coordination memorandum or in the Project’s weekly report to FPOM, as appropriate. Users of the structures would record the number of lamprey collected each day and report on a regular basis (likely weekly and annually, but to be determined through further coordination with structure users and FPOM). At the conclusion of each of the first three seasons of operation of new structures, Corps biologists – with input from users of the structures – would produce a memorandum reporting on the number of lamprey collected and performance of the new structures. The memoranda would include recommendations for modification of structures (e.g., water supply or other mechanical or structural issues).

Performance Target

This would be a qualitative assessment. A new structure would be determined to be successful if it successfully attracts and collects lamprey (as analogous LPSs at other locations do), operates reliably (i.e., minimal disruptions due to pump failures or similar operational issues), and does not require modification.

Adaptive Management

If the Corps determines that a new LPS is not performing as anticipated, the structure would be modified and qualitative evaluation would continue as described above. Any follow-on modifications would be coordinated with the FFDRWG and FPOM working groups, as appropriate, and the Corps-Tribal Lamprey Work Group.

Monitoring Metric 4: Evaluate performance of John Day North Fish Ladder LPS extension (and other fully volitional LPSs). For planning purposes, monitoring and adaptive management described here is specific to the John Day North Fish Ladder LPS. A similar approach would be applied to any other fully volitional LPS installed or extended at other locations. LPSs that terminate in exit chutes deliver lamprey directly into fishways or forebays of dams, necessitating more rigorous evaluation and quantification of passage success. Each fully volitional structure will include counting systems (mechanical, video or other) to record the number of lamprey that successfully pass the structure. Structures will also include PIT monitoring (full- and half-duplex) to facilitate both short-term and long-term monitoring capabilities.

Although exact operation dates of the extended John Day North Fish Ladder LPS and other structures would be dependent on FPOM coordination, the LPS would likely be operated sometime between April and October each year. Peak lamprey passage activity is expected to occur from June through August. Corps staff would visually inspect the new structures during daily fishway inspections when the structure is being operated to look for operational issues (e.g., water supply, lamprey mortalities) or other problems. Any in-season disruption to normal operation of these structures would be reported to the FPOM via a coordination memorandum or in the John Day Project’s weekly report to FPOM, as appropriate.

Corps staff or Corps-funded researchers would monitor and routinely report preliminary LPS counts to FPOM at the Corps-Tribal Lamprey Work Group throughout the passage season and provide an annual corrected total in the Annual Fish Passage Report and, if appropriate, integrate into fish counts published online. If the structure is routed to the forebay of the dam or anywhere upstream of the fish count station of the John Day North Fish Ladder, the LPS will present a new, independent passage route and thus counts will need to be integrated into total dam passage counts for the dam. If the structure delivers lamprey to a fishway section downstream of the count station, LPS counts will only be used by the Corps and/or Corps-funded researchers to assess LPS performance and identify possible operational issues. LPS counting systems have been problematic in the past, as it is challenging to accurately and reliably count lamprey exiting LPS exit chutes. A combination of mechanical and visual counters are employed for existing systems and the Corps continues to improve reliability and validation and correction of LPS counts. Although the extended John Day North Fish Ladder would benefit from lessons learned from other systems, the Corps anticipates that LPS counts will require correction and that the LPS counting system may need to be modified.

In coordination with the SRWG and the Corps-Tribal Lamprey Work Group, the Corps would determine the appropriate post-construction evaluation approach for the extended John Day North Fish Ladder LPS and each new fully volitional LPS. For planning purposes, it is assumed that a combination of active (radio or acoustic) telemetry, PIT tag detections, LPS counts and window counts would be used to assess performance of the extended John Day North Fish Ladder LPS or other fully volitional LPSs. Of particular concern at John Day is fallback past the dam (lamprey ascend the ladder and/or LPS but subsequently move downstream via the spillway or other routes) and fish ladder fallout (lamprey ascend a portion of the fishway but do not successfully pass to the forebay).

Active telemetry and PIT would be used to compare post-modification lamprey passage performance at the North Fish Ladder and for John Day Dam overall. To ensure consistency with past passage studies, lamprey would likely be collected at Bonneville Dam, tagged with radio- or acoustic-telemetry tags and/or PIT tags, and released downstream of Bonneville (Keefer et al. 2012). Telemetry and PIT arrays fixed in locations previously monitored would be used to monitor tagged lamprey as they approach and pass John Day Dam. Tagging and monitoring would occur during the spring/summer adult lamprey migration. The primary metrics of interest will include fishway passage efficiency for the North Fish Ladder, and total dam passage efficiency at John Day Dam. An increase in total dam passage efficiency (i.e., getting more lamprey past the dam) is the ultimate goal of the LPS extension but evaluation at the fishway scale allows for meaningful pre- and post-modification comparisons of passage performance. Other metrics, such as passage times (at the two scales noted above), fallback past the dam, etc. will also be reported. Study results will be compared with historic data (i.e., a pre-modification study is not needed). Tagged fish would be monitored as they pass other dams as well.

Due to inter-annual variability in passage metrics, this evaluation would require a minimum of two years of study. To reduce cost and handling and tagging of lamprey, the Corps – in coordination with regional fish managers through the SRWG and the Corps-Tribal Lamprey Work Group – may elect to wait until other measures requiring telemetry studies are completed, particularly at Bonneville Dam, before implementing this measure and the associated study. In the interim, fish counts (window counts) and Lamprey Passage Structure (LPS) counts would be used to monitor passage.

Performance Target

Overall success would be defined as relative increases in passage efficiency at the two scales mentioned above. While increasing total dam passage efficiency for lamprey at John Day Dam is the ultimate goal of this measure, a comparison at the scale of the North Fish Ladder would be used to identify issues and diagnose any potential problems that need correction. As in past studies, sample sizes are expected to be low so comparison of pre- and post-modification metrics will rely both on quantitative analysis and expert opinion.

LPS counting systems must provide accurate and reliable counts so the Corps can report accurate counts to the region and understand the relative contribution of the LPS to overall John Day Dam lamprey counts. This is particularly important if the LPS is routed to the forebay, bypassing lamprey around the conventional fish count window. Consistent with other fish counts at Corps dams, a successful LPS counting system would reliably produce lamprey counts within +/- 5% of actual passage (video counts).

Adaptive Management

If two years of post-construction evaluation suggests that overall John Day Dam passage efficiency *decreased* following the extension of the LPS and analysis suggests that the structure was the likely cause of this decrease, the Corps would, in coordination with regional fish managers and the Corps-Tribal Lamprey Work Group, determine whether modification of the structure or reversion to the existing trap-and-haul design is the most appropriate solution. This decision would be based on study results, expert opinion regarding the likely reasons why the design failed to improve lamprey passage, and funding availability for (if appropriate) follow-on modifications. As noted previously, fully volitional systems – including the John Day North Fish Ladder LPS – would retain the ability to operate as trap-and-haul structures.

If study results and other analysis suggest that follow-on modifications would likely address observed design deficiencies, the Corps would (pending funding availability) modify the structure, in coordination with appropriate Regional Forum work groups (i.e., FFDRWG and FPOM) and the Corps-Tribal Lamprey Work Group.

If study results and other analysis is inconclusive and the Corps determines that additional information is required to inform potential modifications or decisions, the Corps would (pending funding availability) develop and implement an additional study. This study would likely include use of visual tools such as video and acoustic imaging technology to evaluate lamprey use of the structure at a finer scale. The objectives of the follow-on evaluation would be to: (a) determine whether the decrease in passage efficiency was likely due to the structure itself or other factors, and; (b) identify and diagnose design deficiencies to inform potential modifications. If follow-on study results suggest the structure is performing as designed and is likely not contributing to a decrease in total dam passage efficiency, the Corps would, in coordination with others, determine whether to continue to operate the structure as a volitional structure or as a trap-and-haul structure. If follow-on study results and other analysis suggest that follow-on modifications would likely address observed design deficiencies, the Corps would (pending funding availability) modify the structure, in coordination with appropriate Regional Forum work groups (i.e., FFDRWG and FPOM) and the Corps-Tribal Lamprey Work Group.

If the extended John Day North Fish Ladder LPS counts do not meet the +/- 5% of actual (video verified) counts standard, the Corps will modify the counting system as needed to achieve this goal.

If the Corps, in coordination with the appropriate Regional Forum work groups and the Corps-Tribal Lamprey Work Group, determines that the extended LPS is not performing as intended and that there are no feasible or economical solutions to addressing poor performance, the structure would be reverted to a trap-and-haul structure. If appropriate and as funding allows, the extended sections of the structure may be removed.

Contingency Planning and Implementation

Portland and Walla Walla districts, U.S. Army Corps of Engineers, in coordination with appropriate Regional Forum work groups and the Corps-Tribal Lamprey Work Group.

Timing of implementation is dependent on funding availability, program prioritization, fish ladder maintenance schedules (which determines when ladders are available for modification) and other factors.

- **Refuge boxes at Bonneville Dam.** Qualitative assessment during the first year of operation would inform any necessary follow-on modifications, refuge box removal, or other actions. At Bonneville Dam, fish ladder outages are alternated annually to ensure that one ladder is in operation at all times. Thus, any follow-on actions would occur two years following initial installation. Following this period, the refuge boxes would be considered operational and would be operated and maintained by the Corps, in coordination with FPOM.
- **Wetted wall at Bonneville Washington Shore Fish Ladder.** Qualitative assessment during the first year of operation would inform any necessary follow-on modifications or other actions. At Bonneville Dam, fish ladder outages are alternated annually to ensure that one ladder is in operation at all times. Thus, any follow-on actions would occur two years following initial installation. Following this period, the wetted wall would be considered operational and would be operated and maintained by the Corps, in coordination with FPOM and any users of the structure (e.g., tribal biologists).
- **Lamprey Passage Structures (LPS) that terminate in collection boxes (Bonneville, The Dalles and John Day dams).** Performance of new structures would be formally monitored and qualitatively assessed for three years following construction. Follow-on modifications, if necessary, are expected to occur during or immediately following this three years of qualitative assessment. Following this period, the LPSs would be considered operational and would be operated and maintained by the Corps, in coordination with FPOM and any users of the structures (e.g., tribal biologists).
- **John Day North Fish Ladder LPS extension.** The initial lamprey passage evaluation (telemetry and PIT study) would take up to two years following construction. Final study results would be reported in June of the year following the final study year (for each fish ladder). LPS and window counts would be available during the passage season and are

summarized annually. Follow-on studies are expected to take one year of field work, with final study results available in June of the year following field work. Any necessary follow-on modifications to the structure may occur following either the initial evaluation or the follow-on study. Following this period of construction and follow-on modification, the LPS would be considered operational and would be operated and maintained by the Corps, in coordination with FPOM and (if it is reverted to a trap-and-haul structure) any users of the LPS (e.g., tribal biologists).

2.1.6 Turbine Strainer Lamprey Exclusion

Structures would be installed to prevent juvenile lamprey, juvenile salmonids, and other fish from being entrained into the intakes of turbine unit cooling water systems. Hood-like structures would be installed over existing intake gratings and would allow sweeping flows to move fish past the opening, with the intent of reducing entrainment and related risk of fish injury or mortality. This measure may be implemented at all lower Snake River and all lower Columbia River Projects.

2.1.6.1 Measure Monitoring Objectives

This measure has the potential to reduce lamprey and other juvenile fish mortality.

2.1.6.2 Monitoring Metrics, Targets, and Adaptive Management Measures

MONITORING METRIC LAMPREY ENTRAINMENT:

Exclusion devices will be installed when turbines are either replaced or maintained to the degree that the scroll case is dewatered. Corps staff would continue to inspect turbine cooling water strainer systems and count the number of juvenile lamprey (and other fish) mortalities observed. Inspection regimes vary based on project operations and cooling water system operations.

Methods and Timing

Check the strainers once a month from mid-December until mid-June at the four lower Snake River dams and from mid-December to mid-July at McNary Dam. If 10 or more juvenile lamprey are collected during the last sample date in June/July, an additional month of inspections should be made.

Inspections are not made at Bonneville, The Dalles and John Day dams. They use self cleaning strainers that do not need inspecting.

These inspections would continue after new exclusion devices are installed and may be refined as needed.

Performance Target

Success would be defined as a reduction in the number of juvenile lamprey (and other fish) mortalities collected from turbine cooling water strainers during routine inspections.

Adaptive Management

Design review and discussion would occur to improve exclusion design and operation and would be implemented as other projects and units are overhauled or extended outages. Design would be reviewed by hydraulic design committee and regional fish managers.

Contingency Planning and Implementation

USACE NWW and NWP staff would conduct periodic cooling water strainer inspections.

Inspections would continue following the installation of lamprey exclusion devices.

2.2 OPERATIONAL MEASURES

2.2.1 Juvenile Fish Passage Spill Operations

This measure was modified using the analysis from the range of spill levels evaluated in the MOs to attempt to provide a high potential benefit to salmon and steelhead through increased spill while avoiding many of the adverse impacts to power generation and reliability associated with MO4. Juvenile fish passage spill would be implemented to aid juvenile salmonid migration at the lower Snake River projects and the lower Columbia River projects. The initial spring component of juvenile fish passage spill is a flexible spill operation over a 24-hour period to take advantage of peak and off-peak load hours for hydropower, while also providing high levels of spill intended to test the CRSO EIS modeled estimates of the benefits to downstream juvenile passages, while also ensuring operational feasibility for the Corps.

2.2.1.1 Measure Monitoring Objectives

The implementation of the juvenile fish passage spill operations is intended to:

- decrease the number of juvenile fish that bypass the dams through non-spillway routes,
- improve fish travel through the forebays,
- gain scientific information on latent (delayed) mortality
- provide flexibility for hydropower generation.
- Increase smolt to adult survival rate of salmon and steelhead.

2.2.1.2 Monitoring Metrics, Targets, and Adaptive Management Measures

Monitoring Metrics, Targets and Adaptive Management Measures are described this measure is described in detail in the *Process for Adaptive Implementation of the Flexible Spill Operational Component of the Columbia River System Operations EIS* found in Appendix R, Part 2.

2.2.2 Early Start Transport (Lower Columbia and Lower Snake)

This measure was modified from the version of the measure in MO1. The transport of juvenile salmon collected at Lower Granite, Little Goose, and Lower Monumental projects could begin as early as April 15, approximately 1 week earlier than current fish transport operations described in the No Action Alternative, if warranted based on transportation benefits or to facilitate transport research. Transport operations would end September 30 at Lower Monumental and October 31 at Lower Granite and Little Goose. Collected juvenile fish would be transported to a location below Bonneville Dam via barge or truck on a daily or every-other-day schedule, depending on the numbers of fish collected at the collector projects. This measure does not preclude the co-lead agencies from ceasing juvenile transportation June 21 through August 14 with allowances for adaptive management adjustments through the Technical Management Team as was contemplated in the 2019-2021 Spill Operation Agreement.

Monitoring and adaptive management is already in place for the transportation program. Protocols and criteria for collection, holding, and transport of juvenile fish are defined in the Juvenile Fish Transportation Plan, included as Appendix B of the annual Fish Passage Plan, available online at: http://pweb.crohms.org/tmt/documents/fpp/. Implementation of the Juvenile Fish Transportation Plan, including adaptive management and criteria described in Appendix B of the Fish Passage Plan, is coordinated through the Regional Forum. For more than a decade, the analysis of the seasonal effects of transportation has been conducted by NMFS to inform adaptive management of the program. Key metrics used in assessing the benefits of fish transportation include SAR for in-river and transport treatment groups, along with various ratios derived from the SAR estimates, generally referred to as the transport to in-river migrant ratio. This study is expected to continue into the future and along with annual water supply forecasts and in-river condition, will be used by the Regional Forum to annually set the start date of spring transportation.

2.2.3 Predator Disruption Operations (John Day)

The John Day reservoir normal operating range is up to 266.5 feet (although it is authorized to operate up to 268 feet). The Corps would operate John Day within a +/- 2 foot MIP range of 262.5 to 264.5 feet, except from April 10 to as late as June 15, when the John Day forebay would operate from 264.5 to 266.5 feet, except as needed for flood risk management. These operations would be initiated prior to the start of nesting by Caspian terns, to avoid take. Unless adaptively managed due to changing run timing, the co-lead agencies intend to return the reservoir elevations of 262.5 to 264.5 on June 1, which generally captures 95 percent of the annual juvenile steelhead migration. The results of this action would be monitored and coordinated with USFWS and NMFS.

2.2.3.1 Measure Monitoring Objectives

The measure has the potential to manipulate the John Day reservoir elevation to decrease avian predation on ESA-listed juvenile salmon and steelhead in the lower Columbia River.

2.2.3.2 Monitoring Metrics, Targets, and Adaptive Management Measures

MONITORING METRIC 1: PISCIVOROUS WATERBIRD USE OF LOW-LYING NESTING HABITAT IN JOHN DAY RESERVOIR

Methods and Timing

Evaluate Caspian tern use of low-lying areas within the Blalock Islands complex (RM 275). Use survey techniques suitable for the John Day Reservoir such as aerial flights and/or boat-based surveys to determine: (1) presence/absence information of potentially nesting Caspian terns, (2) counts of nesting Caspian terns, and (3) qualitatively assess suitable nesting habitat availability. Information regarding presence/absence and numbers of Caspian terns present combined with an assessment of available low-lying habitat is anticipated to be sufficient for assessing the effectiveness of this measure and making adaptive management decisions.

Surveys would be performed while the action is being implemented (i.e., April-June) and focus on isolated (i.e., island) areas potentially suitable for Caspian tern nesting. Assessment of nesting habitat is anticipated to be qualitative in nature and reflect the observational survey methods being used (i.e., habitat would be described in general terms and would not be numerically quantified through on-the-ground measurements or photogrammetry).

It is anticipated that monitoring would occur for the first three years of implementation or as needed thereafter to meet monitoring metrics. Monitoring objectives and methods would be coordinated with regional fish and wildlife managers through the Regional Forum work groups, including SRWG and the Fish Passage Operations and Maintenance Work Group (FPOM). Reporting would consist of concise summaries of qualitative field observations and corresponding system operations. These summaries would be transmitted to regional fish and wildlife managers through the appropriate Regional Forum work groups (e.g., via Memorandum for the Record (MFR) to FPOM).

Performance Target

Success would be defined as effective reduction of Caspian tern nesting activities on low-lying habitat within the John Day reservoir (i.e., nesting habitat below a water surface elevation of 268’ as measured at the JDA forebay) with emphasis on the Blalock Islands complex during the operation period (i.e., April – June) for three consecutive years.

Adaptive Management

If the operation appears to be ineffective in reducing Caspian tern nesting activities, the Action Agencies would discuss adaptive management strategies through the Regional Forum work groups. Any changes to Fish Passage Plan (FPP) operations would be coordinated with regional fish and wildlife managers via Regional Forums, including the FPOM and the Technical Management Team (TMT), as appropriate. Potential changes could include modifying implementation timing to reflect juvenile salmon run timing and/or timing of use of low-lying nesting habitat by Caspian terns, or a re-assessment of water surface elevations required to effectively inundate potential nesting areas during the period of operation.

If the Corps, in coordination with regional fish managers, determines that additional monitoring is necessary to inform management decisions, monitoring may be extended beyond the initial three years and/or additional monitoring objectives may be developed. Specific monitoring objectives and methods would be coordinated through the SRWG, in coordination with FPOM and TMT, as appropriate.

MONITORING METRIC 2: MONITOR JUVENILE SALMON AND STEELHEAD RUN TIMING

Methods and Timing

The existing Smolt Monitoring Program would be used to determine when 95 percent of the annual juvenile steelhead migration has passed through the John Day Dam reservoir. This information would be used annually by the Corps, in coordination with others through the FPOM and TMT work groups, to determine the end date of the operation (no earlier than June 1 and no later than June 15, per the measure).

Performance Target

The end date of the operation is intended to occur no earlier than June 1 and no later than June 15, but after 95 percent of the annual juvenile steelhead migration has passed John Day Dam.

Adaptive Management

The co-lead agencies anticipate that in most years, the end date of this operation would occur on June 1, which generally captures 95 percent of the annual juvenile steelhead migration through the John Day Dam reservoir. However, the end date may be adjusted each year due to changes in run timing.

If 95 percent of the annual juvenile steelhead migration has *not* passed through the John Day Dam reservoir by June 1, the Corps, in coordination with others through TMT and FPOM, would continue to monitor juvenile passage. Once 95 percent of the annual juvenile steelhead migration has passed through the John Day Dam reservoir, the Corps would end the operation.

The Corps would end the operation by June 15, even if 95 percent of the annual juvenile steelhead migration has still *not* passed through the John Day Dam reservoir.

The Action Agencies would coordinate any proposed changes to operation dates, including any changes to Fish Passage Plan (FPP) operations, with regional fish and wildlife managers via FPOM and TMT, as appropriate.

Contingency Planning and Implementation

The Corps, in coordination with the co-lead agencies, would implement monitoring activities and coordinate with appropriate Regional Forum work groups. Monitoring objectives and methods would be coordinated through the SRWG. Operational changes, including any changes to Fish Passage Plan (FPP) operations would be coordinated with regional fish and wildlife managers through FPOM and TMT, as appropriate.

As this action is primarily an operational change to John Day Dam operations, it is anticipated that implementation could begin during the first spring period following completion of the CRSO EIS and associated Record of Decision, subject to availability of funding for monitoring actions. It is anticipated that direct monitoring actions, as described above, would occur for the first three years of implementation.

2.3 MITIGATION MEASURES

2.3.1 Temporary extension of performance standard Spill Operations

It is expected that higher spill levels and the resultant TDG associated with the Juvenile Fish Passage Spill measure could result in delays to adult passage. Eddies created by a high spill operation may confound upstream passage by salmonids. If a delay in adult salmon and steelhead upstream passage is observed, operations would revert to performance standard spill until the adult fish pass the dam.

2.3.1.1 Measure Monitoring Objectives

The measure has the potential to decrease travel time for adult passage

2.3.1.2 Monitoring Metrics, Targets, and Adaptive Management Measures

Monitoring Metrics, Targets and Adaptive Management Measures are described this measure is described in detail in the *Process for Adaptive Implementation of the Flexible Spill Operational Component of the Columbia River System Operations EIS* found in Appendix R, Part 2.

2.3.2 Spawning Habitat Augmentation at Lake Roosevelt

In Lake Roosevelt, changes in elevation would result in higher rates of kokanee and burbot egg dewatering in winter, and lower reservoir levels in spring would decrease access to tributary spawning habitat for redband rainbow trout. Increased flexibility of refilling Lake Roosevelt that may occur through the month of October, depending on the annual water conditions, may impact the spawning success of kokanee, burbot and redband rainbow trout. In 2019, Bonneville funded year one of a three-year study to determine potential impacts of modifications in Lake Roosevelt refill to resident fish spawning habitat access. Other evaluations will be conducted to determine potential impact areas. If study evaluations and other available data indicate resident fish spawning habitat areas are impacted by changes in reservoir elevations, the co-lead agencies will work with regional partners to determine where to augment spawning habitat at locations along the reservoir and in the tributaries (up to 100 acres).

This mitigation measure is to develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish by (a) Determining where to site spawning habitat augmentation at Lake Roosevelt for burbot and kokanee, (b) determining where redband trout and kokanee spawning migration are impacted by reduced access in tributary varial zones, (c) and to mitigate by placing appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.

This mitigation measure adopted by Bonneville in its Mitigation Action Plan (see 10 C.F.R. § 1021.331) will be implemented through Bonneville's Fish and Wildlife Program. Bonneville must protect, mitigate, and enhance fish and wildlife affected by the development and operation of the Columbia River System and do so in a manner consistent with the Northwest Power and Conservation's Council's (Council) Fish and Wildlife Program and the purposes of the Northwest Power Act. 16 U.S.C. § 839b(h)(10)(A).

The Northwest Power Act requires the Council to appoint an Independent Scientific Review Panel (ISRP) to review projects funded through Bonneville's annual fish and wildlife mitigation budget. 16 U.S.C. § 839b(h)(10)(D). The law does not require review of all Bonneville's projects, but in practice, most are reviewed. The reviews ensure the projects are consistent with the Council's Fish and Wildlife Program by considering whether they "are based on sound scientific principles; benefit fish and wildlife; and, have a clearly defined objective and outcome with provisions for monitoring and evaluation of results." 16 U.S.C. § 839b(h)(10)(D)(iv). The Council relies on the ISRP reviews in recommending mitigation for Bonneville to fund. Proposals for research, monitoring and evaluation associated with mitigation actions are generally reviewed by the ISRP prior to a recommendation from the Council to Bonneville.

Bonneville would continue to support review of mitigation actions discussed in Section 7.6.4 that would be adopted in Bonneville's Mitigation Action, including: Spawning Habitat Augmentation at Lake Roosevelt, Plant Cottonwood Trees (Up to 100 acres) near Bonners Ferry, Plant Native Wetland and Riparian Vegetation (Up to 100 acres) on the Kootenai River Downstream of Libby Dam, and Bull Trout Access to Perched Tributaries in Kootenai River. To implement these actions, Bonneville would work closely with Reclamation and Corps on any mitigation measures related to their respective projects and with its existing project sponsors, including the Kootenai Tribe of Idaho and the Spokane Tribe of Indians, and other entities as appropriate.

2.3.3 Plant Cottonwood Trees (Up to 100 acres) near Bonners Ferry

The flow regime at Libby Dam makes natural establishment of riparian vegetation downstream of the dam challenging. Winter flows often exceed the river stage at which riparian vegetation is established during the previous spring, making it difficult to sustain young stands of cottonwoods to maturity. The co-lead agencies would plant up to 100 acres of riparian forest along the braided and meander reaches of the Kootenai River near Bonners Ferry, using 1 to 2 gallon cottonwood trees, with the expectation that the larger size trees would be better suited to withstand the higher winter flows. This would improve habitat to benefit ESA-listed Kootenai River White Sturgeon, and complement other actions already being taken in the Kootenai River to benefit their habitat. To the extent possible, this work will be completed through ongoing projects under Bonneville's F & W Program, such as the Kootenai Tribe of Idaho's Kootenai River Habitat Restoration Program.

This mitigation measure adopted by Bonneville in its Mitigation Action Plan (see 10 C.F.R. § 1021.331) will be implemented through Bonneville's Fish and Wildlife Program. Bonneville must protect, mitigate, and enhance fish and wildlife affected by the development and operation of the Columbia River System and do so in a manner consistent with the Northwest Power and Conservation's Council's (Council) Fish and Wildlife Program and the purposes of the Northwest Power Act. 16 U.S.C. § 839b(h)(10)(A).

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2.3.4 Plant Native Wetland and Riparian Vegetation (Up to 100 acres) on the Kootenai River Downstream of Libby Dam

The co-lead agencies would plant up to 100 acres of native forested and scrub-shrub wetland vegetation at a lower river elevation in the Kootenai River, which may partially offset effects to existing wetlands and riparian forests downstream of Libby Dam caused by the Modified Draft of Lake Koocanusa and associated lower water levels on the Kootenai River. This mitigation measure adopted by Bonneville in its Mitigation Action Plan (see 10 C.F.R. § 1021.331) will be implemented through Bonneville's Fish and Wildlife Program. Bonneville must protect, mitigate, and enhance fish and wildlife affected by the development and operation of the Columbia River System and do so in a manner consistent with the Northwest Power and Conservation's Council's (Council) Fish and Wildlife Program and the purposes of the Northwest Power Act. 16 U.S.C. § 839b(h)(10)(A).

The Northwest Power Act requires the Council to appoint an Independent Scientific Review Panel (ISRP) to review projects funded through Bonneville's annual fish and wildlife mitigation budget. 16 U.S.C. § 839b(h)(10)(D). The law does not require review of all Bonneville's projects, but in practice, most are reviewed. The reviews ensure the projects are consistent with the Council's Fish and Wildlife Program by considering whether they "are based on sound scientific principles; benefit fish and wildlife; and, have a clearly defined objective and outcome with provisions for monitoring and evaluation of results." 16 U.S.C. § 839b(h)(10)(D)(iv). The Council relies on the ISRP reviews in recommending mitigation for Bonneville to fund. Proposals for research, monitoring and evaluation associated with mitigation actions are generally reviewed by the ISRP prior to a recommendation from the Council to Bonneville.

Bonneville would continue to support review of mitigation actions discussed in Section 7.6.4 that would be adopted in Bonneville's Mitigation Action, including: Spawning Habitat Augmentation at Lake Roosevelt, Plant Cottonwood Trees (Up to 100 acres) near Bonners Ferry, Plant Native Wetland and Riparian Vegetation (Up to 100 acres) on the Kootenai River Downstream of Libby Dam, and Bull Trout Access to Perched Tributaries in Kootenai River. To implement these actions, Bonneville would work closely with Reclamation and Corps on any mitigation measures related to their respective projects and with its existing project sponsors, including the Kootenai Tribe of Idaho and the Spokane Tribe of Indians, and other entities as appropriate.

2.4 ESA SPECIES MITIGATION MEASURES

2.4.1 Bull Trout Access to Perched Tributaries in Kootenai River

The co-lead agencies are evaluating whether delta formations at tributary confluences of the Kootenai River, downstream of Libby Dam, may be causing upstream fish passage barriers to bull trout seeking access to spawning grounds during late spring and summer months. In 2021, the co-lead agencies would evaluate key bull trout spawning tributaries downstream of Libby Dam to (1) perform an initial assessment of tributary confluences with access barriers and develop implementation planning, and (2) based on the initial assessment, prioritize planning to identify two projects, which would be completed over a specified time period. Upon completion of the initial assessment, tributaries identified as having blocked access from the Kootenai River would be prioritized based on biological effectiveness provided by passage of adult bull trout and feasibility of restoration actions that are unlikely to result in long-term operations and maintenance needs. The co-lead agencies would work with USFWS and regional partners to complete the initial assessment and initiate up to two restoration or improvement projects benefitting tributary access over the period of 2021–2026. Any additional improvement opportunities to benefit bull trout passage in Kootenai River tributaries would be evaluated based on biological priorities and available funding**.**

This mitigation measure adopted by Bonneville in its Mitigation Action Plan (see 10 C.F.R. § 1021.331) will be implemented through Bonneville's Fish and Wildlife Program. Bonneville must protect, mitigate, and enhance fish and wildlife affected by the development and operation of the Columbia River System and do so in a manner consistent with the Northwest Power and Conservation's Council's (Council) Fish and Wildlife Program and the purposes of the Northwest Power Act. 16 U.S.C. § 839b(h)(10)(A).

The Northwest Power Act requires the Council to appoint an Independent Scientific Review Panel (ISRP) to review projects funded through Bonneville's annual fish and wildlife mitigation budget. 16 U.S.C. § 839b(h)(10)(D). The law does not require review of all Bonneville's projects, but in practice, most are reviewed. The reviews ensure the projects are consistent with the Council's Fish and Wildlife Program by considering whether they "are based on sound scientific principles; benefit fish and wildlife; and, have a clearly defined objective and outcome with provisions for monitoring and evaluation of results." 16 U.S.C. § 839b(h)(10)(D)(iv). The Council relies on the ISRP reviews in recommending mitigation for Bonneville to fund. Proposals for research, monitoring and evaluation associated with mitigation actions are generally reviewed by the ISRP prior to a recommendation from the Council to Bonneville.

Bonneville would continue to support review of mitigation actions discussed in Section 7.6.4 that would be adopted in Bonneville's Mitigation Action, including: Spawning Habitat Augmentation at Lake Roosevelt, Plant Cottonwood Trees (Up to 100 acres) near Bonners Ferry, Plant Native Wetland and Riparian Vegetation (Up to 100 acres) on the Kootenai River Downstream of Libby Dam, and Bull Trout Access to Perched Tributaries in Kootenai River. To implement these actions, Bonneville would work closely with Reclamation and Corps on any mitigation measures related to their respective projects and with its existing project sponsors, including the Kootenai Tribe of Idaho and the Spokane Tribe of Indians, and other entities as appropriate.

2.4.2 Surface Spill to Reduce Take of Overshooting Adult Steelhead

To reduce the take of overshooting adult Middle Columbia River and Snake River Basin steelhead, the co-lead agencies, beginning in 2020, would implement offseason surface spill as a means of providing safe and effective downstream passage for adult steelhead that overshoot and then migrate back downstream through McNary Dam and the Snake River dams during months when there is no scheduled spill for juvenile passage. The co-lead agencies would implement this measure within the October 1 to November 15 and March 1 to March 30 timeframes based on the analysis. Surface spill operations for adult steelhead can be modified through adaptive management processes so long as the proposed operations are equally or more protective. Additionally, the spillway weirs can be modified to reduce the amount of water spilled through the weir for adult steelhead so long as the proposed structure and operation, together, are equally or more protective.

The potential monitoring and adaptive management of this measure will be developed in the future.

CHAPTER 3 - CITATIONS

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Columbia River System Operations
Final Environmental Impact Statement

Appendix R, Mitigation, Monitoring, and Adaptive Management
Part 2, Process for Adaptive Implementation of the Flexible Spill Operational Component of the Columbia River System Operations Environmental Impact Statement

Table of Contents

CHAPTER 1 - INTRODUCTION

The purpose of this document is to provide a framework for an adaptive management implementation plan to improve downstream passage of ESA-listed juvenile salmonids through the four Lower Snake River and four Lower Columbia River projects to reduce or minimize impacts to these species from bypassing these dams that is included as part of the preferred alternative in the Columbia River System Operations Environmental Impact Statement (CRSO EIS). The co-lead agencies anticipate working collaboratively with regional sovereigns to develop a more detailed adaptive management plan after the CRSO EIS Records of Decision are signed.

Adaptive Management is a structured decision making process that allows decision makers focus attention on what, why, and how actions will be taken (Williams et al, 2009). It is described by the National Research Council (2004) as follows:

> Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders.

The adaptive management process is a collaborative process among stakeholders. Adaptive Management promotes collaboration, flexible decision-making through deliberately designing and implementing management actions to test hypotheses and maximize learning about critical uncertainties to better inform management decisions (Williams and Brown 2012). A simplified model of the adaptive management process is shown in Figure 1.

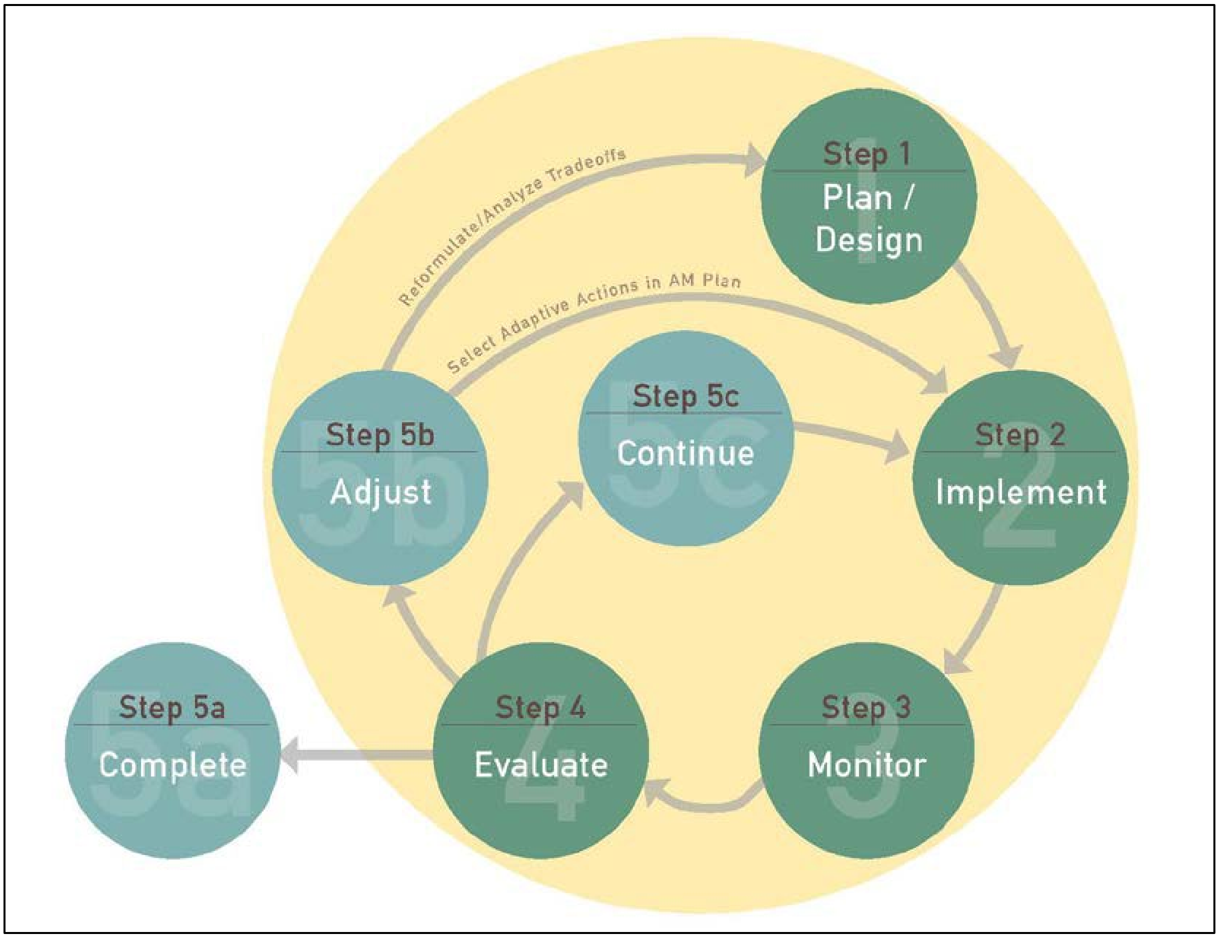

Figure 1. A simplified conceptual model of the adaptive management process.

The uncertainties associated with spill on the Lower Columbia River and Lower Snake River are ideal to be address through the adaptive management process. Gregory (2006) describes the five conditions where adaptive management are most suitable.

- Management is required in spite of uncertainty
- Clear and measureable objectives for decision making
- Opportunity to apply learning to management
- Monitoring can be used to better understand the system
- Sustained commitment by stakeholders

All five of these conditions are met for spill on the Lower Columbia River and Lower Snake River with regard to downstream passage of juvenile salmonids. This adaptive implementation and monitoring framework defines the elements of a flexible spill operation, determines monitoring questions, scopes the review and evaluation of the effects of the spill operation, and adjusts management towards desired conditions and away from undesirable conditions. The stakeholder participation and collaboration process that occurred during the 2019 and 2020 flex spill planning process was significantly aided by the efforts of the collaborative workgroup of diverse sovereign stakeholders.

CHAPTER 2 - 2019-2021 SPILL OPERATIONS AGREEMENT AND THE PREFERRED ALTERNATIVE

To build off the success and momentum achieved through the *2019-2021 Spill Operation Agreement* (Agreement), the Action Agencies (U.S. Army Corps of Engineers, Bonneville Power Administration, and Bureau of Reclamation) plan to formally continue the collaborative approach and operational framework developed by the Flexible Spill Working Group (FSWG), although the future role of this group is currently being evaluated. See discussion in Chapter 3 of this Appendix. In any event, this process would be incorporated into and complementary to the existing Regional Forum. The *Juvenile Fish Passage Spill Operations* measure in the Preferred Alternative would be managed via an adaptive implementation framework outlined herein. The intent is that this adaptive implementation framework will be utilized over a multi-year timeframe and would be within the bounds of the operations analyzed in the EIS. The *Juvenile Fish Passage Spill Operations* measure in the Preferred Alternative builds off the range of spill analyzed in the alternatives, as well as the core principles, objectives, and model of successful regional collaboration underlying the *2019-2021 Spill Operation Agreement* and includes an updated approach to adaptively implement spill. The flexible spill operation in the Preferred Alternative is designed to continue to meet the three pillar principles of power, fish benefits, and feasible operation of the Columbia River system. These pillars include performance targets assumed to result in neutral power revenue as compared to 2018 Court Ordered spill operations and continued power reliability, increased biological benefits to migratory salmon and steelhead, and safe operation of the 8 federal dams. The preferred alternative also adds a fourth pillar focused on evaluation and learning. Evaluating the effectiveness of these operations will require multiple years of data given the lifecycle of salmon and the potential changes in regional energy markets. See discussion in Chapter 4 of this Appendix for more detail on the four pillars.

A flexible spill operation is envisioned to incorporate a range of spring spill levels up to a 125% TDG spill cap during designated hours each day consistent with the concepts tested as part of the Agreement. The intent of that operation would be to meet shared “performance targets” for fish, power generation/transmission, and other implementation and operational considerations developed through collaboration with regional stakeholders. While flex spill is focused on spring operations, it is anticipated that some reduction of summer spill will be required to offset the power system impacts due to higher spring spill.

Spill levels implemented would be adapted or modified based on the framework in this document to account for unanticipated outcomes that affect the ability of the Action Agencies to maintain their individual federal mandates. Those modifications could include, but are not limited to, implementation of spill levels that are within the range of alternatives analyzed in the EIS. The primary goals of this framework are to align with and to complement existing Regional Forum processes to:

- Continue the participation of federal, state and tribal resource managers and the collaborative learning that occurred during the development of flexible spill operations in 2019 and 2020;
- Encourage and support the continuation of the collaborative FSWG/RIOG efforts throughout implementation;
- Ensure the implementation of CRS spill operations is responsive to dynamic conditions experienced during implementation of this novel operation, new scientific information, and regional input;
- Demonstrate compliance with management direction specified in the FEIS/ROD;
- Coordinate with NOAA Fisheries and/or U.S. Fish and Wildlife Service to ensure consistency with the consultations associated with the CRSO EIS;
- Conduct a transparent adaptive implementation process that keeps stakeholders informed of and involved in annual operation decisions on timing, design, and monitoring;
- Ensure integrated engagement of interdisciplinary team members, project personnel (e.g. dam operators, power schedulers), scientists, federal agency policy leads;
- Focus on shared priorities and work to resolve concerns and solve problems related to implementation of flexible spill operations;
- Conduct monitoring activities, interpret and share results, adapt implementation practices to improve results and better meet project objectives; and,
- Evaluate the value of flex spill for fish and power over a range of environmental and economic conditions.

CHAPTER 3 - BACKGROUND – IMPLEMENTATION AND GOVERNANCE

3.1 LESSONS LEARNED FROM THE 2019-2021 SPILL OPERATION AGREEMENT

Through implementation of the 2019 flexible spill operation, the FSWG was able to pilot many of the adaptive implementation concepts detailed in this framework. There was a pre-season review of the specific directions given to project operators through the 2019 Fish Operations Plan (FOP) by members of the Regional Implementation Oversight Group (RIOG). In limited instances, specifications in the FOP clarified and refined points in the Agreement. When spill operations commenced in April of 2019, the Technical Management Team (TMT) monitored, and in some cases modified, operations in real-time to account for unanticipated challenges with implementation. Examples of these in-season changes included spill at John Day Dam producing TDG levels that reduced the spill at the next downstream project (The Dalles Dam) below performance standard levels, and adult salmon passage impacts at Little Goose Dam. In instances where members of the TMT were not able to resolve the issue to the satisfaction of all parties, the FSWG met and advised on outcomes for the Corps to implement without requiring further dispute resolution.

After the 2019 spring spill operation concluded, the FSWG met again to discuss whether or not the three pillars of the Agreement were satisfied under the first and only year of flex spill operation, and to finalize the details of the 2020 operation based on the lessons learned from 2019.[1] All Parties agreed that actual results were within the modeled pre-season predictions for both powerhouse encounter rates[2] as well as power system generation. The Corps was able to successfully implement the operational requirements of the 2019 operation.

3.2 BASE OPERATION FOR INITIAL IMPLEMENTATION

In order to start and then adapt from a common reference point, a base operation for the first year of implementation of the flexible spill operation component of the preferred alternative from the CRSO EIS needs to be defined. Prior to the change in EIS schedule, the Agreement was intended to last three years. To be consistent with this intent and to define a base operation that can be adaptively managed in the future, the Action Agencies are planning to continue the 2020 Spring and Summer spill operations in 2021. Lessons learned from the 2020 operation could be used to refine the 2021 operation where warranted. These operations will also form the basis for any additional analysis of impacts and can serve as the basis for deriving future performance targets for power and fish. This approach will give the co-lead agencies time to coordinate with regional sovereigns on the development of scenarios and conduct additional analysis around potential future operations prior to the 2022 spill season.

[1] The future of the FSWG after the termination of the Agreement, is currently being evaluated. Options include the formal incorporation of the FSWG into the Regional Forum process or transitioning this function from the FSWG to the RIOG. Were the FSWG to continue, participation would be open to any Columbia River System sovereign that expresses a desire to participate.

[2] Powerhouse encounter rates based on PITPH metric.

Table 3-1. Planned 2020 spring spill operation, applying estimated 125% mean total dissolved gas (TDG) spill caps and performance standard spill operations at six projects ("125 flex"), applying estimated 120% mean TDG spill caps and performance standard spill ("120 flex") at John Day Dam (JDA), and 24 hour performance standard spill (40%) at The Dalles Dam (TDA).

Location	Estimated mean 125% Total Dissolved Gas Spill Cap (16 hours), with alternative operation at JDA and TDA.	Performance Standard Spill (8 hours).
Lower Granite (125 flex)	72 kcfs	20 kcfs
Little Goose (125 flex)	79 kcfs	30%
Lower Monumental (125 flex)	98 kcfs	30 kcfs
Ice Harbor (125 flex)	119 kcfs	30%
McNary (125 flex)	265 kcfs	48%
John Day (120 flex)	146 kcfs	32%
The Dalles (Performance Standard)	40%	40%
Bonneville (125 flex with 150 kcfs spill constraint)	150 kcfs	100 kcfs

Table 3-2. Planned summer spill operations for 2020.

Location	Initial Summer Spill Operation: Volume/Percent of Total Flow Routed to Spillway (June 21/16 – August 14)	Late Summer Transition Spill Operation: Volume/Percent of Total Flow Routed to Spillway (August 15 – August 31)
Lower Granite	18 kcfs	RSW or 7 kcfs
Little Goose	30%	ASW or 7 kcfs
Lower Monumental	17 kcfs	RSW or 7 kcfs
Ice Harbor	30%	RSW or 8.5 kcfs
McNary	57%	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	55 kcfs - includes 5k corner collector

CHAPTER 4 - OBJECTIVES, PRINCIPLES, AND PERFORMANCE TARGETS

The flex spill operation in the preferred alternative is designed to continue to meet the three pillar principles of power, fish benefits, and feasible operation of the Columbia River system. These pillars include performance targets assumed to result in neutral power revenue as compared to 2018 Court Ordered spill operations and continued power reliability, increased biological benefits to migratory salmon and steelhead, and safe operation of the 8 federal dams. These principles are all compatible with and directly support the overall objectives of the EIS, specifically:

4.1 THE FLEX SPILL FISH PRINCIPLE:

Provide fish benefits, with the understanding that (i) in 2019, overall juvenile fish benefits associated with dam and reservoir passage through the lower Snake and Columbia rivers during the spring fish passage season must be at least equal to 2018 spring fish passage spill operations ordered by the Court, and (ii) in 2020 and 2021[3], these fish benefits are improved further (as estimated through indices of improved smolt-to-adult returns, e.g., PITPH, reservoir reach survival, fish travel time);is directly related to Objectives 1, and 2 of the CRSO EIS:

- Improve ESA-listed anadromous salmonid juvenile fish rearing, passage, and survival;
- Improve ESA-listed anadromous salmonid adult fish migration

4.2 THE FLEX SPILL POWER PRINCIPLE:

Provide federal power system benefits as determined by Bonneville, with the understanding that Bonneville must, at a minimum, be no worse financially compared to the 2018 spring fish passage spill operations ordered by the Court; is directly related to Objective 5 of the CRSO EIS:

- Provide an adequate, efficient, economical and reliable power supply that supports the integrated CR Power System

4.3 AND THE FLEX SPILL IMPLEMENTATION PRINCIPLE:

- Provide operational feasibility for the Corps implementation that will allow the Corps to make appropriate modifications to planned spring fish passage spill operations is directly related to meeting the authorized project purposes consistent with the Purpose and Need statement
- Allows the CRS to be operated for the authorized purposes of the system, including flood risk management, navigation, irrigation, hydropower, fish and wildlife conservation, and recreation

[3] For the preferred alternative, the fish principle would be maintained such that fish benefits as defined and estimated above, would continue to be as good as or better than in 2020.

Also, given the longer term nature of these operations and acknowledging the uncertainties over how fish will respond to these operations, the Action Agencies are planning to add a fourth principle to the flex spill decision framework:

4.4 PRINCIPLE 4: EVALUATE THE EFFECTIVENESS OF THE SPILL OPERATION BY:

- Evaluate the extent to which further increases in spill lead to improved adult returns by reducing latent mortality
- Monitoring other interim metrics to evaluate progress and avoid unintended consequences
- Evaluating the impacts to power revenues and rates

For Principle 4 to be achieved, the operation will need to be accompanied by a robust study design that can provide statistically meaningful results within a reasonable management timeframe. The analysis of future scenarios and the adaptive implementation of future operations will need to consider and achieve all four principles to provide an optimized outcome that supports improved SARs for fish, affordable and reliable power, feasible implementation, and the ability to discern if the operation is having a measurable benefit.

Over time, the adaptive implementation framework will incorporate new information and aid in optimizing Columbia River System operations to meet all four principles. While power related performance targets will be initially measured as relative to the 2018 spill operation, the results of the 2020 operations will help future operations. Likewise, because it will be an adaptively implemented operation that, to-date, has only been modeled to predict outcomes, the biological metrics evaluated in 2020 will also likely provide a basis for defining biological performance targets during future spill operations.

Power, fish, and operation metrics will be evaluated to ensure that spill operations are meeting the four principles and that operations are not resulting in negative impacts. The last decade of monitoring the effects of operations under the current configuration of the projects (since approximately 2010) will provide a reference point for evaluation. Power performance metrics will focus on revenue targets and reliability.

Biological performance metrics will be managed for annual targets (e.g., survival, travel time and gas bubble trauma (GBT)) of migrating salmonids through the Columbia River System, and modeled powerhouse encounter rates (PITPH[4]). Where information specific to bull trout is available, it will be incorporated into assessments of both biological performance as well as monitoring for unintended consequences (e.g. adult passage through fish ladders). Where bull trout specific data is not available, surrogate species (i.e. steelhead or Chinook salmon) may be considered if appropriate.

[4] The calculated probability, based on Passive Integrated Transponder (PIT) tag detections, that a juvenile fish will pass through up to 8 powerhouse routes or associated bypass systems on its outmigration, given operations and water flows.

While many factors that influence adult returns are generally outside of the direct influence of the federal agencies, this operation is explicitly designed to test and monitor the magnitude of the effect of passage through the CRS by using long-term performance targets (e.g., smolt-to-adult return (SARs) ratios measured by the return of adult salmon in the years to follow the initiation of this operation). Many different factors may contribute to uncertainty during implementation, including annual flow levels that will define how much water can be spilled; the natural variability of TDG; and ocean conditions experienced after juvenile fish have left the CRS. Additional biological monitoring of salmonids, non-salmonid fish, and water quality will be conducted to identify and resolve unintended consequences.

An operational feasibility assessment will be developed, monitored, and managed by the Corps and is anticipated to include dam safety/erosion and navigation. These indicators will be informed by past spill operations including the 2018 injunction spill and the first year of flexible spill operations in 2019.

4.5 POWER SYSTEM PERFORMANCE TARGETS

- Bonneville revenue target (neutral or positive compared to 2018 baseline)
  - Annual power sales
  - Rate impacts (Tier 1 System Firm Critical output)
  - Annual Fish and Wildlife Program budgets
- Power and Transmission reliability
  - Regional Loss of Load Probability

4.6 DRAFT BIOLOGICAL PERFORMANCE TARGETS TO BE REFINED DURING STUDY DESIGN DEVELOPMENT

- Salmonid Targets
  - In-river survival
    - (placeholder for actual metrics - TBD)
      - Snake River spring Chinook (2009-2018 averages)
        - Lower Granite - Bonneville: 53%
        - Lower Granite-McNary: 76%
        - McNary-Bonneville: 70%
      - Snake River Steelhead (2009-2018 averages)
        - Lower Granite – Bonneville: 57%
        - Lower Granite - McNary: 73%
        - McNary - Bonneville: 78%

- Travel time
  - Juvenile downstream travel time (placeholder for actual metric - TBD)
  - Adult upstream migration time (placeholder for actual metric - TBD)
- Powerhouse Encounter Rates (PITPH)
  - Snake River Yearling Chinook: Avg. of 1.4
    - (should not exceed 2.0 on any year of the flexible spill operation)
  - Snake River Steelhead: Avg. of 1.3
    - (should not exceed 2.0 on any year of the flexible spill operation)
- Smolt to Adult Return Ratios (SARs)
  - (placeholder for actual metric - TBD)
  - Adult conversion rates

- **Non-salmonids** (monitor and evaluate for unintended consequences)
- **Water Quality** (monitor and evaluate)

4.7 OPERATIONAL PERFORMANCE TARGETS (TBD)

- Dam safety/erosion
- Navigation

If, as actual experience implementing the base operation develops each year, and if changes to the base operation were found to be required to meet any of the objectives and performance targets listed above, potential options for modification could include: changes to spill levels at individual dams; changes in dates to either start, stop, or reduce spill; daily duration of spill cap operations; or other reservoir related changes. The process to determine the necessity that would drive these types of alterations and the efficacy of those changes would be the focus of the adaptive implementation framework stepwise process detailed in this appendix.

CHAPTER 5 - DECISION MAKING, ACTION AGENCY AUTHORITY, AND THE REGIONAL FORUM

The RIOG was established following the 2008 Biological Opinion to provide a high-level policy forum for discussion and coordination of CRS management. The overall purpose of the group remains to inform the federal, state and tribal agencies that are actively engaged in salmon recovery efforts regarding implementation issues from each sovereign's perspective. The Technical Management Team (TMT) is the interagency technical group responsible for making recommendations on dam and reservoir operations for implementation of the CRS BiOps. It is anticipated that both the RIOG and TMT will continue under the current CRS BiOps.

The RIOG is a forum for interagency coordination and does not supplant existing federal, state or tribal decision making authorities. All decisions under the authority of the federal government continue to be made by the appropriate federal agency with the statutory authority to make such decisions. As it applies to the flexible spill operations contemplated in this framework, the federal Action Agencies retain final decision making authority related to operations of the dams while taking into account the perspectives of members of the FSWG.

Technical teams, such as TMT, make a reasonable effort to resolve proposals within the team, and allow issues to be fully developed. When policy guidance is needed or if there is a dispute at technical teams, the issues are brought to the RIOG through the RIOG Chair. If a team is unable to reach resolution, the members will frame the issue using the RIOG Policy Issues template.

In the context of flex spill in 2020, the Parties to the Agreement agreed to implement a modified understanding, consistent with the terms of the Agreement and as noted through this adaptive implementation framework, existing Regional Forums (e.g. TMT) will evaluate the need for in-season operational changes. However, if any party that is a signatory to the Agreement objects to an in-season adaptive management operational change coordinated at the adaptive management forums that impacts implementation of the Agreement and that objection requires elevation, elevation of that objection will first be brought to the FSWG by the party objecting for an opportunity to resolve the objection before elevation to RIOG. The FSWG, at a minimum, includes a representative from each signatory to the Agreement.

As mentioned above, the future of the FSWG, after the termination of the Agreement, is currently being evaluated. Options include the formal adoption of the FSWG as an official group in the Regional Forum process or the integration of the FSWG function into the RIOG and the dissolution of the FSWG as separate group. Were we continue to use the FSWG after the expiration of the Agreement, the forum would be open to any interested CRS sovereign that requests to be included.

CHAPTER 6 - ADAPTIVE IMPLEMENTATION FRAMEWORK

This framework is based on existing adaptive management models that have been used by other federal agencies. The specifics of this particular framework have been adapted to the existing Regional Forum processes that have been utilized in the CRS over the past decade but also include some revisions in order to acknowledge the effectiveness of recent collaborative processes that led to the Flex Spill Agreement. Through this framework, the Action Agencies are committing to a transparent and scientifically robust adaptive management process that incorporates knowledge to date, as well as new information as it becomes available.

The FSWG/RIOG role in implementation of the flexible spill operation component of the selected alternative is outlined for each step of the process below. Opportunities for input are confined by the sideboards of the selected alternative, as outlined in Record of Decision (ROD), and consistent with the Endangered Species Act consultations associated with the CRSO EIS. Further, the Action Agencies retain the authority to make final decisions related to actual project operations planned and completed consistent with the FEIS/ROD. However, if at any time a FSWG/RIOG member has a specific question or concern related to any aspect of flex spill implementation, the appropriate Action Agency will respond to that input to the extent practicable and will provide feedback on how the member's concerns were addressed.

The adaptive implementation steps will cover pre-season operations planning; post-implementation review; annual monitoring, evaluation, and new science integration; and annual management review with the Action Agency policy team.

Flexible spill operations that will occur after the FEIS/ROD will take several years to pass through all the phases of implementation. Therefore, at any given time there will be several brood year cohorts of salmon and steelhead that have passed through different steps of implementation and monitoring. Evaluating the effects of flex spill on these fish will require both annual and longer term evaluations as described in the steps below.

Initially consult the FEIS/ROD for direction on operational priorities and formally develop a study design to determine the effectiveness of the selected spill operation.

(Prior to year 1 Implementation)

The alternative selected for implementation in the FEIS/ROD reflects comprehensive public participation and collaborative efforts conducted between 2016 and 2020. The public had opportunities to influence all elements of these documents.

In coordination with sovereign parties with interests in CRS spill operations, the FSWG/RIOG will design a long-term study plan to assess the impacts of high spill on latent mortality on Columbia and Snake River salmon and steelhead. The study will need to address the following criteria:

- Statistically meaningful results
- Within a reasonable timeframe
- While providing safe fish passage

This initial step would not be an annual exercise, but a one-time effort that would be managed under the provisions in this appendix. Products of this process are envisioned to include clearly defined targets with stakeholder buy-in. Clearly defined expectations for the duration of the study/monitoring program, off-ramps if unintended affects are observed that preclude continuation of initial operation, and alternate operations should the initial effort become untenable.

FSWG/RIOG Opportunities:

- Become knowledgeable with the implementation parameters of the FEIS/ROD to develop an understanding of these limits and requirements and enhance ability to more meaningfully participate in implementation and adaptive management;
- Participate in the development of spill operation monitoring strategy and ISAB review;
- Operational implementation needs outside of the FEIS/ROD would need to be addressed under separate planning efforts.
  - Step 1) Complete annual erosion/dam safety surveys of mainstem fish passage projects. (Annually – typically late summer to late fall)
  - Step 2) Conduct a pre-season study design and monitoring workshop with FSWG/RIOG, implementation, and science teams. (Annually – typically January or February)
  - Step 3) Assess any proposed study design changes within the CRS mainstem fish passage project area. (Annually – post off season workshop sponsored by Action Agencies)
  - Step 4) Action Agencies prepare Fish Operations Plan (FOP) and implementation instructions, including applicable study design features, project specific guidance, and monitoring requirements. (Annually – Action Agencies complete by early to mid-March)
  - Step 5) Provide opportunity to comment on updated operational plans and schedule to regional sovereign parties through RIOG. (Annually – Complete by mid to late-March)
  - Step 6) Action Agencies implement the spill operation including administration and dispute resolution through the Regional Forum processes. (Annually – April through August)
  - Step 7) Complete annual monitoring as specified in the scientifically developed study plans. (Annually – April through August concurrent with spill operation)
  - Step 8) Conduct formal post-season review. (Annually-- after monitoring results are available)
  - Step 9) Complete management review by the Action Agency leadership team (Executives and/or Deputies). (Annually)
  - Step 10) Publish annual report of implementation activities, stakeholder participation, and management review findings. (Annually)

Comprehensive Review – conducted every 3-5 years to review long term efficacy and assess accuracy of initial assumptions.

CHAPTER 7 - SUMMARY

This adaptive management and monitoring framework is intended to set up the initial steps in the development of a strategy to develop, implement, and monitor spill operations through coordination with sovereign parties with the goal of assessing the magnitude of latent mortality associated with juvenile salmonid passage through the CRS projects on the lower Snake and lower Columbia Rivers. The intent is, without ceding the decision making authorities of each Action Agency, to develop a transparent, collaborative process where regional experts will work with the Action Agencies to develop and monitor an operation that yields scientifically robust information to inform the efficacy of the CRSO EIS preferred alternative and proposed action from the consultations associated with the EIS. By following this adaptive implementation and monitoring framework, the Action Agencies will be able to collaborate with the regional experts, while maintaining the ability to adapt to new information and respond to unanticipated outcomes or challenges that may arise as a result of testing the magnitude of latent mortality.

CHAPTER 8 - REFERENCES

National Research Council. 2004. Adaptive Management for Water Resources Planning, The National Academies Press. Washington, DC

Williams, B. K., and E. D. Brown. 2012. Adaptive Management: The U.S. Department of the Interior Applications Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC. 120 pp.

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Columbia River System Operations
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Appendix R, Mitigation, Monitoring, and Adaptive Management
Part 3, Mitigation Process

CHAPTER 1 - INTRODUCTION

Mitigation was only developed for adverse impacts; if an action resulted in negligible effects or the effect was beneficial, then no additional mitigation was proposed. For resources with minor effects, the co-lead agencies generally practice avoidance where practical through operations and implement BMPs, but did not propose taking additional mitigation actions. For purposes of meeting compliance with different federal laws, regulations, and EOs, the co-lead agencies have proposed mitigation measures, where appropriate, even if effects are minor, such as for wetland impacts. Conversely, if a proposed operational or structural measure would result in a moderate or major impact to any resource, then a range of mitigation measures were developed to address the impacted resource or resources. To differentiate among minor, moderate, and major effects as described in Section 3.1, the effect descriptors were used to evaluate the intensity of the impact in relation to significance (see 40 C.F.R. § 1508.27). The rationale for why an effect is considered to fall under one of the preceding intensity descriptors is included in each resource section and summarized in Chapter 3.

The full suite of proposed mitigation measures were assessed based on five criteria developed by the co-leads with cooperating agencies input, which helped to identify the likelihood that a measure would be adopted by the co-lead agencies:

Category type: in-kind and in-place mitigation measures were preferred over out-of-kind or out-of-place measures.

Effectiveness: a qualitative assessment of the mitigation measure’s effectiveness in reducing the impact from the alternative.

Scale: a qualitative assessment of the spatial (i.e., site-specific or regional) and temporal scale (i.e., short-term or long-term, seasonal or annual, or temporary or permanent) of the mitigation measure relative to the severity and duration of the impact.

Feasibility: a qualitative assessment of the feasibility of implementing a measure based on technical and economic factors. For example, a mitigation measure may not be feasible if there are other technical actions that would effectively reduce the severity or duration of impact. Similarly, if the expense of implementing a measure would be unreasonable, then the measure would not be feasible.

Jurisdiction: an assessment of the co-lead agencies’ jurisdiction or authority to implement the measures

CHAPTER 2 - MITIGATION SELECTION PROCESS

The co-lead agencies developed mitigation measures using actions suggested during the public scoping period and by technical teams. These preliminary mitigation measures were further refined, compared, and then vetted through a robust selection process. The process started with the co-lead agencies, using input from cooperating agencies on the technical teams, as they considered potential mitigation measures. In April 2019, the technical leads were provided with instructions to prepare for the June 2019 mitigation workshop, including guidelines for the first task. This first task was to review the list of potential mitigation measures to assess and add or delete measures with justification. The technical leads worked with their teams as appropriate based on expertise. This list of possible mitigation measures was a compilation of brainstormed input from multiple sources including scoping comments and workshops. Refer to Annex A for Mitigation Toolbox Instructions and April Mitigation Toolbox.

In May 2019, the next step in the mitigation process was to populate an Impact Summary spreadsheet. The technical leads were provided the template Impact Summary spreadsheet and instructions for how to populate it in preparation for the June 2019 mitigation workshop. Refer to Annex B for Strategy for Mitigation Workshop Preparation instructions, Fish Team - Strategy for Mitigation Workshop Preparation instructions, and Template Impact Summary spreadsheet.

Prior to the June 2019 mitigation workshop, the technical teams worked on identifying which mitigation measures from the June Mitigation Toolbox, with rationale, could be applied to offset known effects to their resource of expertise. The June Mitigation Toolbox includes the potential mitigation measures resulting from the refinement of the completed April Mitigation Toolbox task. The refinement was a step by step process of filtering for duplications, technical feasibility, definition of mitigation as defined in §1508.20, and completed mitigation measures. Refer to Annex C for June Mitigation Toolbox.

In June 2019, the technical leads attended the mitigation workshop in Portland, OR. The purpose of the workshop was to review the effects to resources from each of the 4 multiple objective alternatives (MO1-4) and assign appropriate mitigation measures to address those effects. The outcomes of this effort were the completed Impact Summary spreadsheets (refer to Annex D).

The potential mitigation measure identified in the Impact Summary spreadsheets were further screened using the decision framework (described above) to identify if mitigation was warranted based on the adverse effects of implementing a measure in the MOs, and an evaluation of the severity of the impact on a resource. The areas of analysis were divided into four regions (regions A, B, C, D), which correspond to the regions identified in Chapter 3, to assess regional and localized impacts. During the last round of the selection process, those screened mitigation measures were matched to adverse effects based on their ability to reduce specific effects, based upon a refined, and more comprehensive effects analysis. At this stage, the mitigation measures were further developed, refined, and screened, which resulted in the proposed mitigation as shown in Section 5.3. Annex E presents the proposed mitigation measures for each MO from the outcome of the mitigation workshop and further screened as more information and analysis become available.

Draft Columbia River System Operations
Environmental Impact Statement

Appendix R, Mitigation, Monitoring and Adaptive Management
Part 3, Mitigation Process

Annex A
Mitigation Toolbox Instruction April 2019
April Mitigation Toolbox

CHAPTER 1 - MITIGATION TOOLBOX INSTRUCTION APRIL 2019

1.1 CRSO MITIGATION EFFORT OVERVIEW

Background: In preparation for consideration of potential mitigation needs associated with each of the 4 action alternatives (MO1-4), a list of possible mitigation measures is being compiled and will be referred to as the "mitigation toolbox" for use during the June 2019 Mitigation Workshop. The attached list is a compilation of brainstormed input from multiple sources including scoping comments and workshops. Final selection of the mitigation measures within the Draft EIS will be determined by the co-lead agencies.

Tech Team Task 1: Review the attached list of potential mitigation measures with appropriate team members to assess and add or delete measures with justification. The Tech Lead will provide a single, compiled mitigation toolbox spreadsheet to Hannah Hadley by COB April 22nd.

Tech Team Task 2: Identify which measures, with rationale, could be applied to offset known impacts to their resource of expertise. This prep work is intended to increase the efficiency of group discussion during the Mitigation Workshop.

Mitigation Workshop Product: The purpose of this workshop is to evaluate the impacts to resources from each of the 4 action alternatives (MO1-4) and assign appropriate mitigation measures to offset those impacts. Workshop attendance will be limited to Technical Leads.

1.2 TECH TEAM TASK 1 INSTRUCTIONS

Toolbox Input Duration: April 8 – 22, 2019

Tech Lead Role: Disseminate the draft mitigation toolbox to technical team members of your choice, which may be the entire team or subset inclusive of Cooperating Agency team members, as appropriate based upon expertise. The Tech Lead will provide a single, compiled mitigation toolbox spreadsheet to Hannah Hadley by COB April 22nd. Hannah will disseminate all Tech Teams' spreadsheets to the NEPA Team for compilation and further refinement with Policy and ESA Teams prior to Task 2.

Task 1 Instructions: Review the draft list of potential mitigation measures. For measures the technical team advises to be removed from consideration, use strikeout in the measure cell and provide rationale for removal (e.g. previously studied and determined not feasible/effective, etc). For new measures to be added, please briefly note which anticipated resource impact the measure is intended to offset. Purpose of brief note on impact to be offset is to both aid next-step refinement of the mitigation toolbox and to aid Task 2. Tech Leads: please guide your teams to focus on developing the list of potential measures and not yet on assigning the proposed mitigation measures to impact types/locations, which is Task 2.

1.3 TECH TEAM TASK 2 INSTRUCTIONS

Pre-Mitigation Workshop Brainstorm Duration: May 22 – June 21, 2019

Tech Lead Role: Disseminate the final mitigation toolbox to technical team members of your choice, which may be the entire team or subset inclusive of Cooperating Agency team members, as appropriate based upon expertise. The Tech Lead will bring compiled team notes to the Mitigation Workshop.

Task 2 Instructions: Determine which measures from the final mitigation toolbox are recommended in specified locations to offset impacts to your respective resource of expertise (e.g. anadromous fish, water supply, etc). Indicate what the anticipated impacts are and provide details of the mitigation measure such as location, duration, and structural or operational implementation details. Goal is for each technical team to provide the information Tech Leads will need to bring to the Mitigation Workshop.

These Task 2 Instructions are preliminary to guide planning of next steps. Refined instructions will be provided with the final mitigation measure toolbox.

1.4 APRIL MITIGATION TOOLBOX

1.4.1 Water Quality

Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
Implement a more flexible water management strategy during low flow years to preserve water in storage projects for release during summer to cool downstream water temperatures	–	–	–
Operate run-of-river projects that stratify (e.g., LSR projects) to pass cooler water from deeper in the forebay to cool downstream temperatures during warm/low flow conditions.	–	–	–
Minimize reservoir drawdown throughout the basin	–	–	–
Decreasing/stopping spill (stop voluntary spill)	–	–	–
Implement TDG reduction measures at GCD (flip lip, other)	–	–	–
Additional flow deflectors for TDG	–	–	–
Improve (lower) water temperatures (in summer) through additional selective withdrawal at storage projects that stratify	–	–	–
Change seasonal/monthly turbine operations/priorities to change temperature mixing for cooling	–	–	–
Install Submerged outlets below spillbay flow deflectors to reduce TDG	–	–	–
Reconfigure stilling basins (project specific) to higher elevation/less depth for plunging flows to limit TDG	–	–	–

1.4.2 Fish

types of species	Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
–	Alter spill (change timing, duration, frequency)	–	–	–
–	Spill outside fish passage season	–	–	–
–	Optimize dam flows for White Sturgeon spawning and early life stage survival	–	–	–
–	Reduce load following limited to +/- 5% on the big 10	–	–	Operations for peaking at Lower Snake and Lower Columbia plus CHJ and GCL.
–	Ops for temp	–	–	–
–	Change turbine operations to change temperature	–	–	–

types of species	Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
–	Change FRM to make more water available to fish (relax rule curves ; go towards normative hydrograph)	–	–	–
–	Dry year strategy where we have additional reservoir draft in dry years and load management strategies in dry years	–	–	–
–	Modify flow by reducing irrigation to increase flow (reallocation)	–	–	–
–	Mimic natural hydrograph (ops) (including in the estuary)	–	–	–
–	Fish ladders/passage (add or improve)	–	–	Bull trout at Albeni Falls. No Action. Implemented through another program
–	Maintain less than 1 degree celsius differential (fish ladders)	–	–	–
–	cooling water pumped through fish ladder as an attractent	–	–	–
–	Intake fish screens	–	–	–
–	Spill Increase to maximize SPE (shouldn't change hydrograph) to improve juvenile fish passage	–	–	–
–	Stop all Spillway spill to improve adult fish passage	–	–	year-round
–	Selective spillway bay use (which gates lift)	–	–	–
–	re-design spillway to mimic normal step-pool/waterfall elevations. Look at stepped spillway (MSH SRS?)	–	–	–
–	Reintroduction - passage at dams	–	–	Duplicate of Fish ladders/passage (add or improve)
–	Environmental flow (intentional overbank)	–	–	Both in fish and wetlands
–	Albeni Falls stop Flexible Winter Power Ops for resident fish	–	–	–
–	Albeni Falls expand FWPO for chum	–	–	–
–	Outlet exclusion	–	–	–
–	Selective outlet withdrawal for D/s temp	–	–	–
–	Max transport no spill	–	–	–
–	Balance optimize transport for all salmon/steelhead	–	–	–
–	No transport of juvenile fish	–	–	–
–	Re-design bypass to allow for microtopography and macroinvertebrate populations. Look at more of an oxbow type design.	–	–	–

types of species	Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
–	Cease using juvenile bypass facilities	–	–	–
–	Re-design nav locks to allow for microtopography and macroinvertebrate populations, riffles and pools or to allow them to remain open during low boat traffic times (i.e. remove the navigational lock sill). #3 = breach?	–	–	–
–	Allow for periodic flow through locks to maximize flow rates	–	–	–
–	Additional flow deflectors for TDG	–	–	–
–	Close spillway weir(s) and other high-TDG routes (corner collector at BON, sluiceway at BON, TDA).	–	–	–
–	Managing for stable reservoir elevation (promote wetlands and grow riparian vegetation on shorelines)	–	–	Both in fish and wetlands
–	maximize storage of cold water at DWA, LIB and CJO	–	–	–
–	minimize pool level variability	–	–	–
–	Decrease the draft rates	–	–	–
–	Partial breach combined with Bypass channel to mimic natural river (including resting pools)	–	–	–
–	Reduce the amount of water level fluctuations in dam tailraces due to load following (for sturgeon this would be directed to early life stage development time)	–	–	–
–	Implement "slow-roll" procedures for all turbine start-ups to reduce fish mortality	–	–	–
–	Increase spillways	–	–	–
–	Pull one turbine from each dam (effectively, increase spill)	–	–	–
–	At columbia falls, increase minimum flow in high water years to 5000 cfs and adjust linearly down to 3,200 cfs in the driest water years to benefit bull trout and other native fish species	–	–	–
–	[At hungry Horse] maintain lowered winter flows in years following high spring runoff to aid in the establishment of riparian vegetation with positive benefits to both aquatic and terrestrial communities.	–	–	Needs more development. Impact analysis for Bull Trout FMO?
–	Add biomimicry heat exchangers to tops of fish ladders	–	–	–
–	Use "Woosh!" - this is a technology, doesn't specify in what situation	–	–	Assume for reintroduction Coulee & DWA

types of species	Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
–	Add bubble curtains to dams to aid fish entering ladders and exclude predators - excluding predators = predation management theme below	–	–	–
–	Increase liklihood of refill at storage projects that provide downstream water temperature mangement	–	–	–
–	Increase shoreline vegetation for habitat and shading	–	–	Managing reservoir elevation (promote wetlands and grow riparian vegetation on shorelines)
–	Increase use of spillway Weirs at projects	–	–	this is a technical analysis, but more spillway weirs would increase eddies and reduce spill volume through higher TDG production
–	Relax storage reservation diagram at 6 FRM projects	–	–	–
–	Deeper (existing) storage reservation diagrams to reduce FRM	–	–	–
–	Investigate development of guide\ curves to avoid situations where heavy spill has to occur in the spring to meet FRM requirements. Concept would be to have a guide curve that is forecast based (to only be used in high water supply situations) to allow for earlier draft than the current SRDs.	–	–	–
–	Increase discharge capability at Libby Dam for sturgeon flow with addition of 6th turbine	–	–	–
–	Implement TDG reduction measures at GCD (flip lip, other)	–	–	Already studied
–	Reduce impoundments, stream restoration to reduce impacts to stream channels	–	–	–
–	Create riffle pool complex within the reservoirs.	–	–	–
–	Increase hatchery production for steelhead	–	–	–
–	Add/increase spawning gravel	–	–	–
–	Add pheromones/"scents" to suitable spawning tributaries	–	–	–
–	Eliminate mainstem harvest	–	–	–
–	Allow only terminal harvest	–	–	–
–	Eliminate gill nets and allow harvest at fish ladders via trap	–	–	–

types of species	Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
–	Reduce harvest of Listed Fish	–	–	–
–	Stop Harvest of listed fish	–	–	–
–	Develop additional shallow water rearing habitat (e.g., for fall chinook in the lower snake river)	–	–	–
–	Build an alternate channel around the dams	–	–	–
Adult Salmon and Steelhead	–	–	–	–
–	Spill proportional to juvenile numbers. Minimizes TDG and spill effects on adult passage	–	–	–
–	Stop spill in August; Minimizes TDG and spill effects on adult passage	–	–	–
–	Change seasonal/monthly turbine operations/priorities to change temperature mixing for cooling	–	–	–
–	Modify existing adult trap configurations and use to reduce handling stress	–	–	–
–	Reduce passage of non-native species through selective modification of ladders (e.g., American shad)	–	–	–
–	Alter Transport to decrease straying of adult migrants	–	–	–
–	Maintain estuary water levels that promote fish passage - unclear; passage into rearing tributaries below BON?	–	–	–
–	Modify DWA spillway to reduce TDG levels during spill	–	–	–
–	Restore passage to North Fork Clear Water River (aka passage at Dworshak)	–	–	–
–	Truncate DWA Drawdown	–	–	–
–	Improve adult ladder passage through modification of adult trap and adult trap bypass loop (potential for structural and operational changes)	–	–	–
Juvenile Salmon and Steelhead	–	–	–	–
–	Reduce fish handling at Little Goose JFF	–	–	–

types of species	Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
–	Reduce flow augmentation (CSS)	–	–	–
–	Build Juvenile Bypass Structure Upgrade Phase 2 to improve fish handling for Smolt Monitoring Program and transportation program	–	–	–
–	Develop additional shallow water habitat throughout the length of the reservoir; reduce available holding habitat for fish predators in conjunction (e.g., convert rip rap areas to shallow water habitat)	–	–	–
–	Reduce fish handling at Lower Monumental JFF	–	–	–
–	Develop additional shallow water rearing habitat at McNary Pool	–	–	–
–	Progressive Spill: to better mimic the natural hydrograph: percent spill increases as inflow increases (ie Snake River- 20% spill up to 40 kcfs inflow rising to 50% spill at 100 kcfs inflow…)	–	–	–
–	Install Submerged outlets below spillbay flow deflectors to reduce TDG	–	–	–
–	Reconfigure stilling basins (project specific) to higher elevation/less depth for plunging flows to limit TDG	–	–	–
–	Install deterents to fish entrance of draft tubes when not in operation	–	–	–
–	Pull Screens where turbine survival is high	–	–	–
–	Reduce fish handling at bypass locations	–	–	–
–	Improve (survival, reliability, operational ease, etc) JBS facilities at locations where JBS's will likely continue to be operated (for SMP, due to low turbine survival, transport program objectives, etc)	–	–	–
–	Alter Transport to focus on when there is demonstrable benefit to smolt survival	–	–	Mitigation
–	Establish an annual four-month "normal pool" period on Lake Pend Oreille (Memorial Day to October 1) and a higher winter lake level	–	–	–
–	Restore mainstem habitat through increased habitat complexity (rapid, riffle, run, pool), shallow water rearing habitat connectivity, temperature reduction, riparian function restoration, restore ecosystem processes	–	–	–
–	Reconnect mainstem and offchannel habitats	–	–	–
–	Maintain water levels that promote fish passage and access to habitat	–	–	–
–	Develop adult trap and haul facility at Ice Harbor to improve research/monitoring & truck/haul capabilities (e.g., for emergency sockeye truck & haul in hot water years)	–	–	–

types of species	Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
Resident Fish (Bull Trout, Sturgeon, Kokanee)	–	–	–	–
–	Increase Access to fish habitat and the tributaries	–	–	–
–	Minimize reservoir fluctuations	–	–	–
–	Manage reservoir levels to protect spawning areas	–	–	–
–	Improve natural and “normative” flows to improve salmon life stages	–	–	–
–	Install deterents to reduce fish entering draft tubes when not in operation	–	–	–
–	Activate fish lifts to move Sturgeon - where feasible (BON)	–	–	–
–	Catch and transport adult sturgeon (BON)	–	–	–
–	Increase Selective Withdrawal Gate temperature management flexibility (enable capability to provide a normative river thermograph)	–	–	–
–	Limit use of spillway to avoid bull trout entrainment at Libby	–	–	–
–	Minimize drawdown of storage reservoirs for resident fish lifestage production	–	–	–
–	Mitigate for White Sturgeon population losses due to dam impacts	–	–	–
–	Use White Sturgeon conservation aquaculture to mitigate for population losses due to the hydrosystem	–	–	–
–	Use screening technology to preclude White Sturgeon from entering draft tubes	–	–	–
–	Decrease White Sturgeon habitat fragmentation through dam passage improvements and/or dam removal	–	–	–
–	Improve White Sturgeon populations in the impounded river sections by improving flow conditions	–	–	–
–	Provision of volitional passage for White Sturgeon if reasonable and feasible means are developed	–	–	–
–	Reduce the amount of water level fluctuations in dam tailraces due to load following (for sturgeon this would be directed to early life stage development time)	–	–	–

types of species	Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
Piscivore Control	–	–	–	–
–	Draw Down John Day	–	–	–
–	continue to use spray deterrents and antideterrant measures	–	–	–
–	Minimize predation	–	–	–
–	expand wire arrays	–	–	–
–	Minimize predation on adult White Sturgeon by pinnipeds	–	–	–
–	Minimize predation of early life stages of White Sturgeon	–	–	–
–	Maintain high water flows with minimal river islands/decrease island habitat (island use by pinnipeds)	–	–	–
–	Increase harvest of invasive fish	–	–	–
–	Install deterents to minize predatory fish holding near intakes (e.g., around trash racks) and exits	–	–	–
–	Reduce predatory fish habitat through reduction of off chanel habitat, non-natural structures (e.g., removal/modification of large riprap structurs, pile dikes, in-water structures, etc), flow/velocities changes (reduce spawning, recruitment, etc)	–	–	–
–	Install wire array to dissuade piscivorous waterbirds at McNary	–	–	–
–	Remove non-native species and piscine predators passing through/residing in Juvenile Bypass Structure - predation management	–	–	–
–	Manage water levels/flows to reduce spawning habitat and recruitment success of non-native fish species at locations such as Yakima & Walla Walla River delta's	–	–	–
–	Manage avian nesting habitat to reduce predation losses to avian predators - predation management	–	–	–
–	Conduct predatory fish removal throughout each of the reservoirs with emphasis on hotspots - predation management	–	–	–
–	Reduce predatory fish through reductions in spawning, rearing, foraging abilities - predation management	–	–	–
–	A bounty system for small mouth bass and walleyed pike would be effective (similar to Northern Pike Minnow program) - excluding predators	–	–	–

types of species	Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
Lamprey	–	–	–	–
–	Reduce hydrosystem effects on distribution and escapement of adult lamprey spawning	–	–	–
–	Modify project operations to allow larval lamprey (ammocoetes) in shallow water rearing areas to safely move to deeper water as water surface elevation drops.	–	–	–
–	Modify spill operations to improve passage and survival of juvenile lamprey (through all routes) during pulses of outmigration (freshets).	–	–	–

1.4.3 Vegetation, Wetlands, and Wildlife

Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
Acquisition/deacquisition of Corps managed lands to ameliorate changes in wildlife habitat and recreational useage (coordinate HMUs with USFWS)	–	–	–
Environmental flow (intentional overbank)	–	–	in both fish and wetlands
Managing for stable reservoir elevation (promote wetlands and grow riparian vegetation on shorelines)	–	–	in both fish and wetlands
Increase shoreline vegetation for habitat and shading	–	–	in both fish and wetlands
Prevention measures must be identified, assessed and implemented to stop the invasion and spread of zebra and quagga mussels, and invasive aquatic plants such as Eurasian mi/foil, hydrilla, and flowering rush. These measures should include, but are not limited to, education and public outreach efforts to promote awareness of the potential impacts and costs of a successful invasion, and the potential solution provided by required inspection, detection, and decontamination of boats previously moored in infested waters and then transported on our roadways in the region	–	–	–

1.4.4 Power and Transmission

Draft Mitigation Measure: **if delete, please use strike through**	**Reason to add or delete?**	**Citations**	**Notes**
Decreasing/stopping spill (stop voluntary spill)	–	–	–
add RSWs or TSWs to reduce need for other spill	–	–	Evaluation: water temperature considerations
Increase capacity	–	–	redundant to adding turbines, improving turbine efficiency, raise head at projects (all already on list here)
More flexibility on seasonal, daily hourly flow	–	–	–
reduce restrictions on seasonal pool elevations	–	–	LSN-MOP, JDA-MIP
expand range of operating pools, esp at LCOL and LSN	–	–	Maybe at JDA? Probably not anywhere else. do not surcharge due to dam safety
fewer restrictions on ramping rates	–	–	Beneficial to generation if allowed to ramp down much faster than rates. Some restrictions for bank sloughing need to stay - earthen embankment projects (don't ramp @ rate to slough)
Store more in spring, optimize hydrograph to the annual energy cycle (store more in the spring)	–	–	subject to FRM
Rehabilitate turbines	–	–	Economically feasible units are already going to be rehabed. Waiting for $/limited in # at a time (year)
Index test all units to optimize current turbine operations	–	–	–
Use all turbine bays (ie. add turbines)	–	–	Economically feasible units are already going to be rehabed. Waiting for $/limited in # at a time (year)
Additional turbines at Dworshak, Libby, for resident fish, TDG abatement/management	–	–	Economically feasible units are already going to be rehabed. Waiting for $/limited in # at a time (year)
spill could be better managed to take advantage of power production during periods of time when insufficient numbers of smolts are migrating – both at the beginning and tail end of the runs; spill program is based on fish abundance rather than hard dates	–	–	–
Integrate renewable energy on breached structures	–	–	–
Reliability (keep loss-of-load within Council's standards) - could include keeping relability despite other actions that might	–	–	–

Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
reduce reliability such as removing dams or constraining operations -- could include keeping relability despite climate change			
Develop alternative energy sources (non-hydropower)	–	–	–
Install low head high efficiency turbines in earthen fill sections of existing dams (or hydro-combine)	–	–	–
Increase probability of refill	–	–	–

1.4.5 Air Quality and Greenhouse Gases

Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
The EPA supports incorporating mitigation strategies to minimize fugitive dust and toxic emissions, as well as emission controls for particulate matter (PM) and ozone precursors for construction-related activity. We recommend that best management practices, all applicable requirements under local or State rules, and the following additional measures be incorporated into the EIS, a Construction Emissions Mitigation Plan, and ultimately the Record of Decision. See EPA's Clean Construction USA website for additional information [http://www.epa.gov/cleandlesel/sector-programs/construct-overvlew.htm].	–	–	–
Identify all commitments to reduce construction emissions and incorporate these reductions into the air quality analysis to reflect additional air quality improvements that would result from adopting specific air quality measures. Prepare an inventory of all equipment prior to construction, and identify the suitability of add-on emission controls for each piece of equipment before groundbreaking. (Suitability of control devices is based on: whether there is reduced normal availability of the construction equipment due to increased downtime and/or power output, whether there may be significant damage caused to the construction equipment engine, or whether there may be a significant risk to nearby workers or the public.) ? Meet EPA diesel fuel requirement for off-road and on-highway (i.e., 15 ppm), and where appropriate use alternative fuels such as natural gas and electric. ? Develop construction traffic and parking management plan that minimizes traffic interference and maintains traffic flow. ? Identify sensitive receptors in the project area, such as children, elderly, and infirm, and specify the means by which you will minimize impacts to these populations. For example, locate construction equipment and staging zones away from sensitive receptors and fresh air intakes to buildings and air conditioners.	–	–	–

1.4.6 Flood Risk Management

Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
Relax storage reservation diagram at 6 FRM projects	–	–	–
Optimize FRM – best FR projection for impact on storage reservoir	–	–	–
Guide curve for Hungry Horse to relax draft rate in high water conditions	–	–	–
Allow floodplain expansion	–	–	–
Modify levees	–	–	–
Remove levees*	–	–	–
Minimize trapped storage by drafting storage projects earlier so we have option to use the space for spring capture. Include creating a decision-point for modifying the draft rate (potential example is 1 or 2 standard deviations above/below the forecast)	–	–	–
In dry water year, operate to local flood control requirements only rather than system requirements (Note: include refill timing and Initial Controlled Flow (ICF))	–	–	–
Develop a definition of “system flood” that is based on the volume forecast (Note: a refill trigger already exists)	–	–	–
In a dry water year, establish a decision-making process for allowance of transitioning refill timing from system ICF approach versus local approach	–	–	–
Initiate refill based on flood risk decisions/assumptions on local hydrology versus system criteria	–	–	–
Blending local and system operations	–	–	–
In dry water year, establish a decision making process for reducing system flood control space requirement during spring draft (Note: local versus system trigger)	–	–	–
during transitions (draft/refill), situationally identify opportunities for movement of flood control space within the system	–	–	–
develop rules to limit flood control space shift between projects in high water years	–	–	–
use banded operation of specific target elevation and allowance for a range of +/- 2 ft of SRD target elevation	–	–	–
change channel capacity by intentional scouring flows by changing discharge during refill	–	–	–
minimize April drafting of Libby for purpose of reducing backwater effect at Bonners Ferry control point	–	–	–
Allow floodplain expansion	–	–	–

1.4.7 Navigation and Transportation

Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
Change spill patterns to facilitate nav	–	–	–
Limit dredging	–	–	–
Dredging	–	–	–

1.4.8 Recreation

Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
No extreme high/low flows for rafting	–	–	–
More parks and boat ramps (Mitigation or w/ scope?)	–	–	–
Establish an annual four-month "normal pool" period on Lake Pend Oreille (Memorial Day to October 1)	–	–	–
Conserve/improve reservoir sport fisheries	–	–	–
Establish a higher winter lake level (i.e. Lake Pend Oreille)	–	–	–

1.4.9 Water Supply

Draft Mitigation Measure: if delete, please use strike through	Reason to add or delete?	Citations	Notes
Increase storage	–	–	for irrigation
Keep reservoirs higher (lowers pumping costs)	–	–	–
More flow during irrigation season so states will permit more withdrawals	–	–	–
Change storage rule curves	–	–	–
Increase refill probability	–	–	–
Reduce flows for fish for irrigation (reduce fish flows to benefit irrigation)	–	–	–
Increase pump strength and capacity for irrigation	–	–	–
Augment downstream flow with release of upper basin project storage	–	–	–
Current operations require that USBR provide M&I and Odessa subarea water through draft of Banks during juvenile migration then refill be restricted to period outside of juvenile anadromous fish migration season. This caused complicated operations and coordination this is not necessary.	–	–	Does not change the colume of water delivered, bur does change the timing of pumping

Draft Mitigation Measure: if delete, please use strike through	**Reason to add or delete?**	**Citations**	**Notes**
Increase diversion to the CBP to serve an additional 220,000 acres of land (estimated increase in withdrawals of about 660,000 acre-feet of water)	–	–	Will be refined by USBR
Improve water delivery efficiency	–	–	–
Employ conservation measures	–	–	assuming water conservation measures?
Extend irrigation systems that currently rely on the slackwater pools of the LSRDs to pump directly from the channel of the undammed Snake River.	–	–	–
Buy water from farmers and industry for fish	–	–	–
Improve irrigation practices	–	–	–
Aquifer recharge	–	–	–

1.4.10 Cultural Resources

Draft Mitigation Measure: if delete, please use strike through	**Reason to add or delete?**	**Citations**	**Notes**
Operate reservoirs so as to minimize fluctuation in elevation	–	–	–
Operate reservoirs so as to maintain full pool elevation as much as possible	–	–	–
fish passage on the Columbia Rier at Grand Coulee and Chief Joseph	–	–	–
Fish passage on the Snake River at Hells Canyon Complex	–	–	–
Replace lost roads if Lower Snake Kams are Removed	–	–	–

Draft Columbia River System Operations
Environmental Impact Statement

Appendix R, Mitigation, Monitoring and Adaptive Management
Part 3, Mitigation Process

Annex B
Strategy for Mitigation Workshop Preparation Instructions
Fish Team - Strategy for Mitigation Workshop Preparation Instructions
Template Impact Summary Spreadsheet

CHAPTER 1 - STRATEGY FOR MITIGATION WORKSHOP PREPARATION INSTRUCTIONS MAY 2019

Strategy for Mitigation Workshop Preparation

May 17, 2019

- May 17: Introduce template Impacts Summary Table with instructions.
- May 20 – June 14: Tech Leads work with their teams to populate the Impacts Summary Table.
- June 14: Impacts Summary Table fully completed. POC: Hannah Hadley

1.1 OVERVIEW OF IMPACTS SUMMARY TABLE

Use the Impacts Summary Table to summarize effects and discuss potential mitigation with your technical team. During the Mitigation Workshop (June 24-27, 2019 in Portland, OR), all Technical Leads will review the proposed mitigation for impacts to each resource by alternative.

Use the Mitigation Toolbox to select potential mitigation measures to offset impacts. If no mitigation measure exists in the Mitigation Toolbox to address the impact, propose a new measure.

Please reference the Mitigation Development Process diagram on page 2 of these instructions.

1.2 "SUMMARY OF NEGATIVE IMPACT(S) COMPARED TO NO ACTION ALTERNATIVE"

Provide a very brief summary of the impact(s). Please reference the Water Quality MO1 tab as an example to guide your team.

1.3 "CAUSE OF IMPACT (INDICATE THE MEASURE OR GROUP OF MEASURES FROM THIS ALTERNATIVE)"

Please use the abbreviated name of the alternatives' measures to identify impacting measure.

Analysis may have provided information as to which measure or group of measures resulted in the negative impact. Identification of the impacting measure will facilitate assignment of an effective mitigation measure.

1.4 "INDICATOR/METRIC USED TO DESCRIBE IMPACT"

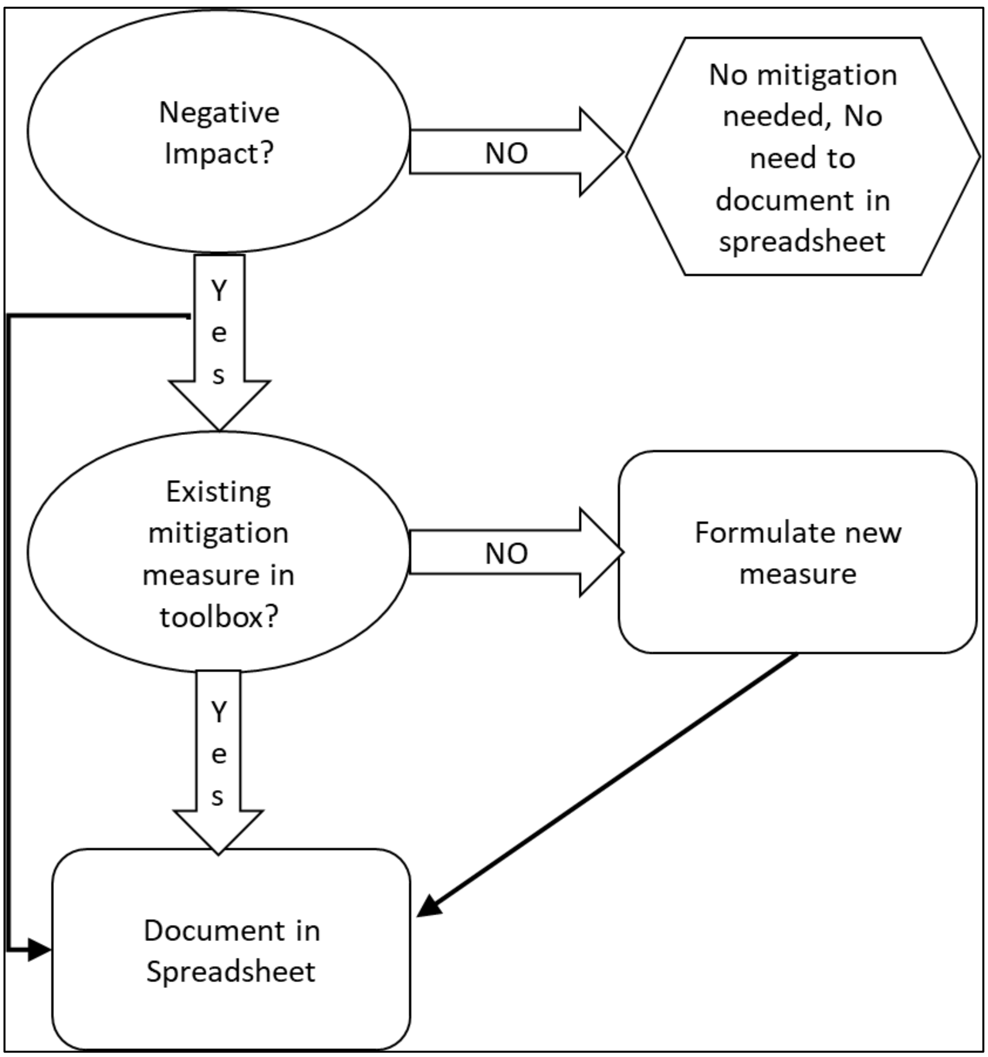
The indicator/metric provides the type of impact. For example, temperature, TDG, water surface elevation, fish travel time, etc. In some instances, the specific measure or group of measures from the alternative may not be identifiable as the source of the impact(s). Identifying the indicator/metric assists assignment of effective mitigation measures.

1.5 "PROPOSED MITIGATION MEASURE TO OFFSET IMPACT(S)"

Mitigation needs to be related to the effect (e.g. high water temperature effect mitigated by action to reduce water temperature in the area of effect). Mitigation should also be known to be effective and implementable (e.g. technically, environmentally, and economically feasible). Use the Mitigation Toolbox to select potential mitigation measures to offset impacts. If no mitigation measure exists in the Mitigation Toolbox to address the impact, propose a new measure.

If your team cannot identify a potential mitigation measure, it is appropriate to leave the cell blank.

NOTE: Task is to identify locations for and/or types of proposed mitigation. The task is NOT to develop the details of mitigation such as quantity or scale. These details would be a future exercise.



CHAPTER 2 - FISH TEAM - STRATEGY FOR MITIGATION WORKSHOP PREPARATION INSTRUCTIONS MAY 2019

FISH TEAM: Strategy for Mitigation Workshop Preparation, May 17, 2019

- May 17: Introduce template Impacts Summary Table with instructions to Technical Leads.
- May 29 (1-2pm PST): NEPA Team presents the concept of the Impacts Summary Table and assignment of mitigation to the whole Resident Fish Team.
- May 31 (10-11am PST): NEPA Team presents the concept of the Impacts Summary Table and assignment of mitigation to the whole Anadromous Fish Team.
- May 31 (12-3pm PST): Solicit input from the Clark Fork Fish Team to assign potential mitigation measures for impacts. Sue Camp and Pam Druliner will lead the discussion and Triangle will facilitate.
- June 6 (9-12pm PST): NEPA Team and Fish Tech Leads prepopulate potential mitigation measures into the Impacts Summary Table to expedite upcoming subteam effort.
- June 11 (9-12pm PST): Solicit input from the Lower Columbia Anadromous and Resident Teams plus Middle Columbia Resident Team to assign potential mitigation measures for impacts. Tina Teed will lead discussion and Triangle will facilitate.
- June 11 (1-4pm PST): Solicit input from the Lamprey Team to assign potential mitigation measures for impacts. Tina Teed will lead discussion and Triangle will facilitate.
- June 12 (1-4pm PST): Solicit input from the Upper Columbia River Anadromous and Resident Teams to assign potential mitigation measures for impacts. Tina Teed will lead discussion and Triangle will facilitate.
- June 17 (9-12pm PST): Solicit input from the Snake River Anadromous and Resident Fish Teams to assign potential mitigation measures for impacts. Hannah Hadley and Cindy Boen will lead discussion and Triangle will facilitate.
- June 17 (1-4pm PST): Solicit input from the Kootenai and Pend Oreille Resident Fish Teams to assign potential mitigation measures for impacts. Hannah Hadley and Cindy Boen will lead discussion and Triangle will facilitate.

2.1 OVERVIEW OF IMPACTS SUMMARY TABLE

The Impacts Summary Table presents the effects from analysis and will be used to identify potential mitigation from your technical team. During the Mitigation Workshop (June 24-27, 2019 in Portland, OR), all Technical Leads will review the proposed mitigation for impacts to each resource by alternative.

Use the Mitigation Toolbox to select potential mitigation measures to offset impacts. If no mitigation measure exists in the Mitigation Toolbox to address the impact, propose a new measure.

Please reference the Mitigation Development Process diagram on page 3 of these instructions. The Water Quality MO1 tab is provided as an example to guide your team.

CHAPTER 3 - INSTRUCTIONS FOR IMPACTS SUMMARY TABLE COLUMNS

3.1 "CAUSE OF IMPACT (INDICATE THE MEASURE OR GROUP OF MEASURES FROM THIS ALTERNATIVE)"

Please use the abbreviated name of the alternatives' measures to identify impacting measure.

Analysis may have provided information as to which measure or group of measures resulted in the negative impact. Identification of the impacting measure will facilitate assignment of an effective mitigation measure.

3.2 "INDICATOR/METRIC USED TO DESCRIBE IMPACT"

The indicator/metric provides the type of impact. For example, temperature, TDG, water surface elevation, fish travel time, etc. In some instances, the specific measure or group of measures from the alternative may not be identifiable as the source of the impact(s). Identifying the indicator/metric assists assignment of effective mitigation measures.

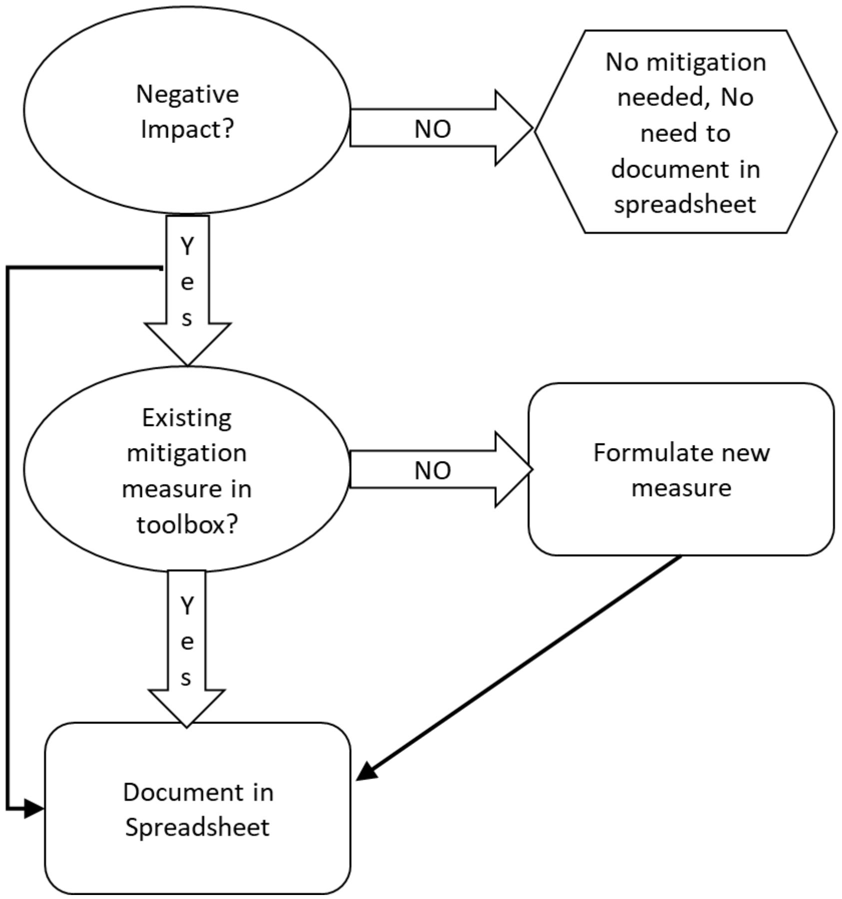
3.3 "PROPOSED MITIGATION MEASURE TO OFFSET IMPACT(S)"

Mitigation needs to be related to the effect (e.g. high water temperature effect mitigated by action to reduce water temperature in the area of effect). Mitigation should also be known to be effective and implementable (e.g. technically, environmentally, and economically feasible).

Use the Mitigation Toolbox to select potential mitigation measures to offset impacts. If no mitigation measure exists in the Mitigation Toolbox to address the impact, propose a new measure.

If your team cannot identify a potential mitigation measure, it is appropriate to leave the cell blank.

NOTE: Task is to identify locations for and/or types of proposed mitigation. The task is NOT to develop the details of mitigation such as quantity or scale. These details would be a future exercise.


Negative Impact?
NO
No mitigation needed, No need to document in spreadsheet
Yes
Existing mitigation measure in toolbox?
NO
Formulate new measure
Yes
Document in Spreadsheet

Template Impact Summary Spreadsheet

team name		–	–	–
Location	**Summary of Negative Impact(s) Compared To No Action Alternative**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Proposed Mitigation Measure to offset impact**
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–
–	–	–	–	–
–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–
–	–	–	–	–
–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–
–	–	–	–	–
–	–	–	–	–
Region D: 4 Lower Columbia Projects	–	–	–	–
–	–	–	–	–
–	–	–	–	–

Draft Columbia River System Operations Environmental Impact Statement

Appendix R, Mitigation, Monitoring and Adaptive Management
Part 3, Mitigation Process

Annex C
June Mitigation Toolbox

CHAPTER 1 - JUNE MITIGATION TOOLBOX

1.1 JUNE MITIGATION TOOLBOX - 2019

1.1.1 Water Quality

Draft Mitigation Measure	Reason to addition	Citations	Notes
move spill from Coulee to Chief Joe to manage TDG in the system	add	–	already do some of this, but should identify in report as a continued mitigation measure
system reserves shifts	–	–	
Bank stabilization	Lower reservoir elevation Increased reservoir refill rate	–	Increased risk and occurrence of landslides resulting in increased turbidity and impacts to local infrastructure.
Begin higher levels of juvenile fish passage spill later, when significant numbers of fish are in the river (e.g. start April 15, April 30 or start per fish count but only if also accompanied by 2-4 days' notice). Either no spill in the first part of April or spill to "performance standard" starting April 3/10.	This measure would: a) help to alleviate reductions in power generation; b) reduce TDG in early April and not "pre-gas" the river before significant numbers of juveniles show up	–	Power would need 2 days' notice before fish spill starts (longer if it is right after a weekend) because power is marketed 1-3 days in advance. --mitigation measure also added to power
Change seasonal/monthly turbine operations/priorities to change temperature mixing for cooling	add	–	additional studies would need to occur to determine feasibility
Compensate other large, mainstem dam operators (non-CRS) to operate their dams in a way that is beneficial for fish passing through CRS. For example, releasing cooler water during warm periods when they may not need to for their own environmental compliance, but has the opportunity to offset elevated mainstem temperatures in CRS areas that would benefit fish migration (juvenles or adults). Elevated flows is another option (pay them to store more/less water for downstream fish/water quality benefit).	–	–	Actions of other nonfederal operators is outside the scope of the EIS. Regulations of dams are the responsibility of FERC and EPA.
Decreasing/stopping spill (stop voluntary spill)	add	–	continue to explore idea of benefits to this operational strategy; July may be a more beneficial month to try this; look at MO2 results to inform discussion
Finanical/Monitoring	Financial support for native plantings and restoration of natural shorelines to help capture nutrients in stormwater runoff	–	–
Flow diversion structures, increased channel and habitat complexity to divert flows around in-channel slag deposits	Increased water velocities in contaminated reaches Decreased storage will change depositional zones to transitional/transport zones. Contaminants will spread further downstream.	–	Sediment transport of slag-bound metals
Implement a more flexible water management strategy during low flow years to preserve water in storage projects for release during summer to cool downstream water temperatures	add	–	Dworshak only viable project; we do this already, but could still discuss in mitigation section of report.

Draft Mitigation Measure	Reason to addition	Citations	Notes
Implement TDG reduction measures at other structural measures	Add, to reduce TDG generation from Grand Coulee Dam spill. Add. High priority for CTCR due to TDG-caused fish & aquatic life mortality downstream of GCD. An "extend and cover" modification would be superior to "flip lips" in reducing TDG per USBR analysis.	Frizell, K. H., & Cohen, E. (2000) Structural Alternatives for TDG Abatement at Grand Coulee Dam Feasibility Design Report. U.S. Bureau of Reclamation.	Analysis and report by USBR concluded the "extend and cover" structural alternative at GCD best lowers TDG and was the second least expensive alternative studied, ranking highest overall of three alternatives studies
Improve (lower) water temperatures (in summer) through additional selective withdrawal at storage projects that stratify	GCL temperature paper: USBR, 2008. Thermal Regime of the Columbia River at Lake Roosevelt. U.S Department of Interior, Bureau of Reclamation, Pacific Northwest Regional Office. Boise, Idaho	Eric R. to provide citation	Hungry Horse, Dworshsak & Libby already have SWS; Coulee not feasible.
Infrastructure improvements and repair	Lower reservoir elevation Increased reservoir refill rate	–	Increased risk and occurrence of landslides resulting in increased turbidity and impacts to local infrastructure.
Install Submerged outlets below spillbay flow deflectors to reduce TDG	add	–	not likely feasible to utilize lower level from technical perspective (Coulee); could be studied further
Minimize reservoir drawdown throughout the basin	–	–	It would be useful to add what environmental impact this measure will mitigate.
Operate run-of-river projects that stratify (e.g., LSR projects) to pass cooler water from deeper in the forebay to cool downstream temperatures during warm/low flow conditions.	add	–	(similar to row 5) continue to explore idea of benefits to this operational strategy; July may be a more beneficial month to try this; look at MO2 results to inform discussion
Summer and Fall water temps in the Columbia and Snake rivers commonly exceed mandated temps for salmonid survival. In the 1960's and 1970's these excessive temps were limited to a few days a year, now its months straight. The JD resevoir has no cold water refugia so does the McNary to Priest Rapids reach. Cold water wells must be used in conjunction with natural bays and embayments to create new CWR in this areas to allow returning adults successful passage during periods of excessive temperatures.	EPA Report https://www.epa.gov/columbiariver/columbia-river-cold-water-refuges. NOAA PP https://www.epa.gov/sites/production/files/2017-07/documents/columbia-river-cold-water-refuges-epa-presentation-sept2016.pdf	–	–
Tributary and upland restoration	Lower reservoir elevation Increased reservoir refill rate	–	Increased risk and occurrence of landslides and erosion leading to increased turbidity

1.1.2 Fish

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Additional turbines at Dworshak, Libby, for resident fish, TDG abatement/management	–	–	Moved from Power tab. Economically feasible units are already going to be rehabed. Waiting for $/limited in # at a time (year) Maximizing the efficiency of existing turbines and output from existing dam projects can result in increased carbon-free hydropower output.
–	Alter spill (change timing, duration, frequency)	–	OR provided citation: United States. The Endangered Species Act As Amended by Public Law 97-304 (the Endangered Species Act Amendments of 1982). Washington: U.S. G.P.O., 1983. Print. 2014 Columbia River Basin Fish and Wildlife Program https://www.nwcouncil.org/reports/2014-columbia-river-basin-fish-and-wildlife-program	*Alter for benefit of juvenile passage and survival? *We are doing this now, tweaking spill regimes in order to achieve better results. The PIT array at Granite may help in aiding spill programs in the Lower Snake. *Any ESA jeopardy analysis of the proposed action must comply with legal requirements.OR *Oregon remains open to consideration of flexibility in spill strategies so long as any alternative moved forward is robust enough to avoid jeopardy under the ESA and achieve regional recovery goals of 4-6% SARs of ESA-listed salmonids.
–	Balance optimize transport for all salmon/steelhead	–	–	Transportation strategy may be developed to optimize benefits based on water year and temperature.
Juvenile Salmon and Steelhead	Install Submerged outlets below spillbay flow deflectors to reduce TDG	–	–	Many of these seem to be latent mortality effects. Will the Spillway PIT tag arry lead us to management decisions regarding these?
–	Allow transport in only the lower 25% of water years and only in circumstances of reduced flows and limited spill.	–	–	Generally, transport has negative adult return results, except in years/periods of low flow when smolt survival through the CRS outweighs the negative impacts associated with adult straying upon return. Consider revising mitigation measure to allow transport in only the lower 25% of water years and only in circumstances of reduced flows and limited spill.
–	Reduce harvest of Listed Fish through continued development and implementation of selective harvest gears such as purse seines and pound nets or Reduce harvest of Listed Fish	–	–	Harvest regulation is outside the authority of the action agencies, but could be done by others.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Juvenile Salmon and Steelhead	Restore mainstem habitat through increased habitat complexity (rapid, riffle, run, pool), shallow water rearing habitat connectivity, temperature reduction, riparian function restoration, restore ecosystem processes.	–	–	–
–	Apply spill configurations that maximize smolt passage in spill, minimize eddy development to minimize predation opportunity on smolts and mimimize negative impacts to adult migration (confusion) and minimize TDG.	(2) During periods of reduced spill, maximizes benefits of spill for juvenile survival and minimizes potential negative impacts to adults.	–	–
–	Spill Increase to maximize SPE (shouldn't change hydrograph) to improve juvenile fish passage	–	–	Maybe some measure of the data we get from the PIT array at Granite might inform us for improved efficiency post BiOp? Assuming adaptive management will continue? So a lot of these measures could be considered post BiOp.
Adult Salmon and Steelhead	Spill proportional to juvenile numbers. Minimizes TDG and spill effects on adult passage.	–	–	How do we get numbers? JFF?
Adult Salmon and Steelhead	Stop spill in August; Minimizes TDG and spill effects on adult passage	–	–	Does pulling through turbines help cooling?
Piscine Predator Control	*Manage water levels/flows to reduce spawning habitat and recruitment success of non-native fish species at locations such as Yakima & Walla Walla River delta's *Manipulate reservoir elevations (and/or use culverts, etc.) to reduce or eliminate spawning habitat of non-native game fishes (example: Walleye spawning areas near the mouth of the Yakima River).	Not enough detail to evaluate. Although this measure may be beneficial at a localized scale or at certain locations for native fish, it may also introduce difficulties with operations such as MOP and MIP and therefore carry with it important resource trade offs. Oregon recommends this mitigation action be explored further from the perspective of scope, location, time, potential trade offs, etc. before moving it forward or deleting it at this time.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
resident fish	[At hungry Horse] maintain lowered winter flows in years following high spring runoff to aid in the establishment of riparian vegetation with positive benefits to both aquatic and terrestrial communities. [Add'l comment: this is already a CRSO measure in MO4, double this up as both operation and mitigation?]	Not enough detail to evaluate.	Merz (unpub data), Casey (2006), Braatne and Jamieson (2001), Auble and Scott (1998)	*Oregon needs more detail about this mitigation action prior to making a technical recommendation. Needs more development. Impact analysis for Bull Trout FMO? *This measure may be more helpful to wildlife. Consider moving it to the Wetland, Vegetation, Wildlife tab. Maybe consider at other dams as well *This measure is included for Libby Dam under MO4 and the same benefits would occur along the Flathead. Use citations, rationale, imact analysis etc. from that effort.
Piscine Predator Control	A bounty system for small mouth bass and walleyed would be effective (similar to Northern Pike Minnow program) - excluding predators	KEEP but not within USACE authority to implement.	–	*Outside authority of action agencies to implement, but could potentially be implemented by others *Did not see this when I added the metric above. I'd consider this critical. *Oregon needs more detail about this mitigation action prior to making a technical recommendation. *Make sure to consider Northern Pike too
–	Activate fish lifts to move Sturgeon - where feasible (BON)	Not enough detail to evaluate. Although Oregon supports the concept of increasing passibility at projects (both upstream and downstream) of sturgeon. The fish lifts are just one mechanism which may help achieve that outcome. It is Oregon's understanding that sturgeon may use fish ladders, spillways, and locks as means to pass the projects depending on size and passage direction. See referenced document	J. Parsley, M & Wright, Corey & van der Leeuw, Bjorn & E. Kofoot, E & Peery, Christopher & L. Moser, M. (2007). White sturgeon (Acipenser transmontanus) passage at the Dalles Dam, Columbia River, USA. Journal of Applied Ichthyology. 23. 627 - 635. 10.1111/j.1439-0426.2007.00869.x.	*Oregon needs more detail about this mitigation action prior to making a technical recommendation. *What about other facilities (CJO, GCD, Dalles, McNary, John Day, Snake River)? Methods to use the navigation channels for sturgeon movement?
–	Add biomimicry heat exchangers to tops of fish ladders	Need more detail to evaluate.	–	–
Adult Salmon and Steelhead	Add deflectors to DWR spillway to reduce TDG (impacts to incubating and rearing SR fall Chinook salmon)	–	–	–
–	Add flex spill operation both 120% and 125%	We are currently using the Flex 120% operations so makes sense to add as an option. 125% also since there was agreement to evaluate and if 120% is not getting us where we need to 125% could be used.	2018 BiOp and Flex spill agreement	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Lamprey	Add pheromones/"scents" to suitable spawning tributaries	Presumably this is for lamprey, only lamprey or other species too?	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.
Sturgeon	Add recommendations from the Sturgeon plan.	The plan's recommendation should be added to the CRSO mitigation tool box.	Contact CRITFC	–
–	Add/increase spawning gravel	Neutral; keep	–	*We considered this back in the late 80's when there were just a few fall chinook in the snake spawning between the Grande Rhone and Lewiston. Thought was to bring up a barge to the two key spawning areas defined and drop gravel every few years. I thought it had merit. Now however we have lots of fall shinook spawning. We drop dredge material, why not proper sized gravel. The hells canyon complex was what eliminated sediment transport into the Snake- poor above the Salmon confluence for instance. *Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. *may be important for native mainstem spawners (e.g. mountain whitefish)
Fish/Salmon, Steelhead, & Lamprey	Address conditions in the Yakima Delta portion of the McNary Pool The confluence of the Yakima with the Columbia is located in the McNary Pool and managed by the Corp of Engineers. The Mid-Columbia Fisheries Enhancement Group, WDFW, the Yakama Nation and other partners are actively working to design and implement modifications to the causeway that would restore more natural flow patterns. Backwater conditions behind the causeway to Bateman Island create highly artificial conditions that benefit non-native predators (bass, walleye and catfish) while harming migrating salmon, steelhead and lamprey.	–	–	–
–	Albeni Falls expand FWPO for chum	–	–	Needs refinement of activity and limit impacts to local resident fish
–	Albeni Falls stop Flexible Winter Power Ops for resident fish	Not enough detail to evaluate.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
general	All locations with fish bypass: JBS screen systems; Total overhaul, rebuilding and upgrading where needed	–	–	–
general	All locations with TSW or RSW: Install gates with electric winches to allow easy opening and closing so they can be used for fish passage during the non-spill season	–	–	–
–	All projects from 2018 Lower River tribes fish Accords should be incorporated in the Mitigation Tool package	This is on going and future proposed work that was not included in the base case and needs to be considered future CRSO mitigation	2018 Lower Tribal Fish Accords	Mitigation specific to the impacts of the actions will be considered. If mitigation components are identified, they can be evalauted and used.
Piscivore Control	Allow removal of invasive fish incidentally caught during dam angling	–	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
Adult Salmon and Steelhead	Alter Transport to decrease straying of adult migrants	A good suggestion: Proposals have been devloped by NWFSC.	–	–
Juvenile Salmon and Steelhead	Alter Transport to focus on when there is demonstrable benefit to smolt survival	–	–	–
–	At Columbia falls, increase minimum flow in high water years to 5000 cfs and adjust linearly down to 3,200 cfs in the driest water years to benefit bull trout and other native fish species	–	–	–
ADD: Resident Fish, bull trout, westslope cutthroat trout, KR white sturgeon, burbot	At Libby, maintain lower winter flows in years following high spring runoff to aid in the establishment of riparian vegetation.	MO4 would implement this measure with much more detail, but this more generic approach would provide beneficial mitigation for the other MO alternatives.	Merz (unpub data), Casey (2006), Braatne and Jamieson (2001), Auble and Scott (1998)	The more frequently we can meet these conditions, the greater the likelihood of cottonwood regeneration and associated ecosystem benefits.
–	At the current Dam angling program to remove Northern Pike Minnow, remove other juvenile salmon predator fish such as walleye, small and large mouth bass, catfish, etc…..	Currently these species are returned to river. This would increase the effectivness of this program and remove additional predation fish species from hot spots and areas where the general public does not have access to help reduce these populations.	https://www.nwcouncil.org/fish-and-wildlife/fw-independent-advisory-committees/independent-scientific-advisory-board/non-native-species-impacts-on-native-salmonids-in-the-columbia-river-basin-including-recommendations-for-evaluating-the-use-of-non-native-fish-species-in-resid	*Outside authority of action agencies to implement, but could potentially be implemented by others
–	Balance optimize transport for all salmon/steelhead	–	–	–
–	Ban harvest for 1-2 years	Harvest regulation is outside the scope of the action agencies, but could be done by others	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
–	Breach scenario	–	–	A general note that breaching is modeled to remove O2 from the snake for a few weeks. This action, while it may improve smolt migration could have a serious impact on native species

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Breach the Bateman Island causeway, near the mouth of the Yakima River, Richland Washington	This site impact juvenile outmigration, creates piscivorous predators feeding and spawning habitat, impacts returning adult salmonid migration, NOAA needs to mandate this action	http://midcolumbiafisheries.org/restoration/fish-passage/yakima-delta-assessment/ http://midcolumbiafisheries.org/wp-content/uploads/2016/06/Executive-Summary.pdf	–
Juvenile Salmon and Steelhead	Build Juvenile Bypass Structure Upgrade Phase 2 to improve fish handling for Smolt Monitoring Program and transportation program	Not enough detail to evaluate.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.
Adult Salmon and Steelhead	Buy out harvesters to allow more adults to reach the spawning grounds.	Outside the authority of action agencies, but could be done by others.	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
–	Catch and transport adult sturgeon (BON)	Oregon would be supportive of catch and transport of sub-adult white sturgeon from Bonneville Pool to other Zone 6 locations within the context of CRITFC's sturgeon Master Plan, but not adults and not to other locations and not from below Bonneville dam.	–	*What about other facilities (CJO, GCD, Dalles, McNary, John Day, Snake River)? Methods to use the navigation channels for sturgeon movement? *Oregon needs more detail about this mitigation action prior to making a technical recommendation.
general	Cease Transport Operations if TIR ratios are consistently less than 1	–	–	–
–	Change FRM to make more water available to fish (relax rule curves ; go towards normative hydrograph)	*Add targeted evaluation of FRM based on CRT-13 Tribes Ecosystem Function recommendations. *Oregon strongly supports further development of operational and/or structural mitigation actions to optimize flow augmentation particularly of cold water for cold water fish	–	*Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. *May not be feasible in high water years due to the potential increase in flood risk
Adult Salmon and Steelhead	Change seasonal/monthly turbine operations/priorities to change temperature mixing for cooling	*KEEP. However, measure has limited application *Oregon strongly supports further development of operational and/or structural mitigation actions to optimize water temperatures for cold water fish	–	Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to irrigators.
–	Change turbine operations to change temperature	Oregon strongly supports further development of operational and/or structural mitigation actions to optimize water temperatures for cold water fish	–	* If altering turbine flows can reduce temperatures during migration season (upstream and downstream), then it should be considered. * Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Piscine Predator Control	Conduct predatory fish removal throughout each of the reservoirs with emphasis on hotspots - predation management	KEEP w/State support. Projects include: TDA	–	*Outside authority of action agencies to implement, but could potentially be implemented by others *Add measures like derbies/bounties on non native fish, and a good PR campaign on why to keep, recipes. *Oregon needs more detail about this mitigation action prior to making a technical recommendation.
Adult Salmon and Steelhead	Continue to reconnect the estuarine floodplain (BON to mouth) to restore rearing habitat and increase flux of prey to the mainstem (support condition of outmigrants before ocean entry)	–	–	–
Predation	Continued disaussion activities (both active and passive) on avian colonies in the Potholes Reservoir	Very high avian predation rate from CATE colonies seen on UCR steelhead	Inland Avain Plan	–
general	Convert Bypass channels to surface passage routes where possible (JDA, MCN, and Snake River projects)	–	–	–
–	cooling water pumped through fish ladder as an attractant	Investigate other projects using results from Lower Granite Dam as the pilot project? Keep this measure but clarify intent.	–	*Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. *It has provided benefits in the Snake.
–	Decrease the draft rates	Oregon strongly supports further development of operational and/or structural mitigation actions to optimize flow augmentation particularly of cold water for cold water fish	–	Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.
Sturgeon	Decrease White Sturgeon habitat fragmentation through dam passage improvements and/or dam removal	Keep	–	–
Predation	Deployment of green laser device to dissuade piscivorous waterbirds from facilities, loafing or nesting habitat	–	TERN Management Plan	–
Adult Salmon and Steelhead	Design, Construct, and Operate cooling water structures or showers at ladder exits to reduce temps to below 1 degree C differential in the ladders	–	–	–
–	Develop 3-to-5 year implementation plans for tributary habitat actions that identify specific actions expected to be implemented, rationale for action, and expected benefits.	Offsite mitigation for impacts of hydrosystem to abundance, productivity, and survival.	–	See 2019 CRS BiOp, Term and Condition #5

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Juvenile Salmon and Steelhead	Develop additional shallow water habitat throughout the length of the reservoir; reduce available holding habitat for fish predators in conjunction (e.g., convert rip rap areas to shallow water habitat)	Keep. KEEP. Affirmative. This action could include "softening the shorelines", i.e., keep the structual features, but soften them with soil wrapped walls, dredge material placement, etc. to naturalize the shoreline.	–	Similar to previous comments. Why not habitat above the Salmon too? Hard to do but it's known that Hell's canyon complex is stopping sediment transport
–	Develop additional shallow water rearing habitat (e.g., for fall chinook in the lower snake river)	Keep. KEEP to the extent possible.	–	Similar to bringing in spawning gravel in the snake from leweiston upstream.
Juvenile Salmon and Steelhead	Develop additional shallow water rearing habitat at McNary Pool	Keep.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.
Juvenile Salmon and Steelhead	Develop adult trap and haul facility at Ice Harbor to improve research/monitoring & truck/haul capabilities (e.g., for emergency sockeye truck & haul in hot water years)	Keep	–	–
general	Develop method to extract deeper colder water for longer periods during late spring, summer and early fall at Grand Coulee (extended intakes?); and fill Banks Lake with warmer surface waters (variable intake) to help mitigate for climate change impacts.	–	–	–
–	developing a downstream passage route for non-spillway or turbine passage for resident fish at certain facilities (Libby, HH, Dworshak, others) to reduce entrainment mortality	Increase entrainment survival downstream of high head dams, possible increases to support downstream populations.	–	–
Piscivore Control	Dissuade Terns on Blalock Islands	–	–	–
salmon and steelhead	Draw down Snake River reservoirs to spillway crest during juvenile salmon out migration period.	Improve conditions for outmigrating juvenile salmon and steelhead.	Previous FCRPS EIS	This action has been discussed and analyzed in previous processes.
–	Dry year strategy where we have additional reservoir draft in dry years and load management strategies in dry years	*Keep. *Develop different operational strategies based on flow year. Enable adaptive management to respond to flow year. *Oregon strongly supports further development of flexible mitigation actions that can be applied in dry/warm water years.	–	*A hedge against climate change/drought years. *Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.
–	Effective debris management to keep debris off of trashracks where it can impact smolts, auto release on boat barriors, shape debris booms to RSW	moved from WQ	–	Debris is a recurring issue with the safe and effective passage of fish through the Juvenile Bypass Systems and some adult laddders.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Flows/Chum/Lower River/Estuary	Eliminate lower Columbia chum flow operations to benefit other fish. Lake Roosevelt experiences a drawdown in August and September to assist lower river Chum Salmon migration. However, there has been little consideration or mitigation for the effects these flows have on fish populations of Lake Roosevelt. A review of the current chum operations and other similar single species operations must be reviewed within the alternatives.	–	–	–
–	Environmental flow (intentional overbank)	*Neutral. *Oregon strongly supports further development of operational and/or structural mitigation actions to return the hydrograph to a more normative (pre-hydrosystem) pattern. *See Ecosystem Function description from Columbia River Treat discussions.	–	Both in fish and wetlands. Re-engaging flood plans is shown to be beneficial. Depends on where. I've heard from our calls that it may be doable on the Upper Columbia?
Juvenile Salmon and Steelhead	Establish an annual four-month "normal pool" period on Lake Pend Oreille (Memorial Day to October 1) and a higher winter lake level	–	–	–
–	Evaluate optimal operations by flow level balancing good egress and reduced PITph in the spring for juveniles, with retention of water needed to reduce late spring, summer, and early fall temperatures for adults.	–	–	Moved from water supply

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Evaluate potential for improving tributary habitat productivity in populations in the Middle Fork Salmon River spring Chinook MPG. Habitat in the Middle Fork Salmon spring Chinook MPG is generally of high quality due to the preponderance of wilderness areas and other federal lands, and there appears to be relatively low potential for improving habitat productivity in most populations in this MPG. However, as noted in the ESA recovery plan (NMFS 2017), further exploration of ways to improve habitat is warranted. The potential of the following actions to improve freshwater productivity in the populations in this MPG should be evaluated: (1) continued efforts to address localized impacts of past land uses; (2) reintroduction of beaver in populations with significant marsh habitat; (3) nutrient supplementation; (4) management of non-native brook trout improve the function of spawning and rearing habitat and provide population benefits. Based on the results of this evaluation, the Action Agencies should develop implementation plans as appropriate.	Offsite mitigation for impacts of hydrosystem to abundance, productivity, and survival.	–	See 2019 CRS BiOp, Conservation Recommendation #18
–	Evaluate/construct entrainment reduction or downstream passage routes for facilities	Maintain survival of greater than 90% for all downstream routes. Use surogate species to estimate impacts in absence of BT data	Examine effects of entrainment on Lake Koocanusa Core Area Populations (USFWS 2015, Recov Plan D-111).	–
–	Existing BPA Fish and Wildlife program project implementation measures that are listed in PICSES and CBFISH should be incorporated into the mitigation toolkit. Most of these projects are intended to implement the Northwest Power Act's mitigation mandates. Most of the projects have at least a 10-year history. Few, if any, will sunset during the timeframe of this EIS. Many will, however, continue to add mitigation consequences to the mitigation actions that havve already occurred.	–	The Norwest Power and Conservation Council Website.	–
–	Expand tributary habitat projects to resident fish species (bull trout) waters	–	–	See all tributary suggestions by NOAA and expand to include areas of bull trout and the upper basin.
Invasives/Monitoring	Financial support for invasive species monitoring and mitigation programs	–	–	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
predation	Fish collector in or near GCD forebay, equipped with exclusionary netting - remove non-native predators	Increased water outflow Decreased water residence time	–	Capture and removal of Northern Pike and other non-native predators as they disperse downstream
–	Fish ladders/passage (add or improve)	Keep	–	*Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. This mitigating action should be considered at all project locations where it has the potential improve upstream or downstream passage of adults or resident species across a broad set of operations (low spill to high spill). Bull trout at Albeni Falls. No Action. Implemented through another program *Bull trout passage at Albeni Falls is critically important. Consider passage at other facilities that currently do not have passage (e.g. Dworshak, HHD, Libby, GCD, Chief Joe). Confirm passage efficiencies at other dams for bull trout. Need to improve to allow passage of species other than salmon (e.g., bull trout, sturgeon, lamprey, and westslope cutthroat trout).
–	Fish ladders/passage (add or improve). Fish passage in the "blocked areas" of the Columbia and Snake Rivers to achieve additional production in currently inaccessible historical habitats.	Potential to produce UCR summer/fall Chinook smolts in currently inaccessible habitats that may partially offset increased juvenile mortality in the lower Columbia dams and reservoirs as a result of reduced or suspended spill and reduced flow in late July and August. Keep.	–	Bull trout at Albeni Falls. No Action. Implemented through another program
–	Forecast and program O&M needs to address aging infrastructure.	ADD Aging infrastructure is an issue at all facilties. Need to further develop a strategy and plan to identify major rehabs and funding.	–	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Fully implement Tern Management Plan at ESI in the estuary.	Currently only managing to an acre plan and have not achieved population targets in plan. This program has failed to meet the predation reduction objectives set out in the management plan. No additional actions are planned but additional actions are needed. In past studies it was shown that river flows has an effect on predation rates and by altering the base case flows this could increase or decrease tern predation and thus should be included in the CRSO.	DCCO management Plan	–
–	Fully implement The Double Crested Cormorant Plan at ESI in the estuary and look to partner and expand to Megler-Astoria Bridge.	Currently the plan has not achieved the population numbers as outlined in the management plan. The COE used erronous data to cite that population goals were achieved but current population's estimates have the DCCO numbers back to near pre managment levels. The COE needs to continue to utilize population controls measures and look at partnering with others in estuary to help effectively manage cormorants. At the very least work with Astoria-Megler Bridge to reduce nesting.	–	–
Piscivore Control	Fund dissuasion efforts of Pinnpeds haul out sites and increase hazing intensity in the spring and fall at Bonneville Dam	–	–	–
Piscivore Control	Further reduce predation on juvenile salmonids from Caspian terns at ESI using a variety of methods (lethal and/or non-lethal means), which could include habitat modifications or colony reduction. Habitat modifications at ESI could reduce available habitat to less than 1.0 acres, translating into a reduction in colony size over time which is assumed to reduce predation rates (change is not immediate); colony reduction would reduce the number of terns breeding and foraging in the CRE.	–	–	–
Passage/Structural	Gentler slopes in fish ladder access to increase survival and passage rates	–	–	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Predation piniped	Give sea lions human appetite suppressants to reduce their consumption of fish below Bonneville without lethal effect on sea lions.	Reduce predation on juvenile and adult fish below Bonneville dam.	https://www.smithsonianmag.com/smart-news/human-diet-drugs-may-be-secret-stopping-mosquitoes-180971459/	–
Piscivore Control	Haze, dissuade, and facilitate removal of pinnipeds at TDA and BON	–	–	–
–	If flows prove to influence mainstem temperatures, draft storage reservoirs (like Libby) deeper in lower flow years as a response to climate change.	–	–	–
white sturgeon	Implement "slow-roll" procedures for all turbine start-ups to reduce fish mortality, particularly for those projects with white sturgeon	Because this technique/procedure has been demonstrated to reduce mortality from blade strike on sturgeon, particularly on adult fish, a critical segment of all sturgeon populations.	https://www.nwcouncil.org/sites/default/files/ColumbiaBasinWhiteSturgeonPlanningFramework2013Dec_0.pdf	This is a concern at Dworshak Dam, others?
–	Implement 2018/2019/2020 flex spill as a mitigation action to allow adult salmon and steelhead to pass Little Goose Dam in the spill to gas cap alternatives.	–	–	–
Hatcheries	Implement an aggressive program of stocking the river with steelhead/salmon.	–	–	*Outside authority of action agencies to implement, but could potentially be implemented by others *Unclear what the effects of the action would be, but all alternatives improve steelhead and salmon. No action would maintain current mitigation activities.
Flows/Lower River/Estuary	Implement higher spring and summer flows to lessen duration of hypoxia in the Columbia River plume and nearshore ocean.	–	–	–
Piscivore Control	Implement NOAA ITS and conservation recommendations	–	–	–
Resident Fish (Bull Trout, Sturgeon, Kokanee)	Implement 'off-site', within subbasin actions that address resident fish losses attributable to hydrosystem operations in circumstances where mitigation cannot be adequately or sustainably acheived within the immediate affected environment.	In some circumstances, 'off-site' mitigation results in more effective and sustainable outcomes.	–	–
Juvenile Salmon and Steelhead	Improve (survival, reliability, operational ease, etc) JBS facilities at locations where JBS's will likely continue to be operated (for SMP, due to low turbine survival, transport program objectives, etc)	KEEP 1) CLARIFCATION: "JBS facilities" to include "JBS systems, such as screens"; 2) Prioritize improvements at JBS facilities where the JBS's will be operated.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Adult Salmon and Steelhead	Improve adult ladder passage through modification of adult trap and adult trap bypass loop (potential for structural and operational changes)	Oregon would likely recommend retaining this mitigation action when and where it would be beneficial. More detail on the where and why of implementation would help clarify potential action efficacy.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.
–	Improve hydraulic conditions in fishways, e.g., reduce velocities and radius corners, to benefit adult LR	ADD Measure has been implemented and shown to be a benefit.	–	–
resident fish	Improve natural and "normative" flows to improve life stages for native resident fish	Keep	–	This should be for all native species (i.e. sturgeon, bull trout, cutthroat, redband, whitefish, etc.)
–	Improve tributary channels to provide safe fish passage through drawdown zone	Increased duration of drawdown Lower reservoir elevations	–	Migration to and from tributaries and Lake Roosevelt is physically inhibited by channels within drawdown zone Increased predation of juveniles/adults as they migrate to/from tributaries through drawdown zone
Sturgeon	Improve White Sturgeon populations in the impounded river sections by improving flow and Spawning conditions	Oregon strongly supports further development of operational and/or structural mitigation actions to return the hydrograph to a more normative (pre-hydrosystem) pattern.	–	Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.
general	Improved monitoring capabilities, so we know how these changes are truly affecting fish i.e. the new spill levels and changes, hydrograph changes. Improved monitoring could improve the accuracy of inriver survival estimates (mitigate reduced accuracey of estimates due to higher spill levels, etc.) and better assess the latent mortality hypothesis for juveniles (basis for the Flex Spill operation). Invest in more spillway PIT detectors at LGR, MCN and BON and the Ice & Trash Sluiceway at TDA. Invest in setting up the PIT barge system below Bonneville and in optimization of the new PIT trawl design.	–	–	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	In most all cases, significant time and large-scale efforts at tributary habitat restoration are required to yield substantial benefits. The Action Agencies should consider the effects of a long-term tributary habitat improvement implementation strategy designed to more fully address limiting factors for particular populations over a time period that reasonably considers limitations on annual implementation capacity and other factors. Life-cycle modeling results for spring Chinook salmon in the Grande Ronde and Catherine Creek populations, for example, demonstrate that long-term, strategic implementation of habitat improvement actions can have marked effects (see Pess and Jordan et al., in press). The Action Agencies should ensure that their NEPA analysis includes consideration of long-term, strategic implementation of habitat improvement actions.	Offsite mitigation for impacts of hydrosystem to abundance, productivity, and survival.	–	See 2019 CRS BiOp, Conservation Recommendation #14
–	Increase Access to fish habitat and the tributaries	*Oregon assumes this mitigation action envisions remediation of existing artificial fish passage impediments? If so, Oregon is supportive of retaining this mitigation action. *Modify operations or construct habitat projects to flush out tributary mouths in Kootenai River, Lake Roosevelt, Upper Lake Pend Oreille/Clark Fork River, and other known areas where aggradation may be occurring.	–	–
–	Increase artificial production capacity	Increased water outflow Decreased water residence time	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
Piscivore Control	Increase dam angling at all 8 CRS projects	–	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
–	Increase discharge capability at Libby Dam for sturgeon flow with addition of 6th turbine	Keep	–	
Piscine Predator Control	Increase harvest of invasive fish	Not enough detail to evaluate. The action agencies do not have authority to regulate harvest, but his could be done by others.	–	*Outside authority of action agencies to implement, but could potentially be implemented by others

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Increase hatchery production for steelhead	–	–	only if this measure is intended to ensure all mitigation targets are met (which they aren't now). Increasing hatchery production should be tied to a specific mitigation obligation. Unclear what the effects of the action would be. No action would maintain current mitigation activities.
–	Increase likelihood of refill at storage projects that provide downstream water temperature management	Oregon strongly supports further development of operational and/or structural mitigation actions to optimize flow augmentation particularly of cold water for cold water fish	–	Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.
–	Increase liklihood of refill at storage projects that provide downstream flow mangement	Storage reservoirs that provide increased flow for juvenile and/or adult migration also need to be priority to refill for resident fish, cultural resources and subsequent year flow/temperature modulation	–	–
–	Increase Sea Lion hazing of both stellars and California outside of current management time frame.	This is being considered in the current 2018 BiOp so should be included in the CRSO	2018 BiOp	The NPCC and all regional co-managers worked together to help facilitate an amendment to the MMPA to legally allow this mitigation action. The Action Agencies should immediately adopt this mitigation action as a measure in each of the Alternative currently under consideration.
–	Increase Selective Withdrawal Gate temperature management flexibility (enable capability to provide a normative river thermograph)	Oregon strongly supports further development of operational and/or structural mitigation actions to optimize water temperatures for cold water fish	–	Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.
–	Increase shoreline vegetation for habitat and shading	KEEP if feasible	–	*Managing reservoir elevation (promote wetlands and grow riparian vegetation on shorelines) *Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. Managing reservoir elevation (promote wetlands and grow riparian vegetation on shorelines) *Managing reservoir elevation (promote wetlands and grow riparian vegetation on shorelines). Consider development or expansion of existing cottonwood galleries.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Increase spillways	CLARIFICATION / KEEP: Good idea if bays are reconfigured to aid fish passage	–	–
–	Increase the turbidity of water in the mainstem Columbia River at key locations by introducing biologically inert dyes or small colloidal sediments to the water column (spillways). Increasing turbidity would reduce predation rates and make turbidity levels closer to the pre-dam condition.	–	Slide 27 - https://www.westcoast.fisheries.noaa.gov/publications/col_basin_partnership/jun_7_wrkshp/6.7.2016_hydro_1_-_cbp_workshop_ritchie_graves.pdf	Dams generally increase water clarity by reducing the amount of fine sediment et. In the water column.
–	Increase use of spillway Weirs at projects -	–	–	–
–	Draft GCL and maybe upstream storage projects slightly deeper by April 10 or completely eliminate the April 10 requirement. Potentially lower the April 30 elevation as well.	This measure would a) help to alleviate reductions in power generation b) reduce April flows thereby permitting a higher percentage of spill within the TDG parameters which would lead to lower PITPH and would help fish	–	–
Juvenile Salmon and Steelhead	Install deterents to fish entrance of draft tubes when not in operation	Keep. A lot of efforts at this have been tried and failed… is this new ideas, or old (failed) ideas again? If former, need specificity, if latter, remove.	–	–
Piscene Predator Control	Install deterrents to minimize predatory fish holding near intakes (e.g., around trash racks) and exits	–	–	–
general	Install exclusion screens at DWR during turbine testing to avoid steelhead mortality	–	–	–
general	Install fish friendlier units (e.g. IHR unit 2,3) with modified draft tubes at all dams	–	–	–
Adult Salmon and Steelhead	Install North Jetty at LGO. Remove Peninsula at LGO to break up the hydraulic fence at high spill	–	–	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
juvenile salmon	Install surface collection/weirs along the dam face of all powerhouses to provide directed fish passage into a gentle graded channel (like the Bonneville PH2 Corner Collector) that delivers fish beyond tailrace boat restricted zones. This could improve collection of surface oriented fish while removing passage concerns associated with tailrace eddies or unstable flow vectors associated with dam operations.	Oregon supports reducing powerhouse passage rates by providing alternative passage routes that avoid turbine and bypass routes though the powerhouse structure. Developing surface collection channels along the face of the powerhouses that direct emigrants to a gentle sloping bypass channel (like Bonneville 2 Corner Collector) could aide in improving juvenile survival for more surface oriented fish while covering more area than an orifice cut in the concrete of a powerhouse.	***In part, for emphasis***: Johnson, G. E., S. M. Anglea, N. S. Adams, and T. O. Wik. 2005a. Evaluation of a prototype surface flow bypass for juvenile salmon and steelhead at the powerhouse of Lower Granite Dam, Snake River, Washington, 1996–2000. North American Journal of Fisheries Management 25:138–151.; Evans, S.D., N.S. Adams, D.W. Rondorg, J.M. Plumb and B.D. Ebberts. 2008. Performance of a prototype surface collector for juvenile salmonids at Bonneville Dam's first powerhouse on the Columbia River Oregon. River Research and Applications 24: 960–974 DOI: 1002/rra.1113; Gary E. Johnson, Fenton Khan, John R. Skalski & Bernard A. Klatte. 2013. Sluiceway Operations to Pass Juvenile Salmonids at The Dalles Dam, Columbia River, USA, North American Journal of Fisheries Management, 33:5, 1000-1012, DOI: 10.1080/02755947.2013.822441	This will not eliminate the need for powerhouse bypass operations, because deeper oriented emigrants will continue to require fish mitigation for passing powerhouse. This addition should be equipped with PIT detection capabilities and potentially include collection capabilities for Smolt Monitoring Program operations. All must be equipped with a channel similar to Bonneville 2 Corner Collector that delivers fish downstream of the tailrace, especially where tailrace conditions are considered to be a concern for delay.
Avian Predator Control	Install wire array to dissuade piscivorous waterbirds at McNary	KEEP. If avian wires don't exist at McN, then install.	–	–
Avian Predator Control	Install wire array to dissuade piscivorous waterbirds such as McNary and improve wire arrays at other locations where avain predators are problematic.	–	–	–
–	Intake fish screens	–	–	Need to improve to reduce impingment and entrainment by species other than salmon (e.g., Pacific lamprey macrothalmia).
Invasives	Invasive aquatic vegetation control	Lower reservoir elevation Increased duration of drawdown	–	Increased predation due to reservoir conditions benefiting predators resulting from increased predator/prey proximity during drawdown, and increased area and biomass of inundated vegetation upon refill
Adult Salmon and Steelhead	John Day: Replace or totally rebuild south fish ladder auxiliary supply system,	–	–	–
Avian Predator Control	Lethal control of persistant avian predators at key hot spots(e.g. egg oiling and adult removal) example location TDA.	Currently Walla Walla District employs lethal control at their projects but PDX projects do not. This would make current hazing programs more effective.	https://plan.critfc.org/ Evans, A., Q. Payton, B. Cramer, K. Collis, N. Hostetter, and D. Roby. 2019. System-wide effects of avian predation on the survival of Upper Columbia River steelhead: Implications for predator management. Draft Report submitted to Grant County Public Utility District No. 2 and the Priest Rapids Coordinating Committee.	–
Piscivore Control	Lethal removal of gulls at all projects	–	–	–
predation	Lethally take avian predators at CRS projects	ADD Lethal control is authorized at NWW projects but not NWP projects. Lethal control has been effective at NWW projects.	–	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
resident fish	Limit use of spillway to avoid bull trout entrainment at Libby	Not enough detail to evaluate.	–	*Oregon needs more detail about this mitigation action prior to making a technical recommendation. *Study entrainment reduction methods, including this method. Also, developing a downstream passage route?
Steelhead	Look at adding modified Surface Spill bays (long verticle slots) similar to those at Rock Is. These could be used outside the spill season to aid overshots and kelts but use less water.	This would allow for protection of overshots and kelts but use less water and be more effient with water usage.	–	–
Chinook - adult	lower flows in the John Day tailrace to promote fall chinook spawning	to increase fall chinook populations in this section of the river which was a major spawning location for fall chinook.	https://plan.critfc.org/	–
Adult Salmon and Steelhead	Maintain estuary water levels that promote fish passage - unclear; passage into rearing tributaries below BON?	KEEP. Consider for Chum access to spawning channels.	–	–
Predation	Maintain high water flows with minimal river islands/decrease island habitat (island use by pinnipeds) and island use birds	–	–	This might be helpful upstream of BON, but not for pinnepeds since they are downstream of BON. which islands are being used by pinnipeds or how project operations can decrease island habitat.
–	Maintain less than 1 degree Celsius differential (fish ladders)	Keep	–	*Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. *This may be critically important in summer months for migrating sockeye.
Juvenile Salmon and Steelhead	Maintain water levels that promote fish passage and access to habitat	KEEP. Affirmative - off-set loss of shallow water habitat in the estuary	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.
Avian Predator Control	Manage avian nesting habitat to reduce predation losses to avian predators - predation management	CLARIFICATION: "Manage avian nesting habitat" on USACE property means altering the habitat or processes surrounding those habitats to preclude nesting by avian colonies known to predate on juvenile salmon (e.g., cormorants, terns, gulls, etc.)	–	–
Avian Predator Control	Manage avian nesting habitat to reduce predation losses to avian predators - predation management at the inland cites as identified in the inland avian management plan	Currently the Inland management plan dealt with limited species and locations, additional locations such as Blalocks Terns and Miller Rocks gulls are continued locations of problem predation.	Inland Avain Plan	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Manage flows at Libby to improve passage at downstream tributaries	–	–	Determine if altered flows or flows during certain timing might provide better flushing of aggrading sediments at downstream tributary mouths.
–	Manage reservoir levels (keep high) to minimize available nesting habitat on Blalock Island complex	High avian predation rate from this colony seen on steelhead smolt	–	–
–	Manage reservoir levels to protect spawning areas	–	–	–
–	Managing for stable reservoir elevation (promote wetlands and grow riparian vegetation on shorelines)	Not enough detail to evaluate. Although this measure may be beneficial at a localized scale or at certain locations for fish, it may also introduce difficulties with operations such as MOP and MIP and therefore carry with it important resource trade offs. Oregon recommends this mitigation action be explored further from the perspective of scope, location, time, potential trade offs, etc. before moving it forward or deleting it at this time.	–	*Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. *A stable reservoir elevation is a crically important mitigative measure for a multitude of fish and wildlife species.
avain predator	maximize flow and reservoir elevation to prevent nesting of piscivorous birds in all reservoirs, particularly JD	Unmanaged Caspian terns, gulls, and other piscivorous water birds need to be controlled via river flows to prevent nesting and population increases.	https://plan.critfc.org/ Evans, A., Q. Payton, B. Cramer, K. Collis, N. Hostetter, and D. Roby. 2019. System-wide effects of avian predation on the survival of Upper Columbia River steelhead: Implications for predator management. Draft Report submitted to Grant County Public Utility District No. 2 and the Priest Rapids Coordinating Committee.	–
–	maximize storage of cold water at DWA, LIB and CJO	*Keep. *Oregon strongly supports further development of operational and/or structural mitigation actions to optimize flow augmentation particularly of cold water for cold water fish	–	*If Climate predictions become realized we will need all the cold water we can get. Even with MO3! This is probably a Key recover component. *Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.
Adult Salmon and Steelhead	McNary: Replace or rebuild auxiliary water system	–	–	–
–	Mimic natural hydrograph (ops) (including in the estuary)	*See Ecosystem Function description from Columbia River Treat discussions *Oregon strongly supports further development of operational and/or structural mitigation actions to return the hydrograph to a more normative (pre-hydrosystem) pattern.	–	*Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. * A more normative hydrograph will provide the outmigration conditions necessary to optimize smolt survival

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	minimize pool level variability	Not enough detail to evaluate. Although this measure may be beneficial at a localized scale or at certain locations for fish, it may also introduce difficulties with operations such as MOP and MIP and therefore carry with it important resource trade offs. Oregon recommends this mitigation action be explored further from the perspective of scope, location, time, potential trade offs, etc. before moving it forward or deleting it at this time.	–	Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.
Predation	Minimize predation	–	–	Support northern pike, walleye, and lake trout removal projects across basin.
Predatio	Minimize predation of early life stages of White Sturgeon	–	–	–
Predation	Minimize predation on adult White Sturgeon by pinnipeds	Keep	–	–
–	Minimize reservoir fluctuations		–	–
Adult Salmon and Steelhead	Modify DWA spillway to reduce TDG levels during spill	Keep	–	–
Adult Salmon and Steelhead	Modify existing adult trap configurations and use to reduce handling stress	Keep	–	This may be important to bull trout handling at some facilities as well.
–	Modify flow by reducing irrigation to increase flow (reallocation)	Several MO alternatives appear to include Water Supply operations that cannot be currently delivered due to lack of infrastructure and demand. This measure could be meant to identify that water savings and return it to the river for the purpose of modeling benefits to fish. This measure could also be used to support the Columbia RIver Transaction Program, funded by BPA to purchase water rights from willing irrigators and provide additional flow for fish. Keep this measure but clarify its purpose.	–	Reducing water withdrawals will benefit fish, but will also benefit hydropower by keeping water in the river, thereby offsetting some of the power lost to spill. For example, water taken out at the Columbia Basin Project (Grand Coulee) for water supply does not go through 11 hydropower projects, including 6 Federal projects. Keeping this water in the river improves fish survival and helps the power system.
–	Promote streamflow restoration through improved operational efficiencies (irrigation and municipal) and voluntary water transactions.	Oregon strongly supports further development of flexible mitigation actions that can be applied in dry/warm water years	Columbia Basin Water Transactions Program https://www.nfwf.org/cbwtp/Pages/home.aspx	Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences
Adult Salmon and Steelhead	Modify LGR trap to reduce impacts to non-target fish; improve the BON AFF system so fish don't dewater	–	–	–
Lamprey	Modify or remove ESBS so they do not impact lamprey	–	–	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Lamprey	Modify project operations to allow larval lamprey (ammocoetes) in shallow water rearing areas to safely move to deeper water as water surface elevation drops.	KEEP. Reasonable measure to allow LR to move as wse is reduced.	–	–
Lamprey	Modify spill operations to improve passage and survival of juvenile lamprey (through all routes) during pulses of outmigration (freshets).	CLARIFICATION: Assume this means project operations. Keep. Measure has been discussed but not yet implemented.	–	–
juvenile salmon	No transport of juvenile fish	Not enough detail to evaluate.	–	*Oregon needs more detail about this mitigation action prior to making a technical recommendation. *We believe that if the juvenile salmon remain in the river, we can optimize spill during the migration season, and maximize the benefits of whatever spill regime is established.
–	Non-native predator control	Increased water outflow Decreased water residence time Reduction in storage	–	Removal of pike and other non-native predators for the benefit of native species and prevention of downstream distribution. Increased predation due to decreased storage by increasing proximity of predators and prey and reducing shallow water habitat for juvenile fish.
–	Nutrient enhancement in tributaries upstream of Dworshak Reservoir to mitigate for the effects that annual drawdown is having on shoreline productivity in the reservoir.	–	–	–
Adult Salmon and Steelhead	Open Corner Collector March 1 to improve kelt survival at Bonneville Dam	–	–	–
Salmon and steelhead	Operate John Day reservoir at Minimum Operating Pool (MOP)	Opportunity for improved juvenile out migration, improved habitat for wildlife, potential to reduce predation, etc.	Previous FCRPS EIS	Not enough time to research specifics but this action has been discussed and analyzed in previous processes.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Ops for temp	Keep. How different is this from NAA? Delete? Maintain Dworshak operations for mitigating temperatures during fish migration.	–	*In particular Dworshak Reservoir can be used to keep the Snake from irreversible warming in August and Early Sept. Which is somewhat considered, may even be needed for MO3 operations. If we are solely looking at fish benefits, and not power production, which is this metric, then we need to operate for favorable temperatures. In the past we have experienced adult steelhead thermal block in the snake in late August and Early September. We now also have a sockeye program with a summer timing in the snake. Water temperatures in the Snake is likely a critical component of recovery. *Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. *Managing cold water will continue to be an important consideration for hydropower operations.
sturgeon	Optimize dam flows for White Sturgeon spawning and early life stage survival	To create spawning habitat (ie flow, stable hydrograph, and temps) to create conditions that will benefit sturgeon production in tailrace reaches for all reaches that have populations of white sturgeon. M&E: Investigate sturgeon flows in lower river to encourage spawning	https://www.nwcouncil.org/sites/default/files/ColumbiaBasinWhiteSturgeonPlanningFramework2013Dec_0.pdf	*Assuming this is meant for dams other than Libby. More research on this topic is needed, but flows for white sturgeon are critical to spawning and rearing. *Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.
–	Outlet exclusion	Not enough detail to evaluate.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.
Lamprey	Passage structures for lamprey at all facilities across range	–	–	–
–	Prior to the spring migration, dredge and deepen river mouths if existing deltas create shallow predator feeding stations (i.e. Klickitat, Hood River, Umatilla, etc)	River operations have eliminated flushing flows that would remove this deltas. These pinch points expose outmigrating smolts to predation by avian and piscivorous predators. Mitigation actions are necessary to maximize smolt survival in a permanently altered habitat.	https://plan.critfc.org/	–
Adult Salmon and Steelhead	Provide money and support to harvest managers to develop improved harvest monitoring and reporting systems	–	–	*Outside the authority of action agencies to implement, but could potentially be implemented by others

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Steelhead	Provide spill in Fall and Spring to protect overshot adults and downstream migrating kelts. (McNary study is evaluating this for overshoots)	This is currently being planned for McNary. Past McNary work has shown that adults will used the RSW spill routes when they are opened. It is newest 2018 BiOp and should be added to the CRSO.	2018 BiOp	–
Adult Salmon and Steelhead	Provide surface spill outside of fish passage season for adult overshoot and kelt steelhead at all 8 dams	Keep	–	–
Juvenile Salmon and Steelhead	Pull Screens where turbine survival is high	Keep.	–	–
–	Purchase/improve supplemental spawning habitat outside area impacted by drawdown	Increased duration of drawdown Change in timing of drawdown with regard to spawning.	–	Dewatering of native species' eggs/redds
Lamprey	Quit messing with ladder entrances. LPS are the biggest benefit for lamprey	–	–	–
Juvenile Salmon and Steelhead	Reconfigure stilling basins (project specific) to higher elevation/less depth for plunging flows to limit TDG	Technically unlikely, potentially harmful to juveniles, and not as cost effective as improved flip lips	–	*Oregon needs more detail about this mitigation action prior to making a technical recommendation.
Juvenile Salmon and Steelhead	Reconnect mainstem and offchannel habitats	KEEP and CLARIFY. Reconnect and restore mainstem and off-channel habitats to off-set reduced inundation (and access to) shallow water habitats resulting from (anticipated - TBD) preferred alternative. In kind, in place mitigation. Develop mainstem habiat projects that provide rearing and holding habitat for juvenile and adult migrating fish. In kind, in place mitigation. Develop mainstem habiat projects that provide rearing and holding habitat for juvenile and adult migrating fish.	–	Reconnection of side channel and floodplain habitats through land acquisitions and habitat improvement projects
–	re-design spillway to mimic normal step-pool/waterfall elevations. Look at stepped spillway (MSH SRS?)	Not enough detail to evaluate.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.
–	Reduce and/or characterize water quality at the outflows from irrigation waters	Unknown levels of discharge both flows and contaminants from irrigation waters into Columbia, Snake and other waters likely impact spawning, rearing, and foraging success of salmonids and other resident species.	–	–
Juvenile Salmon and Steelhead	Reduce fish handling at bypass locations	–	–	–
Juvenile Salmon and Steelhead	Reduce fish handling at Little Goose JFF	–	–	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Juvenile Salmon and Steelhead	Reduce fish handling at Lower Monumental JFF	–	–	–
Lamprey	Reduce hydrosystem effects by modifying structure and operations as needed to increase upstream passage efficiency for adults of all four species of lamprey to achieve increased escapement, better distribution, and increased spawning success. Identify and remediate any locations where weirs cul-de-sac or other structural deficiencies are accumulating delayed adults.	Keep	• Pacific Lamprey (Entosphenus tridentatus) -- Anadromous • Western River Lamprey (Lampetra ayresii) -- Anadromous • Western Brook Lamprey, (L. richardsoni) -- Resident • Pacific Brook Lamprey, (L. pacifica) –Resident	–
–	Reduce impoundments, stream restoration to reduce impacts to stream channels	Keep	–	–
–	Reduce load following limited to +/- 5% on the big 10	Keep	–	*Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. *Operations for peaking at Lower Snake and Lower Columbia plus CHJ and GCL. may only be necessary during the smolt migration season.
–	Reduce or eliminate areas of hard armoring/levees	Identify areas where levee setbacks could occur, or replace hard amoring (riprap) with "soft" or natural armoring to increase refugia for resident fish and improve migration habitat.	–	*If not on Corps or BOR owned land, then this action would be outside authority of action agencies to implement, but could potentially be implemented by others
Adult Salmon and Steelhead	Reduce passage of non-native species through selective modification of ladders (e.g., American shad, shrimp)	KEEP. Good idea. Reframe as an investigation (research)? Can dams be modified to reduce shad populations in Columbia?	–	American shad are non-native species that likely consumes a large biomass of productivity in the Columbia Basin that could be utilized by endemic species and should be reduced in abundance. However, short-stopping their adult migration through ladder modifications may result in large numbers of shad occupying the ladders and negatively impacting adult salmonid passage. Consider other strategies to effectively reduce shad abundance.
Piscene Predator Control	Reduce predatory fish habitat through reduction of non-natural structures (e.g., removal/modification of large riprap structurs, pile dikes, in-water structures, etc), flow/velocities changes (reduce spawning, recruitment, etc)	CLARIFICATION: Omit reference to off-channel habitats. These areas do not necessarily invite predators. See comment above regarding "softening shorelines".	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Piscene Predator Control	Reduce predatory fish through reductions in spawning, rearing, foraging abilities - predation management	KEEP but CLARIFICATION: USACE led habitat management could only occur on USACE managed lands or authorities.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.
–	Reduce the amount of water level fluctuations in dam tailraces-(for sturgeon this would be directed to early life stage development time)	Keep	–	Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.
–	Relax storage reservation diagram at 6 FRM projects	–	–	*Needs explanation on what this is *Has the potential to increase flood risk downstream and likely only feasible during normal to low water years. *Oregon needs more detail about this mitigation action prior to making a technical recommendation.
general	Remove JBS screens in the event that fish friendlier units demonstrate high survival rates	–	–	–
Piscivore Control	Remove Miller Rocks nesting habitat via blasting, rock removal, or other means to reduce habitat availability for bird colonies in TDA pool.	–	–	–
Piscene Predator Control	Remove non-native species and piscine predators passing through/residing in Juvenile Bypass Structure - predation management	KEEP but do not believe this is within USACEs authority. Could coordinate with States.	–	*Surprised we are not doing this already. *Oregon needs more detail about this mitigation action prior to making a technical recommendation.
Adult salmon and steelhead	Remove or reconfigure AFF at Bonneville	ADD AFF delays fish passage and potentially increases mortality.	–	–
Adult Salmon and Steelhead	Remove Shad from adult fishways to reduce stress on summer migrating adults.	–	–	–
–	Remove the double crested cormorant colonies that currently nest on the Troutdale BPA towers. There are hundreds of birds nesting and roosting on the towers, consuming smolts at a much higher rate than birds in the estuary due to lack of prey diversity.	Unneccesary loss of listed smolts , protection of a known salmonid predator, destruction of historically registered structures, a no-brainer to remove this colony.	DDC 2015 EIS	BPA Power Division knows about the problem, but lack the proper motivation from BPA administration
Avian Predator Control	restore barren deltas to forested deltas to maximize safe smolt passage	–	Cite work by Bill Sharp, YKFP, Yakama Nation	these deltas are death traps with shallow water and access by avian predators
–	Restore mainstem habitat through increased habitat complexity (rapid, riffle, run, pool), shallow water rearing habitat connectivity, temperature reduction, riparian function restoration, restore ecosystem processes	–	–	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Restore/enhance thermal refugia at mainstem confluences	–	–	develop projects and prioritization for improving LWD recruitment, habitat complexity, nutrient enhancement, and refugia in mainstem rivers downstream of projects
–	Restore/enhance thermal refugia at mainstem confluences in the lower Columbia River	–	–	thermal refugia are import for the survival of upstream migrating adult salmon and steelhead. We expect that these locations will become even more important given expected temperature increases due to climate change
–	Selective outlet withdrawal for D/s temp	–	–	Keep. This should be tested and implemented at all possible CSRO projects to combat climate change in-river.
–	Selective spillway bay use (which gates lift)	–	–	*Recommend managing adaptively thru existing operational forums. *Oregon supports further development of spill patterns which minimize unintended adverse consequences to fish.
General?	Slow down speeds of the ships on the Columbia River to reduce the size of waves that wash fingerlings up on beaches where they become stranded along the river.	–	–	*Outside authority of action agencies to implement, but could potentially be implemented by others *Not clear what species this action would be aimed at. Need more information/documentation that this is an issue.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Snake River Spring time spillway crest drawdown	Should dramatically improve Snake River Chinook, steelhead,and sockeye SAR's through reduced travel time, reduced predation, reduced energy expendature, and reduction of powerhouse direct and delayed mortality. During mid-summer through winter would allow for barge transportation and full power production during time of year when hydropower is more important and valuable to region. Would also assist with seditment management in the Snake and Clearwater rivers confluence area.	COE sediment management plan for the Lewistion/Clarkston area. COE drawdown report. Any Snake River Breach report since would likely provide most of the biological benefits of breaching the 4 LSR dams while still allowing for most of the economic and reservoir recreation benefits of current configuration and operations. Congelton reports from 1990's showed that in-river Snake River juveniles arrive at Bonnevile Dam in a depleted energy condition.	Reduced travel time throught increase water velocity by dramtically reducing cross sectional area of each reservoir to allow smolts to arrive at esturary during more normative timeframe. Predation reduction would occur with dramatically increased spring turbity levels, disruption of piscivorous fish spawning and reduction of their suitable habitat and therefore populations, and reduced juvenile travel times. Juvenile evergy expendature would be reduced by them being able to naturally drift downstream with the increased velocities instead of having to actively swim through slower reservoir velocities. Powerhouse direct and delayed mortality would be reduced through reduced powerhouse encounter probabilities as well as less strikes and pressure changes for those juveniles that do enter a powerhouse. At spillway crest could potentially open locks as a primary alternative juvenile passage route, and possibly roughen the bottom of the lock so it could serve as an adult passage route during drawdown. COE Engineers would need to determine if best to operate high head turbines at lower head, speed-no-load, or shut off. Could consider replacing 2-4 of high head turbines with those designed for drawdown operation since generally only can operate fewer high head turbine summer through winter.
–	Spill Increase to maximize SPE (shouldn't change hydrograph) to improve juvenile fish passage	Keep	–	This sounds like it may be synonymous with the measure in MO4 originally proposed by the Nez Purse to minimize Power House encounters project by project. If so, Oregon supports further development of this mitigation action.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Spill outside fish passage season	May be advisable to address kelt and overshoot downstream passage needs	–	*Need more discussion/clarification on how, where, and when to achieve desired outcomes. Operations for peaking at Lower Snake and Lower Columbia plus CHJ and GCL. *Spill should be considered for downstream passage of steelhead kelts and bull trout adults outside the timeframe for smolt migration. Downstream movement of adult bull trout may be an important issue on the Lower Snake River. There is a need to identify how to facilitiate adult passage during the "non-spill" season.
–	Stop all Spillway spill to improve adult fish passage	–	–	* In general, spill should not be reduced during the outmigration season unless it is clear that spill is causing a delay in adult passage for salmon, steelhead, and bull trout, and that the delay may result in pre-spawn mortality of salmon or delays in forage/migratory movements of bull trout. *Oregon believes implementation of this mitigation action would result in severe reduction in juvenile salmonid survival and a severe decrease in life cycle survival as measured in SARs.
–	Support artificial propagation programs that provide harvest, and conservation efforts for salmon and steelhead	Artificial propagation is necessary to partially offset CRSO impacts to harvest, conservation and Tribal cultural/subsistence.	–	Unclear what the effects of the action would be. No action would maintain current mitigation activities.
Piscene Predator Management	Support non-native fish derbies	NEW	–	*Outside authority of action agencies to implement, but could potentially be implemented by others *Fish tagging w/reward. Other rewards. Harvest proportionally larger fish. Low cost.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	The effectiveness of tributary habitat improvement actions can be enhanced when actions are implemented consistent with best available science and within a within a strategic framework that places near-term actions within a long-term strategic objective and plan. The Action Agencies should work through the Tributary Habitat Program Steering Committee to help maximize the effectiveness of tributary habitat improvement actions in terms of their benefits to targeted populations and to ensure implementation of the program in a manner consistent with long-term recovery goals. Efforts should include (a) ensuring that actions are prioritized, sequenced, and implemented actions consistent with approaches recommended in best available science on watershed restoration (see, e.g., Beechie et al. 2008, 2010; Hillman et al. 2016) and (b) working with NMFS, through the tributary habitat steering committee and the Columbia Basin RM&E steering committee, to improve alignment between tributary habitat improvement actions prioritized for implementation and NMFS focal populations (Cooney, in press).	Offsite mitigation for impacts of hydrosystem to abundance, productivity, and survival.	–	*See 2019 CRS BiOp, Conservation Recommendation #13 *The action alternatives have minimal to no impact on tributaries, and therefor are not anticipated to have mitigation. Fish impacts will first look at inplace inkind mitigation opertunities.
–	The Northwest Power and Conservation Council's Fish and Wildlife Program is in its 47th year. It follows the Northwest Power Act, 16 USC 839b (h). The Program mititagation measures must be included in the EIS, which is otherwise flawed for failing to take the Program into account at this relevent stage of the Action Agencies decision making process. 16 USC 839b (h)(11)(A).	–	The Norwest Power and Conservation Council Website.	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Lamprey	The Tribal Pacific Lamprey Restoration Plan sets forth near term and long term plans for mitigating the effects of the Corps dams on Pacific Lamprey. All of the mitigation measures in this plan should be addressed in the mitigation section of the EIS. Detailed implementation schedules have been developed by the Corps/Tribal Lamprey Technical Team and the individual actions within this plan should be listed in the mitigation measures	–	https://www.critfc.org/fish-and-watersheds/columbia-river-fish-species/lamprey/lamprey-plan/	–
–	To mitigate for high levels of kokanee entrainment at Dworshak Dam, emphasis should be put on maintaining the nutrient restoration program that occurs in the reservoir. This program has proven successful in maintaining higher numbers of kokanee in the reservoir and shortening the amount of time it takes the kokanee population to rebound from significant entrainment events. To shorten the amount of time it takes kokanee to rebound from a significant entrainment event, supplementation should also be a mitigation measure to be considered.	–	Wilson, S. M., and M. P. Corsi. 2016. Dworshak Reservoir nutrient restoration research, 2007-2015. IDFG report #16-22, Boise, ID.	Due to flood risk management at Dworshak Reservoir there are years when entrainment to kokanee can be significant (>80% of the entire population). Not only does this influence kokanee abundance in the reservoir for multiple years but it also influences smallmouth bass (and likely Bull Trout) growth and abundance, and stream productivity where kokanee spawn.
–	To mitigate for the effects that annual drawdown is having on shoreline productivity and survival of littoral species, emphasis should be put on maitaining the nutrient restoration program. In addition, investigations could occur to evaluate if there are aeas where shoreline habitat could be modified to provide population level effects for certain fish species.	–	–	Annaul water level fluctuations at Dworshak typically reach 80 feet. This annual drawdown has significantly reduced shoreline productivity and survival of critters (fish/crayfish/insects) that are more shoreline oriented.
UCR spring chinook; UCE steelhead; mid-C steelhead; SR Sp Chinook; SR steelhead.	Transport juvenile salmonids from McNary Dam in spring.	*Of collected UCR Spring Chinook and UCR Steelhead 20% more would retun as adults if transported rather than bypassed. *For those Columiba River summer outmigrants collected 11-17%, more could be expected to return as adults if transported.	*Marsh et al. 2011 *Axel 2009	–

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
Juvenile Salmon and Steelhead	Tributary habitat protection/enhancement to promote increased juvenile salmonid	There will always be some level of motality and adverse impacts to juvenile and adult migrants as a function of the CRSO. Increasing juvenile production increases as a result of habitat mitigation measures will partially offset the 'unavoidable" impacts of the CRSO	–	–
–	Tributary restoration to improve habitat and channel complexity	Increased duration of drawdown Lower reservoir elevations	–	Migration to and from tributaries and Lake Roosevelt is physically inhibited by channels within drawdown zone Increased predation of juveniles/adults as they migrate to/from tributaries through drawdown zone
Adult Salmon and Steelhead	Update and maintain fish ladders, pumps, and turbines to reduce outages and impacts	–	–	–
–	Upstream fish passage for adult salmon	Increased water outflow Decreased water residence time Extension of drawdown period. Delay of refill.	–	Entrainment/removal of mitigation fish which has already been documented to have not mitigated for the loss of anadromous species (NPCC 2000). Reduction of in-reservoir primary and secondary productivity which translate to reduced forage base for the mitigation fishery. Anadromous fishes accumulate the majority of their biomass in the ocean, reducing the importance of in-reservoir production.
Piscivore Control	Use findings from upcoming Avian Predation Synthesis Report to develop a conceptual management plan for warranted actions that would further reduce the size of piscivorous waterbird colonies at human created or influenced sites in the Columbia basin for the purpose of reducing predation rates.	–	–	–
Piscivore Control	Use green lasers or other dissuasion methods to discourage avian predators from roosting, foraging or loafing at hydro project infrastructure, resulting in reduction of predation on juvenile salmonids.	–	–	–
–	Use screening technology to preclude White Sturgeon from entering draft tubes	Not enough detail to evaluate.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.

Fish Type	Draft Mitigation Measure	Reason to addition	Citations	Notes
–	Use seasonal crews to conduct hazing/lethal control during spring outmigration at all hatchery release points, major trib mouth (Umatilla, Walla Walla, Yakima, etc), timed to maximize successful passage of hatchery, natural releases	Each spring, millions of smolts are consumed by avian predators throughout the basin. The predation near hatchery release points, river mouths, diversion dams, etc. is needless, wasteful, and can be mitigated.	https://plan.critfc.org/	The managed river has created these locations over time and therefore need to be properly mitigated for to maximize the regions investment in salmon recovery.
Passage/Structural	Use slot passageways (alternative to fish ladders)	–	–	–
Sturgeon	Use White Sturgeon conservation aquaculture to mitigate for population losses due to the hydrosystem	Oregon would be supportive of white sturgeon supplementation within the context of CRITFC's sturgeon Master Plan, but not otherwise.	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.
Piscivore Control	Where possible, use dredge spoils to connect avian island habitat to mainland making them unsuitable for nesting	–	–	–
Piscivore Control	Work with regional stakeholders to dissuade avian predators (terns and cormorants) from nesting on non-Federal structures (bridges, navigation towers, transmission towers, etc.).	–	–	–
Piscivore Control	Work with regional stakeholders to identify property ownership of Miller Rocks in TDA pool and implement warranted actions to reduce habitat availability for avian predators (gulls and terns).	–	–	–
–	Stop Harvest of listed fish	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.	*Outside authority of action agencies to implement, but could potentially be implemented by others *There is no direct harvest of listed fish other than tribal harvest through treaty right.
–	Allow only terminal harvest	–	Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.	Outside authority of action agencies to implement, but could potentially be implemented by others
–	Eliminate gill nets and allow harvest at fish ladders via trap	–	–	Outside authority of action agencies to implement, but could potentially be implemented by others
–	Eliminate mainstem harvest	–	Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.	*Outside authority of action agencies to implement, but could potentially be implemented by others *Implementation of this wholesale action would result in unintended consequences to listed-salmonids
–	Wy-Kan-Ush-Mi Wa-Kish-Wit is the Columbia River Treaty Tribes Spirit of the Salmon Plan. It contains numerous measures intended to mitigate the effects of the federal dams on anadromous fish.	–	https://www.critfc.org/fish-and-watersheds/fish-and-habitat-restoration/the-plan-wy-kan-ush-mi-wa-kish-wit/	–

1.1.3 Vegetation, Wetlands, and Wildlife

Draft Mitigation Measure	Reason to addition	Citations	Notes
Acquisition/deacquisition of Corps managed lands to ameliorate changes in wildlife habitat and recreational useage (coordinate HMUs with USFWS)	Add: The Corps needs to maintain activities at HMU's as part of operations. Additional Acquition of additional lands may be necessary to offset additional impact to riparian habitat (i.e. fill or conversion of habitat) if selected alternative has additional impacts. This additional acquition may be necessary through the Fish and Wildlife Coordination Act.	Lower Snake River Comp Plan.	Lower Snake River HMU's were created to offset the initial impact of building the dams in accordance with the Fish and Wildlife Coordination Act.
Maintain lowered winter flows at Libby and Hungry Horse Dams in years following high spring runoff to aid in the establishment of riparian vegetation.	MO4 would implement this measure with much more detail, but this more generic approach would provide beneficial mitigation for the other alternatives.	Merz (unpub data), Casey (2006), Braatne and Jamieson (2001), Auble and Scott (1998)	The more frequently you can meet these conditions, the more benefit from this mitigation measure. Irregular, periodic establishment of woody riparian vegetation will provide measurable benefits to the aquatic and terrestrial ecosystem. Similar benefits would result if this measure were incorporated in other dams with significant acreage of altered floodplain downstream of the hydropower project.
Buy up land in estuary for restoration to tidal wetlands	–	–	–
Continue to reconnect the estuarine floodplain (BON to mouth) to restore rearing habitat and increase flux of prey to the mainstem (support condition of outmigrants before ocean entry)	Added by L Krasnow (4/19/19) - see also measures for "Juvenile salmon and steelhead" in Fish tab	–	–
Create AIS field survey and removal season crews to Initiate annual removals of known and new occurences of invasive aquatic plants on within and on Federal property.	Invasive species and their associated impacts will be a permanent concern for the basin, increased monitoring will help with early dection and rapid response to eradicate and/or control. Similar to the need the reason for row 2, the problem is increasing and stable involvement by action agencies.	https://plan.critfc.org/2013/spirit-of-the-salmon-plan/technical-recommendations/invasive-species/ https://www.nwcouncil.org/fish-and-wildlife/topics/invasive-species https://www.westernais.org/monitoring	Well documented issues and concerns, need overall increase and participation by the action agencies on AIS Proposed under new tab "Aquatic Invasive Species"
Elk Foraging areas in storage dams	Add. Maintaining elk habitat by creating deer browse areas replaces lands lost by the storage dam projects. Dworshak does have lands dedicated to providing elk browse.	Management of the corps' forested lands surrounding the project has involved providing mitigation for some of the impacts under the Fish and Wildlife coordination Act (Public Law 85-624) and Department of the Army Engineer Regulations (ER 1105-2-129, ER 1120-2-400, and ER 1165-2-104).	–
Environmental flow (intentional overbank)	Add: This measure would restore relic floodplains by allowing them to flood, thereby restoring riparian areas and allowing cottonwood dispersal. It would regain connectivity. Could be used to mitigate for any cottonwood impacts. It may conflict with FRM. Used in the Williamette Valley to get high flow events to overbank. Hungry Horse, looking for bankful flows for the cottonwoods and gravel sorting. *Oregon strongly supports further development of operational and/or structural mitigation actions to return the hydrograph to a more normative (pre-hydrosystem) pattern.	Hoag 2001, Hoag and Landis 1999.	in both fish and wetlands *may be appropriate to restore riparian habitat, in particular cottonwood/willow; emulate natural hydrograph *Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish.
Estuary Habitat Improvements: Prohibit development within the estuary	–	–	*Outside the authority of action agencies to implement, but could potentially be implemented by others
Estuary Habitat Improvements:Reconnected floodplains throughout the river including a reconnected lower river estuary ecosystem	–	–	–
Habitat restoration.	Add. Habitat restoration for areas that were previous wetlands or other habitat types that are now managed for human use (i.e. they are currently in agricultural use).	–	–

Draft Mitigation Measure	Reason to addition	Citations	Notes
If drying out wetlands: creation or restoration of wetlands (wetland mitigation banks?)	Add. Can we create wetland mitigation banks along the Snake and Columbia River to serve multi-use projects? Can we restore wetland benefits for areas that are no longer wetlands (i.e. relic wetlands).	–	–
Increase shoreline vegetation for habitat and shading	Add: Add in areas where it may enhance the riparian buffer. It may not be appropriate in some sections of the project area (i.e. sagebrush areas).	–	in both fish and wetlands *Need more discussion/clarification on how, where, and when to achieve desired outcomes w/o other unintended consequences to fish. Managing reservoir elevation (promote wetlands and grow riparian vegetation on shorelines)
Minimize recreational events during nesting and breeding periods or near sensitive nesting sites	Jet boat races and other highly disrupting activities during nesting season.	–	*Outside the authority of action agencies to implement, but could potentially be implemented by others
Naturalize hydrograph / manage for environmental flows to promote survival and regeneration of riparian habitat downstream from dams	ADD: Managing flow regime in a way that mimics a natural river hydrograph can restore and revitalize riparian habitat and provide the best overall benefit and mitigation for environmental processes and wildlife in a dammed river system	Rood et al. 2005. Managing river flows to restore floodplain forests. Frontiers in Ecology and the Environment 3(4):193-201.	–
Prevention measures must be identified, assessed and implemented to stop the invasion and spread of zebra and quagga mussels, and invasive aquatic plants such as Eurasian mi/foil, hydrilla, and flowering rush. These measures should include, but are not limited to, education and public outreach efforts to promote awareness of the potential impacts and costs of a successful invasion, and the potential solution provided by required inspection, detection, and decontamination of boats previously moored in infested waters and then transported on our roadways in the region	Delete the zebra/quagga mussel component of this measure. This is more likely BMP's not mitigation. Add removal of flowing rush, reed canary grass, and other invasive aquatic plants as mitigation. This would be considered habitat enhancement as removing these invasive species can create an ecological lift in the environment by encouraging native vegetation, native animals, pollenators, etc. Areas where invasive species are being removed would likely need to be replanted with native species.	Federal Noxious Weed Act of 1974 (Public Law 93-629), the Carlson-Foley Act of 1968 (PL 90-583), and Executive Order 13112 (Invasive Species, 1999). Engineering Regulation 1130-2-540.	Invasive species have the potential to seriously disrupt the Columbia Basin ecosystem and critical infrastructure.
Provide funding for private landowners to do riparian fencing/improvement projects (Grants?)	–	–	*Outside the authority of action agencies to implement, but could potentially be implemented by others
Recreate the river pulse for cottonwoods.	Add. This would recreate the pulse necessary for cottonwood recruitment (spring freshet). This would only be needed in areas where it would be appropriate (areas that can sustain cottonwood habitat).	–	–
Reduce or eliminate avian predation control projects on native migratory birds	–	–	–
Trib Habitat Improvements	Focus mitigation on the Salmon and Clearwater basins, Idaho contains some of the best habitat in the Columbia River basin yet much of that habitat is not fully seeded.	–	–
Tributary restoration efforts?	Add. The tributaries provide wildlife habitats for animals and plants that utilize the mainstem of the Columbia and Snake River (i.e. beaver, otter, eagles, heron, osprey). More riparian habitat benefits can be provided on the tributaries.	–	–
Waterfowl habitat enhancement	Add. Waterfowl may be affected by loss of nesting habitat, loss of foraging areas due to water quality changes (i.e. temperature, turbidity). This mitigation measure would include creation of nesting habitat and foraging areas for waterfowl.	–	–
Winter Elk mitigation: This mitigation measure would provide enhancement of elk habitat to increase breeding success of elk populations as well as mitigation measures to prevent ice sheets from creating barriers to elk migration	Add. Elk migration in the storage projects can be treacherous during winter months because of the ice. .	Dworshak EIS	Changes in the reservoir levels as a result of project operation will resulting the ice covering being weakened along the shoreline. This will also cause problems for any animals venturing onto the ice since the dropping water levels and weakened ice will increase the chance of fall through.

1.1.4 Power and Transmission

Draft Mitigation Measure	Reason to addition	Citations	Notes
add RSWs or TSWs to reduce need for other spill	This measure would help offset loss in power generation but only if accompanied by a decrease in spill.	–	From a power perspective, this is only worth spending money on if there is an assurance that overall spill will be reduced because of the addition of the spillway weir.
expand range of operating pools, esp at LCOL and LSN	This measure would help offset loss in flexibility as well as offset increased costs for power.	–	*May be applicable at JDA only? Probably not anywhere else. do not surcharge due to dam safety *Operations measure may serve as mitigation for MOs that don't contain this measure. *Reducing restrictions on pool levels during certain seasons increases flexibility, thereby increasing the ability of FCRPS to integrate more non-hydro renewable energy.
fewer restrictions on ramping rates	This measure would help offset loss in flexibility as well as offset increased costs for power.	–	*Beneficial to generation if allowed to ramp down much faster than current rates. Some restrictions for bank sloughing need to stay - earthen embankment projects (don't ramp @ rate to slough) *This measure may serve as mitigation for MOs that don't already contain this measure. *Increasing ramp rates would allow BPA to better monetize the flexibility of federal hydropower by responding more quickly to changes in market conditions. Resources that can quickly ramp output up or down are increasingly valuable to integrate the output of more variable resources, such as wind and solar.
reduce restrictions on seasonal pool elevations	This measure would help offset loss in flexibility as well as offset increased costs for power.	–	*LSN-MOP, JDA-MIP *Operations measure may serve as mitigation for MOs that don't contain this measure. *Reducing restrictions on pool levels during certain seasons increases flexibility, thereby increasing the ability of FCRPS to integrate more non-hydro renewable energy.
Store more in spring, optimize hydrograph to the annual energy cycle (store more in the spring)	This measure would help offset loss in power generation as well as offset increased costs for power.	–	*subject to FRM *This measure may serve as mitigation for MOs that don't already contain this measure. *Power needs are different seasonally and are changing over time. For example, there is likely to be a growing need for increased summer generating capacity due to climate change. There is also likely to be less demand from California to import Northwest hydropower from excess spring runoff due to the abundance of solar power output at that time of year. Climate change is likely to influence changes in both demand and generation capacity into the future.
Add or modify resources (thermal, renewable, demand response, etc)	This measure would help to alleviate regional transmission congestion if added/modified in a location nearer loads.	–	This is outside of scope of the action agencies, but could be done by others.
Add price for carbon to all fossil-fuel generation to increase the value of hydropower	This measure would help offset loss in power rates.	–	This is outside of scope of the action agencies, but could be done by others.
Add transmission facillites (transmission lines, voltage reactor, RAS, etc)	This measure would help to alleviate transmission congestion and potential reliability issues.	–	This is in scope. We would not be able to determine where to determine impacts, site locations, but would include parametric costs.
Adjust (increase) minimum generation at Lower Columbia projects	This measure would help with transmission operations and reliability.	–	–
Adopt flex spill operation in the preferred alternative. Would need to choose what levels of spill are the upper and lower levels of spill	This measure would help offset loss in power generation, flexibility and reliability and would offset impact to power rates compared to spill that it at higher levels all the time.	–	–
Allow for flexibile draft target for Libby below 2420 ft at the end of December.	This measure would help offset loss in power flexibility.	–	This could be a compromise between the MO1/MO4 and the MO2/MO3 levels.

Draft Mitigation Measure	Reason to addition	Citations	Notes
allow spill curtailments to increase water available for generation to meet load during events with unusually high demand such as during summer heat-waves. (This would not replace much of the lost energy from new operations, but would help with reliability and reduce the need for replacement resources.) This could be only during emergencies or during driest X% of years or when flow is below y kcfs	This measure would help offset loss in power generation and reliability.	–	Note that this would be an operation separate from (or in addition to) flex spill. Flex spill would only be in the spring, and the bigger problem is in the summer. This measure is a more narrow version of the broader measure (currently in row 2 of the spreadsheet) "Decreasing/stopping spill (stop voluntary spill)"
average spill in 12-hour, 24-hour or shorter blocks. For example, in flex spill spring, average spill during the flex blocks and during the full-spill blocks. In the summer, average over 24-hours.	This measure would help offset loss in flexibility.	–	Adds flexibility to meet peak demands for power which is important for meeting load and for integrating other renewable energy sources in light of climate change.
Begin higher levels of juvenile fish passage spill later, when significant numbers of fish are in the river (e.g. start April 15, April 30 or start per fish count but only if also accompanied by 2-4 days' notice). Either no spill in the first part of April or spill to "performance standard" starting April 3/10.	This measure would a) help to alleviate reductions in power generation b) reduce TDG in early April and not "pre-gas" the river before significant numbers of juveniles show up.	–	Power would need 2 days' notice before fish spill starts (longer if it is right after a weekend) because power is marketed 1-3 days in advance. --mitigation measure also added to water quality for TDG impact
build LMS100 reciprocating plants instead of single-cycle and combined-cycle plants	This measure would help offset loss in flexibility.	–	LMS100 units are more expensive but also more flexible than the single-cycle gas plants
Change draft and refill timing in certain years, based on a prescribed trigger, to be earlier in response to climate change.	This may or may not help power generation. Would probably help FRM and fish	–	Not sure if this will be helpful (mitigation) or detrimental to power. drafting sooner moves water into winter, good for power. Touching full earlier is good for power in some years (head gain), but not in years where there is a risk of running out of water in August. May need to be done with adaptive management measures.
Decreasing/stopping spill (stop voluntary spill)	This measure would help offset loss in overall generation and in certain months helps reliability.	–	*This measure may serve as mitigation for MOs that don't already contain this measure. *Reductions in voluntary spill are helpful in the context balancing competeing needs from water. Giving federal agencies the flexibility to reduce spill during certain hours can enable BPA to maximize the value of its power sales in wholesale markets.
Delay the start of when turbines on the fish passage projects must operate within 1% (or within and above 1%) of their peak efficiency range until April 3/10 or even later when significant number of juvenile fish are in the river	This measure would help to alleviate reductions in power generation and power flexibility	–	–
demand response for increased flexibility	This measure would help offset loss in flexibility and perhaps reliability.	–	demand response is an option in the zero-carbon portfolios of potential replacement power to meet reliability needs. However, additional demand response may be applied in other circumstances to increase flexibility for hydropower generation.
Develop alternative energy sources (non-hydropower)	–	–	Utilities across the region have been developing new sources of non-hydro renewable output (mainly from wind, but increasingly solar, projects) in recent years in addition to continuing to develop cost-effective energy efficiency resources. This is occurring both to meet new electric demand, but also to supplant other existing supply resources (namely fossil fuel-powered generators). To the extent that any of these draft alternatives result in a reduction in output of hydropower from the federal system, additional regional investments in energy efficiency and non-hydro renewables could likely replace the output.
Develop dedicated funding sources for energy efficiency and demand response	Add-New Mitigation Measure	–	The federal hydropower system provides a significant amount of carbon-free flexibility that can help to integrate increasing volumes of wind and solar output at least cost. If that flexibility is diminished for any reason, developing dedicated funding sources for targeted energy efficiency and/or demand response investments can help to lessen the adverse impacts. Efficiency can reduce overall peak demand, while demand response can increase the flexibility of electric demand in instances where cost-effective flexibility in the available supply has been exhausted.

Draft Mitigation Measure	Reason to addition	Citations	Notes
Develop new renewable winter capacity resources (e.g., off-shore wind or wave)	Add-New Mitigation Measure	–	The federal hydro system contributes to the region's climate change goals in a variety of ways. First, the system provides a significant amount of carbon-free energy to meet the region's electric needs. Second, its flexibility helps to integrate solar and wind output. But third, it is capable of providing a significant amount of carbon-free winter capacity to meet the region's electric demand during sustained winter peaks. Carbon-free winter capacity is currently difficult to replace. One measure to mitigate any loss of winter capacity from the federal hydro system would be to develop new types of renewable resources with output profiles that peak in the winter, such as off-shore wind or off-shore wave energy. These types of generators could take advantage of strong winter storms to deliver additional winter capacity to the region.
Draft GCL and maybe upstream storage projects slightly deeper by April 10 or completely eliminate the April 10 requirement. Potentially lower the April 30 elevation as well.	This measure would a) help to alleviate reductions in power generation b) reduce April flows thereby permitting a higher percentage of spill within the TDG parameters which would lead to lower PITPH and would help fish	–	--mitigation measure also added to water quality tab as it helps with TDG management and to fish tab as it reduces PITPH
Draft GCL deeper at end of August to keep August flows higher	This measure would help offset loss in reliability. It would, however, reduce total power generation, if there is spill in August	–	Increases August flow (high value to power and may help adult fish migration). Could be particularly usefil in MO4 if the MCN flow augmentation measure I implemented because of that measure's large impact on reliability.
End fish spill spill earlier in drier years to increase power generation (may also help fish). May use more often and potentially start earlier as climate change leads to longer periods of low flows	This measure would help offset loss in power generation.	–	The value of this mitigation action to power is dependent on whether or not there is spill for juvenile fish passage in August.
explore other sources of funding for structural measures and fish mitigation measures	This measure would help offset impacts to power rates	–	Not sure this is feasible.
If the build-out of water supply is in the preferred alternative, modify the measure to be phased in as the water demand is phased in, rather than assuming it will all be used right away.	–	–	Two particular concerns: 1. if mitigation is required for the water withdrawals, the mitigation shouldn't be required until the water withdrawals really begin. 2. for any planning modeling in the region, it would certainly be more accurate to model the expected irrigation withdrawals, not the future irrigation withdrawals.
Implement 2018/2019/2020 flex spill as a mitigation action to reduce cost of spill to gas caps on hydropower generation	Reduce cost of spill to gas caps on hydropower generation in some alternatives	2019 NOAA BiOp	–
Implement some of the measures not selected for the PA in limited circumstances where/when the impacts to power are higher	This measure would help offset loss in power generation and flexibility.	–	presume we would refine this further during the mitigation workshops
Increase coordination across utilities in the Northwest and the west (e.g., grid regionalization)	Add-New Mitigation Measure	–	Increasing coordination (e.g., such as through expanded regional markets such as the Energy Imbalance Market) between utilities in the Northwest and in adjacent regions in the west can help mitigate the loss of any energy or capacity resulting from the draft alternatives being considered. For example, participation in the EIM could allow BPA to increase its revenues from the sale of hydropower to help offset any costs associated with loss in output from the draft alternatives. Alternatively, participation in EIM, or in other regional markets, could create new opportunities for the Northwest to replace carbon-free energy with imports from out-of-region.
Increase performance of PGs	This measure would help offset loss in power flexibility.	–	can be used more for reshaping power to load.
Increase probability of refill	This measure would help offset loss in summer power generation, but perhaps at the expense of winter power generation.	–	This measure may serve as mitigation for MOs that don't already contain this measure. Primary beneficiary might be anadromous fish and recreation, not power

Draft Mitigation Measure	Reason to addition	Citations	Notes
Increase transfer capabilities of regional transmission interties	Add-New Mitigation Measure	–	Increasing the transfer capability across regional transmission interties (e.g., at the California-Oregon Border) could enable the Northwest to import more carbon-free renewable power from other regions to mitigate against the loss of any energy or capacity resulting from the draft alternatives being considered.
Increasing investments in energy efficiency programs (potentially focus on low income communities).	This measure would help offset effects of MOs on cost of power to end users.	–	Could also be an Environmental Justice Mitigation measure. However, the load forecast assumed in these studies already includes all the cost-effective energy efficiency that the NW Power and Conservation Council has identified in the region.
Install low head high efficiency turbines in earthen fill sections of existing dams (or hydro-combine)	This measure would help offset loss in power generation.	–	*This can only be done for MO3. This will likely not be cost-effective and counter to the effort to have a free-flowing river. *Maximizing the efficiency of existing turbines and output from existing dam projects can result in increased carbon-free hydropower output
Look at adding modified Surface Spill bays (long verticle slots) similar to those at Rock Is. These could be used outside the spill season to aid overshots and kelts but use less water.	This would allow for protection of overshots and kelts but use less water and be more effient with water usage.	–	–
Look for more opportunities with Non-Treaty Storage water from Canada	This measure would help offset loss in reliability.	–	don't know if this is in scope for the CRSO EIS, and of course it depends on negotiations with Canada
Modify the measure that protets against rain-induced flooding. Allow Grand Coulee to be slightly higher when there is no low-elevation snow, but draft Grand Coulee more if low-elevation is falling. Presumably this would involve some sort of adaptive management	This measure would help offset loss in power generation and flexibility.	–	If low elevation snow is falling, it is often so cold that streamflows decrease, so this is coincidentally a perfect time to be drafting Grand Coulee deeper.
More flexibility on seasonal, daily hourly flow	*This measure would help offset loss in flexibility and power generation as well as offset increased costs for power. *Could be applied if it does not impact other operational purposes/requirements. We have a measure like this at Libby already.	–	*Operations measure may serve as mitigation for MOs that don't contain this measure. *Increasing this type of flexibility increases general operational flexiblity. This type of flexibility is expected to be increasingly valuable in future years as more variable output non-hydro renewable generation is added in the Northwest.
Participate in an energy market	This measure would help to alleviate regional transmission congestion.	–	this would offset effects to power
Reduce fraction of capital costs of MOs that get integrated into revenue requirement.	This measure would help offset effects of MOs on cost of power to end users. Most relevant to MO3.	–	Unsure if feasible; passes on costs to taxpayers.
Rehabilitate turbines	–	–	Economically feasible units are already going to be rehabed. Waiting for $/limited in # at a time (year) Maintaining optimal operation of the turbines can result in increased hydropower output.
Shut off spill in part or all of the summer on the Snake and possibly the lower Columbia to increase power production. (It could be implemented all summer, only July and Aug, or only during heat waves)	This measure would help offset loss in power generation.	–	Also a fish mitigation measure as it reduces temp in the Snake River
spill could be better managed to take advantage of power production during periods of time when insufficient numbers of smolts are migrating – both at the beginning and tail end of the runs; spill program is based on fish abundance rather than hard dates	This measure would help offset loss in power generation as well as offset increased costs for power.	–	*This measure may serve as mitigation for MOs that don't already contain this measure. *Looking at opportunities to apply this type of flexibility across the entirety of spill season--based on a scientific assessment of actual fish needs--could increase hydropower output and allow BPA to better monetize the value of the flexibility of federal hydro system.
Use all turbine bays (ie. add turbines)	–	–	Economically feasible units are already going to be rehabed. Waiting for $/limited in # at a time (year) Maximizing the efficiency of existing turbines and output from existing dam projects can result in increased carbon-free hydropower output.

1.1.5 Air Quality and Greenhouse Gases

Draft Mitigation Measure:	Reason to addition	Citations	Notes
The EPA supports incorporating mitigation strategies to minimize fugitive dust and toxic emissions, as well as emission controls for particulate matter (PM) and ozone precursors for construction-related activity. We recommend that best management practices, all applicable requirements under local or State rules, and the following additional measures be incorporated into the EIS, a Construction Emissions Mitigation Plan, and ultimately the Record of Decision. See EPA's Clean Construction USA website for additional information [http://www.epa.gov/cleandlesel/sector-programs/construct-overvlew.htm].	–	–	This is for BMPs for air quality.
All the mitigation measures that increase power generation have the possible, perhaps even likely effect of reducing CO2 emissions by reducing the use of fossil-fuel power generation in the PNW	–	–	–
Watershed nutrient reduction and erosion management aimed at preventing reservoir eutrophication may mitigate greenhouse gas emission, especially CH4 and NO2 release	–	–	–

1.1.6 Flood Risk Management

Draft Mitigation Measure	Reason to addition	Citations	Notes
Avoidance/mitigation of potential FRM impacts during system operations	–	–	Suggest consulting with water management for better language on operation strategies aimed at avoiding/mitigating FRM
Minimize trapped storage by drafting storage projects earlier so we have option to use the space for spring capture. Include creating a decision-point for modifying the draft rate (potential example is 1 or 2 standard deviations above/below the forecast)	Would need more detail as to which project this applies to. If the project regularly has trapped storage under a specific operation applying something like this suggestion would be appropriate.	–	We need to provide for a spring freshet; drafting water earlier doesn't help outmigration and then when spring flows do come they are not allowed to flow to the provide the spring flows needed instead they are used for refill. NOTE: Do any projects have trapped storage under new measures?
Modify levees	Assume this means modifying levee or raise levee height to decrease flood risk. Levee modification could be a mitigation measure for very specific location based increases in flood risk. However, it is dependent on many factors which make it difficult to apply as a mitigation measure on a CRSO basin wide scale.	–	Keeping, if there are FRM impacts at specfic locations, this may be mitigation.
Nonstructural measures	–	–	–
Purchase water rights to increase instream flows	–	–	–

1.1.7 Navigation and Transportation

Draft Mitigation Measure	Reason to addition	Citations	Notes
Build new highways to transport goods from Lewiston	–	–	This is outside of scope of the action agencies, but could be done by others. Note: Agencies do not mitigate for economic losses.
Build new railroad infrastructure to transport goods from Lewiston (might require more rail lines from Lewiston plus rail yards in Lewiston and in Portland/Vancouver harbor region)	–	–	*could be a challenge acquiring the land for new rail facilities in Portland/Vancouver area. Cost expected to be very high *This is outside of scope of the action agencies, but could be done by others. Note: Agencies do not mitigate for economic losses.
Change spill patterns to avoid or minimize navigation impacts	Added clarifying language	–	
Consider infrastructure improvements to ensure safety and minimized impacts along routes where increased traffic (rail or truck) may occur, especially if crossing through EJ communities. I.e., develop appropriate alternative routes to mitigate for increased wait times for local traffic.	–	–	This is outside of scope of the action agencies, but could be done by others. Note: Agencies do not mitigate for economic losses.
create an aquaduct/channel parallel to the river for barge traffic	–	–	–
Dredging to maintain authorized nav channel depth	–	–	–
Increase maintenance activities to address added wear on nav locks	–	–	–
Stabilize roadways that could be impacted by dam breach or draw down of LSR	Maintain usability of roadway	–	This is an assumption for MO3, however need to double check
Subsidize farmers in Idaho, eastern WA, eastern OR+ for the added transportation cost for shipping grain via rail or truck.	–	–	This is outside of scope of the action agencies, but could be done by others. Note: Agencies do not mitigate for economic losses.

1.1.8 Recreation

Draft Mitigation Measure	Reason to addition	Citations	Notes
Adjust operations to accommodate recreation	If substantial impacts to recreation conditions are identified could adjust operational plans	–	
Conserve/improve reservoir sport fisheries	–	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
Establish a higher winter lake level (i.e. Lake Pend Oreille)	This appears to be a measure, not mitigation for a measure? However, if evaluated for mitigation it could impact FR.	–	–
Establish an annual four-month "normal pool" period on Lake Pend Oreille (Memorial Day to October 1)	This appears to be a measure, not mitigation for a measure? However, if evaluated for mitigation it would impact FR. I don't believe there are	–	–
Establish decontamination (invasive species) stations including wash stations at all boat launches	Reduce or eliminate spread of invasive species	–	existing programs are ongoing
Extend boat ramps in Lake Roosevelt	Ramps during spring draw down are OOS and restricts access for those working with fisheries, subsistence fishermem, enforcement officers can't get on water to patrol for protection of cultural sites.	–	–
Extension of pre-existing or addition of new boat ramps	Lower reservoir elevation Increased duration of drawdown	–	Inoperable boat ramps inhibit access temporally and geographically) to the mitigation fishery and prevent fisheries research and monitoring from being conducted. Additionally, inoperable boat ramps reduce recreators of all kinds, resulting in economic loss to the region and prevention of tribal members from obtaining access to the focal feature of their usual and accustomed range.
Lengthen boat ramps	If access to reservoirs and/or rivers occurs due to change in water levels, boat ramps could be lengthened	–	–
Replace and/or relocate impacted recreation resources (parks, boat ramps, public facilities, etc.)	Mitigation measure will address direct impacts to rec resources	–	–

1.1.9 Water Supply

Draft Mitigation Measure	Reason to addition	Citations	Notes
Develop potential mitigation and solution options in the context of a nonstationary system, rather than continuing to treat streamflow (and climate) as stationary, and our water supply as probabilistic.	Add, new mitigation action	–	–
Employ conservation measures	–	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
Extend irrigation systems that currently rely on the slackwater pools of the LSRDs to pump directly from the channel of the undammed Snake River.	–	–	This is being explored in the socioeconomic analysis of the MO3
Given important advances on the horizon in water supply, weather and climate forecasting, including improved accuracy in amount (e.g., distribution over the water year); longer lead time (e.g., as early as Oct 1, the beginning of the water year), it will be imperative that the forecast information integrates with operations and mitigate measures.	Add, new mitigation action	–	Not sure if this is mitigation. What is the impact?
Improve irrigation practices	–	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
Improve water delivery efficiency	–	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
Increase pump strength and capacity for irrigation	–	–	Evaluating some of this in socioeconomic analysis
Increase storage	–	–	–
Higher and more stable headwater reservoir levels	–	–	–
Make irrigation practices more efficient, so that less water is lost through evaporation	–	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
Modification of John W Keys III pump generators to be able to operate below 1240 feet	Add	–	–
Modification of pumps where access may be changed (MO3 - LSD and MO4 - John Day)	Add	–	–

Draft Mitigation Measure	Reason to addition	Citations	Notes
Address Lewiston/Clarkston area pumps that might be affected by the disappearance of reservoirs and monitored for twenty years or more. If water levels drop and some pumps go dry, mitigation money could extend these wells.	–	–	Where data is available, the possible impacts to wells in this area (within 1 mile of the river/reservoir) will be evaluated. Extending wells using a mitigation fund will not be evaluated. J. Johnson BOR 7May19
Reduce and/or characterize water quality at the outflows from irrigation waters	Unknown levels of discharge both flows and contaminants from irrigation waters into Columbia, Snake and other waters likely impact spawning, rearing, and foraging success of salmonids and other resident species.	–	–

1.1.10 Cultural Resources

Draft Mitigation Measure:	Reason to addition	Citations	Notes
Add physical barriers/protections for cultural sites.	–	–	
Continue to use the FCRPS cultural resource program to identify impacts to cultural resources	–	–	The FCRPS cultural resources program is currently being used as mitigation to cultural resources and it will continue to address impacts with all the alternative proposed.
Data recovery of archaeological sites	–	–	Data recovery is a mitigation for impacts to cultural resources.
Develop Tribal In-lieu fishing locations below CJD to facilitate greater Tribal access and fish-harvest success.	Discharge, stages (tailrace elevation) and spill all can have a negative effect on ability of anglers to access existing fishing sites and fishing success. Improving fish access and locations for fishing can partially offset cultural impacts associated with reduced havest associated with CRSO that affect fish prodcution (i.e. adult abundance) and reduced efficacy of fish efforts.	–	–
Disposal of excess federal land with sensitive sites to tribal governments.	–	–	–
Land or site 'banking': purchase of private/county/state land with at-risk, sensitive, or highly valued/visible cultural properties to bring into either federal or tribal ownership/management. Similar to current wetland mitigation processes used.	–	–	–
Native flora and fauna restoration within the study area	–	–	Restoration of flora and fauna would only be an appropriate mitigation for cultural resources if the intention was to facillitate traditional tribal use of said restored flora and fauna. There would possibly be ancillary benefits, such as to veg/wildlife mitigation projects
Offsite mitigation of all sorts	–	–	Off site mitigation, such as museum exhibits, language programs, and education, are good mitigations for cultural resources, as long as they tie to cultural resource impacts.
Operate reservoirs so as to maintain full pool elevation as much as possible	This might be good for some sites but bad for others. Show me the data. Also, again, would we overrule the flow regime established in the alternative?	Pool elevation is dictated by the need for power supply, as such it would not be possible to use pool elevation as a cultural resource mitigation.	Keeping pool elevation at full pool would help mitigate the impacts to cultural resources. It would help with erosion, exposure of sites from looters and recreationalists, and wave action on lower elevation sites. However, pool elevation is dictated by the need for power supply, as such it may not be possible to use pool elevation as a cultural resource mitigation.
Operate reservoirs so as to minimize fluctuation in elevation	Isn't this what the alternatives do, change the fluctuations? How could this be a mitigation? Could we overrule the alternative?	–	Minimizing pool elevation fluctuation would help mitigate the impacts to cultural resources. It would help with erosion, exposure of sites from looters and recreationalists, and wave action on additioanl sites. However, pool elevation is dictated by the need for power supply, as such it may not be possible to use pool elevation as a cultural resource mitigation.

Draft Mitigation Measure:	Reason to addition	Citations	Notes
Replace lost roads if Lower Snake Dams are Removed	What are you mitigating here? Loss of access for tribal members on the roads that currently go over the dam? Do we really want people to have more access to the newly exposed archaeological sites?	–	This could be a mitigation to cultural resource impacts because it would allow access to TCP and sacred sites that are hard or impossible to get to currently, making it easier for tribes to use the sites.
Shoreline stabilization	–	–	Stabilization of the shore would also stabilze the cultural resource sites along the shore. It would be important to not impact the sites during stabilization.
Stabilization of cultural resoure sites	–	–	Stabilization of cultural resource site would address direct impacts to the sites.
Support artificial propagation programs that provide harvest, and conservation efforts for salmon and steelhead	Artificial propagation is necessary to partially offset CRSO impacts to harvest, conservation and Tribal cultural/subsistence.	–	Unclear what the effects of the action would be. No action would maintain current mitigation activities. This is also in Fish
Creative mitigation measures to address tribal interests and concerns	–	–	Creative mitigation measures, such as language studies, education, and museum exhibits, could be used as mitigation to impacts to cultural resources as long as they tie to the impacts of cultural resources and not impacts to other fields of study, such as ESA, fish, or water quality, as these impacts will need to be mitigated by those areas.

1.1.11 Socio-Economics

Draft Mitigation Measure	Reason to addition	Citations	Notes
Cost-share recovery efforts with fisherman.	–	–	*Outside authority of action agencies to implement, but could potentially be implemented by others
Financial support for efforts to replace aging septic systems with upland community systems or sewer	–	–	–
Include meaningful mitigation to protect and improve the physical and spiritual health of the Tribe and its members (CTCR) diabetes prevention and other health protection improvements; language preservation, creation of employment opportunities; educational opportunities	–	–	–
Reclamation Fund Each federal hydropower facility annually generates revenue for the Reclamation Fund according to the Congressional Research Service. Each of the agencies participating in this EIS should identify the funding contribution to or receipt of funds from the Reclamation Fund, A mechanism to tap these funds could be developed and explored for the development of a system-wide and project specific mitigation fund. Because there already are funds for wildlife and habitat mitigation, a regional mitigation fund could be used to compensate counties for loss of tax revenue, infrastructure development, citizen participation, research, or other projects.	–	–	Came from scoping comment
Utilize the Reclamation Fund. The fourteen (14) federal dams contribute an annual percentage of hydropower revenue to the Reclamation Fund. A portion of that fund could be used as a system-wide and facility-specific mitigation fund for counties and private landowners, education, infrastructure improvements and other actions.	–	–	–

1.1.12 Mitigation – Screened Out

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
FISH	–	–	–	–
~~Add bubble curtains to dams to aid fish entering ladders and exclude predators - excluding predators = predation management theme below~~	REJECT. Measure would deter salmon, similar to predators. Any studies suggesting this would work for salmon/steelhead and exclude predators?	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.	–
~~Allow for periodic flow through locks to maximize flow rates~~	Not feasible structurally……. Remove. structurally unfeasible unless under spillway crest alternative which has been removed from consideration.	–	This could lower TGD. Surface passage instead? Or Flow deflectors?	–
Consider differential mitigation effects of various levels of effort and combinations of focus populations and identify the option that most effectively addresses mitigation needs in a manner that also contributed to long-term recovery goals.	There does not appear to be a mitigation suggestion; this is a comment.	–	Offsite mitigation for impacts of hydrosystem to abundance, productivity, and survival.	–

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
~~Cease using juvenile bypass facilities~~	Not a beneficial fish mitigation action. Even with spill, other non-turbine passage routes are necessary for non-spill passed fish to avoid powerhouse passage routes. Delete. REJECT. More fish will go through turbines which are generally lower survival routes.	–	For MO3, there will be no bypass facilities on the Lower Snake. Have we considered restoring McNary transport under breach? Our modeling says that food will be gone from the lack of oxygen in the snake during spring migrations the first year after breach (two seasons straight at this time) and then may have to build up. Should we consider transport post breach?	–
Evaluate shallow water ponds cut off from maintstem by rip-rap, highways and railroads that create warm water habitats.	Evaluation is not mitigation as defined under NEPA. Evaluation, itself, does not offset an effect.	–	These shallow water lake type habitat types could either be re-connected for rearing habitat for native fish species Or should they be closed off so they are not provided rearing habitat for non-native species. This may be an opportunity to provide bass habitat disconnected from the main Columbia channel and perform bass eradication from shallow water areas that are connected to the main channel.	–
~~Close spillway weir(s) and other high-TDG routes (corner collector at BON, sluiceway at BON, TDA).~~	This routes provide some of the best SBE and have higher survival routes. As we understand, these are important structures to facilitate improved passage and survival of juvenile emigrants. Remove. REJECT. This would significantly lower fish passage survival. These routes more juvenile passage effective per TDG production than deep spill gates.	–	Oregon believes implementation of this mitigation action would result in severe reduction in juvenile salmonid survival and a severe decrease in life cycle survival as measured in SARs.	–
~~continue to use spray deterrents and antideterrant measures~~	*REJECT. Captured in NAA *Oregon supports avian predation deterrents but also understands these are continuing actions under the NAA so therefore not new mitigation.	–	–	–
~~Create riffle pool complex within the reservoirs.~~	Remove. Remove. Would require drawdown to create riffles. Would not allow barging and not as effective as springtime spillway crest drawdown or breaching.	–	Do habitat work in tribs instead.	–
~~Deeper (existing) storage reservation diagrams to reduce FRM~~	Drafting to reduce FRM is not a beneficial fish mitigation measure. Not a benefit to fish.	–	If this mitigation measure is for deeper drafts to reduce flood risk, how is that a mitigation measure for fish?	–
~~Eliminate gill nets and allow harvest at fish ladders via trap~~	Implementation of this wholesale action would result in unintended consequences to listed-salmonids	–	Oregon needs more detail about this mitigation action prior to making a technical recommendation.	–
~~Pull one turbine from each dam (effectively, increase spill)~~	Measure not needed. Just do not operate and during high flow times need more turbines to help reduce high TDG. Uncontrolled spill already at times results in TDG > 130% and GBT. Have we tried a deepwater passage route at the Columbia River dams? Possibly add as a conceptual investigation?	–	–	–
~~Pull one turbine from each dam (effectively, increase spill)~~	Delete, decreasing power flexibility and reliability capacity will not help fish.	–	–	–

Deleted Mitigation Measure:	**Reason for deleting**	**Citations**	**Notes**	**Additional notes**
~~Re-design bypass to allow for microtopography and macroinvertebrate populations. Look at more of an oxbow type design.~~	Not feasible……. Delete. Delete. Developing mainstem habitat features that support healthy macroinvertebrate populations would likely create more natural environments and support fish productivity; however, it is not clear what this measure is.	–	Talked about for years, even in the 80's when I worked for IDFG. Build a natural stream channel around granite etc. with a gate, then water it up during outmigration. We are far beyond this now with improvements to fish passage. Now if you are talking about some sort of natural channel in the bypass system, same thing just get the fish through the bypass as quick as we can.	–
~~Re-design nav locks to allow for microtopography and macroinvertebrate populations, riffles and pools or to allow them to remain open during low boat traffic times (i.e. remove the navigational lock sill). #3 = breach?~~	Not feasible……. Remove Structurally unfeasible unless under spillway crest alternative which has been removed from consideration	–	Just does not seem like a good idea. Obviously I have not been citing literature but I don't see the benefit. Instead of breach? May work but I think it would damage the infrastructure over time.	–
Limit fisherman from foreign countries coming too close to the coastline - limits anywhere between 3 to 50 miles of our territorial coastline for catching salmon. Recommend 50 miles.	could be some confusion about fishing in US Waters, foreign counties may not be allowed to fish that close to shore already. (double check)	–	–	–
Make fishing licenses transferrable	Doesn't seem this would offset an impact to fish and thus would not be a mitigation measure.	–	–	–

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
Native Redband Trout and kokanee are significant to the cultures and economies surrounding Lake Roosevelt. There are a breadth of detrimental impacts operations inflict upon these species. Current operations impede access to spawning habitats and entrain juveniles of these species as they exhibit migratory behavior. Both of these factors have profoundly impacted the status of these species populations as reflected in the recent Washington Department of Fish and Wildlife fishing regulation change to release all unclipped Redband Trout. During crucial times of the year, the mouths of tributaries are routinely exposed within the drawdown zone. This presents a hazardous migration corridor both in terms of channel morphology and the absence of cover. The drawdown also exposes the redds of shore spawning species, rendering the embryos unviable. Current reservoir operations also result in entrainment of hatchery-reared sport fish (Rainbow Trout and kokanee), the Tribe's partial mitigation for the loss of anadromous species, and may account for 30% of the mortality of these species.13 [13Baldwin,C.and M.Polacek. 2002. Evaluation of Limiting Factors for Stocked Kokanee and Rainbow Trout in Lake Roosevelt,Washington,1999.] This considerably diminishes the level of mitigation. Reservoir operations are also responsible for the creation of habitats that support both native and non-native piscivorous fish species. The bounty of Northern Pike Minnow in the lower River targets a culturally important First-Food of tribes. Simultaneously, management of non-native predators in other regions receive comparably little financial support, despite the risk they pose to native resident species and downstream ESA-listed populations. Alternatives considered in the EIS need to evaluate piscivorous fish populations and their current management priorities. Alternatives presented in the EIS need to address these impacts imposed upon resident species. It should also be noted that Redband Trout offer the opportunity to assist in the recovery of the ESA-listed Upper Columbia River Evolutionarily Significant Unit of steelhead by improving genetic diversity. These fish are already, ??considered a mitigating factor by many of the BRT [biological review team] members in rating extinction risk,- for the UCR steelhead ESU.14 [14M.J.Ford(ed.). 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Region. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-113, 281p.] This is emphasized by the Independent Scientific Advisory Board's determination that, "the loss of either the anadromous or resident life history form [of O. mykiss]- would put the [population's] long-term viability at risk."15 [15Independent Scientific Advisory Board. 2005. Viability of ESU's Containing Multiple Types of Populations. ISAB2005-2. April 8, 2005. Available at: http://www.nwcouncil.org/fw/isab/isab2005-2/] Given this perspective, preservation of Redband Trout should become a primary consideration when developing the EIS. Such considerations could include the implementation of a conservation hatchery program for Redband Trout in our Region to ensure their long-term viability in addition to providing passage for these fish at Chief Joseph and Grand Coulee Dams.	Does not appear to identify a mitigation action. There does not appear to be a mitigation suggestion; this is a comment.	–	–	–
Transportation should be de-emphasized as a fish mitigation measure in favor of increased spill operations and an improved in-river migration environment	Delete. This is a comment about mitigation; not a mitigation measure	–	One of the MO alternatives is analyzing this idea.	–
Studies show that dam breaching by itself would not recover the fish. Continuing aggressive fish mitigation efforts should continue to help fish get safely past the dams, and maintain effective habitat and hatchery programs.	Delete. This is a comment about mitigation; not a mitigation measure	–	–	–

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
Continued PIT tag work (on the Columbia Plateau) for M&E regarding avian predation rates	Monitoring and evaluating (M&E) is not mitigation as defined under NEPA. M&E does not offset an effect.	–	filter mitigation through NEPA definition of mitigation as defined in §1508.20, includes avoid, minimize, rectify, reduce, and compensate. For example, research, monitoring, and evaluation would not be included because they are not mitigation as defined by CEQ Regulations	–
Develop PR campaign to kill, keep, consume non-native fish species	Outreach efforts is not mitigation as defined under NEPA. Outreach efforts does not offset an effect.	–	Bass, Walleye etc. Outreach low cost buy-in from dam proponents.	–
Ensure that an RM&E program is in place to test and validate the hypotheses of the program in terms of mitigation benefits and to guide adaptive management of implementation.	Monitoring and evaluating (M&E) is not mitigation as defined under NEPA. M&E does not offset an effect.	–	–	–
Include adequate Monitoring and Evaluation to evaluate the impacts of all proposed actions.	Monitoring and evaluating (M&E) is not mitigation as defined under NEPA. M&E does not offset an effect.	January 14, 2011, Memorandum for Heads of Federal Departments and Agencies, From Nancy Sutley describing the Appropriate Use of Mitigation and Monitoring and Clarifying the Appropriate Use of Mitigated Findings of No Significant Impact	"Monitoring is fundamental for ensuring the implementation and effectiveness of mitigation commitments, meeting legal and permitting requirements, and identifying trends and possible means for improvement."	–
~~Reduce flow augmentation (CSS)~~	*Delete. How is this a mitigation measure that benefits fish? Seems Counterproductive *Delete, Oregon strongly supports further development of operational and/or structural mitigation actions to return the hydrograph to a more normative (pre-hydrosystem) pattern. Implementation of this mitigation measure would likely have the opposite outcome. Ultimately and if the action agencies choose not to delete this mitigation action, Oregon questions why this measure appears to be associated with CCS?	–	–	–
~~Build an alternate channel around the dams~~	*Remove. The attraction flow would presumably be low relative to existing dam passage routes… if relatively high flow in new channel, it may be similar to dam breach concept. Relative effectiveness of building a new channel (v. more spill, bypass, breach) is questionable. *Remove - duplicate. *Is this the same a measures in the MO3 LSR Breach Alternative? Not enough detail to evaluate.	–	*Oregon needs more detail about this mitigation action prior to making a technical recommendation. *Building a channel around the dams will likely compromise the integrity of the structure.	–
~~Draw Down John Day~~	Delete. Captured in alternatives	–	–	–
Install PIT tag arrays at each Lower Snake dam and McNary	Monitoring and evaluating (M&E) is not mitigation as defined under NEPA. M&E does not offset an effect. ; however could be discussed as adaptive management	–	Yes, not a mitigation metric but something that can identify mitigation measures. Rather than adopting many spillway measures, use our data to move forward mitigation measures, like spill stilling basins, etc.	–
Investigate development of guide\ curves to avoid situations where heavy spill has to occur in the spring to meet FRM requirements. Concept would be to have a guide curve that is forecast based (to only be used in high water supply situations) to allow for earlier draft than the current SRDs.	Evaluation or investigation is not mitigation as defined under NEPA. Evaluation or investigation does not offset an effect.	–	*How is this a mitigation measure benefiting fish? *Oregon needs more detail about this mitigation action prior to making a technical recommendation.	–

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
Ongoing fish tissue monitoring to update fish consumption advisory	Monitoring is not mitigation as defined under NEPA. Monitoring does not offset an effect.	–	Increased mercury methylation and bioaccumulation (see Willacker 2016, Reservoirs and Water Management Influence Fish Mercury Concentrations in the Western United States and Canada)	Lower reservoir elevation Increased duration of drawdown Increased sediment exposure during the spring and summer growing season
Study feasibility of recommended measures before implementing	Evaluation or investigation is not mitigation as defined under NEPA. Evaluation or investigation does not offset an effect.	–	ADD measure to study any NEW measures to determine feasibility of implementing and estimate effectiveness of treatment	–
Support productivity studies in BN, TD, & JD reservoirs for white sturgeon	Evaluation or investigation is not mitigation as defined under NEPA. Evaluation or investigation does not offset an effect.	https://www.nwcouncil.org/sites/default/files/ColumbiaBasinWhiteSturgeonPlanningFramework2013Dec_0.pdf	The reservoirs must be evaluated to determine production and mitigation measures to improve production for resident native fishes, particularly white sturgeon.	–
Support system-wide monitoring program to understand effectiveness of predation management measures (cumulative predation rates over time)	Monitoring is not mitigation as defined under NEPA. Monitoring does not offset an effect.	–	–	–
Install PIT detector arrays at all project spillway weirs and other undetected passage routes as technology allows.	Monitoring and evaluating (M&E) is not mitigation as defined under NEPA. M&E does not offset an effect. ; however could be discussed as adaptive management	–	This will greatly enhance the Action Agencies ability to collect data on fish passage routes and survival and inform adaptive management through time.	–
Anadromous translocation above CJD and GCD - delete Reintroduction	More research and science needed to determine best methods for fish passage, and habitat availability to determine a successful reintroduction of fish. There are current efforts ongoing to address this problem. The alternatives being analyzed do not change fish passage for these projects from the no action - so mitigation is not needed.	–	–	[Could utilize a portion of escapement of UCR summer/fall Chinook and sockeye to the upper Columbia (above PRD) for translocation to increase production in currently inaccessible habitats above CJD and GCD to partially offset potentially reduced smolt survival due to reduced or suspended spill and reduced flow in late July and August.] from Fish team review

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
Re-design spillway to mimic normal step-pool/waterfall elevations. Look at stepped spillway (MSH SRS?)	Remove. REJECT. Violates USACE's FRM authorities and dam safety concerns.	–	Interesting idea, but too complex at this point. Maybe something way down the road if our next measures don't recover. Back in the day it was thought that breaching just granite and goose would do the trick. Breach one dam instead? I don't know…Haven't we found that we get great results from changing the ogee and the weirs?	–
Truncate DWA Drawdown	Remove. In the past we have had trouble cooling the river back down after shutting off Dworshak spill. Look at old newspaper articles to see the outrage of thermal blocks (reinventing the wheel)	–	–	–
Mitigate for White Sturgeon population losses due to dam impacts	No mitigation action is identified, rather it is a comment that mitigation should be done.	–	Keep, Although Oregon recommends development of specific actions to achieve the desired outcome	–
Mitigation for operational impacts causing loss of resident fish	No mitigation action is identified, rather it is a comment that mitigation should be done.	–	Studies have shown substantial losses due to operations at GCD of up to 500k fish per year at the third powerhouse. Another study suggested draw downs below 1255 msl entrain fish resulting in a reduced fishery the following year.	–
Fish collector in/near GCD forebay, equipped with exclusionary netting, and fish transportation - return/transport mitigation fish and native species to Roosevelt	*More research and science needed to determine best methods for fish passage, and habitat availability to determine a successful reintroduction of fish. There are current efforts ongoing to address this problem. The alternatives being analyzed do not change fish passage for these projects from the no action - so mitigation is not needed.	–	Entrainment/removal of mitigation fish and native species. Increased water outflow Decreased water residence time	The exclusionary netting is in the Fish mitigation tab. The transport of fish to Lake Roosevelt would be consider reintroduction. See "Reason for deleting" column for reason for deletion.
Further Develop "Wooshh!" for multiple sized fish and volitional entry, and test efficacy of system as a means to decrease ladder passage times at dams in the extant anadromous zone and for passage above Chief Joseph and Grand Coulee dams ~~this is a technology, doesn't specify in what situation~~	*The performance of this is unteasted technology and unlear any benefits or impacts to captured fish. *More research and science needed to determine best methods for fish passage, and habitat availability to determine a successful reintroduction of fish. There are current efforts ongoing to address this problem. The alternatives being analyzed do not change fish passage for these projects from the no action - so mitigation is not needed.	–	~~Assume for reintroduction Coulee & DWA.~~ Needs consideration in the future.	[Initial investigations at PRD indicate excelerrated passage rates for "Whooshh"ed fish versus conventional ladder passage.] per fish team comments

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
Restore passage to North Fork Clear Water River (aka passage at Dworshak)	deleted. The alternatives being analyzed do not change fish passage for this project from the no action - so mitigation is not needed. More research and science needed to determine best methods for fish passage, and habitat availability to determine a successful passage of fish. There are current efforts ongoing to address this problem.	Columbia River Treaty, Ecosystem-based Function, Coalition of Columbia Basin Tribes, June 2013	*Always strive to reintroduce where it is feasible. Need to be careful about genetics, NF fish were known to be the largest B's. Do their genetics still exist in a redband form above the dam? Or are they gone and it does not matter. Consider Hell's canyon complex as well. https://www.critfc.org/wp-content/uploads/2014/12/ecosystem-booklet-single-page.pdf *Oregon needs more detail about this mitigation action prior to making a technical recommendation.	–
Reporting on tributary habitat improvement actions shall provide adequate information to evaluate the tributary habitat program, including adequate inputs for future life-cycle modeling and for qualitative evaluation of the program's implementation and effectiveness.	Monitoring and evaluating (M&E) is not mitigation as defined under NEPA. M&E does not offset an effect.	–	See 2019 CRS BiOp,Term and Condition #5	–
~~Progressive Spill: to better mimic the natural hydrograph: percent spill increases as inflow increases (i.e. Snake River- 20% spill up to 40 kcfs inflow rising to 50% spill at 100 kcfs inflow…)~~	*Delete, Oregon remains open to consideration of flexibility in spill strategies so long as any alternative moved forward is robust enough to avoid jeopardy under the ESA and achieve regional recovery goals of 4-6% SARs of ESA-listed salmonids. However, this spill strategy will not achieve the desired survival benefit. *REJECT. During dry years, there'd be very little spill.	United States. The Endangered Species Act As Amended by Public Law 97-304 (the Endangered Species Act Amendments of 1982). Washington: U.S. G.P.O., 1983. Print. 2014 Columbia River Basin Fish and Wildlife Program https://www.nwcouncil.org/reports/2014-columbia-river-basin-fish-and-wildlife-program	Any ESA jeopardy analysis of the proposed action must comply with legal requirements.	–
~~Max transport no spill~~	Clarify, this could be used during times of extreme low flow late season or power emergency requiring reduced or spill cessation. Need to better clarify. Have done this 2001, 2004 and 2005 and was shown to not meet survival and recovery goals. Not a beneficial fish mitigation action. With adult stray rates associated with transport, max transport and no spill will result in diminishing adult returns to natal areas in most years. REJECT. Not a good idea for juvenile fish survival during normal flows. We did that already, pops declined and were listed. Delete. Transportation strategy needs to be implemented based on water year.	–	–	Spread the risk! Consider transport at McNary Dam if Breach? i.e spread the risk now from McNary?
~~Partial breach combined with Bypass channel to mimic natural river (including resting pools)~~	Remove. Not as cost effective as spillway crest alternative which would allow barging and full power production summer-winter.	–	Not really sure what partial breach over breach would give us when we are talking solely fish. In the power metric yeah I suppose we could still produce power.	–
WILDLIFE		–	–	–
Managing for stable reservoir elevation (promote wetlands and grow riparian vegetation on shorelines)	Delete: The native vegetation found in wetlands and riparian areas can benefit by a fluctuating water table within a target range. It is natural for there to be some fluctuation of water elevations within a range (i.e. spring freshet). It encourages cottonwood recruitment.	Jamieson, Bob-BioQuest International Consulting Ltd., Jeff Braatne-University of Idaho, 2001, Riparian Cottonwood Ecosystems and Regulated Flows in Kootenai and Yakima Sub-Basins: Volume I Kootenai River.	in both fish and wetlands	–

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
Create a adaptive monitoring plan in areas where changes may occur. Decline or change could then determine wetland mitigation needs. Action as warrented.	An adaptive monitoring plan is not mitigation as defined under NEPA. Monitoring does not offset an effect.	–	Add. This would allow for long-term monitoring of wetland functions and values to identify continued losses of habitat caused by changes in inundation and exposure.	–
Increase monitoring for aquatic invasive species to include plankton nets, veliger plates and visual inspections of all submerged project locations (ie turbine blades, submerged traveling screens, fishways etc)	Increased monitoring is not mitigation as defined under NEPA. Monitoring does not offset an effect.	https://plan.critfc.org/2013/spirit-of-the-salmon-plan/technical-recommendations/invasive-species/ https://www.nwcouncil.org/fish-and-wildlife/topics/invasive-species https://www.westernais.org/monitoring	Well documented issues and concerns, need overall increase and participation by the action agencies on AIS Proposed under new tab "Aquatic Invasive Species"	Invasive species and their associated impacts will be a permanent concern for the basin, increased monitoring will help with early dection and rapid response to eradicate and/or control.
Organize and implement shoreline monitoring for invasive plants and animals.	Implementation of monitoring is not mitigation as defined under NEPA. Monitoring does not offset an effect.	https://plan.critfc.org/2013/spirit-of-the-salmon-plan/technical-recommendations/invasive-species/ https://www.nwcouncil.org/fish-and-wildlife/topics/invasive-species https://www.westernais.org/monitoring	Well documented issues and concerns, need overall increase and participation by the action agencies on AIS Proposed under new tab "Aquatic Invasive Species"	Similar to the need the reason for row 2, the problem is increasing and stable involvement by action agencies.
FRM	–	–	–	–
In a dry water year, establish a decision-making process for allowance of transitioning refill timing from system ICF approach versus local approach	I don't think this is a mitigation measure for FRM impacts. Project operating criteria already include operations specific to dry (and avg and wet) years. And most also take into account local flood control requirements. Specific measures in the EIS for Libby include modifications to refill for local requirements.	–	–	–
Optimize FRM – best FR projection for impact on storage reservoir	This is not an implementable mitigation measure as described. I am not sure if they mean optimize FRM operations for mitigation on FRM impacts or other impacts. Would need more information about what is being optimized.	–	–	–
Relax storage reservation diagram at 6 FRM projects	this is not a mitigation measure for FRM impacts. This would increase flood risk.	–	–	–
Remove levees*	this is not a mitigation measure for FRM impacts. This would increase flood risk.	–	–	–
Allow floodplain expansion	Not sure if this implies expansion of the flood plain or expansion into the flood plain and the location of the flood plain in mind. I will assume expansion of the flood plain so that floodwaters can flow into the flood plain. If this is for the lower Columbia it would have very little impact on flooding unless the flood plain was very large and designed to capture water under a very specific scenario, and even then it may not affect that actual peak flows.	–	Assuming this is measure is to expand floodplain storage, the CRT review looked at this measure and determined there is not enough floodplain storage to effectively reduce flood risk in the lowerr Columbia River. (per Sara Marxen)	–
change channel capacity by intentional scouring flows by changing discharge during refill	this is not a mitigation measure for FRM impacts. This would increase flood risk.	–	The sediment you scour out will end up somewhere else. Annual scour from spring freshet would clean spawning gravels. This can't be used here and there it must be system wide	–

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
Develop a definition of "system flood" that is based on the volume forecast (Note: a refill trigger already exists)	Does not mitigate for FRM.	–	–	–
develop rules to limit flood control space shift between projects in high water years	Does not mitigate for FRM.	–	–	–
use banded operation of specific target elevation and allowance for a range of +/- 2 ft of SRD target elevation	Does not mitigate for FRM.	–	–	–
during transitions (draft/refill), situationally identify opportunities for movement of flood control space within the system	Does not mitigate for FRM.	–	–	–
Guide curve for Hungry Horse to relax draft rate in high water conditions	Does not mitigate for FRM.	–	–	–
In dry water year, establish a decision making process for reducing system flood control space requirement during spring draft (Note: local versus system trigger)	Does not mitigate for FRM. A reduction in draft would increase flood risk.	–	–	–
In dry water year, operate to local flood control requirements only rather than system requirements (Note: include refill timing and Initial Controlled Flow (ICF))	Does not mitigate for FRM.. Project operating criteria already include operations specific to dry (and avg and wet) years. And most also take into account local flood control requirements. Specific measures in the EIS for LIbby include a implementation of a local flood control draft requirement.	–	–	–
Initiate refill based on flood risk decisions/assumptions on local hydrology versus system criteria (ICF)	Does not mitigate for FRM.	–	–	–
minimize April drafting of Libby for purpose of reducing backwater effect at Bonners Ferry control point	I don't believe that April drafts are causing flooding at Bonners Ferry. Does not mitigate for FRM.	–	–	–
develop rules to limit flood control space shift between projects in high water years	Does not mitigate for FRM.	–	–	–
Blending local and system operations	Does not mitigate for FRM.	–	–	–
WATER SUPPLY		–	–	–
Aquifer recharge	Delete - not a feasible solution in the study area	–	I don't think there are any places within the study area that would benefit from aquifer recharge	–
Augment downstream flow with release of upper basin project storage	Delete - irrigation is incidental to reservoir operations; would not change operations to mitigate	–	–	–
Buy water from farmers and industry for fish	Delete - this seems like mitigation for Fish, not water supply	–	–	–
Change storage rule curves	Delete - irrigation is incidental to reservoir operations; would not change operations to mitigate	–	–	–
~~Current operations require that USBR provide M&I and Odessa subarea water through draft of Banks during juvenile migration then refill be restricted to period outside of juvenile anadromous fish migration season. This caused complicated operations and coordination this is not necessary.~~	This is not a mitigation measure for CRSO impacts to water supply.	–	Does not change the colume of water delivered, bur does change the timing of pumping	–
Increase refill probability	Delete - unclear	–	This is not clear - how would you do this? Reduce outflows? Change rule curves? Make it rain more?	–
Keep reservoirs higher (lowers pumping costs)	Delete - irrigation is incidental to reservoir operations; would not change operations to mitigate	–	–	–
More flow during irrigation season so states will permit more withdrawals	Delete - unclear	–	Unclear - increase reservoir outflows for diversion? Make it rain more?	–
Reduce flows for fish for irrigation (reduce fish flows to benefit irrigation)	Delete - irrigation is incidental to reservoir operations; would not change operations to mitigate	–	–	–
Higher and more stable headwater reservoir levels	Delete - this would be a result of the analysis, J. Johnson BOR 7May19	–	–	–
Increase water runoff storage capacity that is achieved through a highly distributed, smaller scale reservoir system	Delete - additional storage is not being included in this EIS, J. Johnson BOR 7May19	–	–	–

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
Similarly, an accurate analysis should occur for the few irrigators taking water from the reservoir above Ice Harbor Dam looking at targeted mitigation for the dozen or so irrigators involved, not subsidizing the whole unsustainable system. The LRSD were built in the 1960s and 70s; and an agricultural industry was already in place. It is not as if irrigators won't still have a source of water between the river and groundwater that will still be present.	Evaluation is not mitigation as defined under NEPA. Evaluation does not offset an effect.	–	Impacts to all irrigators who receive water from Ice Harbor reservoir will be evaluated; targeted groups can use the information to do their own analysis, J. Johnson BOR 7May19	–
WATER QUALITY	–	–	–	–
Reconfigure stilling basins (project specific) to higher elevation/less depth for plunging flows to limit TDG	delete,likely not feasbile	–	–	–
Additional flow deflectors for TDG	already done; delete; every dam except The Dalles and Grand Coulee. The natural rocky area downstream of The Dalles that provides degassing. Refer to "Implement TDG reduction measures at Grand Coulee (flip lip)" line for rationale for not including this mitigation measure at Grand Coulee.	–	–	–
Finanical/Monitoring	Monitoring is not mitigation as defined under NEPA. Monitoring does not offset an effect.	–	Financial support for water quality monitoring of the nearshore areas to determine nutrient levels	–
Finanical/Monitoring	Education efforts is not mitigation as defined under NEPA. Education efforts does not offset an effect.	–	Financial support for education efforts to help shoreline residents reduce nutrient loading from their upland activities	–
Hyporheic and groundwater monitoring	Monitoring is not mitigation as defined under NEPA. Monitoring does not offset an effect.	–	Lake Roosevelt surface and groundwater interactions are not well understood. Dynamics may change in response to proposed operational measures.	–
Saltwater Intrusion/Lower River/Estuary	No mitigation action identified.	–	Reduce saltwater intrusion during summer and fall in connected floodplains throughout the lower river estuary ecosystem	–
Implement TDG reduction measures at Grand Coulee (flip lip)	The Studies concluded that "…the ability to reach 110 percent TDG in the river below Grand Coulee is more dependent on the TDG levels present in the reservoir than on any of the structural or operational changes studies. A 110 percent saturation level is only attainable for combined spill and power releases if the initial TDG saturation level of Franklin Delano Roosevelt Lake is at or below 105 percent…" Through the Dissolved Gas and System Configuration Team it was decided that the best way to manage TDG from the Upper Basin was to build energy dissipaters (flip buckets) at Chief Joseph Dam and manage operations between the two projects to minimize TDG in the mid and lower Columbia River below Chief Joseph Dam.	"Structural Alternatives for TDG Abatement at Grand Coulee Dam, Conceptual Design report in October 1998 Kathleen H. Frizell and Elisabeth Cohen "Structural alternatives for TDG abatement at Grand Coulee Dam" Feasibility Design Report in October 2000, Kathleen H. Frizell and Elisabeth Cohen. – A model of Grand Coulee Dam was built in Reclamations Water Resources Research Laboratory in Denver, Colorado to study structural alternatives for TDG abatement at Grand Coulee.	–	–
REC	–	–	–	–
~~More parks and boat ramps (Mitigation or w/ scope?)~~	Delete, more parks and/or boat ramps above existing levels is not likely	–	–	–
~~No extreme high/low flows for rafting~~	Delete as action seems more like a constraint or consideration but not a mitigation measure	–	–	–
NAV	–	–	–	–
~~Change spill patterns to facilitate nav~~	This is already addressed in the FOP each year and each oproject already temporarly alters spill for navigation saftey as needed.	USACE 2019 FOP	–	–
~~Limit dredging~~	Delete, limited dredging is not a mitigation measure for maintiaining navigation channel	–	–	–

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
Dredging	This is too vague, please remove if specificity is not provided in review	–	–	–
AIR QUALITY	–	–	–	–
Identify all commitments to reduce construction emissions and incorporate these reductions into the air quality analysis to reflect additional air quality improvements that would result from adopting specific air quality measures. Prepare an inventory of all equipment prior to construction, and identify the suitability of add-on emission controls for each piece of equipment before groundbreaking. (Suitability of control devices is based on: whether there is reduced normal availability of the construction equipment due to increased downtime and/or power output, whether there may be significant damage caused to the construction equipment engine, or whether there may be a significant risk to nearby workers or the public.) ? Meet EPA diesel fuel requirement for off-road and on-highway (i.e., 15 ppm), and where appropriate use alternative fuels such as natural gas and electric. ? Develop construction traffic and parking management plan that minimizes traffic interference and maintains traffic flow. ? Identify sensitive receptors in the project area, such as children, elderly, and infirm, and specify the means by which you will minimize impacts to these populations. For example, locate construction equipment and staging zones away from sensitive receptors and fresh air intakes to buildings and air conditioners.	These are BMPs for air quality, if project assumes BMPs are part of the design/specs, then this is not mitigation.	–	–	–
CULTURAL RESOURCES	–	–	–	–
~~Enhance habitat in the tributaries and estuary~~	This may be an appropriate mitigation for wetlands/veg/wildlife, but is not appropriate for impacts to cultural resources	–	–	–
~~fish passage on the Columbia River at Grand Coulee and Chief Joseph~~	–	–	Fish passage at CJ and GC may be appropriate for ESA mitigation, not mitigation for impacts to cultural resources	–
~~Fish passage on the Snake River at Hells Canyon Complex~~	There are current efforts ongoing to address this problem. The alternatives being analyzed do not change fish passage for these projects from the no action - so mitigation is not needed.	–	Fish passage at the Hells Gate Complex is not appropriate mitigation for cultural resources, but may be appropriate for ESA mitigation	–
~~From "Public Scoping Report for the CRSO EIS": consider and mitigate impacts to treaty rights, tribal resources, treaty fishing rights, tribal way of life, tribal culture and cultural practices (e.g. ceremonial activities, religious activities, subsistence activities, and physical health) that are dependent upon healthy migratory fish runs (especially lamprey, salmon, and steelhead). In addition, impacts on the protection and mitigation of traditional fishing and hunting locations, sacred sites, historic cultural resources, and traditional cultural properties need to be mitigated.~~	This comment does not propose a specific mitigation, but impacts to fish should be addressed as impacts to ESA, not cultural resources.	–	–	–
~~Mitigate any adverse impacts to a healthy ecosystem, ecosystem function (as discussed in the Columbia River Treaty process)~~	This may be an appropriate mitigation for wetlands/veg/wildlife, but is not appropriate for impacts to cultural resources		–	–

~~Mitigate other mitigation measures~~	This comment does not propose a specific mitigation. In addition, other mitigation projects that currently occur within or because of operations of the system undergo individual NEPA review, including review of impacts to cultural resources, to include, but not limited to, review/compliance with Section 106 of the NHPA.	–	–	Some of the mitigation measures proposed would adversely affect cultural resources, such as "change channel capacity by intentional scouring flows by changing discharge during refill." Recreation requests more parks. The parks that already exist are a huge problem for cultural resources. Water Supply wants to micromanage the depth of the reservoirs; as noted, changes in water elevation impacts cultural resources. States permitted more water withdrawal may result in conversion of more shrub-steppe to farmland, which is an adverse impact to cultural resources; 220,000 acres are proposed. Changes in irrigation flows that advantage irrigators and disadvantage fish are bad for cultural resources. Extending the irrigation infrastructure to reach an undammed Snake River could impact archaeological sites. Integrating or

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
				developing renewable energy could impact all types of cultural resources. Integrating HMUs with USFWS may be unhelpful; USFWS has even more difficulty protecting cultural resources than the Corps does.
Reintroduction of anadromous species to historic habitats upstream of Chief Joseph and Grand Coulee dams, providing upstream and downstream fish passage at these projects	More research and science needed to determine best methods for fish passage, and habitat availability to determine a successful reintroduction of fish. There are current efforts ongoing to address this problem. The alternatives being analyzed do not change fish passage for these projects from the no action - so mitigation is not needed.	–	Loss of anadromous species is the loss of a cultural resource that cannot be replaced nor adequately mitigated by resident fish substitution.	–
–	–	–	–	–
POWER	–	–	–	–
Increase capacity	Deleting because it is redundant with more specific draft measures 1. adding turbines, see item 11, 12, 13 or 18 2. improving turbine efficiency, see 10 3. raising head at projects is an operational measure in some Mos	–	redundant to adding turbines, improving turbine efficiency, raise head at projects (all already on list here)	–
~~Integrate renewable energy on breached structures~~	***ODOE:** While it is likely possible to physically site other types of renewable generation (e.g., wind or solar) on top of breached dam structures, it is likely **not** the most cost-effective approach. The primary reason for this concerns the quality of the resource at the particular geographic locations where the dams are located. Cost-effective solar and wind projects tend to be sited in areas with the strongest resources (e.g., high average wind speeds or good southern exposure and strong solar irradiance). Second, the power output from the number of renewable generators that could be physically sited on the breached structures themselves would likely be significantly less than the output of the dams themselves. *Not sure what "on breached structures" means. You can't put a structure on something that is removed to the river-bed.	–	–	–

Deleted Mitigation Measure:	Reason for deleting	Citations	Notes	Additional notes
Reliability (keep loss-of-load within Council's standards) -- could include keeping reliability despite other actions that might reduce reliability such as removing dams or constraining operations -- could include keeping reliability despite climate change	This wouldn't really be a consideration. Any change to the operation of the dams within the FCRPS that negatively impacts electric reliability would be identified by the NW Power Council (and other stakeholders) and would be addressed in the same manner as any other reliability shortfall. For example, as coal plants in the region retire, the Power Council (and specifically, its Resource Adequacy Advisory Committee) evaluates how much additional capacity needs to be added to the Northwest power system to maintain overall reliability consistent with the Loss of Load Probability standard adopted by the Council. The question becomes a matter of how much it will cost the region to procure the necessary additional resources to maintain reliability.	–	–	–
Index test all units to optimize current turbine operations	This is a routine action that is expected to occur regardless of this EIS and therefore it has been removed from the mitigation toolbox.	–	This measure may help offset the impact to power generation	–

Draft Columbia River System Operations
Environmental Impact Statement

Appendix R, Mitigation, Monitoring and Adaptive Management
Part 3, Mitigation Process

Attachment D
Completed Impact Summary Spreadsheets

CHAPTER 1 - COMPLETED IMPACT SUMMARY SPREADSHEETS [1]

Water Quality – Multiple Objective 1

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby Reservoir	In-reservoir water temperatures too cold in spring/early summer	Reservoir held higher Dec - Feb for the majority of years, which may result in colder reservoir water temperatures in spring and summer. State WQS still met below LIB.	reservoir elevation	low	mitigation not possible	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	In-reservoir water temperatures could be too cold in spring/early summer in most years, butparticularly when reservoir is held high during winter months.
Kootenai River d/s of Libby	River water temperatures too cold in spring/early summer	Reservoir held higher Dec - Feb for the majority of years, which may result in colder reservoir water temperatures in spring and summer. State WQS still met below LIB.	reservoir elevation	low	mitigation not possible	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	River water temperatures too cold in spring/early summer, even with use of SWS.

[1] Note that the effects in this toolbox were preliminary and analysis was continuing to be completed in the summer of 2019

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Kootenai River d/s of Libby	River water temperatures too warm in winter	Increased outflows from Jan - March. By increasing the flows to draw the pool down aggressively, the MO1 Alternative may prevent the natural cooling of the river as it moves downstream. State WQS still met below LIB.	total outflow	low	mitigation not possible	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	River water temperatures too warm in winter, even with use of SWS.
Kootenai River d/s of Libby	High TDG	Higher winter flows would likely increase TDG > 110% in the river downstream of Libby Dam (from 8 to 35 days out of POR).	total outflow	low	Add sixth turbine to Libby powerhouse.	yes	yes	Add sixth turbine to Libby powerhouse.	CWA (TDG state water quality standard)	yes	n/a	no; level of impact is low and would occur rarely. Mitigation costs outweigh impact.	no; level of impact is low and would occur rarely. Mitigation costs outweigh impact.	n/a	TDG would still exceed state water quality standards at times.
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grand Coulee Reservoir	elevated turbidity	Deeper winter draft may lead to increase shoreline erosion.	reservoir elevation/retention time	low	no mitigation proposed	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	n/a
Grand Coulee Reservoir	increased mercury methlyation	Increased methylation of mercury from deeper and longer reservoir drawdowns (wetting/drying of sediments).	reservoir elevation/retention time	med	no mitigation proposed	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	n/a

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee Reservoir	reduced dissolved oxygen	Spokane Arm DO in low flow/high temperature conditions have a greater portion of the water column that is anoxic.	reservoir elevation/retention time	low	Install aeration or bubbler system in impacted area (near mouth of Spokane River).	yes	yes	Install aeration or bubbler system in impacted area (near mouth of Spokane River).	DO TMDL exists for Little Spokane River, but not for reservoir.	yes	n/a	no; level of impact is low and occurs in small area within reservoir; conditions may improve from efforts conducted by other. Mitigation costs outweigh impact.	no; level of impact is low and occurs in small area within reservoir; conditions may improve from efforts conducted by other. Mitigation costs outweigh impact.	n/a	n/a
Grand Coulee Tailrace	River water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	total outflow/residence time	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Chief Joseph Reservoir	In-reservoir water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	upstream conditions	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Chief Joseph Tailrace	River water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	upstream conditions	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	**Summary of Impact(s) Compared To NAA** **if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Dworshak Tailwater	River water temperatures too high in August	Warmer water temperatures in August; affects LSR temps. State WQS still met below DWR.	change in August Dworshak outflows	high	no mitigation proposed (without changing alternative); recommend not moving forward with this measure in preferred.	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	n/a
Lower Snake River Projects (LWG - IHR)	River water temperatures too high in August	Warmer water temperatures in August; 68°F LWG TW temp target exceeded.	change in August Dworshak outflows	high	no mitigation proposed (without changing alternative); recommend not moving forward with this measure in preferred.	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Lower Snake River Projects (LWG - IHR)	Increased algae growth due to high August water temperatures	Potential increased algal blooms, pH and DO (supersaturation) in August.	change in August Dworshak outflows	med	Increased harmful algae bloom monitoring at recreational areas; if algal blooms produce toxins, post recreational areas with public advisories.	yes	yes	Increased harmful algae bloom monitoring at recreational areas; if algal blooms produce toxins, post recreational areas with public advisories.	no	yes	n/a	yes; impact is seasonal and could be carried during summer months when recreational activity is high.	yes	yes; water quality and recration	algal blooms would still occur, as this mitigation measure stives to protect public, not reduce blooms.
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
none	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
none	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Water Quality – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby Reservoir	reduced in-lake biological productivity	Reservoir drawdowns and higher flushing rates.	reservoir elevation and total outflow	med	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	yes, the nutrient suplementation program currently being carried out at Dworshak Reservoir has improved overall reservoir productivity.	yes	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	ESA (bulltrout?)	yes	n/a	yes; there have been numerous studies on Hungry Horse Reservoir that link drawdowns and flushing flows to reduced in-lake productivity.	yes	yes, resident fish and water quality	resident fish populations may still struggle; nutrient additions can risk balance between in-lake nutrient levels (nitrogen and phosphorus). If these nutrients become out of balance, harmful algae (cyanotoxins) may bloom and dominate system. Monitoring and adaptive management is necessary.

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Kootenai River d/s of Libby	River water temperatures too warm in winter	Higher winter flows may impact natural cooling of river downstream of Libby Dam in early winter.	total outflow	low	no mitigation possible	n/a	n/a	no mitigation proposed	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungry Horse Reservoir	reduced in-lake biological productivity	Reservoir drawdowns and higher flushing rates.	reservoir elevation and total outflow	med	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	yes, the nutrient suplementation program currently being carried out at Dworshak Reservoir has improved overall reservoir productivity.	yes	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	ESA (bulltrout?)	yes	n/a	yes; there have been numerous studies on Hungry Horse Reservoir that link drawdowns and flushing flows to reduced in-lake productivity.	yes	yes, resident fish and water quality	resident fish populations may still struggle; nutrient additions can risk balance between in-lake nutrient levels (nitrogen and phosphorus). If these nutrients become out of balance, harmful algae (cyanotoxins) may bloom and dominate system. Monitoring and adaptive management is necessary.
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee Reservoir	elevated turbidity	Deeper winter draft may lead to increase shoreline erosion.	reservoir elevation/retention time	low	no mitigation proposed	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	n/a
Grand Coulee Reservoir	increased mercury methlyation	Increased methylation of mercury from deeper and longer reservoir drawdowns (wetting/drying of sediments).	reservoir elevation/retention time	med	no mitigation proposed	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	n/a
Grand Coulee Reservoir	reduced dissolved oxygen	Spokane Arm DO in low flow/high temperature conditions have a greater portion of the water column that is anoxic.	reservoir elevation/retention time	low	Install aeration or bubbler system in impacted area (near mouth of Spokane River).	yes	yes	Install aeration or bubbler system in impacted area (near mouth of Spokane River).	DO TMDL exists for Little Spokane River, but not for reservoir.	yes	n/a	no; level of impact is low and occurs in small area within reservoir; conditions may improve from efforts conducted by other. Mitigation costs outweigh impact.	no; level of impact is low and occurs in small area within reservoir; conditions may improve from efforts conducted by other. Mitigation costs outweigh impact.	n/a	n/a
Grand Coulee Tailrace	River water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	total outflow/residence time	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Chief Joseph Reservoir	In-reservoir water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	upstream conditions	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Chief Joseph Tailrace	River water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	upstream conditions	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dworshak	High TDG	Some increases in TDG below Dworshak Dam would be expected during high flow years due to increased outflow in the spring time in order to stay 10 feet below the upper rule curve (URC) (measure O2d).	total spill, TDG	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
none	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
none	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Water Quality – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby Reservoir	reduced in-lake biological productivity	Reservoir drawdowns and higher flushing rates.	reservoir elevation and total outflow	med	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	yes, the nutrient suplementation program currently being carried out at Dworshak Reservoir has improved overall reservoir productivity.	yes	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	ESA (bulltrout?)	yes	n/a	yes; there have been numerous studies on Hungry Horse Reservoir that link drawdowns and flushing flows to reduced in-lake productivity.	yes	yes, resident fish and water quality	resident fish populations may still struggle; nutrient additions can risk balance between in-lake nutrient levels (nitrogen and phosphorus). If these nutrients become out of balance, harmful algae (cyanotoxins) may bloom and dominate system. Monitoring and adaptive management is necessary.

Location	**Summary of Impact(s) Compared To NAA** **if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Kootenai River d/s of Libby	River water temperatures too warm in winter	Higher winter flows may impact natural cooling of river downstream of Libby Dam in early winter.	total outflow	low	no mitigation possible	n/a	n/a	no mitigation proposed	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hungry Horse Reservoir	reduced in-lake biological productivity	Reservoir drawdowns and higher flushing rates.	reservoir elevation and total outflow	med	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	yes, the nutrient suplementation program currently being carried out at Dworshak Reservoir has improved overall reservoir productivity.	yes	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	ESA (bulltrout?)	yes	n/a	yes; there have been numerous studies on Hungry Horse Reservoir that link drawdowns and flushing flows to reduced in-lake productivity.	yes	yes, resident fish and water quality	resident fish populations may still struggle; nutrient additions can risk balance between in-lake nutrient levels (nitrogen and phosphorus). If these nutrients become out of balance, harmful algae (cyanotoxins) may bloom and dominate system. Monitoring and adaptive management is necessary.

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grand Coulee Tailrace	River water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	total outflow/residence time	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Chief Joseph Reservoir	In-reservoir water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	upstream conditions	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Chief Joseph Tailrace	River water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	upstream conditions	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Snake River Projects (LWG - LMN)	Reduced dissolved oxygen/anoxia	High amounts of suspended sediemtn would be released during both years of reservoir drawdown and breach which could create very low and potentially anoxic conditions following 1st dam breach.	Total suspended sediments, sediment oxygen demand (as exist today), combined with river mechanics sediment transport modeling.	high	(1) Install aeration system in LMN to inject oxygen into water; (2) make an aerated backwater area to provide a refuge for resident fish	no, area likely too large for aeration system to work effectively, especially given that the environment will be changing quickly and aeration system is likley to be innudated/clogged with moving sediments.	no, area likely too large for aeration system to work effectively, especially given that the environment will be changing quickly and aeration system is likley to be innudated/clogged with moving sediments.	no mitigation proposed	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lower Snake River Projects (LWG - IHR)	Resuspension of contaminants and increased biological uptake	Suspension and downstream deposition of fine grained sediment that contains bioaccumulative compounds (PCBs, dioxins, pesticides, Hg, etc) will expose fish populations to new, higher levels of contaminants, with expected increases in fish tissue concentrations for at least a few years.	Sediment quality information collected over the years, combined with river mechanics sediment transport modeling.	high	Strategic removal (dredging) of any sediment "hot spots" with high contaminant levels.	yes, dredging contaminated areas first would reduce re-suspension of contaminated sediment.	yes, the Corps dredges some of these areas already.	Strategic removal (dredging) of any sediment "hot spots" with high contaminant levels.	yes, CWA	yes	n/a	yes, known contaminated sediment would be transported downstream and could be mitigated for.	yes, however costs would be high	yes, water quality, wildlife, resident fish, anadromous fish	some contaminated sediment would remain and potentially be taken up by fish and terrestrial animals.

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Snake River Projects (LWG - IHR)	Contaminated groundwater flows may increase pollution in LSR	Impacts to groundwater flows (several known polluted ground water sources near Lewiston); NPDES permits would likely need to be redefined (less dilution).	Total river flow/reservoir elevation	high	Groundwater control: (1) Install groundwater cutoff walls or groundwater "treatment curtains/walls" along areas of known groundwater contamination; (2) pump and treat groundwater aggressively to prevent flows from entering river; (3) Remediate known contamination areas prior to dam breach.	yes, containing or cleaning-up contaminated groundwater areas would reduce polluted inputs into lower Snake River post-breaching.	yes, these mitigation measures have been successful in other parts of the country.	Groundwater control: (1) Install groundwater cutoff walls or groundwater "treatment curtains/walls" along areas of known groundwater contamination; (2) pump and treat groundwater aggressively to prevent flows from entering river; (3) Remediate known contamination areas prior to dam breach.	yes, CWA	yes	n/a	yes, known contaminated groundwater is present and could be mitigated for.	yes, however costs would be high	yes, water quality, wildlife, resident fish, anadromous fish	if groundwater is contained rather than remediated, it would still be considered contaminated and potentially pose future risks to humans and animals.
Lower Snake River Projects (LWG - IHR)	High temperatures in summer	Water temperatures could still exceed state water quality standards during the summer months due to shallow river post-breaching.	Water temperature/total flow/reservoir elevation	med	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	**Summary of Impact(s) Compared To NAA** **if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Lower Columbia River Projects (MCN - BON)	High TDG	Higher TDG limits as called for in MO3 would create TDG that is higher than NAA; new state water quality standards would need to be established.	total spill, TDG	low	no mitigation proposed, as MO3 measures call for higher TDG limits in lower Columbia River.	n/a	n/a	none	CWA, until new TDG waivers are established.	n/a	n/a	n/a	n/a	n/a	n/a
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
none	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Water Quality – Multiple Objective 4

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby Reservoir	reduced in-lake biological productivity	Reservoir drawdowns and higher flushing rates.	reservoir elevation and total outflow	med	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	yes, the nutrient suplementation program currently being carried out at Dworshak Reservoir has improved overall reservoir productivity.	yes	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	ESA (bulltrout?)	yes	n/a	yes; there have been numerous studies on Hungry Horse Reservoir that link drawdowns and flushing flows to reduced in-lake productivity.	yes	yes, resident fish and water quality	resident fish populations may still struggle; nutrient additions can risk balance between in-lake nutrient levels (nitrogen and phosphorus). If these nutrients become out of balance, harmful algae (cyanotoxins) may bloom and dominate system. Monitoring and adaptive management is necessary.

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Libby Reservoir	In-reservoir water temperatures too cold in spring/early summer	Reservoir held higher Dec - Feb for the majority of years, which may result in colder reservoir water temperatures in spring and summer.	reservoir elevation	low	no mitigation possible	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	n/a
Kootenai River d/s of Libby	River water temperatures too cold in spring/early summer	Reservoir held higher Dec - Feb for the majority of years, which may result in colder reservoir water temperatures in spring and summer.	reservoir elevation	low	no mitigation possible	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	n/a
Kootenai River d/s of Libby	River water temperatures too warm in winter	Higher winter flows may impact natural cooling of river downstream of Libby Dam in early winter.	total outflow	low	no mitigation possible	n/a	n/a	no mitigation proposed	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Kootenai River d/s of Libby	High TDG	Some increases in TDG below Libby Dam would be expected during high flow years due to aggressive drafting of Libby Reservoir following the end-of-December draft target measure (O12).	total spill, TDG	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Hungry Horse Reservoir	Reduced in-lake biological productivity	Reservoir drawdowns and higher flushing rates.	reservoir elevation and total outflow	med	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	yes, the nutrient suplementation program currently being carried out at Dworshak Reservoir has improved overall reservoir productivity.	yes	Perform in-reservoir nutrient supplementation to increase primary and secondary productivity.	ESA (bulltrout?)	yes	n/a	yes; there have been numerous studies on Hungry Horse Reservoir that link drawdowns and flushing flows to reduced in-lake productivity.	yes	yes, resident fish and water quality	resident fish populations may still struggle; nutrient additions can risk balance between in-lake nutrient levels (nitrogen and phosphorus). If these nutrients become out of balance, harmful algae (cyanotoxins) may bloom and dominate system. Monitoring and adaptive management is necessary.

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Albeni Falls	Nearshore areas used for recreation may be more difficult to access due to the lower lake level, as well as from greater macrophyte and periphyton growth.	McNary Dam augmentation (O7) measure would results in slightly warmer downstream water temperatures in the summer months.	reservoir elevation, conditions under NAA	low	Implement and expand existing invasive aquatic plant removal program (e.g. Eurasian water milfoil).	yes, current removal program has been successful	yes	Implement and expand existing invasive aquatic plant removal program (e.g. Eurasian water milfoil).	no	yes	n/a	yes, current removal program has been successful	yes	yes, water quality and recreation	some invasive aquatic plants may still be present and negatively impact recreation, since impact area is so large.
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grand Coulee Reservoir	elevated turbidity	Deeper winter draft may lead to increase shoreline erosion.	reservoir elevation/retention time	low	no mitigation proposed	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	n/a
Grand Coulee Reservoir	increased mercury methlyation	Increased methylation of mercury from deeper and longer reservoir drawdowns (wetting/drying of sediments).	reservoir elevation/retention time	med	no mitigation proposed	n/a	n/a	none	no	n/a	n/a	n/a	n/a	n/a	n/a

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee Reservoir	reduced dissolved oxygen	Spokane Arm DO in low flow/high temperature conditions have a greater portion of the water column that is anoxic.	reservoir elevation/retention time	low	Install aeration or bubbler system in impacted area (near mouth of Spokane River).	yes	yes	Install aeration or bubbler system in impacted area (near mouth of Spokane River).	DO TMDL exists for Little Spokane River, but not for reservoir.	yes	n/a	no; level of impact is low and occurs in small area within reservoir; conditions may improve from efforts conducted by other. Mitigation costs outweigh impact.	no; level of impact is low and occurs in small area within reservoir; conditions may improve from efforts conducted by other. Mitigation costs outweigh impact.	n/a	n/a
Grand Coulee Tailrace	River water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	total outflow/residence time	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Chief Joseph Reservoir	In-reservoir water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	upstream conditions	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a
Chief Joseph Tailrace	River water temperatures too high in some summers	Minor increase in spring/summer water temperatures in low water years.	upstream conditions	low	no mitigation proposed	n/a	n/a	none	CWA	n/a	n/a	n/a	n/a	n/a	n/a

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lower Snake River Projects (LWG - IHR)	High TDG	Higher TDG limits as called for in MO3 would create TDG that is higher than NAA; new state water quality standards would need to be established.	total spill, TDG	low	no mitigation proposed, as MO3 measures call for higher TDG limits in lower Columbia River.	n/a	n/a	none	CWA, until new TDG waivers are established.	n/a	n/a	n/a	n/a	n/a	n/a
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lower Columbia River Projects (MCN - BON)	High TDG	Higher TDG limits as called for in MO3 would create TDG that is higher than NAA; new state water quality standards would need to be established.	total spill, TDG	low	no mitigation proposed, as MO3 measures call for higher TDG limits in lower Columbia River.	n/a	n/a	none	CWA, until new TDG waivers are established.	n/a	n/a	n/a	n/a	n/a	n/a
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Fish (Chinook, Steelhead, and Sockeye) – Multiple Objective 1

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low) and brief explanation why	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ice Harbor	Increased frequency of high water temperatures (> 20 °C (68 °F)) that can cause migrating adult salmon to stop or delay their migration or can increase fallback at a dam.	Dworshak augmentation measure	Water temperature	high	No mitigation option (don't implement operation)	NA	NA	NA	ESA, CWA	NA	NA	seasonal (August and September)	NA	NA	NA

Location	**Summary of Impact(s) Compared To NAA** **if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low) and brief explanation why**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Lower Monumental	Increased number days with >2 °C differential in adult ladder that can delay adult migration	Dworshak augmentation measure	Water temperature	high	Install pumps at ladders to select cooler water. This action is a structural measure included in MO 1, MO 2, and MO 4.	This measure is estimated by Engineering to be effective in extreme hot years (25% of the time), but only if paired with a trap and haul facility/operation, which would allow fish to be transported upstream above Lower Granite. (Pumps would be required for an effective trap and haul operation). In normal years this would not be needed.	Yes. It is feasible to install, but would need to be combined with a trap and haul facility/operation. Engineering recommends Ice Harbor as a higher priority location for this operation, not Lower Monumental.	No - already included as a measure in the alternative.	ESA, CWA	NA	NA	NA	No. This action is already included in the alternatives as a structural measure.	This measure would benefit bull trout using the fish ladders	

Location	**Summary of Impact(s) Compared To NAA** **if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low) and brief explanation why**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
All projects	TDG experience from increased spill	Increased spill measures. Change to this measure (lower Spill level) would reduce or eliminate this negative impact.	TDG	medium	*implement mainstem habitat improvement projects to increase food sources and reconnect back-channel habitats *increase pinniped and avian predator measures	These measures will not change TDG, but would improve conditions for existing fish migrating into and out of the system.	Yes.	Yes	ESA, CWA	No	TDG impacts cannot be mitigated without changing the alternative. Taking offsite actions would generally improve conditions for juvenile and adult fish in the river.	all years	No. There is an option for effective, onsite mitigation.	Habitat improvements would benefit resident fish (bull trout and others) and other species than anadromous fish	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low) and brief explanation why	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Granite and Little Goose	TDG experience from increased spill	Increased spill measures. Change to this measure (lower Spill level) would reduce or eliminate this negative impact.	TDG	medium	*install divider wall at LSR projects to isolate the high TDG and reduce/eliminate confounding eddies for u/s adult passage *Add ladder entrances at LWG & LGS	1)Divider walls have been studied in the past (NWW) and found not to be effective at isolating TDG. There is no effective measure available to isolate TDG, short of not implementing the spill or changing spill levels. 2) Additional ladder entrances could provide a more direct route outside of eddies created by spill, for upstream adult passage.	The walls would not isolate TDG. Additional fish ladder entrances are feasible and implementable.	Yes - ladder entrances. Divider walls are not recommended.	ESA, CWA	Yes. The construction of additional ladder entrances is an onsite mitigation measure. Construction of divider walls is not recommended.	TDG impacts cannot be mitigated without changing the alternative.	all years	Yes	–	–
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

LCOL Projects	TDG experience from increased spill	Increased spill levels. Change to this measure (lower Spill level) would reduce or eliminate this negative impact.	TDG	medium	*implement mainstem habitat improvement projects to increase food sources and reconnect back-channel habitats *increase pinniped and avian predator measures	These measures will not change TDG, but would improve conditions, including resting and food sources, for existing fish migrating into and out of the system. An increase in the level of avian or pinniped predator management would help to lessen impacts to fish that are stunned or temporarily incapacitated by higher TDG levels, or adult fish that may become stalled looking for ladder entrances.	Yes	Yes	ESA, CWA	No	TDG impacts cannot be mitigated without changing the alternative. Taking offsite actions would generally improve conditions for juvenile and adult fish in the river.These measures will not change TDG, but would improve conditions, including resting and food sources, for existing fish migrating into and out of the system. An increase in the level of avian or pinniped predator management would help to lessen impacts to fish that are stunned or temporarily incapacitated by higher TDG levels, or adult fish that may	all years	No. There is no option for effective, onsite mitigation.	Habitat improvements would benefit resident fish and other wildlife.	TDG levels in the river would remain the same, but the number of fish affected may decrease.

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low) and brief explanation why	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
											become stalled looking for ladder entrances.				
LCOL Projects	TDG experience from increased spill	Increased spill levels. Change to this measure (lower Spill level) would reduce or eliminate this negative impact.	TDG	medium	*install divider wall at LCR projects to isolate the high TDG and reduce/eliminate confounding eddies for u/s adult passage *Shad removal at BON and TDA within ladders	Neither measure is effective. 1)Divider walls have been studied in the past (NWW) and found not to be effective at isolating TDG. There is no effective measure available to isolate TDG, short of not implementing the spill or changing spill levels. 2) A study at The Dalles conducted by NWP found that shad to not impact use of the fish ladders by adult salmon.	No	No mitigation recommended	ESA, CWA	NA	NA	–	Yes	–	–
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Fish (Chinook, Steelhead, and Sockeye) – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
LSR	decreased in-river survival due to increased Powerhouse encounters/increased predation and reduced spill (increased travel time)	Operational measures to increase hydropower flexibility/lifting of restrictions	survival rates: latent effects of survival for fish who move through bypasses	Med	*Add divider walls to tailrace downstream of PHs to improve egress *Behavioral guidance structures at individual dams, e.g. solid curtain in forebay (artificial shoreline), pile dikes, nets *Reduce fish handling at bypass locations, only at LSR collector prjects and MCN for transport if at all. *Increase in the level of avian and pinniped predation management	None of these actions directly and effectively address the effects of powerhouse encounters.	None of these actions directly address the effects.	Only the measure to increase the level of avian and pinniped predation management.	ESA	No.	The effects cannot be effectively and directly offset. An increase in the level of management of predators could help to limit predation on stunned or injured fish.	Yes.	Yes. Increase the level of predator management.	May be a benefit for resident fish.	–
–	Slight increase in juvenile downstream travel time by approximately 13-15 hours.	Reduction in spill to 110% TDG	juvenile fish travel times	medium	Effect cannot be mitigated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward (Y/N) from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Slight increase in juvenile downstream travel time by approximately 13-15 hours.	Reduced spill levels (Spill to 110%)	juvenile fish travel times	medium	Effect cannot be mitigated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
–	Increased juvenile transportation results in increased adult migration delay from fallback and straying due to impared homing ability.	Increase transport measure	Upstream travel times/SARs. Fallback and straying is measured with PIT tagged fish	medium	Effect cannot be mitigated	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Fish (Chinook, Steelhead, and Sockeye) – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lower Snake River Projects	Dam breaching would create high levels of turbidity/suspended sediment from Lower Granite Dam to Ice Harbor Dam during Snake Rier fall Chinook and upper Snake River sockeye migration. This could result in mortality to 20-40% of the populations.	Dam Breach	Water Quality	high	a)Construct new trap and haul operation for Snake River salmon and sturgeon b) Change dam breach timing to outside of the salmon migration window (two months later) c)Raise additional hatchery fish to offset two lost year classes prior to start of breach	Yes	Trap and Haul is feasible. Feasibility of (b) is questionable for safety reasons. Item C) may be feasible, but capacity at existing hatcheries is uncertain.	Yes	ESA	Yes	NA	Temporary result of breach, but may take years to stabilize river	Trap and Haul - Yes Change Dam Breach timing - No, due to safety concerns Raise additional hatchery fish - Yes, if capacity exists	Salmon, Steelhead, and Sturgeon would be trapped and moved prior to breaching.	There would be a proportion of fish that stray and spawn elsewhere due to extreme conditions.

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Snake River Projects	Very low dissolved oxygen level from dam breaching would result in mortality in the Little Goose and Lower Monumental reservoirs during first phase of demolition, potentially wiping out year class of migrating Snake River fall Chinook and upper Snake RIver sockeye.	Dam Breach	Water Quality	high	a)Construct new trap and haul operation for Snake River fish b) Change dam breach timing to outside of the salmon migration window; c)Raise additional hatchery fish to offset two lost year classes prior to breach	Yes	Trap and Haul is feasible. Feasibility of (b) is questionable for safety reasons. Item C) may be feasible, but capacity at existing hatcheries is uncertain.	Yes	ESA	Yes	NA	Temporary result of breach, but may take years to stabilize river	Trap and Haul - Yes Change Dam Breach timing - No, due to safety concerns Raise additional hatchery fish - Yes, if capacity exists	Salmon, Steelhead, and Sturgeon would be trapped and moved prior to breaching.	Water quality would be bad, but fewer fish would be impacted
Lower Snake River Projects	Potential island creation post-dam breaching could result in additional avian nesting habitat and increase predation pressure on migrating fish.	Dam Breach	Water Quality	low	No mitigation proposed	NA	NA	NA	ESA	NA	NA	NA	NA	NA	NA
Lower Snake River Projects	Additional days over 18° C would cause thermal stress and potential increased mortality of Snake River sockeye.	Dam Breach	Water Quality	high	No mitigation proposed - cannot be mitigated	NA	NA	NA	ESA	NA	NA	NA	NA	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended ?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Snake River Projects	Decreased spawning success of Snake River spring Chinook salmon and steelhead due to perched tributaries from breaching of lower Snake River dams.	Dam Breach	Water Quality	–	Trap and haul fish during breaching; create pilot channels in tributaries likely to perch from breaching.	Yes	Yes	Yes	ESA	Yes	NA	Temporary result of breach, but may take years for river to stabilize	Trap and Haul - Yes Change Dam Breach timing - No, due to safety concerns Raise additional hatchery fish - Yes, if capacity exists	Salmon, Steelhead, and Sturgeon would be trapped and moved prior to breaching.	Water quality would be bad, but fewer fish would be impacted
Lower Snake River Projects	high turbidity/sediment levels during migration resulting in 20-40% mortality	Dam Breach	Water Quality	high	*construct new trap and haul SR Sockeye above LWG at Ice Harbor. * change dam breach timing to miss salmon migrations *raise additional hatchery fish to offset two lost year classes	Yes	Yes	Yes	ESA	Yes	NA	Temporary result of breach, but may take 8 years to stabilize river	Trap and Haul - Yes Change to timing of breach - No Additional hatchery fish - Yes	Salmon, Steelhead, and Sturgeon would be trapped and moved prior to breaching.	Water quality would be bad, but fewer fish would be impacted
Lower Snake River Projects	low dissolved oxygen levels resulting in mortality in the LGS and LMO pools during first phase of deconstruction	Dam Breach	Water Quality	high	*construct new trap and haul SR Sockeye above LWG at Ice Harbor. * change dam breach timing to miss salmon migrations *raise additional hatchery fish to offset two lost year classes	Yes	Yes	Yes	ESA	Yes	NA	Temporary result of breach, but may take 8 years to stabilize river	Trap and Haul - Yes Change Dam Breach timing - No, due to safety concerns Raise additional hatchery fish - Yes, if capacity exists	Salmon, Steelhead, and Sturgeon would be trapped and moved prior to breaching.	Water quality would be bad, but fewer fish would be impacted

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lower Columbia River projects	TDG experience from increased spill	Spill to 120% TDG measure	Water Quality, TDG	medium	*implement mainstem habitat improvement projects to increase food sources and reconnect back-channel habitats *increase pinniped and avian predator measures	Yes	Yes	Yes	ESA, CWA	No	TDG impacts throughout the river cannot be mitigated without changing the alternative to avoid the effect. Taking offsite actions would generally improve conditions for juvenile and adult fish in the river. Increasing management of predators would lower predation on fish stunned or injured by TDG.	All years	Yes	Habitat improvements would provide a benefit to other wildlife. Predator measure could provide benefits to resident fish.	High TDG levels would still be present in the river.

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward (Y/N) from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Lower Columbia River projects	High levels of turbidity as from the dam breaching measure could result in high levels of turbidity downstream of McNary Dam. This could result in 20-40% mortality of migraing Upper Columbia and Upper Snake River fall Chinook and sockeye	Dam Breaching	Water Quality	high	* Create MCN collection facility to allow trap and haul from MCN (to collect fall migrating fish below Snake) *Modify/improve BON collection facitlity to allow trap and haul from BON *change dam breach timing to miss Salmon Migrations *raise additional hatchery fish to offset two lost year classes	Yes	Yes	Yes	ESA, CWA	No, the trap and haul sites are downstream of the breach site.	Collection of fish downstream would keep them from entering the breach zone and keep them out of the area negatively affected by breaching.	Temporary result of breach, but may take 8 years to stabilize river	Trap and Haul - Yes Change Dam Breach timing - No, due to safety concerns Raise additional hatchery fish - Yes, if capacity exists	Bull Trout and Sturgeon would also be trapped and moved prior to breaching.	Water quality would be bad, but fewer fish would be impacted

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Columbia River projects	low dissolved oxygen levels resulting in mortality in the LGS and LMO pools during first phase of deconstruction	Dam Breaching	Water Quality	high	* Create MCN collection facility to allow trap and haul from MCN *Modify/improve BON collection facitlity to allow trap and haul from BON *change dam breach timing to miss Salmon Migrations *raise additional hatchery fish to offset two lost year classes	Yes	Yes	Yes	ESA, CWA	No, the trap and haul sites are downstream of the breach site.	Collection of fish downstream would keep them from entering the breach zone and keep them out of the area negatively affected by breaching.	Temporary result of breach, but may take 8 years to stabilize river	Trap and Haul - Yes Change Dam Breach timing - No, due to safety concerns Raise additional hatchery fish - Yes, if capacity exists	Bull Trout and Sturgeon would also be trapped and moved prior to breaching.	Water quality would be bad, but fewer fish would be impacted
Lower Columbia River projects	TDG experience from increased spill	Spill to 120% TDG measure	Water Quality, TDG	medium	1)install divider wall at LCR projects to isolate the high TDG and reduce/eliminate confounding eddies for u/s adult passage 2)Modify transport facility raceways to reduce TDG at McNary using steel infrastructure to degass the raceway during collection for transport.	1) Divider walls have been studied and found to not be effective for lowering TDG effects. Cost is too high to apply for confounding eddies. 2) Modification of raceways would be effective and is recommended.	Modification of raceways is feasible and implementable.	Modification of raceways carried forward for recommendation	ESA, CWA	NA	NA	Seasonal, as Spill to 120% measure is implemented	Yes. Modification of the raceways is recommended	Yes	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Columbia River projects	Decreased survival due to higher turbidity and low DO; decreased spawning success due to perched tributaries in lower Snake reach	Dam Breaching	Water Quality	High	*Trap and haul fish during implementation of breach	Yes	Yes	Yes	ESA, CWA	No, the trap and haul sites are downstream of the breach site. Construction of pilot channels prior to breaching would insure that fish had access to the tributaries, and may help to create refuges during high turbidiy and periods of low DO.	Collection of fish downstream would keep them from entering the breach zone and keep them out of the habitat area negatively affected by breaching.	Temporary result of breach, but may take 8 years to stabilize river	Trap and Haul - Yes Change Dam Breach timing - No, due to safety concerns Raise additional hatchery fish - Yes, if capacity exists	Bull Trout and Sturgeon would also be trapped and moved prior to breaching.	Water quality would be bad, but fewer fish would be impacted
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Fish (Chinook, Steelhead, and Sockeye) – Multiple Objective 4

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Okanogan River confluence	Dry years may see mainstem temps rise over 20C in fall, which causes confounding water temperatures and adults can't find spawning grounds.	McNary flow targets measure	water temperature, fish passage numbers	medium	no known feasible mitigation options	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Snake Projects	a) Increased frequency of high water temperatures (> 20° C or 68° F). This can cause migrating adult salmon to stop or delay their migration or can increase fallback at a dam would negatively impact Snake River Fall Chinook.	Change to Dworshak Spill schedule	Water Quality	High	No mitigation proposed/no mitigation possible	NA	NA	NA	Yes	NA	NA	NA	NA	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable ?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended ?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Snake Projects	Elevated TDG could harm upstream migrants and/or affect upstream migration of Snake River fall Chinook and Upper Snake River sockeye.	Spill to 125% TDG measure	Water Quality	High	1) Install divider wall at lower Snake River projects to isolate the high TDG and reduce/eliminate eddies that slow upsteram adult passage; 2) Add fish ladder entrances at Lower Granite and Little Goose Dams.	1)Divider walls have been studied in the past (NWW) and found not to be effective at isolating TDG. There is no effective measure available to isolate TDG, short of not implementing the spill or changing spill levels. 2) Additional ladder entrances would be effective in providing upstream passage to adult salmon and steelhead who are impacted by confounding eddies under a high spill regime.	1)Divider Walls are not feasible. 2) Additional ladder entrances are feasible.	Yes - Additional Ladder entrances only.	Yes	Yes	–	All years	Yes - Ladder Entrances	–	High TDG remains, but adult fish would have an easier upstream migration through the eddies created by high spill.
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Columbia Projects	Slight increases in TDG throughout the lower Columbia River could have negative impacts on migrating Upper Columbia spring Chinook and steelhead and sockeye.	Spill to 125% TDG measure	Water Quality	High	1)Install divider wall at John Day ad McNary Dams to isoate the high TDG and reduce/eliminate confounding eddies for upstream adult fish passage; 2)implement mainstem habitat improvement projects to increase food sources and reconnect back-channel habiatats; 3)increase pinniped and avian predation measures; 4)perfom shad removal in the fish ladders at Bonneville and the Dalles.	Neither onsite measure (1 and 4) is effective. 1)Divider walls have been studied in the past (NWW) and found not to be effective at isolating TDG. There is no effective measure available to isolate TDG, short of not implementing the spill or changing spill levels. 2) A study at The Dalles conducted by NWP found that shad to not impact use of the fish ladders by adult salmon.	Divider walls and shad removal would not have the desired effect.	The offsite measures for habitat improvement and increased avian and pinniped management are recommended.	Yes	No. The measures are offsite	TDG impacts cannot be mitigated without changing the alternative. Taking offsite actions would generally improve conditions for juvenile and adult fish in the river.	all years	No. There is no option for effective, onsite mitigation.	Habitat improvements would benefit resident fish and other wildlife.	TDG levels in the river would remain the same, but the number of fish affected may decrease.

Lower Columbia Projects	TDG experience from increased spill	Spill to 125% TDG measure	Water Quality	High	1)Implement mainstem habitat improvement projects to increase food sources and reconnect back-channel habitats; 2)increase pinniped and avian predation measures; 3) perform shad removal in the fish ladders at Bonneville and the Dalles.	These measures will not change TDG, but would improve conditions, including resting and food sources, for existing fish migrating into and out of the system. An increase in the level of avian or pinniped predator management could help to minimize mortality from predation to fish that are stunned or temporarily incapacitated by higher TDG levels, or adult fish that may become stalled looking for ladder entrances. Shad removal would alleviate crowding in the fish ladders.	Yes	Yes	Yes	The habitat measures and predation managemen t measures are offsite. The Shad removal measure is onsite.	There is no effective mitigation measure to offset the levels of TDG expected to be generated throughout the river with the spill to 125% level. However, improvement s to habitat, and removal of predators and shad would benefit ESA fish as they move through the system by providing healthier conditions and food sources, and decreasing pressure from predators and competition.	All years	Yes	–	High TDG remains.
McNary	TDG experience from increased spill	Spill to 125% TDG measure	Water Quality	High	*Modify transport facility raceway at McNary to reduce TDG. Use	Yes	Yes	Yes	Yes - ESA fish	Onsite	Yes	Yes	Yes	Yes	High TDG in the river, but fish collected for transport at McNary

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward (Y/N) from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
					steel infrastructure in the raceway to degass during collection for transport.										would go into a lower TDG environment.
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable ?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended ?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Entire Reach	TDG experience from increased spill	Spill to 125% measure	Water Quality/TDG	High	1)implement mainstem habitat improvement projects to increase food sources and reconnect back-channel habitats 2) increase pinniped and avian predator measures	These measures will not change TDG, but would improve conditions, including resting and food sources, for existing fish migrating into and out of the system. An increase in the level of avian or pinniped predator management would help to lessen impacts to fish that are stunned or temporarily incapacitated by higher TDG levels, or adult fish that may become stalled looking for ladder entrances.	Yes	Yes	Yes	No. Offsite.	There is no effective mitigation measure to offset the levels of TDG expected to be generated with the spill to 125% level. However, improvements to habitat, and removal of predators and shad would benefit ESA fish as they move through the system by providing healthier conditions and food sources, and decreasing pressure from predators and competition.	All years	Yes	–	–

Fish (Resident) – Multiple Objective 1

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low) brief explanation of why	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
libby/kootenai	ecosystem & Burbot - the potential change in the range of spring freshet flows impacts the ecosystem and fish including burbot	–	flow	low	Construct in-channel habitats that resemble Ferry Island	Mixed results - Need data from Kootenai.	Yes - has been done in some areas.	No - see Column E - low impact for unlisted species.	–	–	–	–	–	–	–
Bonner Ferrys	Burbot - flows and temperatures affect burbot development	–	flow and temp	low	reconnect floodplain to benefit early life history for Burbot	Yes - has been attempted and worked	Yes - has been done in some areas.	No - see Column E - low impact for unlisted species.	–	–	–	–	–	–	–
Bonner Ferrys	KRWS - High winter flows continue trends of reduced riparian vegetation establishment (e.g. cottonwoods).	–	flow and temp	low	plant cottonwoods trees (1 to 2 gallon trees). (mitigate for wildlife/habitrat as well)	Benefit to KRWS is unknown.	Yes - already been done. This would expand areas.	Yes	ESA- KRWS listed as endangered	Yes/This is designed to improve habitat - then improves water quatlity - improves fish survival	–	Scale not set for this mitigation	Yes	Partial	Unknown

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libby/kootenai	KRWS- decrease the number of days high flows exceed 30 kcfs at Bonners Ferry relative to the NAA. This could potentially reduce the number of spawning adults that migrate to spawning habitat upstream of Bonners Ferry.	KRWS need high flows similar to natural hydrograph to induce successful spawning - induces them to move up to adequate habitat	flow	med	Restore or improve spawning habitats near Bonners Ferry	Has been completed, but impact or effect is uncertain.	Yes - has been done in some areas.	Yes	ESA- KRWS listed as endangered	Yes - is on site and replaces in-kind losses of spawning habitat.	–	Scale not set for this mitigation	Yes	Partial	Unknown

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)** brief explanation of why	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Hungry Horse	Bull trout - Lower elevations in summer (4'-16' lower at end of Sept) and fewer full pool results in smaller productive euphotic zone, less surface for feeding in summer, and dewaters benthic insect production; less food source (terrestrial inspects/aquatic) for bull trout	HH lake elevations affect production of phytoplanzkton, zooplankton, and invertebrates that are the base of food source for fish.	Volume of euphotic zone, percent decrease in benthic area (indexed from surface area); and surface area for summer feeding.	Med	Revegetate areas withi the top 10' of the reservoir that are adjacent to tributaries used by bull trout; combine with creation of subimpoundments (vegetate within them) in the upper reservoir bays for improved benthic production, potection from predation (varial zone issues), and to protect tributary access. Where feasible, use existing contract for debris removal to dispose of the tree material by anchoring and sinking it in strategic places in the reservoir instead of hauling it out. LIkely very low cost difference than what doing now.	Yes - studied by Reclamatiion. Recommened by FWP and FWS to increase bull trout habitat, increase survival of juveniles outmigrating from tribs, and provide additional area for insect production and proximity of terrestrial insects in summer.	Yes, a study has been done to determine spp and techniques that are successful. Vegetation is a natural process that is disrupted at the seed stage by reservoir operations. Plantings proposed would get vegetation past the vulnerable seed stage to establish natural vegetation closer to the water surface at most times of year and inundated for a couple of months.	Yes	Yes - Bull trout Listed as Threatened	Yes.	–	Scale with area treated. Recommend about 15 streams important to bull trout.	Yes	Yes, offsets loss of insect production. Note - same action also mitigates wildlife effects.	Can scale to fully offset food effects; likely still some tributary access and varial zone effects (predation danger minimized and area of suitable habitat increased, but stilll have more distance of varial zone to travel).

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)** brief explanation of why	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Hungry Horse	Bull trout -Increased summer outflows (17%-21% higher) would increase zooplankton loss; zooplanknton concentrated at outlets; reduced food for fish in late summer.	Increased outflows result in increased entrainment of zooplankton food resources from the reservoir.	Outflows	med	Restore operation of slide gates on temp control structure (Actual physical restoration will be done as part of HH Modernization; this measure is to use them.	Yes - used to function; water pulled from two different thermal zones and mixed to get target temp to avoid pulling from where zooplankton (and fish) are concentrated.	Yes	yes	Yes, bull trout are ESA-listed.	Yes	–	Yes	Yes	Yes, reduces entrainment of zooplankton and fish.	Depending on water temps, bull trout may still be found at deeper depths than zooplankton and still be entrainmed.
Hungry Horse	Bull trout - in wet and average water years (Aug-Oct) for increases varial zone which increases exposure to angling/predation and difficulty entering spawning tributaries; however dry years, these effects are greater.	Drawdowns - Low reservoir elevations at time of migration	Reservoir elevation	med	Use native woody species to stabilize tributary channels and provide cover (same measure as line 8). Priority for Wounded Buck, Sullivan, Wheeler, and Bunker Creeks, but this is not an exhaustive list.	Yes. Common practice and recommended by local managers, including Reclamation.	Yes - has been done before. Woody plant species proposed have been studied to determine best species and techniques for best success.	Yes	Yes - Bull trout Listed as Threatened	Yes	–	Yes, can be scaled with increased or decreased area treated.	Yes	Yes, offsets varial zone predation effects by providing cover for migrating bull trout thorugh the open varial zone.	Fish still would have further distance through the varial zone, but predation and thermal issues would be imporved.
Hungry Horse	bull trout and spring spawners - Increased risk of access issues to tribs in Aug-Oct for bull trout and Apr-May for spring spawners.	Drawdowns - Low reservoir elevations at time of migration	Reservoir elevation	Med	Same action as line 8.	Yes. Success of woody species studied. Strategic placement to stabilize tributary mouths.	Yes - has been done before.	Yes - would require site specific stratey go stabilize tributary entrance into reservoir.	Yes - Bull trout Listed as Threatened	Yes	–	Can be scaled to number of tributaries affected by lower reservoir.	Yes	Yes, offsets migration impediments by stabilizing stream and providing cover.	Potentially still some delay in migration or difficulty with outmigration of juveniles.

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)** brief explanation of why	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
SF and main Flathead	all fish /aquatic invertebrates. - Higher summer flows benefit food production *(benefit)* but could result in less suitable habitat due to high velocities.	Higher summer flows.	flow and temp	low	Create back-channel habitat for juvenile bull trout or otherwise create trout habitat in mainstem Flathead River	Yes - common practice	Yes	Yes	Yes, Bull trout are ESA-listed, but effect likely not biologically noticeeable in mainstem Flathead River. SF Flathead River has higher effect but not critical habitat for bull trout.	Yes.	–	NA	No.	–	–
Albeni Falls	Bull trout - **no difference from the NAA** in entrainment from flows or effects from changes in water elevation	Delete	–	–	–	–	–	No	–	–	–	–	–	–	–
Albeni Falls	cut throat and kokanee - n**o difference from the NAA** in entraiment	Delete	–	–	–	–	–	No	–	–	–	–	–	–	–
Albeni Falls	gamefish -northern pike-**no difference from NA**A in habitat availability	Delete	–	–	–	–	–	No	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CHJ -MCN	bull trout - TDG effects **Similar to NAA**	Delete	–	–	–	–	–	No	–	–	–	–	–	–	–

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Canada - CHJ	white sturgeon - Slightly decrease in recruitment window (June 15-July 31), 3 days instead of 8 days in 25%ile water years; 42days instead of 43days in highest water years)	–	flow	low	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	White Sturgion - **similar to NAA**; L. Roosevelt pool elevation may influence riverine reach available for sturgeon recruitment(June30 -July15).	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	white sturgeon-high flows are ~ 2.4% lower and WS spawning success may be reduced when compared to the NAA.	–	flow	low	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	**Similar flows as NAA** and would not change the risk for outmigration of supplemental fish from the project area.	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	white sturgeon - Turbidity is not expected to change; **same as NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–

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CHJ -MCN	white sturgeon - **similar flows and risk of mortality in large sturgeon as NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	white sturgeon- slight increase in the occurance of high temperatures above MCN potentially resutling in minor increase in risk of mortality.	–	flow and temp	low	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	Burbot - lower water elevation in Columbia River (March) and L. Roosevelt (winter/early spring) potentially reduce burbot habitat and stranding eggs.	–	WSE	med	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	burbot, kokanee, redband rainbow trout and mitigation fishery - Slighlty reduced food and increased entrainment in Dec-Mar spawning period.	–	–	low	Fish collector in/near GCD forebay, equipped with exclusionary netting, and fish transportation - return/transport mitigation fish and native species to Roosevelt	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	redband trout and kokonee - **similar to NAA**; access to trib habitat/varial zone	–	–	–	–	–	–	No	–	–	–	–	–	–	–

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Canada - CHJ	kokonee - 3'-10' deeper drops than NAA and earlier draft would put eggs/fry at higher risk of stranding/dessication.	–	WSE	low	increase spawning habitat by supplementing gravel (offsite) and/or improve spawning habitat at lower elevation (onsite)	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	Mitigation fishery fish - **same as NAA**; released coincide with initiation of refill (to minimize loss).	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	Northern Pikeminnow - potentially **slight improvement from NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	walleye -slight effect on juveniles with drawdown	–	WSE	low	No mitigation - Walleye are not limited in MCN pool and reducing rearing success would be a mitation measure for Salmon and Steelhead.	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	small mouth bass - slight effect on nesting with drawdown	–	WSE	low	No mitigation - SMB are not limited in MCN pool and reducing nesting success would be a mitation measure for Salmon and Steelhead.	–	–	No	–	–	–	–	–	–	–

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Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DWA	Bull trout - drafting for cooling/augmentation is begun sooner and could be as much as 6 feet lower than the NAA at the end of the bull trout migration which could limit access to spawning tribs. This could have an impact to bull trout migrating in the later half of June.	–	–	med	Channel rehab to ensure that inlet channels have passage under low water conditions.	–	–	–	–	–	–	–	–	–	–
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
McNary	WS - **Similar to NAA** for recruitment (temperature and flows), slightly fewer days for spawning and recruitment	–	–	–	–	–	–	–	–	–	–	–	–	–	–
John Day	WS - spill testTDG affects on sturgeon larvae	block test spill	TDG	med	–	–	–	–	–	–	–	–	–	–	–

Fish (Resident) – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low) brief explanation of why	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
libby/kootenai	ecosystem & Burbot - the potential change in the range of spring freshet flows impacts the ecosystem and fish including burbot	–	–	low	Construct in-channel habitats that resemble Ferry Island	–	–	No	–	–	–	–	–	–	–
Bonner Ferrys	Burbot - flows and temperatures affect burbot development	–	–	low	reconnect floodplain to benefit early life history for Burbot	–	–	No	–	–	–	–	–	–	–
Bonner Ferrys	KRWS - High winter flows continue trends of reduced riparian vegetation establishment (e.g. cottonwoods).	–	–	low	plant cottonwoods trees (1 to 2 gallon trees). (mitigate for wildlife/habitat as well)	–	–	See MO1	–	–	–	–	–	–	–

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)** brief explanation of why	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Hungry Horse	Bull trout - Deeper winter drafts reduce substrate for insect production; reduces food available in spring, and reduced summer volume reduces food available.	HH lake elevations affect production of phytoplanzkton, zooplankton, and invertebrates that are the base of food source for fish.	Volume of euphotic zone, percent decrease in benthic area (indexed from surface area); and surface area for summer feeding.	Med	Revegetate areas withi the top 10' of the reservoir that are adjacent to tributaries used by bull trout; combine with creation of subimpoundments (vegetate within them) in the upper reservoir bays for improved benthic production, potection from predation (varial zone issues), and to protect tributary access. Where feasible, use existing contract for debris removal to dispose of the tree material by anchoring and sinking it in strategic places in the reservoir instead of hauling it out. LIkely very low cost difference than what doing now.	Yes - studied by Reclamatiion. Recommended by FWP and FWS to increase bull trout habitat, increase survival of juveniles outmigrating from tribs, and provide additional area for insect production and proximity of terrestrial insects in summer.	Yes, a study has been done to determine spp and techniques that are successful. Vegetation is a natural process that is disrupted at the seed stage by reservoir operations. Plantings proposed would get vegetation past the vulnerable seed stage to establish natural vegetation closer to the water surface at most times of year and inundated for a couple of months.	Yes	Yes - Bull trout Listed as Threatened	Yes.	–	Scale with area treated. Recommend about 15 streams important to bull trout.	Yes	Yes, offsets loss of insect production. Note - same action also mitigates wildlife effects.	Can scale to fully offset food effects; likely still some tributary access and varial zone effects (predation danger minimized and area of suitable habitat increased, but stilll have more distance of varial zone to travel).

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)** brief explanation of why	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Hungry Horse	Over 100% increase in winter outflows increases entrainment of zooplankton and fish from the reservoir.	Increased outflows in winter.	Outflows	High	See line 8; improve food production in winter insects.	Yes, will increase insect production but may reach limitations with loss of zooplankton for aquatic insectts to eat.	Yes	yes	Yes, bull trout are ESA-listed.	Yes, with nuance of increasing insect production to offset zooplankton loss.	–	Yes	Yes	–	Fish entrainment, zooplankton still entrained.
Hungry Horse	Bull trout - lower elevations in spring increases varial zone which increases exposure to angling/predation and difficulty entering spawning tributaries;	Drawdowns - Low reservoir elevations at time of migration	Reservoir elevation	Low	Use native woody species plantings described in line 8 would help offset effects while improving food resources. Strategically select sites for food production that would also benefit tributary access and varial zone effects.	Yes. Common practice and recommended by local managers, including Reclamation.	Yes - has been done before. Woody plant species proposed have been studied to determine best species and techniques for best success.	Yes	Westslope Cutthroat Trout are primary species affected and are not ESA-listed, but the same mitigation would offset food web effects to bull trout, an ESA-listed species.	Yes	–	Yes, can be scaled with increased or decreased area treated.	Yes	Fish, Aquatic Invertebrates, Wildlife, Terrestrial vegetation.	Fish still would have further distance through the varial zone, but predation and thermal issues would be improved.
Hungry Horse	bull trout and spring spawners - Increased risk of access issues to tribs in Aug-Oct for bull trout and Apr-May for spring spawners.	Drawdowns - Low reservoir elevations at time of migration	Reservoir elevation	Med	Same action as line 8.	Yes. Success of woody species studied. Strategic placement to stabilize tributary mouths.	Yes - has been done before.	Yes - would require site specific strategy go stabilize tributary entrance into reservoir.	Yes - Bull trout Listed as Threatened	Yes	–	Can be scaled to number of tributaries affected by lower reservoir.	Yes	Yes, offsets migration impediments by stabilizing stream and providing cover.	Potentially still some delay in migration or difficulty with outmigration of juveniles.

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)** brief explanation of why	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward from Column F**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
SF and main Flathead	all fish /aquatic invertebrates. - Winter outflows over 100% increased over NAA. Reduces winter habitat available in mainstem Flathead River by 30%. Winter habitat is important to subyearling bull trout especially. Increase in SF Flathead River volume would also increase winter temps in mainstem Flathead River.	High winter outflows from HH.	flow and temp	High	Create back-channel habitat for juvenile bull trout or otherwise create trout habitat in mainstem Flathead River	Yes - common practice	Yes	Yes	Yes, Bull trout are ESA-listed,	Yes.	–	Yes	Yes	Fish and aquatic invertebrates.	Likely not able to completely offset velocity and temp effects.
Albeni Falls	Bull trout - n**o difference from the NAA** in effects from changes in water elevation and slight decrease in entrainment risk (*benefit)*	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Albeni Falls	cut throat and kokanee - slight decrease in entrainment risk *(benefit)*	–	–	–	–	–	–	No	–	–	–	–	–	–	–

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Albeni Falls	gamefish - northern pike- slight decrease in entrainment risk *(benefit)* and **no difference from NAA** in habitat availability	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	NA	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CHJ -MCN	bull trout - TDG effects, greater potential for negative effects from TDG just below Chief Joseph dam and a reduced potential for negative impacts near McNary dam.	–	–	med	A) Reduce Spill at Chief Joseph dam during bull trout migration period. B) Put structures on GCL dam to reduce TDG, e.g. cover cap over tubes to reduce TDG. Tribal criteria is 110% TDG for hatchery.	A) yes B)	A) feasible but could change the intent of the alternative B)	No - Conferred with WQ team and there should not be increases in TDG in MO2 at CHJ	–	–	–	–	–	–	–
Canada - CHJ	White Sturgeon - **similar to NAA**; L. Roosevelt pool elevation may influence riverine reach available for sturgeon recruitment(June30-July15).	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	white sturgeon- effects from high flows, **no change from NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–

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CHJ -MCN	white sturgeon - Turbidity is not expected to change; s**ame as NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	white sturgeon - Slightly lower flows under MO1 may increase the risk of mortality in large WS	–	–	low	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	white sturgeon- High temperatures under MO1 would not differ from the NAA.	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	Burbot - lower water elevation in Columbia River (March) and L. Roosevelt (winter/early spring) potentially reduce burbot habitat and stranding eggs. Higher magitude of effect than MO1	–	–	med	–	–	–	Missing Mitigation - I believe this was supposed to be the habitat construction similar to Ferry Island	–	–	–	–	–	–	–

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Canada - CHJ	burbot, kokanee, redband rainbow trout and mitigation fishery - reduced food and increased entrainment in Dec-Mar spawning period.	–	–	low	Fish collector in/near GCD forebay, equipped with exclusionary netting, and fish transportation - return/transport mitigation fish and native species to Roosevelt	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	redband trout and kokonee - potential reduced access to trib habitat/varial zone in dry years	–	–	low	Habitat and access improvements in tribs and varial zones (structures for cover, etc.)	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	kokonee - similar to MO1, with 8.5' deeper draft in all water years.	–	–	low	increase spawning habitat by supplementing gravel (offsite) and/or improve spawning habitat at lower elevation (onsite)	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	Mitigation fishery fish - **same as NAA**; released coincide with initiation of refill (to minimize loss).	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	Northern Pikeminnow - **no change from NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	walleye - **no change from NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–

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CHJ -MCN	small mouth bass - **no change from NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DWA	kokonee - Increase in risk of entrainment in January and early February	–	–	low	Maintain enhance nutrient restoration at DWA. This program has proven successful in maintaining higher numbers of kokanee in the reservoir and shortening the amount of time it takes the kokanee population to rebound from significant entrainment events.	–	–	No	–	–	–	–	–	–	–

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LSR	all fish - Fish would continue to pass projects in similar numbers. However, reduced survival as a higher portion of fish would pass via turbine routes instead of spill route. This passage route generally has lower survival.	–	–	low	–	–	–	No	–	–	–	–	–	–	–
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–		–	–	–	–	–	–	–
McNary	WS - **Similar to NAA** for recruitment (temperature and flows), more days fall below NAA in dry years.	–	–	–	–	–	–	No	–	–	–	–	–	–	–
John Day	WS -Lower spill (to 110%TDG) resulting in less risk to sturgeon larvae than NAA *(benefit).*	–	–	–	–	–	–	No	–	–	–	–	–	–	–

Fish (Resident) – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low) brief explanation of why	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bonner Ferrys	KRWS - High winter flows continue trends of reduced riparian vegetation establishment (e.g. cottonwoods).	–	–	low	plant cottonwoods trees (1 to 2 gallon trees). (mitigate for wildlife/habitrat as well)	–	–	See MO1	–	–	–	–	–	–	–
Bonner Ferrys	Burbot - flows and temperatures affect burbot development	–	–	low	reconnect floodplain to benefit early life history for Burbot	–	–	No	–	–	–	–	–	–	–
libby/ kootenai	ecosystem & Burbot - the potential change in the range of spring freshet flows impacts the ecosystem and fish including burbot	–	–	low	Construct in-channel habitats that resemble Ferry Island	–	–	No	–	–	–	–	–	–	–

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Hungry Horse	Bull trout - Lower elevations in summer (4'-16' lower at end of Sept) and fewer full pool results in smaller productive euphotic zone, less surface for feeding in summer, and dewaters benthic insect production; less food source (terrestrial inspects/aquatic) for bull trout	HH lake elevations affect production of phytoplanzkton, zooplankton, and invertebrates that are the base of food source for fish.	Volume of euphotic zone, percent decrease in benthic area (indexed from surface area); and surface area for summer feeding.	Med	Revegetate areas withi the top 10' of the reservoir that are adjacent to tributaries used by bull trout; combine with creation of subimpoundments (vegetate within them) in the upper reservoir bays for improved benthic production, potection from predation (varial zone issues), and to protect tributary access. Where feasible, use existing contract for debris removal to dispose of the tree material by anchoring and sinking it in strategic places in the reservoir instead of hauling it out. LIkely very low cost difference than what doing now.	Yes - studied by Reclamatiion. Recommeneded by FWP and FWS to increase bull trout habitat, increase survival of juveniles outmigrating from tribs, and provide additional area for insect production and proximity of terrestrial insects in summer.	Yes, a study has been done to determine spp and techniques that are successful. Vegetation is a natural process that is disrupted at the seed stage by reservoir operations. Plantings proposed would get vegetation past the vulnerable seed stage to establish natural vegetation closer to the water surface at most times of year and inundated for a couple of months.	Yes	Yes - Bull trout Listed as Threatened	Yes.	–	Scale with area treated. Recommend about 15 streams important to bull trout.	Yes	Yes, offsets loss of insect production. Note - same action also mitigates wildlife effects.	Can scale to fully offset food effects; likely still some tributary access and varial zone effects (predation danger minimized and area of suitable habitat increased, but stilll have more distance of varial zone to travel).

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Hungry Horse	Bull trout -Increased summer outflows (17%-21% higher) would increase zooplankton loss; zooplankton concentrated at outlets; reduced food for fish in late summer.	Increased outflows result in increased entrainment of zooplankton food resources from the reservoir.	Outflows	med	Restore operation of slide gates on temp control structure (Actual physical restoration will be done as part of HH Modernization; this measure is to use them.	Yes - used to function; water pulled from two different thermal zones and mixed to get target temp to avoid pulling from where zooplankton (and fish) are concentrated.	Yes	yes	Yes, bull trout are ESA-listed.	Yes	–	Yes	Yes	Yes, reduces entrainment of zooplankton and fish.	Depending on water temps, bull trout may still be found at deeper depths than zooplankton and still be entrainmed.
Hungry Horse	Bull trout - in wet and average water years (Aug-Oct) for increases varial zone which increases exposure to angling/predation and difficulty entering spawning tributaries; however dry years, these effects are greater.	Drawdowns - Low reservoir elevations at time of migration	Reservoir elevation	med	Use native woody species to stabilize tributary channels and provide cover (same measure as line 8). Priority for Wounded Buck, Sullivan, Wheeler, and Bunker Creeks, but this is not an exhaustive list.	Yes. Common practice and recommended by local managers, including Reclamation.	Yes - has been done before. Woody plant species proposed have been studied to determine best species and techniques for best success.	Yes	Yes - Bull trout Listed as Threatened	Yes	–	Yes, can be scaled with increased or decreased area treated.	Yes	Yes, offsets varial zone predation effects by providing cover for migrating bull trout thorugh the open varial zone.	Fish still would have further distance through the varial zone, but predation and thermal issues would be imporved.

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Hungry Horse	bull trout and spring spawners - Increased risk of access issues to tribs in Aug-Oct for bull trout and Apr-May for spring spawners.	Drawdowns - Low reservoir elevations at time of migration	Reservoir elevation	Med	Same action as line 8.	Yes. Success of woody species studied. Strategic placement to stabilize tributary mouths.	Yes - has been done before.	Yes - would require site specific stratey go stabilize tributary entrance into reservoir.	Yes - Bull trout Listed as Threatene d	Yes	–	Can be scaled to number of tributaries affected by lower reservoir.	Yes	Yes, offsets migration impediment s by stabilizing stream and providing cover.	Potentially still some delay in migration or difficulty with outmigratio n of juveniles.
SF and main Flathead	all fish /aquatic invertebrates. - Higher summer flows benefit food production *(benefit)* but could result in less suitable habitat due to high velocities.	Higher summer flows.	flow and temp	low	Create back-channel habitat for juvenile bull trout or otherwise create trout habitat in mainstem Flathead River	Yes - common practice	Yes	Yes	Yes, Bull trout are ESA-listed, but effect likely not biologicall y noticeeabl e in mainstem Flathead River. SF Flathead River has higher effect but not critical habitat for bull trout.	Yes.	–	NA	No.	–	–
Albeni Falls	Bull trout - **no difference from the NAA** in entrainment from flows or effects from changes in water elevation	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Albeni Falls	cut throat and kokanee - slight decrease in entrainment risk *(benefit)*	–	–	–	–	–	–	No	–	–	–	–	–	–	–

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Albeni Falls	gamefish -northern pike-**no difference from NA**A in habitat availability	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CHJ -MCN	bull trout - TDG effects Same as NAA	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	White Sturgeon - **similar to NAA**; L. Roosevelt pool elevation may influence riverine reach available for sturgeon recruitment(June30-July15).	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	white sturgeon-high flows are ~ 2.4% lower and WS spawning success may be reduced when compared to the NAA.	–	–	low	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	white sturgeon - short term substantial increase in turbidity after dam breach;	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	white sturgeon - Slightly lower flows under MO1 may increase the risk of mortality in large WS	–	–	low	–	–	–	No	–	–	–	–	–	–	–

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CHJ -MCN	white sturgeon - Food resources will be reduced during breach in the Snake River and from the confluence of Snake and Columbia downstream until a new equilibrium established	–	–	low	no mitigation : Sturgeon in the Columbia are not food limited and would likely avoid the area of impact until new resources had re-established.	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	white sturgeon- High temperatures under MO1 **would not differ from the NAA.**	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	Burbot - **no change from NAA** to burbot habitat.	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	burbot, kokanee, redband rainbow trout and mitigation fishery - **similar to NAA** in retention time	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	redband trout and kokonee - **similar to NAA**; access to trib habitat/varial zone	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	kokonee - improvement from NAA for eggs/fry with the exception of short-term drops could dessicate eggs and strand fry.	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	Mitigation fishery fish - **same as NAA**; released coincide with initiation of refill (to minimize loss).	–	–	–	–	–	–	No	–	–	–	–	–	–	–

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CHJ -MCN	Northern Pikeminnow - depressed productivity	–	–	low	No Mitigation - NPM would likely avoid the area of impact until new resources had re-established.	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	walleye - short term losses of suitable spawning substrate on the south shore of MCN pool	–	–	low	No mitigation - Walleye are not limited and are not native	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	walleye - short term depressed zooplankton in MCN	–	–	low	No mitigation - Walleye are not limited and are not native	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	small mouth bass - slight temperature change effecting nesting at mouth of SR and Columbia	–	–	low	no mitigation - Nesting may renest if disturbed by a temperature drop.	–	–	No	–	–	–	–	–	–	–
CHJ -MCN	small mouth bass - short term effects to flow/productivity due to dam breach	–	–	low	no mitigation - SMB in the Columbia would likely avoid the area of impact until new resources had re-established.	–	–	No	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

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LSR	bull trout - Short term passage issues after breaching and until new streams are established at tributary mouth; perched streams and tributaries limiting to bull trout migration. Fish come to mainstem and cannot reascend. Mainstem passage of	Drawdown leaves stream delta perched until high flows can create a new passable Channel	Stream Passage	high	pilot channel or Stream Rehab at Tucannon tributary mouth	Yes	Yes	Yes	Bull trout listed as Threatened	Yes	–	Yes	Yes	Fish	No
LSR	bull trout / WS - Temporary reduction (2-7 years) in forage fish and invertbrate for bull trout/all species as a result of breaching Change from zooplankton to macroinvertebrates would benefit juvenile subadult bull trout	Forage fish Lost from high sediment/Low oxygen during breach.	Sediment/Oxygen Concentrations	high	Trap and Haul White Sturgeon from impacted area prior to breach. Relocation to Hells Canyon and below McNary	Yes - Brady Allen from BPA has past experience in this.	Yes	Yes	No	Yes	–	Yes	Yes	–	Still expect to lose unknown part of the WS population
LSR	bull trout / WS - Temporary reduction (2-7 years) in forage fish and invertbrate for bull trout/all species as a result of breaching Change from zooplankton to macroinvertebrates would benefit juvenile subadult bull trout	Forage fish Lost from high sediment/Low oxygen during breach.	Sediment/Oxygen Concentrations	high	Trap and Haul White Sturgeon from impacted area prior to breach. Relocation to Hells Canyon and below McNary	Yes - Brady Allen from BPA has past experience in this.	Yes	Yes	No	Yes	–	Yes	Yes	–	Still expect to lose unknown part of the WS population

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LSR	bull trout/WS - Reduced Oxygen may be lethal. However, during Aug thru Oct - limited numbers of bull trout occur in the system and short term effects to bull trout are not likely to occur. BOD would occur after initial flush of sediment. Any fish in the mainstem would likely be killed. Most bull trout leave mainstem river by July.	–	–	high	Catch and haul WS to release sites above LWG prior to Breaching - Set Lines can be efffective at capturing numbers of WS.	–	–	–	–	–	–	–	–	–	–
LSR	northern pike minnow/small mouth bass/walleye- temperature and flow changes after the breach would effect these species (all stages)	–	–	low	no mitigation - all these species are not limited in LSR and reducing success would be a benefit for Salmon and Steelhead.	–	–	No	–	–	–	–	–	–	–
Region D: 4 Lower Columbia Projects		–	–	–	–	–	–	–	–	–	–	–	–	–	–
McNary	WS - More days in June with flows below 250kcfs in dry years.	–	–	low	–	–	–	No	–	–	–	–	–	–	–

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John Day	WS - Higher TDG at John Day mid-Apr thorugh June, could be at critical time for emerging larvae seeking refuge in interstitial spaces where susceptible to TDG.	–	–	med	–	–	–	None recommended	–	–	–	–	–	–	–

Fish (Resident) – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low) brief explanation of why	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bonner Ferrys	Burbot - flows and temperatures affect burbot development	–	–	low	reconnect floodplain to benefit early life history for Burbot	–	–	No	–	–	–	–	–	–	–
libby/ kootenai	ecosystem & Burbot - the potential change in the range of spring freshet flows impacts the ecosystem and fish including burbot	–	–	low	Construct in-channel habitats that resemble Ferry Island	–	–	No	–	–	–	–	–	–	–

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Hungry Horse	Bull trout - Lower elevations in summer (4'-16' lower at end of Sept) and fewer full pool results in smaller productive euphotic zone, less surface for feeding in summer, and dewaters benthic insect production; less food source (terrestrial inspects/aquatic) for bull trout	HH lake elevations affect production of phytoplanzkton, zooplankton, and invertebrates that are the base of food source for fish.	Volume of euphotic zone, percent decrease in benthic area (indexed from surface area); and surface area for summer feeding.	High	Revegetate areas withi the top 10' of the reservoir that are adjacent to tributaries used by bull trout; combine with creation of subimpoundments (vegetate within them) in the upper reservoir bays for improved benthic production, potection from predation (varial zone issues), and to protect tributary access. Where feasible, use existing contract for debris removal to dispose of the tree material by anchoring and sinking it in strategic places in the reservoir instead of hauling it out. LIkely very low cost difference than what doing now.	Yes - studied by Reclamatiion. Recommeneded by FWP and FWS to increase bull trout habitat, increase survival of juveniles outmigrating from tribs, and provide additional area for insect production and proximity of terrestrial insects in summer.	Yes, a study has been done to determine spp and techniques that are successful. Vegetation is a natural process that is disrupted at the seed stage by reservoir operations. Plantings proposed would get vegetation past the vulnerable seed stage to establish natural vegetation closer to the water surface at most times of year and inundated for a couple of months.	Yes	Yes - Bull trout Listed as Threatened	Yes.	–	Scale with area treated. Recommend about 15 streams important to bull trout. Compared to MO1 or MO3, recommend increased effort of subimpoundments in upper reservoir bays to offset lower elevation effects.	Yes	Yes, offsets loss of insect production. Note - same action also mitigates wildlife effects.	Can scale to fully offset food effects; likely still some tributary access and varial zone effects (predation danger minimized and area of suitable habitat increased, but stilll have more distance of varial zone to travel).

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Hungry Horse	Bull trout - Increased summer outflows (37% higher) would increase zooplankton loss; zooplanknton concentrated at outlets; reduced food for fish in late summer.	Increased outflows result in increased entrainment of zooplankton food resources from the reservoir.	Outflows	med	Restore operation of slide gates on temp control structure (Actual physical restoration will be done as part of HH Modernization; this measure is to use them.)	Yes - used to function; water pulled from two different thermal zones and mixed to get target temp to avoid pulling from where zooplankton (and fish) are concentrated.	Yes	yes	Yes, bull trout are ESA-listed.	Yes	–	Yes	Yes	Yes, reduces entrainment of zooplankton and fish.	Depending on water temps, bull trout may still be found at deeper depths than zooplankton and still be entrainmed.
Hungry Horse	Bull trout - in wet and average water years (Aug-Oct) for increases varial zone which increases exposure to angling/predation and difficulty entering spawning tributaries; however dry years, these effects are greater.	Drawdowns - Low reservoir elevations at time of migration	Reservoir elevation	med	Use native woody species to stabilize tribustary channels and provide cover (same measure as line 8). Priority for Wounded Buck, Sullivan, Wheeler, and Bunker Creeks, but this is not an exhaustive list.	Yes. Common practice and recommended by local managers, including Reclamation.	Yes - has been done before. Woody plant species proposed have been studied to determine best species and techniques for best success.	Yes	Yes - Bull trout Listed as Threatened	Yes	–	Yes, can be scaled with increased or decreased area treated. Increased scale from MO1 or MO3.	Yes	Yes, offsets varial zone predation effects by providing cover for migrating bull trout thorugh the open varial zone.	Fish still would have further distance through the varial zone, but predation and thermal issues would be imporved.
Hungry Horse	bull trout and spring spawners - Increased risk of access issues to tribs in Aug-Oct for bull trout and Apr-May for spring spawners.	Drawdowns - Low reservoir elevations at time of migration	Reservoir elevation	Med	Same action as line 8.	Yes. Success of woody species studied. Strategic placement to stabilize tributary mouths.	Yes - has been done before.	Yes - would require site specific stratey go stabilize tributary entrance into reservoir.	Yes - Bull trout Listed as Threatened	Yes	–	Can be scaled to number of tributaries affected by lower reservoir.	Yes	Yes, offsets migration impediments by stabilizing stream and providing cover.	Potentially still some delay in migration or difficulty with outmigration of juveniles.

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SF and main Flathead	all fish /aquatic invertebrates. - Higher summer flows benefit area for food production *(benefit)* but flow fluctuations set back food production (offsetting the increase potential).	Steep drops in outflows and more fluctuations throughout the summer.	Aquatic insect production life cycle disruption.	Med	If possible, smooth operations to reduce wide fluctuations.	Yes	Yes. Minor adjustment to operations as modeled. (Would likely operate more smoothly than modeled anyway.)	Yes	Yes. Bull trout are ESA-listed.	Yes	–	Yes	Yes	Fish and Aquatic invertebrates.	Depends on ability to smooth operations.
SF and main Flathead	all fish /aquatic invertebrates. - Higher summer flows benefit area for food production *(benefit)* but could result in less suitable habitat due to high velocities. Flow fluctuations set back food production (offsetting the increase potential).	Higher summer flows.	flow and temp	Med	Create back-channel habitat for juvenile bull trout or otherwise create trout habitat in mainstem Flathead River	Yes - common practice	Yes	Yes	Yes, Bull trout are ESA-listed,	Yes.	–	NA	Yes.	–	Likely.
Albeni Falls	Bull trout - **no difference from the NAA** in entrainment from flows	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Albeni Falls	cut throat and kokanee - slight decrease in entrainment risk *(benefit)*	–	–	–	–	–	–	No	–	–	–	–	–	–	–

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Albeni Falls	Bull Trout - In dry years MO4 would not reach full pool. Mean elevation in September = 2059.7 ~ 2 ft lower than NAA.	drawdowns - McNary Flow measure	WSE	low	Stream Rehab for inlet areas to improve trib acces in the varial zone. (priest river, lightning creek, etc)	Yes - dependent on	–	Yes - Would need some additional investigation to see which tribs to rehab and improve.	–	–	–	–	–	–	–
Albeni Falls	cut throat and kokanee - **no difference from the NAA** in entraiment	–	–	–	–	–	–	No	–	–	–	–	–	–	–
Albeni Falls	gamefish Northen Pike - On dry years Lake Pend Oreille may be as much as 2.5 feet lower June through September compared to NAA resulting a potential decrease in suitable habitat.	–	–	low	no mitigation -N. Pike are not limited	–	–	No	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CHJ - MCN	bull trout - TDG effects **Similar to NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–

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Canada - CHJ	white sturgeon - Slightly decrease in recruitment window (June 15-July 31), 3days instead of 8days in 25%ile water years; 42days instead of 43days in highest water years)	–	–	low	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	White Sturgeon - **Similar in NAA** in wet and average years; dry years much lower but dry years typically have no recruitment anyway in the L. Roosevelt riverine reach (June30-July31)	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ - MCN	white sturgeon- high flows are ~ 2.4% lower and WS spawning success may be reduced when compared to the NAA.	–	–	low	–	–	–	No	–	–	–	–	–	–	–
CHJ - MCN	**Similar flows as NAA** and would not change the risk for outmigration of supplemental fish from the project area.	–	–	–	–	–	–	No	–	–	–	–	–	–	–

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CHJ - MCN	white sturgeon - Turbidity is not expected to change; **same as NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ - MCN	white sturgeon - **similar flows and risk of mortality in large sturgeon as NAA**	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ - MCN	white sturgeon- slight increase in the occurance of high temperatures above MCN potentially resutling in minor increase in risk of mortality.	–	–	low	–	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	Burbot - lower water elevation in Columbia River (March) and L. Roosevelt (winter/early spring) potentially reduce burbot habitat and stranding eggs. Dry years have more effect.	–	–	med	–	–	–	No	–	–	–	–	–	–	–

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Canada - CHJ	burbot, kokanee, redband rainbow trout and mitigation fishery - Slighlty reduced food and increased entrainment in Dec-Mar spawning period. Wet and Ave years similar to MO1, Dry years much higher magnitude of effect.	–	–	med	Fish collector in/near GCD forebay, equipped with exclusionary netting, and fish transportation - return/transport mitigation fish and native species to Roosevelt	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	kokonee - Wet and Ave water years similar to MO1, Dry years extensive drawdowns would further reduce habitat and strand more eggs.	–	–	low	increase spawning habitat by supplementing gravel (offsite) and/or improve spawning habitat at lower elevation (onsite)	–	–	No	–	–	–	–	–	–	–
Canada - CHJ	Mitigation fishery fish - Dry years refill is up to 6 weeks later, into June. Likely result in reduced survival of fish in pens or forced releases when entrainment susceptibility is high.	Mitigation given to local fishery then taken away by this operation - entrained by high releases.	Fish Losses/Flows	med (socio-econ)	Expancd hatchery capacity for mitigation fishery	? Sue	–	–	–	–	–	–	–	–	–

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CHJ - MCN	Northern Pikeminnow - potentially slight improvement from NAA *(benefit)*	–	–	–	–	–	–	No	–	–	–	–	–	–	–
CHJ - MCN	walleye -slight effect on juveniles with drawdown	–	–	low	No mitigation - Walleye are not limited in MCN pool and reducing rearing success would be a mitation measure for Salmon and Steelhead.	–	–	No	–	–	–	–	–	–	–
CHJ - MCN	small mouth bass - slight effect on nesting with drawdown	–	–	low	No mitigation - SMB are not limited in MCN pool and reducing nesting success would be a mitation measure for Salmon and Steelhead.	–	–	No	–	–	–	–	–	–	–
	Northern Pike	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

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LSR	Bull trout - Additional spill may cause delays in bull trout passage at dams in May and June when they are moving out of the system to avoid temps.	High Spill may cause delay, reduce passage, and reduce survival when bull trout cannot get back to tributaries	–	Low	improve bull trout habitat	Yes - dependent on habitat needs passage improvements on local tributaries would be the focus (culverts)	Yes - passage projects have been shown to be feasible and successful in the past	Yes	Bull trout listed as Threatened	No	Projects do not allow for on site improvments - so mitigate in tributary streams	Can be	Yes	–	–
LSR	Bull trout / white sturgeon - Bull Trout: Days over elevated TDG 110% (~10% increase over NAA 3) Higher TDG may impact additional (vs NAA) bull trout in May and June when leaving the system. WS: elevated TDG 136% TDG; ~ add 27 days compared to NAA; WQ plots show increases in exposure to high TDG from Apr through July and siginificant increases in parts of April and May when compared with the NAA.	high spill will increase TDG concentrations	Spill/TDG	med	Divider walls between spillways and turbines	Yes - would train flows so fish could find ladders better and would lower TDG on Power house side where bull trout and white sturgeon would find refuge.	Yes - Very expensive but little maintenance.	Yes	Bull trout listed as Threatened	Yes	–	May be overscaled	No	–	–

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Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
McNary	WS - More days in May with flows below 250kcfs in dry years.	–	–	low	–	–	–	No	–	–	–	–	–	–	–
John Day	WS - Expect detrimental effect to juvenile sturgeon with high TDG. Eggs and larvae most susceptible, but in deep eddy areas depth compensation reduces effects.	–	–	med	–	–	–	No	–	–	–	–	–	–	–

Vegetation, Wetlands, and Wildlife – Multiple Objective 1

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Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby pool	Winter WSE higher in pool, changes spatial extent of drawdown zone could result in shift in vegetation and habitat. Drying in summer, conversion to upland habitat (summer). Affects to shoreline riparian nesting passerines/waterfowl.	December Libby Target Elevation	Drawdown of water surface elevation	low	no mitigation proposed, due low impact and no regulated resource	–	–	–	yes, MBTA	–	–	–	–	–	–
Libby Pool	Explosure of mudflats and barren lands during the summer months could result in establishment of non-native, invasive plant species.	Modified Draft at Libby	–	low	Update and implement Invasive Plant Management Plan for the shoreline	yes	yes	Update and implement Invasive Plant Management Plan for the shoreline	yes, Invasive EO	yes	–	yes	yes due to comply with Invasive EO	–	–
Kootenai River including Kootenai Falls Wildlife Management Area	Conversion of wetland to upland habitat in May through summer (off-channel habitat). Impacts on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Occurs seasonal and would result in permanent effect habitat	December Libby Target Elevation	Drawdown of water surface elevation	med	A) planting of native wetland and riparian vegetation (~100 acres along river) B) regrading the bank to estiblish same hydrology as the NAA	A) yes B) yes;	A) yes, B) yes, however it would require more permiting (CWA, 106, ESA) and would result more land disturbance than A) Planting mitigation	A) planting of native wetland and riparian vegetation (~100 acres along river)	EO11990 ?, CWA ?	yes	NA	yes	yes, long term medium impact to habitat inlcuding wetlands.	yes, resident fish	no remaining impact

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Kootenai National Wildlife Refuge (RM 147)	WSE and spring freshet decreases during peak of the growing season may cause conversion of habitats to a drier composition. Note: impact captured in Kootenai River habitat impact, see line above	–	Drawdown of water surface elevation	low	no mitigation proposed, due low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Bonner Ferry	High winter flows continue trends of reduced riparian vegetation establishment (e.g. cottonwoods).	December Libby Target Elevation	WSE	low	no mitigation proposed, due low impact; however ~100 acres of planting mitigation (see above) would also offset this impact	–	–	–	–	–	–	–	–	–	–
Hungry Horse	Slight increase in the size of the barren zone which would increase the risk of wildlife predation, including from raptors, wolves, and mountain lions.	Hungry Horse Additional Water Supply, Sliding Scale at Libby and Hungry Horse	Drawdown of water surface elevation	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Hungry Horse	slight decrease in the quantity, quality and distribution of wetlands along the shoreline transitions to more tolerant of dry or drought conditions., birds would be displaced from nesting and sheltering habitat in forested, scrub-shrub and/or emergent wetland habitats and would likely experience increased competition in remnant wetland habitats.	Hungry Horse Additional Water Supply, Sliding Scale at Libby and Hungry Horse	Drawdown of water surface elevation	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Albeni Falls	no change in vegetation, wildlife. **Simiilar to the NAA**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee Dam study area	Collectively, these measures influence WSE in Lake Roosevelt and downstream reaches of the Columbia River, as well as outflow from Grand Coulee Dam, resulting in changes to the quantity, quality and ditribution of habitats in the study area. Changes to wildlife habitats have a corresponding effect on wildlife populations in the study area. Fluctuations in WSE in response to daily operations are similary expected to impact the quantity, quality and distribution of habitats in the study area. impact is seasonal and could result in permanent	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.	WSE	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Grand Coulee Dam study area	Decrease in WSE immediately upstream of the dam in Lake Roosevelt by 5-6 feet during the winter months and by 3 feet farther upstream, transition of wetlands to more upland habitats	Lake Roosevelt Additional Water Suplly	WSE	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
L. Roosevelt	Increase barren zone increases area for mountain lions to hunt and kill prey animals	Planned Draft Rate at Grand Coulee and Winter System FRM Space measures	WSE	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Columbia River below Chief Joe	Diversion of 9,600 acre-feet of water between April through October. Minimal impact (1% or less) on water surface elevations immediately downsream from the dam, and diluted further downstream. **No measurable effects to habitats or wildlife populations upstream of the dam. Negligible effects downstream of dam.**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DWA	drawdown of reservoir increases barren zone during summer causes predation increase of small mammals	Modified Dworshak Summer Draft	WSE	low	no mitigation proposed due low impact and no regulated resources	–	–	–	–	–	–	–	–	–	–
DWA/ Clearwater River	potential conversion of vegetation to wetter vegetation with slight increase in inundation of the pool	Modified Dworshak Summer Draft	WSE	low	no mitigation proposed due low impact and no regulated resources	–	–	–	–	–	–	–	–	–	–
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
McNary	areas within McNary Wildlife Refuge could be drier in May and June causing loss of amphibian breeding areas	–	WSE	low	no mitigation proposed due low impact and no regulated resources	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
John Day / The Dalles / Lake Bonneville	drawdown of water surface elevations can cause wetland habitat to convert to upland habitat	–	WSE	low	no mitigation proposed due low impact and no regulated resources	–	–	–	–	–	–	–	–	–	–
John Day, Blalock	inundation portions of the island that support avian species	Increased Forebay Range Flexibility	reducing avian habitat	med	Create avian nesting areas (~2 acres) to replace lost nesting locations	yes	Yes	Create avian nesting areas (~2 acres) outside of the Columbia Basin	Yes. Migratory Bird Treaty Act	No - offsite	Piscivorous birds are protected under the MBTA. Replacing nesting habitat within the Columbia Basin would not support the purpose of the measures. Offsite mitigation (California) has been successfully implemented in the past and would replace lost habitat in a location with less impact to ESA salmon.	yes, due to impacting MBTA species	yes due to long term medium impact and triggering MBTA	–	no remaining impacts
Patterson Slough	could inundate wetland habitats approximately 1.5 feet vertically. Umatilla NWR would experienced an increased duration of inundation which could disrupt wetland habitats, amphibian, bird, reptiles, mammals and migratory waterfowl	Increased Forebay Range Flexibility	WSE	low	no mitigation proposed due low impact and no regulated resources	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Estuary	drawdown in spring/summer could slightly change quality of wetland habitats at Franz Lake, Pierce, and Steigerwald NWR, as well as Beacon Rock State Park	–	WSE	low	no mitigation proposed due low impact and no regulated resources	–	–	–	–	–	–	–	–	–	–

Vegetation, Wetlands, and Wildlife – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby pool	Winter WSE higher in pool, changes spatial extent of drawdown zone could result in shift in vegetation and habitat. Drying in summer, conversion to upland habitat (summer). Affects to shoreline riparian nesting passerines/waterfowl.	December Libby Target Elevation	WSE	low	no mitigation proposed, due low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Libby Pool	Explosure of mudflats and barren lands during the summer months could result in establishment of non-native, invasive plant species.	December Libby Target Elevation Measure	–	low	Update and implement Invasive Plant Management Plan for the shoreline	yes	yes	Update and implement existing Invasive Plant Management Plan for the shoreline	yes, Invasive EO	yes	–	yes	yes due to comply with Invasive EO	–	–
Kootenai River including Kootenai Falls Wildlife Management Area	Conversion of wetland to upland habitat in May through summer (off-channel habitat). Impacts on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Occurs seasonal and would result in permanent effect habitat	December Libby Target Elevation Measure	WSE	med	A) planting of native wetland and riparian vegetation (~100 acres along river) B) regrading the bank to estiblish same hydrology as the NAA	A) yes B) yes;	A) yes, B) yes, however it would require more permiting (CWA, 106, ESA) and would result more land disturbance than A) Planting mitigation	A) planting of native wetland and riparian vegetation (~100 acres along river)	EO11990 ?, CWA ?	yes	NA	yes	yes, long term medium impact to habitat inlcuding wetlands.	yes, resident fish	no remaining impact

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Bonner Ferry	High winter flows continue trends of reduced riparian vegetation establishment (e.g. cottonwoods).	December Libby Target Elevation Measure	WSE	low	no mitigation proposed, due low impact; however ~100 acres of planting mitigation (see above) would also offset this impact	–	–	–	–	–	–	–	–	–	–
Hungry Horse	minor change in shoreline that could be more prone to invasive species	December Libby Target Elevation Measure	WSE	low	Update and implement Invasive Plant Management Plan for the shoreline	yes	yes	Update and implement Invasive Plant Management Plan for the shoreline	yes, Invasive EO	yes	NA	yes	yes	–	–
Libby and Hungry Horse	Increase barren zone increases area for mountain lions to hunt and kill prey animals	December Libby Target Elevation Measure	WSE	low	no mitigation proposed, due low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
South Fork of the Flathead River	riparian vegetation change to drier habitats; exposure of mudflats, wildlife daily activities (i.e. foraging)	Ramping Rates for Safety measure	WSE	low	no mitigation proposed, due low impact.	–	–	–	–	–	–	–	–	–	–
South Fork of the Flathead River	conversion of cottonwood stands to other vegetation	December Libby Target Elevatin Measure	WSE	low	no mitigation proposed, due low impact and no regulated resource.	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Pend Oreille	Decline in wetland vegetation and decline of submerged aquatic vegetation due to increased ramping rates Decline in western grebe habitat nesting area due to drawdown	Ramping rates for Safety Measure	WSE	low	no mitigation proposed due to low impact and no regulated resource.	–	–	–	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lake Roosevelt	deeper drafts in Lake Rooevelt during winter months, **neglible changes to habitats d**uring growing season	Slightly Deeper Draft for Hydropower	WSE	–	–	–	–	–	–	–	–	–	–	–	–
Lake Roosevelt	fluctuating water conditions could impact quantity and quality of foraging habitat for wintering waterfowl**, neglible changes to Water Surface Elevation**	Slightly Deeper Draft for Hydropower	WSE	–	–	–	–	–	–	–	–	–	–	–	–
Lake Roosevelt	Increase barren zone increases area for mountain lions to hunt and kill prey animals	Slightly Deeper Draft for Hydropower	WSE	low	no mitigation proposed, due low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Downstream of Lake Roosevelt	no effet to the quantity, quality or distributino of wildlife habitats or populations	Ramping Rates for Safety	WSE	low	no mitigation proposed, due low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DWA pool	Drawdown of reservior an additional 20 feet from NAA increase barren zone	Slightly Deeper Draft for Hydropower	WSE	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Clearwater River	Dessicate amphbian eggs, alter the patterns of seed dispersal, germination of establishment of forested, scrub-shrub wetland plants like willows and cottonwoods	Ramping Rates for Safety	WSE	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Lower Snake River	changes in available fish for avian predators	increase Juenile Fish Transportation Measure	COMPASS; CSS	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
John Day, McNary, The Dalles, Bonneville	**similar to NAA conditions**	–	WSE	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Estuary	drawdown in spring/summer could slightly change quality of wetland habitats at Franz Lake, Pierce, and Steigerwald NWR, as well as Beacon Rock State Park	–	WSE	low	no mitigation proposed due low impact and no regulated resources	–	–	–	–	–	–	–	–	–	–
John Day, McNary, The Dalles, Bonneville	changes in available fish for avian predators	increase Juenile Fish Transportation Measure	COMPASS; CSS	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–

Vegetation, Wetlands, and Wildlife – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby pool	Winter WSE higher in pool, changes spatial extent of drawdown zone could result in shift in vegetation and habitat. Drying in summer, conversion to upland habitat (summer). Affects to shoreline riparian nesting passerines/waterfowl.	December Libby Target Elevation	WSE	low	no mitigation proposed, due low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Libby pool	Explosure of mudflats and barren lands during the summer months could result in establishment of non-native, invasive plant species.	December Libby Target Elevation Measure	WSE	low	Update and implement existing Invasive Plant Management Plan for the shoreline	yes	yes	Update and implement existing Invasive Plant Management Plan for the shoreline	yes Invasive EO	yes	NA	yes	yes, due to complying with invasive EO	–	–
Libby , Hungry Horse, Albeni Falls	Decline in wetland vegetation and decline of submerged aquatic vegetation due to increased ramping rates Decline in western grebe habitat nesting area due to drawdown	Ramping rates for Safety Measure	WSE	low	no mitigation proposed, due low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Kootenai River including Kootenai Falls Wildlife Management Area	Conversion of wetland to upland habitat in May through summer (off-channel habitat). Impacts on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Occurs seasonal and would result in permanent effect habitat	Modified Draft at Libby, Sliding Scale at Libby and Hungry Horse Measure	WSE	med	A) planting of native wetland and riparian vegetation (~100 acres along river) B) regrading the bank to estiblish same hydrology as the NAA	A) yes B) yes;	A) yes, B) yes, however it would require more permiting (CWA, 106, ESA) and would result more land disturbance than A) Planting mitigation	A) planting of native wetland and riparian vegetation (~100 acres along river)	EO11990 ?, CWA ?	yes	NA	yes	yes, long term medium impact to habitat inlcuding wetlands.	yes, resident fish	no remaining impact
Bonner Ferry	High winter flows continue trends of reduced riparian vegetation establishment (e.g. cottonwoods).	December Libby Target Elevation Measure	WSE	low	no mitigation proposed, due low impact; however ~100 acres of planting mitigation (see above) would also offset this impact	–	–	–	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chief Joe/Grand Coulee	**negligble effects** to habitats or wildlife populations	–	WSE	–	–	–	–	–	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Snake River	Upland mammals (Bats, small mammals, deer, bobcat), Aquatic mammals, Waterfowl; amphbians, birds	Dam Breaching	WSE	high	none. These impacts would be temporary and immediately following dam breaching. It would be anticipated that these animals would recover from effects.	–	–	–	–	–	–	–	–	–	–
Lower Snake River HMU's	Perched habitats (HMUs) with dam breach to convert to arid lands	Dam Breaching	WSE	High	Planting plan with Arid Lands Restoration to target establishment of native, arid spp	yes	yes, with a planting plan	Planting plan with Arid Lands Restoration to target establishment of native, arid spp (13,000 acres planting)	CAA, CWA (Section 402)	yes	NA	yes	yes, due to high impact and complying with regulated resources. The planting plan could also be a BMP or part of the design	–	no remaining effect
Lower Snake River Shoreline (New exposure)	Exposed sediment and exposed shoreline with dam breach (approximately 13,800 acres), includes wetland and riparian plantings	Dam Breaching	WSE	High	Planting plan with wetlands/riparian restoration (1,500 acres) to target establishment of native spp	yes	yes, with a planting plan	Planting plan with wetlands/riparian restoration (1,500 acres) to target establishment of native spp	CWA (Section 402), CAA, CWA (Section 404/401) 404(b)1 assessment.	yes	NA	yes	yes, due to high impact and complying with regulated resources. The planting plan could also be a BMP or part of the design	–	no remaining effect
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
McNary Pool (includes MWR)	Sediment Deposition (McNary Pool= 779 acres uplands, 13,639 acres open water, 97 acres forested wetlands, 58 acres emergent wetlands, 37 acres urban and mixed environs) Total is 14,610 acres	–	River Mechnaics analysis	high	a planting plan (155 acres of wetlands), possible excavation of deposited sediment (?)	yes	yes	a planting plan (155 acres of wetlands), possible excavation of deposited sediment (?)	CWA (section 404), 404(1)(b) analysis.	yes	NA	yes	yes due to high impacts and complying with regulated resources	–	–
McNary Wildlife Refuge	Sediment Deposition (McNary NWR only= 8 acres uplands, 4,748 acres open water, 23 acres forested wetlands, 12 acres urban and mixed environs)	–	River Mechnaics analysis	high	a planting plan (23 acres of the above 155 acres of wetlands), possible excavation of deposited sediment (?)	yes	yes	a planting plan (23 acres of the above 155 acres of wetlands), possible excavation of deposited sediment (?)	CWA (section 404), 404(1)(b) analysis.	yes	NA	yes	yes due to high impacts and complying with regulated resources	–	–
John Day, Blalock	inundation portions of the island that support avian species	Increased Forebay Range Flexibility	COMPASS, CSS, WSE	med	Create avian nesting areas (~2 acres) within LCR	yes	?, feasible / implementable; however concerns of avian predation on fish could result in this mitigation measure being limited or not implemented	Create avian nesting areas (~2 acres) within LCR	yes, MBTA	yes	NA	yes, due to impacting MBTA species	yes due to long term medium impact and triggering MBTA	–	no remaining impacts
Patterson Slough	could inundate wetland habitats approximately 1.5 feet vertically. Umatilla NWR would experienced an increased duration of inundation which could disrupt wetland habitats, amphibian, bird, reptiles, mammals and migratory waterfowl	Increased Forebay Range Flexibility	WSE	low	no mitigation proposed due low impact and no regulated resources	–	–	–	–	–	–	–	–	–	–

Vegetation, Wetlands, and Wildlife – Multiple Objective 4

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby pool	Winter WSE higher in pool, changes spatial extent of drawdown zone could result in shift in vegetation and habitat. Drying in summer, conversion to upland habitat (summer). Affects to shoreline riparian nesting passerines/waterfowl.	December Libby Target Elevation	WSE	low	no mitigation proposed, due low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Libby Pool	Exposure of mudflats and barren lands during the summer months could result in establishment of non-native, invasive plant species.	December Libby Target Elevation Measure	WSE	low	Update and implement existing Invasive Plant Management Plan for the shoreline	yes.	yes.	Update and implement existing Invasive Plant Management Plan for the shoreline	yes, Invasive EO	yes	NA	Yes	Yes, comply with invasive EO	–	–
Kootenai River including Kootenai Falls Wildlife Management Area	Conversion of wetland to upland habitat in May through summer (off-channel habitat). Impacts on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Occurs seasonal and would result in permanent effect habitat	Modified Draft at Libby, Sliding Scale at Libby and Hungry Horse Measure	WSE	med	A) planting of native wetland and riparian vegetation (~100 acres along river) B) regrading the bank to establish same hydrology as the NAA	A) yes B) yes;	A) yes, B) yes, however it would require more permitting (CWA, 106, ESA) and would result more land disturbance than A) Planting mitigation	A) planting of native wetland and riparian vegetation (~100 acres along river)	EO11990 ?, CWA ?	yes	NA	yes	yes, long term medium impact to habitat including wetlands.	yes, resident fish	no remaining impact

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Bonner Ferry	Lower winter flows would encourage riparian vegetation establishment (e.g. cottonwoods). **Beneficial impact/no impact**	Winter Stage for Riparian measure	WSE	–	–	–	–	–	–	–	–	–	–	–	–
Hungry Horse	**negligible impacts. Similar to the NAA**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pend Oreille	Exposure of mudflats and barren lands during the summer months could result in establishment of non-native, invasive plant species.	McNary Flow Target	WSE	med	Update and implement Invasive Plant Management Plan for the shoreline	yes.	yes	Update and implement Invasive Plant Management Plan for the shoreline	invasive EO	yes	NA	yes	Yes, comply with invasive EO	–	–
Pend Oreille	Denton Slough: Change in nesting areas for waterfowl (grebes).	McNary Flow Target	WSE	med	Construct a floating boom system across Denton Slough to reduce free floating nests from entering the main part of the reservoir.	yes.	yes	Construct a floating boom system across Denton Slough to reduce free floating nests from entering the main part of the reservoir.	MBTA	yes	NA	yes	yes, due medium impact and comply MBTA	–	–
Pend Oreille	Denton Slough: Loss of approximately 1,200 acres of vegetated wetlands due to drawdown (Denton Slough, Pack River Delta, Clark Fork Delta).	McNary Flow Target	WSE	med	Plant or restore wetland habitat (approximately 1,200 acres) to create vegetated wetlands.	yes.	yes	Plant or restore wetland habitat (approximately 1,200 acres) to create vegetated wetlands.	CWA, EO 11990	yes	NA	yes	yes due medium impact and comply with CWA and EO 11990	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
L. Roosevelt	Lower WSE, Potential loss of forested, scrub-shrub wetlands and gallery forests, including through lack of suitable conditions for recruitment and establishment, impacting wildlife including resident and migratory waterfowl.	Winter System FRM	WSE	Low.	no mitigation proposed due to low impact and no regulated resource		–	–	–	–	–	–	–	–	–
L. Roosevelt	Slight increase in the size of the barren zone which would increase the risk of wildlife predation, including from raptors, wolves, and mountain lions.	Hungry Horse Additional Water Supply, Sliding Scale at Libby and Hungry Horse	Drawdown of water surface elevation	low	no mitigation proposed due to low impact and no regulated resource	–	–	–	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
LSR	WSE is 1ft lower in March than NAA, potential exposure of unvegetated areas could cause exposure of unvegetated barren land. Colonization of invasive speices.	McNary Target Flow	WSE	low	Update and implement Invasive Plant Management Plan for the shoreline	yes	yes	Update and implement Invasive Plant Management Plan for the shoreline	yes, Invasive EO	yes	NA	yes	yes, due to complying with invasive EO	–	–
LSR/ Clearwater River	potential conversion of vegetation to wetter vegetation (inundation of the pools above 4 inches until the end of June); potential of affecting groundnesting birds	McNary Target Flow	WSE	low	No mitigation proposed due to benefit to wetland habitat. Low effect to groundnesting birds.	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward from column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
McNary, John Day, The Dalles, Bonneville	~ 0.5 to 1.5 foot lower WSE upstream of mcNary and ~ 2.3 to 4 feet lower in Lake Bonnevillle, increase in exposed mudflats, increase invasive species	McNary Target Flow	WSE	low	Update Corps' Invasive Species management plan.	yes	yes	Update Corps' Invasive Species management plan.	yes, Invasive EO	yes	NA	yes	Yes, to comply with Invasive EO	–	–
McNary, and Umatilla NWR	lower WSE upstream of mcNary, critial bird habitat may be impacted. Vegetation may change in composition. Exposing more island.	McNary Target Flow	WSE	med	Planting plan with wetlands/riparian vegetation (Umatilla NWR [Blalock 115 acres, Patterson Slough 180 acresl], Foundation Island 222 acres). Update existing Invasive Plant Management plan for shoreline	yes	yes	Planting plan with wetlands/riparian vegetation (Umatilla NWR [Blalock 115 acres, Patterson Slough 180 acresl], Foundation Island 222 acres. Update existing Invasive Plant Management plan for shoreline	yes, Invasive EO, MTBA	yes	NA	yes	Yes, for med impact and comply with Invasive EO and MBTA	–	–
upper portions of Region D	lower WSE, **negligible changes (similar to NAA)** in wetland habitat can have effect on amphibians, migratory songvbirds, and mammals.	–	WSE	–	–	–	–	–	–	–	–	–	–	–	–

Power and Transmission – Multiple Objective 1

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	None - see region-wide	NA	NA	NA	NA	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	None - see region-wide	NA	NA	NA	NA	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	None - see region-wide	NA	NA	NA	NA	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	None - see region-wide	NA	NA	NA	NA	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Per Discussions at Mitigation Workshop No mitigation is recommended for this resource.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Loss of Load Probability (LOLP) increases to 11.2%. May be higher	–	–	–	Construct replacement energy sources to meet regional energy demand. (This would be market-driven and accomplished by others). Gas plants are	NA	NA	NA	No	NA	NA	NA	NA	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
	due to coal being taken offline.				cheapest replacements, but are not likely due to climate change considerations and focus on renewable energy. These replacement energy plants may be constructed by others or could be funded (partially) by BPA. This may not be implemented by co-lead agencies.										
–	Significant energy loss May - Sept due to spill, and Dworshak measure (critical water year *of 1937)*	–	–	–	Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
–	Significant LOLP increase in August	–	–	–	Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
–	large cost to power for structural measures	–	–	–	Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
–	winter reduction in power and flexibility	–	–	–	Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA	NA	No	NA	NA	NA	NA	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
–	December power losses	–	–	–	Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
–	all the above decreasing power value	–	–	–	Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA	NA	No	NA	NA	NA	NA	NA	NA
–	Increased NW wind and solar spill	–	–	–	Add export transmission facilities; Add energy storage	NA	To be implemented by others. (market-driven)	NA	No	NA	NA	NA	NA	NA	NA
–	Increased transmission congestion on certain paths - such as PDCI, MT to NW, and Hemingway-Summer Lake	–	–	–	Energy market participation; Add or modify resources (thermal, renewable, demand response, etc); Add transmission facilities (transmission lines, voltage reactors, RAS, etc)	NA	To be implemented by others. (market-driven)	NA	No	NA	NA	NA	NA	NA	NA

Power and Transmission – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Renewable energy spill associated with changes in generation	–	–	–	Add export transmission facilities; Add energy storage (battery banks; pump storage) - Not an action likely taken by BPA	NA	To be implemented by others. (market-driven)	NA	No	NA	NA	NA	No	NA	NA
–	Several power limiting measures combine to reduce average and peak generation	–	–	–	Energy market participation (BPA is looking into this for all scenarios); Add or modify resources (thermal, renewable, demand response, etc); Add transmission facilities (transmission lines, voltage reactors, RAS, etc) - creative transmission is likely mitigation for MO2.	NA	To be implemented by others. (market-driven)	NA	No	NA	NA	NA	No	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Per Discussions at Mitigation Workshop No mitigation is recommended for this resource.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Power and Transmission – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	See below	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	See below	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	See below	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	See below	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Per Discussions at Mitigation Workshop No mitigation is recommended for this resource.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
–	LOLP increases to 13.9% because several limiting measures combine to reduce average and peak generation.	–	–	–	Replace lost power: $294.10 million/year (gas); $341.30 million/year (solar) (to achieve LOLP of NAA) to achieve 2017 reliability levels	NA	NA	No	No	NA	NA	NA	No. Actions recommended would be taken by others (market-driven)	NA	NA
–	Significant energy deficit Ap1-July of 1937, caused by several power-limiting measures cobining to reduce average generation.	–	–	–	Adjust (increase) minimum generation at Lower Columbia projects (also helps with transmission reliability) Draft GCL and maybe upstream storage projects slightly deeper by April 10 or completely eliminate the April 10 requirement. Potentially lower the April 30 elevation as well. reduce the MCN flow aug measure to be only 1 MAF phase in the water supply measures slowly as demand materialized	NA	NA	No	No	NA	NA	NA	No. Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
–	within-day flexibility is significantly reduced	–	–	–	not spill or reduce spill in March, reduce summer spill to performance standard levels, stop spill early or mid-August, Reduce refill probability needed to lower VDLs slightly Add flex spill Allow JDA to operate up to 266.4 ft not only in the fall but also in the winter until MIP operation starts in the spring. Criteria can be developed to draft lower as needed when the Corps determines that there is an imminent threat of flood stages downstream, similar to the criteria now in effect in the fall. implement flex spill in the spring; Allow DWR to increase discharge with power demand is unusually high, e.g. during heat waves in August.	NA	NA	No	No	NA	NA	NA	No. Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
–	Loss of voltage support provided by the Lower Snake Project	–	–	–	Adjust minimum generation at Lower Columbia projects	NA	NA	No	No	NA	NA	NA	No. Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA
–	Increased transmission congestion on certain paths - such as Hemingway-Summer Lake caused by several power-limiting measures, which combine to reduce average and peak generation.	–	–	–	Increase transmission paths going north- south (highest priority), strategically locating power generation.	NA	NA	No	No	NA	NA	NA	No. Recommended action is outside of scope and would be accomplished under a separate NEPA action. Removed from mitigation recommendation and archived for potential use later.	NA	NA

Power and Transmission – Multiple Objective 4

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Considerations for establishment of riparian vegetation below Libby Dam limit power generation flexibility	Operational measure to establish riparian vegetation below Libby Dam	Survival rate of previous plantings	Med.	Plant larger diameter cottonwoods below Libby dam to aid in their establishment	Use of larger diameter stock to aid establishment is warranted, given the site conditions. However, this is a consideration in the implmentation of this measure, not an action that would offset an impact of this measure. As such, it is not recommended as a mitigation action.	Yes	No. This would be a consideration for implementation of the measure. Removed from mitigation recommendation and archived to inform implementation of this measure if warranted.	No	Yes	NA	NA	No. This would be a consideration for implementation of the measure. Removed from mitigation recommendation and archived to inform implementation of this measure if warranted.	Yes. This action would also provide benefits for fish and wildlife.	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	See below	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	See below	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward (Y/N)**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	See below	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Per Discussions at Mitigation Workshop No mitigation is recommended for this resource.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Increased transmission congestion on certain paths - such as Hemingway-Summer Lake caused by several power-limiting measures, which combine to reduce average and peak generation.	–	–	–	Increase transmission paths going north- south (highest priority), strategically locating power generation.	NA	NA	No	No	NA	NA	NA	No. Recommended action is outside of scope and would be accomplished under a separate NEPA action. Removed from mitigation recommendation and archived for potential use later.	NA	NA

–	Within-day flexibility is significantly reduced caused by drawdown to MOP on Lower Columbia projects, combined with spill to 125% beginning in March (not enough water in the system)	–	–	–	reduce summer spill to performance standard levels, stop spill early or mid-August, Allow forebay operations above the MOP/MIP restriction on occasion, such as when power prices hit a certain trigger level or for a certain number of days per month to increase power flexibility when it is most needed. This would help with flexibility, reliability, and generally help power. Allow JDA to operate up to 266.4 ft not only in the fall but also in the winter until MIP operation starts in the spring. Criteria can be developed to draft lower as needed	NA	NA	No	No	NA	NA	NA	No. Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
					when the Corps determines that there is an imminent threat of flood stages downstream, similar to the criteria now in effect in the fall. Stop spill when the temperature is high (when power demand is particularly high). This would help with flexibility, reliability, and generally help power.										
–	Measures that reduce operating ranges, increase spill, operate at MOP result in loss of flexibility in hydropower generation; would aid wind/solar integration	–	–	–	–	NA	NA	No	No	NA	NA	NA	No. Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
–	August has very large generation loss and loss-of-load probability caused by the McNary Flow Augmentation measure	–	–	–	Draft upstream projects deeper in August to increase flows; end spill earlier in dry years	NA	NA	No	No	NA	NA	NA	No. Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA
–	Large impacts to power for structural measures	–	–	–	Remove fish screens to lower O&M costs (b/c most fish are going through spillway) Alternatively, remove fish screens during Nov-Dec since adults will be going through winter spill	NA	NA	No	No	NA	NA	NA	No. Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
–	Winter reduction in power generation and flexibility caused by rain-induced flooding measure	–	–	–	Modify the measure that protects against rain-induced flooding. Allow Grand Coulee to be slightly higher when there is no low-elevation snow, but draft Grand Coulee more if low-elevation is falling. Presumably this would involve some sort of adaptive management	NA	NA	No	No	NA	NA	NA	No. Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA
–	December power generation losses caused by Libby End - of -December Measure	–	–	–	Allow Libby to draft deeper in December, at least during cold snaps	NA	NA	No	No	NA	NA	NA	No. Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
–	Potential reduction of voltage support from the lower Columbia Project caused by decreased generation at the Lower Columbia projects (spill).	–	–	–	Adjust minimum generation at Lower Columbia and Snake River projects	NA	NA	No	No	NA	NA	NA	No. Recommended action is a change to the alternative. Removed from mitigation recommendation and archived for potential use later.	NA	NA
–	Increased transmission congestion on certain paths - such as Hemingway-Summer Lake caused by several power-limiting measures, which combine to reduce average and peak generation.	–	–	–	Increase transmission paths going north- south (highest priority), strategically locating power generation.	NA	NA	No	No	NA	NA	NA	No. Recommended action is outside of scope and would be accomplished under a separate NEPA action. Removed from mitigation recommendation and archived for potential use later.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
–	Several power-limiting measures combine to reduce average and peak generation, resulting in LOLP increases to 29.6%	–	–	–	build $420.50 million/year (gas); or $511.0 million/year (solar) (to achieve LOLP of NAA)	NA	NA	No	No	NA	NA	NA	No. Recommended action is outside of scope and would be accomplished under a separate NEPA action. Removed from mitigation recommendation and archived for potential use later.	NA	NA

Air Quality and Greenhouse Gases – Multiple Objective 1

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby/Lake Koocanusa	Potential for short term windblown fugitive dust (PM) emissions that cause negative human health effects	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	Med due to potential for human health effects	1)Seeding dry sediment areas with vegetation if severe. 2)Prohibiting vehicle traffic on dry sediment. 3)Wind barriers if necessary. 4) BMPs during construction.	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Hungry Horse	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	Low	See above	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee/Lake Roosevelt	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	Low	See above	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Dworshak	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	Low	See above	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
McNary Area - Replacement Power Resources	Air pollutant and GHG emissions from natural gas replacement power generation *(only under the least cost power portfolio)*	Natural gas power generation replaces changes in hydropower generation increasing GHG emissions and air pollutants	Changes in GHG emissions from power generation; air pollutants described qualitatively and proportionally relative to change from No Action	Low	Carbon capture and storage technology and/or ensuring stringent emissions controls and best available technology. Offsetting emissions through planting of vegetation or other offsetting sequestration methods (e.g., credits)	–	–	No	–	–	–	–	–	–	–
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Multiple	Air pollutant and GHG emissions from power resource construction	The construction and interconnection of new power resources generates air pollutants and GHG emissions from construction activities at various locations across the Pacific Northwest	Qualitative discussion about need for replacement power and magnitude of generation requiring replacement	Low	Watering construction roads. BMPs for construction operations. Additional fuel and construction practices as directed by EPA Clean Construction guidance	–	–	No. Will be implemented as a BMP	–	–	–	–	–	–	–

Air Quality and Greenhouse Gases – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby/Lake Koocanusa	Potential for short term windblown fugitive dust (PM) emissions that cause negative human health effects	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	Med due to potential for human health effects	if multiple measures, please number them. 1)Seeding dry sediment areas with vegetation if severe. 2)Prohibiting vehicle traffic on dry sediment. 3)Wind barriers if necessary. 4) BMPs during construction.	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Hungry Horse	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	Low	See above	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee/Lake Roosevelt	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	–	See above	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Dworshak	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	–	See above	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
McNary Area - Replacement Power Resources	Air pollutant and GHG emissions from natural gas replacement power generation *(only under the least cost power portfolio)*	Natural gas power generation replaces changes in hydropower generation increasing GHG emissions and air pollutants	Changes in GHG emissions from power generation; air pollutants described qualitatively and proportionally relative to change from No Action	–	Carbon capture and storage technology and/or ensuring stringent emissions controls and best available technology. Offsetting emissions through planting of vegetation or other offsetting sequestration methods (e.g., credits)	–	–	No	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Multiple	Air pollutant and GHG emissions from power resource construction	The construction and interconnection of new power resources generates air pollutants and GHG emissions from construction activities at various locations across the Pacific Northwest	Qualitative discussion about need for replacement power and magnitude of generation requiring replacement	–	Watering construction roads. BMPs for construction operations. Additional fuel and construction practices as directed by EPA Clean Construction guidance	–	–	No. Will be implemented as a BMP	–	–	–	–	–	–	–

Air Quality and Greenhouse Gases – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby/Lake Koocanusa	Potential for short term windblown fugitive dust (PM) emissions that cause negative human health effects	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	Med due to potential for human health effects	if multiple measures, please number them. 1)Seeding dry sediment areas with vegetation if severe. 2)Prohibiting vehicle traffic on dry sediment. 3)Wind barriers if necessary. 4) BMPs during construction.	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Hungry Horse	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	Low	See above	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable ?**	**Mitigation Carried Forward (Y/N)**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended ?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Grand Coulee/Lake Roosevelt	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	Low	See above	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lower Snake Projects	Fugitive dust from construction activities (on road and non-road)	Dam Breaching and other Construction	Area of exposed shoreline	Low	No known effective mitigation actions	–	–	NA	–	–	–	–	–	–	–

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward (Y/N)**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Lower Snake Projects	GHG and air pollutant emissions from construction vehicles	Dam Breaching and other Construction	Scale of Demolition/Construction	Low	No known effective mitigation actions	–	–	NA	–	–	–	–	–	–	–
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
McNary Area - Replacement Power Resources	Air pollutant and GHG emissions from natural gas replacement power generation *(only under the least cost power portfolio)*	Natural gas power generation replaces changes in hydropower generation increasing GHG emissions and air pollutants	Changes in GHG emissions from power generation; air pollutants described qualitatively and proportionally relative to change from No Action	–	Carbon capture and storage technology and/or ensuring stringent emissions controls and best available technology. Offsetting emissions through planting of vegetation or other offsetting sequestration methods (e.g., credits)	–	–	No	–	–	–	–	–	–	–
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable ?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended ?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Multiple	Air pollutant and GHG emissions from power resource construction	The construction and interconnection of new power resources generates air pollutants and GHG emissions from construction activities at various locations across the Pacific Northwest	Qualitative discussion about need for replacement power and magnitude of generation requiring replacement	–	Watering construction roads. BMPs for construction operations. Additional fuel and construction practices as directed by EPA Clean Construction guidance	–	–	Implement as BMP	–	–	–	–	–	–	–

Air Quality and Greenhouse Gases – Multiple Objective 4

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Libby/Lake Koocanusa	Potential for short term windblown fugitive dust (PM) emissions that cause negative human health effects	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	Low	1)Seeding dry sediment areas with vegetation if severe. 2)Prohibiting vehicle traffic on dry sediment. 3)Wind barriers if necessary. 4) BMPs during construction.	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward (Y/N)**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Hungry Horse	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	–	See above	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee/Lake Roosevelt	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	–	See above	1) No, as flucutation will inundate new plantings 2) Yes 3)Uncertain 4)Yes	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Dworshak	Fugitive windblown dust from exposed river sediment	Additional drawdown relative to No Action risks potential fugitive dust emissions from exposed sediment	Feet of reservoir elevation change relative to No Action; potential associated effects on PM emissions qualitative	–	See above	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down. Implement as construction BMP 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Yes	1) No, as flucutation will inundate new plantings 2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 3)No, wind barriers efficacy are uncertain 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Clean Air Act	Yes	NA	Seasonal and Temporary	2) Yes, prohibiting vehicle traffic on shorelines will help keep dust and erosion down 4)Yes, but BMPs are implemented anyway, so don't need to call them out as mitigation	Prohibiting vehicular traffic will also protect wildlife and wildlife habitat	Seasonal and temporary episodes of blowing dust
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
McNary Area - Replacement Power Resources	Air pollutant and GHG emissions from natural gas replacement power generation *(only under the least cost power portfolio)*	Natural gas power generation replaces changes in hydropower generation increasing GHG emissions and air pollutants	Changes in GHG emissions from power generation; air pollutants described qualitatively and proportionally relative to change from No Action	–	Carbon capture and storage technology and/or ensuring stringent emissions controls and best available technology. Offsetting emissions through planting of vegetation or other offsetting sequestration methods (e.g., credits)	No	–	–	–	–	–	–	–	–	–
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Multiple	Air pollutant and GHG emissions from power resource construction	The construction and interconnection of new power resources generates air pollutants and GHG emissions from construction activities at various locations across the Pacific Northwest	Qualitative discussion about need for replacement power and magnitude of generation requiring replacement	–	Watering construction roads. BMPs for construction operations. Additional fuel and construction practices as directed by EPA Clean Construction guidance	Implement as BMP	–	–	–	–	–	–	–	–	–

Navigation and Transportation – Multiple Objective 1

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grand Coulee	Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members	Operational measures that draft Grand Coulee deeper	Reservoir Levels	High	Extend the ramp at the Gifford-Inchelium Ferry so that it's available at lower water elevations.	Yes	Yes	Yes	No	Yes	NA	Temporary but severe effect	Yes	NA	None
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
LSR Projects	Negligible effects on navigation operating costs	NA	NA	Low	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
LCOL Projects	Negligible effects on navigation operating costs	NA	NA	Low	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Navigation and Transportation – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grand Coulee	Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members	Operational measures that draft Grand Coulee deeper	Reservoir Levels	High	Extend the ramp at the Gifford-Inchelium Ferry so that it's available at lower water elevations.	Yes	Yes	Yes	No	Yes	NA	Temporary but severe effect	Yes	NA	None
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
LSR Projects	Negligible effects on navigation operating costs	NA	NA	Low	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	**Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward (Y/N)**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
LCOL Projects	Negligible effects on navigation operating costs	NA	NA	Low	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Navigation and Transportation – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grand Coulee	Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members	Operational measures that draft Grand Coulee deeper	Reservoir Levels	High	Extend the ramp at the Gifford-Inchelium Ferry so that it's available at lower water elevations.	Yes	Yes	Yes	No	Yes	NA	Temporary but severe effect	Yes	NA	None
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
LSR Projects	Carbon emission increase with increased movement on road and rail with LSR navigation channel no longer operational	Dam Breaching	air quality	Low	None proposed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LSR Projects	Potential increased traffic on road and/or rail lines impacting congestion and/or capacity of system to move goods after breaching eliminates barge navigation on the LSR	Dam Breaching	Traffic volumes on roads	Low	None proposed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LSR Projects	Potential congestion or capacity issues at road and/or rail shipping facilities after breaching eliminates barge traffic on the LSR	Dam Breaching	Traffic volumes on rail	Low	None proposed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
LCOL projects	Commercial navigation eliminated at four LSR projects potentially causing additional storage and/or movement at Lower Columbia port facilities	Dam Breaching	shipping volume from LSR	NA	None - market driven	–	–	–	–	–	–	–	–	–	–
LCOL projects	Potential sediment issues above McNary dam - Lake Wallula and confluence of Snake and Columba (note unclear if this is Region C or extends in to Region D)	Dam Breaching	volume of sediment	medium - several commercial berths/ports may become inaccessible	Dredge channel and around impacted facilities and/or relocate impacts port and dock facilities to alternate, unaffected location, or expand existing port facilities	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
LCOL projects	Potential increased traffic on road and/or rail lines impacting congestion and/or capacity of system to move goods	Dam Breaching	Traffic volumes on roads	Low	None - market driven	–	–	–	–	–	–	–	–	–	–
LCOL projects	Potential congestion or capacity issues at road and/or rail shipping facilities	Dam Breaching	Traffic volumes on rail	Low	None - market driven	–	–	–	–	–	–	–	–	–	–
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Navigation and Transportation – Multiple Objective 4

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grand Coulee	Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members	Operational measures that draft Grand Coulee deeper	Reservoir Levels	High	Extend the ramp at the Gifford-Inchelium Ferry so that it's available at lower water elevations.	Yes	Yes	Yes	No	Yes	NA	Temporary but severe effect	Yes	NA	None
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Neglible effects on navigation operating costs	NA	NA	NA	NA	NA	NA	None	NA	NA	No	NA	NA	NA	NA
Lower Monumental, Little Goose	Increased shoaling in nav channel	High Spill combined with tailrace conditions	Sediment movement	med	Installation of Coffer cells to dissipate energy	Yes	Yes	Yes	No	Yes	NA	Yes - impact is all years	Yes	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
McNary, John Day	Increased shoaling in nav channel	High Spill combined with tailrace conditions	Sediment movement	med	Installation of Coffer cells to dissipate energy	Yes	Yes	Yes	No	Yes	NA	Yes - impact is all years	Yes	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Recreation – Multiple Objective 1

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Negligible - No mitigation recommended	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Negligible - No mitigation recommended	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Negligible - No mitigation recommended	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Negligible - No mitigation recommended	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Recreation – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Negligible	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Negligible	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Dworshak	Reduced access to the Dworshak State Park Boat Ramp (up to 108 days) from mid-Jan - May. Impacting access for hunters and fishermen at a heavily used boat ramp. Most lost usage is outside of the recreation season, but changes in WSE take the ramp out of service in the month of April (30 days), during turkey hunting season and a time when the reservoir is open for the start of bass fishing season. Because of the steep terrain and limited road network, this ramp is important for recreation access.	Operational measures for increased power flexibility	Visitor days	med (loss of access at mid-reservoir, in prime hunting areas)	Extension of the Dworshak State Park Boat ramp by approximately 26 feet.	Yes	Yes	Yes	No	Yes	NA	Yes. The impact is seasonal, but this boat ramp provides access to mid-reservoir hunting areas, and is one of most efficient ways to access.	Yes	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Negligible	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Recreation – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Negligible - No mitigation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ice Harbor/McNary	Sedimentation of boat ramp at Hood Park (below Ice Harbor Pool). Drop in pool elevations may require that boat ramp is extended	Dam Breaching	Accessibility of river for recreation	med	Dredge after breach, probably annually over 5-10 years until river stabilizes, and extend the Hood Park boat ramp.	Yes	Yes	Yes	No	Yes	NA	Temporary over 6-10 years until river stabilizes.	Yes	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
McNary	Sedimentation in the McNary Pool caused by breaching would negatively impact access to the McNaryYacht Club, a leased area in the McNary Pool.	Dam Breaching	Accessibility of river for recreation	High	Dredge approach and marina at McNary Yacht Club to maintain access. It is estimated this may need to be done annually (of varying scales) until the sediment load in the Snake River stabilizes.	Yes	Yes	Yes	No	Yes	NA	Likely within the first 5 years after completion of breaching. Will require monitoring to understand scale of the action.	Yes	NA	NA
McNary	Sedimentation in the McNary Pool caused by breaching would negatively impact access to the Walla Walla Yacht Club, a leased area in the McNary Pool.	Dam Breaching	Accessibility of river for recreation	High	Dredge approach and marina at the Walla Walla Yacht Club to maintain access. It is estimated this may need to be done annually (of varying scales) until the sediment load in the Snake River stabilizes.	Yes	Yes	Yes	No	Yes	NA	Likely within the first 5 years after completion of breaching. Will require monitoring to understand scale of the action.	Yes	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Ice Harbor	Breaching the LSR Dams would convert that area from lake recreation to river recreation. WSE drop approximately 95 feet.	Dam Breaching	Accessibility of river for recreation	High	Extend the boat ramp at Charbonneau Park approx. 95 feet to facilitate water access to the river from the existing park	Yes	TBD - engineering awaiting additional terrain data to determine feasibility	Yes	No	Yes	NA	All years after breaching	Yes	NA	NA
Ice Harbor	Breaching the LSR Dams would convert that area from lake recreation to river recreation. WSE drop approximately 70 feet.	Dam Breaching	Accessibility of river for recreation	High	Extend the boat ramp at Charbonneau Park approx. 70 feet to facilitate water access to the river from the existing park	Yes	Yes	Yes	No	Yes	NA	All years after breaching	Yes	NA	NA
Little Goose	Breaching the LSR Dams would convert that area from lake recreation to river recreation. WSE drop in elevation impacts recreational access.	Dam Breaching	Accessibility of river for recreation	High	Extend the boat ramp at Boyer Park approx. 20 feet to facilitate water access to the river from the existing park	Yes	Yes	Yes	No	Yes	NA	All years after breaching	Yes	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Monumental	Breaching the LSR Dams would convert that area from lake recreation to river recreation. WSE drop in elevation impacts recreational access.	Dam Breaching	Accessibility of river for recreation	High	Extend the boat ramp at Lyon's Ferry Park approx. 65 feet to facilitate water access to the river from the existing park	Yes	Yes	Yes	No	Yes	NA	All years after breaching	Yes	NA	NA
Lower Granite	Breaching the LSR Dams would convert that area from lake recreation to river recreation. WSE drop in elevation impacts recreational access.	Dam Breaching	Accessibility of river for recreation	High	Extend the boat ramp at Swallow's Park 25'	Yes	Yes	Yes	No	Yes	NA	All years after breaching	Yes	NA	NA
Lower Granite	Breaching the LSR Dams would convert that area from lake recreation to river recreation. WSE drop in elevation impacts recreational access.	Dam Breaching	Accesibility of river for recreation	High	Extend the Greenbelt Ramp near Lewiston, ID 30 '	Yes	Yes	Yes	No	Yes	NA	All years after breaching	Yes	NA	NA

Location	**Summary of Impact(s) Compared To NAA** **if no impact or beneficial impact, no mitigation needed**	**Cause of Impact (indicate the measure or group of measures from this alternative)**	**Indicator/Metric used to describe impact**	**Severity of impact (high, med, low)**	**Proposed Mitigation Measures**	**Is the measure likely to be effective?**	**Is the measure feasible/implementable?**	**Mitigation Carried Forward (Y/N)**	**Does impact effect a regulated resource (CWA, ESA, 106)**	**Is the mitigation action in-kind and on site?**	**If no in-kind and onsite, then document logic for proposing the off site mitigation**	**Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years**	**Is this mitigation action recommended?**	**Note if this mitigation action offsets impacts for multiple resources, which ones?**	**Remaining Effects after Mitigation Implemented**
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
McNary	Sedimentation of boat ramps on McNary project at Hat Rock State Park, Sacajawea State Park, and Warehouse Beach (Corps boat launches)	Dam Breaching	Accesibility of facilities	med	dredge after breach, probably annually over 5-10 years until river stabilizes	Yes	Yes	Yes	No	Yes	NA	Temporary over 6-10 years until river stabilizes.	Yes	NA	NA
McNary	Sedimentation of Walla Walla Yacht Club Marina, and McNary Yacht Club Marina (private marinas)	Dam Breaching	Accesibility of facilities	med-high	dredge after breach, probably annually over 5-10 years until river stabilizes	Yes	Yes	Yes	No	Yes	NA	Temporary over 6-10 years until river stabilizes.	Yes	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Recreation – Multiple Objective 4

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Negligible - no mitigation	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grand Coulee Lake Roosevelt	lower water levels reduce accessibility at 11 boat ramps for 7-19 days per year.	Operational measures - McNary Flow Aug.	Accessibility of boat ramps	Low	Extend boat ramps	Yes	Yes	No - impact is less than 10 days/year	No	Yes	NA	Seasonal, with worst impacts in January, February, and May.	No - scale of impact and timing does not warrant	NA	Boat ramp will remain inaccessible during period described.

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N)	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee Lake Roosevelt	Lower water levels reduce accessibility at 6 (Evans, Hawk Creek, Marcus Island, Napolean Bridge, North Gorge) boat ramps for 55-63 days per year.	Operational measures - McNary Flow Aug.	Accessibility of boat ramps	Low	Extend boat ramps	Yes	Yes	No - impact is less than 10 days/year	No	Yes	NA	Seasonal, with greatest impacts in May, June, and August.	Yes	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Visual – Multiple Objective 1

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Temporary construction activities at projects	Structural measures - Construction	Visual	Med	None	NA	NA	NA	NA	NA	NA	Temporary	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Temporary construction activities at projects	Structural measures - Construction	Visual	Med	None	NA	NA	NA	NA	NA	NA	Temporary	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Visual – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Temporary construction activities at projects	Structural measures - Construction	Visual	Med	None	NA	NA	NA	NA	NA	NA	Temporary	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Temporary construction activities at projects	Structural measures - Construction	Visual	Med	None	NA	NA	NA	NA	NA	NA	Temporary	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Visual – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Temporary construction activities at projects	Dam Breaching	Visual	Med	None	NA	NA	NA	NA	NA	NA	Temporary	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Temporary construction activities at projects	Structural measures - Construction	Visual	Med	None	NA	NA	NA	NA	NA	NA	Temporary	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Visual – Multiple Objective 4

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Temporary construction activities at projects	Structural measures - Construction	Visual	Med	None	NA	NA	NA	NA	NA	NA	Temporary	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Temporary construction activities at projects	Structural measures - Construction	Visual	Med	None	NA	NA	NA	NA	NA	NA	Temporary	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Noise – Multiple Objective 1

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Increase in noise from temporary construction activities at projects	Structural Measures - Construction	Noise - decibels	low	None	NA	NA	NA	NA	NA	NA	temporary	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Increase in noise from temporary construction activities at projects	Structural Measures - Construction	Noise - decibels	low	None	NA	NA	NA	NA	NA	NA	temporary	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Noise – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Increase in noise from temporary construction activities at projects	Structural Measures - Construction	Noise - decibels	low	None	NA	NA	NA	NA	NA	NA	temporary	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Increase in noise from temporary construction activities at projects	Structural Measures - Construction	Noise - decibels	low	None	NA	NA	NA	NA	NA	NA	temporary	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Noise – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Increase in noise from temporary construction activities at projects	Structural Measures – Dam Breaching	Noise - decibels	low	None	NA	NA	NA	NA	NA	NA	temporary	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Increase in noise from temporary construction activities at projects	Structural Measures - Construction	Noise - decibels	low	None	NA	NA	NA	NA	NA	NA	temporary	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Noise – Multiple Objective 4

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Increase in noise from temporary construction activities at projects	Structural Measures - Construction	Noise - decibels	low	None	NA	NA	NA	NA	NA	NA	temporary	NA	NA	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	Increase in noise from temporary construction activities at projects	Structural Measures - Construction	Noise - decibels	low	None	NA	NA	NA	NA	NA	NA	temporary	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Cultural Resources – Multiple Objective 1

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hungry Horse	Reservoir fluctuation leads to exposure of archaeological resources increase by 17%, leading to increased erosion, recreational impacts, possible looting.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Hungry Horse	Amplitude of reservoir elevation changes (from max to min) icreases by 10%, leading to increased erosion, recreational impacts, possible looting.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee	Exposure of archaeological resources increase by 10%, leading to increase by 10%, leading to increased erosion, recreational impacts, and possible looting.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee	Frequency of reservoir elevatinal changes increases by 32% relative to the NAA, increasing the rate at which erosion occurs.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Dworshak	High draft rate events increase from an average of 2 times a year to above 4 times a year, leading to increased potential for slumping and other kinds of mass wasting	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Cultural Resources – Multiple Objective 2

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hungry Horse	Reservoir fluctuation result in exposure of archaeological resources increased by 6%, leading to increased erosion, recreational impacts, and possible looting.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Hungry Horse	Reservoir fluctuation results in amplitude of reservoir elevation changes (from max to min) increase by 13%, leading to increased erosion.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Hungry Horse	High draft rate events increase from an average of 1 time every 2 years to once a year, leading to increased potential for slumping and other kinds of mass wasting.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Libby	High draft rate events increase from an average of 0.7 times a year to abouve 1.3 times a year, leading to increased potential for slumping and other kinds of mass wasting.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Libby	Reservoir fluctuation results in increase in exposure of archaeological resources by 8%, leading to increased erosion, recreational impacts, and possible looting.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Hungry Horse	High draft rate events increase from an average of 1 time every 2 years to once a year, leading to increased potential for slumping and other kinds of mass wasting.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation. Creative mitigation measures to address tribal interests and concerns, to be implemented under existing FCRPS program.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grand Coulee	Reservoir fluctuations result in exposrure of archaeological resources increase by 13%	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee	Frequency of reservoir elevational changes increase by 26% relative to NAA, increasing the rate at which erosion occurs.	Operational Measures	Exposure of shoreline/erosion	varies by site	continued archaeological monitoring; drone monitoring; satellite monitoring; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Grand Coulee	Frequency of reservoir elevational changes increase by 26% relative to NAA, increasing the rate at which erosion occurs.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation. Creative mitigation measures to address tribal interests and concerns, to be implemented under existing FCRPS program.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Dworshak	Reservoir fluctuations result in exposure of archaeological resources increase by 13%.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Dworshak	Amplitude of reservoir elevation changes (from max to min) increase by 28%, leading to increased erosion.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation proposed. Use existing FCRPS program for continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Dworshak	Amplitude of reservoir elevation changes (from max to min) increase by 28%, leading to increased erosion.	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation. Creative mitigation measures to address tribal interests and concerns, to be implemented under existing FCRPS program.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Cultural Resources – Multiple Objective 3

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hungry Horse	Hungry Horse - Exposure of archaeological resources increased by 18%	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation. Continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery under existing FCRPS mitigation program.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Hungry Horse	Hungry Horse - Amplitude of reservoir elevation changes (from max to min) increases by 11%, leading to increased erosion	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation. Continued archaeological monitoring; drone monitoring; satellite monitoring; develop/continue site protective capping or stabilization program; data recovery under existing FCRPS mitigation program.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Libby	Libby - Exposure of archaeological resources increased by 8%	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation. continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery under existing FCRPS mitigation program.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Libby	Libby - High draft rate events increase from an average of 0.7 times a year to above 1.2 times a year, leading to increased potential for slumping and other kinds of mass wasting	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation. Continued archaeological monitoring; periodic monitoring of landslides and other unstable landforms; develop/continue site protective capping or stabilization program; data recovery under existing FCRPS mitigation program.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Hungry Horse	Hungry Horse - Amplitude of reservoir elevation changes (from max to min) increases by 11%, leading to increased erosion	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation. Creative mitigation measures to address tribal interests and concerns (language programs, etc.) under existing FCRPS mitigation program.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grand Coulee	Grand Coulee - High draft rate events increase from an average of 5.8 times a year to above 6.3 times a year, leading to increased potential for slumping and other kinds of mass wasting	Operational Measures	Exposure of shoreline/erosion	varies by site	continued archaeological monitoring; periodic monitoring of landslides and other unstable landforms; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee	Grand Coulee - High draft rate events increase from an average of 5.8 times a year to above 6.3 times a year, leading to increased potential for slumping and other kinds of mass wasting	Operational Measures	Exposure of shoreline/erosion	varies by site	No new mitigation. Creative mitigation measures to address tribal interests and concerns (language programs, etc.) under existing FCRPS mitigation program.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
–	–	–	–	–	–	–	–	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
–	–	–	–	–	–	–	–	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	–	–	–	–	–	–	–
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lower Snake Projects	Lower Snake Projects - Draw down rate of 2 ft. per day leads to slumping and mass wasting of post-reservoir sediments on archaeological sites	Dam Breach measures	Exposure of shoreline/erosion	varies by site	Monitor drawdown zones and newly exposed banks for cultural resources. - Implementation BMP	NA	NA	No. This action is a cultural resources BMP proposed during the implementation phase. No new mitigation.	Section 106 of NHPA, possible NAGPRA	NA	NA	NA	NA	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Snake Projects	Lower Snake Projects - Invasive weeds take over exposed soils leading to the development of a post-reservoir plant community that does not resemble pre-reservoir conditions. This would diminish the integrity of exposed traditional cultural properties	Dam Breach measures	Exposure of shoreline	varies by site	Restoration of native plants (using plant list developed with Payos Kuus Cuukwe group) within the newly exposed area on LSR.	Yes	Yes	Yes	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. Implementation of native plantings will prevent other issues such as noxious weed establishment.	Yes	Cultural and Wildlife Effects	NA
Lower Snake Projects	Existing plants fail to propogate over areas exposed by removal of reservoir due to lack of water. The lack of plant cover leads to accelerated erosion of archaeological resources	Dam Breach measures	Exposure of shoreline/erosion	varies by site	Targeted irrigation and replanting with native species in newly exposed areas.	Yes	Yes	Yes. Irrigation for 3 years will be essential in successful establishment of newly planted vegetation.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. Implementation of native plantings will prevent other issues such as noxious weed establishment.	Yes	Cultural and Wildlife Effects	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Snake Projects	Lower Snake Projects - Exposure of archaeological sites due to removal of reservoir waters leads to increased looting	Dam Breach measures	Exposure of shoreline/erosion	varies by site	Increase law enforcement patrols; develop agreements with local law enforcement; public outreach campaign to deter looting; signage; develop site protective capping program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	–	–	Cultural Only	NA
Lower Snake Projects	Lower Snake Projects - Exposure of sandy areas along rivers leads to increase vehicle traffic on the former bed of the reservoir, which leads to rutting and damage to exposed sites	Dam Breach measures	Exposure of shoreline/erosion	varies by site	Increase law enforcement patrols; develop agreements with local law enforcement; public outreach campaign to deter off-road vehicle traffic; signage; creation of vehicle barriers along access routes; develop site protective capping program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	–	–	Cultural Only	NA
Lower Snake Projects	Lower Snake Projects - Draw down rate of 2 ft. per day leads to slumping and mass wasting or deposition of post-reservoir sediments on traditional cultural properties	Dam Breach measures	Exposure of shoreline/erosion	varies by site	No new mitigation. Creative mitigation measures to address tribal interests and concerns (language programs, etc.) under existing FCRPS mitigation program.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Lower Snake Projects	Lower Snake Projects - Draw down rate of 2 ft. per day leads to slumping and mass wasting or deposition of post-reservoir sediments on traditional cultural properties	Dam Breach measures	Exposure of shoreline/erosion	varies by site	Stabilization of traditional cultural properties (revegetating, capping, erosion control, maintain site/intact site)	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	Cultural Only	NA
Lower Snake Projects	breaching leads to the dismantling of historic structures (eligible)	Dam Breach measures	Historic Properties criteria and requirements	varies by site	HABS-HARE documentation; public outreach campaign to deter looting; signage; data recovery (museum curation of "pieces"), security fencing to prevent access	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes	Yes	Cultural (interpretation of sites). The Fencing is a security/life safety measure to keep the public out of the dam structures post-breaching.	NA
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/ Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/ implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
McNary	Release of accumlated sediment from Lower Snake River dam breaching overwhelms some wetlands, and affects distribution of plant communities that are critical to some traditional cultural properties (such as tule).	Dam Breach measures	Sediment accumulation	varies by site	Develop tule habitat at alternate sites; language program to perpetuate cultural knowledge of tule; interpretative signage;	Yes	Yes	Yes	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This mitigation action proposes to reestablish tule communities at sites impacted by sedimentation from Dam Breaching.	Yes	Cultural and Wildlife Effects	NA
Not Region Specific	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
General - LSR	Drawdown of reservoirs will expose at least 360 known culutral resources sites, possibly more, making them susceptible to damage and looting.	Dam Breach Measures	Exposure of shoreline	High	Develop dedicated mitigation program to address exposure of known cultural sites under drawdown conditions, as suggested in 2002 Lower Snake Feasibility Study. This would be a separate program from the existing cultural mitigation program for the FCRPS.	Yes	Yes	Yes	Section 106 of NHPA, possible NAGPRA	Yes	NA	Yes. This mitigation action proposes to reestablish tule communities at sites impacted by sedimentation from Dam Breaching.	Yes	Cultural and Wildlife Effects	NA

Cultural Resources – Multiple Objective 4

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Region A: Libby, Hungry Horse, Albeni Falls	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hungry Horse	Hungry Horse - Exposure of archaeological resources increased by 23%, leading to increased erosion, recreational impacts, and possible looting	Operational Measures	Exposure of shoreline/erosion	med	continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA
Hungry Horse	Hungry Horse - Amplitude of reservoir elevation changes (from max to min) increases by 10%, leading to increased erosion	Operational Measures	Exposure of shoreline/erosion	med	continued archaeological monitoring; drone monitoring; satellite monitoring; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Hungry Horse	Hungry Horse - Frequency of reservoir elevational changes increases by 8% relative to the NAA, increasing the rate at which erosion occurs	Operational Measures	Exposure of shoreline/erosion	med	continued archaeological monitoring; drone monitoring; satellite monitoring; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA
Albeni Falls	Albeni Falls - Exposure of archaeological resources increased by 7%, leading to increased erosion, recreational impacts, and possible looting	Operational Measures	Exposure of shoreline/erosion	med	continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Libby	Libby - Frequency of reservoir elevational changes increases by 9% relative to the NAA, increasing the rate at which erosion occurs	Operational Measures	Exposure of shoreline/erosion	med	continued archaeological monitoring; drone monitoring; satellite monitoring; develop/continue site protective capping or stabilization program; data recovery	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA
Hungry Horse	Hungry Horse - Amplitude of reservoir elevation changes (from max to min) increases by 10%, leading to increased erosion	Operational Measures	Exposure of shoreline/erosion	med	Creative mitigation measures to address tribal interests and concerns under existing programs.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA
Region B: Grand Coulee, Chief Joseph	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee	Grand Coulee - Exposure of archaeological resources increased by 47%, leading to increased erosion, recreational impacts, and possible looting	Operational Measures	Exposure of shoreline/erosion	med	increased continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery using existing mitigation programs	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA
Grand Coulee	Grand Coulee - Frequency of reservoir elevational changes increases by 24% relative to the NAA, increasing the rate at which erosion occurs	Operational Measures	Exposure of shoreline/erosion	med	increased continued archaeological monitoring; drone monitoring; satellite monitoring; develop/continue site protective capping or stabilization program; data recovery using existing mitigation programs.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee	Grand Coulee - Amplitude of reservoir elevation changes (from max to min) increases by 9%, leading to increased erosion (still within the normal operating range)	Operational Measures	Exposure of shoreline/erosion	med	increased continued archaeological monitoring; drone monitoring; satellite monitoring; develop/continue site protective capping or stabilization program; data recovery using existing mitigation programs.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA
Grand Coulee	Grand Coulee - High draft rate events increase from an average of 5.8 times a year to above 6.3 times a year, leading to increased potential for slumping and other kinds of mass wasting	Operational Measures	Exposure of shoreline/erosion	med	increase continued archaeological monitoring; drone monitoring; satellite monitoring; develop/continue site protective capping or stabilization program; data recovery using existing mitigation programs.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA
Grand Coulee	Grand Coulee - Frequency of reservoir elevational changes increases by 24% relative to the NAA, increasing the rate at which erosion occurs	Operational Measures	Exposure of shoreline/erosion	med	Creative mitigation measures to address tribal interests and concerns. (creative mitigation = language programs, interpretive materials, etc) under existing mitigation programs.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
Grand Coulee	Grand Coulee - High draft rate events increase from an average of 5.8 times a year to above 6.3 times a year, leading to increased potential for slumping and other kinds of mass wasting	Operational Measures	Exposure of shoreline/erosion	med	Creative mitigation measures to address tribal interests and concerns under existing mitigation programs.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA
Region C: Dworshak, 4 Lower Snake Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Region D: 4 Lower Columbia Projects	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Location	Summary of Impact(s) Compared To NAA if no impact or beneficial impact, no mitigation needed	Cause of Impact (indicate the measure or group of measures from this alternative)	Indicator/Metric used to describe impact	Severity of impact (high, med, low)	Proposed Mitigation Measures	Is the measure likely to be effective?	Is the measure feasible/implementable?	Mitigation Carried Forward (Y/N) from Column F	Does impact effect a regulated resource (CWA, ESA, 106)	Is the mitigation action in-kind and on site?	If no in-kind and onsite, then document logic for proposing the off site mitigation	Is the mitigation scaled to the level of impact? Including: seasonal, temporary, dry-year only, all years	Is this mitigation action recommended?	Note if this mitigation action offsets impacts for multiple resources, which ones?	Remaining Effects after Mitigation Implemented
John Day	John Day - Exposure of archaeological resources increased by 23%	Operational Measures	Exposure of shoreline/ erosion	med	Continued archaeological monitoring; drone monitoring; satellite monitoring; law enforcement patrols; public education regarding not digging in archaeological sites; signage; develop/continue site protective capping or stabilization program; data recovery under existing mitigation programs.	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA
John Day	John Day - Exposure of archaeological resources increased by 23%	Operational Measures	Exposure of shoreline/ erosion	med	Creative mitigation measures to address tribal interests and concerns under existing mitigation programs	Yes	Yes	Yes. Mitigation is implentation of existing FCRPS cultural program/PA. May require increase in existing mitigation program budgets.	Sec. 106, NAGPRA	Yes	NA	Yes. This will be implemented on a case-by-case basis using an existing program.	No new mitigation is proposed. Use existing program to address impacts.	NA	NA

Draft Columbia River System Operations
Environmental Impact Statement

Appendix R, Mitigation, Monitoring and Adaptive Management

Part 3, Mitigation Process

Annex E

- **Proposed Mitigation Summary Tables for Each Multiple Objective Alternative**

CHAPTER 1 - PROPOSED MITIGATION SUMMARY FOR MULTIPLE OBJECTIVE 1 [2]

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization only	Proposed to move forward or rationale for removal
Water Quality	On the Lower Snake River Increased harmful algae bloom monitoring at recreational areas; if algal blooms produce toxins, post public advisories at recreational areas with to protect the public	Increased algae growth due to high August water temperatures in the Lower Snake River Projects	Best Management Practices/Update Plans	Yes, as Avoidance/Minimization
Vegetation, Wildlife, & Wetlands	Implement Invasive Plant Management Plan for the shoreline at Libby	Exposure of mudflats and barren lands caused by drawdown during the summer months could result in establishment of non-native, invasive plant species.	Best Management Practices/Update Plans	Yes, as Avoidance/Minimization
Vegetation, Wildlife, & Wetlands	On Kootenai River downstream of Libby: Plant native wetland and riparian vegetation (~100 acres along river)	Conversion of wetland to upland habitat in May through summer (off-channel habitat). Impacts on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Impacts would occur seasonally, and would result in permanent effect habitat	–	Yes, as Mitigation

[2] Note that the effects in this table are draft

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization only	Proposed to move forward or rationale for removal
Vegetation, Wildlife, and Wetlands	Create up to 2 acres of avian nesting habitat outside of the Columbia River Basin	Inundation of nesting habitat from measure intended to fluctuate reservoir levels to reduce avian nesting habitat	–	Not carried forward the reservoir levels for this alternative are within the normal operating range. This operating range associated with John Day has been mitigated for with the creation of Umatilla National Wildlife Refuge in compliance with Fish and Wildlife Coordination Act Report for John Day construction and operations. In addition, the existing mitigation sites for both the estuary and inland tern management projects have capacity for additional birds.
Anadromous Fish	Add additional fish ladder entrances at Little Goose to provide additional ladder entry location for adult salmon and steelhead during high spill conditions	Increased spill levels cause turbulence and eddies below the dams. Direct offset to the eddies due to the spill. Onsite mitigation	–	Replaced with “Temporary extension of performance standard spill levels in coordination with the Regional Forum to assist fish migration.”

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization only	Proposed to move forward or rationale for removal
Anadromous Fish	Increase level of avian predator management on the LSR and LCOL, and pinniped predator management on the LCOL projects.	This is an onsite/offsite measure to minimize impacts to fish that may be negatively impacted by TDG levels in the river.	–	Not included in the mitigation chapter because the existing programs are part of the NAA and all MOs. The existing avian predator management programs will be carried forward. In addition, Predation Disruption Operation measure would address this impact. For pinniped management program, the existing program would continue with potential for extending the timeframe.
Anadromous Fish	Implement mainstem habitat improvement projects to increase food sources and reconnect back-channel habitats	This is offsite mitigation recommended to offset impacts from TDG of spill. Habitat actions would improve the health of fish, making them better able to overcome negative conditions in the river.	–	Not carried forward - this alternative would result in an overall reduction in impacts to anadromous fish. In addition, this mitigation would not directly offset the impact.
Resident Fish - ESA Kootenai River White Sturgeon	Plant 1-2 gallon cottonwoods at Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon (KWRS) by providing a food source. This would complement ongoing habitat actions already being taken in the region.	The flow regime at Libby has made establishment of riparian vegetation challenging. High flows have made it difficult to sustain young stands of cottonwoods.	–	Yes, as Mitigation

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization only	Proposed to move forward or rationale for removal
Resident Fish – ESA Bull Trout	On the Hungry Horse Reservoir install structural components like woody debris, and plant vegetation at the tributaries (Wounded Buck, Sullivan and Wheeler and Bunker Creeks,) 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.	Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make Bull Trout more susceptible to angling/predation.	–	Yes, as Mitigation
Resident Fish - Burbot, Kokanee, & Redband Rainbow Trout	Region B: Changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	–	Yes
Navigation & Transportation	Extend the ramp at the Inchelium- Gifford- Ferry on Lake Roosevelt so that it's available at lower water elevations.	Inchelium- Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members	–	Yes, as Mitigation

Proposed Mitigation Summary for Multiple Objective 2 [3]

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Water Quality	Perform in-reservoir nutrient supplementation at Libby and Hungry Horse to increase primary and secondary productivity	Reduced in-lake biological productivity caused by reservoir drawdowns and higher flushing rates.	–	Yes. Continue implementation of nutrient supplementation at Libby, and add a nutrient supplementation program at Hungry Horse.
Vegetation, Wildlife, & Wetlands	Update, and/or prepare and implement invasive species management plans	Decreased in quality and quantity of wetland habitat at Libby and Hungry Horse caused by lower water elevations from implementation of the December Libby Target Elevation measure. This could result in the establishment and spread of invasive plant species.	Best Management Practices/Update Plans	Yes
Vegetation, Wildlife, & Wetlands	On Kootenai River downstream of Libby: planting of native wetland and riparian vegetation (~100 acres along river)	Conversion of wetland to upland habitat in May through summer (off-channel habitat). Impacts on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Occurs seasonal and would result in permanent effect habitat	–	Yes, as Mitigation
Anadromous Fish	Increase level of avian predator management on the LSR and LCOL, and pinniped predator management on the LCOL projects.	This measure is recommended to offset the anticipated increase in powerhouse encounter rate for anadromous fish.	–	The existing avian predator management programs will be carried forward. In addition, Predation Disruption Operation measure would address this impact. For pinniped management program, the existing program would continue with potential for extending the timeframe.

[3] Note that the effects in this table are draft

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Resident Fish – ESA Kootenai River White Sturgeon (Libby)	Plant 1-2 gallon cottonwoods at Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon (KWRS) by providing a food source. This would complement ongoing habitat actions already being taken in the region.	The flow regime at Libby has made establishment or riparian vegetation challenging. High flows have made it difficult to sustain young stands of cottonwoods.	–	Yes, as Mitigation
Resident Fish – ESA Bull Trout (Hungry Horse)	Plant the top 10' of the varial zone in areas adjacent to tributaries used by Bull Trout at Hungry Horse. Use vegetation that will withstand reservoir fluctuations and provide food sources for ESA Bull Trout. Construct sub-impoundment berms in the upper reservoir for establishment of vegetation, plantings, install large woody debris, and grading to provide access to tributaries used by Bull Trout (up to 15 Tributaries) at Hungry Horse	Deeper winter drafts (100% increase in winter outflows) reduce substrate for winter insect production, which reduces food availability in spring. Reduced summer water volume reduces food availability for Bull Trout	–	–

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Resident Fish – ESA Bull Trout	On the Hungry Horse Reservoir install structural components like woody debris, and plant vegetation at the tributaries (Wounded Buck, Sullivan and Wheeler and Bunker Creeks,) 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.	Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make Bull Trout more susceptible to angling/predation.	–	Yes
Resident Fish – ESA Bull Trout (Hungry Horse)	Create back channel habitat for juvenile Bull Trout on the Flathead River	Winter outflows increase over 100% over NAA, which reduces winter habitat available in the mainstem Flathead River by 30%. Winter habitat is important to sub yearling bull trout especially. Increase in SF Flathead River volume would also increase winter temps in mainstem Flathead River.	–	–
Resident Fish - Burbot, Kokanee, & Redband Rainbow Trout	Region B: Changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	–	Yes
Navigation & Transportation	Extend the ramp at the Inchelium-Gifford- Ferry so that it's available at lower water elevations.	Inchelium-Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members	–	Yes, as mitigation

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Recreation	Extend the boat ramp at Dworshak State Park (Freeman Creek) to make it accessible in April, when it is used by turkey hunters and bass fishermen	Changes in water levels would make this boat ramp inaccessible for 30 days in the month of April, the start of turkey hunting season and early bass fishing season. Because of the steep terrain and limited road access at Dworshak, this boat ramp is heavily used by recreators, especially hunters and fishermen, outside of the traditional recreation season.	–	Yes, as Mitigation

Proposed Mitigation Summary for Multiple Objective 3 [4]

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Water Quality	Perform in-reservoir nutrient supplementation at Libby and Hungry Horse to increase primary and secondary productivity.	Reduced in-lake biological productivity caused by reservoir drawdowns and higher flushing rates.	–	–
Water Quality	Strategic removal (dredging) of any sediment "hot spots" with high contaminant levels in Lower Snake River prior to breaching	Suspension and downstream deposition of fine grained sediment that contains bioaccumulative compounds (PCBs, dioxins, pesticides, Hg, etc.) will expose fish populations to new, higher levels of contaminants, with expected increases in fish tissue concentrations for at least a few years.	–	The co-lead agencies do not have authority to implement this mitigation measure. It would need to be implemented by others.

[4] Note that the effects in this table are draft

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Water Quality	Prior to breaching implement groundwater control near Lewiston, ID (1) Install groundwater cutoff walls or groundwater "treatment curtains/walls" along areas of known groundwater contamination; (2) pump and treat groundwater aggressively to prevent flows from entering river; (3) Remediate known contamination areas prior to dam breach.	Impacts to groundwater flows (from several known polluted ground water sources near Lewiston); NPDES permits would likely need to be redefined (less dilution). Containing or cleaning-up contaminated groundwater areas would reduce polluted inputs into lower Snake River post-breaching.	–	This mitigation measure would need to be implemented by others.
Water Quality	Install bubble curtain fixtures for DO supplementation.	Impacts from low DO to aquatic species creates dead zones, mobilizing these pockets or creating new ones will likely have major impacts to aquatics. Bubble curtains provide for DO.	–	Replaced with: “The co-leads would conduct these studies to investigate more accurately the impacts of water quality and specifically, dissolved oxygen to aquatic organisms and fish. The co-lead agencies would coordinate with state and Federal resource agencies to determine the best way to minimize any impacts to water quality. Some potential options could include aeration, dilution from upstream sources (e.g., the North Fork Clearwater River), or chemical treatment (e.g., peroxide dosing).”
Vegetation, Wildlife, and Wetlands	Update and implement existing Invasive Plant Management Plan for the shoreline at Libby	At Libby: Exposure of mudflats and barren lands during the summer months could result in establishment of non-native, invasive plant species.	Best Management Practices/Update Plans	Yes, as Avoidance/Minimization

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Vegetation, Wildlife, and Wetlands	A) planting of native wetland and riparian vegetation (~100 acres along river) on the Kootenai River	Conversion of wetland to upland habitat in May through summer (off-channel habitat). Impacts on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Occurs seasonal and would result in permanent effect habitat	–	Yes, as Mitigation
Vegetation, Wildlife, and Wetlands	Planting plan and implementation of arid lands restoration to target establishment of native, arid spp (13,000 acres planting) on the lower Snake River, post-breaching	Perched habitats (HMUs) with dam breach to convert to arid lands	–	Yes, as Mitigation
Vegetation, Wildlife, and Wetlands	Planting plan and implementation of wetlands/riparian restoration (1,500 acres) to target establishment of native species on the lower Snake River post-breaching	Exposed sediment and exposed shoreline with dam breach (approximately 13,800 acres), includes wetland and riparian plantings	–	Yes, as Mitigation
Vegetation, Wildlife, and Wetlands	Develop a planting plan (155 acres of wetlands) for areas downstream of Ice Harbor. This plan may include possible excavation of deposited sediment from dam breaching.	Sediment Deposition (McNary Pool= 779 acres uplands, 13,639 acres open water, 97 acres forested wetlands, 58 acres emergent wetlands, 37 acres urban and mixed environs) Total is 14,610 acres.	–	Yes, as Mitigation

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Vegetation, Wildlife, and Wetlands	Create avian nesting areas (~2 acres) outside of the Columbia River Basin	inundation of portions of the island that support avian species	–	Not carried forward the reservoir levels for this alternative are within the normal operating range. This operating range associated with John Day has been mitigated for with the creation of Umatilla National Wildlife Refuge in compliance with Fish and Wildlife Coordination Act Report for John Day construction and operations. In addition, the existing mitigation sites for both the estuary and inland tern management projects have capacity for additional birds.
Anadromous Fish	Construct new trap and haul operation for Snake River fish (Chinook Salmon, Sockeye, Steelhead) at McNary to allow removal of Chinook salmon, sockeye, and steelhead prior to breaching.	Dam breaching would create high levels of turbidity/suspended sediment from Lower Granite Dam to Ice Harbor Dam during Snake River fall Chinook and upper Snake River sockeye migration. This could result in mortality to 20-40% of the populations. Very low dissolved oxygen level from dam breaching would result in mortality in the Little Goose and Lower Monumental reservoirs during first phase of demolition, potentially wiping out year class of migrating Snake River fall Chinook and upper Snake River sockeye.	–	Yes, as Mitigation

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Anadromous Fish	Raise additional hatchery fish to offset two lost year classes prior to start of breach on the lower Snake River*	Dam breaching would create high levels of turbidity/suspended sediment from Lower Granite Dam to Ice Harbor Dam during Snake River fall Chinook and upper Snake River sockeye migration. This could result in mortality to 20-40% of the populations. Very low dissolved oxygen level from dam breaching would result in mortality in the Little Goose and Lower Monumental reservoirs during first phase of demolition, potentially wiping out year class of migrating Snake River fall Chinook and upper Snake River sockeye.	–	Yes, as Mitigation
Anadromous Fish	Create MCN collection facility to allow trap and haul from MCN (to collect fall migrating fish below the Snake) Modify/improve Bonneville collection facility to allow trap and haul from Bonneville	Dam breaching would create high levels of turbidity/suspended sediment from Lower Granite Dam to Ice Harbor Dam during Snake River fall Chinook and upper Snake River sockeye migration. This could result in mortality to 20-40% of the populations. Very low dissolved oxygen level from dam breaching would result in mortality in the Little Goose and Lower Monumental reservoirs during first phase of demolition, potentially wiping out year class of migrating Snake River fall Chinook and upper Snake River sockeye.	–	Redundant with the McNary measure above.

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Anadromous Fish	Modify the McNary Raceway using stainless steel infrastructure to degas the water in the raceway during collection for transport.	Water in the raceway is expected to have high TDG. Degassing in the raceway would allow fish to be transported in water with lower TDG than what is in the river.	–	–
Resident Fish - ESA Kootenai River White Sturgeon	Plant 1-2 gallon cottonwoods at Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon (KWRS) by providing a food source. This would complement ongoing habitat actions already being taken in the region.	The flow regime at Libby has made establishment or riparian vegetation challenging. High flows have made it difficult to sustain young stands of cottonwoods.	–	Yes, as Mitigation
Resident Fish – ESA Bull Trout (Hungry Horse)	On the Hungry Horse Reservoir install structural components like woody debris, and plant vegetation at the tributaries (Sullivan, Bunker, Wounded Buck, and Wheeler Creeks, 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.	Lower elevations in summer (4'-16' lower at end of Sept) and fewer days of full pool results in smaller productive euphotic zone, less surface for feeding in summer, and dewaters benthic insect production; less food source (terrestrial inspects/aquatic) for bull trout	–	Yes, as Mitigation
Resident Fish – ESA Bull Trout (LSR)	Modify channel (pilot channel) at mouth of the Tucannon River (tributary to Snake) to allow Bull Trout passage after reservoir levels drop from breaching.	Breaching will result in reservoir drawdown which would leave the river delta perched until high flows can create a new passable channel for Bull Trout.	–	Yes, as Mitigation

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Resident Fish – White Sturgeon	On the Snake River, trap and haul White Sturgeon from impacted area(s) prior to breach. Relocate to Hells Canyon and below McNary	Dam breaching would create high levels of turbidity/suspended sediment from Lower Granite Dam to Ice Harbor Dam on the Snake River. Very low dissolved oxygen level from dam breaching would result in mortality in the Snake River for sturgeon and the forage fish they feed on. Although sturgeon are not ESA-listed, they are important to regional tribes and sport fishers.	–	Yes, as Mitigation
Resident Fish – ESA Bull Trout	Construct passage improvements in the Tributaries, to include replacement of culverts.	Additional spill may cause delays in bull trout passage at dams in May and June when they are moving out of the system to avoid warming water temps.	–	Not carried forward - not sufficient information about known impacts to develop mitigation measure
Resident Fish - Burbot, Kokanee, & Redband Rainbow Trout	Region B: Changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	–	Yes
Engineering/ Infrastructure	Armor up to 25 bridge piers to protect from erosion caused by higher velocity water caused by breaching	Breaching the LSR dams will result in higher water velocities, increasing scour around bridge piers	–	Yes, as Mitigation

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Engineering/ Infrastructure	More than 80 miles of railroad and highway embankments would need to be armored to protect from erosion	Breaching the LSR dams will result in higher water velocities in the river, increasing erosion and higher flows through drainage structures/culverts.	–	Yes, as Mitigation
Engineering/ Infrastructure	Repair roads and railroad beds along the LSR after drawdown is completed	It is expected that repairs to roads and rail beds would be needed as a result of settlement and slope failures of embankments after breaching.	–	Yes
Navigation & Transportation	Dredge channel and around impacted facilities and/or relocate impacts port and dock facilities to alternate, unaffected location, or expand existing port facilities on the McNary Reservoir below Ice Harbor	Potential sedimentation issues above McNary near confluence of Snake/Columbia. Potential impacts to ports and/or docks following breach for 2-7 years and possibly beyond	–	–
Navigation & Transportation	Extend the ramp at the Inchelium -Gifford Ferry so that it's available at lower water elevations.	Inchelium -Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members	–	Yes
Cultural Resources	Prepare and implement a new programmatic agreement to avoid, minimize, and mitigate impacts to over 360 known cultural sites that would be exposed or accessible after drawdown. Actions covered within the PA could include law enforcement patrols, vegetation and reseeding, and archaeological monitoring.	Drawdown of the reservoirs will expose known cultural resources sites.	–	Yes, as Mitigation

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Cultural Resources	Implement the Historic American Building Survey and Historic American Engineering Record programs to document historic places, infrastructure, and landscape features. At the dams install security fencing and signs, and implement a public outreach campaign to document and excavate exposed sites.	Drawdown of the reservoirs may expose known historic structures. Breaching the dams would impact the historic integrity of the dams.	–	Yes
Real Estate	Construct cattle watering corridors to avoid damage from cattle to terrestrial and spawning habitat along the river. Install wells and pumps for flow into stock watering tanks. Install fencing to control cattle access.	Breaching would affect access to the river for cattle watering operations. Original land use agreements allowed cattle ranchers access to the reservoir for water for their cattle. Modifications to honor these agreements would need to be made under the drawdown condition.	–	–
Real Estate	Following breach, replace gas lines that cross the Snake River near Lyons Ferry	Higher water velocities would create scour conditions that could damage existing pipes	–	This measure would be coordinated prior to implementation
Engineering	Modify/replace the large scale irrigation pumping plants in the 13 mile reach of the Snake River upstream of Ice Harbor. (Supply 680 cfs) Replace the existing large scale plants with one large pumping and distribution system	Drawdown would leave existing irrigation pumping plants without access to the river, creating a high impact for existing irrigators.	–	Not carried forwarded - these are private water supply facilities and any modification due to changed conditions would be implemented by owners.
Engineering	Evaluate impacts to existing wells. Exact impacts are uncertain, but it is expected that existing wells in the shallow aquifer would need to be deepened and have new pumps installed.	Drawdown of the reservoirs will impact existing wells within 1 mile of the Snake River.	–	Not carried forwarded - Wells are private water supply infrastructure. Co-leads do not have authority to modify.

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Engineering	Install auxiliary water intakes in deep water to supply the existing Potlatch corporation well in Lewiston, ID	The lower water surface elevation caused by reservoir drawdown will not allow existing Potlatch water intake to function properly during low flow periods.	–	Not carried forwarded - Private infrastructure. Modifications to be implemented by others.
Engineering	Relocate Potlatch Corp. effluent diffuser to a deeper reach of the river downstream from current location	The lower water surface elevation caused by reservoir drawdown will not allow the existing wastewater effluent diffusers to function.	–	Not carried forwarded - Private infrastructure. Modifications to be implemented by others.
Recreation	Dredge sediment from McNary Yacht Club to maintain access	Sediment deposition in McNary Pool from breaching the LSR dams will prevent access to the McNary Yacht Club, a leased recreation area.	–	Not carried forward – upon completion of the recreation analysis, impact was not realized.
Recreation	Dredge sediment from Walla Walla Yacht Club to maintain access.	Sediment deposition in McNary Pool from breaching the LSR dams will prevent access to the McNary Yacht Club, a leased recreation area.	–	Not carried forward - upon completion of the recreation analysis, this impact would be short term and would resolved itself in the long term, so no long term impact
Recreation	Extend the boat ramp at Charbonneau Park, on the Ice Harbor project near the Tri Cities, WA, approximately 95 feet to facilitate access to the river from the existing park.	Breaching would convert area from lake recreation to river recreation, necessitating extension of the boat ramps to provide access to the river.	–	Not carried forwarded - Lands would be deauthorized if breaching implemented.
Recreation	Extend the boat ramp at Fishhook Park, on the Ice Harbor Project near the Tri Cities, WA, approximately 70 feet to facilitate access to the river from the existing park.	Breaching would convert area from lake recreation to river recreation, necessitating extension of the boat ramps to provide access to the river.	–	Not carried forwarded - Lands would be deauthorized if breaching implemented.
Recreation	Relocate boat ramp at Boyer Park on Little Goose project to provide river access (approx. 20’ ramp)	Breaching would convert area from lake recreation to river recreation, necessitating extension of the boat ramps to provide access to the river.	–	Not carried forwarded - Lands would be deauthorized if breaching implemented.

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Recreation	Relocate boat ramp at Lyons Ferry Park to provide river access on the Lower Monumental project. This would require construction of a boat ramp approximately 65’ in length.	Breaching would convert area from lake recreation to river recreation, necessitating extension of the boat ramps to provide access to the river.	–	Not carried forwarded - Lands would be deauthorized if breaching implemented.
Recreation	Extend the existing four lane boat ramp at Swallow’s Park, on the Lower Granite project near Clarkston, WA (annual visitation 268k) to provide access to the river.	Breaching would convert area from lake recreation to river recreation, necessitating extension of the boat ramps to provide access to the river.	–	Not carried forwarded - Lands would be deauthorized if breaching implemented.
Recreation	Extend the existing 2-lane Greenbelt Ramp on the Lower Granite project near Lewiston, ID to provide access to the river.	Breaching would convert area from lake recreation to river recreation, necessitating extension of the boat ramps to provide access to the river.	–	Not carried forwarded - Lands would be deauthorized if breaching implemented.

Proposed Mitigation Summary for Multiple Objective 4 [5]

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Water Quality	Perform in-reservoir nutrient supplementation at Libby and Hungry Horse to increase primary and secondary productivity.	Reduced in-lake biological productivity caused by reservoir drawdowns and higher flushing rates.	–	Yes. Continue implementation of nutrient supplementation at Libby, and add a nutrient supplementation program at Hungry Horse.

[5] Note that the effects in this table are draft

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Vegetation, Wildlife, and Wetlands	At all projects, implement and expand existing Invasive Plant Management Plans including the invasive aquatic plant removal program (e.g. Eurasian water milfoil) at Albeni Falls	Exposure of mudflats and barren lands during the summer months could result in establishment of non-native, invasive plant species. ~ 0.5 to 1.5 foot lower WSE upstream of McNary and ~ 2.3 to 4 feet lower in Lake Bonneville, increase in exposed mudflats, increase invasive species With regards to invasive aquatic plants, nearshore areas used for recreation may be more difficult to access due to the lower lake level, as well as from greater invasive macrophyte and periphyton growth.	Best Management Practices/Update Plans	Yes, as Avoidance and Minimization
Vegetation, Wildlife, & Wetlands	planting of native wetland and riparian vegetation (~100 acres along river)	Conversion of wetland to upland habitat in May through summer (off-channel habitat). Impacts on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Occurs seasonal and would result in permanent effect habitat	–	Would use existing programs at Lake Pend Oreille to address impacts.
Vegetation, Wildlife, & Wetlands	Construct a floating boom system across Denton Slough on Lake Pend Oreille to reduce free floating nests from entering the main part of the reservoir.	Denton Slough: Change in nesting areas for waterfowl (grebes) as a result of the drafts to support McNary Flow target measure.	–	–
Vegetation, Wildlife, & Wetlands	Plant or restore wetland habitat (approximately 1,200 acres) to create vegetated wetlands on Lake Pend Oreille	Denton Slough: Loss of approximately 1,200 acres of vegetated wetlands due to drawdown (Denton Slough, Pack River Delta, Clark Fork Delta) at Lake Pend Oreille	–	Would use existing programs at Albeni Falls and Lake Pend Oreille to address effects.

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Vegetation, Wildlife, & Wetlands	Planting plan with wetlands/riparian vegetation (Umatilla NWR [Blalock 115 acres, Patterson Slough 180 acres], Foundation Island 222 acres) on Lower Columbia Update existing Invasive Plant Management plan for shoreline.	Lower WSE upstream of McNary, critical bird habitat may be impacted. Vegetation may change in composition. Deeper drafts may expose more island.	Best Management Practices/Update Plans	Not carried forward – At Umatilla NWR, the reservoir levels for this alternative are within the normal operating range. This operating range associated with John Day has been mitigated for with the creation of Umatilla National Wildlife Refuge in compliance with Fish and Wildlife Coordination Act Report for John Day construction and operations. In addition, the existing mitigation sites for both the estuary and inland tern management projects have capacity for additional birds. In addition, at Foundation Island, the level of impact offset is not commiserate with the cost.
Anadromous Fish	Add fish ladder entrances at Little Goose Dams to help migrating Chinook avoid confounding eddies.	Elevated TDG could harm upstream migrants and/or affect upstream migration of Snake River fall Chinook and Upper Snake River sockeye due to eddies created by High Spill conditions.	–	Replaced with "Temporary extension of performance standard spill levels in coordination with the Regional Forum to assist fish migration."
Anadromous Fish	Increase level of avian predator management on the LSR and LCOL, and pinniped predator management on the LCOL projects.	This is an onsite/offsite measure to minimize impacts to fish that may be negatively impacted by TDG levels in the river	–	The existing avian predator management programs will be carried forward. In addition, Predation Disruption Operation measure would address this impact. For pinniped management program, the existing program would continue with potential for extending the timeframe.

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Anadromous Fish	Implement mainstem habitat improvement projects to increase food sources and reconnect back-channel habitats	This is offsite mitigation recommended to offset impacts from TDG of spill. Habitat actions would improve the health of fish, making them better able to overcome negative conditions in the river.	–	Not carried forward - this alternative would result in an overall reduction in impacts to anadromous fish. In addition, this mitigation would not directly offset the impact.
Anadromous Fish	Modify the McNary Raceway using stainless steel infrastructure to degas the water in the raceway during collection for transport	Water in the raceway is expected to have high TDG. Degassing in the raceway would allow fish to be transported in water with lower TDG than what is in the river.	–	Yes.
Resident Fish - Burbot, Kokanee, & Redband Rainbow Trout	Region B: Changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	–	Yes
Resident Fish – ESA Bull Trout	On the lower Snake: improve tributary passage by replacing culverts on the Tucannon and Asotin Creek.	High spill levels may cause delays in bull trout passage at dams in May and June when they are moving out of the system to avoid temps.	–	–
Resident Fish – ESA Bull Trout	Operate slide gates at Hungry Horse to provide optimum water temperatures. Use of the slide gates (after the Hungry Horse Modernization is complete) would reduce entrainment of food sources for Bull Trout.	Increased summer outflows in MO 4 would increase the entrainment of zooplankton, phytoplankton, and invertebrates used as food sources for Bull Trout. Use of the slide gates to mix to the desired water temperature would eliminate this issue. This impact is the most severe for MO 4, with high effect in wet and average years and extreme effect in dry years	Within operations of NAA	This operation is described in the No Action Alternative, and is not considered a mitigation action.

Resource	Proposed Mitigation Action	Impact Offset	Avoidance / Minimization	Proposed to move forward or rationale for removal
Resident Fish – ESA Bull Trout	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	Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make Bull Trout more susceptible to angling/predation.	–	Yes, as Mitigation
Navigation & Transportation	Extend the ramp at the Inchelium - Gifford Ferry so that it's available at lower water elevations.	Inchelium –Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members	–	Yes, as Mitigation
Navigation & Transportation	Installation of Coffer cells to dissipate energy at Lower Monumental, Little Goose, McNary, and John Day	High Spill combined with tailrace conditions would result in Increased shoaling in the navigation channel	Monitoring would inform the need to install coffer cells.	Yes, as Avoidance and Minimization, and mitigation
Recreation	Extend the public and private boat ramps in Lake Pend Oreille so that it's available at lower water elevations.	Increase draft at Lake Pend Oreille for the McNary flow measure would drop elevations 1-3ft during the period of drafting.	–	This effect is identified, but effects to non-federal docks would need to be addressed by others.

Columbia River System Operations
Final Environmental Impact Statement

Appendix S, Public Scoping Report for the Columbia River System Operations Environmental Impact Statement

Note: The Section 508 amendment of the Rehabilitation Act of 1973 requires that the information in federal documents be accessible to individuals with disabilities. The Agency has made every effort to ensure that the information in *Appendix S: Public Scoping Report for the Columbia River System Operations Environmental Impact Statement* is accessible. However, if readers have any issues accessing the information in this appendix, please contact the *U.S. Army Corps of Engineers* at (800) 290-5033 or info@crso.info so additional accommodations may be provided.

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Public Scoping Report for the Columbia River System Operations Environmental Impact Statement

October 2017

Public Scoping Report for the Columbia River System Operations Environmental Impact Statement

October 2017

U.S. Army Corps of Engineers
Northwestern Division
Portland, Oregon

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Boise, Idaho

Bonneville Power Administration
Portland, Oregon

ACRONYMS AND ABBREVIATIONS

BPA	Bonneville Power Administration
CO2	Carbon Dioxide
CRSO	Columbia River System Operations
EIS	Environmental Impact Statement
ESA	Endangered Species Act
GHG	Greenhouse Gas
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
ROD	Record of Decision
TDG	Total dissolved gas

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APPENDICES

1.0 INTRODUCTION

This public scoping report was prepared by the U.S. Army Corps of Engineers (Corps), the U.S. Bureau of Reclamation (Reclamation), and the Bonneville Power Administration (BPA), collectively referred to as the "co-lead agencies." This report provides a summary of the public scoping comments received during the scoping period for the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS). This report includes a description of the communications and outreach to solicit public participation on the scope of the CRSO EIS and a summary of the comments received by topic area.

2.0 BACKGROUND - COLUMBIA RIVER SYSTEM

The co-lead agencies are preparing a comprehensive EIS under the National Environmental Policy Act (NEPA) for the coordinated water management functions for the operation, maintenance, and configuration of the 14 federal multiple purpose dams and related facilities ("projects") within the interior Columbia River Basin in Idaho, Montana, Oregon, and Washington (Figure 1). The Corps was authorized by Congress to construct, operate and maintain twelve of these projects for flood control, power generation, navigation, fish and wildlife conservation, recreation, water quality, and municipal and industrial water supply, though not every project is authorized for every one of these purposes. These projects include Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. Reclamation was authorized to construct, operate, and maintain two projects for purposes of flood control, power generation, navigation, and irrigation. The Reclamation projects include Hungry Horse and Grand Coulee. BPA is responsible for marketing and transmitting the power generated by these projects. Together, the co-lead agencies are responsible for managing the Columbia River System (System) for these various purposes.

In the 1990s, the co-lead agencies analyzed the socioeconomic and environmental effects of operating the System in the System Operation Review (SOR) EIS and issued respective Records of Decision (RODs) in 1997 that adopted a system operation strategy, which included operations for Endangered Species Act (ESA) listed fish while fulfilling all other authorized purposes required by Congress. Since the completion of the SOR EIS, the co-lead agencies have operated the System consistent with the analyses in the SOR EIS, while adopting some changes to System operations under subsequent ESA consultations and additional NEPA documents.

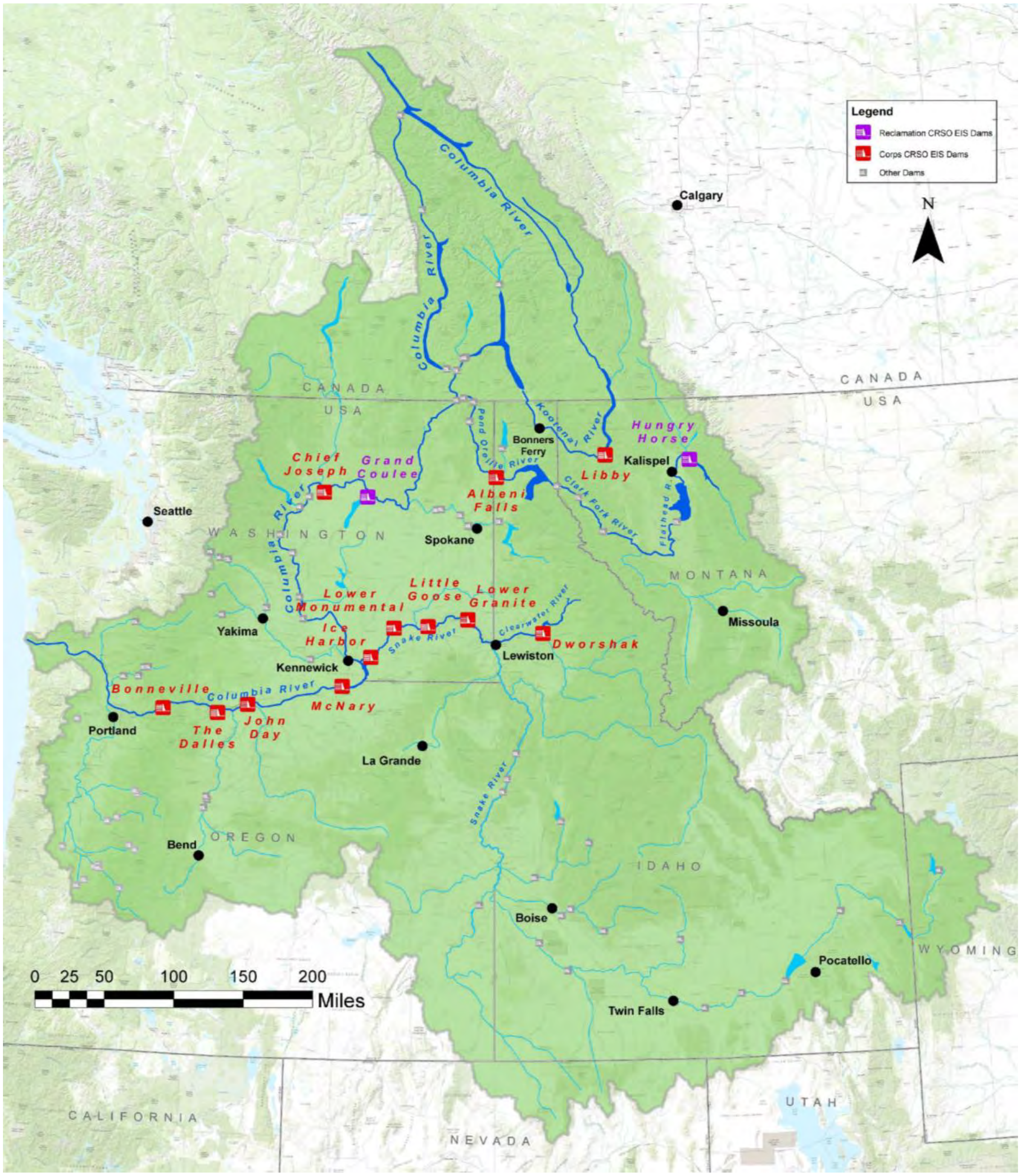

Figure 1. System Overview Map

2.1 Draft Purpose and Need Statement

DRAFT PURPOSE AND NEED FOR ACTION

The Corps, Reclamation, and BPA are co-leads in preparing this Environmental Impact Statement under NEPA on the coordinated water management functions for the operation, maintenance, and configuration ("management") of the 14 multiple-purpose federal dam and reservoir projects that comprise the Columbia River System (System). The U.S. Congress authorized the Corps and Reclamation to construct, operate and maintain the System projects to meet multiple specified purposes, including flood control (also referred to as flood risk management), navigation, hydropower production, irrigation, fish and wildlife conservation, recreation, municipal and industrial water supply, and water quality, though not every project is authorized for every one of these purposes. BPA is authorized to market and transmit the power generated by these coordinated System operations.

The on-going action that requires evaluation under NEPA is the long-term coordinated management of the System projects for the multiple purposes identified above. An underlying need to which the co-lead agencies are responding is reviewing and updating the management of the System, including evaluating measures to avoid, offset, or minimize impacts to resources affected by the management of the System in the context of new information and changed conditions in the Columbia River Basin. In addition, the co-lead agencies are responding to the Opinion and Order issued by the U.S. District Court for the District of Oregon[1] such that this EIS will evaluate how to insure that the prospective management of the System is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat, including evaluating mitigation measures to address impacts to listed species. The EIS will evaluate actions within the co-lead agencies' current authorities, as well as certain actions that are not within the co-lead agencies' authorities, based on the District Court's observations about alternatives that could be considered and comments received during the scoping process. The EIS will also allow the co-lead agencies and the region to evaluate the costs, benefits and tradeoffs of various alternatives as part of reviewing and updating the management of the System.

The co-lead agencies will use the information garnered through this process to inform future decisions and allow for a flexible approach to meeting multiple responsibilities including resource, legal, and institutional purposes.

Resource Purposes:

- Provide for a reliable level of flood risk by managing the System to afford safeguards for public safety, infrastructure, and property
- Provide an adequate, efficient, economical and reliable power supply that supports the integrated Columbia River Power system
- Provide water supply for irrigation, municipal, and industrial uses
- Provide for waterway transportation capability
- Provide for the conservation of fish and wildlife resources, including threatened, endangered, and sensitive species
- Consider and plan for climate change impacts on resources and on the management of the System

[1] *NWF v. NMFS*, 184 F.Supp. 3d 861 (D. Or. 2016).

- Provide opportunities for recreation at System lakes and reservoirs
- Protect and preserve cultural resources

Legal and Institutional Purposes:

- Act within the authorities granted to the agencies under existing statutes; and when applicable, identify where new statutory authority may be needed
- Comply with environmental laws and regulations and all other applicable federal statutory and regulatory requirements, including those specifically addressing the System such as requirements under the Northwest Power Act "to adequately protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, affected by such projects or facilities in a manner that provides equitable treatment for such fish and wildlife with the other purposes for which such system and facilities are managed and operated." 16 U.S.C.A. § 839b(11)(A)
- Protect Native American treaty rights and trust obligations for natural and cultural resources
- Continue to utilize a collaborative Regional Forum framework to allow for flexibility and adaptive management of the System
- Ensure project Water Control Manuals adequately reflect the management of the System

3.0 SCHEDULE TO RECORD OF DECISION

The Draft Environmental Impact Statement (DEIS) will be prepared taking into consideration all public scoping comments received.[2] According to the schedule ordered by the U.S. District Court for the District of Oregon (Court), the co-lead agencies will publish the DEIS by March 2020 for public review and comment and will hold public meetings to solicit comments on the DEIS. Public comments received on the DEIS will be considered and responses provided in the Final Environmental Impact Statement (FEIS). The FEIS will be published in March 2021 and the RODs will be signed on or before September 24, 2021.

4.0 DESCRIPTION OF THE FEDERAL ACTION

The federal action for this EIS is the coordinated water management functions for the long-term operations, maintenance and configuration (management) of the fourteen federal dam and reservoir projects that comprise the System for the purposes of flood risk management, navigation, hydropower, irrigation, fish and wildlife conservation, recreation, water quality, and municipal and industrial water supply in a manner that is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of

[2] The co-lead agencies are not required under NEPA to address or reflect all of the submitted comments in the analyses in the DEIS. For instance, issues or alternatives addressing issues outside the scope of the EIS or which are not feasible may not be addressed in the DEIS.

designated critical habitat, including mitigation measures to address impacts to ESA-listed species, and in compliance with other statutory and regulatory responsiblilties.

5.0 PUBLIC SCOPING PROCESS

The co-lead agencies implemented a robust public scoping process intended to provide ample opportunity for the public to understand how the System currently operates and identify issues of concern to be addressed in the EIS. The co-lead agencies invited the public to provide assistance to help define the issues, concerns, and the scope of alternatives to be addressed. The Notice of Intent to prepare the CRSO EIS provided a a summary of the intent of the EIS, established a schedule of public meetings, and provided points of contact for each of the co-lead agencies.

6.0 PUBLIC NOTIFICATIONS

A variety of notifications were used to announce the open houses/public scoping meetings and public comment period, including publishing the Notice of Intent in the *Federal Register* to prepare the EIS, sending a public scoping letter to interested parties, issuing news releases, and updating the CRSO website (see Section 7.2).

7.0 FEDERAL REGISTER NOTICES AND PUBLIC SCOPING LETTER

The Notice of Intent to prepare the EIS was published in the *Federal Register* on September 30, 2016 (81 FR 67382). The comment period was scheduled to end on January 17, 2017 and a schedule was announced for 15 public meetings and two webinars. Also on September 30, 2016, a public scoping letter was sent to interested parties. On November 4, 2016, the co-lead agencies issued a *Federal Register* notice that an additional public meeting would be held in Pasco, Washington (81 FR 76962). On January 3, 2017, the comment period was extended to February 7, 2017 (82 FR 137). Copies of the Notices of Intent are in Appendix A. A copy of the public scoping letter is in Appendix B.

7.1 News Articles and Newspaper Advertisements

The co-lead agencies issued a series of press releases intended to keep the public informed about the EIS public scoping process. The press releases were also provided on the CRSO website (See Section 7.2). Copies of the press releases and the published articles about the CRSO EIS public scoping process are in Appendix C.

Each public meeting was announced in at least two local newspapers, with ads running two to three times beginning approximately two weeks prior to the meeting. Three ads were placed in the Boise area newspaper for the Boise meeting. Copies of the newspaper advertisements and a complete list of the newspapers and ad run dates are in Appendix D.

7.2 Website

A public website was established at the time the Notice of Intent was published to communicate and share information about the CRSO EIS: www.crso.info. The website announced public scoping meeting dates, times, and locations in addition to providing all the information shared during the public scoping meetings (e.g. overview video and posters). The public could also use the comment submission link on the website to submit comments during the public comment period. News releases, documents, and upcoming public meeting information were available to the public through the website.

7.3 Public Scoping Meetings

The 16 open house-style public meetings were held across the region to allow the public to ask questions in person, and contribute their comments and ideas on what should be included in the EIS. Two webinars were held on December 13, 2016 to provide the same opportunity for those unable to participate at one of the in-person locations. The meeting in Pasco was added after the first Notice of Intent at the request of several public entities and the meeting was noticed through the *Federal Register* on November 21, 2016 and through public outreach. The Astoria meeting was originally scheduled for December 8th and was cancelled due to inclement weather and was rescheduled for December 15th, but adverse weather conditions again required its the cancellation. It was rescheduled again and held on January 9th, 2017.

An interdisciplinary team from the Corps, Reclamation, and BPA attended all public scoping meetings to provide subject matter expertise in the areas of NEPA process, cultural resources, Columbia River System operations, flood risk management, hydropower, irrigation, river navigation, fish and wildlife conservation, recreation, climate change, water quality, and endangered species. Each of the 14 projects also had available a project-specific expert to discuss features and operations of a specific dam or reservoir complex.

The specific dates and times of the public meetings are contained in Table 1 below and the locations throughout the Pacific Northwest are shown in Figure 2 also below.

The meetings were held in an informal open house format, with 35 poster stations staffed by technical experts from the co-lead agencies. The style of meeting was chosen to provide attendees an opportunity to comment after reviewing information about the System and how it is currently operated, as well as on the NEPA process that will lead to the development of the DEIS, ask questions, and have informal one-on-one discussions with various subject-matter experts. A total of 2,318 people signed in at the 16 public scoping meetings. The agencies intended this style of meeting to help generate informed scoping comments. Two webinars were also held to cover the same information available at the open house, with subject matter experts in attendance to address comments provided through the webinar. The co-lead agencies held the webinars for interested members of the public that could not attend the open houses in person. All materials from the open house were available on the CRSO website so that participants could review in their own time.

Upon arrival at an open house meeting, attendees were invited to sign in and then view a short orientation video. The video introduced most of the poster topics, and explained the methods to provide comments. Following the video, attendees were invited to visit the poster stations to discuss the subjects and ask questions of the technical subject matter experts staffing the boards. A handout was provided with a short description of each station (Appendix E). Attendees were also invited to submit public scoping comments at the meeting in a number of ways including: 1) verbally through a court reporter, 2) online at a computer station, or 3) in hard copy form. Attendees were also advised that they could review all the materials, including the video, online and submit comments via either email, online using a prepared webform, or in hard copy mailed to a post office box established specificially for the purpose of collecting scoping comments for this project. All meeting materials and all comments submitted during the scoping period can be viewed online at www.crso.info. Copies of the posterboards are included in Appendix F.

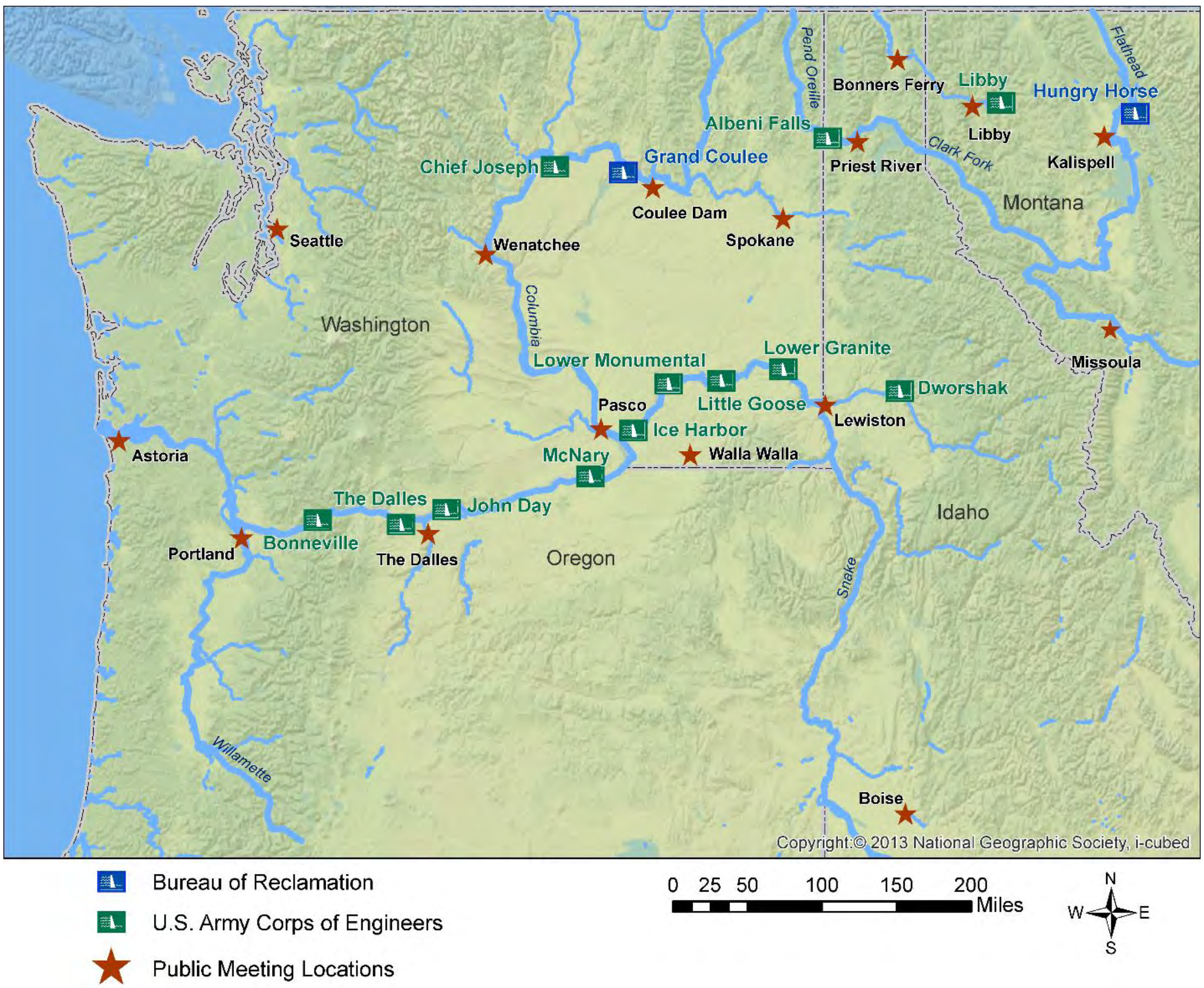

Figure 2. Map of public scoping meeting locations

Table 1. Public scoping meeting dates and locations

Date	Time	Location	Address	Attendees[3]
Monday, October 24	4 p m. to 7 p.m.	Wenatchee Community Center	504 S. Chelan Ave., Wenatchee, WA	63
Tuesday, October 25	4 p m. to 7 p.m.	The Town of Coulee Dam, City Hall	300 Lincoln Ave., Coulee Dam, WA	15
Wednesday, October 26	4 p m. to 7 p.m.	Priest River Community Center	5399 Hwy 2, Priest River, ID	36
Thursday, October 27	4 p m. to 7 p.m.	Kootenai River Inn Casino & Spa	7169 Plaza St., Bonners Ferry, ID	29
Tuesday, November 1	4 p m. to 7 p.m.	Red Lion Hotel Kalispell	20 North Main St., Kalispell, MT	56
Wednesday, November 2	4 p.m. to 7 p.m.	City of Libby City Hall	952 E. Spruce St., Libby, MT	14
Thursday, November 3	4 p m. to 7 p.m.	Hilton Garden Inn Missoula	3720 N. Reserve St., Missoula, MT	116
Monday, November 14	4 p m. to 7 p.m.	The Historic Davenport Hotel	10 South Post Street, Spokane, WA	265
Wednesday, November 16	4 p m. to 7 p.m.	Red Lion Hotel Lewiston, Seaport Room	621 21st St., Lewiston, ID	315
Thursday, November 17	4 p m. to 7 p.m.	Courtyard Walla Walla, The Blues Room	550 West Rose St., Walla Walla, WA	123
Monday, November 21	4 p m. to 7 p.m.	Holiday Inn Express & Suites	4525 Convention Place, Pasco, WA	305
Tuesday, November 29	4 p m. to 7 p.m.	The Grove Hotel	245 S. Capital Blvd., Boise, ID	229
Thursday, December 1	4 p m. to 7 p.m.	Town Hall, Great Room	1119 8th Ave., Seattle, WA	313
Tuesday, December 6	4 p m. to 7 p.m.	The Columbia Gorge Discovery Center, River Gallery Room	5000 Discovery Drive, The Dalles, OR	100
Wednesday, December 7	4 p m. to 7 p.m.	Oregon Convention Center	777 NE Martin Luther King Jr. Blvd., Portland, OR	271
Monday, January 9	4 p m. to 7 p.m.	The Loft at the Red Building	20 Basin St., Astoria, OR	57

[3] Number of attendees based on counts from sign-in sheets.

Photo 1 - Public scoping meeting in Spokane, Washington on November 14, 2016

7.4 Webinars

Two webinars were held on December 13, 2016 at 10:00 a.m. and at 3:00 p.m. Pacific Time for an hour and a half each, to accommodate individuals who were not able to attend one of the public meetings in person. The online webinars were staffed by subject matter experts who presented the same visual material provided during the open house public meetings. Through the webinars, the public was able to submit questions and comments.

8.0 COMMENTS

The co-lead agencies received 412,016 comment submittals during the scoping period. The comment submittals were provided by members of the public, tribes, local and state governmental agencies, non-governmental organizations, and other stakeholders. In early February, the co-lead agencies developed a methodology for reviewing and sorting the large number of comments received, with the intent of providing consistency across the three agencies and capturing each unique comment provided within the submittals. The methodology followed several steps. First, comments within each letter were characterized as either a study objective, proposed methodology, recommendation for the scope of analysis, or a comment about a particular resource. The comments determined to be a resource concern were further categorized based on the resource referenced in the comment, such as Fisheries Management, Non-hydropower Energy, or Transportation, among others. Then, comments were further sorted into categories (such as structural measures) and subcategories (for example, items related to fish passage).

After sorting and categorizing, the comments were compiled into spreadsheets, grouped by comment summary category and resource, and distributed to the broader co-lead agency team for use and consideration in the initial development of draft alternatives and the scope of analysis. This input is being considered by the co-lead agency alternatives development teams in formulating measures for potential analysis and inclusion in the draft array of alternatives developed for the DEIS. Additionally, resources that may be significantly affected or were identified through the scoping process as resources of public concern will also be considered for inclusion in the DEIS for purposes of analysis and evaluation. Proposed methodologies and sources of data identified in scoping comments are currently being investigated for potential use in the analyses underpinning the DEIS.

Unique content submittals were identified if there were no duplicates of that specific submittal. Submittals were considered a form letter if two or more identical submittals were received. Form letters that had additional, unique content were identified and this content was processed for identification and sorting by topic area. Each comment submittal (unique, form letter, and form letter and added content) was reviewed and specific comments identified and sorted by topic area.

The following subsections provide a summary of all submittals received and comments identified by topic or resource area(s) for the purposes of this report.[4] In some cases, several topic areas were mentioned within a single sentence or statement (i.e., "The EIS should evaluate climate change, dam removal, and impacts to salmon."), and the intent of the comment was assigned to a broader topic area that captured complex interactions or combinations of resource concerns (Scope of Analysis). Many of the topic areas are closely related with regard to the types of comments that were received. Identification and assignment of comments to a topic area for this report was made using best assumptions of the author's overall intent. As a result, some of the themes within a topic area may be repeated within another topic area, but from a different perspective in order to accurately capture and summarize the intent.

[4] These subsections are not intended as a comprehensive list of all comments received, but rather a summary of these comments. While a specific comment may not be listed, it will be considered in the CRSO EIS process. The comments summarized here do not reflect the co-lead agencies' agreement with the content or accuracy of the comment.

8.1 NEPA Process

The co-lead agencies received a variety of comments addressing NEPA process topics, such as schedule, coordination with local governments, and other NEPA projects, and the way in which the NEPA process is conducted. Summarized comments included the following:

- The co-lead agencies should have developed the purpose and need prior to requesting scoping input from the public, and that purpose and need statement should comply with minimum legal standards under Section 7 of the ESA.
- The EIS process currently underway is expensive and unnecessary. The 2002 EIS concluded that the lower Snake River dams should be breached, and that action should be taken now without further study through an emergency response action by the Corps.
- The co-lead agencies should involve local government as cooperating agencies in the development of the EIS. Concurrent NEPA efforts on hatcheries/harvest and ongoing Canadian efforts should be combined.
- The co-lead agencies should shorten the five-year timeline for the EIS and take action immediately to protect salmon.
- The three co-lead Agencies have a vested interest in the process and cannot conduct an unbiased NEPA process, despite five court decisions that found that the BiOps failed to meet the standards of the ESA.
- The co-lead agencies should involve independent technical review in the EIS process to assure accuracy and transparency.
- The co-lead agencies should provide novel or new solutions that better preserve and protect environmental resources.

8.2 Public Scoping Involvement

This summary of comments reflect feedback on the public scoping meeting format, requests for additional public scoping meetings, requests for additional information, and suggestions for how public comments should be collected and used to develop the EIS. Other general comment summaries for Public Scoping Involvement include:

- General support was expressed for the effort made to hold the public scoping meetings. All comments received should be made available on the project website. Moving forward, the co-lead agencies should conduct outreach among interested parties and schools, and should communicate regularly with the public during development of the EIS. The EIS should be written using plain language and the sources used should be available electronically to the public.
- The co-lead agencies should have conducted an open hearing where members of the public could address the attendees. It would have been helpful to advertise the meetings as an "Open House," not a public meeting.
- A longer comment period was requested.

- The co-lead agencies should have provided notice further in advance of the public meeting and should have provided formal notification to affected parties, such as local homeowners, farmers, and ranchers.
- The co-lead agencies did not include enough meetings in communities where fisheries are affected, such as the Pacific Northwest coast, California, and Alaska.
- Additional meetings were requested in the Tri-Cities area, in Idaho including the Clearwater River Basin and the Salmon River Basin, the entire Snake River Basin including northwest Oregon, and in Montana.
- The information provided by the co-lead agencies did not provide an adequate depth of information on some topics. Background information and access to experts was requested as well as specific information on barging, irrigation, reservoir temperatures, comparison of fish counts to target counts, and mitigation.

8.3 Alternatives

Comments summarized in this section are primarily focused on requests to consider alternative actions to be analyzed or considered in the EIS. Other general comment summaries for alternatives include:

- The EIS should analyze resource specific impacts and mitigation actions for each developed alternative.
- The EIS should consider the need for congressional approval for funding of analyses if alternatives are developed that change authorized dam uses.
- The EIS should consider changes in any adaptive management or mitigation plans for each alternative.
- The EIS needs to cover a range of reasonable alternatives for long-term operations, and provide comprehensive analyses of impacts for each alternative on economic, environmental, public, and energy resources.
- General recommendations for breaching one or more dams.
- Requests for the removal or breaching of one or more of the Snake River dams due to multiple resource concerns, such as salmon migration and survival, economic opportunities for tourism, general environmental considerations, disagreement with river transportation and irrigation needs, and minimal energy output.
- General recommendation to leave all dams in place because dam removal is not a reasonable alternative and would require congressional action, dams and fish can coexist, that dam removal does not guarantee salmon recovery, and that the hydropower, irrigation, transportation, recreation, and flood control benefits the dams provide far outweigh the cost and/or risk of removing any dams.
- The EIS alternatives should consider an "All-H" approach, including measures on hydropower, habitat, harvest, and hatcheries.

- The EIS alternatives should consider fish passage and reintroduction of salmon above various dams such as Grand Coulee and Chief Joseph.
- The EIS should consider an alternaive considering modifications to flood risk management levels.
- The EIS should consider a “dry-water year” strategy alternative.

8.4 Scope of Analysis for the EIS

Comments summarized on this topic are directed at general topics or combinations of resource areas that should be considered in developing the EIS. Other general comment summaries for Scope of Analysis include:

- The EIS should use a balanced approach and include a number of ecological, biological, environmental, economic, power, public interest, and hydrological interest areas that need to be assessed individually, in combination, and cumulatively.
- The EIS should identify the win-win alternative and evaluate habitat, hydrology, hatcheries and harvest actions.
- The EIS should analyze impacts that are larger than dam breaching from a regional perspective, to include additional water storage acreage or other water management capabilities.
- The multipurpose properties and authorized uses of the dams, and consideration of these uses related to river management and dam operations, should be included in the EIS.
- The EIS should discuss reconsideration of Columbia River Fish Accord (Fish Accord) actions, and should address their funding, effectiveness, and future needs.
- The EIS should address the funding for salmon mitigation plans, the effectiveness of mitigation plans, and a requirement for more comprehensive mitigation.
- The co-lead agencies should rely on the 2002 EIS for breaching (not configuration and operational changes) the four lower Snake River dams, and not include this alternative in the EIS. There is enough information already from past studies and analyses to expedite EIS development and make changes to CRSO. A new EIS is not necessary and any changes to the CRSO can be made now.
- The analysis for the EIS should include a review of scenarios that consider a range of operation and configuration changes for Snake River dams, including breaching, spill, flow augmentation, passage improvements, and other dam modifications to improve salmon recovery.
- The co-lead agencies should be transparent and provide novel or new solutions that better preserve and protect environmental resources.
- Dams outside of the named 14 federal projects should be included in the EIS for impacts and analyses, and the EIS should include the effects that changes at the 14 federal projects have on other regional dams and related resources.

- The EIS should consider impacts to specific dams from any operational or configuration changes across the CRSO.
- The EIS should compare Snake River dam breaching with examples of successful dam breaching, such as on the Elwha River, in order to assess impacts and realize the potential benefit to environmental resources such as salmon.
- The EIS should include information on coordination required with other local, state, and federal agencies, and compliance with their regulations and requirements.
- The EIS should incorporate the history and status of the Biological Opinion, how it affects current operations, and how coordination between the EIS and the Biological Opinion will proceed in assessing the alternatives and mitigation actions that will be required.
- The EIS should examine how System operation changes will affect Hungry Horse, Albeni Falls, Chief Joseph, Grand Coulee, and Libby Dams as flow conditions needed for fish survival and resources are different from dams downriver on the Columbia.
- The EIS should consider the river system as a whole—with basinwide water volume depending on rainfall, temperature, watershed soils, and riparian areas—and should consider how the river ecosystem will respond in the future if those watershed attributes do not follow historical patterns.

8.5 Impact Analysis Methodologies

This summary of comments identifies recommended specific approaches, methodologies or models for assessing impacts to specific resources in the context of analyzing alternatives. Other general comment summaries for Impact Analysis Methodologies include:

- The EIS should consider a variety of appropriate models to assess the effects of different alternatives on different resources.
- The co-lead agencies should use cold water refugia information being developed by the Environmental Protection Agency for assessing alternatives that enhance salmon recovery.
- The EIS should assess and integrate ecosystem services in determining impacts from each alternative.
- The EIS should use a plan for analyzing and testing hypotheses estimates and survival studies in assessing the impact of alternatives for salmon recovery.
- Predictive analyses or generation of new study information should be used in the EIS rather than a dependence on historic information.

8.6 Hydrology and Hydraulics

This summary of comments reflects concerns about changes in hydrologic conditions, flow and spill, reservoir drawdown, and sedimentation under current and future climate conditions. Other general comment summaries for Hydrology and Hydraulics include:

- The EIS should consider the historical, current, and projected environmental conditions in the Columbia River watershed to determine the historical and predicted extent of glacial water storage loss and implications of the loss for System operations, and should model what changes can be expected in the Columbia River watershed hydrologic regime.
- The EIS should model various flow and spill scenarios for System operation and configuration alternatives (including a natural flow pattern), to assess impacts of seasonal flow, and changes in reservoir elevation at the reach-level and ecosystem-level (i.e., water supply, groundwater levels, flood control, flow augmentation for fish).
- This EIS should include the impacts of drawdowns or dam removal on water quality from runoff, on aquifer recharge, on the elevation changes of the affected rivers, and on riverine and structural erosion.
- This EIS should take into consideration scientific literature regarding sediment transport as it pertains to dam removal and dam operations.
- The EIS should describe the role of hydrosystem operations and alternative reservoir operations on distribution, transport, and cycling of toxic pollutants, contaminated sediments, contaminat mobility, and contaminant bioavailability.

8.7 Climate Change

This summary of comments expresses concern that climate change be taken into account in the EIS with respect to how a changing environment would affect the System, and with respect to how the factors that contribute to climate change (e.g. greenhouse gas (GHG) emissions) would change with each alternative. Other general comment summaries for Climate Change include:

- The EIS should include information on the regional climate change forecast and incorporate a range of climate change scenarios when evaluating impacts of alternatives on water quantity and quality (particularly temperature in streams and reservoirs), salmonid survival and recovery, hydropower production, and groundwater recharge. Increasing temperatures, reduced snowpack, altered amount and timing of runoff, drought, and low water conditions were of particular concern.
- The EIS should address how climate change could affect current salmon recovery mitigation actions (e.g. habitat improvements in tributaries and the estuary).
- The EIS should address the GHG emissions associated with each alternative in the context of contributing to or mitigating for climate change.
- The EIS should address the feasibility of various alternatives to mitigate for climate change (e.g. operational changes to balance water storage and flow augmentation for water quality; configuration changes to minimize GHG emissions).
- The analysis of alternatives with respect to climate change scenarios should include community public health impacts.

8.8 Water Quality

This summary ofcomments addresses water quality concerns to be considered in the analysis of current and proposed changes to operations or System configuration—temperature, total dissolved gas (TDG), suspended sediment, and pollutants. Other general comment summaries for Water Quality include:

8.8.1 General and Alternatives Considerations

- The EIS should consider how municipal, industrial, and stormwater discharges affect water quality, and how improving discharge practices could improve water quality.
- The analysis of alternatives should consider how current permit holders (e.g. municipal, industrial, and stormwater dischargers) would be affected by changes in water quality characteristics.
- The analysis of alternatives should consider impacts on groundwater quality resulting from fluctuating water levels.
- The EIS should consider the effects of livestock grazing and the resultant habitat degradation on water quality and should consider retiring grazing permits as a mitigation action under the alternatives.
- When evaluating operational alternatives, the EIS should examine water quality issues affecting the upper Columbia River and tributaries where mining contaminants are a concern, as well as assess fish and wildlife health and recovery efforts.
- The EIS should consider management practices (e.g. improved spill prevention and response planning) related to use of oil and lubricants for dam operation and maintenance.

8.8.2 Temperature, Total Dissolved Gas, and Sediment

- The EIS should include a description of the water temperature and TDG regimes under current operations; it should describe the relationship between System operations and temperature and TDG levels and the current water quality standards for temperature and TDG. It should also describe the effectiveness of mitigation to address water temperature and TDG issues.
- The analysis of alternative System operations, modifications, and mitigating actions should assess temperature and TDG against limits relevant to salmon recovery and at locations relevant to salmon recovery.
- The EIS should develop a water temperature model for the Columbia and Snake Rivers (from the base of Hells Canyon Dam to the confluence of the Snake with the Columbia) to estimate water temperatures.
- The EIS should address the impacts of water temperature and lack of flow on juvenile and adult salmonid health, survival, and spawning success if water temperatures exceed their optimal range.
- The EIS should consider the historic (pre-dam) water temperatures in the river system.

- The EIS should consider future temperature regimes associated with earlier runoff and lower flows expected with climate change.
- The EIS should consider temperature and related fish loss data from other large river systems.
- In the analysis of a dam breach or removal alternative, the EIS should address sediment characteristics, present sediment transport and deposition modeling data, and provide an assessment of the ecological impacts of siltation, suspended sediment, and sediment release to aquatic and ESA-listed species downstream. Turbidity and water clarity effects on outmigrating smolts and returning adult salmon should be analyzed in the EIS.

8.8.3 Other Pollutants

- In its description of the affected environment, the EIS should describe the distribution of toxic pollutants in river sediment and water, their effects on fish, and their effects on human health (both directly and via fish consumption). Pollutants from upstream mining and smelting operations, the Hanford site, and agricultural runoff were stated as issues that should be analyzed; polychlorinated biphenyls, flame retardants, and pharmaceutical chemicals were also mentioned.
- The EIS should describe the role of hydrosystem operations and alternative reservoir operations on distribution, transport, and cycling of toxic pollutants, contaminated sediments, contaminat mobility, and contaminant bioavailability.
- In the analysis of alternatives, the EIS should address nutrient levels in the river and reservoirs and their associated impacts (e.g. eutrophication) on aquatic habitat, anadromous fish, and resident fish. Comments were also received that nutrient cycling and supply of nutrients to the ocean should be analyzed in the EIS.

8.9 Water Supply and Irrigation

This summary of comments concerns water availability and supply for municipal, industrial, and agricultural uses, currently and under future changes in the river system. Most of the comments were related to irrigation—the importance of the System for supplying irrigation water and alternatives for supplying irrigation water under a dam breaching alternative. Other general comment summaries for Water Supply and Irrigation include:

- The EIS should consider local watershed management plans in its assessment of water availability and supply.
- The analysis of alternatives should describe where the water is being diverted for municipal, industrial, and agricultural uses, and the impact of alternative operations or configurations on the availability of water for those uses, as well as for drought seasons and fire control.
- The EIS should describe current water sources for irrigation, irrigation practices, and levels of water use for irrigation throughout the watershed and particularly in the lower Snake River. The description should address the water- and power-efficiency of the various types of irrigation systems.

- The analysis should include impacts of diversions and irrigation drawdowns on water supply for ecosystem, recreation, and tourism activities.
- The analysis should address changes in hydrological conditions related to climate change, such as changes in glacial storage and changes in precipitation and runoff patterns, and their impact on water supply in the river system.
- The EIS should consider alternatives involving construction of new water storage reservoirs and/or smaller distributed reservoirs for both irrigation and climate change mitigation purposes.
- The analysis of alternatives needs to address groundwater supply (recharge and availability); including in the Odessa and Grand Ronde aquifers.

8.10 Air Quality

This summary ofcomments is directed at regional and global air quality impacts of alternative System configurations, primarily CO_2 and other GHG emissions from power generation and transportation, but they also include comments regarding regulated pollutants. Other general comment summaries for Air Quality include:

- The EIS should compare the emissions of all regulated air pollutants, CO_2, and other GHGs from any proposed alternative sources of power generation, if needed to replace lost hydroelectric power generation. The EIS should clearly articulate assumptions about how and from where power would be sourced in the absence of hydropower production.
- The analysis of alternatives should compare the emissions of all regulated air pollutants, CO_2, and other GHGs from rail or semi-trucks to that of barge transportation.
- The analysis of alternatives needs to consider the impacts of fugitive dust and toxic emissions from any demolition, drawdown, construction, and maintenance activities. The analysis should incorporate mitigation strategies to minimize fugitive dust and toxic emissions.
- The EIS should address the impacts of methane and other GHG emissions from the reservoirs.

8.11 Anadromous and Resident Fish – General

This summary of comments isdirected at requests and suggestions to address the status of anadromous and resident fish populations in the EIS and for consideration of how fish populations in general are affected by different activities and other actions throughout the Columbia River System. Other general comment summaries for Anadromous and Resident Fish include:

8.11.1 Consideration of Habitat, Harvest, Hatchery, and Hydropower Impacts

- The impacts of hatchery fish on wild fish should be analyzed in the EIS.
- The EIS should address if and how hatchery production of fish is needed to help fish populations recover.

- The EIS should analyze if sport, commercial, and tribal fishing have a negative effect on fish populations.
- Climate change may affect fish habitat quality in the future and should be assessed in the EIS.
- Fish habitat degradation impacts should be studied and quantified in the EIS.
- The EIS should fully assess fish mortality from dams.
- The EIS needs to describe effective habitat and hatchery programs to mitigate hydropower impacts to fish.

8.11.2 Positive Fish Survival Efforts

- The EIS should describe all of the fish restoration efforts and how they have improved fish survival.
- Habitat mitigation is working and salmon populations are recovering.
- Monies spent for improving fish migration are working and survival percentages for salmon are going up.

8.11.3 Fish Declines from Impacts Other than Hydropower

- The EIS should analyze how ocean conditions affect the current status of anadromous fish population abundances.
- The impacts of vessel traffic should be considered in assessing the current status of salmon and other fish species' decline.
- The EIS should describe what is known regarding the prevalence of diseases in salmon and how that has contributed to their population levels.

8.11.4 Predatory Fish Species

- The EIS should examine the impacts on salmon populations from native and non-native predatory fish species, such as walleye, smallmouth bass, Northern pikeminnow, and channel catfish, and should consider measures to control these populations of predatory fish.
- The EIS should consider how reintroduction of Pacific lamprey in the Columbia and Snake Rivers will affect populations of salmon through potential predation.
- The EIS should consider how changing environmental conditions, such as habitat, water temperature, and dam removal, may affect native and non-native predatory fish species, and what the subsequent impacts to salmon populations may be.

8.11.5 General Salmon (Anadromous Fish) Considerations

- The EIS should describe the importance of salmon to the environment of the Pacific Northwest and how salmon contribute to key ecosystem services.

- The EIS should consider how the recovery of Snake River sockeye salmon will be accomplished.
- General sentiment that salmon should be recovered and protected.
- ESA status of protected salmonids should be revisited due to population changes and allowable harvest.
- The EIS should consider fish passage and reintroduction of salmon above various dams such as Grand Coulee and Chief Joseph.

8.11.6 Resident Fish and Fish Other Than Salmon Considerations

- The EIS should provide an overview of status and impacts to Pacific lamprey populations historically and under current and future operation scenarios.
- The EIS should provide an overview of bull trout status and impacts to bull trout populations historically and under current and future operation scenarios.
- The EIS should evaluate and assess all impacts to sturgeon species from historic and current operations and future System changes that may affect specific populations of sturgeon such as Kootenai River white sturgeon.
- The EIS should evaluate and assess all impacts to resident fish species such as burbot, native kokanee, and native rainbow trout and native redband trout populations.

8.12 Threatened and Endangered Fish Species – Dam Configuration & Operation

These comments are specifically directed at the relationship between ESA-listed fish species such as salmon, bull trout, and white sturgeon and dam configuration and/or operations. Other general comment summaries for Threatened and Endangered Fish Species – Dam Configuration and Operation include:

8.12.1 Effects of Dam Operations on Salmon and Resident Fish Species

- Removal of dams will not help salmon recovery, and the EIS should provide an analysis to support this.
- The co-lead agencies are relying on past studies and information that may not provide a correct interpretation of fish survival through the hydropower System, and are misrepresenting the impacts of dams on juvenile fish survival.
- The EIS should specifically analyze the impact of Snake River dam operations on salmon.
- The EIS should consider impacts of dam operations on other fish species such as bull trout and Kootenai River white sturgeon.

8.12.2 Improvements to Dam Operations and Alternatives for Salmon and Resident Fish Species Survival

- The EIS should include information on how specific dam improvements for operations, such as spill scenarios for migration of juvenile salmon and fish ladders for returning adults, have improved salmon population abundances.
- The EIS should consider impacts of reservoir and temperature operations for ESA-listed resident fish.
- General comments remarking that both dams and fish are needed.
- The EIS should consider improvements to specific dams to optimize salmon habitat, migration, and abundance at those locations.
- The EIS should assess the minimum operating pool for dams and optimize habitat conditions for salmon survival.
- The EIS should specifically analyze different spill scenarios and the impact of spill operations on salmon.
- The EIS should specifically analyze the effectiveness of fish transport and the long-term benefits to juvenile salmon survival and returning adults.

8.12.3 Effects of Dam Configuration on Salmon and Resident Fish Species

- The EIS should describe how implementation of fish passage technologies and structures have helped improve salmon recovery, and what additional changes or configurations could be used to optimize salmon survival.
- The EIS does not need to consider dam breaching as salmon populations are recovering.
- The EIS should consider modernization efforts at specific dams and the subsequent configuration changes needed to optimize fish survival.
- An analysis of how dam breaching could negatively affect salmon habitat and water quality should be included in the EIS.
- The EIS should consider new fish passage facilities at specific dams.
- Investments in dam technologies to promote salmon passage or optimize salmon recovery should continue.
- The EIS should consider additional dam technologies, studies, or analyses for how salmon and other ESA-listed fish can increase in abundance and survival related to hydropower operations.
- The EIS should analyze the need for new turbine technologies and turbine replacement programs for salmon survival.
- The EIS should analyze the effectiveness and need for fish ladders at dams to improve salmon migration.

8.12.4 Dam Removal or Other Configuration Alternatives Needed for Salmon and Resident Fish Species Recovery

- The EIS should analyze the benefits to salmon survival and abundance from breaching one or more dams, including the Snake River dams.
- The EIS should consider alternative salmon passage technologies or engineered solutions to allow free migration for juveniles and adults returning to spawn to enhance species recovery.
- The EIS should consider how dam removal may provide opportunity to consider delisting salmon populations.
- The EIS should describe the importance of salmon and salmon recovery equally with the need for hydropower structures and consider how structures can be modified or removed to support fish populations.
- The EIS should consider and examine the relationship between recovery of salmon populations, economics, and energy needs in an alternative to breach one or more of the Snake River dams.
- The EIS should consider the success of ongoing mitigation efforts to improve fish passage and survival, and should analyze engineering improvements, spill modifications, hatcheries, and habitat restoration efforts rather than removing any dams.
- Many general comments requesting the Snake River dams be breached for the sake of restoring salmon and providing abundant salmon as prey for Orca.
- Some comments stating that the EIS should consider modernization efforts at specific dams and the subsequent configuration changes needed to optimize fish survival.
- The EIS should consider and examine the relationship between recovery of salmon populations, economics, and energy needs in an alternative to breach one or more of the Snake River dams.

8.13 Wetlands and Vegetation

This summary of comments voices concern for impacts and recovery of wetland habitats and riparian or native vegetated areas. Other general comment summaries for Wetlands and Vegetation include:

- The EIS should include impacts on wetlands and vegetation or loss of riparian and wetland habitats from current or planned operations.
- The EIS should consider how vegetation and riparian areas will be restored from shoreline erosion or from operation or breaching impacts.

8.14 Wildlife

This summary of comments covers a range of predation and population concerns for species other than fish. Other general comment summaries for Wildlife include:

8.14.1 Predation Control

- The EIS should analyze the effectiveness of salmon predation control programs and efforts.

8.14.2 General Predator Assumptions

- The EIS should not focus on the level of salmon predation by avian or pinniped species because they are not a major contributor to salmon decline.
- The EIS should include impacts to predator species populations from culling or predator control efforts.

8.14.3 General Predation of Salmon

- The EIS should analyze all predatory impacts to salmon populations, especially from invasive predator species.
- The EIS should consider the effects of predation on salmon, and include control of predation of salmon as a contributor to salmon recovery.

8.14.4 Pinniped Predation

- The EIS should discuss the effectiveness of efforts to control salmon predation by pinnipeds.
- Protections for pinniped species under the Marine Mammal Protection Act should be reviewed for current applicability given increases in pinniped populations.

8.14.5 Avian Predation

- The EIS should evaluate the effectiveness of programs and efforts directed at limiting salmon predation by avian species.
- The EIS should assess the contribution of different avian species to salmon predation, and assess how predation can be controlled or minimized.

8.14.6 Impacts to Orca

- The EIS should include the effects to Orca when assessing impacts to salmon populations.
- The Snake River dams should be breached to restore salmon populations that will increase overall prey abundance for Orca.
- The 2002 Lower Snake River Juvenile Salmon Migration Feasibility EIS should be used now to breach the Snake River dams and allow salmon to recover in time to feed Orca and prevent the Puget Sound pods from further decline.
- The EIS should consider impacts to Orca from other sources such as exposure to toxic substances and pollutants and vessel strike and not just from any changes in salmon predation.

8.14.7 Wildlife Affected by Salmon Abundance

- The EIS should consider how changes to salmon populations affects populations of different predator species.

8.14.8 General Impacts to Wildlife and their Habitats

- The EIS needs to take an ecosystem approach and consider impacts to all wildlife and their habitats when assessing the various alternatives.

8.14.9 Impacts to Invertebrate Species

- The EIS should consider impacts to mussels and their habitat as well as zooplankton for each alternative, and their relationship to support the food chain and other ecosystem functions.

8.15 Invasive and Nuisance Species

This summary ofcomments mentioned concerns about the impact of invasive or nuisance plant and animal species that may become further established, or voiced concerns over how these species will be controlled. Other general comment summaries for Invasive and Nuisance Species include:

- The EIS should consider how changes in System operations will affect or control invasive or nuisance plant and animal species.
- The EIS should address what measures will be used to identify and control the spread of invasive mussels, such as the zebra and quagga mussels.
- The EIS should address what measures will be used to identify and control the spread of invasive plant species, such as Eurasian milfoil, hydrilla, and flowering rush.

8.16 Cultural, Historic, and Tribal Interests and Resources

This summary of comments is directed at the impact of dam removal, current operations, and future operations on cultural and historic resources in general, and on tribal interests and resources of concern. Comments are also directed at the National Historic Preservation Act (NHPA) Section 106 compliance process as it relates to the protection of cultural resources important to tribes. Some comments describe recommendations for how and when the co-lead agencies need to engage, consult with, and involve tribes in the EIS process. Other general comment summaries for Cultural, Historic, and Tribal Interests and Resources include:

- When analyzing the breach alternative, the EIS should consider the value of recovering currently inundated archaeological and sacred sites such that these resources can be made accessible to tribes, scientists, and the public for research, educational, and cultural perpertuation purposes.
- In consultation with tribes, the co-lead agencies should conduct NEPA and NHPA Section 106 analysis of historic and current adverse impacts that dams (i.e., infrastructure, erosion, operations, and mitigation activities) have on tribal treaty rights and tribal resources

of concern as well as identify correlating mitigation for these impacts. Specificially, the co-lead agencies' EIS should address impacts to tribal treaty fishing rights, tribal way of life, tribal culture, and cultural practices (e.g., ceremonial activities, religious activities, subsistence activities, and physical health) that are dependent upon healthy migratory fish runs (especially Pacific lamprey, salmon, and steelhead). In addition, impacts on the protection and mitigation of traditional fishing and hunting locations (i.e., Celilo Falls), sacred sites, historic cultural resources, and traditional cultural properties should be addressed in the EIS.

- The EIS should analyze how breaching of the lower Snake River dams will benefit tribal treaty fishing rights, tribal resources, tribal way of life, tribal culture, and cultural practices, which are dependent upon healthy migratory fish runs (especially salmon and lamprey).
- The EIS should analyze impacts to cultural resources in a holistic manner by incorporating local and traditional knowledge to address impacts to archaeological sites, historic sites, traditional cultural properties, traditional foods, human health, cultural landscapes, cultural traditions, and other values associated with healthy ecosystems.
- The co-lead agencies should develop a cohesive, holistic, and integrated approach to tribal consultation such that cultural resources can be managed in a holistic and meaningful manner.
- The co-lead agencies should work with tribes to honor the Fish Accord partnership and work to protect and recover salmon and steelhead and associated habitat.
- The co-lead agencies should place emphasis on ecosystem function as developed through the Columbia River Treaty process in their analysis of alternatives.
- The EIS should analyze ongoing tribal fish mitigation activities (e.g., efforts to improve fish passage (Pacific lamprey and salmon) at current projects, enhance habitat in the tributaries and estuary, and reduce the adverse impact of predation on juvenile and adult salmonids by pinnipeds, other fish, and avian predators, as well as fish reintroduction efforts.
- The EIS should consider creative mitigation measures to address tribal interests and concerns (e.g., cultural resources and wildlife resource mitigation, diabetes prevention and other health protection improvements, language preservation, resource access, improved and protected fishery harvest opportunities, land and water acquisition, creation of employment opportunities, and educational opportunities).
- The EIS should include an assessment of how alternatives may impact current tribal economic and cultural adaptations and dependence upon current dam operations such as fish hatcheries and subsistence hunting and other associated economic and cultural benefits of current operations.
- The EIS should analyze Grand Coulee Dam operational alternatives on the erosion, deposition, changes in availability of metals to the aquatic ecosystem, and the effects on the ecosystem of contaminated sediment in the upper Columbia River between the U.S.–Canadian border and Grand Coulee Dam.

- The EIS should analyze and mitigate operational and infrastructure impacts to watershed ecosystems and associated habitat within the context of impacts on traditional cultural properties and sacred sites in consultation with tribes such that mitigation can be accomplished in a manner consistent with federal treaty rights and trust obligations to Indian tribes.
- Upper Columbia tribal interests regarding reintroduction of salmon and other fish species, socioeconomic impacts, and water quality should be addressed in the EIS.

8.16.1 Tribal Involvement

- The co-lead agencies should make every effort to involve the tribes and address tribal concerns and perspectives on resources important to them (such as treaty rights) and consider giving more weight to these concerns in the EIS process.
- The co-lead agencies should consider using tribal media outlets such as tribal newspapers and hosting meetings on reservations in order to have more comprehensive outreach to tribal members such that they are provided with an adequate opportunity to participate in the process and become more involved.
- Tribes would like to participate as Cooperative Agencies in the EIS, providing input/analysis into several resource areas, but also expect the co-lead agencies to recognize that their treaty rights, and trust and government-to-government consultation obligations are distinct from and not altered by such participation.
- The co-lead agencies should consider using the Fish Accord agreements as a model for cooperating agency agreements.
- Tribes request early formal policy-level government-to-government level consultation with tribes, during scoping and prior to any Agency decisions regarding alternatives.
- Tribes request the co-lead agencies to develop clear and realistic work schedules and establish technical working group meetings with tribes for various resource areas analyzed by the EIS (e.g., cultural resources, water quality, etc.).

8.16.2 National Historic Preservation Act Compliance

- The co-lead agencies should consult with tribes as required under NHPA, and incorporate tribal perspectives on impacts to and protection of cultural resources important to tribes. Specifically, these resources include those that meet the broad definition of cultural resources as defined by NEPA, traditional cultural properties, historic properties of religious and cultural significance, First Food locations, archaeological sites, and a holistic view of cultural resources as an integrated landscape of both natural and cultural resources.
- As part of the NHPA Section 106 compliance process, the co-lead agencies should seek tribal concurrence on the definition of area of potential effect and seek tribal input and participation on comprehensive cultural resources inventories, evaluations, mitigations, and treatments such that adverse effects to tribal cultural resources can be adequately resolved in culturally sensitive ways.

- The EIS should incorporate other cultural resources compliance requirements and social impact assessment methodologies into their analysis and should consider engaging tribal experts, as well as archaeologists and anthropologists, to assist in a holistic analysis.
- The Agencies should reconsider their NHPA Section 106 approach in consultation with tribes with regard to the applicability of the existing programmatic agreement to the proposed action.

8.17 Flood Risk Management

Comments summarized on flood risk management concerned the flood control benefits provided by the dams in general, whether or not the four lower Snake River dams provide any flood control; flood risk specifically at Lewiston, Idaho; reservoir operations in Montana; and changes in flood risk management that would need to be considered under alternative System configurations. Other general comment summaries for Flood Risk Management include:

- The scope of the EIS needs to include how reservoirs would be managed for flood control under various operational or configuration alternatives. The analysis should consider a suite of "dry year" operations in which upper Columbia reservoirs are managed to increase spring and early summer flows to benefit migrating juvenile fish; several comments suggested a change in the control point for triggering "dry year" operations from The Dalles to be able to adjust for water supply in upstream reservoirs. The analysis should also consider climate change models and future changes in runoff patterns, flow regimes, reservoir storage, and instream flows for fish.
- The EIS needs to clearly state its assumptions regarding the flood risk management requirements of the Columbia River Treaty, potential renegotiation of the treaty, and to consider the impacts of the changes in flood risk management scheduled to take effect in 2024 under the treaty. Comments expressed concern that when flood storage is no longer assured in Canada, the need to draw down more volume in U.S. reservoirs more often would adversely affect ecosystem function for both anadromous and resident fish.
- The agencies' NEPA process should include a watershed-wide programmatic review of flood protection, infrastructure capacity and capability, floodplain management, levees, and reservoir operations. The analysis should include alternative flood risk management regimes such as less reliance on reservoirs.
- In its analysis of alternatives, the EIS needs to describe the change in flood risk to affected communities and the impacts of flooding on those communities, especially communities on the mainstem such as the Tri-Cities, The Dalles, Portland, and Vancouver, as well as communities downstream of Hungry Horse and Libby dams in Montana. Potential impacts include loss of life, property damage, road washouts, maintenance of flood control structures, loss of agricultural land, potential for relocation, flood insurance, and potential need for disaster relief funding.
- In its analysis of alternatives, the EIS needs to describe the change in flood risk specifically to Lewiston, Idaho, where there is significant sediment accumulation. The cost of managing both flood risk (e.g. raising or maintaining levees) and sediment at Lewiston should also be considered in the analysis.

- In its analysis of a lower Snake River dam breaching alternative, the EIS should consider the degree of flood control provided by those dams compared with the flood protection provided by a restored flood plain.
- The analysis of flood risk management on the upper Columbia should consider the relationship between BPA property acquisition, Hungry Horse Reservoir operations, Flathead Lake levels, and Flathead River flows, and the effects of changes to that system on adjacent property owners and nearby communities.

8.18 Power Generation/Energy

Comments summarized for power and energy include power generation, power capacities, energy alternatives and energy integration, the cost of production, the Columbia River Treaty with Canada, and impact analyses. Comments also expressed general support for hydropower. Other general comment summaries for Power Generation/Energy include:

- The EIS should analyze the significance of the contribution of the four lower Snake River dams to the regional power supply, particularly the inability of the dams to provide power at peak load due to low water flows, and whether the benefits of the hydropower exceed the cost to maintain the dams.
- The EIS should consider energy alternatives such as demand side management, conservation, and solar, wind, natural gas, geothermal, and nuclear generation. The analysis of energy alternatives should include the cost of replacement, the cost of production, reliability of supply, carbon dioxide emissions, and the potential for anadramous fish restoration.
- The alternatives analysis should include feasibility studies for energy alternatives that would evaluate whether those alternative energy sources are capable of supplying the necessary baseload energy.
- The EIS should consider integration of renewable energy, such as wind and solar, with continued operation of the hydropower dams.
- The EIS should address alternatives under which the hydropower system is expanded to include more dams.
- The evaluation of the continued operation of hydropower in the EIS should consider the use of pumped storage for load leveling and the benefits of additional pumped storage should be considered.
- When considering alternatives that retain the dams, the EIS should include the stability of hydropower supply and the multiple regional benefits, including regional navigation, carbon-free electricity, irrigation, and jobs.
- The analysis in the EIS should include a detailed forecast of future power supply and demand, power purchase contracts, and changes in the transmission network.
- The alternatives in the EIS should be coordinated with the ongoing Columbia River Treaty negotiations, and the EIS analysis scenarios should consider potential changes in river operation resulting from future treaty modifications.

8.19 Power Transmission

This summary ofcomments primarily expressed concern about the power transmission system reliability, as well as the cost and timeframe for potential upgrades or new transmission related to replacement power generation should any dams be removed. Other general comment summaries for Power Transmission include:

- The EIS should include an analysis of impacts on the power transmission system and the cost of any needed changes to the transmission system associated with each hydro system alternative.
- In its analysis of transmission system impacts, the EIS should include an accurate description of the current transmission system including recent upgrades.
- The EIS should suggest replacement power options when analyzing the breaching or removal of one or more of the Snake River dams.

8.20 River Navigation

Comments summarizing the river navigation system ranged from stressing its local and global economic importance to the cost of maintaining it, alternatives for replacing it, and the impacts of changes to the CRSO related to river navigation. The majority of comments called for considering the impacts of rail and trucking alternatives to barge transportation, under any dam breaching or drawdown scenarios. Some comments stated that barge transportation could be replaced by truck and rail, and that the navigation system was costly to maintain. Other comments stated that the low carbon footprint and socioeconomic benefits of the current river navigation system and the expense of replacing it were too great to consider drastic changes to it. Other general comment summaries for River Navigation include:

8.20.1 River Navigation System General Considerations

- The EIS needs to consider that transportation is an authorized use of the river system, thus the alternatives must include analysis of appropriate navigation channel configuration for barge transportation.
- The EIS needs to accurately characterize the current level and type of navigation activity throughout the System as a whole, particularly the lower Snake River portion in relation to the rest of the System, and including commercial and recreational activity upstream in Idaho and Montana. Some comments emphasized that an evaluation of commercial navigation on the lower Snake River should be limited to freight through the locks (e.g. reaches upstream of Ice Harbor Dam).
- The EIS should accurately characterize the past trends, current level, and projected future use of the river navigation system for commercial shipping compared with other modes of transportation. Comments concerned the volume, dollar value, number of trips, and frequency of trips for various commodities shipped. Some comments were specific about the analysis methodology that should be used (e.g. address the economic value of freight transport using ton-miles of freight vs. just tons).

- Analysis of alternatives maintaining a river navigation channel should investigate potential beneficial uses for dredged material as well as disposal options with fewer environmental impacts.

8.20.2 Scope of Analysis for Alternative Columbia River System Operations or Configurations for River Navigation

This summary of comments pertains to the analysis of alternatives to barge transportation for alternatives calling for dam breaching or significant reservoir drawdowns.

- The analysis of alternatives should compare the efficiency and price stability of barge transport relative to that of other modes of shipping wheat, forest products, and other agricultural commodities to national and international markets. The analysis should also consider the impact on competitiveness of U.S. products in the global economy.
- The analysis of alternatives should compare the emissions of CO_2 and other GHGs and air pollutants from barge transport relative to that of replacement modes of transportation for an equivalent volume and tonnage.
- The analysis of alternatives should consider the scope, capital cost, and maintenance cost of adequate truck and rail infrastructure to serve Idaho, Montana, eastern Washington, and eastern Oregon farms. The analysis should include the amount of fossil fuel required, the cost of fuel per ton of goods moved, and availability of qualified labor related to these modes of transportation.
- The analysis should consider the public safety and traffic congestion issues associated with a large number of additional semi-trucks on roads and highways as well as increased freight rail use.
- The analysis should consider the number of jobs both directly and indirectly related to river navigation system.
- The analysis should consider impacts on transportation infrastructure affected by reservoir drawdowns (e.g., shoreline structures, roads, bridges, railways).
- Analysis of any alternative calling for breaching the four lower Snake River dams should consider the loss of recreational navigation on the Snake River and the socioeconomic impacts of lower Snake River dam breaching on Lewis Clark Valley communities, including the number of industries, recreational opportunities, and associated beneficial tax revenues.

8.20.3 Costs/Subsidies of River Navigation

- The analysis of alternatives should include the cost of operating and maintaining the navigation system relative to the payments from users. Many commenters felt the lower Snake River dams in particular were not cost-effective, that barge transportation on this section of the river navigation system principally benefits wheat growers (a single industry/small group), and that barge transportation could easily be replaced by (or was already being replaced by) rail transport.

- The analysis of alternatives should describe the level of investment needed to maintain shipping, particularly crops for export markets, and the socioeconomic impact on the communities that would become the hubs for truck and rail transportation, if dams are breached or removed.
- The EIS should consider the "lost opportunity cost of a free-flowing river" in its analysis of alternatives.

8.21 Transportation

This summary of comments concerns transportation other than the river navigation system. Other general comment summaries for Transportation include:

- In its analysis of alternatives, the EIS should evaluate the impacts of System operational or configuration changes on the existing transportation infrastructure, (e.g. where breaching or drawdown might affect adjacent roads, bridges, railways, and recreational boating facilities).
- The analysis of transportation infrastructure impacts should include the cost and socioeconomic impacts (e.g. traffic disruption, reduced visitation) of repairing any damage and protection from future damage.

8.22 Recreation

This summary of comments concerns impacts to recreational activities along the river system. Other general comment summaries for Recreation include:

- The EIS should consider the negative impacts dam breaching would have on recreation including effects to individuals that regularly partake in recreational activities on and along the river such as camping, boating, and fishing; businesses that offer recreational and tourism activities; and athletic organizations such as the Washington State University rowing team.
- The EIS should consider the positive impacts dam breaching would have on recreation including introducing new recreational activities to the area, such as whitewater rafting.
- The EIS should include analysis of existing recreational opportunities and their areas for improvements, potential recreational opportunities, and the economic impact of recreation and tourism on surrounding communities.

8.23 Socioeconomics and Environmental Justice

Comments summarized on Socioeconomics and Environmental Justice are directed at both the positive and negative impacts of the proposed action to tourism, recreation, fisheries, hydropower generation and flood control, industry, the tribes, transportation, and agriculture. Other general comment summaries for Socioeconomics and Environmental Justice include:

8.23.1 Scope of Socioeconomic Analysis and Alternatives

- The EIS should include a thorough analysis of the direct and indirect economic impact of the current System. This analysis should include identification and valuation of all businesses dependent on the System across multiple industries. This analysis should also compare the current costs of operating the dams to the benefits they provide.
- The EIS should include a thorough analysis of the direct and indirect economic impact of a free-flowing river system. This analysis should include forecasted impacts on all relevant industries and dam removal costs and details concerning the cost recovery.
- The EIS should include socioeconomic analyses that are consistent across each alternative and the current System. These analyses should not only include quantitative measures but also qualitative measures. The degree of uncertainty and risk in the analysis should also be included.
- The EIS needs to address the direct and indirect employment changes that would result from each alternative. This analysis needs to include the industries where jobs would be lost as well as industries where new jobs would arise due to each alternative.
- The EIS should address the costs of replacing baseload electric generation should the dams be removed. This analysis should also include the effect this would have to rate payers and their standard of living.
- The EIS should discuss what would happen with the land that was obtained by the Corps in the event of the dams being removed.
- Economic analysis included in the EIS should include adequate economic forecasting of each alternative's costs and benefits. Examples of figures that should be included are the dams operations and maintenance cost trends over recent years and revenue from electric production and cargo ton-miles transportation trends.
- The EIS should thoroughly discuss and address the socioeconomic considerations for water concerns including, but not limited to, water rights consideration, access to drinking water, access to irrigation for agriculture, and access to adequate water supply to support firefighting activities.
- The EIS should thoroughly analyze the rising operations and maintenance costs of the lower Snake River dams in question. These costs should also include forecasts of expected major maintenance of aging infrastructure.

8.23.2 Economic Effects of Dam Breaching

- The EIS should specifically include the impacts that dam breaching would have to the agricultural industry due to the potential unavailability of irrigation. Included in these impacts should be the direct job loss in the agricultural industry and also the associated indirect losses. The EIS should also consider the industries that rely on the agricultural industries, such as food processing.
- The EIS needs to recognize the recreation and tourism industry's impact on surrounding areas and the reliance these industries have on the current river system. A detailed analysis of jobs lost and the indirect impact of declines in these industries needs to be included.

- The complete impact of the benefits of the existing navigation of the Columbia and Snake Rivers should be included in the EIS. These benefits come from many industries including agriculture, recreation, tourism, and transportation. The use of the current river system in these industries and the economic impact they have on surrounding communities should be completely captured in the EIS.
- The EIS should analyze all industries' sensitivity to increased electricity prices and the ability of local businesses to remain a cost competitive member of their respective industry if electricity prices were to increase due to breaching.
- The EIS should discuss potential road and other infrastructure upgrades that could be needed if dams were breached. If these upgrades were needed, what are the impacts to surrounding industries (e.g. discussion about how the logging industry would be impacted by roads needing repair should be included).
- The EIS should consider the cost of dam removal, replacing irrigation and transportation infrastructure, and flood protection/mitigation as reason enough to not remove any dams.
- The EIS should analyze and consider the effect of dam breaching on the agricultural industry. This should include topics such as a decrease in production and subsequently jobs, increased wheat transportation costs, and the cost of food locally.
- The EIS should consider the effect of dam breaching on waterfront properties and the personal financial impacts those changes have on homeowners. The drop in the housing market that would result from a loss of local jobs and increased living expenses should also be considered.
- The EIS should include discussion and analysis of increased economic activity in the tourism, recreation, commercial fishing, and rail activities that would result from breaching the dams as well as the indirect impacts of these increases.
- Inclusion of qualitative benefits in addition to quantitative benefits resulting from breaching the dams, such as communities reconnecting with the waterfront, must be a part of the EIS.

8.23.3 Impacts to Businesses and Communities

- The EIS should consider that low cost hydropower provided by the dams have allowed jobs in industries such as wood, chemical companies, and aluminum manufacturing to remain.
- The EIS needs to consider the benefit of the cargo that can be transported via barge on the river because of the dams as well as the positive impact the dams have in the commerce, shipping, irrigation, flood control, and recreation industries.
- The EIS should consider the negative impacts of increased electricity costs on residents and the effect those cost increases have on the standard of living.
- The EIS should analyze and consider the effect of dam breaching on the agricultural industry. This should include topics such as a decrease in production and subsequently jobs, increased wheat transportation costs, and the cost of food locally.
- The EIS should recognize the loss in direct and indirect jobs from the recreation and tourism industry that currently exist due to the dams as well as the impact of loss of recreation on

quality of life. Also, the EIS should consider the sunk cost to residents with propeller watercraft that will no longer be usable.

- The EIS needs to report the loss of property tax income to schools and local governments resulting from mitigation land purchases.
- The EIS should consider the effect of dam breaching on waterfront properties and the personal financial impacts those changes have on homeowners. The drop in the housing market that would result from a loss of local jobs and increased living expenses should also be considered.
- The EIS should include analysis of the decline in the commercial fishing industry that took place as the hydroelectric System was developed. This should include the findings from the Lower Snake River Juvenile Salmon Migration Feasibility Study Anadromous Fish Economic Analysis.
- The EIS should include the impact on the existing commercial fishing that breaching may result in. This analysis should include both positive impacts and any negative impacts to downstream fishing operations. This should also include the indirect impacts of the potential changes in the industry.

8.23.4 Power System

- The EIS should address the fish and wildlife mitigation funding that will be affected by dam breaching and the subsequent loss of revenue from the dams. The EIS should also discuss the potential of a reclamation fund that each federal hydropower facility contributes to being used for mitigation efforts.
- The EIS should address the impact of mitigation efforts on ratepayers, including an analysis of the portion of electric rates paid that are directed toward mitigation efforts.
- The EIS should include a comprehensive analysis of the costs and benefits of hydropower generation at the four lower Snake River dams; this analysis should address both the value of the power produced and the cost of replacement power should the dams be breached. The analysis should also address integration of renewables, particularly wind power, impacts on electric rates, and the carbon emissions of existing vs. replacement power sources.
- If hydropower production is reduced by configuration or operational changes to the CRS, the EIS should consider improving the infrastructure and financial structure (fees, taxes) for transitioning to wind and solar power.
- The EIS should consider additional revenue sources that could be generated by the CRS and the impact the revenue would have on local economies.
- The EIS should consider the affordable, carbon-free, and firming power (for integration of wind and solar energy) benefits of hydropower as reason enough to not remove any dams.

8.23.5 Environmental Justice

- In accordance with E.O. 12898, the EIS should address environmental justice. The EIS should include a thorough analysis to identify any disproportionately high and adverse health or environmental effects any action or lack thereof would have on minority populations, low-income populations, and Native American tribes.

8.24 General Perspectives on the CRSO EIS Process

This summary of comments includes the expressed opposition to the EIS or NEPA process and the express support for the EIS or NEPA process. Those opposing primarily question its necessity, the cost to taxpayers and ratepayers, and the commitment of the agencies to complete the process. Those supporting this effort reinforced the work by the co-lead agencies. Other comments in this category expressed support for the CRSO and its continued operation in general..

9.0 CONCLUSION

The co-lead agencies engaged in a robust scoping process including public meetings, public notifications, and scoping comment solicitation and received tremendous public participation in the scope and scale of comments to guide the development of the scope of analysis for the CRSO EIS. This includes public comments on the scope of EIS, ideas for alternatives, methods of evalautions, and resource concerns expressed by public, state and federal agencies, and tribes. The co-lead agencies are using these comments to develop the EIS and focus on those issues expressed through public scoping as important in the analysis.

10.0 REFERENCES

59 FR 7629. February 16, 1994. “Executive Order 12898 of February 11, 1994, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.” *Federal Register*, Office of the President.

81 FR 67382. September 30, 2016. “Notice of Intent to Prepare the Columbia River System Operations Environmental Impact Statement.” *Federal Register,* U.S. Army Corps of Engineers, Bonneville Power Administration, and Bureau of Reclamation.

81 FR 76962. November 4, 2016. “Notice of Additional Scoping Meeting for the Columbia River System Operations Environmental Impact Statement.” *Federal Register,* Bureau of Reclamation.

82 FR 137. January 3, 2017. “Notice to Extend the Public Comment Period for the Notice of Intent to Prepare the Columbia River System Operations Environmental Impact Statement.” *Federal Register,* Bureau of Reclamation.

Endangered Species Act of 1973. Public Law 100-478, as amended, 16 U.S.C. § 1531 *et seq*.

Marine Mammal Protection Act of 1972. 86 Stat. 1027, as amended, 16 U.S.C. § 1361 *et seq*.

National Environmental Policy Act of 1969 (NEPA). Public Law 91-190, as amended, 42 U.S.C. § 4321 *et seq*.

National Historic Preservation Act of 1966 (NHPA). Public Law 89-665, as amended, 54 U.S.C. § 300101 *et seq*.

Pacific Northwest Electric Power Planning and Conservation Act. Public Law 96-501, S. 885, as amended, 16 U.S.C. § 839 *et seq*.

Appendix A

Federal Register Notices

Three Notices of Intent regarding the preparation of the Columbia River System Operations environmental impact statement were published in the *Federal Register*. The original, dated September 30, 2016 (81 FR 67382; Figure A.1), announced the comment period ending date as January 17, 2017, and published a schedule for public meetings and webinars. On November 4, 2016, the Action Agencies issued a *Federal Register* notice that an additional public meeting would be held in Pasco, Washington (81 FR 76962; Figure A.2). On January 3, 2017, the comment period was extended to February 7, 2017 (82 FR 137; Figure A.3).

Figure A.1. September 30, 2016 *Federal Register* Notice (81 FR 67382)

Alternative 2 would not store San Juan-Chama Project water in Elephant Butte Reservoir. Alternative 3 would not include the carryover accounting provision. Alternative 4 would not include the diversion ratio adjustment. Alternative 5 is the No Action Alternative and it would eliminate both the carryover accounting and diversion ratio adjustment from Rio Grande Project allocation and accounting procedures.

The FEIS analyzes the effect of these five alternatives on (1) water resources (total storage, Elephant Butte Reservoir elevations, allocation, releases, net diversion, farm surface water deliveries, farm groundwater deliveries, groundwater elevations, and water quality); (2) biological resources (vegetation communities including wetlands, wildlife, aquatic species, and special status species and critical habitat); (3) cultural resources (historic properties, Indian sacred sites, and resources of tribal concern); and (4) socioeconomic resources (Indian trust assets, recreation, hydropower, regional economic impacts and economic benefits, and environmental justice).

On January 15, 2014, a Notice of Intent was published in the **Federal Register** (79 FR 2691) inviting public scoping comments on the proposed action of continuing to implement the Operating Agreement through 2050. A Notice of Availability was published in the **Federal Register** on March 18, 2016 (81 FR 14886), and the public was invited to provide comments on the Draft EIS during an 83-day comment period ending on June 8, 2016.

Public Disclosure

Before including your address, phone number, email address, or other personal identifying information in your comment, please be advised that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

Dated: September 7, 2016.

Brent Rhees,

Regional Director, Upper Colorado Region.

[FR Doc. 2016–23525 Filed 9–29–16; 8:45 am]

BILLING CODE 4332–90–P

DEPARTMENT OF DEFENSE

Department of the Army, U.S. Army Corps of Engineers

DEPARTMENT OF ENERGY

Bonneville Power Administration

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

[RR01041000, 16XR0680G3, RX.16786921.2000100]

Notice of Intent To Prepare the Columbia River System Operations Environmental Impact Statement

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD; Bonneville Power Administration, Energy; Bureau of Reclamation, Interior.

ACTION: Notice of intent to prepare an environmental impact statement.

SUMMARY: In accordance with the National Environmental Policy Act, the U.S. Army Corps of Engineers (Corps), Bureau of Reclamation (Reclamation), and the Bonneville Power Administration (BPA) (Action Agencies) intend to prepare an environmental impact statement (EIS) on the system operation and maintenance of fourteen Federal multiple purpose dams and related facilities located throughout the Columbia River basin. The Action Agencies will use this EIS process to assess and update their approach for long-term system operations and configuration through the analysis of alternatives and evaluation of potential effects to the human and natural environments, including effects to socio-economics and species listed under the Endangered Species Act (ESA). The Action Agencies will serve as joint lead agencies in developing the EIS.

DATES: Written comments for the Action Agencies' consideration are due to the addresses below no later than January 17, 2017. Comments may also be made at public meetings. Information on the public meetings is provided under the **SUPPLEMENTARY INFORMATION** section of this notice.

ADDRESSES: Written comments, requests to be placed on the project mailing list, and requests for information may be mailed by letter to U.S. Army Corps of Engineers Northwestern Division Attn: CRSO EIS, P.O. Box 2870, Portland, OR 97208–2870; or online at *comment@crso.info.* All comment letters will be available via the project Web site at *www.crso.info.* All personally identifiable information (for example, name, address, etc.) voluntarily submitted by the commenter may be publicly accessible. Do not submit confidential business information or otherwise sensitive or protected information.

FOR FURTHER INFORMATION CONTACT: Call the toll-free telephone 1–(800) 290–5033 or email *info@crso.info.* Additional information can be found at the project Web site: *www.crso.info.*

SUPPLEMENTARY INFORMATION:

Background

The fourteen Federal multiple purpose dams and related facilities are operated as a coordinated system within the interior Columbia River basin in Idaho, Montana, Oregon, and Washington. A map identifying the locations of these dams can be found on the project Web site at *www.crso.info.* The Corps was authorized by Congress to construct, operate and maintain twelve of these projects for flood control, power generation, navigation, fish and wildlife, recreation, and municipal and industrial water supply purposes. The Corps' projects that will be addressed in this EIS include Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. Reclamation was authorized to construct, operate, and maintain two projects for purposes of flood control, power generation, navigation, and irrigation. The Reclamation projects that will be addressed in this EIS include Hungry Horse and Grand Coulee. BPA is responsible for marketing and transmitting the power generated by these dams. Together, these Action Agencies are responsible for managing the system for these various purposes.

In the 1990s, the Action Agencies analyzed the socio-economic and environmental effects of operating the system in the Columbia River System Operation Review (SOR) EIS and issued respective Records of Decision in 1997 that adopted a system operation strategy, which included operations supporting ESA-listed fish while fulfilling all other congressionally-authorized purposes. Since the completion of the SOR EIS, the Action Agencies have operated the system consistent with the analyses in the SOR EIS, while some changes to system operations have been adopted under subsequent ESA consultations and project-specific National Environmental Policy Act documents.

Proposal for New EIS

The proposed Columbia River System Operations EIS will assess and update the approach for long-term system operations and configuration. In addition to evaluating a range of alternatives, the EIS will consider the direct, indirect, and cumulative impacts of these alternatives on affected resources, including geology, soils, water quality and quantity, air quality, fish and wildlife (*e.g.*, ESA-listed species and their designated critical habitat), floodplains, wetlands, climate, cultural resources, tribal resources, social and economic resources, and other resources that are identified during the scoping process. The impacts to the resources will be addressed in light of anticipated climate change impacts, such as warmer water temperatures, diminished snow-pack, and altered flows. The Action Agencies will evaluate a range of alternatives in the EIS, including a no-action alternative (current system operations and configuration). Other alternatives will be developed through the scoping period based on public input and Action Agency expertise, and will likely include an array of alternatives for different system operations and additional structural modifications to existing projects to improve fish passage including breaching one or more dams.

The EIS will also identify measures to avoid, offset or minimize impacts to resources affected by system operations and configuration, where feasible. For instance, non-operational mitigation measures to address impacts to the fish resources, such as habitat actions in the tributaries and estuary, avian predation management actions, and conservation and safety net hatcheries, may be proposed.

Additionally, the Action Agencies will comply with all applicable statutory and regulatory requirements in evaluating the proposed action, such as the ESA, Clean Water Act, Section 106 of the National Historic Preservation Act (NHPA), and Executive Orders, including E.O. 12898 *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*.

Request for Comments

The Action Agencies are issuing this notice to: (1) Advise other Federal and state agencies, tribes, and the public of their plan to analyze effects related to system operations and configuration; (2) obtain suggestions and information that may inform the scope of issues and range of alternatives to evaluate in the EIS; and (3) provide notice and request public input on potential effects on historic properties from system operations and configuration in accordance with Section 106 of the NHPA (36 Code of Federal Regulations 800.2(d)(3)).

The Action Agencies are inviting interested parties to provide specific comments no later than January 17, 2017, on issues the agencies should evaluate related to the Columbia River System Operations EIS. All comments and materials received, including names and addresses, will become part of the administrative record and may be released to the public.

Public Meetings

The Action Agencies will hold 15 public scoping meetings during the fall and winter of 2016 to invite the public to comment on the scope of the EIS. The 15 public meetings will be held on:

- Monday, October 24, 2016, 4 p.m. to 7 p.m., Wenatchee Community Center, 504 S. Chelan Ave., Wenatchee, Washington.
- Tuesday, October 25, 2016, 4 p.m. to 7 p.m., The Town of Coulee Dam, City Hall, 300 Lincoln Ave., Coulee Dam, Washington.
- Wednesday, October 26, 2016, 4 p.m. to 7 p.m., Priest River Community Center, 5399 Highway 2, Priest River, Idaho.
- Thursday, October 27, 2016, 4 p.m. to 7 p.m., Kootenai River Inn Casino & Spa, 7169 Plaza St., Bonners Ferry, Idaho.
- Tuesday, November 1, 2016, 4 p.m. to 7 p.m., Red Lion Hotel Kalispell, 20 North Main St., Kalispell, Montana.
- Wednesday, November 2, 2016, 4 p.m. to 7 p.m., City of Libby City Hall, 952 E. Spruce St., Libby, Montana.
- Thursday, November 3, 2016, 4 p.m. to 7 p.m., Hilton Garden Inn Missoula, 3720 N. Reserve St., Missoula, Montana.
- Monday, November 14, 2016, 4 p.m. to 7 p.m., The Historic Davenport Hotel, 10 South Post Street, Spokane, Washington.
- Wednesday, November 16, 2016, 4 p.m. to 7 p.m., Red Lion Hotel Lewiston, Seaport Room, 621 21st St., Lewiston, Idaho.
- Thursday, November 17, 2016, 4 p.m. to 7 p.m., Courtyard Walla Walla, The Blues Room, 550 West Rose St., Walla Walla, Washington.
- Tuesday, November 29, 2016, 4 p.m. to 7 p.m., The Grove Hotel, 245 S. Capitol Blvd., Boise, Idaho.
- Thursday, December 1, 2016, 4 p.m. to 7 p.m., Town Hall, Great Room, 1119 8th Ave., Seattle, Washington.
- Tuesday, December 6, 2016, 4 p.m. to 7 p.m., The Columbia Gorge Discovery Center, River Gallery Room, 5000 Discovery Drive, The Dalles, Oregon.
- Wednesday, December 7, 2016, 4 p.m. to 7 p.m., Oregon Convention Center, 777 NE Martin Luther King Jr. Blvd., Portland, Oregon.
- Thursday, December 8, 2016, 4 p.m. to 7 p.m., The Loft at the Red Building, 20 Basin St., Astoria, Oregon.
- Tuesday, December 13, 2016, 10 a.m. to 11:30 a.m., and 3 p.m. to 4:30 p.m., PST, webinar. For those that cannot participate in person, an online webinar will be provided to interested parties. The webinar will cover the material discussed in the in-person public scoping meetings. Detailed instructions on how to participate in the webinar may be found on the project Web site at *www.crso.info*. To submit written comments, please follow the instructions in the **ADDRESSES** section of this notice.

The Action Agencies will consider requests for an extension of time for public comment and additional opportunities for public involvement if requests are received in writing by December 1, 2016. Requests for additional time to comment and opportunities for public involvement should be sent to the address listed in the **ADDRESSES** section of this notice. Requests should include an explanation of the specific purposes served by the requested extension, and should explain how the extension could benefit the National Environmental Policy Act process and analysis. Announcements for any such further opportunities for public involvement, if appropriate given the court-ordered schedule for this EIS, will be published in the **Federal Register** and by news releases to the media, newsletter mailings, and posting on the project Web site.

The draft EIS is scheduled to be published by March 2020 for public review and comment, and after it is published, the Action Agencies will hold public comment meetings. The Action Agencies will consider public comments received on the draft EIS and provide responses in the final EIS.

Scott A. Spellmon,

Brigadier General, US Army, Division Commander.

Elliot E. Mainzer,

Administrator, Bonneville Power Administration.

Lorri J. Lee,

Regional Director—Pacific Northwest Region, Bureau of Reclamation.

[FR Doc. 2016–23346 Filed 9–29–16; 8:45 am]

BILLING CODE 4332–90–P

Figure A.2. November 4, 2016 *Federal Register* Notice (81 FR 76962)

the terms and conditions of an approved permit and any other applicable provision under these regulations.

The NPS consulted with traditionally associated American Indian tribes and groups, State Historic Preservation Officers, United States Fish and Wildlife Service, United States Environmental Protection Agency, state oil and gas regulatory commissions, and the state of Alaska.

The ROD includes a summary of the purpose and need for action, synopses of alternatives considered and analyzed in detail, a description of the selected alternative, including measures that are included in the rule to minimize environmental harm, the basis for the decision, a description of the environmentally preferable alternative, and findings on impairment of park resources. The ROD is not the final agency action for those elements of the EIS that require promulgation of regulations to be effective. Promulgation of such regulations will constitute the final agency action for such elements, and will be published in a separate **Federal Register** document.

Dated: October 23, 2016.

Jonathan B. Jarvis,

Director, National Park Service.

[FR Doc. 2016–26402 Filed 11–3–16; 8:45 am]

BILLING CODE 4312–52–P

DEPARTMENT OF THE INTERIOR

Bureau of Ocean Energy Management

[MMAA104000]

Notice on Outer Continental Shelf Oil and Gas Lease Sales

AGENCY: Bureau of Ocean Energy Management (BOEM), Interior.

ACTION: List of Restricted Joint Bidders.

SUMMARY: Pursuant to the joint bidding provisions of 30 CFR 556.511—556.515, the Director of the Bureau of Ocean Energy Management is publishing a List of Restricted Joint Bidders. Each entity within one of the following groups is restricted from bidding with any entity in any of the other following groups at Outer Continental Shelf oil and gas lease sales to be held during the bidding period November 1, 2016, through April 30, 2017. This List of Restricted Joint Bidders will cover the period November 1, 2016, through April 30, 2017, and replace the prior list published on May 17, 2016, which covered the period of May 1, 2016, through October 31, 2016.

Group I BP

America Production Company
BP Exploration & Production Inc.
BP Exploration (Alaska) Inc.

Group II Chevron Corporation

Chevron U.S.A. Inc.
Chevron Midcontinent, L.P.
Unocal Corporation
Union Oil Company of California
Pure Partners, L.P.

Group III

Eni Petroleum Co. Inc.
Eni Petroleum US LLC
Eni Oil US LLC
Eni Marketing Inc.
Eni BB Petroleum Inc.
Eni US Operating Co. Inc.
Eni BB Pipeline LLC

Group IV

Exxon Mobil Corporation
ExxonMobil Exploration Company

Group V

Petroleo Brasileiro S.A.
Petrobras America Inc.

Group VI

Shell Oil Company
Shell Offshore Inc.
SWEPI LP
Shell Frontier Oil & Gas Inc.
SOI Finance Inc.
Shell Gulf of Mexico Inc.

Group VII

Statoil ASA
Statoil Gulf of Mexico LLC
Statoil USA E&P Inc.
Statoil Gulf Properties Inc.

Group VIII

Total E&P USA, Inc.

Abigail Ross Hopper,

Director, Bureau of Ocean Energy Management.

[FR Doc. 2016–26737 Filed 11–3–16; 8:45 am]

BILLING CODE 4310–MR–P

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

[RR01041000, 17XR0680G3, RX.16786921.2000100]

Notice of Additional Scoping Meeting for the Columbia River System Operations Environmental Impact Statement

AGENCIES: Bureau of Reclamation, Interior.

ACTION: Notice.

SUMMARY: The Bureau of Reclamation, along with the U.S. Army Corps of Engineers and the Bonneville Power Administration as joint lead agencies, are adding one public scoping meeting to invite the public to comment on the scope of the Columbia River System Operations Environmental Impact Statement.

DATES: The additional scoping meeting will be held on Monday, November 21, 2016, 4 p.m. to 7 p.m., in Pasco, Washington.

ADDRESSES: The meeting will be held at the Holiday Inn Express & Suites Pasco-Tri Cities, 4525 Convention Place, Pasco, Washington 99301.

FOR FURTHER INFORMATION CONTACT: Call the toll-free telephone 1–(800) 290–5033 or email *info@crso.info*. Additional information can be found at the project Web site: *www.crso.info*.

SUPPLEMENTARY INFORMATION: One scoping meeting is being added to the schedule. All other scoping meetings for the Columbia River System Operations Environmental Impact Statement were previously announced in a notice that was published in the **Federal Register** on September 30, 2016 (81 FR 67382). As the project evolves, there may be additional scoping meetings. All additional scoping meetings for this project will be announced on the project Web site at *www.crso.info*.

Dated: October 26, 2016.

Lorri J. Lee,

Regional Director—Pacific Northwest Region, Bureau of Reclamation.

[FR Doc. 2016–26740 Filed 11–3–16; 8:45 am]

BILLING CODE 4332–90–P

INTERNATIONAL TRADE COMMISSION

Notice of Receipt of Complaint; Solicitation of Comments Relating to the Public Interest

AGENCY: U.S. International Trade Commission.

ACTION: Notice.

SUMMARY: Notice is hereby given that the U.S. International Trade Commission has received a complaint entitled *Certain UV Curable Coatings for Optical Fibers, Coated Optical Fibers, and Products Containing Same, DN 3181;* the Commission is soliciting comments on any public interest issues raised by the complaint or complainant's filing under the Commission's Rules of Practice and Procedure.

FOR FURTHER INFORMATION CONTACT: Lisa R. Barton, Secretary to the Commission, U.S. International Trade Commission, 500 E Street SW., Washington, DC 20436, telephone (202) 205–2000. The public version of the complaint can be

Figure A.3. January 3, 2017 *Federal Register* Notice (82 FR 137)

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

[RR01041000, 17XR0680G3, RX.16786921.2000100]

Notice To Extend the Public Comment Period for the Notice of Intent To Prepare the Columbia River System Operations Environmental Impact Statement

AGENCY: Bureau of Reclamation, Interior.

ACTION: Notice of extension.

SUMMARY: The U.S. Army Corps of Engineers, Bonneville Power Administration, and Bureau of Reclamation (Action Agencies) are extending the public comment period for the Notice of Intent (NOI) to Prepare the Columbia River System Operations Environmental Impact Statement (EIS) to Tuesday February 7, 2017. The NOI and Notice of Public Meetings was published in the **Federal Register** on Friday, September 30, 2016. The public comment period for the NOI was originally scheduled to end on Tuesday, January 17, 2017.

DATES: Comments on the NOI will be accepted until close of business on Tuesday February 7, 2017.

ADDRESSES: Written comments, requests to be placed on the project mailing list, and requests for information may be mailed by letter to U.S. Army Corps of Engineers Northwestern Division Attn: CRSO EIS, P.O. Box 2870, Portland, OR 97208–2870; or online at *comment@crso.info*. All comment letters will be available via the project Web site at *www.crso.info*. All personally identifiable information (for example, name, address, etc.) voluntarily submitted by the commenter may be publicly accessible. Do not submit confidential business information or otherwise sensitive or protected information.

FOR FURTHER INFORMATION CONTACT: Call the toll-free telephone 1-(800) 290–5033, or email *info@crso.info*. Additional information can be found at the project Web site: *www.crso.info*.

SUPPLEMENTARY INFORMATION: In response to requests for an extension, the Action Agencies are extending the close of the public comment period for the NOI to Prepare the Columbia River System Operations Environmental Impact Statement to Tuesday February 7, 2017.

Public Disclosure

Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

Dated: December 6, 2016.

Lorri J. Lee,

Regional Director—Pacific Northwest Region, Bureau of Reclamation.

[FR Doc. 2016–31621 Filed 12–30–16; 8:45 am]

BILLING CODE 4332–90–P

INTERNATIONAL TRADE COMMISSION

[Investigation No. 731–TA–410 (Fourth Review)]

Light-Walled Rectangular Pipe and Tube From Taiwan Institution of a Five-Year Review

AGENCY: United States International Trade Commission.

ACTION: Notice.

SUMMARY: The Commission hereby gives notice that it has instituted a review pursuant to the Tariff Act of 1930 ("the Act"), as amended, to determine whether revocation of the antidumping duty order on light-walled rectangular pipe and tube from Taiwan would be likely to lead to continuation or recurrence of material injury. Pursuant to the Act, interested parties are requested to respond to this notice by submitting the information specified below to the Commission.

DATES: Effective January 3, 2017. To be assured of consideration, the deadline for responses is February 2, 2017. Comments on the adequacy of responses may be filed with the Commission by March 17, 2017.

FOR FURTHER INFORMATION CONTACT: Mary Messer (202–205–3193), Office of Investigations, U.S. International Trade Commission, 500 E Street SW., Washington, DC 20436. Hearing-impaired persons can obtain information on this matter by contacting the Commission's TDD terminal on 202–205–1810. Persons with mobility impairments who will need special assistance in gaining access to the Commission should contact the Office of the Secretary at 202–205–2000. General information concerning the Commission may also be obtained by accessing its internet server (*https://www.usitc.gov*). The public record for this proceeding may be viewed on the Commission's electronic docket (EDIS) at *https://edis.usitc.gov*.

SUPPLEMENTARY INFORMATION:

Background.—On March 27, 1989, the Department of Commerce issued an antidumping duty order on imports of light-walled rectangular pipe and tube from Taiwan (54 FR 12467). Following first five-year reviews by Commerce and the Commission, effective August 22, 2000, Commerce issued a continuation of the antidumping duty order on imports of light-walled rectangular pipe and tube from Taiwan (65 FR 50955). Following second five-year reviews by Commerce and the Commission, effective August 9, 2006, Commerce issued a continuation of the antidumping duty order on imports of light-walled welded rectangular carbon steel tubing from Taiwan (71 FR 45521). Following the third five-year reviews by Commerce and the Commission, effective February 2, 2012, Commerce issued a continuation of the antidumping duty order on imports of light-walled welded rectangular carbon steel tubing from Taiwan (77 FR 5240). The Commission is now conducting a fourth review pursuant to section 751(c) of the Act, as amended (19 U.S.C. 1675(c)), to determine whether revocation of the order would be likely to lead to continuation or recurrence of material injury to the domestic industry within a reasonably foreseeable time. Provisions concerning the conduct of this proceeding may be found in the Commission's Rules of Practice and Procedure at 19 CFR parts 201, subparts A and B and 19 CFR part 207, subparts A and F. The Commission will assess the adequacy of interested party responses to this notice of institution to determine whether to conduct a full review or an expedited review. The Commission's determination in any expedited review will be based on the facts available, which may include information provided in response to this notice.

Definitions.—The following definitions apply to this review:

(1) *Subject Merchandise* is the class or kind of merchandise that is within the scope of the five-year review, as defined by the Department of Commerce.

(2) The *Subject Country* in this review is Taiwan.

(3) The *Domestic Like Product* is the domestically produced product or products which are like, or in the absence of like, most similar in characteristics and uses with, the *Subject Merchandise*. In its original investigation determination, its full first and second five-year review determinations, and its expedited third

Appendix B

Scoping Letter

The scoping letter provided by the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the Bonneville Power Administration requesting information for the preparation of an environmental impact statement for Columbia River System operations is provided on the following three pages.

COLUMBIA RIVER SYSTEM OPERATIONS

Environmental Impact Statement P.O. Box 2870, Portland, OR 97208-2870 1-800-290-5033

U.S. ARMY CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

BUREAU OF RECLAMATION
DEPARTMENT OF THE INTERIOR

BONNEVILLE POWER ADMINISTRATION
DEPARTMENT OF ENERGY

IN REPLY REFER TO: CRSO-EIS

30 SEP 2016

TO WHOM IT MAY CONCERN:

The U.S. Army Corps of Engineers (Corps), Northwestern Division, Bonneville Power Administration (BPA) and Bureau of Reclamation (Reclamation) (collectively, the Agencies), are serving as co-leads in preparation of an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) on Columbia River System operations and configurations for 14 federal projects in the interior Columbia basin. The Agencies are requesting your assistance in gathering information that will help define the issues, concerns, and the scope of alternatives to be addressed in the EIS. Information will be gathered from interested parties during the scoping period beginning September 30, 2016 and ending January 17, 2016.

The EIS will evaluate and update the Agencies' approach for long-term system operations and configuration through the analysis of different alternatives to current operations and maintenance; including changes to flood risk management, navigation, hydropower, irrigation, fish and wildlife conservation, recreation and municipal and industrial water supply. The Agencies will also analyze potential effects on species, including those listed under the Endangered Species Act, cultural resources, tribal resources, and other social and natural resources. This EIS will be used to select a preferred alternative, which will be adopted by the Agencies in order to operate and maintain the Columbia River System.

The EIS evaluation area under consideration includes 14 federal multiple purpose dams and related facilities, operated as a coordinated system in Idaho, Montana, Oregon, and Washington. Congress authorized the Corps to construct, operate, and maintain 12 of these projects for flood risk management, navigation, power generation, fish and wildlife conservation, recreation, and municipal and industrial water supply purposes. The Corps' projects that will be addressed in this EIS include Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. Congress authorized Reclamation to construct, operate, and maintain two of these projects for purposes of irrigation, flood risk management, power generation, and navigation. Reclamation projects include Hungry Horse and Grand Coulee. BPA is responsible for marketing and transmitting the power generated by these dams. Together, the Agencies are responsible for managing the system for all of these various purposes.

During the preparation of the EIS, the Agencies will be identifying potential alternatives that best meet our responsibilities for providing for authorized purposes while minimizing or eliminating environmental impacts and meeting all federal statutory and regulatory requirements. The Agencies plan to identify a preferred alternative in the draft EIS. The Agencies will evaluate a range of alternatives in the EIS, including a no-action alternative (current system operations and configuration). Other alternatives will be developed through the scoping period based on public input and the Agencies' expertise, and will likely include an array of alternatives for different system operations and additional structural modifications to existing projects to improve fish passage, including breaching one or more dams.

The EIS will also identify measures to avoid, offset, or minimize impacts to resources affected by system operations and configuration, where feasible. For instance, non-operational mitigation measures to address impacts to the fish resources, such as habitat actions in the tributaries and estuary, avian predation management actions, and conservation and safety net hatcheries, may be proposed.

The Agencies welcome your comments, suggestions and information that may inform the scope of issues, potential effects, and range of alternatives that should be evaluated in the EIS. Letters of comment or inquiry can be submitted to comment@crso.info, or addressed to U.S. Army Corps of Engineers, Northwestern Division, Attn: CRSO EIS, P.O. Box 2870, Portland, Ore. 97208-2870. Comments may also be submitted at public scoping meetings to be conducted by the Agencies as follows:

Week of October 24th

- Monday, October 24, 4 p.m. to 7 p.m., Wenatchee Community Center, 504 S. Chelan Ave., Wenatchee, WA.
- Tuesday, October 25, 4 p.m. to 7 p.m., The Town of Coulee Dam, City Hall, 300 Lincoln Ave., Coulee Dam, WA.
- Wednesday, October 26, 4 p.m. to 7 p.m., Priest River Community Center, 5399 Hwy 2, Priest River, ID.
- Thursday, October 27, 4 p.m. to 7 p.m., Kootenai River Inn Casino & Spa, 7169 Plaza St., Bonners Ferry, ID.

Week of October 30th

- Tuesday, November 1, 4 p.m. to 7 p.m., Red Lion Hotel Kalispell, 20 North Main St., Kalispell, MT.
- Wednesday, November 2, 4 p.m. to 7 p.m., City of Libby City Hall, 952 E. Spruce St., Libby, MT.
- Thursday, November 3, 4 p.m. to 7 p.m., Hilton Garden Inn Missoula, 3720 N. Reserve St., Missoula, MT.

Week of November 14th

- Monday, November 14, 4 p.m. to 7 p.m., The Historic Davenport Hotel, 10 South Post Street, Spokane, WA.
- Wednesday, November 16, 4 p.m. to 7 p.m., Red Lion Hotel Lewiston, Seaport Room, 621 21st St., Lewiston, ID.
- Thursday, November 17, 4 p.m. to 7 p.m., Courtyard Walla Walla, The Blues Room, 550 West Rose St., Walla Walla, WA.

Week of November 28th

- Tuesday, November 29, 4 p.m. to 7 p.m., The Grove Hotel, 245 S. Capital Blvd., Boise, ID.
- Thursday, December 1, 4 p.m. to 7 p.m., Town Hall, Great Room, 1119 8th Ave., Seattle, WA.

Week of December 5th

- Tuesday, December 6, 4 p.m. to 7 p.m., The Columbia Gorge Discovery Center, River Gallery Room, 5000 Discovery Drive, The Dalles, OR.
- Wednesday, December 7, 4 p.m. to 7 p.m., Oregon Convention Center, 777 NE Martin Luther King Jr. Blvd., Portland, OR.
- Thursday, December 8, 4 p.m. to 7 p.m., The Loft at the Red Building, 20 Basin St., Astoria, OR.

Week of December 12th

- Tuesday, December 13, 2016, 10 a.m. to 11:30 a.m., and 3 p.m. to 4:30 p.m., PST, webinar. For those that cannot participate in person, an online webinar will be provided to interested parties. The webinar will cover the material discussed in the in-person public scoping meetings. Detailed instructions on how to participate in the webinar may be found on the project website at www.crso.info.

All comments need to be submitted by January 17, 2017. Should you need additional information, do not hesitate to contact www.crso.info or call: 1-800-290-5033. Thank you for your participation. We look forward to working with you on this important effort.

On behalf of the Action Agencies,
Sincerely,

David J. Ponganis, SES
Director, Programs

Appendix C

News Releases and Other Publications

Columbia River System Operations press releases were issued during the project scoping period and copies of each are presented on the ensuing pages of this appendix. The press release titles and issue dates are listed in Table C.1. In addition, various local and regional news articles, editorials, news programs, and letters to the editor were published concerning the scoping action (Table C.2).

Table C.1. Press Releases Issued by the Action Agencies During Scoping

Federal Agencies Begin Scoping Process for Columbia River System Operations EIS	9/30/2016
Federal Agencies to Hold Nine More Scoping Meetings for Columbia River System Operations EIS	11/09/2016
Federal Agencies to Host Two Webinars December 13 for Columbia River System Operations EIS	12/01/2016
Federal Agencies Postpone Astoria Public Scoping Meeting for Columbia River System Operations EIS	12/12/2016
Federal Agencies Postpone Astoria Public Scoping Meeting for Columbia River System Operations EIS	12/15/2016
Scoping Comment Period Extended for Columbia River System Operations EIS	12/23/2016
Update on Columbia River System Operations EIS Scoping Comments	3/31/2017

Environmental Impact Statement P.O. Box 2870, Portland, OR 97208-2870 1-800-290-5033

U.S. ARMY CORPS OF ENGINEERS DEPARTMENT OF THE ARMY | BUREAU OF RECLAMATION DEPARTMENT OF THE INTERIOR | BONNEVILLE POWER ADMINISTRATION DEPARTMENT OF ENERGY

NEWS RELEASE

Contact
Amy Gaskill, U.S. Army Corps of Engineers, (503) 808-3710
Kelly Bridges, Bureau of Reclamation, (208) 378-5020
David Wilson, Bonneville Power Administration, (503) 230-5607

For Release: September 30, 2016

Federal agencies begin scoping process for Columbia River System Operations EIS

PORTLAND, Oregon – The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration have announced their intent to prepare an environmental impact statement (EIS) on the Columbia River System operations and configurations for 14 federal projects in the interior Columbia Basin.

In this Columbia River System Operations EIS, the three agencies will present a reasonable range of alternatives for long-term system operations and evaluate the potential environmental and socioeconomic impacts on flood risk management, irrigation, power generation, navigation, fish and wildlife, cultural resources and recreation.

Beginning today, and concluding Jan. 17, 2017, the agencies are seeking comments through a public scoping period that provides anyone who is interested an opportunity to help the agencies identify issues and concerns that could be analyzed in the EIS. As part of the comment period, the agencies will host public scoping meetings throughout the Northwest at the following locations:

Oct. 24 Wenatchee Community Center 504 S. Chelan Ave. Wenatchee, Wash. 4-7 p.m.	Oct. 25 Coulee Dam City Hall 300 Lincoln Ave. Coulee Dam, Wash. 4-7 p.m.	Oct. 26 Priest River Community Center 5399 Highway 2 Priest River, Idaho 4-7 p.m.
Oct. 27 Kootenai River Inn Casino and Spa 7169 Plaza St. Bonners Ferry, Idaho 4-7 p.m.	Nov. 1 Red Lion Hotel Kalispell 20 North Main St. Kalispell, Mont. 4-7 p.m.	Nov. 2 City of Libby, City Hall Ponderosa Room 952 E. Spruce St. Libby, Mont. 4-7 p.m.

Nov. 3 Hilton Garden Inn Missoula 3720 N. Reserve St. Missoula, Mont. 4-7 p.m.	Nov. 14 The Historic Davenport Hotel 10 South Post St. Spokane, Wash. 4-7 p.m.	Nov. 16 Red Lion Lewiston Seaport Room 621 21st St. Lewiston, Idaho 4-7 p.m.
Nov. 17 Courtyard Walla Walla The Blues Room 550 West Rose Street Walla Walla, Wash. 4-7 p.m.	Nov. 29 The Grove Hotel 245 S. Capitol Blvd. Boise, Idaho 4-7 p.m.	Dec. 1 Town Hall Great Room 1119 8th Ave. Seattle, Wash. 4-7 p.m.
Dec. 6 The Columbia Gorge Discovery Center River Gallery Room 5000 Discovery Drive The Dalles, Ore. 4-7 p.m.	Dec. 7 Oregon Convention Center 777 NE Martin Luther King Jr. Blvd. Portland, Ore. 4-7 p.m.	Dec. 8 The Loft at the Red Building 20 Basin St. Astoria, Ore. 4-7 p.m.

Additionally, two webinars will be held Dec. 13, 2016, at 10-11:30 a.m. and 3-4:30 p.m. PST. Information and links to the webinar will be provided on the project website.

For more information about the Columbia River System Operations EIS, please visit www.crso.info. Information is also available by calling 800-290-5033, though official comments are not accepted over the phone. Written comments may be submitted at any of the public meetings or mailed to U.S. Army Corps of Engineers, Attn: CRSO EIS, P.O. Box 2870, Portland, Oregon 97208-2870. Emailed comments should be sent to comment@crso.info.

When submitting comments, please be aware that your entire comment including your name, address and email will become part of the public record.

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Environmental Impact Statement P.O. Box 2870, Portland, OR 97208-2870 1-800-290-5033

U.S. ARMY CORPS OF ENGINEERS DEPARTMENT OF THE ARMY | BUREAU OF RECLAMATION DEPARTMENT OF THE INTERIOR | BONNEVILLE POWER ADMINISTRATION DEPARTMENT OF ENERGY

NEWS RELEASE

Contact
Amy Gaskill, U.S. Army Corps of Engineers, (503) 808-3710
Kelly Bridges, Bureau of Reclamation, (208) 378-5020
David Wilson, Bonneville Power Administration, (503) 230-5607

For Release: Nov. 9, 2016

Federal Agencies to hold nine more scoping meetings for Columbia River System Operations EIS

PORTLAND, Oregon – About 300 people attended one of seven scoping meetings regarding the operation of 14 federal hydropower projects in the Columbia Basin. Nine more meetings and two webinars will be convened before the public comment period closes January 17, 2017, on the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS).

Hosted by the U.S. Army Corps of Engineers (Corps), the Bureau of Reclamation (Reclamation) and the Bonneville Power Administration (BPA), the open-house style meetings include more than a dozen learning stations, staffed by agency subject matter experts. The public comment period began on Sept. 30, 2016. Together the Corps, Reclamation, and BPA are using the scoping meetings to solicit public input on CRSO impacts such as flood risk management, irrigation, power generation, navigation, fish and wildlife, cultural resources, recreation and socioeconomic interests.

The agencies will accept comments until January 17, 2017, after which they will analyze the comments and develop a reasonable range of alternatives for long-term system operations. The range of alternatives will be further analyzed in the EIS draft that is expected to be completed by 2020 with a final due in 2021.

To date, the agencies have hosted scoping meetings at Wenatchee and Coulee Dam, Washington; Priest River and Bonners Ferry, Idaho and Kalispell, Libby and Missoula, Montana. A meeting in Pasco, Washington was added to the schedule.

Nov. 14 The Historic Davenport Hotel 10 South Post St. Spokane, Wash. 4-7 p.m.	Nov. 16 Red Lion Lewiston Seaport Room 621 21st St. Lewiston, Idaho 4-7 p.m.	Nov. 17 Courtyard Walla Walla The Blues Room 550 West Rose Street Walla Walla, Wash. 4-7 p.m.

Nov. 21 Holiday Inn Express Vineyard Ballroom 4525 Convention Place Pasco, Wash. 4-7 p.m.	Nov. 29 The Grove Hotel 245 S. Capitol Blvd. Boise, Idaho 4-7 p.m.	Dec. 1 Town Hall Great Room 1119 8th Ave. Seattle, Wash. 4-7 p.m.
Dec. 6 The Columbia Gorge Discovery Center River Gallery Room 5000 Discovery Drive The Dalles, Ore. 4-7 p.m.	Dec. 7 Oregon Convention Center 777 NE Martin Luther King Jr. Blvd. Portland, Ore. 4-7 p.m.	Dec. 8 The Loft at the Red Building 20 Basin St. Astoria, Ore. 4-7 p.m.

Two webinars, December 13, 2016 from 10-11:30 a.m. and 3-4:30 p.m. PDT are being hosted for those who are unable to attend one of the 16 meetings. Information and links to the webinars will be provided on the project website (www.crso.info).

For more information about the CRSO EIS, please visit www.crso.info. Information is also available by calling 800-290-5033. Although official comments are not accepted over the phone, written comments may be submitted at any of the public meetings or mailed to U.S. Army Corps of Engineers, Attn: CRSO EIS, P.O. Box 2870, Portland, Oregon 97208-2870. Emailed comments should be sent to comment@crso.info.

When submitting comments please be aware that your entire comment including your name, address and email will become part of the public record.

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Environmental Impact Statement P.O. Box 2870, Portland, OR 97208-2870 1-800-290-5033

U.S. ARMY CORPS OF ENGINEERS DEPARTMENT OF THE ARMY | BUREAU OF RECLAMATION DEPARTMENT OF THE INTERIOR | BONNEVILLE POWER ADMINISTRATION DEPARTMENT OF ENERGY

NEWS RELEASE

Contact:
Amy Gaskill, U.S. Army Corps of Engineers, 503-808-3710
Kelly Bridges, Bureau of Reclamation, 208-378-5020
David Wilson, Bonneville Power Administration, 503-230-5607

For Release: December 1, 2016

Federal Agencies to Host Two Webinars December 13 for Columbia River System Operations EIS

PORTLAND, Oregon – The U.S. Army Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration will host two public scoping webinars December 13 from 10 to 11:30 a.m. and 3 to 4:30 p.m. PST on the operation of 14 federal hydropower projects in the Columbia River Basin.

These electronic meetings are being hosted for those who are unable to attend one of the 16 face-to-face meetings scheduled across the Pacific Northwest from October 24 through December 8. A presentation on current system operations will be provided with a question and answer session following. Once the webinar has concluded, participants can then submit comments in one of three ways as discussed below.

Comments will be accepted through January 17, 2017, and can be submitted through the online comment form, via email at comment@crso.info, or mailed to U.S. Army Corps of Engineers, Attn: CRSO EIS, P.O. Box 2870, Portland, Oregon 97208-2870.

The call-in information for the morning webinar is as follows:
The conference begins at 10:00 AM Pacific Time on December 13, 2016; you may join 10 minutes prior.
Step 1: http://ems7.intellor.com/login/708750
Step 2: Enter Web Access ID hand578dhtkv
Step 3: Instructions for connecting to conference audio will then be presented on your computer.

You will be connected to the webinar with the AT&T Connect Web Participant Application; there is no software download or installation required.
If you are unable to connect to the conference by computer, you may listen by telephone only at 1-877-369-5243.
If you need technical assistance, please call the AT&T Help Desk at 1-888-796-6118 or 1-847-562-7015.

The call-in information for the afternoon webinar is as follows:
The conference begins at 3:00 PM Pacific Time on December 13, 2016; you may join 10 minutes prior.

Step 1: http://ems7.intellor.com/login/708737
Step 2: Enter Web Access ID hand578dhtkv
Step 3: Instructions for connecting to conference audio will then be presented on your computer.

You will be connected to the webinar with the AT&T Connect Web Participant Application; there is no software download or installation required.
If you are unable to connect to the conference by computer, you may listen by telephone only at 1-877-369-5243.
If you need technical assistance, please call the AT&T Help Desk at 1-888-796-6118 or 1-847-562-7015.

For more information about the Columbia River System Operations EIS, please visit www.crso.info or call 1-800-290-5033. Comments will not be accepted over the phone.

When submitting comments, please be aware that your entire comment, including your name, address, and email will become part of the public record.

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U.S. ARMY CORPS OF ENGINEERS DEPARTMENT OF THE ARMY | BUREAU OF RECLAMATION DEPARTMENT OF THE INTERIOR | BONNEVILLE POWER ADMINISTRATION DEPARTMENT OF ENERGY

MEDIA ADVISORY — Dec. 15, 2016

Federal agencies postpone Astoria public scoping meeting for Columbia River System Operations EIS

Who: U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration

What: The Dec. 8 Astoria Public Scoping meeting for Columbia River System Operations EIS was postponed due to anticipated inclement weather. The new date and time are listed below.

When and Where:

December 15
4 p.m. to 7 p.m.
The Loft at the Red Building
20 Basin St.
Astoria, Oregon

Instructions: For more information on this change please contact one of three media representatives: Amy Gaskill, U.S. Army Corps of Engineers, 503-808-3710; David Walsh, Bureau of Reclamation, 208-378-5020; or David Wilson, Bonneville Power Administration, 503-230-5607.

Background: As part of the CRSO environmental review, the three federal agencies are holding 16 public scoping meetings in the fall of 2016. Two webinars will also be held Tuesday, December 13 from 10 to 11:30 a.m. and 3 to 4:30 p.m. PST. The CRSO public scoping process ends, Jan. 17, 2017.

To learn more about the public scoping process, how to submit public comments and the preparation of the Columbia River System Operations EIS, please visit www.crso.info.

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Environmental Impact Statement P.O. Box 2870, Portland, OR 97208-2870 1-800-290-5033

U.S. ARMY CORPS OF ENGINEERS DEPARTMENT OF THE ARMY | BUREAU OF RECLAMATION DEPARTMENT OF THE INTERIOR | BONNEVILLE POWER ADMINISTRATION DEPARTMENT OF ENERGY

MEDIA ADVISORY — Dec. 15, 2016

Federal agencies postpone Astoria public scoping meeting for Columbia River System Operations EIS

Who: U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration

What: The Dec. 15 Astoria Public Scoping meeting for Columbia River System Operations EIS is postponed due to inclement weather. A new date and time has not been set but will likely be after Jan. 6, 2017.

Instructions: For more information on this change please contact one of three media representatives: Amy Gaskill, U.S. Army Corps of Engineers, 503-808-3710; David Walsh, Bureau of Reclamation, 208-378-5020; or David Wilson, Bonneville Power Administration, 503-230-5607.

Background: As part of the CRSO environmental review, the three federal agencies have held 15 public scoping meetings and two webinars in the fall of 2016. The CRSO public scoping process ends, Jan. 17 2017.

To learn more about the public scoping process, how to submit public comments and the preparation of the Columbia River System Operations EIS, please visit www.crso.info.

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Environmental Impact Statement P.O. Box 2870, Portland, OR 97208-2870 1-800-290-5033

U.S. ARMY CORPS OF ENGINEERS DEPARTMENT OF THE ARMY | BUREAU OF RECLAMATION DEPARTMENT OF THE INTERIOR | BONNEVILLE POWER ADMINISTRATION DEPARTMENT OF ENERGY

Amy Gaskill, U.S. Army Corps of Engineers, (503) 808-3710
David Walsh, Bureau of Reclamation, (208) 378-5020
David Wilson, Bonneville Power Administration, (503) 230-5607

For Release: 23 December 2016

Scoping Comment Period Extended for Columbia River System Operations EIS

PORTLAND, Oregon – The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration are extending the public scoping comment period for the Columbia River System Operations Environmental Impact Statement (EIS) by 3 weeks.

The previous comment period deadline was Jan. 17, 2017, and will now be extended to Feb. 7, 2017.

"Scoping comments from the public are a vital part of the EIS process, "said U.S. Army Corps of Engineers Northwestern Division Commander Major General Scott A. Spellmon. "We want to be sure the public has a chance to weigh in on the alternatives and impacts to be studied," he said.

Since Oct. 24, the three Action Agencies have held 15 public scoping meetings and two webinars across the Pacific Northwest. During this period the public and stakeholders were able to gather information and provide comment on the Columbia River System Operations and configurations for 14 federal projects in the interior Columbia Basin.

Comments collected during the scoping meetings, either in person, online or by mail will help inform a range of alternatives and impacts to resources for evaluation in the EIS. The agencies are committed to considering all regional perspectives and to running an open and transparent public process. To that end, the action agencies will continue to provide opportunities for meaningful engagement and dialogue with the region after the scoping comment period closes. A draft EIS will be completed and available for public review no later than spring 2020.

For more information about the Columbia River System Operations EIS, please visit www.crso.info. Written comments may be submitted by mail Attn: CRSO EIS, P.O. Box 2870, Portland, Oregon 97208-2870. Emailed comments should be sent to comment@crso.info. Information is also available by calling 800-290-5033, though official comments are not accepted over the phone.

When submitting comments, please be aware that your entire comment including your name, address and email will become part of the public record.

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NEWS RELEASE

For Release: March 31, 2017

Contact:
Amy Gaskill, U.S. Army Corps of Engineers, 503-808-3710
Michael Coffey, Bureau of Reclamation, 208-378-5020
David Wilson, Bonneville Power Administration, 503-230-5607

Update on Columbia River System Operations EIS Scoping Comments

More than 2,300 people attended a series of public meetings and webinars provided by the U.S. Army Corps of Engineers, Bonneville Power Administration, and the Bureau of Reclamation (Action Agencies) regarding the environmental impact statement (EIS) the Action Agencies are developing for the operations and maintenance of the Columbia River System (CRSO EIS).

The meetings were held throughout the Pacific Northwest from Oct 24, 2016 through Jan 9, 2017. The CRSO includes 14 federal dams and their related facilities located in the interior Columbia and Snake River Basins that are operated in a coordinated manner for multiple purposes.

During the four month public comment period, the Action Agencies urged members of the public to provide input on the scope of issues, potential effects, and range of alternatives to evaluate in the draft EIS. Together, the Action Agencies received 393,352 comments.

Some topics the public suggested for study include:

- Dam breaching
- Dam construction
- Operational changes
- Transportation analysis
- Recreational opportunities
- Replace hydropower generation with other sources of energy generation
- Increase hydropower generation
- Fish passage (non-structural)
- Fish management actions

The Action Agencies are producing the CRSO EIS to fulfill our National Environmental Policy Act responsibilities. Once completed, the CRSO EIS will describe the impacts associated with the long-term future operation and configuration of the Columbia River System projects.

To ensure stakeholders and other members of the public are kept informed during the CRSO EIS process, the Action Agencies plan to provide periodic updates through newsletters, fact sheets and dynamic content to the www.crso.info website. A draft CRSO EIS is expected by early 2020. The final EIS is expected in 2021.

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Table C.2. Publications Concerning CRSO Scoping

Date	Affiliation	Title	Link
1/26/2017	King-5	Snake River dams examined after decades of lawsuits	http://www.king5.com/tech/science/environment/snake-river-dams-examined-after-decades-of-lawsuits/393726964
1/19/2017	Pullman Daily News	Dams: To keep or to breach?	http://dnews.com/local/dams-to-keep-or-to-breach/article_e901fb00-5681-5389-a4ec-98381f6e33db.html
1/17/2017	The Daily News	Removing dams could affect Cowlitz industries, electric rates	http://tdn.com/news/local/removing-dams-could-affect-cowlitz-industry-electric-rates/article_6347b242-b7df-5233-8b13-ac42fd8be9b6.html
1/12/2017	Tri-City Herald	Letter: Lower four Snake River Dams are not the problem	http://www.tri-cityherald.com/opinion/letters-to-the-editor/article125972084.html
1/9/2017	The Guardian	Dams be damned, let the world's rivers flow again	https://www.theguardian.com/global-development-professionals-network/2017/jan/09/dams-building-let-rivers-flow
1/2/2017	Bend Bulletin	Historical sites enter debate over dams	http://www.bendbulletin.com/localstate/4947753-151/historical-sites-enter-debate-over-dams
12/30/2016	Tri-City Herald	Letter: Breaching Snake River dams would cause incalculable harm	http://www.tri-cityherald.com/opinion/letters-to-the-editor/article123610824.html
12/25/2016	Tri-City Herald	Letter: Snake Dams have decimated salmon productivity	http://www.tri-cityherald.com/opinion/letters-to-the-editor/article122813404.html
12/22/2016	Coeur d'Alene/ Post Falls Press	Keep our Snake River Dams	http://www.cdapress.com/archive/article-7248453e-7350-5a61-9c66-2dada69bf3ee.html
12/7/2016	Idaho Statesman	Lower Snake River farmers seek federal ruling to allow Idaho salmon to go extinct	http://www.idahostatesman.com/news/local/news-columns-blogs/letters-from-the-west/article119599948.html
12/7/2016	Sequim Gazette	Brunell: Removing Snake Dams is unwise	http://www.sequimgazette.com/opinion/brunell-removing-snake-river-dams-is-unwise/
12/6/2016	PRNE News Wire	Groups urge Trump Administration to protect lower Snake River dams in	http://www.prnewswire.com/news-releases/groups-urge-trump-administration-to-protect-lower-snake-river-dams-in-washington-state-300373609.html?wb48617274=E2AF4723

Date	Affiliation	Title	Link
		Washington State	
12/5/2016	Oregonian	Portland meeting on future of Snake River dams expected to draw big crowd	http://www.oregonlive.com/environment/index.ssf/2016/12/portland_meeting_on_future_of.html
11/29/2016	Forbes	Will removing large dams on the Snake River help salmon?	http://www.forbes.com/forbes/welcome/?toURL=http://www.forbes.com/sites/jamesconca/2016/11/29/will-removing-large-dams-on-the-snake-river-help-salmon/&refURL=&referrer=
11/27/2016	Tri-City Herald	Guest column: Breaching dams won't help Orcas	http://www.tri-cityherald.com/opinion/opn-columns-blogs/article117168133.html
11/25/2016	Idaho Statesman	Chris Carlson Commentary: Here's my idea for breaching the dams; what's yours?	http://lmtribune.com/opinion/here-s-my-idea-for-breaching-the-dams-what-s/article_59438323-310e-5054-84cd-46652e6d27b4.html
11/23/2016	Tri-City Herald	Letter: Snake River dams are vital part of state's economy	http://www.tri-cityherald.com/opinion/letters-to-the-editor/article116478368.html
11/19/2016	myfoxtricities.com	Public meeting to discuss Snake River dams	http://www.myfoxtricities.com/public-meeting-held-to-discuss-the-situation-involving-snake-river-dams/ No long available
11/21/2016	Tri-City Herald	People passionate about saving Snake River dams	http://www.tri-cityherald.com/news/local/article116355413.html
11/21/2016	OPB Radio	Courtney Flatt: Why the northwest is debating dams on the Snake River (again)	http://www.opb.org/news/article/future-of-the-snake-river-dams/
11/21/2016	Defenders of Wildlife	Public Hearing on orcas, salmon and Seattle	http://www.defenders.org/event/public-hearing-orcas-salmon-seattle No longer available
11/21/2016	KEPR TV	River OPS Meeting	http://mms.tveyes.com/Transcript.asp?StationID=4360&DateTime=11%2F21%2F2016+6%3A05%3A33+PM&Term=Bonneville+Power&PlayClip=TRUE No longer available.
11/20/2016	Tri-City Herald	Our Voice: Snake River dams in peril, so speak up	http://www.tri-cityherald.com/opinion/editorials/article116010548.html
11/20/2016	Seattle Times	Irrigators ask Trump for 'God Squad' as Snake River dam breaching floated	http://www.seattletimes.com/seattle-news/environment/irrigators-ask-trump-for-god-squad-as-snake-river-dam-breaching-floated/

Date	Affiliation	Title	Link
11/19/2016	Capital Press	Breaching Snake River dams would ‘devastate’ wheat industry, growers say	http://www.capitalpress.com/Idaho/20161120/breaching-snake-river-dams-would-devastate-wheat-industry-growers-say
11/18/2016	The Columbia Basin Bulletin	Hundreds turn out for Lewiston federal scoping meeting regarding draft EIS for Snake River Dams	http://www.cbbulletin.com/437988.aspx
11/17/2016	Spokesman Review	Big crowd turns out in Spokane to talk about lower Snake River dams	http://www.spokesman.com/stories/2016/nov/14/big-crowd-turns-out-in-spokane-to-talk-about-lower/#/0
11/17/2016	Spokesman Review	Snake River dams meetings raise flood of interest	http://www.spokesman.com/blogs/outdoors/2016/nov/17/snake-river-dams-meetings-raise-flood-interest/
11/16/2016	KPQ Radio	Dams on the Snake River?	http://kpq.com/dams-snake-river/
11/16/2016	Idaho Statesman	Dam Removal is poised for a breakthrough	http://www.idahostatesman.com/opinion/readers-opinion/article114829658.html
11/15/2016	East Oregonian,	Region depends on Columbia-Snake River system	http://www.eastoregonian.com/eo/columnists/20161115/region-depends-on-columbia-snake-river-system
11/15/2016	East Oregonian	Meeting to weigh in on Columbia River system	http://www.eastoregonian.com/eo/local-news/20161115/meeting-to-weigh-in-on-columbia-river-system
11/15/2016	OPB Radio	Conservation groups ask for changes to Snake River Dams Hearings	http://www.opb.org/news/article/conservation-groups-ask-for-changes-to-snake-river-dams-hearings/
11/15/2016	Public News Service	lower Snake River Dams, Nez Perce Treaty Rights at Issue	https://www.nmtribune.com/lower-snake-river-dams-nez-perce-treaty-rights-at-issue/. No longer available
11/15/2016	KXLY TV	Removing Snake Dams	http://mms.tveyes.com/Transcript.asp?StationID=3560&DateTime=11%2F14%2F2016+6%3A50%3A10+PM&Term=Bonneville+Power&PlayClip=TRUE. No longer available
11/15/2016	KPVI TV	Meeting on Snake River Dam Removal	http://mms.tveyes.com/Transcript.asp?StationID=5225&DateTime=11%2F15%2F2016+6%3A39%3A15+AM&Term=Bonneville+Power&PlayClip=TRUE. No longer available
11/13/2016	Spokesman Review	Columbia, Snake dams topic of public meetings	http://www.spokesman.com/stories/2016/nov/13/columbia-snake-dams-topic-of-public-meetings/

Date	Affiliation	Title	Link
11/12/2016	Tri-City Herald	Under pressure, Corps adds dam meeting in Tri-Cities	http://www.tri-cityherald.com/news/local/article114468843.html
11/9/2016	Spokesman Review	Snake River dams vs salmon hearing in Spokane on Monday	http://www.spokesman.com/blogs/outdoors/2016/nov/09/snake-river-dams-vs-salmon-hearing-spokane-monday/
11/6/2016	Idaho Statesman	Judge's order revives movement to remove dams	http://www.idahostatesman.com/news/state/idaho/article112912313 html. No longer available.
11/3/2016	National Resources Defense Council	Without salmon, we lose our killer whales	https://www.nrdc.org/experts/giulia-cs-good-stefani/without-salmon-we-lose-our-killer-whales
11/2/2016	Peninsula Daily News	PAT NEAL: Dam removal a whale of an issue -	http://www.peninsuladailynews.com/opinion/pat-neal-dam-removal-a-whale-of-an-issue/
11/2/2016	Chiwulff.com	Throw your two cents in on the Snake River Dams	http://chiwulff.com/2016/11/02/throw-your-two-cents-in-on-the-snake-river-dams/
11/2/2016	Priest River Times	Feds come to town to gather input	http://www.priestrivertimes.com/article/20161102/ARTICLE/161109997
11/2/2016	Kpax.com	Dam hearings come to Western Montana	http://www.kpax.com/story/33594221/dam-hearings-come-to-western-montana
11/1/2016	AgInfo net	Public meetings to discuss scope of Columbia River System	http://aginfo.net/index.cfm/report/id/Farm-and-Ranch-Report-35543
10/31/2016	Flathead Beacon	Federal agencies examining Columbia River Dam operations	http://flatheadbeacon.com/2016/10/31/federal-agencies-examining-columbia-river-dam-operations/
10/28/2016	Christian Science Monitor and AP	Puget Sound orcas: Would removing dams save the whales?	http://www.csmonitor.com/Environment/2016/1029/Puget-Sound-orcas-Would-removing-dams-save-the-whales
10/28/2016	Tribal Tribune	Federal agencies to host scoping meetings	http://www.tribaltribune.com/news/article_9f8a0e74-9d1e-11e6-81ca-3366e8fd7b0b html
10/27/2016	Spokesman Review	Feds release recovery plan for Snake River chinook and steelhead	http://www.spokesman.com/stories/2016/oct/27/feds-release-recovery-plan-for-snake-river-chinook/

Date	Affiliation	Title	Link
10/27/2016	Char-Koosta News	Agencies preparing environmental impact statement	http://www.charkoosta.com/2016/2016_10_27/EIS.html
10/26/2016	Natural Resource Report	Ag Action Call over Columbia Basin plan	http://naturalresourcereport.com/2016/10/ag-action-call-over-columbia-basin-plan/
10/25/2016	Capital Press	Ag voices must be heard on Columbia River System, group says	http://www.capitalpress.com/Water/20161025/ag-voices-must-be-heard-on-columbia-river-system-group-says
10/25/2016	Wenatchee World	Feds begin meeting tour on salmon-protection plans	http://www.wenatcheeworld.com/news/2016/oct/25/feds8217-salmon-outreach-long-on-content-short-on-context/
10/24/2016	Spokesman Review	Pressure mounts on lower Snake dams as fish runs sag	http://www.spokesman.com/stories/2016/oct/24/pressure-mounts-on-lower-snake-dams-as-fish-runs-s/
10/24/2016	Spokesman Review	Lower Snake River Dams have a long history of controversy	http://www.spokesman.com/stories/2016/oct/24/lower-snake-river-dams-have-a-long-history-of-cont/
10/22/2016	Spokesman Review	Nancy Hirsh: We can restore salmon and have carbon-free energy	http://www.spokesman.com/stories/2016/oct/22/we-can-restore-salmon-and-have-carbon-free-energy/
10/21/2016	OPB	Taking down Snake River Dams: It's back on the table	http://www.opb.org/news/article/taking-down-snake-river-dams-on-table/
10/19/2016	Priest River Times	River OPS meeting set	http://www.priestrivertimes.com/article/20161019/ARTICLE/161019947
10/19/2016	The Star	A federal review of the entire river will be worth watching	http://www.grandcoulee.com/story/2016/10/19/opinion/a-federal-review-of-the-entire-river-will-be-worth-watching/7971.html
10/17/2016	Seattle Times	Environmental effects of Columbia, Snake River Dams scrutinized	http://www.seattletimes.com/seattle-news/environment/environmental-effects-of-columbia-snake-river-dams-scrutinized/
10/12/2016	Forbes	Global warming versus salmon: Dam if You Do, Dam if You Don't	http://www.forbes.com/sites/jamesconca/2016/10/12/global-warming-versus-salmon-dam-if-you-do-dam-if-you-dont/#2a63ed8b614e

Date	Affiliation	Title	Link
10/7/2016	Columbia Basin Bulletin	Agencies seek public scoping comments for EIS related to new basin salmon/steelhead recovery plan	http://www.cbbulletin.com/437702.aspx
10/4/2016	The Idaho Statesman	Will federal agencies' review of Columbia, Snake dams lead to removal?	http://www.idahostatesman.com/news/local/news-columns-blogs/letters-from-the-west/article105835657.html
10/03/2016	newsdata.com	Analysis: How might the Columbia's hydro system be altered to strengthen fish rebuilding?	http://www.newsdata.com/fishletter/362/2story html
10/03/2016	Greenwire.com	Ruling prompts debate on dam removal - Staff	No link, full article in "summary" section
10/2/2016	The Register Guard	A federal judge is forcing discussion of a radical step to save endangered salmon: taking out four dams on the lower Snake River -- Becky Kramer	http://projects registerguard.com/apf/ore/wa-salmon-habitat-restoration/. No longer available
10/2/2016	Bonner County Daily Bee	Updated EIS sought for Columbia River dams	http://www.bonnercountydailybee.com/local_news/20161002/updated_eis_sought_for_columbia_river_dams
10/01/2016	Lewiston Tribune	Feds Taking Comments on Plan for Snake-Columbia Dams: Planned environmental statement expected to take five years to complete	http://lmtribune.com/northwest/feds-taking-comments-on-plan-for-snake-columbia-dams/article_ad452e2b-7935-5bcc-af01-b9ddf0ea072a html
9/30/2016	Earthjustice	Feds announce hearings for public to weigh in on lower Snake River dam removal	http://earthjustice.org/news/press/2016/feds-announce-hearings-for-public-to-weigh-in-on-lower-snake-river-dam-removal

Date	Affiliation	Title	Link
9/30/2016	Idaho Rivers United	Unfolding comment period give Idahoans a voice for salmon	http://www.idahorivers.org/newsroom/2016/9/30/upcoming-hearings-will-give-idahoans-a-voice-for-salmon
9/30/2016	Spokesman Review	Feds asking public to weigh in on breaching Snake River Dams	http://www.spokesman.com/stories/2016/sep/30/should-lower-snake-river-dams-be-breached/

Appendix D

Newspaper Advertisements

The U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the Bonneville Power Administration issued a series of advertisements in local newspapers to announce public meetings regarding the preparation of an environmental impact statement for Columbia River system operations, which are presented on the following pages.

Wenatchee Public Meeting
October 24, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Wenatchee World	Sunday, Tuesday, Friday	10/11/16 (T)	10/16/16 (Su)	10/18/16 (T)
Cashmere Valley Record	Wednesday	10/12/16 (W)	10/19/16 (W)	

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Monday, October 24, 2016
4 p.m. to 7 p.m.
Wenatchee Community Center
504 S. Chelan Avenue
Wenatchee, Washington

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*

Information is also available by calling 800-290-5033.

Coulee Dam Public Meeting
October 25, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date
Coulee City News Standard	Wednesday	10/12/16 (W)	10/19/16 (W)
The Star	Wednesday	10/12/16 (W)	10/19/16 (W)

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Tuesday, October 25, 2016
4 p.m. to 7 p.m.
The Town of Coulee Dam, City Hall
300 Lincoln Avenue
Coulee Dam, Washington

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*

Information is also available by calling 800-290-5033.

Priest River Public Meeting
October 26, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date
Priest River Times	Wednesday	10/12/16 (W)	10/19/16(W)

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

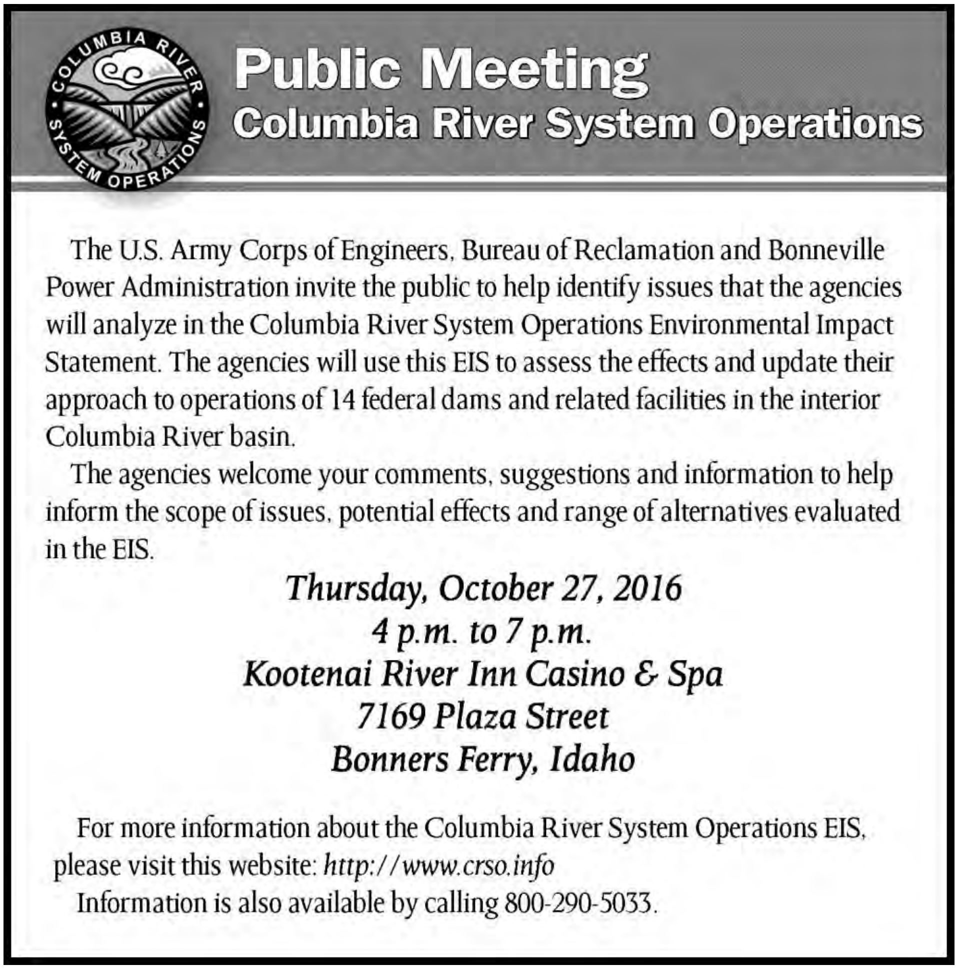
Wednesday, October 26, 2016
4 p.m. to 7 p.m.
Priest River Community Center
5399 Hwy 2
Priest River, Idaho

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*

Information is also available by calling 800-290-5033.

Bonners Ferry Public Meeting
October 27, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Bonner County Daily Bee	Daily	10/13/16 (Th)	10/20/16 (Th)	10/22/16 (Su)
Bonners Ferry Herald	Thursday	10/13/16 (Th)	10/20/16 (Th)	



Kalispell Public Meeting
November 1, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Daily Inter Lake	Daily	10/18/16 (Tu)	10/25/16 (Tu)	10/30/16 (Su)
Flathead Beacon	Wednesdays	10/19/16 (W)	10/26/16 (W)	

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Tuesday, November 1, 2016
4 p.m. to 7 p.m.
Red Lion Hotel Kalispell
20 North Main Street
Kalispell, Montana

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Libby Public Meeting
November 2, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date
The Montanian	Wednesday	10/19/16 (W)	10/26/16 (W)
Western News	Tuesdays, Fridays	10/18/16 (Tu)	10/25/16 (Tu)

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Wednesday, November 2, 2016
4 p.m. to 7 p.m.
City of Libby City Hall
952 E. Spruce Street
Libby, Montana

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Missoula Public Meeting
November 3, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Missoula Independent	Thursday	10/20/16 (Th)	10/27/16 (Th)	
The Missoulian	Daily	10/20/16 (Th)	10/27/16 (Th)	10/30/16 (Su)

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Thursday, November 3, 2016
4 p.m. to 7 p.m.
Hilton Garden Inn Missoula
3720 N. Reserve Street
Missoula, Montana

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Spokane Public Meeting
November 14, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Cheney Free Press	Thursday	11/3/16 (Th)	11/10/16 (Th)	
Spokesman-Review	Daily	10/31/16 (M)	11/7/16 (M)	11/13/16 (Su)
Spokane Valley News Herald	Friday	11/4/16 (F)	11/11/16 (F)	

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Monday, November 14, 2016
4 p.m. to 7 p.m.
The Historic Davenport Hotel
10 South Post Street
Spokane, Washington

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Lewiston Public Meeting
November 16, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Lewiston Morning Tribune	Daily	11/2/16 (W)	11/9/16 (W)	11/13/16 (Su)
Moscow Pullman Daily	Monday - Saturday	11/2/16 (W)	11/9/16 (W)	11/12/16 (Sa)

COLUMBIA RIVER SYSTEM OPERATIONS

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Wednesday, November 16, 2016
4 p.m. to 7 p.m.
Red Lion Hotel Lewiston, Seaport Room
621 21st Street
Lewiston, Idaho

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Walla Walla Public Meeting
November 17, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Tri-City Herald	Daily	11/3/16 (Th)	11/10/16 (Th)	11/13/16 (Su)
Waitsburg Times	Thursday	11/3/16 (Th)	11/10/16 (Th)	
Walla Walla Union-Bulletin	Daily	11/3/16 (Th)	11/10/16 (Th)	11/13/16 (Su)

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Thursday, November 17, 2016
4 p.m. to 7 p.m.
Courtyard Walla Walla, The Blues Room
550 West Rose Street
Walla Walla, Washington

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Pasco Public Meeting
November 21, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Hermiston Herald	Wednesday	11/9/16 (W)	11/16/16 (W)	
Tri-City Herald	Daily	11/16/16 (W)	11/18/16 (F)	11/20/16 (Su)
Walla Walla Union Bulletin	Daily	11/18/16 (F)	11/20/16 (Su)	

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Monday, November 21, 2016
4 p.m. to 7 p.m.
Holiday Inn Express & Suites
4525 Convention Place
Pasco, Washington

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Boise Public Meeting
November 29, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Boise Idaho Statesman	Daily	11/15/16 (Tu)	11/22/16 (Tu)	11/27/16 (Su)

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Tuesday, November 29, 2016
4 p.m. to 7 p.m.
The Grove Hotel
245 S. Capital Blvd.
Boise, Idaho

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Seattle Public Meeting
December 1, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Bellevue Reporter	Friday	11/18/16 (F)		
Seattle Times	Daily	11/17/16 (Th)	11/24/16 (Th)	11/27/16 (Su)
Seattle Weekly	Wednesday	11/16/16 (W)	11/23/16 (W)	

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Thursday, December 1, 2016
4 p.m. to 7 p.m.
Town Hall, Great Room
1119 8th Avenue
Seattle, Washington

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

The Dalles Public Meeting
December 6, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date
The Dalles Chronicle	Sunday, Tuesday - Friday	11/22/2016 (Tu)	11/29/2016 (Tu)
Hood River News	Wednesday and Saturday	11/23/2016 (W)	11/30/2016 (W)

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Tuesday, December 6, 2016
4 p.m. to 7 p.m.
The Columbia Gorge Discovery Center, River Gallery Room
5000 Discovery Drive
The Dalles, Oregon

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Portland Public Meeting
December 7, 2016

Newspaper	Publication Cycle	1st Run Date	2nd Run Date	3rd Run Date
Portland Oregonian	Sunday, Wednesday, Friday, Saturday	11/23/2016 (W)	11/30/2016 (W)	
Portland Tribune	Tuesdays, Thursdays	11/22/2016 (Tu)	11/24/2016 (Th)	11/29/2016 (Tu)
Beaverton Valley Times/Tigard Times/Lake Oswego Review/West Linn Review	Thursdays	11/24/2016 (Th)	12/1/16 (Th)	
Hood River News	Wednesday and Saturday	11/23/16 (W)	11/30/2016 (W)	

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Wednesday, December 7, 2016
4 p.m. to 7 p.m.
Oregon Convention Center
777 NE Martin Luther King Jr. Blvd.
Portland, Oregon

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Astoria Public Meeting
December 15, 2016 (Cancelled due to weather)

Newspaper	Publication Cycle	1st Run Date	2nd Run Date
Daily Astorian	Monday–Friday	11/24/16 (Th)	12/1/16 (Th)
Warrenton Columbia Press	Friday	11/25/16 (F)	12/2/16 (F)

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Thursday, December 15, 2016
4 p.m. to 7 p.m.
The Loft at the Red Building
20 Basin Street
Astoria, Oregon

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Astoria Public Meeting
January 9, 2017

Newspaper	Publication Cycle	1st Run Date	2nd Run Date
Daily Astorian	Monday–Friday	12/30/2016 (F)	1/6/2017 (F)
Warrenton Columbia Press	Friday	1/6/2017 (F)	

Public Meeting
Columbia River System Operations

The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration invite the public to help identify issues that the agencies will analyze in the Columbia River System Operations Environmental Impact Statement. The agencies will use this EIS to assess the effects and update their approach to operations of 14 federal dams and related facilities in the interior Columbia River basin.

The agencies welcome your comments, suggestions and information to help inform the scope of issues, potential effects and range of alternatives evaluated in the EIS.

Monday, January 9, 2017
4 p.m. to 7 p.m.
The Loft at the Red Building
20 Basin Street
Astoria, Oregon

For more information about the Columbia River System Operations EIS, please visit this website: *http://www.crso.info*
Information is also available by calling 800-290-5033.

Appendix E

Scoping Meeting Handout

Public meetings were held to provide information on how the co-leads currently manage the Columbia River system, to allow the public to engage in dialog with subject matter experts from the agencies, and to communicate how the public could contribute their comments and ideas on what should be included in the environmental impact statement. An open house guide was distributed to attendees at each scoping meeting, providing information and guidance as to the scoping process and procedures, as well as the topics to be included in the environmental impact statement. A copy of the guide is provided on the following two pages.

Open House Guide

Today's meeting is to provide you with detailed information on the process we are undertaking, the current system operations, and how the system is used to meet multiple purposes. It is important because we want to make sure you have the information you need to share your ideas on what we should consider in the environmental impact statement (EIS). The EIS will evaluate and update the Agencies' (U.S. Army Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration) approach to long-term system operations and dam configuration through a thorough analysis of alternatives to current practices.

Please stop by and watch the video, then visit with the subject matter experts we have brought along. They are prepared to provide you more information on the following topics:

NEPA
Public participation in the development of an EIS is required by the National Environmental Policy Act (NEPA). The public is encouraged to comment and provide feedback on the potential impacts of Columbia River System Operations (CRSO) operations and configurations.

Cultural Resources
The Agencies seek input regarding steps to avoid, minimize, or mitigate adverse effects that would result from changes in system operations as required under the National Historic Preservation Act.

System Overview
The Columbia River Basin is a large and complex system that supports regional and tribal economies, wildlife, flood risk management, hydropower, navigation, irrigation, recreation, water quality, and fish migration.

Flood Risk Management
Flooding associated with natural weather events in the past had severe consequences. The CRSO provides for flood control through storage and release operations at dams and reservoirs.

Hydropower
The CRSO provides hydropower energy, and is a flexible and sustainable energy resource that provides energy to meet continuous and peak demand needs.

Irrigation
The Bureau of Reclamation delivers irrigation water to the Columbia Basin Project and other smaller projects. This irrigation water supports crops such as grapes, hops, fruit trees, potatoes, sweet corn, onions, and alfalfa.

Navigation
The Columbia River System supports both commercial and recreational vessel navigation. Recreational boaters can enjoy the entire river system, and commercial goods can be transported between the Pacific Ocean and inland ports in Washington and Idaho.

Fish and Wildlife Conservation
The Agencies implement fish and wildlife conservation, protection, and mitigation activities in compliance with the Endangered Species Act, Clean Water Act, and the Northwest Power Act.

Recreation
Residents in the Northwest enjoy many recreational opportunities associated with Federal project reservoirs and lands throughout the Columbia River Basin.

Climate Change
The Columbia River Basin will continue to have fluctuations in temperature and snowpack, which require adaptation to these changing conditions in the future.

Water Quality
Water quality is important for the health of aquatic species that reside in Columbia River Basin waters. The Agencies operate the Columbia River Basin dams to manage temperatures and total dissolved gas, and monitor other water quality parameters such as nutrients and dissolved oxygen.

Endangered Species Act Listed Fish and Lamprey Information
Partnerships among government and tribal entities, non-governmental and private organizations are critical to restoring healthy salmon runs and securing the economic and cultural benefits they provide.

CRSO Projects
Authorized purposes for CRSO dams include flood control, navigation, hydropower, irrigation, recreation, and support fish & wildlife.

The U.S. Army Corps of Engineers, Northwestern Division, Bureau of Reclamation, and Bonneville Power Administration (collectively, the Agencies) are the co-leads in preparation of an EIS under NEPA on CRSO operations and configurations for 14 Federal projects in the interior Columbia Basin. The Agencies request your assistance in gathering information that will help define the issues, concerns, and the scope of alternatives addressed in the EIS. Information will be gathered from interested parties during the scoping period beginning September 30, 2016, and ending January 17, 2017.

The Agencies welcome your comments, suggestions, and information that may inform the scope of issues, potential effects, and range of alternatives evaluated in the EIS. Comments may also be submitted at public scoping meetings at the Comment station.

Comments or inquiries can also be submitted:

By online comment submission: http://www.crso.info

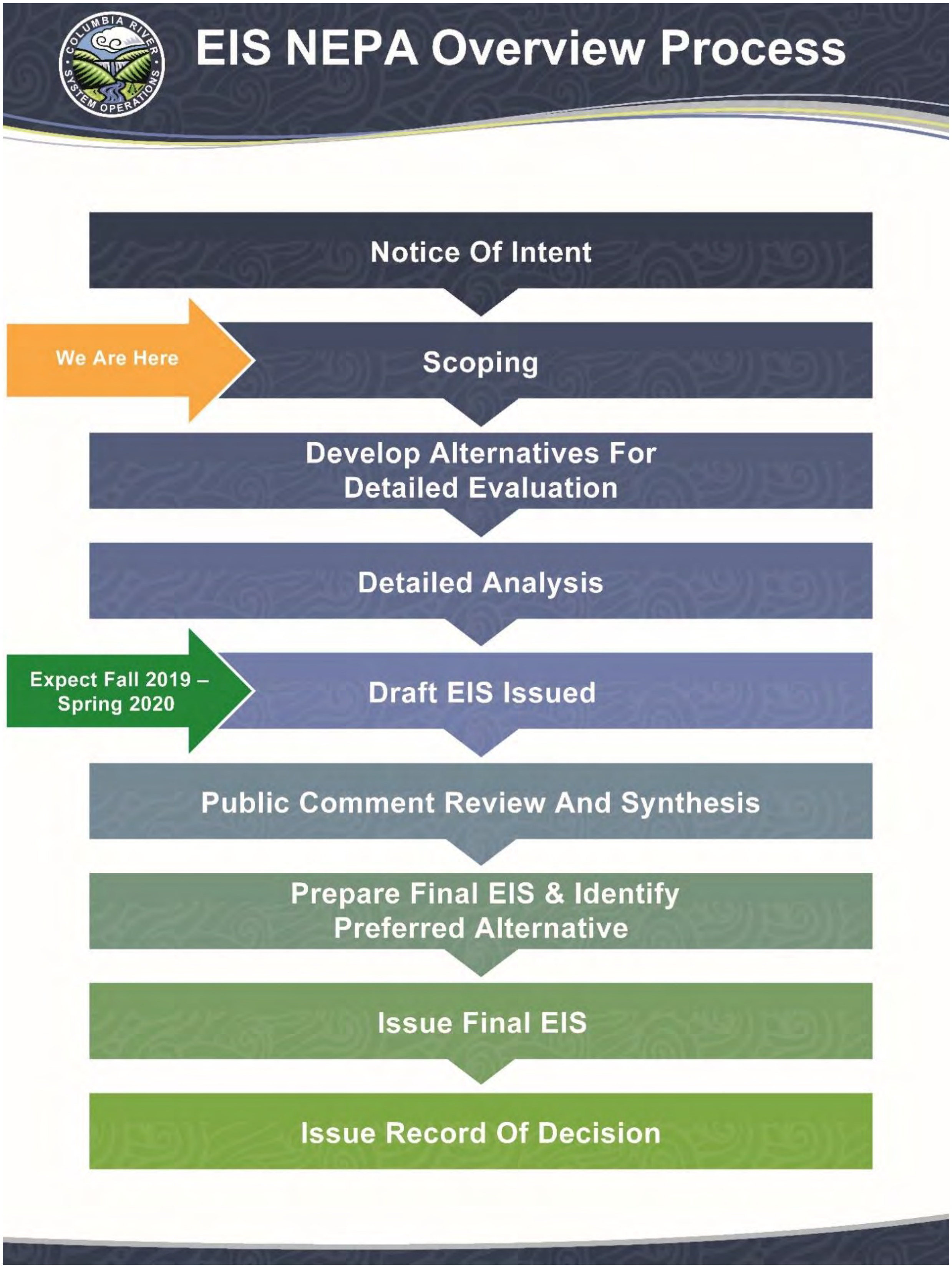
By email to comment@crso.info

By mail addressed to:
U.S. Army Corps of Engineers, Northwestern Division,
Attn: CRSO EIS, P.O. Box 2870, Portland, OR 97208-2870.

Appendix F

Scoping Meeting Posters

Public scoping meetings were held by the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the Bonneville Power Administration, providing information to the public as to the National Environmental Policy Act process and how to contribute comments and ideas concerning the environmental impact statement. At each meeting, poster stations were created, allowing the attendees an opportunity to review information and discuss topics regarding environmental impact statement development. Poster topics included an overview of the National Environmental Policy Act and environmental impact statement process, a map and overview of the Columbia River system, National Historic Preservation Act Section 106 information, a brief history of flood risk management and current flood risks, hydropower, irrigation, navigation, fish and wildlife, recreation, climate change, water quality, and the dams included in the Columbia River System. Copies of each posterboard are provided in the ensuing pages.


EIS NEPA Overview Process
Notice Of Intent
We Are Here
Scoping
Develop Alternatives For Detailed Evaluation
Detailed Analysis
Expect Fall 2019 – Spring 2020
Draft EIS Issued
Public Comment Review And Synthesis
Prepare Final EIS & Identify Preferred Alternative
Issue Final EIS
Issue Record Of Decision

National Environmental Policy Act

The National Environmental Policy Act (NEPA):

Enacted as law in 1970, NEPA establishes a national environmental policy and provides a process for implementing the goals of the law which are protecting, maintaining, and enhancing the environment.

Encourages harmony between people and the environment;

Promotes efforts to prevent or eliminate unnecessary environmental change;

Requires Federal agencies to:

(1) consider potential environmental consequences prior to making a decision to proceed and,
(2) provide opportunities for public involvement in the decision-making process.

NEPA and You - *Your Involvement is Important*

We need your input

Your comments:

- Help shape the direction and analysis of the impacts
- Ensure your concerns are part of the public record and are shared with decision makers who benefit from your knowledge
- Should present reasonable alternatives or components to the project with a rational basis for consideration of the alternative or component
- Should consider potential impacts to you such as your property, your community and local infrastructure, services, economy, etc.
- Should identify resource issues and/or alternatives to the project or its components while providing a rational basis for consideration of issues or alternatives identified.

1. Need for action identified and proposal developed.
2. Are environmental effects likely to be significant?
3. If YES, prepare Environmental Impact Statement.
4. Publish Notice of Intent.
5. Conduct public scoping. PUBLIC INVOLVEMENT — WE ARE HERE
6. Draft Environmental Impact Statement.
7. Public review and comment of Draft EIS. PUBLIC INVOLVEMENT
8. Final Environmental Impact Statement.
9. Public availability of Final EIS.
10. Record of Decision.

NEPA

Section 106 of the National Historic Preservation Act (NHPA)

Your Comments are Invited

NHPA requires Federal agencies to take into account the effects of their actions on historic properties. As a part of this process, the agencies must "seek and consider the views of the public." The Action Agencies are using the CRSO EIS scoping meetings to solicit public comment about historic properties. Your comments are an important part of this process.

Public comments about the steps taken to identify and evaluate historic properties will help the Action Agencies make an informed decision. We also invite comments about the steps that might be taken to avoid, minimize, or mitigate adverse effects that would result from changes in system operations.

NEPA & NHPA Coordination

NEPA and NHPA are separate but related laws that the Action Agencies will coordinate.

NEPA Process	NHPA Section 106
Notice of Intent to prepare an EIS	Initiate Section 106 consultation
Scoping Meeting and public comment	State Historic preservation offices (SHPO), tribes, & other parties provide input on historic properties
Action Agencies publish Draft EIS	
Public reviews Draft EIS and provides comments	SHPOs, tribes and other consulting parties provide input on finding of effects
Action Agencies publish Final EIS	
Public Availability of Final EIS	Conclude Section 106 consultation (End of Section 106 process)
Record of Decision (end of NEPA process)	

Cultural Resources Program

The Action Agencies manage historic properties at 14 Federal dams and reservoirs in the Columbia River basin. ***More than 4000 cultural resources have already been identified.*** *The cultural resources and historic properties are managed for the benefit and enjoyment of the American people while also fulfilling important missions to the public, including providing hydroelectric energy, flood control management, management of endangered species and habitat, and recreation.*

What are "Cultural Resources" and "Historic Properties?"

Cultural resources are objects or places of human activity, occupation, or use that are assigned a value by social or cultural groups.

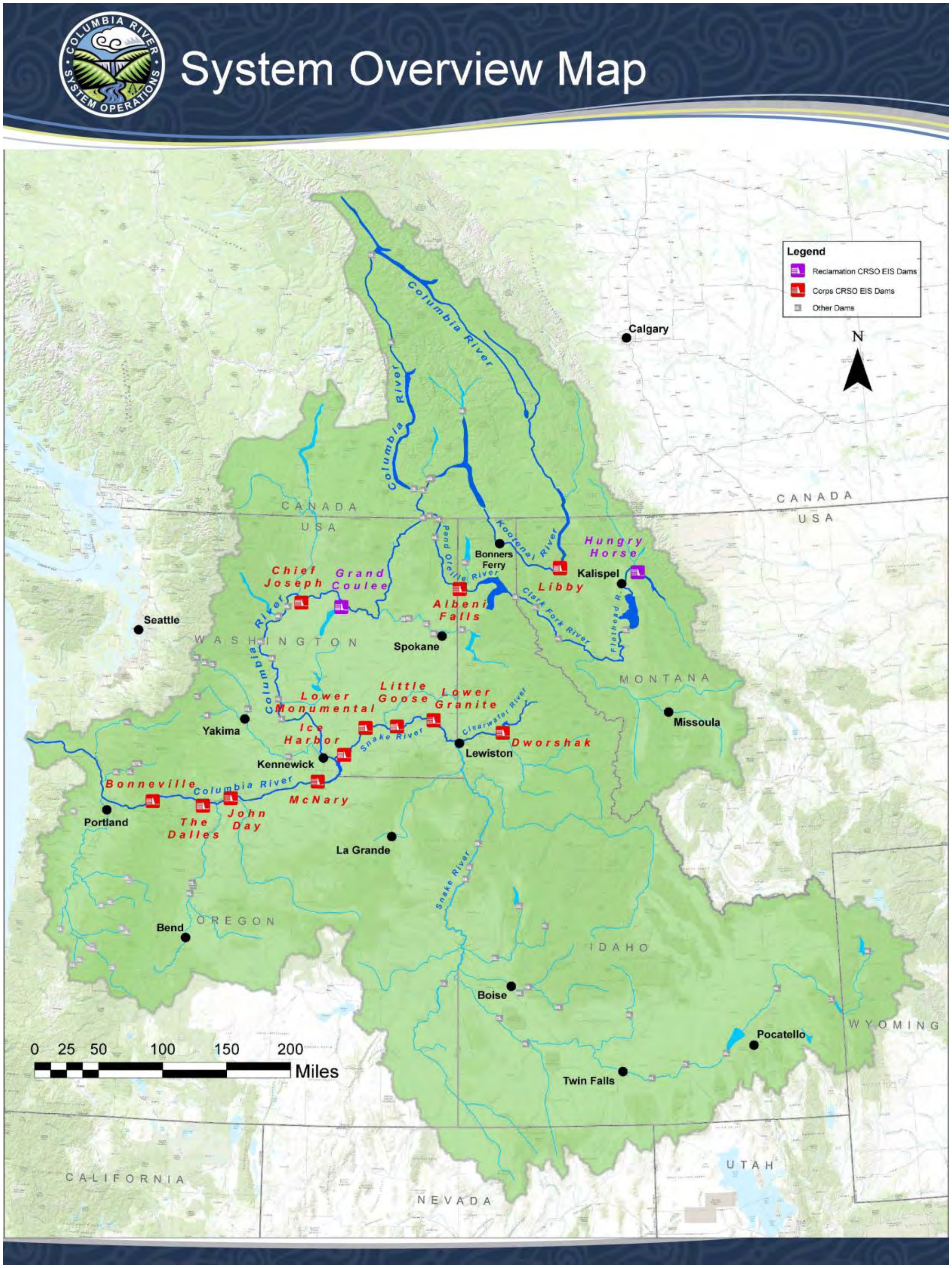
Historic properties are a legally defined subset of cultural resources, and refers specifically to cultural resources that have been determined to be eligible for inclusion on the National Register of Historic Places.

This knoll in central Idaho marks the origin place of the Nez Perce Tribe and is an example of a traditional cultural property.

Pre-contact archaeological sites are frequent throughout the Columbia River basin, as Native Americans focused much of their lives on salmon and other resources.

The historical significance of Bonneville Dam has been recognized by the Secretary of the Interior who made this structure a National Historic Landmark in 1987.

Sometimes, it is not feasible to address adverse effects where they occur. The Action Agencies supported restoration of this historic building as a form of off site mitigation.


System Overview Map
Columbia River System Operations
Legend
Reclamation CRSO EIS Dams
Corps CRSO EIS Dams
Other Dams
N
Calgary
Columbia River
Kootenai River
Pend Oreille River
Clark Fork River
Flathead R.
Snake River
Clearwater River
CANADA
USA
Hungry Horse
Kalispel
Libby
Bonners Ferry
Albeni Falls
Chief Joseph
Grand Coulee
Seattle
WASHINGTON
Spokane
MONTANA
Missoula
Lower Monumental
Little Goose
Lower Granite
Ice Harbor
Dworshak
Yakima
Kennewick
Lewiston
Bonneville
The Dalles
John Day
McNary
Portland
La Grande
OREGON
Bend
IDAHO
Boise
WYOMING
Pocatello
Twin Falls
0 25 50 100 150 200 Miles
CALIFORNIA
NEVADA
UTAH

System Operations Overview

Managing a Complex System

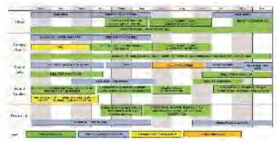
Managing a Complex System

The Columbia River Basin is a large and complex system with variable stream flows and weather patterns. The economic vitality of the region and its tribes, communities, industries, and fish and wildlife species, all depend on the system's ability to provide for multiple uses, including flood risk management, hydropower, navigation, irrigation, recreation, water quality, and fish and wildlife.

Project Authorizations

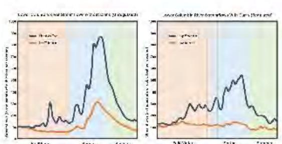
The federal Columbia River Basin projects (dams, reservoirs, and other associated facilities) are operated to meet many authorized purposes. These multiple uses must be considered and balanced in operational decisions. Actions that benefit one use or resource can have the opposite effect on others.

The people of the Northwest use the Columbia River in many ways. The water projects make up a multiple-use system.

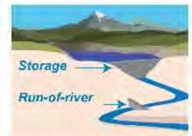


How do dams change river flows?

The Columbia River Basin experiences a wide range in runoff from year to year, from floods to droughts. Each water year poses different challenges for operators. Without the dams in place, the spring months would experience very high flows from melting snow while fall, winter, and summer flows would be low. The dams store water in the spring, reducing potential flooding from damaging river levels downstream. Once reservoirs fill in the summer, some storage projects are drafted (water is released) to augment naturally low summer flows in the lower river. This is done to improve river conditions for migrating fish. In the fall and winter, reservoirs water levels are lowered in preparation for flood risk management operations to capture the spring runoff. This also provides more water in the rivers and generates power and helps meet winter demand for electricity.



Storage vs. Run-of-River

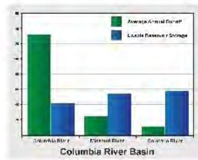


Storage projects hold water in reservoirs and reshape the river's flow patterns to meet a variety of authorized project purposes. Water from rain and snowmelt is stored until it is needed. This water is later released through turbines to generate electricity, to meet irrigation needs and provide flows for fish migration. Storage helps regulate flows, reducing potentially damaging floods downstream, while providing valuable water during dry periods.

Run-of-river projects have limited storage. They allow water to pass the dam at about the same rate it enters the reservoir. They provide power generation and may give sufficient water depth over rapids and other obstacles to permit barge navigation through navigation locks and reservoirs.

Where is the storage?

The Columbia River Basin storage projects primarily lie higher in the basin near the mountains where they can strategically catch snowmelt to help provide flood-damage reduction downstream.



The Columbia River Basin storage projects can only store about 30 percent of the annual runoff. For this reason, reservoirs can be used to change the timing of flows within the year, but cannot store enough water to change a dry year into a wet year.

Managing the System by Season

Streamflow without dams (unregulated) — Streamflow with dams (regulated)

Fall and Winter Operations	**Spring Operations**	**Summer Operations**
(Roughly October to mid-March)	*(Roughly mid-March to mid-June)*	*(Roughly mid-June to September)*

Fall and Winter Operations

In the fall and winter months, storage projects in the Columbia River Basin are preparing for the following spring's runoff (snowmelt and rain). Storage projects are operated to reduce flooding downstream. As snow accumulates in the mountains, reservoirs are lowered (drawn down) to be able to catch high flows in the spring.

In the fall and winter, river flows are flowing at low, base-flow levels. Little is known at this time of year about how much snow will fall throughout the winter and how much water will be coming down the river in the upcoming spring. Winter storms may also bring rises in the river during this season.

In the fall and winter the system is operated to prepare reservoirs for the upcoming spring runoff. During this time operators also must provide a safe navigation corridor, generate power, and protect wildlife habitat and cultural resources.

September – December:
Operate the system to meet downstream flow needs in support of salmon spawning in the Vernita Bar/Hanford Reach and downstream of Bonneville Dam.

November – December:
Provide water conditions for chum, fall chinook and kokanee spawning.

November – December:
Meet winter flood risk management requirements at storage projects.

January – March:
Draft the system for flood risk management and provide river levels to support incubation of chum below Bonneville Dam and fall chinook below Priest Rapids Dam. The amount of draft depends on the water supply forecast. Storage reservoirs are targeted to be as full as possible while meeting flood risk management needs by April 10, in time for fish passage season.

September – March:
Libby and Hungry Horse are operated to provide minimum flow for bull trout.

Spring Operations

Water supply forecasts provide context to the type of runoff anticipated in the spring and they inform the space required for flood risk management (FRM) operations. Runoff can occur earlier in lower elevation basins, because of earlier snowmelt and low elevation rains. Once runoff begins, the storage projects reduce outflow and begin refilling the reservoirs. The Agencies balance FRM requirements and refill by attempting to operate no lower than the FRM elevation as of April 10th.

The system is operated in the spring primarily to manage spring runoff for flood risk management, store water for irrigation use later in the season, and provide conditions to aid juvenile and adult fish migration. During this time operators also must provide a safe navigation corridor, generate power, and protect wildlife habitat and cultural resources.

March-May:
Operate McNary Dam to improve waterfowl nesting conditions.

April-June:
Storage projects begin refilling with the goal to be full in summer.

April-June:
Beginning in April, projects on the lower Columbia and lower Snake rivers release water through the spillway for juvenile fish passage. Spill levels are monitored continuously and adjusted as necessary throughout the spring and summer to manage total dissolved gas (TDG) in the rivers.

April-June:
Storage projects are operated to target spring flow objectives at Lower Granite, McNary and Priest Rapids dams for the benefit of salmon and steelhead. Seasonal flow objectives are developed in-season through coordination with regional salmon managers to shape available water to provide flows that maximize benefits to both juvenile and adult fish during this time.

April-June:
Lower Snake River projects are operated in the spring at minimum operating pool (MOP) to aid juvenile fish passage and provide safe navigation. John Day Dam is operated to minimum irrigation pool (MIP) to aid juvenile fish passage, provide safe navigation and meet irrigation pumping needs.

May-June:
Libby Dam is operated to provide a pulse of water to encourage spawning of Kootenai River white sturgeon downstream of the dam.

April-June:
Libby and Hungry Horse are operated to provide minimum flow for bull trout.

Summer Operations

Storage reservoirs will reach their highest elevation in the summer months, often reaching full pool. Valuable water stored during the spring is then released to augment flows for fish in the lower Columbia and lower Snake rivers. Flows also provide water for irrigation, recreation, and to produce power.

By summer, the peak flows from spring runoff transition to lower summer flows. Projects fill and release water to supplement the lower base-flow period.

In the summer months the system is operated to balance additional flow for augmentation downstream to aid juvenile and adult fish migration, provide water for irrigation use, and generate power. During this time operators also must provide a safe navigation corridor, support recreation interests, and protect wildlife habitat and cultural resources.

June-August:
Projects on the lower Columbia and lower Snake rivers continue to release water through the spillway for juvenile fish passage. Spill levels are monitored continuously and adjusted as necessary throughout the spring and summer to manage TDG in the rivers.

June-August:
Storage projects are operated to target summer flow objectives at Lower Granite and McNary dams for the benefit of salmon and steelhead.

July– August/September:
Lower Snake River projects continue operating at minimum operating pool (MOP) to aid juvenile fish passage and provide safe navigation. John Day Dam remains at the minimum irrigation pool (MIP) to aid juvenile fish passage, provide safe navigation and meet irrigation pumping needs.

July-August:
Key storage reservoirs are lowered in July-August (Libby and Hungry Horse are drafted into September) to provide flows downstream for salmon and steelhead. Libby and Hungry Horse drafts are limited to benefit resident fish that enter the reservoirs.

July-September:
Dworshak Dam is operated to provide cool water to help maintain river temperature in the Lower Granite Dam tailrace below 68° F for the benefit of salmon and steelhead.

July-September:
Libby and Hungry Horse are operated to provide minimum flow for bull trout.

May-September:
Hungry Horse is operated to release warmer water to match water temperatures in the mainstem Flathead River.

HYDROPOWER
Water that flows through turbines generates electricity to power homes and businesses in the Pacific Northwest and beyond year round. System operations generally prioritize flood risk management and environmental responsibilities, and any remaining flexibility to manage water flow is used to shape power production to meet the daily and seasonal demand for electricity. In emergency situations, however, operations to keep the lights on are prioritized to protect human health and safety as well as the safety and reliability of the power grid. The Columbia River Treaty with Canada and the Pacific Northwest Coordination Agreement are used to coordinate power operations among the many Canadian, U.S. federal and nonfederal dams in the Columbia River Basin.

RECREATION
Projects provide lake and river recreational opportunities. The Agencies operate projects with sensitivity to widespread public use and attempt to balance operations in consideration of public safety. Important considerations include providing flows that are neither too high nor too low for safe boating. Another goal is to have water levels high enough for boat ramps to be operational.

IRRIGATION
Storage reservoirs typically fill by early summer by capturing snowmelt runoff. In spring and early summer, runoff is higher than irrigation demand but in July and August, when natural flows have diminished, irrigation demand is highest. To supplement irrigation demand during times of low flow, water is stored in the reservoirs during high runoff and released from storage when streamflow runoff is lower. Storage projects help provide a reliable irrigation water supply which allows for the production of a range of crops.

NAVIGATION
The Corps maintains a congressionally authorized navigation channel from the Pacific Ocean to Lewiston, Idaho and operates navigation locks for commercial and recreational traffic at eight projects. These operations require water levels above minimum levels in affected reservoirs. The four lower Columbia run-of-river projects and the four lower Snake dams operate together to allow river transport of products. Additionally, the lock system enables barge transport of juvenile salmon from below Lower Granite to below Bonneville Dam.

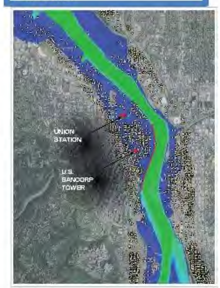
MUNICIPAL AND INDUSTRIAL WATER SUPPLY
Municipal and industrial (M&I) is typically defined to mean water used in the operations of municipal or domestic water systems and for uses in industrial processes. Industrial processes can include thermal power generation and mining operations. Municipal uses include household, commercial and public supplies. Like irrigation, M&I demand is typically higher during July and August as household and public supplies often include watering lawns. To supplement M&I during times of low flow, water is stored in the reservoir during high runoff and released when streamflow runoff is lower. Storage projects help provide a reliable M&I water supply for both personal use and industrial processes.

CULTURAL RESOURCES
Projects are operated to limit impacts and exposure to cultural resource sites.

A Brief History of Columbia River Basin Flood Risk Management

1900 — 1925 — 1950 — 1975 — Present

1894 Flood Downtown Portland



Engineers use computer models to understand potential consequences of flooding. On this map, each circle represents a building in downtown Portland; the blue area depicts where flooding would occur if 1894 happened today.

1948 Columbia River Flood

After 1948, the President directed the U.S. Army Corps of Engineers to include flood control in all future Columbia River Basin planning studies.

Vanport, Oregon in 1948

The 1948 flood destroyed Vanport, Oregon, a city of 20,000-30,000 people. About 50-60 people were killed.

Trail, B.C. in 1948

The flood damaged homes, farms, and levees from British Columbia all the way to Astoria, Oregon.

1950 Flood Control Act

1950 Flood Control Act (House Document 531):

- Addressed new levees and improvements to existing levees
- Added to and modified previous system reservoir design
- Authorized several projects to provide 20.55 Maf* of useable flood control storage (including Libby Dam)

* Maf = million acre feet

1962 Flood Control Act

1962 Flood Control Act (House Document. 403):

- Re-examined projects after studies found that multiple reservoirs authorized by 1950 FCA were impracticable or undesirable
- Authorized 14.9 Maf of useable flood control storage (down from 20.55 Maf, including Dworshak Dam)
- Only two large storage projects authorized by either the 1950 or the 1962 Flood Control Acts were actually constructed: Libby and Dworshak Dams (providing 7 Maf of storage out of the original 14.9 Maf).

Present

Columbia River Basin Flood Risk Management Storage

- All Columbia River dams operating for system flood risk management are authorized for multiple purposes.
- A total of 40 Maf of storage space is available in the Columbia River Basin for flood risk management operations. About half of this storage is located in Canada.

Flood Risk Management in the Columbia River Basin

Managing the System with Forecast-Informed Operations

Flood storage dams in the Columbia River Basin system generally draft in the winter (i.e. empty out water to leave "space") and refill in the spring and early summer. Reservoirs aren't drafted to empty every year but only as much as operators predict is needed to capture spring snowmelt and rain that can cause flooding. Operators also want to ensure that reservoirs are full come summer so that water is available for other things such as recreation, irrigation, and fish.

In order to make sure dams are drafted enough but not too much, engineers create predictions of the volume of water that will run off. These predictions, called seasonal volume forecasts, are created using information such as the amount of snow on the ground upstream of a dam. The most difficult thing to predict, however, is how quickly snow will melt and how much additional rain will fall over the spring and early summer. This is one reason why managing flood risk is challenging. Reducing the drafted flood risk space too much may lead to flooding. If the drafted flood risk space increases too much, reservoirs might not fill by summer.

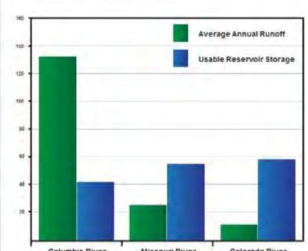
Flood Risk Management Generic Operation

Local and System Flood Risk Management

Flood storage dams can only store inflow into the dam; they cannot capture rain or snowmelt downstream of the dams.

An Overview of the Reservoir Storage Space in the System

Only 1/3 of the average annual flow can be stored in the basins' reservoirs. This means that in the event of a flood, the flood risk management storage in the basin can only REDUCE the peak. It CANNOT ELIMINATE the risk of flooding.

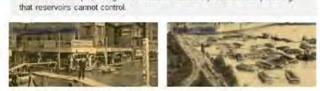


Snowmelt and Rain: A Complicated System

With a larger runoff forecast (more snow), the dams will draft more.

With a smaller runoff forecast (less snow), a dam will draft less, but it still needs space to store spring rainfall.

In years with lots of snow and/or rain, flooding CANNOT BE PREVENTED! After a reservoir reaches its spring draft, the physical risk is set, meaning that there is only so much water the reservoir can capture; the rest is up to mother nature. For example, a huge rainstorm could cause (or has caused) flooding that reservoirs cannot control.

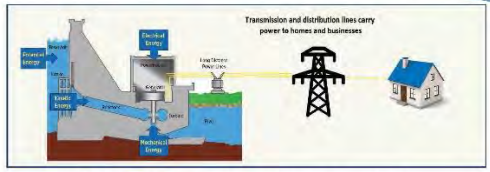


The property and life safety consequences of flooding are severe, whether it's from rain or snowmelt.

Hydropower

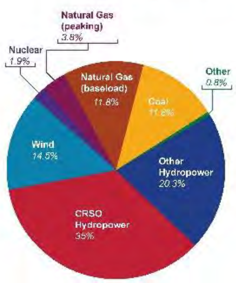
Dams convert potential energy of stored water into electricity.

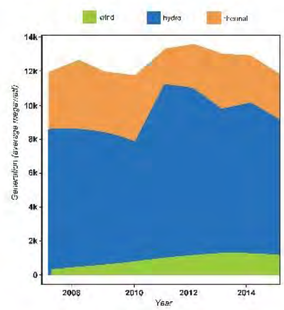
- Water moving through a turbine drives a generator that converts kinetic energy into electrical energy.
- Hydroelectric generation is determined by snowpack and rainfall, and varies from year to year. Seasonal variation in generation occurs due to the timing of snowmelt and rainfall.
- Storage projects allow some water to be stored for later use.

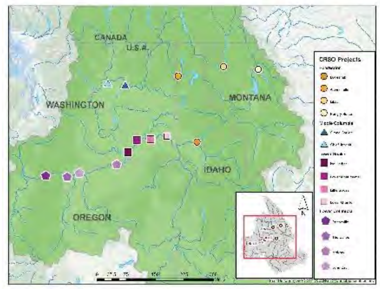


Power from the dams is delivered to local and regional utilities via the transmission system. Local utilities then distribute the power to homes and businesses via distribution lines.

Pacific Northwest Generating Capacity







Hydropower provides the bulk of generating capacity in the region. The Columbia River System Operations (CRSO) alone constitute about 35% of total regional capacity.

Almost all of the CRSO generation is produced by 14 dams located in the Columbia River Basin. Because generation may not occur near homes or businesses, transmission lines carry power generated at the CRSO dams to population centers.

In total, these 14 dams generate enough electricity to power about 7 million homes.

Irrigation

Columbia River System Irrigation

Federal Irrigation

The Bureau of Reclamation delivers water to the three irrigation districts that make up the Columbia Basin Project (CBP), with a combined 720,000 acres of land. The CBP diverts water from the Columbia River at Grand Coulee Dam through a series of pumps to Banks Lake. From there, a network of canals deliver water to farms that produce a variety of crops including potatoes, sweet corn, and onions, as well as specialty crops like grapes, hops, fruit trees and alfalfa. The annual value of CBP crops alone is estimated at $670 million. In addition to the CBP three other Federal project pump directly from the Columbia River to supply water for irrigation to the Bureau of Reclamation's Chief Joseph Dam Project, Umatilla Project Phase I and II, and The Dalles Project.

Authorization

The Columbia Basin Project Act of 1943, based on extensive studies known as the Columbia Basin Joint Investigations, authorized construction of the Columbia Basin Project, which consists of 330 miles of major distribution canals, lakes and reservoirs, and about 2,000 miles of laterals.

Chief Joseph Dam Project, not to be confused with the Corps' Chief Joseph Dam, was incrementally authorized by Congress in the following public laws: 89-557 (September 7, 1966); Public Law 83-540 (July 27, 1954); 85-393 (May 5, 1958); and 88-599 (September 18, 1964).

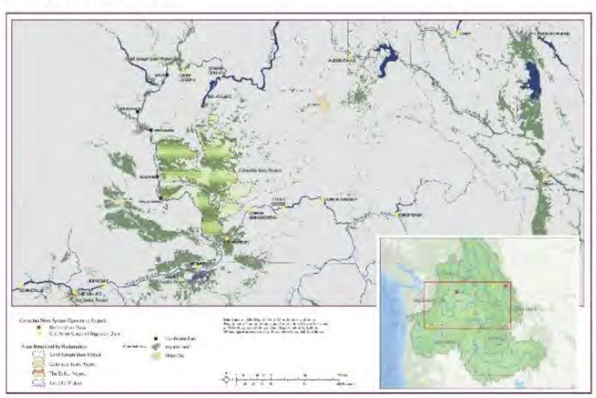
The pumping portion of the Umatilla water exchange facilities were authorized by the Act of October 28, 1988, for the purposes of mitigating losses to anadromous fishery resources and continuing water service to the irrigation districts.

Congress authorized The Dalles Project, not to be confused with the Corps' The Dalles Dam, in Public Law 86-745 dated September 13, 1960.

Private or Non-Federal Irrigation

In addition to these federal irrigation projects, private irrigation projects pump from several Corps reservoirs on the lower Snake and Columbia rivers. The Corps does not operate any of the 12 projects in the Columbia River System for irrigation. However, the projects are operated in such a way as to maintain a pool for other purposes that allow the opportunity for private irrigators and local municipalities to withdraw water from reservoirs or the rivers.

CRSO OPERATIONS FOR FEDERAL IRRIGATION PROJECT	
Columbia Basin Project	720,000
CRSO IMPACTS FEDERAL IRRIGATION PROJECT OPERATIONS	
Chief Joseph Dam Project	13,700
Umatilla Project	24,300
The Dalles Project	5,500
Total Area Benefited by Federal Projects	763,500 Acres



Navigation

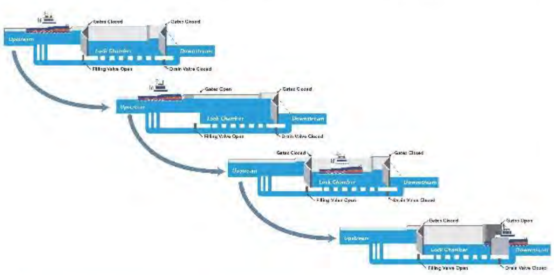
Navigation on the Columbia River System is both commercial and recreational. Commercial goods can be transported by water on federally maintained channels from the Pacific Ocean though the mouth of the Columbia River to the Tri-Cities area on the Columbia River and to Lewiston, Idaho, on the Snake River. Recreation boaters enjoy the entire river system.

Management for Navigation

Ships and barges need minimum water depths to navigate year round. Operations and maintenance for navigation are different above and below Bonneville Dam.

In the Columbia River below Bonneville Dam, the depth of the navigation channel is maintained by regular maintenance dredging.

Above Bonneville Dam and in the Snake River, the inland waterways require maintaining a 14-foot minimum water depth in the channel and at the locks to accommodate the Columbia River tugs, barges, log rafts, and recreations craft.



Construction of the locks at Federal dams has improved navigation on the Columbia and Snake rivers.

Navigation on the Columbia and Snake rivers was improved in two segments.

The first segment is the 106-mile-long open river channel used by deep-draft ships from the Pacific Ocean to the Portland/Vancouver area.

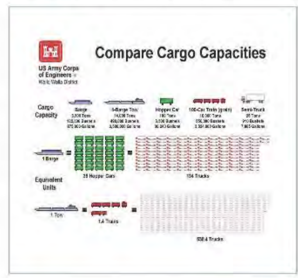
The second segment is a barge channel that extends 359 miles from Vancouver, WA to the Tri-Cities area on the Columbia River and to Lewiston, ID, on the Snake River.

Navigation upstream of Bonneville Dam is made possible by a series of locks and reservoirs at eight Federal dams.

Commercial Navigation

Greater than half of the commercial navigation on the Columbia–Snake River System is exports. However, it is also an important transportation route for goods moving to the interior, such as fuel to the Tri-Cities area and up to Lewiston, ID.
Some of the top exports are wheat, oilseeds (soybean, flaxseed and others), lumber, and corn. The top imports include iron and steel products, manufactured equipment, and building material like sand, gravel, stone, building cement and concrete.

An average of 57 million tons of commodities were transported in 2010–2014, which would have required transport by over 2 million semi-trucks. Of that, approximately 36.6 million tons were exported to foreign destinations (64%).



Fish and Wildlife

For decades, the Agencies have implemented fish and wildlife conservation, protection, and mitigation activities throughout the Columbia River Basin utilizing various authorities:

Project Authorities include fish and wildlife conservation as a project purpose.

The ***Northwest Power Act*** requires hydropower operators to provide for fish and wildlife protection, mitigation, and enhancement activities in a manner that provides equitable treatment with the other purposes.

Fish and wildlife activities in response to ***the Endangered Species Act***, and ***the Clean Water Act***; and for cultural resources protection under the ***National Historic Preservation Act***.

Federal government ***treaty and trust*** responsibilities to Columbia Basin tribes also support fish and wildlife mitigation and enhancement.

System Operations Affect Many Fish and Wildlife Species in the Basin

- Anadromous (ocean going) fish like salmon, steelhead, and lamprey
- Resident (non ocean-going) fish like bull trout, burbot, and Kootenai River white sturgeon
- Wildlife species affected by inundation from reservoirs, such as mule deer, waterfowl, song-birds, and elk

Operations and other actions to benefit fish and wildlife are science-based, relying on biological monitoring to adaptively manage and prioritize actions.

Dam and Reservoir Actions

- Operational Actions
  - Flow augmentation
  - Spill, transport, ramping rates
- Configuration Actions
  - Adult and juvenile passage
  - Water quality features

Predation

- Birds, sea lions, fish

Habitat

- Tributary
- Estuary

Hatchery Management and Reform

- Ongoing hatchery management plans
- Additional hatcheries and modification of structures

Dam Operations and Configuration Improvements for Anadromous Fish Species

Juvenile Salmon Passage

- Surface passage systems
- Turbine intake screened bypass system improvements
- Turbine improvements
- Juvenile fish passage spill
- Juvenile fish collected in screened bypass systems are transported via barge or truck from the uppermost three dams on the Snake River to below Bonneville Dam

Adult Fish Passage

- Fish ladders at all eight lower Snake and lower Columbia River dams provide upstream passage
- Ladder temperature improvements at Lower Granite and Little Goose dams
- Lamprey passage improvements

Flow Augmentation and Temperature Control

- Water stored in reservoirs at Grand Coulee, Libby, Hungry Horse, and Dworshak is released in summer to augment naturally low summer flows
- Cool water stored in Dworshak Reservoir is released during the summer to moderate temperature in the lower Snake River.

Fish and Wildlife

Operations for Resident Fish Species

Operations for ESA-listed resident fish species

- Kootenai River White Sturgeon
  - Flow pulse and outflow temperature management during spring at Libby Dam to support spawning and egg incubation
- Bull Trout
  - Minimum flow requirements and flow fluctuation restrictions at Libby and Hungry Horse dams
  - Pre-drafting storage projects when high flows anticipated to avoid high total dissolved gas

Operations for non-listed resident fish species

- Kokanee
  - Minimum reservoir elevation for Grand Coulee Dam in Fall to improve access to tributaries for spawning and support zooplankton production (an important food source for kokanee)
  - Stable lake elevation during fall at Albeni Falls to support spawning
  - Minimize spill during spring at Dworshak to keep kokanee in the reservoir
- Burbot
  - Flow temperature management during winter at Libby Dam to aid upstream migration to spawning areas in the Kootenai River

Predation on Anadromous Fish in the Columbia River Basin

Fish Predators

- Northern pikeminnow predation on juvenile salmon has been reduced by about 40 percent since 1990

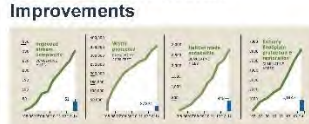
Avian Predators

- Actions are underway in the estuary to reduce Caspian tern and double-crested cormorant predation on juvenile salmon
- Actions are underway inland to reduce Caspian tern predation on juvenile salmon
- Hazing occurs at dams to discourage gull and other avian predation on juvenile salmon as they pass the dams

Pinnipeds (Sea lions)

- Pinniped predation on returning adult salmon has increased sharply in recent years below Bonneville Dam to the mouth of the Columbia River
- The U.S. Army Corps of Engineers enumerates pinnipeds immediately below Bonneville Dam and installs barriers each year to prevent the sea lions from entering fish ladders at the dam
- The Tribes actively haze pinnipeds below Bonneville Dam to discourage predation on adult salmon
- NOAA and the states of Oregon and Washington are actively managing and removing sea lions from the tailrace of Bonneville Dam

Fish and Wildlife Habitat Improvements



Actions in the tributaries from 2007 to 2015:

- Protected over 373,000 acre feet of water which is roughly 186,500 Olympic swimming pools of water
- Opened access to over 3,300 miles of fish habitat, which is about equal to 1.2 times the distance from Los Angeles to New York City
- Restored 400 miles of stream habitat complexity, which is the equivalent of restoring a stream channel that followed I-84 from Portland to Boise

Actions in the estuary from 2007 to 2015:

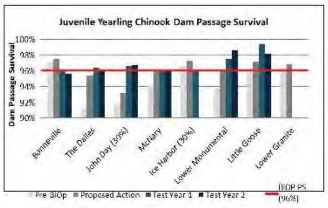
- Protected or restored over 7,700 acres of floodplain = 12.1 square miles
- Restored or enhanced over 42 miles of estuarine tidal channels

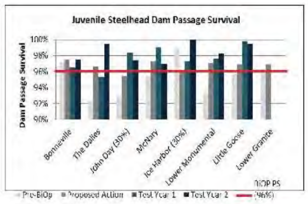
Fish and wildlife

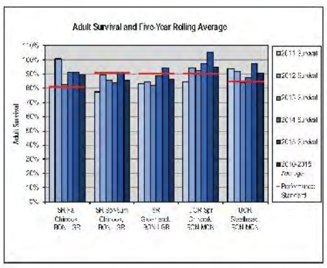
- About a million acres of land have been put under conservation easement for fish and wildlife

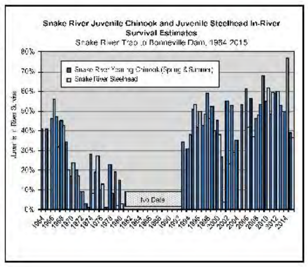
Fish and Wildlife

Fish Survival and Travel Time through the Hydrosystem









Recreation

- The Federal project reservoirs and lands along the Columbia and Snake rivers provide opportunities for many water and land based activities.
- Public waterbodies used for boating, swimming, fishing, water-skiing and windsurfing are directly dependent upon the availability of public access to launch points and shorelines.
- Public waterbodies also provide an "aesthetic complement" to many land-based recreation activities such as camping, trail riding, hiking, wildlife viewing and nature photography.

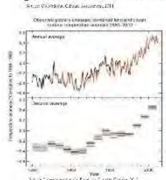
Northwest residents enjoy recreational opportunities at projects throughout the Columbia River Basin. Recreation was not specifically identified as a major project use when most of the dams were authorized, but was recognized as an important public resource during later legislation. A diverse range of recreational opportunities and facilities are located on and near our reservoirs.

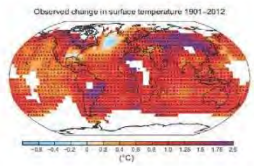
- Federal projects have high visitation at the dams and fish ladders, camping facilities, beaches and boat ramps.
- While recreation occurs throughout the year, the highest visitor numbers are seen during the summer and early fall. Seasonal variations in water levels can have local impacts on the type of recreational opportunities available as well as the quality of the recreational experience. For instance, while low water levels may limit boat launching, variations in downstream river flows that aid in fish mitigation often benefit local fishing.
- The U.S. Corps of Engineers and Bureau of Reclamation cooperate with other Federal and non-federal governmental agencies to enhance and maintain recreational opportunities. These partnerships provide a local presence and ensure that recreational facilities are well maintained and remain open to the public.

Climate Change in the Pacific Northwest

Global Climate Change:

- The Earth is warming
  - Global annual average temperature has increased 1.5°F since 1880 (through 2012)
  - 2001-2015, every year was warmer than 1990s average
- Warming is not spread evenly throughout planet
- Human-induced climate change is projected to continue and accelerate as global emissions increase





Global Emissions Scenarios:

Carbon emissions drive climate change. The more fossil fuels burned, the higher the emissions and global temperatures.

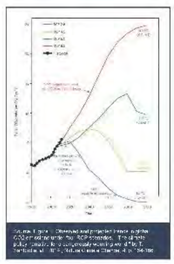
Representative Concentration Pathways (RCP) developed by Intergovernmental Panel on Climate Change (IPCC):

RCP8.5* - Currently surpassing this rate "Business as usual", rising

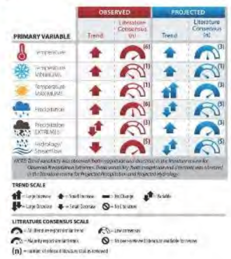
RCP6.0 - Peak at ~2080, stabilization after 2100

RCP4.5* - Peak at ~2050, stabilization after 2100

RCP2.6 - Presently no technology to make feasible near-term peak, decline to net negative emissions

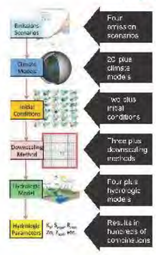


What does Climate Change mean here in the PNW?



Modeling Climate Change in the PNW:

Steps of Modeling Process



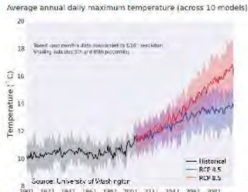
- Federal agencies have been monitoring, studying climate change for over a decade
- Converting data from the global to the local level requires many steps
- Each step has multiple methods
- There is no correct combination
- BPA, Reclamation and the Corps are working with University of Washington/Oregon State University on creating new datasets for the PNW
- In 2017 there will be 172 new climate change streamflow datasets
- Reservoir operation modeling is being completed to look at potential effects of climate change in the region

Climate Change Effects

Temperature and Precipitation Trends for Columbia River Basin

Temperature Change

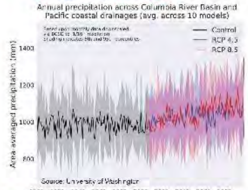
Average annual daily maximum temperature (across 10 models)



- Temperature increase depends on future emissions
- Warmer temperatures means less snow

Precipitation Change

Annual precipitation across Columbia River Basin and Pacific coastal drainages (avg. across 10 models)

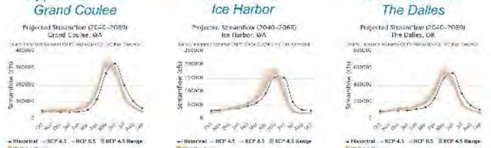


- Precipitation trend is not as clear
- More precipitation in the winter, less in the summer

Federal agencies asked the University of Washington to use the Global Climate Modeling information to give projections of temperature and precipitation for the Columbia River Basin

Streamflow Projections – Without Dam Regulation

Upper Columbia Grand Coulee | *Snake River Ice Harbor* | *Lower Columbia The Dalles*



Expected Flow Changes through Mid-Century (not including dam regulation):

- Higher winter flows, mostly in southern half of the basin
- No significant change in Canadian winter flows
- Higher spring flows, but more uncertainty on individual flow peaks
- Earlier spring runoff peak
- Lower summer flows
- Large year-to-year swings in annual volumes will likely continue

Changes in Snowpack: Nature's Reservoirs

Projected change in April 1st snow water equivalent
RCP 8.5 2040-2069 vs 1971-2000

Data Source: Hydrology: VIC, Multi-Model Mean

- The Columbia River Basin has historically been a snowmelt river system
- Measuring basin snow provides information for forecasting runoff
- Warmer winter temperature means less snow in the mountains
- Rain events in spring and winter are expected to increase
- Ecosystem and hydrology will change in response

Our Future with Climate Change

- Snow will continue in the mountains, but there will be less
- Snowpack, which is a key "natural reservoir" will tend to:
  - shrink, more in US, less in Canada
  - be more variable from year-to-year
  - harder to predict water volumes
- More winter precipitation will fall as rain
- The Columbia River Basin will continue to be dry in the summer and become even drier
- Temperatures will be warmer year round, with more warming east of the Cascades than near the coast
- More runoff in the winter
- Less runoff in the summer
- Meeting all reservoir operations will be more difficult
- Federal agencies are studying future adaptation options

Water Quality - Temperature

Introduction

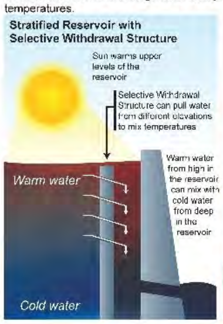
Water quality is important for the health of aquatic species, including ESA-listed fish. The Agencies operate the Columbia River Basin dams to manage total dissolved gas (TDG) and temperatures in the rivers. The Agencies also monitor other water quality parameters such as nutrients, potassium, pH, conductivity, dissolved oxygen, and others.

Which Reservoirs Can Help Manage Temperatures?

Some reservoirs stratify (warm water stays on top, while cold water sinks to the bottom). Water from these reservoirs can sometimes be used to help manage temperature conditions for aquatic species downstream. Depending on the time of year, warmer or cooler water can be released to help manage downstream temperatures.

Other reservoirs are isothermal (temperature is nearly the same from top to bottom). These reservoirs cannot be used for temperature management downstream.

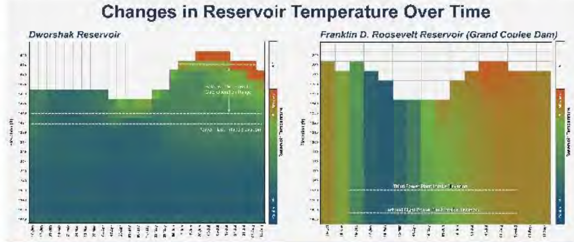
Some reservoirs are stratified in the summer and isothermal in the fall and winter, which can limit the Agencies' ability to manage downstream temperatures.



WQ Operations Map

Libby and Hungry Horse dams in Montana, and Dworshak Dam in Idaho all have reservoirs that stratify and have selective withdrawal structures to release warmer or cooler water for downstream temperature management. Temperature influences are strongest immediately downstream of the dam but lessen as this water travels farther downstream.

Changes in Reservoir Temperature Over Time



Dworshak Reservoir stratifies in the summer with warm and cool water accessible through the dam's selective withdrawal gates. Dworshak is used in the summer months to help cool temperatures on the lower Snake River.

In an average year, the Columbia River flow at Grand Coulee Dam is enough to fill the project approximately eight times. With the high volume of water that flows through the reservoir, the pool weakly stratifies. Grand Coulee Dam has two elevations from which to draw water into three power plants. At these elevations the temperatures are very similar throughout the year. In early summer the outflows from Grand Coulee Dam are typically cooler than the inflows to the reservoir near the border with Canada.

Water Quality - Total Dissolved Gas

Total Dissolved Gas (TDG) Overview

The U.S. Army Corps of Engineers implements a water quality program to manage TDG associated with spill operations at the lower Columbia and lower Snake River dams from April through August, consistent with the National Marine Fisheries Service's Biological Opinion to increase survival of ESA-listed juvenile salmon and steelhead as they pass the dams on their downstream migration to the ocean.

The Corps adjusts the amount of spill in real-time operations based on multiple spill guidance documents, reports, and computer models in order to attempt to maintain TDG within state TDG water quality standards.

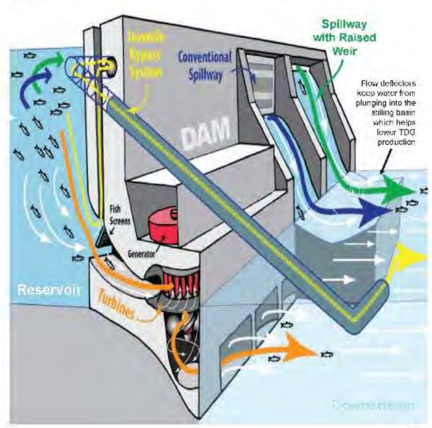
What is TDG?

TDG is a measure of air dissolved into water. When water plunges into a pool, it takes air bubbles with it. The high pressure causes the bubbles to dissolve into the water and the water becomes supersaturated with gases, primarily nitrogen.

High spill levels at the dams can increase TDG in the water below the dam because as water flows over the spillway, air becomes trapped by the spill flow. When fish and other aquatic species are exposed to elevated TDG, the excess gas can build up in their bloodstream and tissues, causing a condition called gas bubble trauma, with symptoms ranging from minor injuries to death depending on the TDG concentration.

Why do Dams Spill?

High levels of spill and associated TDG supersaturation often happen in the spring when melting snowpack creates high river flows and/or flooding. Water that cannot be stored in the reservoir behind a dam or passed through turbines to generate electricity is sent over the spillway or through an outlet. From April through August, the Agencies also spill water to help juvenile salmon migrate downstream to the ocean. Sometimes spill also occurs because maintenance forces operators to send water over a spillway, or through another outlet. So while spill is most common in the spring time, it can happen during other seasons as well.



Salmon and Steelhead in the Columbia River Basin

Restoring healthy salmon runs is a regional challenge

Partnerships among government and tribal entities, non-governmental and private organizations are critical to restoring healthy salmon runs and securing the economic and cultural benefits they provide.

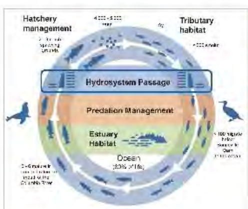
The life cycle of salmon and steelhead make them vulnerable to human and environmental impacts, and their recovery a complex issue.

Columbia and Snake River salmon and steelhead were listed for protection under the Endangered Species Act in the 1990s as a result of steep declines in the numbers of adult fish returning to spawn.

This regional challenge requires regional solutions

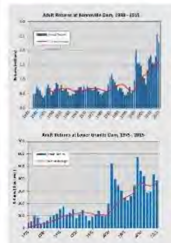
The lifecycle of salmon and steelhead requires the fish to rely on different environments as they grow and mature. Each stage of their lifecycle comes with its own survival challenges.

Salmon and steelhead have been impacted by more than a century of human and environmental impacts including:



- Dams and water diversions
- Fishing
- Hatchery practices
- Habitat degradation
- Mining
- Ocean conditions
- Predation
- Water quality

Fish ladder counts help tell part of the salmon story



About this graph: The total count includes listed and non-listed salmon, natural-origin and hatchery-origin fish, and adults and approximately 120,000 jacks (young males that mature and return to spawning grounds earlier than others in their age class). Currently, hatchery fish comprise approximately 80% of the returning adults.

Major dams along the Columbia and Snake River systems have fish counting stations to monitor adult salmon and steelhead migrations. The combination of natural-origin and hatchery-origin adult fish returning from the ocean is higher than in the 1990s and since dam counts first began.

Several factors contribute to these improvements in abundance, including:

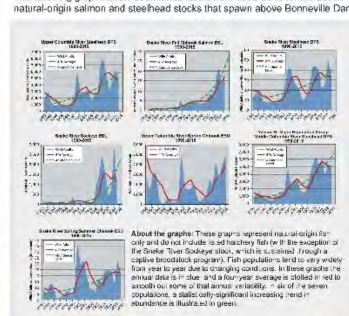
- Fish passage improvements
- Fish travel time improvements
- Habitat enhancement
- Harvest management
- Hatchery actions
- Ocean conditions
- Predation management actions

How are salmon and steelhead in the Columbia River Basin doing?

In the Pacific Northwest, the status of salmon and steelhead is evaluated by measuring several factors, including abundance (the number of adult fish that return each year to spawn).

In 2016, NOAA Fisheries completed a five-year status review of all ESA-listed West Coast salmon and steelhead – including the 13 stocks of the Columbia River Basin – and found that no changes in ESA listing status are warranted.

The following graphs show abundance levels from 1990-2015 for the seven natural-origin salmon and steelhead stocks that spawn above Bonneville Dam

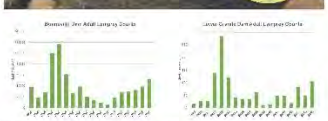


About the graphs: These graphs represent natural-origin fish only and do not include listed hatchery fish (with the exception of the Snake River Sockeye stock, which is sustained through a captive broodstock program). Fish populations tend to vary widely from year to year due to changing conditions. In these graphs the annual data is in blue, and a four-year average is plotted in red to smooth out some of that annual variability. In six of the seven populations, a statistically-significant increasing trend in abundance is illustrated in green.

Lamprey, Kootenai River White Sturgeon and Bull Trout in the Columbia River Basin

Pacific Lamprey

Pacific lamprey belong to a group of eel-like fishes and are a significant cultural and subsistence resource for tribal communities. Lamprey begin their life in fresh water, migrate to the ocean and return to fresh water to spawn. Each stage of their lifecycle comes with its own survival challenges. Since lamprey larvae spend years buried in the soft sediment of stream beds, they are especially susceptible to physical disturbance, dewatering events and contamination. Pacific lamprey populations have declined throughout their west coast range, including in the Columbia River Basin. They are considered a Species of Concern.



*Daytime counts at Bonneville and Lower Granite dam are useful as an index only; many lamprey pass these dams at night and through other upstream passage routes

Impacts:

- Habitat degradation
- Ocean conditions
- Passage barriers
- Predation
- Reduced flows
- Water quality

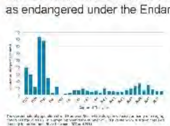
Conservation actions:

- Genetics monitoring
- Passage improvements
- Propagation research
- Tagging studies
- Translocation

Kootenai River white sturgeon

Kootenai River white sturgeon have been genetically isolated from other white sturgeon in the Columbia River system for approximately 10,000 years by the natural impassable barrier of Bonnington Falls in British Columbia, Canada. These long-lived fish live in a 167 river mile stretch of the Kootenai River from Kootenai Falls, Montana — located 31 river miles below Libby Dam — downstream to Kootenay Lake in British Columbia. Approximately 45 percent of their range is located in British Columbia.

They live to approximately 100 years, with females in the Kootenai River reaching reproductive maturity in their late twenties to early thirties. The wild Kootenai River white sturgeon population is comprised mainly of older adults, and significant larval recruitment has not occurred since the 1970s. In 1994, the fish was listed as endangered under the Endangered Species Act.



The wild population of Kootenai River white sturgeon is in decline due to an aging population and low juvenile survival. Although the specific causes of low juvenile survival remain unclear, years of research suggest that most mortality occurs between egg and larval stages. The hatchery program continues to be crucial for the longevity of the species.

Impacts:

- Altered Hydrograph
- Altered Thermograph
- Habitat degradation
- Reduced nutrients and river productivity

Conservation actions:

- Conservation Aquaculture
- Flow augmentation and water temperature management at Libby Dam
- Habitat restoration
- Harvest restriction

Bull trout

Bull trout are members of the salmonid family (Salmonidae) which include salmon, trout, grayling, whitefish and char. Bull trout exhibit both resident and migratory life cycles. Compared to other salmonids, bull trout have more specific temperature requirements. They occur in cold water streams, and are rarely found in waters where temperatures exceed 15.0 to 17.8°C (59 to 64°F). Once found in about 60 percent of the Columbia River Basin, today bull trout occur in less than half of their historic range. Bull Trout were listed as threatened under the Endangered Species Act in 1998.

Impacts:

- Competition with and predation by non-native fish
- Habitat degradation
- Migration barriers
- Overfishing and poaching
- Water temperatures
- Water quality

Conservation actions:

- Controlling non-native fish populations
- Habitat improvements
- Harvest reductions or prohibitions
- Instream flow enhancement
- Land use modifications
- Passage improvements
- Silt and erosion reduction
- Temperature improvements
- Water quality improvements

Bonneville Dam and Lake Bonneville

Quick Facts

- Stream: Columbia River (RM 146.1)
- Location: Cascade Locks, OR
- Owner: U.S. Army Corps of Engineers, Portland District
- Authorized Purposes: Hydropower, Navigation (1935 Rivers and Harbors Act)
- Other Purposes: Fish & Wildlife, Recreation, Water Quality
- Type of Project: Run-of-river

Dam

- Completed: 1938; 1981 (powerhouse 2)
- Height: 171 ft
- Length: 2,477 ft
- Features: 2 powerhouses, spillway, navigation lock, fish passage facilities
- Forebay Elevation Normal Operating Range: 71.5–76.5 ft msl
- Spillway Capacity (max): 1,600,000 cfs

Powerhouse

- Generation Capacity:
  Powerhouse 1 = 518 MW, 10 Units
  Powerhouse 2 = 532 MW, 8 Units
- Hydraulic Capacity:
  Powerhouse 1 = 136,000 cfs
  Powerhouse 2 = 152,000 cfs

Bonneville Dam was authorized by Congress for power and navigation in the 1935 Rivers and Harbors Act. The first powerhouse, spillway, and navigation lock were completed in 1938, and the second powerhouse in 1981. The lock was expanded in 1993.

Bonneville Lock and Dam was placed on the National Register of Historic Places in 1986 and declared a National Historic Landmark in 1987.

Hydropower

Bonneville Dam has 18 turbine units and a total generating capacity of over 1,200 megawatts - enough to power 900,000 homes.

Bonneville Dam, Lake Bonneville, and associated facilities are operated for Hydropower, Navigation, Fish & Wildlife, Recreation, and Water Quality.

Navigation

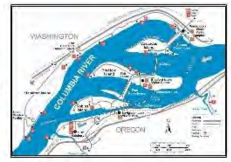
The Bonneville navigation lock was rebuilt in 1993 to accommodate larger tows. Bonneville is the first of eight locks encountered in the Columbia-Snake Inland Waterway, a 465-mile river highway that allows barge transport of commodities between the Pacific Ocean and Lewiston, ID. About 10 million tons of cargo pass through the Bonneville lock annually.

Water Quality

Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species. During spill for juvenile fish passage at the four Lower Columbia and four Lower Snake River projects, the Corps implements a Water Quality Program to manage total dissolved gas.

Recreation

Recreation opportunities are provided at two visitor areas, a fish hatchery, and several trail systems, parks, and designated recreation areas. Popular activities include boating, fishing, windsurfing, kiteboarding, hiking, wildlife viewing, camping, and more.



Fish & Wildlife

Multiple fish ladders provide a passage route for upstream-migrating fish, including adult salmon and steelhead, lamprey, sturgeon, shad, and others. Passage routes operated for downstream-migrating fish are the corner collector, spillway, juvenile bypass system, and sluiceway.

The Bonneville Hatchery on Tanner Creek—one of the oldest hatcheries in Oregon—is funded by the Corps and operated by the Oregon Dept of Fish & Wildlife to mitigate for the loss of spawning habitat that occurred when the reservoir was created.

Surrounding lands are managed to provide 200 acres for waterfowl and non-game species habitat, and 682 acres for wildlife habitat at Steigerwald Lake near Camas, WA.

The Dalles Dam and Lake Celilo

Quick Facts

- Stream: Columbia River (RM 192)
- Location: The Dalles, OR
- Owner: U.S. Army Corps of Engineers, Portland District
- Authorized Purposes: Hydropower, Navigation (1950 Flood Control Act)
- Other Purposes: Fish & Wildlife, Recreation, Water Quality, Irrigation
- Type of Project: Run-of-river

Dam

- Completed: 1957
- Height: 185 ft
- Length: 2,640 ft
- Features: powerhouse, spillway, navigation lock, fish passage facilities
- Forebay Elevation Normal Operating Range: 157–160 ft msl
- Spillway Capacity (max): 2,290,000 cfs

Powerhouse

- Generation Capacity: 1,780 MW, 22 Units
- Hydraulic Capacity: 375,000 cfs

The Dalles Lock and Dam was authorized by Congress for power and navigation in the 1950 Flood Control Act. The project was constructed between 1952 and 1957 near the city of The Dalles, OR, 192 miles upstream of the Pacific Ocean. Lake Celilo extends upstream of the dam for 24 miles to John Day Dam.

Hydropower

The Dalles Dam has 22 turbine units and a total generating capacity of 2,080 megawatts.

The Dalles Dam, Lake Celilo, and associated facilities are operated for Hydropower, Navigation, Fish & Wildlife, Recreation, Water Quality, and Irrigation.

Navigation

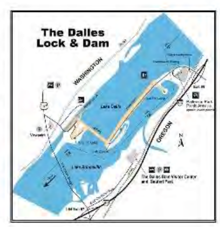
The Dalles Dam navigation lock is the second of eight locks encountered in the Columbia-Snake Inland Waterway, a 465-mile river highway that allows barge transport of commodities between the Pacific Ocean and Lewiston, ID.
The Dalles lock passes up to 10 million tons of cargo annually.

Water Quality

Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species. During spill for juvenile fish passage at the four Lower Columbia and four Lower Snake River projects, the Corps implements a Water Quality Program to manage total dissolved gas.

Recreation

Popular recreational activities at The Dalles Dam and Lake Celilo include boating, fishing, windsurfing, kiteboarding, hiking, wildlife viewing, geocaching, camping, and more. There are several Corps-managed and state parks along the shoreline of Lake Celilo.



Fish & Wildlife

The Dalles Dam has two fish ladders—one on each shore—to provide a passage route for upstream-migrating fish, including adult salmon and steelhead, lamprey, sturgeon, shad, and others. Passage routes operated for downstream-migrating fish are the spillway and sluiceway.

John Day Dam and Lake Umatilla

Quick Facts

- Stream: Columbia River (RM 215.6)
- Location: Rufus, OR
- Owner: U.S. Army Corps of Engineers, Portland District
- Authorized Purposes: Hydropower, Navigation, Flood Control (1950 Flood Control Act)
- Other Purposes: Fish & Wildlife, Recreation, Water Quality, Irrigation
- Type of Project: Storage
- Authorized Flood Storage: 535,000 acre-ft

Dam

- Completed: 1972
- Height: 281 ft
- Length: 5,543 ft
- Features: powerhouse, spillway, navigation lock, fish passage facilities
- Forebay Elevation Normal Operating Range: Jul-Sep = 265–268 ft msl Nov-Jun = 260–265 ft msl
- Spillway Capacity (max): 1,560,000 cfs

Powerhouse

- Generation Capacity: 2,160 MW, 16 Units
- Hydraulic Capacity: 322,000 cfs

John Day Lock and Dam was authorized by Congress for power, navigation, and flood control in the 1950 Flood Control Act and amended in 1957. The project was completed in 1971 near the city of Rufus, OR, 215 miles upstream of the Pacific Ocean. Lake Umatilla extends upstream of the dam for 110 miles to McNary Dam.

Hydropower

John Day Dam has 16 turbine units and a total generating capacity of 2,480 megawatts.

John Day Dam, Lake Umatilla, and associated facilities are operated for Hydropower, Navigation, Flood Risk Management, Fish & Wildlife, Recreation, Water Quality, and Irrigation.

Navigation

John Day Dam navigation lock is the third of eight locks encountered in the Columbia-Snake Inland Waterway, a 465-mile river highway that allows barge transport of commodities between the Pacific Ocean and Lewiston, ID.

Annually, about 10 million tons of commercial cargo pass through the John Day lock.

Flood Risk Management

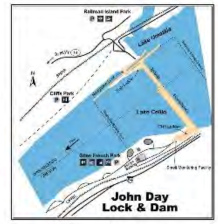
John Day Dam was originally authorized for 2 million acre-feet of flood control storage; however, due to concerns from local and downstream interests, the authorization was amended to 500,000 acre-feet in 1957.

Water Quality

Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species. During spill for juvenile fish passage at the four Lower Columbia and four Lower Snake River projects, the Corps implements a Water Quality Program to manage total dissolved gas.

Recreation

Popular recreational activities at John Day Dam and Lake Umatilla include boating, fishing, windsurfing, kiteboarding, hiking, wildlife viewing, camping, and more. There are several state parks and Corps recreation areas along the shoreline of Lake Umatilla.



Fish & Wildlife

John Day Dam has two fish ladders—one on each shore—to provide a passage route for upstream-migrating fish, including adult salmon and steelhead, lamprey, sturgeon, shad, and others. Passage routes operated for downstream-migrating fish are the spillway, two spillway weirs, and a juvenile bypass system.

McNary Dam and Lake Wallula

Quick Facts

- Stream: Columbia River (RM 292)
- Location: Umatilla, OR
- Owner: U.S. Army Corps of Engineers, Walla Walla District
- Authorized Purposes: Hydropower, Navigation (1945 Rivers and Harbors Act)
- Other Purposes: Fish & Wildlife, Recreation, Water Quality, Irrigation
- Type of Project: Run-of-River

Dam

- Completed: 1957
- Height: 183 ft
- Length: 7,365 ft
- Features: powerhouse, spillway, navigation lock, fish passage facilities
- Forebay Elevation Normal Operating Range: 337–340 ft msl
- Spillway Capacity (max): 2,200,000 cfs

Powerhouse

- Generation Capacity: 980 MW, 14 Units
- Hydraulic Capacity: 232,000 cfs

McNary Lock and Dam was authorized by Congress for power and navigation in the 1945 Rivers and Harbors Act. Construction began in 1947, and all turbine units were operational in 1957. Lake Wallula extends upstream of the dam for 64 miles to Hanford and has over 242 miles of shoreline.

Hydropower

McNary Dam has 14 turbine units and a total project capacity of 980 megawatts, enough to power about 686,000 homes. The Corps and BPA are collaborating to modernize the turbines to improve power and hydraulic capacity and incorporate the latest fish-friendly design.

McNary Dam, Lake Wallula, and associated facilities are operated for Hydropower, Navigation, Fish & Wildlife, Recreation, Water Quality, and Irrigation.

Navigation

McNary Dam navigation lock is the fourth of eight locks encountered in the Columbia-Snake Inland Waterway, a 465-mile river highway that allows barge transport of commodities between the Pacific Ocean and Lewiston, ID. In 2015, more than five million tons of cargo passed through the McNary lock.

Water Quality

Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species. During spill for juvenile fish passage at the four Lower Columbia and four Lower Snake River projects, the Corps implements a Water Quality Program to manage total dissolved gas.

Recreation

Nearly 17,000 acres of public lands surrounding Lake Wallula are utilized for recreation, wildlife habitat, and water-connected industry. Currently, there are about 2,400 acres leased to state or local park agencies, 17 public boat launch facilities, and 8 commercial boat club facilities.

Fish & Wildlife

McNary Dam has two fish ladders—one on each shore—to provide a passage route for upstream-migrating fish, including adult salmon and steelhead, lamprey, sturgeon, shad, and others. Passage routes operated for downstream-migrating fish are the spillway, two spillway weirs, and a juvenile bypass system.

The McNary National Wildlife Refuge is owned and managed by the U.S. Fish & Wildlife Service as part of the larger Mid-Columbia River Refuge Complex.

Chief Joseph Dam and Rufus Woods Lake

Quick Facts
- Stream: Columbia River (RM 545)
- Location: Bridgeport, WA
- Owner: U.S. Army Corps of Engineers, Seattle District
- Authorized Purposes: Hydropower, Irrigation (1945 Rivers and Harbors Act)
- Other Purposes: Recreation, Water Quality
- Type of Project: Run-of-river

Dam
- Completed: 1955 (Units 1-8); 1958 (Units 9-16); 1979 (Units 17-27)
- Features: powerhouse, spillway
- Height: 236 ft
- Length: 5,962 ft
- Forebay Elevation Normal Operating Range: 950–956 ft msl
- Spillway Capacity (max): 1,200,000 cfs

Powerhouse
- Generation Capacity: 2,069 MW, 27 Units
- Hydraulic Capacity: 219,000 cfs

Chief Joseph Dam was originally authorized as Foster Creek Dam in the River and Harbor Act of 1946 for power and irrigation. The project was renamed Chief Joseph Dam in the River and Harbor Act of 1948. Construction began in 1949, and the first eight generating units were brought online in 1955. Eight more units were completed in 1958, then eleven more in 1979, to total 27 units.

The construction of Chief Joseph Dam on the Columbia River created Rufus Woods Lake, which extends upstream for a distance of 51 miles.

Chief Joseph Dam, Rufus Woods Lake, and associated facilities are operated for Hydropower, Irrigation, Recreation, and Water Quality.

Hydropower
Chief Joseph Dam is the 2nd largest hydropower-producing dam in the U.S. and is the largest Corps-operated hydropower dam. The powerhouse is over a third of a mile long and holds 27 house-sized turbines with a total generating capacity of over 2,000 megawatts, enough to power the entire Seattle metropolitan area. Chief Joseph Dam produces approximately $450 million worth of electricity every year.

Water Quality
Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species. The Chief Joseph Dam spillway was fitted with flow deflectors in 2008 that act to reduce total dissolved gas levels downstream of the project when water is passed over the spillway.

Recreation
Recreational opportunities in and around Rufus Woods Lake include boating, swimming, hunting, fishing, hiking, picnicking, and camping. There are two campgrounds near Chief Joseph Dam–Marina Park in Bridgeport and Bridgeport State Park on the north shore of the lake.

Rufus Woods Lake is a favorite spot for anglers from all over the region. Walleye, rainbow trout, and triploid trout are the major game fish caught in the lake.

Grand Coulee Dam

Grand Coulee Dam
Grand Coulee Dam includes three major hydroelectric power generating plants (named Third, Left, and Right) and a pump generating plant. The facilities provide power generation, irrigation, flood risk management, stream flow regulation for fish migration. Additional incidental benefits include providing flows for navigation, and recreation. Grand Coulee Dam is the main feature of the Columbia Basin Project.

Authorization
Authorized under the National Industrial Recovery Act and later by the Rivers and Harbors Act. Right and Left Power Plants were constructed between 1933 and 1941. The Third Power Plant was added in the 1970s.

Irrigation
The Columbia Basin Project Act of 1943 authorized construction of the Columbia Basin Project, which consists of 330 miles of major distribution canals, lakes and reservoirs, and about 2,000 miles of laterals that currently irrigate approximately 720,000 acres of land.

Power Production
Power production facilities at Grand Coulee Dam are among the largest in the world; the total generating capacity is rated at 7,015 megawatts. Average yearly power production is 21 billion kWh with power distributed to Washington, Oregon, Idaho, Montana, California, Wyoming, Colorado, New Mexico, Nevada, Utah and Arizona. In addition, Canada receives power under the Columbia River Treaty. Grand Coulee Dam is operated as part of a coodinated federal system of hydroelectric facilities, which provides 75% of the entire power supply of the Pacific Northwest.

Flood Risk Management
From January through June, the reservoir level is adjusted for flood risk management. Grand Coulee Dam, the largest Federal storage reservoir on the Columbia River system, works with other storage projects in the system to provide flood risk management for the lower Columbia River including Portland, OR and Vancouver, WA areas.

Economic Value
The economic value of the Columbia Basin Project includes irrigated crops, hydropower production, and the prevention of flood damages.

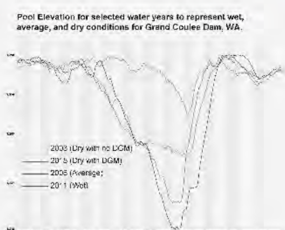
Fish Hatcheries
Grand Coulee Dam funds a complex of three hatcheries (Leavenworth, Winthrop and Entiat), collectively known as the Leavenworth Complex, to mitigate for the loss of anadromous fish above the dam. Over 2 million spring Chinook and summer steelhead are raised annually.

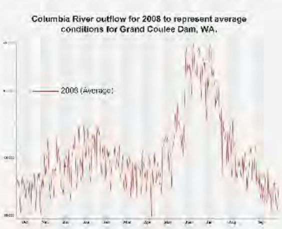
Recreation
Grand Coulee Dam creates Franklin D. Roosevelt (FDR) Lake. The lake stretches 151 miles with about 500 miles of shoreline. A portion of the lake area has been designated a National Recreation Area and is administered by the National Park Service.

Water Operations at Grand Coulee Dam
Grand Coulee Dam operations are closely coordinated to benefit a wide range of needs including hydropower, flood risk management, recreation, and operations to benefit resident and anadromous fish.

Maintenance Activities
Annual maintenance on dam outlet works, spill structures, power plants, etc. is necessary for continued operations. Periodically extraordinary maintenance activities are necessary to safely operate the project. Examples include power plant modernization (such as the ongoing efforts in the Third, Left and Right Power Plants), drum gate maintenance overhaul, and maintenance and upgrades to the John W. Keys III Pump Generating Plant.

Quick Facts about Grand Coulee Dam
- Original Construction: Right and Left Power Plants 1933 – 1941, Third Power Plant added 1967 to 1974
- Dam Type: Concrete Gravity
- Dam Height: 550 feet
- Crest Length: 5223 feet
- River: Columbia River
- Active Capacity: 5,349,560 acre-feet (total capacity of 9,715,346 acre-feet)
- Spillway (type/capacity all at pool elevation 1290 feet):
  - 11 drum gates /1,000,000;
  - 40 outlet works/ 265,000 cubic feet per second (cfs)
- Three Power Plants: Total Generating Capacity 7015 MW
  - The Left and Right Power Plants - 18 units (6,000 cfs each),
  - Third Power Plant - 6 units (3@ 25,000 cubic foot per second (cfs) each and 3@ 30,000 cfs each),
  - John W. Keys III Pump Generating Plant - 6 pump/generators (2 @ 1605 cfs each, and 4@ 1,700 each), and 6 pumps (1,600 cfs each)





Albeni Falls Dam and Lake Pend Oreille

Quick Facts

- Stream: Pend Oreille River (RM 90.1)
- Location: Bonner County, ID
- Owner: U.S. Army Corps of Engineers, Seattle District
- Authorized Purposes: Flood Control, Hydropower (1950 Flood Control Act)
- Other Purposes: Recreation, Fish & Wildlife, Water Quality
- Type of Project: Storage
- Authorized Flood Storage: 600,000 acre-ft

Dam

- Completed: 1955
- Height: 90 ft
- Length: 1,080 ft
- Features: powerhouse, spillway, log chute (currently inactive)
- Forebay Elevation Normal Operating Range: 2,051–2,062.5 ft msl
- Spillway Capacity (at full pool): 106,000 cfs

Powerhouse

- Generation Capacity: 42 MW, 3 Units
- Hydraulic Capacity: 33,000 cfs

Albeni Falls Dam was authorized by Congress in the 1950 Flood Control Act, and construction was completed in 1955.

The dam is located at the site of natural waterfalls that impounded Lake Pend Oreille. On completion, the 90-foot-tall dam increased the storage of Lake Pend Oreille and reduced upstream and downstream flood risks. The dam is made up of a powerhouse with three generating turbine units and a spillway.

Hydropower

Albeni Falls Dam has three turbine units and a total generating capacity of 42 megawatts–enough to power roughly 15,000 homes.

Albeni Falls Dam, Lake Pend Oreille, and associated facilities are operated for Flood Risk Management, Hydropower, Recreation, Fish & Wildlife, and Water Quality.

Flood Risk Management

Prior to construction of the dam, flow was restricted through the natural waterfalls, which caused flooding upstream along Lake Pend Oreille during years of high spring runoff. The construction of the dam expanded the channel and increased capacity to pass water downstream through the spillway, reducing upstream flood risk.

Water Quality

Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species.

Recreation

Recreational opportunities are abundant at scenic Lake Pend Oreille, including camping, fishing, boating, hiking, picnicking, and more. Operation of Albeni Falls Dam benefits recreation at Lake Pend Oreille by maintaining a steady lake level during the summer months at the peak of recreation on the lake.

Fish & Wildlife

Albeni Falls Dam does not have fish passage facilities; however, the project is operated in a manner to mitigate for losses to the kokanee population that have occurred since the dam was constructed. Kokanee are an important food source for bull trout–a threatened species under the Endangered Species Act–and measures to protect the kokanee in Lake Pend Oreille may also serve the recovery efforts for bull trout.

Other fish species found in Lake Pend Oreille include Kamloops trout, whitefish, cutthroat and brown trout, mackinaw or lake trout, large and smallmouth bass, crappie, pumpkinseed sunfish, northern pike, walleye, perch, bullhead catfish, and others.

Libby Dam and Lake Koocanusa

Quick Facts

- Stream: Kootenai River (RM 221.9)
- Location: Libby, MT
- Owner: U.S. Army Corps of Engineers, Seattle District
- Authorized Purposes: Flood Control, Hydropower (1950 Flood Control Act)
- Other Purposes: Recreation, Fish & Wildlife, Water Quality
- Type of Project: Storage
- Authorized Flood Storage: 4,980,000 acre-ft

Dam

- Completed: 1973
- Features: powerhouse, spillway
- Height: 432 ft
- Length: 2,887 ft
- Forebay Elevation Normal Operating Range: 2,287–2,459 ft msl
- Spillway Capacity (at full pool): 150,000 cfs

Powerhouse

- Generation Capacity: 525 MW, 5 Units
- Hydraulic Capacity: 24,100 cfs

Libby Dam was authorized by Congress in the 1950 Flood Control Act for hydropower and flood protection, and construction was completed in 1973. The dam is located on the Kootenai River, 17 miles upstream of Libby, MT.

The reservoir behind the dam, Lake Koocanusa, extends 90 miles upstream into British Columbia, Canada.

Libby Dam is the fourth dam constructed under the Columbia River Treaty between the U.S. and Canada. The other three treaty projects are located in Canada.

Libby Dam, Lake Koocanusa, and associated facilities are operated for Flood Risk Management, Hydropower, Recreation, Fish & Wildlife, and Water Quality.

Flood Risk Management

Libby operations for flood risk management are based on a variable flow operating criteria. Lake Koocanusa has nearly five million acre-feet of storage space available for local and regional flood control.

Hydropower

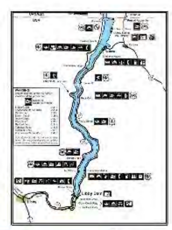
Libby Dam has 5 turbine units and a total generating capacity of 525 megawatts–enough to power roughly 400,000 homes.

Water Quality

Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species.

Recreation

There are nine Corps-managed public recreation areas and visitor facilities at Libby Dam and Lake Koocanusa that provide opportunities for a variety of activities, including fishing, camping, hiking, boating, and dam tours. The U.S. Forest Service manages additional recreation sites along the shores of Lake Koocanusa.



Fish & Wildlife

The Kootenai River, downstream of Libby Dam, is home to two fish species listed for protection under the Endangered Species Act – bull trout (threatened) and white sturgeon (endangered). Libby Dam is operated to provide adequate flows during critical periods for protection of these species.

Lake Koocanusa is home to a variety of sport fish, including rainbow trout, west slope cutthroat, brook trout, kokaneee salmon, burbot, whitefish, Kamloops trout, and others.

Hungry Horse Dam

Hungry Horse Dam

The Hungry Horse Dam project includes the dam, reservoir, powerplant, and switchyard. At the time of its completion the dam was the third largest dam, and the second highest concrete dam, in the world. The project plays an important role for meeting the power needs in the Pacific Northwest and flood risk management. It also contributes to other uses includting irrigation and navigation.

Flood Risk Management Operations

From January through June, the reservoir level is adjusted for flood risk management space requirements. The amount of reservoir draft or space is dependent on inflow forecasts. The objective of the flood risk management season is to provide enough space in the reservoir for system flood risk management operations in the lower Columbia River, and also to provide local flood protection in the mainstem Flathead River near Columbia Falls, Montana.

Operations for Fish

Hungry Horse Dam is operated to augment flows in the spring,from April to June, to aid spring anadromous fish migrating in the lower Columbia River. From July through September, the project is operated to balance reservoir storage to meet local and downstream fish needs. The reservoir is drafted to supplement flows for juvenile anadromous fish migration in the lower Columbia River, but timing and limit of the draft are also intended to benefit resident fish. Flows from the reservoir are maintained year round to preserve fish habitat in the river below the dam.

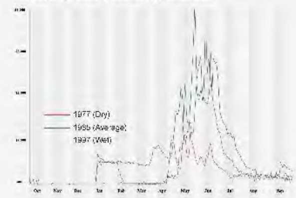
Maintenance Activities

Annual maintenance on dam outlet works, spill structures, power plants, etc. is necessary for continued operations. Periodically, extraordinary maintenance activities are necessary to safely operate the project. An example of extraordinary maintenance at Hungry Horse Dam is the modernization of the power plant.

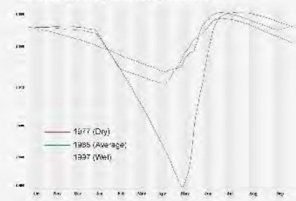
Quick Facts

- Original Construction: 1948 to 1953
- Dam Type: Concrete Arch
- Dam Height: 564 feet
- Crest Length: 2,115 feet
- River: South Fork (SF) of Flathead River
- Active Capacity: 3,467,179 acre-feet at pool elevation 3560 feet
- Spillway (type/capacity all at pool elevation 3565 feet): Gated Morning Glory Spillway /50,000 cubic feet per second (cfs); hollow-jet valves / 14,000 cfs
- Power Plant: Four 107MW generators, with combined hydraulic capacity of 12,000 cfs (transmission limited to 9,000 cfs) at pool elevation 3560 feet.

Modeled SF Flathead River flows near Columbia Falls, MT for wet, average, and dry water supply conditions.



Modeled reservoir pool elevations for Hungry Horse Dam, for wet, average, and dry water supply conditions.



General operational purposes by season.

Ice Harbor Dam and Lake Sacajawea

Quick Facts

- Stream: Snake River (RM 9.7)
- Location: Pasco, WA
- Owner: U.S. Army Corps of Engineers, Walla Walla District
- Authorized Purposes: Hydropower, Navigation (1945 Rivers and Harbors Act)
- Other Purposes: Fish & Wildlife, Recreation, Water Quality, Irrigation
- Type of Project: Run-of-River

Dam

- Completed: 1962
- Height: 141 ft
- Length: 2,822 ft
- Features: powerhouse, spillway, navigation lock, fish passage facilities
- Forebay Elevation Normal Operating Range: 437–440 ft msl
- Spillway Capacity (max): 850,000 cfs

Powerhouse

- Generation Capacity: 603 MW, 6 Units
- Hydraulic Capacity: 106,000 cfs

Ice Harbor Lock and Dam was the first of four dams constructed as part of the Lower Snake River Project, authorized in the Rivers and Harbors Act of 1945. Construction began in 1956, and three turbine units were operational in 1961. Three more turbine units were installed and operational in 1976.

Lake Sacajawea extends 32 miles upstream to Lower Monumental Dam.

Hydropower

Ice Harbor Dam has three 90-megawatt turbines and three 111-megawatt turbines, for a total of 603 megawatts. The first of two new advanced technology, "fish-friendly" turbines is scheduled to be operational in 2017.

Ice Harbor Dam, Lake Sacajawea, and associated facilities are operated for Hydropower, Navigation, Fish & Wildlife, Recreation, Water Quality, and Irrigation.

Navigation

Ice Harbor Dam navigation lock is the fifth of eight locks encountered in the Columbia-Snake Inland Waterway, a 465-mile river highway that allows barge transport of commodities between the Pacific Ocean and Lewiston, ID. In 2015, more than 2.3 million tons of cargo passed through the Ice Harbor lock.

Water Quality

Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species. During spill for juvenile fish passage at the four Lower Columbia and four Lower Snake River projects, the Corps implements a Water Quality Program to manage total dissolved gas.

Recreation

Popular recreation activities around Ice Harbor Dam and Lake Sacajawea include fishing, swimming, picnicking, boating, hunting, hiking, and camping. There are 3,517 acres of public lands around Lake Sacajawea utilized for public recreation, wildlife habitat, wildlife mitigation, and water-connected industry.

Currently, there are seven public boat launch facilities and a marina at Charbonneau Park.

Fish & Wildlife

Ice Harbor Dam has two fish ladders—one on each shore—to provide a passage route for upstream-migrating fish, including adult salmon and steelhead, lamprey, shad, and others. Passage routes operated for downstream-migrating fish are the spillway, a spillway weir, and a juvenile bypass system.

Lower Monumental Dam and Lake West

Quick Facts
- Stream: Snake River (RM 41.6)
- Location: Kahlotus, WA
- Owner: U.S. Army Corps of Engineers, Walla Walla District
- Authorized Purposes: Hydropower, Navigation (1945 Rivers and Harbors Act)
- Other Purposes: Fish & Wildlife, Recreation, Water Quality, Irrigation
- Type of Project: Run-of-River

Dam
- Completed: 1970
- Height: 152 ft
- Length: 3,791 ft
- Features: powerhouse, spillway, navigation lock, fish passage facilities
- Forebay Elevation Normal Operating Range: 537–540 ft msl
- Spillway Capacity (max): 850,000 cfs

Powerhouse
- Generation Capacity: 810 MW, 6 Units
- Hydraulic Capacity: 130,000 cfs

Lower Monumental Lock and Dam was the second of four dams constructed as part of the Lower Snake River Project, authorized in the Rivers and Harbors Act of 1945. Construction began in 1961, and three turbine units were operational in 1970. Three more units were operational in 1978.

Lake Herbert G. West extends upstream of the dam for 28 miles to Little Goose Dam.

Hydropower
Lower Monumental Dam has six 135-megawatt turbines, for a total generating capacity of 810 megawatts.

Lower Monumental Dam, Lake West, and associated facilities are operated for Hydropower, Navigation, Fish & Wildlife, Recreation, Water Quality, and Irrigation.

Navigation
Lower Monumental Dam navigation lock is the sixth of eight locks encountered in the Columbia-Snake Inland Waterway, a 465-mile river highway that allows barge transport of commodities between the Pacific Ocean and Lewiston, ID. In 2015, more than 2 million tons of cargo passed through the Lower Monumental lock.

Water Quality
Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species. During spill for juvenile fish passage at the four Lower Columbia and four Lower Snake River projects, the Corps implements a Water Quality Program to manage total dissolved gas.

Recreation
Popular recreation activities around Lower Monumental Dam and Lake West include fishing, swimming, picnicking, boating, hunting, hiking, and camping. There are more than 7,000 acres surrounding Lake West utilized for public recreation, wildlife habitat, wildlife mitigation, and water-connected industry.

Currently, there are 7 day-use areas, 5 campgrounds, 5 boat launch facilities, and 1 designated swimming beach. Lake West is known for the scenic confluence of the Snake and Palouse rivers, the historic Mullan Road and Lyons Ferry crossing, and the Joso Railroad Bridge.

Fish & Wildlife


Lower Monumental Dam has two fish ladders—one on each shore—to provide a passage route for upstream-migrating fish, including adult salmon and steelhead, lamprey, shad, and others. Passage routes operated for downstream-migrating fish are the spillway, a spillway weir, and a juvenile bypass system.

In 2015, about 1.2 million juvenile salmon and steelhead were collected in the bypass system—of those, 98,000 were returned to the river and over 1 million were transported downstream by barge or truck and released below Bonneville Dam.

Lower Granite Dam and Lake Lower Granite

Quick Facts
- Stream: Snake River (RM 107.5)
- Location: Pomeroy, WA
- Owner: U.S. Army Corps of Engineers, Walla Walla District
- Authorized Purposes: Hydropower, Navigation (1945 Rivers and Harbors Act)
- Other Purposes: Fish & Wildlife, Recreation, Water Quality, Irrigation
- Type of Project: Run-of-River

Dam
- Completed: 1975
- Height: 151 ft
- Length: 3,200 ft
- Features: powerhouse, spillway, navigation lock, fish passage facilities
- Forebay Elevation Normal Operating Range: 733–738 ft msl
- Spillway Capacity (max): 850,000 cfs

Powerhouse
- Generation Capacity: 810 MW, 6 Units
- Hydraulic Capacity: 130,000 cfs

Lower Granite Lock and Dam was the fourth of four dams constructed as part of the Lower Snake River Project, authorized in the Rivers and Harbors Act of 1945. Construction began in 1965 and three turbine units were operational in 1975. Three more turbine units were installed and operational in 1979.

Lake Lower Granite extends from the dam upstream for 40 miles to Lewiston, ID. The Corps constructed roughly 8 miles of levees around Lewiston, ID, to help protect lives and property from potentially destructive high water conditions.

Hydropower
Lower Granite Dam has six 135-megawatt turbines, for a total generating capacity of 810 MW.

Lower Granite Dam, Lower Granite Lake, and associated facilities are operated for Hydropower, Navigation, Fish & Wildlife, Recreation, Water Quality, and Irrigation.

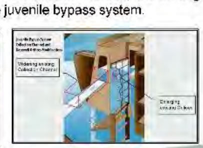
Navigation
Lower Granite Dam navigation lock is the last of eight locks encountered in the Columbia-Snake Inland Waterway, a 465-mile river highway that allows barge transport of commodities between the Pacific Ocean and Lewiston, ID. In 2015, more than 1.1 million tons of commercial commodities passed through the Lower Granite lock.

Water Quality
Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species. During spill for juvenile fish passage at the four Lower Columbia and four Lower Snake River projects, the Corps implements a Water Quality Program to manage total dissolved gas.

Recreation
Popular recreation activities around Lower Granite Dam and Lake include fishing, swimming, picnicking, boating, hunting, and camping. There are several day-use areas, campsites, parks, habitat management units, boat launch facilities, and marinas.

Fish & Wildlife
Lower Granite Dam has one fish ladder with entrances on both shores to provide a passage route for upstream-migrating fish, including adult salmon and steelhead, lamprey, shad, and others. Passage routes operated for downstream-migrating fish are the spillway, a spillway weir, and a juvenile bypass system. In 2015, about 2.7 million juvenile salmon and steelhead were collected in the bypass system—of those, roughly 1.5 million were transported downstream by barge or truck and released below Bonneville Dam.

Recent improvements to Lower Granite fish facilities include installation of pumps to draw cooler water from deep in the forebay to cool the adult ladder in the hot summer months, and an ongoing overhaul and upgrade of the juvenile bypass system.



Little Goose Dam and Lake Bryan

Quick Facts

- Stream: Snake River (RM 70.3)
- Location: Dayton, WA
- Owner: U.S. Army Corps of Engineers, Walla Walla District
- Authorized Purposes: Hydropower, Navigation (1945 Rivers and Harbors Act)
- Other Purposes: Fish & Wildlife, Recreation, Water Quality, Irrigation
- Type of Project: Run-of-River

Dam

- Completed: 1970
- Height: 149 ft
- Length: 2,655 ft
- Features: powerhouse, spillway, navigation lock, fish passage facilities
- Forebay Elevation Normal Operating Range: 633–638 ft msl
- Spillway Capacity (max): 850,000 cfs

Powerhouse

- Generation Capacity: 810 MW, 6 Units
- Hydraulic Capacity: 130,000 cfs

Little Goose Lock and Dam was the third of four dams constructed as part of the Lower Snake River Project, authorized in the Rivers and Harbors Act of 1945. Construction began in 1963, and three turbine units were operational in 1970. Three more turbine units were operational in 1978.

Lake Bryan extends from the dam upstream for 37 miles to Lower Granite Dam.

Hydropower

Little Goose Dam has six 135-megawatt turbine units and a total generating capacity of 810 MW.

Little Goose Dam, Lake Bryan, and associated facilities are operated for Hydropower, Navigation, Fish & Wildlife, Recreation, Water Quality, and Irrigation.

Navigation

Little Goose Dam navigation lock is the seventh of eight locks encountered in the Columbia-Snake Inland Waterway, a 465-mile river highway that allows barge transport of commodities between the Pacific Ocean and Lewiston, ID. In 2015, more than 1.9 million tons of cargo passed through the Little Goose lock.

Water Quality

Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species. During spill for juvenile fish passage at the four Lower Columbia and four Lower Snake River projects, the Corps implements a Water Quality Program to manage total dissolved gas.

Recreation

Popular recreation activities around Little Goose Dam and Lake Bryan include fishing, swimming, picnicking, boating, hunting, and camping. Currently, there are 7 day-use areas, 5 campgrounds, 5 boat launch facilities, and 2 swimming beaches.

Fish & Wildlife

Little Goose Dam has one fish ladder with entrances on both shores to provide a passage route for upstream-migrating fish, including adult salmon and steelhead, lamprey, shad, and others. Passage routes operated for downstream-migrating fish are the spillway, a spillway weir, and a juvenile bypass system.

In 2015, nearly 2.2 million juvenile salmon and steelhead were collected in the bypass system—of those, 480,000 were returned to the river and over 1.8 million were transported downstream by barge or truck and released below Bonneville Dam.

Dworshak Dam and Dworshak Reservoir

Quick Facts

- Stream: North Fork Clearwater River (RM 1.9)
- Location: Ahsahka, ID
- Owner: U.S. Army Corps of Engineers, Walla Walla District
- Authorized Purposes: Flood Control, Hydropower (1962 Flood Control Act)
- Other Purposes: Recreation, Fish & Wildlife, Water Quality
- Type of Project: Storage
- Authorized Flood Storage: 2,015,800 acre-ft

Dam

- Completed: 1972 (flood control); 1973 (power)
- Features: powerhouse, spillway, fish hatchery
- Height: 717 ft
- Length: 3,287 ft
- Forebay Elevation Normal Operating Range: 1,445–1,600 ft msl
- Spillway Capacity (max): 180,000 cfs

Powerhouse

- Generation Capacity: 400 MW, 3 Units
- Hydraulic Capacity: 10,500 cfs

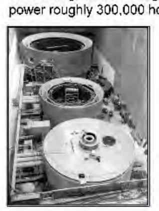
Originally authorized as Bruces Eddy Dam in the 1962 Flood Control Act, the name was changed to Dworshak Dam in 1963. Construction began in 1966, and the project started operating for flood control in 1972. The three turbine units began generating power in 1973.

Dworshak Dam is the third tallest dam in the U.S. The reservoir extends upstream for roughly 54 miles into the Clearwater National Forest in the Bitterroot Mountains.

Dworshak Dam, Dworshak Reservoir, and associated facilities are operated for Flood Risk Management, Hydropower, Recreation, Fish & Wildlife, and Water Quality.

Hydropower

Dworshak Dam has one 220-megawatt turbine unit that is the largest hydroelectric generator in the Corps' inventory. The other two units are 90-megawatt, for a total project generating capacity of 400 megawatts–enough to power roughly 300,000 homes.



Flood Risk Management

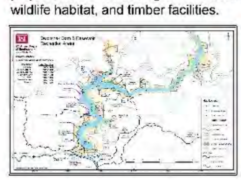
Dworshak Reservoir has over 2 million acre-feet of storage space for local and regional flood control.

Water Quality

Water quality is monitored and managed consistent with Clean Water Act and state standards for the health of aquatic species.

Recreation

Popular recreation activities at Dworshak Dam and Reservoir include boating, swimming, fishing, hunting, camping, picnicking, geocaching, and hiking. There are roughly 30,000 acres of project lands surrounding the reservoir used for public recreation, wildlife habitat, and timber facilities.



Fish & Wildlife

The height of Dworshak Dam made it infeasible to install fish ladders for upstream fish passage. Instead, the Corps constructed the Dworshak National Fish Hatchery just below the dam in 1969. The U.S. Fish & Wildlife Service operates the hatchery and raises Clearwater River "b-run" steelhead, spring Chinook, coho, and rainbow trout.

Dworshak is operated to benefit salmon and steelhead in the Snake River by releasing cool water from the reservoir during the warm summer months. Water is drawn from various depths in the reservoir to adjust the temperature, which typically ranges from 46°–48°F.

Wildlife mitigation lands are managed to offset habitat losses that occurred when the reservoir filled. About 7,000 acres are managed specifically for habitat for the Rocky Mountain elk.