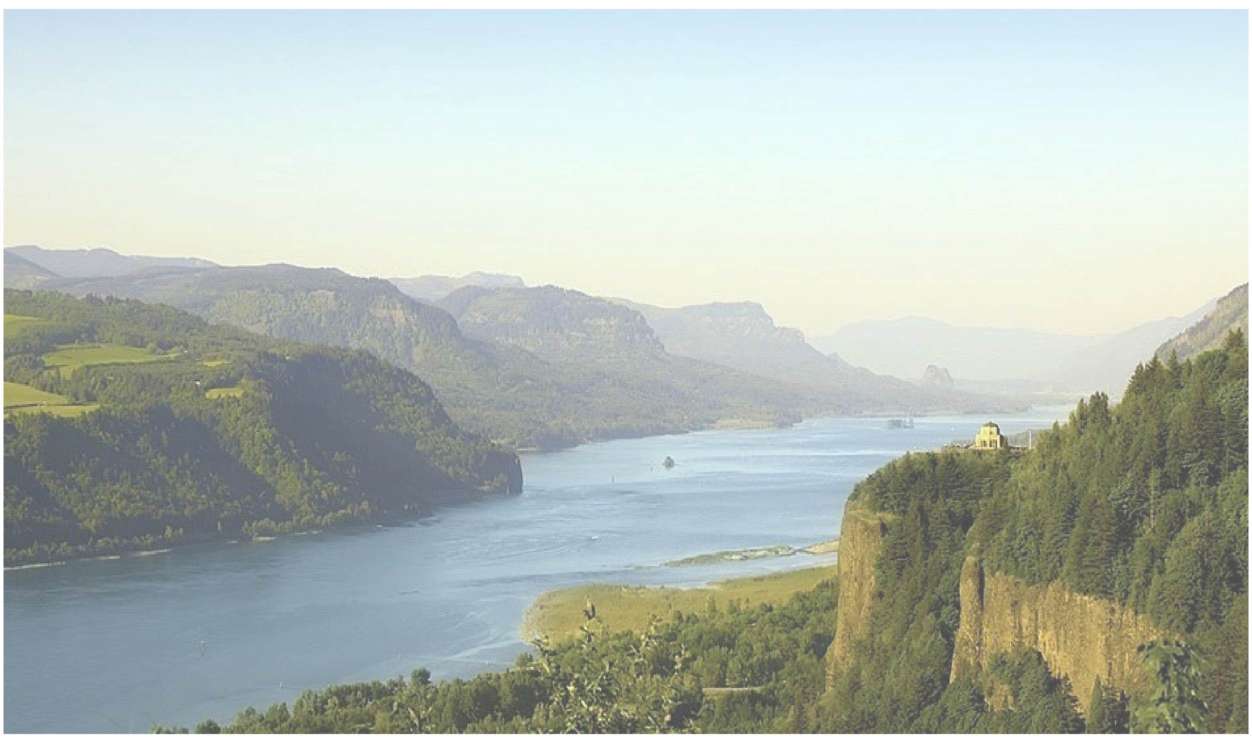
Columbia River System Operations Draft Environmental Impact Statement

February 2020

Co-Lead Agencies:

U.S. Army Corps of Engineers – Northwestern Division
Bureau of Reclamation – Pacific Northwest Region
Bonneville Power Administration (DOE/EIS-0529)



US Army Corps of Engineers®

BUREAU OF RECLAMATION

Bonneville POWER ADMINISTRATION

Columbia River System Operations
Draft Environmental Impact Statement

Co-Lead Agencies: U.S. Department of the Army, U.S. Army Corps of Engineers – Northwestern Division; Bureau of Reclamation – Pacific Northwest Region; U.S. Department of Energy, Bonneville Power Administration (DOE/EIS – 0529)

Cooperating Agencies: U.S. Coast Guard; U.S. Environmental Protection Agency; U.S. Department of Interior, Bureau of Indian Affairs; State of Idaho; State of Montana; State of Oregon; State of Washington; Lake County, Montana; Confederated Salish Kootenai and Tribes of the Flathead Reservation; Confederated Tribes of the Colville Reservation; Confederated Tribes of Grand Ronde Community of Oregon; Confederated Tribes of the Umatilla Indian Reservation; Confederated Tribes and Bands of the Yakama Nation; Cowlitz Indian Tribe; Kootenai Tribe of Idaho; Nez Perce Tribe; Burns Paiute Tribe; Fort McDermitt Paiute and Shoshone Tribes of the Fort McDermitt Indian Reservation; Shoshone-Paiute Tribes of Duck Valley Reservation; Shoshone-Bannock Tribes of the Fort Hall Reservation; and Spokane Tribe of Indians.[1]

Title of Proposed Project: Columbia River System Operations

States Involved: Idaho, Montana, Oregon, and Washington

Abstract: The U.S. Army Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration, as co-lead agencies, have prepared this Columbia River System Operations Draft Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act (NEPA). The co-lead agencies requested Federal, state, and local agencies, and tribes to participate as cooperating agencies based on their jurisdiction by law, or their special expertise. More than 30 entities from across the region agreed to be cooperating agencies in this NEPA process. In addition, co-lead agencies gathered input from the public, tribes, local, state, and Federal governments, and water resource users— including utility customers, commercial navigation and port entities, irrigation users, fishing and commercial fishers, and other public interest groups during the scoping process.

The EIS identifies and evaluates a No Action Alternative and five alternatives for operations, maintenance, and configuration of the Columbia River System (CRS). The alternatives are based on scoping input and expertise from cooperating and co-lead agencies. The alternatives include different system operations and additional structural modifications to existing projects, such as breaching the embankments at the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Projects; modifying fish ladders; or adjusting storage operations to affect the timing of flows for various purposes. The alternatives explore a range of spill levels to support juvenile fish passage, varying levels of hydropower generation by seasonal changes in flows, and differing actions to support the needs of Endangered Species Act (ESA)-listed anadromous and resident fish. Some alternatives evaluate additional future water supply for irrigation purposes

[1] Continued discussions concerning the Spokane Tribe of Indian's cooperating agency status are ongoing.

and increased water management flexibility to react to unexpected river flow changes and increase the likelihood of achieving refill of storage reservoirs. After evaluating the potential effects of the five alternatives on resources, such as flood risk management, water supply, hydropower generation, fish, vegetation, wildlife, wetlands, floodplains, climate, navigation, cultural resources, tribal interests, recreation, and other environmental, social, and economic resources, the co-lead agencies identified a Preferred Alternative that balances multiple, sometimes competing, river resource needs and co-lead agency mission requirements. The co-lead agencies expect that the suite of operational, maintenance, and structural measures included in the Preferred Alternative would allow them to meet the EIS intent as expressed in the Purpose and Need and the EIS objectives, including those to benefit ESA-listed species, while also continuing to meet the congressionally authorized purposes of the system. The EIS also documents measures to avoid, offset, or minimize impacts to resources affected by system operations, maintenance, and configuration where feasible.

Comments Due: April 13, 2020

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Or send a question:

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*A limited number of hard copies will be available upon request due to the size of the document (over 4,000 pages in multiple volumes).

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COLUMBIA RIVER SYSTEM OPERATIONS

EXECUTIVE SUMMARY

Columbia River System Operations Draft Environmental Impact Statement

US Army Corps of Engineers®

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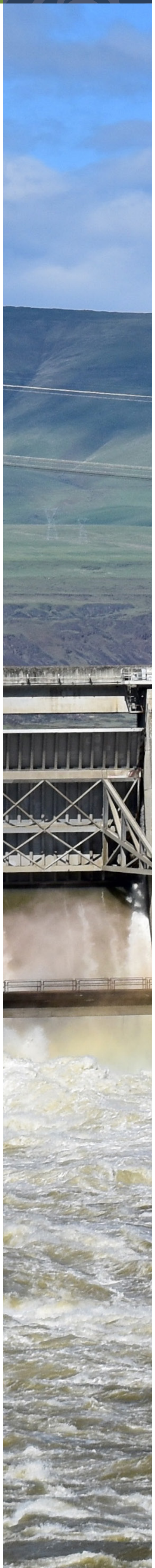


The U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration, as co-lead agencies, have prepared this Columbia River System Operations Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act (NEPA). NEPA requires federal agencies to review and disclose the environmental effects of taking an action. The action referred to in this EIS is not one specific act, but is rather a multi-faceted approach to system operations, maintenance, and configuration of the 14 Federal dam and reservoir projects in Idaho, Montana, Oregon and Washington, called the Columbia River System (CRS). We prepared this document in response to the need to review and update management of the CRS, including evaluating impacts to resources in the context of new information and changed conditions in the Columbia River basin. Information and insights from this process has enabled the development of a comprehensive approach to management of the CRS that meets multiple statutory authorities and complies with all applicable laws and regulations.

More than 30 entities from across the region, consisting of tribes, Federal agencies, and state and local governments, agreed to participate as cooperating agencies in this NEPA process. We greatly appreciate their technical expertise and input on early versions of this document. We are especially grateful to our tribal partners for helping ensure that the document reflects tribal perspectives on the Columbia River System.

The EIS identifies and evaluates six alternatives for operations, maintenance, and configuration of the CRS. After evaluating the potential effects of the six alternatives on flood risk management, water supply, hydropower generation, fish and wildlife, navigation, cultural resources, recreation and other environmental and socioeconomic resources, the co-lead agencies identified a Preferred Alternative that sought to achieve a reasonable balance of multiple river resource needs and co-lead agency mission requirements. The Preferred Alternative is comprised of a suite of operational and structural measures that allow us to meet the congressionally authorized purposes of the System, the Purpose and Need Statement and objectives of the EIS, including those to benefit species listed as threatened and endangered under the Endangered Species Act. Detailed descriptions of the alternatives are presented in Chapter 2 (No Action and Multi-objective Alternatives) and Chapter 7 (Preferred Alternative) of the EIS.

We recognize that the operation and maintenance of the Columbia River System affects threatened and endangered fish populations within the region, and the co-lead agencies are committed to mitigating these effects. Additional regional actions are needed, though, to address other effects that are beyond the co-lead agencies' responsibilities.

It was very important to us to seek input from a wide variety of stakeholders in the region as we developed this EIS. Not surprisingly, there is a wide range of views and opinions about the best approaches to managing the Columbia River System. However, it was also apparent that people throughout the Northwest share many common values and interests. Our goal has been to develop an approach to river management that balances these multiple perspectives and can serve as a springboard to continued progress in the region on recovery and mitigation for fish and wildlife, reliable and affordable clean electricity, and economic vitality for the many communities that depend on the CRS for their livelihoods. Our understanding of the Columbia River System will continue to improve, and the perspectives of the people living in the region will continue to evolve as well. We look forward to working with our many partners throughout the region on these important and timely issues.

Sincerely,

D. Peter Helmlinger, P.E. Brigadier General U.S. Army Division Commander	Lorri Gray Regional Director Columbia-Pacific Northwest Bureau of Reclamation U.S. Department of the Interior	Elliot Mainzer Administrator and CEO Bonneville Power Administration U.S. Department of Energy

PREFACE

The Columbia River basin is one of the greatest natural resources in the western United States, and the rivers and their tributaries form the dominant water system in the Northwest. The headwaters of the Columbia River begin at Columbia Lake, on the west slope of the Rocky Mountain Range in Canada, and the river follows a circuitous path for more than 1,200 miles before emptying into the Pacific Ocean near Astoria, Oregon. As its largest tributary, the Snake River originates in Western Wyoming and travels 1,078 miles before merging with the Columbia near Tri-Cities, Washington. The rivers influence the lives of people, fish and wildlife throughout the Northwest. The Columbia River and its tributaries, including both those in the upper and lower river and the Snake River, impact nearly every resident of the Northwest in some way, by providing hydroelectric power, recreation, navigation, water supply, flood risk management, and more.

Indigenous peoples have depended on the river and its resources for spiritual and economic well-being since time immemorial. These resources are central to tribal culture, ceremony, and subsistence within the interior Columbia River basin and its tributaries. Salmon, steelhead, Pacific lamprey, sturgeon, bull trout, and other native species found in the river are essential to many tribes' identities. Tribal populations also depended on the river for transportation, trade, fishing, and water supply.

As Euroamericans began arriving in the region in the 1800s, the Columbia River and its tributaries became an important resource for them as well. They too depended on the river for transportation, trade, commercial fishing, and irrigation water. By the 1920s, plans were being developed for the construction of multipurpose dams in the Columbia River to manage the river in new ways. With Congress' approval and funding, numerous dams were built along the Columbia River and its tributaries to provide for flood risk management, navigation, hydropower generation, irrigation, recreation, and water supply. The federal dams that are a part of the Columbia River System (CRS) were built and put into service between 1938 and 1976.

Today, the CRS continues to provide valuable social and economic benefits to the region. Operation of the CRS for flood risk management is an important purpose of the system, one that has reduced the risk to lives, property, and infrastructure in the basin. Large floods have occurred in the Columbia River basin throughout history with catastrophic consequences. For example, in 1948, a flood destroyed Vanport, Oregon. Dozens of people lost their lives. Today, the CRS provides flood risk management for communities along the river.

The Columbia-Snake Navigation System is an important component of the regional economy. Between 50 and 60 million tons of cargo are transported each year on barges that can navigate the lower Snake River beginning near Lewiston, Idaho, and Clarkston, Washington, to its confluence with the Columbia River near Pasco, Washington, and then on the Columbia River to its confluence with the Pacific Ocean near Astoria, Oregon. The river system allows farmers to export grain and other crops grown in interior parts of the United States to overseas markets. Cruise line operators also use the system for tourism, which is a growing business on the Columbia and Snake rivers.

The CRS is the source of economical, reliable, and clean power generation, providing the region with some of the least greenhouse gas (GHG) intensive electricity in the United States. On average, the CRS produces 8,500 average megawatts of carbon-free power (equivalent to the power needs of eight cities the size of Seattle) reducing the need to use other carbon-emitting resources, like gas and coal plants. The flexibility of the CRS also helps integrate variable renewable resources like wind and solar by stabilizing the system when these resources are unavailable. In power grid operations, the amount of power produced must match the amount being consumed, second by second. Maintaining this balance requires flexible generating resources. Flexible resources are always available and can be ramped up and down as needed to manage normal fluctuations in supply and demand, as well as to help balance the variable output of renewable resources such as wind and solar. Hydropower is an example of a flexible resource that helps manage the moment-to-moment variability of these renewable generators' output. With 2,500 average megawatts or more of coal capacity expected to be retired in the 2020s, the hydropower system can continue to provide reliable power while helping to decarbonize the regional economy.

The Columbia River and its tributaries provide water for millions of people throughout the Columbia River basin. Farmers depend on water from the system to irrigate crops that contribute to the national economy. These crops include grains, alfalfa, and fruits and vegetables, including the wine grapes that form the foundation of the Northwest wine industry. Water from within the study area irrigates about 1,393,000 acres of land, with the potential for more.

While the region has derived many benefits from the CRS, there have also been adverse effects, particularly to populations of native fish. In addition to the initial construction and ongoing operations of the CRS, over the past century the development of the Columbia River basin has brought with it many stressors which have collectively contributed to population declines of native fish species, including urbanization and development in wetlands and floodplains, overfishing, water diversions, water pollution, invasive species introduction, mining, farming, ranching practices, logging and riparian erosion, hatchery-produced fish and competition, and adverse ocean conditions. It is estimated that before the late 1800s, a range of five to 16 million salmon and steelhead returned to the Columbia River basin each year. Numbers of anadromous fish began to decline in the late 1800s and continued to drop into the late 1900s. Bull trout, sturgeon, and other resident fish species have also experienced significant declines.

An **ANADROMOUS FISH** is born in fresh water, migrates out to the ocean where it spends most of its life, then returns to fresh water to spawn. Salmon, steelhead, and lamprey are all anadromous fish.

Construction of the CRS directly impacted many of the region's tribal communities. Tribal homes, villages, and resource gathering locations and traditional fishing sites were inundated. Some of the most well-known of these are Celilo Falls near The Dalles, Oregon, and Kettle Falls along Lake Roosevelt in Washington. After initial construction, the dams restricted the movement

MEGAWATT (MW) is the standard term of measurement for bulk electricity. One megawatt is 1 million watts. The total possible output of a generating plant is expressed in megawatts. For example, Grand Coulee, the largest dam in the Columbia River Basin and one of the largest in the world, has a maximum capacity of 6,735 megawatts. However, power plants are not operated at full capacity year-round. A generating plant's energy output over a certain period of time (often a year) is expressed in **AVERAGE MEGAWATTS**. One average megawatt is equivalent to one megawatt delivered continuously over a year. Grand Coulee's annual energy output is 2,382 average megawatts.

An elder from the Confederated Tribes of the Colville Reservation points to an inundated home site and fishing station on the north bank of the Snake River.

of resident and anadromous fish, contributing to their population declines. These population declines were devastating to many tribes. As noted previously, fish are central to the identity of tribes. In 1994, Donald Sampson, then Chair of the Confederated Tribes of the Umatilla Indian Reservation Board of Trustees, stated:

"Salmon are the centerpiece of our culture, religion, spirit, and indeed, our very existence. As Indians, we speak solely for the salmon. We have no hidden agenda. We do not make decisions to appease special interest groups. We do not bow to the will of powerful economic interests. Our people's desire is simple—to preserve the fish, to preserve our way of life, now and for future generations."

Tribal Circumstances and Impacts of the Lower Snake River Project on the Nez Perce, Yakama, Umatilla, Warm Springs and Shoshone Bannock Tribes Meyer Resources, Inc., 1999.

Today, the annual runs of salmon and steelhead average just over two million fish, of which 40 percent are naturally produced. The rest come from hatchery programs developed for conservation or safety-net purposes, or as mitigation for the construction of the dams. Since 1992, more than half of Columbia River salmon and steelhead species have been listed under the Endangered Species Act (ESA). Regional debate continues about the relative importance of the different factors that cumulatively led to this decline, but there is little debate that the construction and operation of the CRS has had a sizable impact on fish. Tremendous effort and billions of dollars have been invested in infrastructure, hatcheries, and other projects to improve passage and habitat for fish in the basin over the last 50 years.

The fish ladder at John Day Lock and Dam that allows adult fish to migrate upstream of the dam.

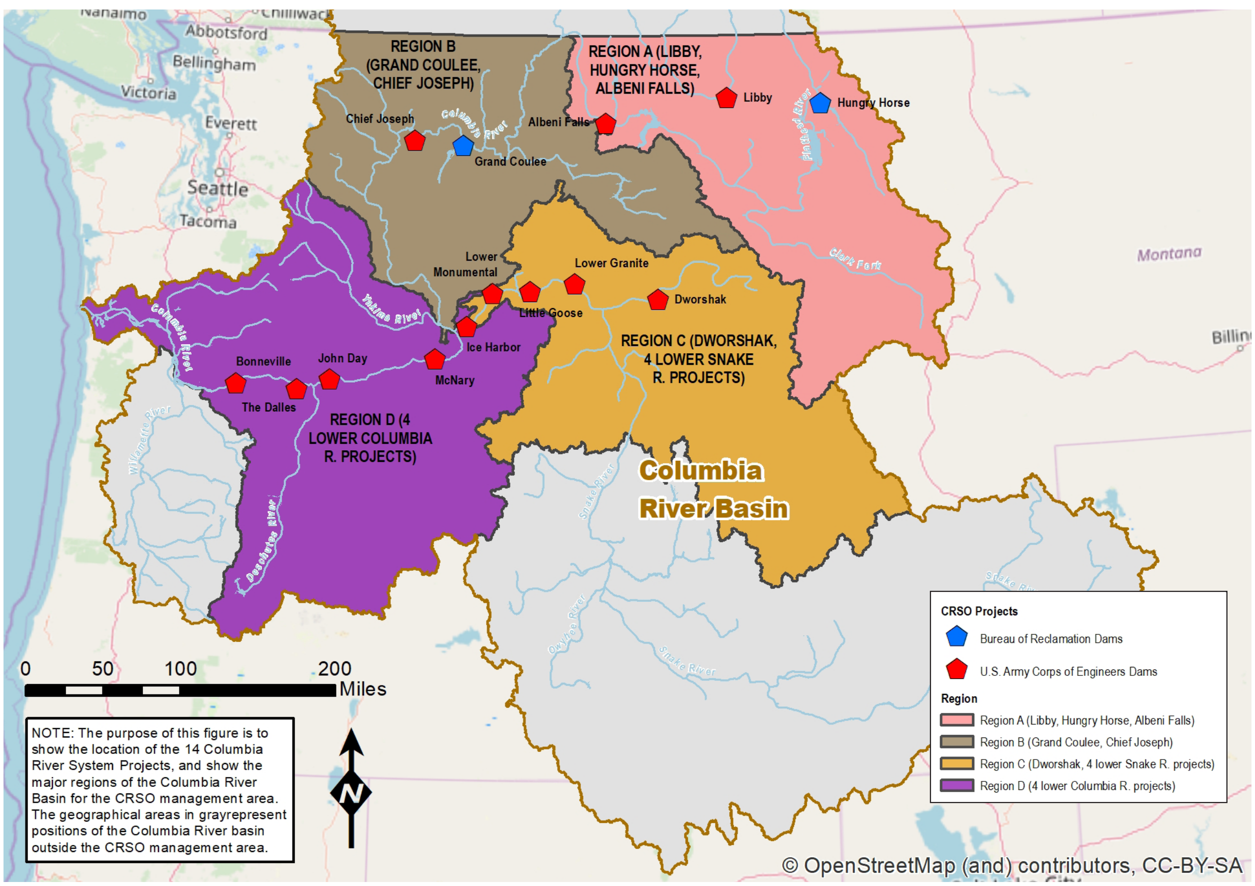
The co-lead agencies have made substantial improvements for resident and anadromous (both adult and juvenile) fish passage at the lower Snake River and lower Columbia River dams. The co-lead agencies have undertaken large-scale efforts to improve fish and wildlife habitat in tributaries and the estuary. In addition to the habitat restoration actions that have been taken to address direct impacts where they occur from operations, these actions typically enhance fish and wildlife habitat not directly impacted by the operation and maintenance of the CRS, but help mitigate for the effects of the CRS. The co-lead agencies have funded an extensive hatchery program that includes conservation hatcheries for ESA-listed fish and other hatcheries to mitigate for the construction and operation of the dams. Many of these hatchery fish support tribal, commercial, and sport harvest. While not inclusive of all actions that have been taken to benefit salmon, steelhead, Pacific lamprey, bull trout, sturgeon, and other native fish species, these examples help provide context for the level of effort that has gone into improving conditions for fish within the basin.

The co-lead agencies are committed to working with the region to continue to improve conditions for fish and wildlife affected by operations of the CRS.

1 INTRODUCTION

The U.S. Army Corps of Engineers (Corps), Bureau of Reclamation (Reclamation) and Bonneville Power Administration (Bonneville), as co-lead agencies, have developed the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act (NEPA). The co-lead agencies prepared this EIS in response to the need to review and update operations, maintenance, and configuration of the 14 CRS multiple purpose dams and related facilities ("projects"). These projects include 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 ES-1). The United States Congress authorized the Corps and Reclamation to construct, operate, and maintain the CRS projects to meet multiple specified purposes, including flood risk management (FRM), navigation, hydropower generation, irrigation,

Figure ES-1: Columbia River System Projects



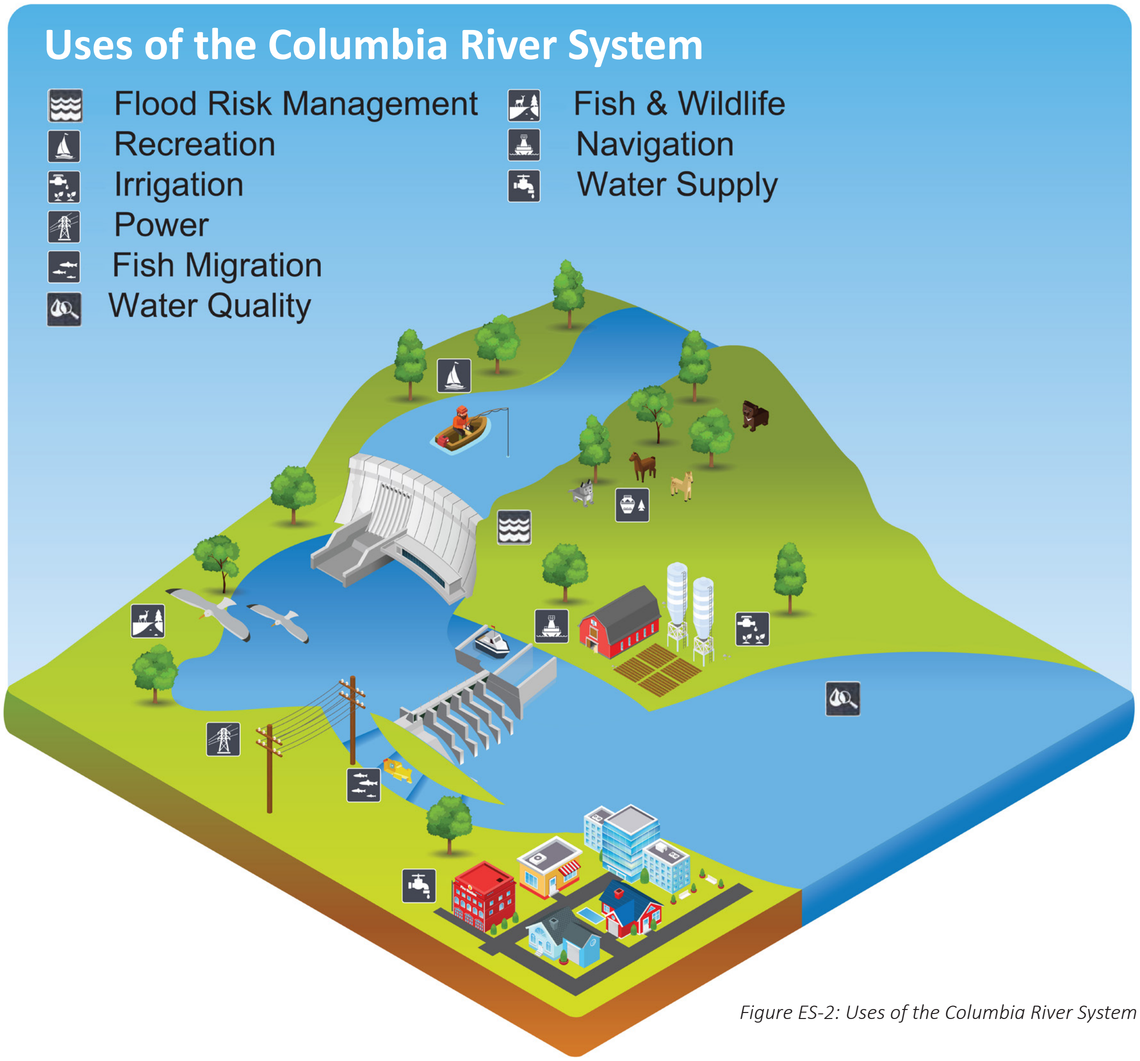


Figure ES-2: Uses of the Columbia River System

fish and wildlife conservation, recreation, and municipal and industrial (M&I) water supply (Figure ES-2). Bonneville is authorized to market and transmit the power generated by these coordinated system operations. Although the CRS has many purposes, it is operated as one interconnected system.

To meet the many uses of the Columbia River System, the co-lead agencies manage a complex operation that includes storing and releasing water at just the right times and in just the right amounts to meet various needs throughout the year. Often, actions to meet one need make it more challenging to meet another. For example, in January, operators begin drafting reservoirs to make room for spring runoff and provide flood risk management space, but sufficient water must still be available in early April to help propel juvenile salmon and steelhead in their migration to the ocean. All of the system's purposes are important and must be carefully choreographed.

As part of the CRSO EIS, the co-lead agencies analyzed the environmental, economic, and social impacts of the No Action and Action Alternatives, reviewing new scientific information, where applicable, and responding to the Opinion and Order from the U.S. District Court for the District of Oregon.[1] The Opinion and Order states the EIS should evaluate how to ensure that the prospective management of the CRS 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. It also ordered the co-lead agencies to complete the Final EIS and records of decision by June 2021 and September 2021 respectively.

This executive summary provides an overview of the draft EIS, which is a much larger document that contains highly detailed analysis and results. This executive summary also provides an overview of the major environmental effects of the Preferred Alternative, but it is not intended to be a substitute for the broader CRSO EIS

[1] *National Wildlife Federation, et al. v. National Marine Fisheries Service (NMFS), et al.,* 184 F. Supp. 3d 861 (D Or. 2016).

document, which provides a comprehensive and detailed description of the environmental effects and mitigation for the Preferred Alternative. The table of contents below identifies the major topics and chapters of the EIS. Where possible, the executive summary points to the EIS chapter and section where the reader can find further details on a topic. Here is a link to the EIS website: www.crso.info.

The geographic scope of the EIS encompasses the 14 federal projects on the Columbia River, Snake River, and some of its major tributaries. Other federal projects located across the Columbia River basin (e.g., the Willamette Valley projects, the Yakima Valley projects, and other federal projects in the Snake River basin), are not included in the specific geographic scope for the effects analysis in this EIS. Those projects are separate from CRS operations and are carried out under different legal authorities.[2] Additionally, non-federal projects in the geographic scope were included in the modeling of hydrology and outflows of operations into the system, cumulative affects considerations, and considerations for how our operations may cause impacts to non-federal projects. However, these were not included in this CRS analysis to scope new measures of how they could operate differently. Non-federal projects are subject to different regulations, and requirements for operations are outlined in FERC licensing. In addition, three projects in the Canadian portion of the basin are partially coordinated with the CRS under the Columbia River Treaty (CRT). These other projects may be included in the cumulative effects analysis, as appropriate.

The temporal scope of the EIS is assumed to be 25 years from the signing of the records of decision (RODs) in order to have a similar period of analysis for comparison of effects across resources for all multiple objective alternatives. However, the socioeconomic analysis uses a 50-year period to capture the full array of changing costs and investments, and to evaluate the total costs, benefits, consequences and tradeoffs of the alternatives considered. The 50-year period of analysis provides a long-term perspective that enables the co-lead agencies to distinguish between short-term socioeconomic impacts that may occur during the implementation of alternatives and long-term effects that would occur after implementation is completed. The range of activities and effects evaluated in this EIS provide the co-lead agencies the ability to learn and adapt to changing conditions and new information over time. Adaptive management will continue to be an important approach to managing the CRS moving forward.

The October 19, 2018 *Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West* directed the co-lead agencies to shorten the timeline to prepare the EIS a year ahead of the original schedule adopted in the Opinion and Order. The schedule was primarily compressed between the completion of the Draft EIS and signing the records of decision. Publication of the Draft EIS represents the noteworthy contributions of numerous entities within the region working to analyze complicated issues.

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[2] For example, the Willamette Basin System, operated by the Corps, is authorized in part by several of the same Flood Control Acts as some of the CRS projects. However, as outlined in these authorizations, the Willamette System was designed as a comprehensive plan of development specific to the Willamette Basin, which would be operated as a separate system from the CRS.

2 REGIONAL INPUT

The co-lead agencies (Corps, Reclamation, and Bonneville) share responsibility and legal authority for managing the CRS and worked together to develop the EIS. While developing the EIS, the co-lead agencies understood the importance of seeking broad input from the region. The co-lead agencies gathered input from the public; tribes; local, state, and federal governments; water resource users, including utility customers, commercial navigation and port entities, irrigation users, fishing and commercial fishers; and other public interest groups during the scoping process.

2.1 PUBLIC SCOPING

The co-lead agencies implemented a robust public scoping process to provide an opportunity for the public to help identify significant issues that should be evaluated in the EIS. The public scoping period extended from September 30, 2016, through February 7, 2017. Also during this time, the co-lead agencies conducted 16 public meetings and two webinars.

More than 400,000 comments were provided by members of the public, tribes, local and state governmental agencies, non-governmental organizations, and other stakeholders during the public scoping period. The scoping comments are summarized in the Public Scoping Report for the Columbia River System Operations Environmental Impact Statement, October 2017, which can be found at www.crso.info.

2.2 COOPERATING AGENCIES

The co-lead agencies requested federal, state, and local agencies, and tribes to participate as cooperating agencies based on their jurisdiction by law, or their special expertise. More than 30 entities from across the region agreed to be cooperating agencies in this NEPA process. The current cooperating agencies are listed in Table ES-1. These cooperating agencies contributed to the EIS by providing information, participating on technical teams, and reviewing draft materials. The cooperating agencies retain the right to comment on the Draft and Final EISs during the public review and comment processes.
As the federal agencies responsible for complying with NEPA, the co-lead agencies retained decision making authority over the content of the Draft and Final EIS, as well as the ultimate content of the Records of Decision. Due to this, the cooperating agencies may or may not agree with or fully support all of the content of these documents.

TABLE ES-1 - COOPERATING AGENCIES
FEDERAL AGENCIES
U.S. Environmental Protection Agency, Region 10
U.S. Coast Guard, 13th Coast Guard District
U.S. Department of the Interior, Bureau of Indian Affairs
STATE AGENCIES
IDAHO
Governor's Office of Species Conservation
Governor's Office of Energy and Mineral Resources
Department of Fish and Game
Department of Agriculture
Department of Lands
Department of Environmental Quality
Historic Preservation Office
Department of Parks and Recreation
Department of Water Resources
Idaho Department of Transportation
OREGON
Department of Fish and Wildlife
Department of Energy
Water Resources Department
Department of Agriculture
Department of Environmental Quality
MONTANA
Montana Office of the Governor
Montana Fish, Wildlife and Parks
WASHINGTON
Department of Ecology
Department of Fish and Wildlife
Department of Agriculture
COUNTY AGENCIES
Lake County, Montana
TRIBES
Confederated Salish and Kootenai Tribes of the Flathead Reservation
Confederated Tribes of the Colville Reservation
Confederated Tribes of Grand Ronde
Confederated Tribes of the Umatilla Indian Reservation
Confederated Tribes and Bands of the Yakama Nation
Cowlitz Indian Tribe
Kootenai Tribe of Idaho
Nez Perce Tribe
Burns Paiute Tribe
Fort McDermitt Paiute and Shoshone Tribes of the Fort McDermitt Indian Reservation
Shoshone-Paiute Tribes of the Duck Valley Reservation
Shoshone-Bannock Tribes of the Fort Hall Reservation
INTERTRIBAL ORGANIZATION
Upper Snake River Tribes Foundation on behalf of: Burns Paiute Tribe, Fort McDermitt Paiute-Shoshone Tribe, and Shoshone-Paiute Tribes of the Duck Valley Reservation

2.3 TRIBAL COORDINATION AND PERSPECTIVE

Since time immemorial, the Columbia River Basin has been inhabited by Native American peoples, who successfully subsisted on the abundant natural resources of the region. They built thriving communities that relied on the lands to sustain their way of life. Through treaties, executive orders, judicial decisions, and legislation, the tribes ceded most of their territory to the United States while retaining smaller portions of land for their reservations. Some tribes, through treaties, retained the right to hunt, fish, and gather in their usual and accustomed locations, including areas outside of their reservations. The potentially affected area of the CRS includes portions of tribal reservations, trust lands, and ceded lands of 19 federally recognized tribes. Reservoirs that are part of the CRS system inundate parts of three existing Indian reservations: the Colville and Spokane reservations, which are partially inundated by Lake Roosevelt; and the Nez Perce Reservation, which is partially inundated by Dworshak Reservoir. In some cases, the U.S. Government has entered into special agreements with these tribes regarding management of the reservoirs because of their location within reservations.

In its relations with tribes, the United States "has charged itself with moral obligations of the highest responsibility and trust" (Seminole Nation v. United States, 1942). These trust responsibilities derive from the historical relationship between the federal government and tribes as expressed in Treaties, Statutes, Executive Orders, and Federal Indian case law. The co-lead agencies are committed to a government-to-government relationship with the tribal governments and recognize the unique character of each tribe. Tribal governments have the primary authority and responsibility for many reservation affairs, and may be co-managers of natural resources within their respective ceded, treaty, or usual and accustomed areas. As a result, the co-lead agencies have sought to involve the tribes from the beginning of this process to gain their perspective on the planning and management activities of water resources, fish and wildlife resources and other natural resources in order to achieve mutually beneficial results. The co-lead agencies engaged with tribes during the development of the EIS by inviting them to be cooperating agencies, participating in formal government-to-government consultations, and engaging with them through other existing processes, such as the Columbia Basin Fish Accords. The co-lead agencies initiated government-to-government engagement with the tribes in Table ES-2.

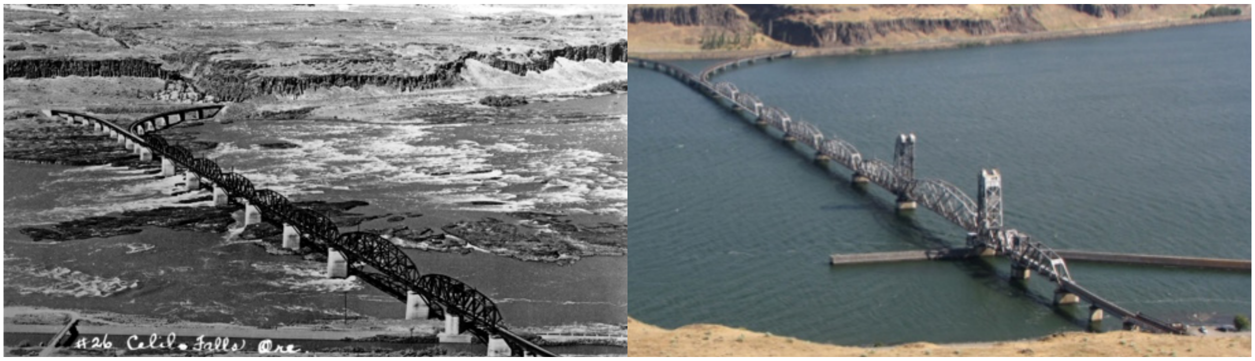
TABLE ES-2 - ENGAGEMENT WITH FEDERALLY RECOGNIZED TRIBES
Burns Paiute Tribe
Coeur D'Alene Tribe of Indians
Confederated Salish and Kootenai Tribes of the Flathead Reservation
Confederated Tribes of the Chehalis Reservation
Confederated Tribes of Grand Ronde
Confederated Tribes of Siletz Indians of Oregon
Confederated Tribes of the Colville Reservation
Confederated Tribes of the Umatilla Indian Reservation
Confederated Tribes of Warm Springs Reservation
Confederated Tribes and Bands of the Yakama Nation
Cowlitz Indian Tribe
Fort McDermitt Paiute and Shoshone Tribes of the Fort McDermitt Indian Reservation
Kalispel Tribe of Indians
Kootenai Tribe of Idaho
Nez Perce Tribe
Shoalwater Bay Indian Tribe
Shoshone-Bannock Tribes of the Fort Hall Reservation
Shoshone-Paiute Tribes of the Duck Valley Reservation
Spokane Tribe of Indians

The tribes of the Columbia River basin represent diverse and distinct cultures, each different from the next. There is one theme, however, that the tribes all have in common: Their association with the natural resources of the region permeates every aspect of their cultures. This association results in a strong sense of stewardship for the land.

It is difficult to overstate the effects the CRS has had on tribal culture, way of life, and traditions. These effects have been explicit—as in the loss of celebrated fishing sites of regional importance such as Celilo and Kettle Falls; and implicit—including the loss of the innumerable and unquantifiable intra- and inter-tribal interactions that occurred at these locations, such as loci-focused ceremonies, traditions, languages and customs, dances and song. The losses of these areas have adversely affected how tribal communities define themselves, interact with each other, and live full spiritual lives; and in the process has undermined the processes through which living cultures are nourished, maintained, and perpetuated. The Confederated Tribes of the Colville Reservation (CTCR) stated:

"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 … 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."

(See Appendix P)



Celilo Falls before and after construction of The Dalles Dam inundated the area, putting the falls underwater. For thousands of years, Celilo Falls served as a culturally significant fishing site for tribes.

Kettle Falls, before and after inundation. This area served as a major fishing location and focal point for tribal interactions, for millennia.

Many of the tribes have not only lost access to traditional places, but have lost access to the one thing that all these places on the river had in common, which bound them together- the salmon. The loss of these foundational aspects of tribal culture has manifested itself across tribal communities in very tangible ways. The tribes cope with levels of poverty, ill health, and unemployment at significantly higher proportional rates than any other ethnic group in the country, which in turn leads to significantly higher mortality rates in comparison to non-native communities.

Many of the facilities and much of the infrastructure that make up the CRS were put in place before legislation or enactment of executive orders that required the U.S. government to consider the effects these actions would have on the natural and cultural environment, and tribes. When the tribes did raise their concerns, they were often ignored or minimized:

"Present tribal suffering stems, in large part, from the cumulative stripping away of tribal Treaty-protected resources to create wealth for non-Indians of the region … In earlier decades, bureaucrats working to convert the river to produce electricity, irrigate agriculture, carry commodities by river barge, and accommodate deposit of waste, asserted that 'uncertainty regarding impacts on salmon could be managed' as the conversion of the river moved forward."

Tribal Circumstances and Impacts of the Lower Snake River Project on the Nez Perce, Yakama, Umatilla, Warm Springs and Shoshone Bannock Tribes, Meyer Resources, Inc., 1999.

Given the co-lead agencies' trust responsibilities, and their relationships with tribes that have deepened over the years through collaboration in the Columbia River basin, it is important that tribal perspectives have a prominent place in this document, as well as in the management of the Columbia River System.

2.4 AREAS OF CONTROVERSY

Lower Snake River Dam Breach

The co-lead agencies received important feedback from tribal engagement, cooperating agencies, and through public scoping pertaining to breaching the four lower Snake River dams. Breaching the four lower Snake River dams has been a topic of public discourse for decades. This EIS provides an updated analysis of the many biological and sociological variables and the costs and benefits of retaining or breaching the lower Snake River dams. In combination with other sources of information and analysis available in the public domain, this document can help inform the regional conversation on this complex and often polarizing issue. New congressional authority and associated funding would be required to implement the dam breaching measures evaluated in the EIS. However, the measures are carried forward in the analysis to align with the District Court's Opinion and Order, as well as in response to comments received during public scoping.

Fish Modeling

The EIS analysis uses two different approaches to estimate how the changes to CRS operations that were developed as part of this EIS will change the rates of adult salmon and steelhead returning to the Columbia and Snake Rivers. These models are the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) Life Cycle Model (LCM), which includes the Comparative Passage (COMPASS) model; and the Comparative Survival Study (CSS) model, which has been collaboratively developed by federal and state agencies and tribal sovereigns. Both models were used to estimate the magnitude of effects on spring Chinook salmon and steelhead, and where applicable, the model results were considered and applied to other species.

The models apply different assumptions and predict survival using different combinations of environmental variables, which are described in more detail in Chapter 3, Section 5. In general, the CSS model predicts that for juvenile salmon and steelhead on their way downstream, additional increases in spring spill would reduce the number of powerhouses these young fish would swim through and increase the number of returning adults in subsequent years. The NMFS LCM does not predict the same magnitude of increases in adult returns due to increases in spill levels beyond performance standard spill, but instead predicts that variables such as ocean conditions or the number of fish transported past the dams have a bigger impact on how many adult fish return.

One element, delayed mortality, stands out as particularly important in explaining the models' different predictions. Delayed or "latent" mortality is mortality attributed to the CRS, but not experienced by juvenile salmon and steelhead until after they pass through the freshwater CRS. The CSS model attributes the majority of recent declines in returning adult salmon and steelhead to decreased ocean survival (delayed mortality) directly associated with passage past the dams, but the CSS models also consider numerous other factors including ocean conditions. NMFS's LCM attributes the majority of recent declines to the arrival time of juveniles entering the ocean (e.g., fish that enter the ocean later in their migration run-timing tend to have lower survival), and deteriorating ocean conditions (decadal scale cycles in ocean productivity and warming water in the Northeast Pacific).

SPILL The co-lead agencies release (or spill) water through the federal dams in the spring and summer to help juvenile salmon and steelhead migrate safely to the ocean. With spill, fish go past the dams in water that flows through spillway openings, rather than traveling through turbines or bypass systems. Spillway weirs allow juvenile salmon and steelhead to pass a dam near the water surface, under lower accelerations and lower pressures, providing a more efficient and less stressful dam passage route (see Figure ES-3).

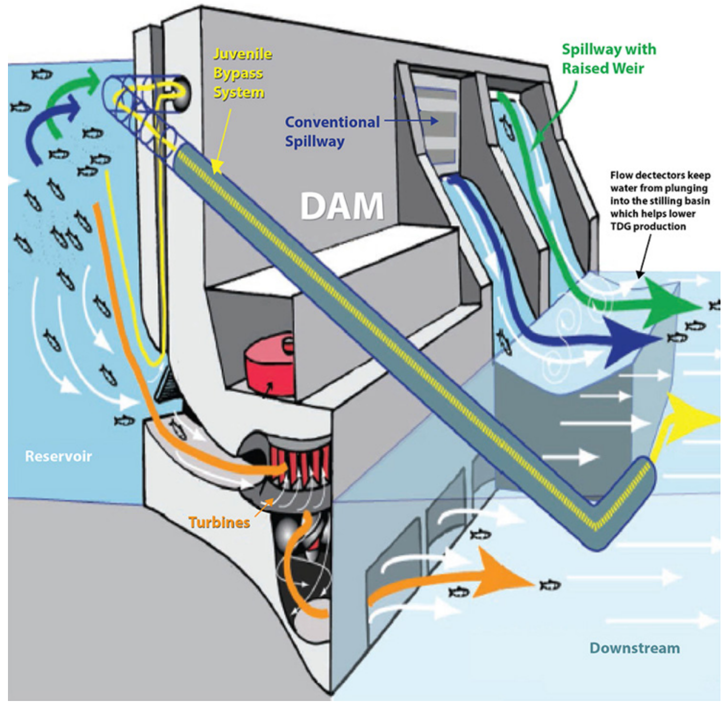


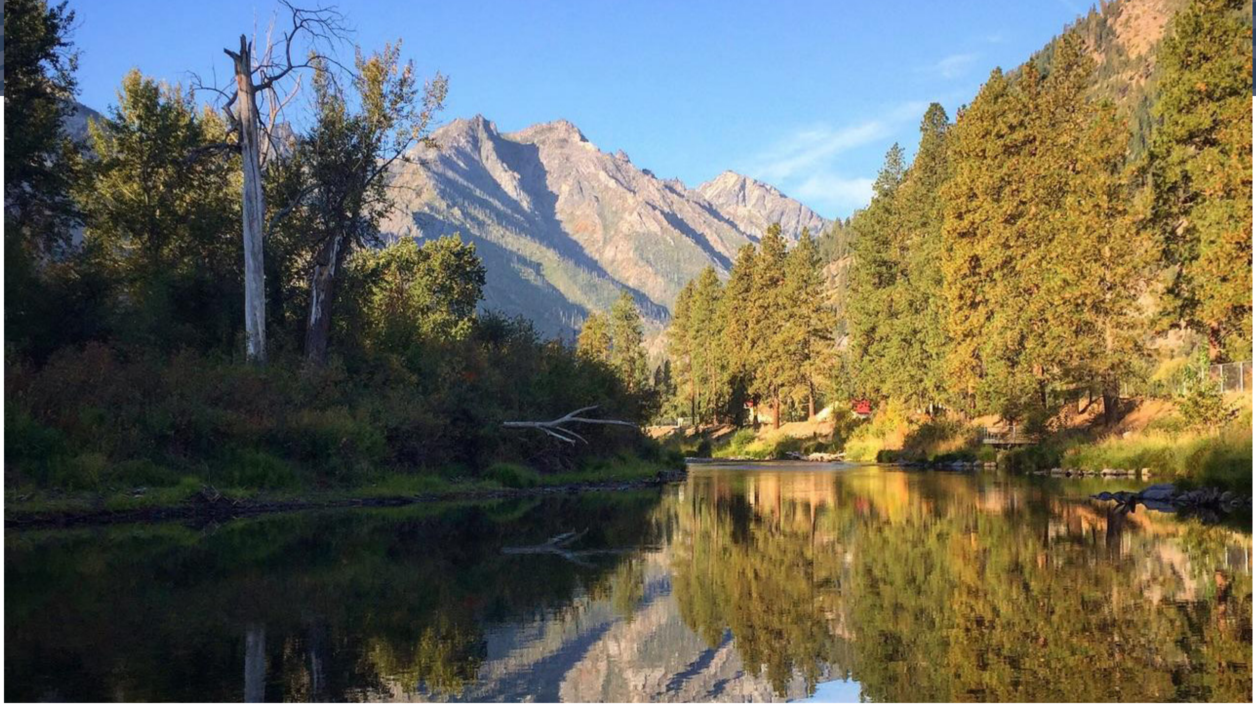
Figure ES-3: Juvenile fish passage routes on Columbia River System dams

Given the ongoing regional and scientific debate over these two models, the co-lead agencies decided to use both models to evaluate the range of potential impacts in the CRSO EIS. This approach allows for a transparent examination of the results and assumptions embedded in the two primary analytical models and allows the co-lead agencies to share the assumptions and results of both models to inform decision making. The differences in the two models illustrate the complexity of predicting how anadromous fish would respond to different management actions and highlight the uncertainty that future research and management decisions will need to address.

Many of the scoping comments expressed a desire to have the EIS include the CSS model. The CSS model is an important part of the broader anadromous fish analysis in the CRSO EIS. Information generated by the CSS model was considered alongside other quantitative and qualitative lines of evidence and played an important role in shaping the preferred alternative. Through the Flexible Spill Agreement signed in 2018 *(2019–2021 Spill Operation Agreement)*, the co-lead agencies have also sought to develop more collaborative and constructive working relationships with the proponents of the CSS model. Through this EIS, the co-lead agencies are creating an additional opportunity to test the assumptions about the potential for significantly increased salmon survival embedded in the CSS model through the adaptive implementation of a flexible spill operation. This adaptive implementation framework includes careful monitoring and evaluation to ensure there are not adverse impacts on aquatic species or other unintended consequences.

Reintroduction

Reintroduction of salmon above Grand Coulee Dam and installation of fish passage at Grand Coulee and Chief Joseph Dams is an important and complex, large-scale concept. Its consideration, evaluation, and implementation should involve multiple tribal, federal, state, and other entities. A coordinated approach among water users, tribes, states, multiple federal agencies, and others would be necessary. To allow so many differing interests to coordinate on such a complex topic, which may include international considerations, a decision-making



framework and a series of regional workshops would be necessary just to approach the first step of defining reintroduction objectives. Given the incompatibility of such a wildlife management decision-making framework with an analysis of the operation of the CRS, it is not feasible to proceed with a detailed consideration of reintroduction in this EIS. Moreover, to meaningfully analyze reintroduction as a measure, the details of the proposal would need to be understood well enough to include in hydrologic, water quality, and fish models. That information is not currently available, and development of those details was not possible in the timeframe of this NEPA process. Nevertheless, the agencies and interested regional sovereigns are developing a framework to address critical information gaps.

Water Quality

The EIS analysis predicted water temperature and total dissolved gas (TDG) effects under various dam configurations and operations as specified in the EIS alternatives.

Temperature

There are elevated water temperatures in the Columbia River Basin due to regular climatic events and climate variability. There is also regional controversy over the role the federal projects may play in contributing to higher water temperatures. Due to this controversy, the co-lead agencies developed a model that could distinguish operational changes and water quality. While other water quality models for the Columbia River Basin exist (e.g. EPA's RBM-10 model), the co-lead agencies used CE-QUAL W2 due to its ability to simulate two-dimensional reservoir stratification (temperature differences at depth) that occurs in the CRS. This was particularly of interest for analyzing changes in Dworshak operations and the effects on water temperatures in the lower Snake River.

Elevated water temperature, above state water quality criteria of 20 °C (68 °F), within much of the Columbia and Snake Rivers is a concern. Water management operations at the projects are able to provide more beneficial water temperatures than have historically been observed. Nonetheless, water temperatures in many locations of the Columbia River Basin are too warm. Concern about water temperatures increasing in the future and contributing to decline of water quality was expressed by cooperating agencies. The co-lead agencies used regionally developed climate and hydrology projections from the River Management Joint Operating Committee (RMJOC-II) study to qualitatively assess potential effects to resources, including water temperatures. This approach was used due to the uncertainty of results in the rapidly evolving science of climate change impacts on water temperature and the role of the CRS.

TOTAL DISSOLVED GAS (TDG) is the amount of gas present in water. Supersaturation of gasses in water released at hydropower dams can cause gas bubble trauma that can lead to mortality if fish are exposed to harmful levels for extended periods of time. Similar risks occur for SCUBA divers when dissolved gasses (mainly nitrogen) come out of solution in bubbles when returning to the surface too quickly and can lead to decompression sickness through temporary injury, paralysis, or death, often referred to as "the bends."

Columbia and Lower Snake River Temperature Total Maximum Daily Load (TMDL)

Over the past two years, EPA has updated the RBM-10 one-dimensional temperature model to assess Columbia and Snake River water temperatures and evaluate the effects from the federal and non-federal dams as part of the re-initiation of the TMDL project. Preliminary results have been shared across the region, which has led some stakeholders to compare the scenarios analyzed in the TMDL effort against CRSO EIS results. There are similarities in the RBM-10 and CE-QUAL W2/HEC-RAS modeling assessments of the lower Snake River, and both project teams have evaluated the similarities and differences in the models as part of an uncertainty assessment. At the same time, direct comparisons are not appropriate given the differences between scenarios and assumptions made between the two projects. These differences are described in Appendix D, Section 2.2.2.

2.5 ISSUES TO BE RESOLVED

Water Quality Standards

Implementation of the Juvenile Fish Passage Spill operations measure in the Preferred Alternative is constrained by the Washington and Oregon total dissolved gas (TDG) standards. The national TDG water quality standard is 110 percent saturation. Before 2019, the states of Oregon and Washington changed their TDG standards to allow for 120 percent TDG in the tailrace (below the dam) and 115 percent TDG in the forebay (above the dam) in Washington, and 120 percent TDG in the tailrace in Oregon, to enable juvenile fish passage on the lower Columbia and Snake rivers during the spring and summer. Beginning in April 2019, the Corps agreed to implement spill for juvenile fish passage as outlined in the 2019–2021 Spill Operation Agreement (Agreement). The second year of flexible spill operations is on track to begin in April 2020. To facilitate higher juvenile fish passage spill in the spring, Oregon and Washington agreed to consider changing their TDG water quality standard. The Agreement called for spring spill up to 120 percent in 2019, a level allowed by Oregon but above the state of Washington's standard at that time. In 2019, Washington temporarily changed their TDG standard to 120 percent TDG in the tailrace and removed the 115 percent TDG forebay limit for a one year duration, allowing for the successful implementation of the first year of the Agreement.

Implementation of the second year of the Agreement requires Oregon and Washington to increase the TDG standard up to 125 percent TDG to allow the Corps to provide 16 hours per day of 125 percent TDG spill in the spring. In Oregon, the Environmental Quality Commission approved a spring TDG standard of 125 percent at its January 2020 hearing. The Oregon modification went into effect on February 11, 2020, once it was signed by the Oregon Department of Environmental Quality Director. In Washington, a permanent rule change to facilitate the 125 percent TDG spring spill for juvenile fish passage as detailed in the Flex Spill Agreement requires approval from the U.S. Environmental Protection Agency. The Washington rule is currently awaiting approval by the U.S. Environmental Protection Agency as of February 14, 2020.

3 DEVELOPMENT AND COMPARISON OF ALTERNATIVES

Alternatives were developed to meet the Purpose and Need Statement and eight study objectives developed for the EIS, and to review and update the operations and management of the 14 CRS projects and the associated analysis of impacts since the last system analysis conducted in the 1990s (System Operation Review EIS, 1997). The three co-lead agencies convened technical subject matter experts from their agencies, as well as the cooperating agencies, to support developing the measures and alternatives.

The EIS contains a "purpose and need" statement to briefly specify the underlying purpose and need to which the agency is responding in proposing the alternatives including the proposed action. This discussion, typically one or two paragraphs long, is important for general context and understanding as well as to provide the framework in which reasonable alternatives to the proposed action will be identified.

PURPOSE AND NEED FOR ACTION

The U.S. Army Corps of Engineers (Corps), the U.S. Bureau of Reclamation (Reclamation), and the Bonneville Power Administration (BPA) are co-leads in preparing this Environmental Impact Statement (EIS) under NEPA on the coordinated water management functions for the operation, maintenance, and configuration ("management") of the 14 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[3] 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 species 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 throughout the environment affected by System operations
- Consider and plan for climate change impacts on resources and on the management of the System
- 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 and reserved rights and trust obligations for natural and cultural resources throughout the environment affected by System operations
- 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] NWF v. NMFS, 184 F. Supp. 3d 861 (D. Or. 2016).

Terminology

Objectives are what the federal agencies are trying to accomplish (the "why"). They are statements of the desired outcome of the EIS, as identified by the federal agencies and from scoping comments. An example of an objective is to improve ESA-listed anadromous salmonid adult fish migration within the project area.

A **measure** is the action the agencies would take to achieve an objective (the "how"). It describes an action, usually in a precise location, that meets an objective, in whole or in part. Using the objective mentioned above, a measure could be to provide structural enhancements for fish passage, such as improving fish ladders.

An **alternative** is a combination of one or more measures that, together, would address one or more of the objectives. In this EIS, the co-lead agencies designed the action alternatives to address several objectives, and are therefore calling them Multiple Objective Alternatives (MOs).

The co-lead agencies, working with the cooperating agencies, developed eight objectives for operating the system, using the Purpose and Need Statement and input from tribal coordination, cooperating agencies, and the public. Several of the objectives relate to key tribal resources and treaty reserved rights—an important consideration for decision makers.

COLUMBIA RIVER SYSTEM OPERATIONS OBJECTIVES

- Improve ESA-listed anadromous salmonid juvenile fish rearing, passage, and survival within the CRS through actions including but not limited to project configuration, flow management, spill operations, and water quality management. (**Improve Juvenile Salmon**)
- Improve ESA-listed anadromous salmonid adult fish migration within the CRS through actions including but not limited to project configuration, flow management, spill operations, and water quality management. (**Improve Adult Salmon**)
- Improve ESA-listed resident fish survival and spawning success at CRS projects through actions including but not limited to project configuration, flow management, improving connectivity, project operations, and water quality management. (**Improve Resident Fish**)
- Provide an adequate, efficient, economical, and reliable power supply that supports the integrated FCRPS. (**Provide a Reliable and Economic Power Supply**)
- Minimize greenhouse gas (GHG) emissions from power production in the Pacific Northwest by generating carbon-free power through a combination of hydropower and integration of other renewable energy sources. (**Minimize GHG Emissions**)
- Maximize operating flexibility by implementing updated, adaptable water management strategies to be responsive to changing conditions, including hydrology, climate, and the environment. (**Maximize Adaptable Water Management**)
- Meet existing contractual water supply obligations and provide for authorized additional regional water supply. (**Provide Water Supply**)
- Improve conditions for lamprey within the CRS through actions potentially including but not limited to project configurations, flow management, spill operations, and water quality management. (**Improve Lamprey**)

Using the Purpose and Need Statement and the objectives, the co-lead and cooperating agencies developed suites of measures and finally, combined measures into a reasonable range of alternatives representing alternatives for long-term system operations. The alternatives consist of the No Action Alternative and four Multiple Objective Alternatives (MOs). The No Action Alternative describes the "status quo" when the Notice of Intent to Prepare the EIS was issued (September 2016) and provides a baseline to which the other alternatives are compared. The MOs include a range of spill levels for juvenile fish passage, varying levels of hydropower production, and differing actions to support the needs of Endangered Species Act (ESA)-listed salmonids and resident fish. The MOs include proposed means to support the future supply of water for irrigation and municipal and industrial purposes. The MOs also include increased water management flexibility that will allow water managers to react to unanticipated changes in river flow, climate variability, and increase the likelihood of achieving refill of storage reservoirs. After evaluating the potential effects of the alternatives on the environmental, social, and economic resources, the ability to meet objectives and fulfil the Purpose and Need Statement, and effects to flood risk management, water supply, hydropower generation, navigation, fish and wildlife conservation, cultural resources, recreation and other purposes, the co-lead agencies developed a Preferred Alternative designed to achieve a reasonable balance of competing river resource needs and co-lead agency mission requirements. Detailed descriptions of the alternatives are presented in Chapter 2 and Chapter 7 of the EIS.

Definition of Effects

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

4 NO ACTION ALTERNATIVE

Overview

The No Action Alternative includes all operations, maintenance, fish and wildlife programs, and mitigation efforts in effect when the EIS was initiated in September 2016. Juvenile fish passage spill operations at the four lower Columbia River and four lower Snake River dams would follow the 2016 Fish Operations Plan developed by the Corps. This plan used performance standard spill developed under previous Endangered Species Act biological opinions.

PERFORMANCE STANDARD SPILL Spill levels from the 2008-2010 Federal Columbia River Power System Biological Opinion that were tailored to meet the BiOp standards of 96 percent average per-dam survival for spring migrants and 93 percent for summer migrating fish (see Figure ES-4).

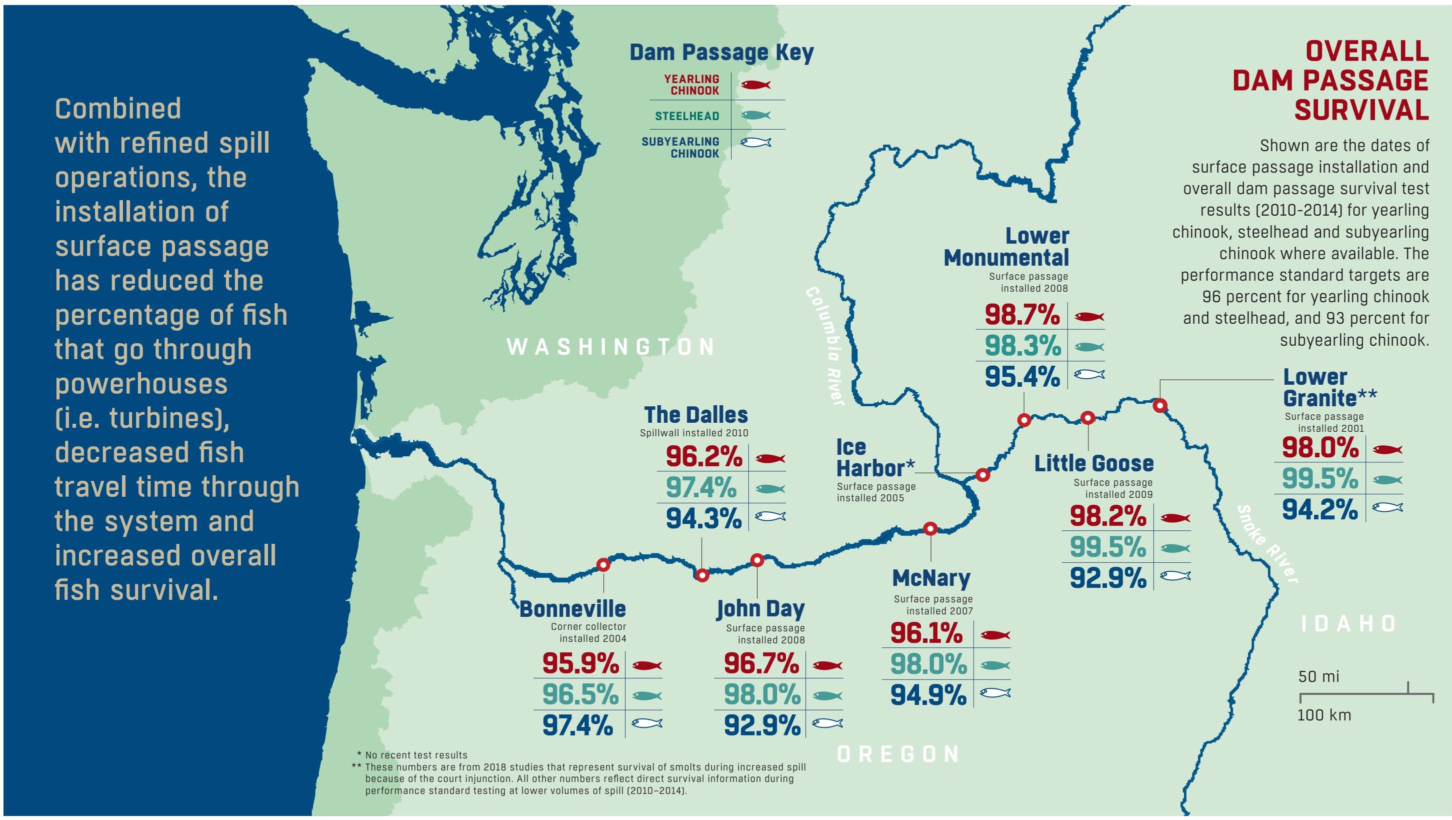


Figure ES-4: Overall Dam Passage Survival

Under the No Action Alternative, the co-lead agencies would also implement structural measures that were already budgeted for and scheduled as of September 2016. The majority of these structural measures are dam modifications to improve conditions for fish listed as threatened and endangered under the ESA. For example, installation of improved fish passage turbines planned for Ice Harbor and McNary Dams would occur as planned. Other ongoing habitat and mitigation programs would continue as planned when the EIS process started. A detailed description of measures included in the No Action Alternative is included in Chapter 2 of the EIS.

Does the No Action Alternative address the EIS Objectives?

The No Action Alternative met the Purpose and Need of the EIS, but it did not meet all of the objectives developed for the EIS.

The No Action Alternative did not provide adequate improvements to meet the **Improve Juvenile Salmon**, **Improve Adult Salmon**, **Improve Resident Fish**, and **Improve Lamprey** objectives. As outlined in this alternative, improvements to fish survival and abundance would be achieved through construction of additional fish passage structural measures at the lower Columbia River and lower Snake River projects that were completed or planned as of 2016. The No Action Alternative also considered previous efforts in offsite improvements from actions such as habitat restoration and hatchery programs and assumed those programs would continue. Additional measures that could be adopted to improve fish survival to meet these objectives were considered but only resulted in small, incremental improvements and did not meet the EIS objectives for larger, more substantial improvements for fish.

The No Action Alternative generally satisfied the **Provide a Reliable and Economic Power Supply** objective as it resulted in no additional upward power rate pressure or potential regional reliability issues. However, it only partially meets the objectives to **Provide Water Supply** and **Maximize Adaptable Water Management** because it would not provide the additional authorized regional water supply. Further, the No Action Alternative does not include a measure to reflect operational restrictions that may be the result from important maintenance activities at Grand Coulee in the near-term. (The multi-objective alternatives all include a measure for additional maintenance at Grand Coulee to assess the impact on operations.)

Additional Effects of the No Action Alternative

It is not expected that there would be any new moderate or major impacts to environmental, economic, or social resources as a result of continuing the No Action Alternative. Information gained from evaluating this alternative was used to inform the development of the Preferred Alternative that seeks to balance managing the system for all authorized purposes while providing additional benefits to fish.

Lamprey

5 MULTIPLE OBJECTIVE ALTERNATIVE 1 (MO1)

Overview of the Alternative

MO1 was developed to meet all objectives while prioritizing benefits to lamprey and ESA-listed fish species relative to the No Action Alternative. MO1 differs from the other alternatives by carrying out a juvenile fish passage spill operation referred to as a block spill design. The block spill design alternates between two operations: a base operation that provides spill over the spillways using tailored spill levels at each project based on historical survival tests; and a fixed higher spill target at all projects. During the high spill block that uses the same target at all projects, the operators would release water through the spillways up to a target of no more than 120 percent total dissolved gas (TDG) in the tailrace (below the dam) of projects and 115 percent TDG in the forebay (above the dam) of those projects. In addition, MO1 sets the duration of juvenile fish passage spill to end based on a fish count trigger, rather than a predetermined date. MO1 proposes to initiate transport operations (barging) for juvenile fish approximately two weeks earlier than under the No Action Alternative. MO1 also includes two predator disruption measures, fluctuating elevations in the John Day pool, to limit both predator fish and birds from reducing ESA-listed juvenile fish populations during the spring migration.

MO1 also incorporated measures to increase hydropower generation flexibility in the lower basin projects and alters the use of stored water at Dworshak for downstream water temperature control in the summer. MO1 includes a number of measures similar to the other action alternatives, including increased water management flexibility and water supply, and using local forecasts in whole-basin planning. Detailed descriptions of the measures that are included in MO1 are described in Chapter 2 of the EIS.

Does MO1 Address EIS Objectives?

MO1 is predicted to provide benefits, although minor, as measured in both models, to most ESA-listed anadromous salmonid fish species, both juvenile and adult. MO1 also includes structural modifications to infrastructure at the dams to benefit passage of adult salmon, steelhead, and Pacific lamprey. MO1 is thus expected to meet the objectives to **Improve Juvenile Salmon**, **Improve Adult Salmon**, **Improve Resident Fish**, and **Improve Lamprey**. The expected degree of these benefits varied depending on specific species, location, and the outputs from the two separate models (Fish Passage Center's CSS and NMFS's LCM). The CSS model generally predicted minor improvements for the species modeled, while the LCM generally predicted negligible decreases to minor improvements to anadromous species that were modeled. Overall, the expected degree of improvements to ESA-listed salmonids was predicted to be less than was desired by the co-lead agencies. MO1 results in both beneficial and adverse effects on resident fish. Cumulatively these effects are expected to be negligible, minor, or in some cases localized moderately adverse, as compared to the No Action Alternative. MO1 proposes mitigation for resident fish, as appropriate.

MO1 marginally could meet the **Provide a Reliable and Economic Power Supply** objective. MO1 reduces hydropower generation by approximately 130 average megawatts (aMW) a year under average water conditions, and 300 aMW under low water conditions. A number of measures contributed to the decrease in hydropower production, including spring spill at higher levels than in the No Action Alternative and additional irrigation withdrawals. Hydropower reliability was impacted by these two measures and several others, including a measure to alter the timing of flows from Dworshak in late summer (a measure that was intended to but did not result in the improvement in lower Snake River water temperatures). An earlier end to summer spill partially moderated the power impact on generation and reliability. The alternative has roughly twice the risk of power shortages (blackouts or emergency conditions) compared to the No Action Alternative and more than twice the risk compared to the Northwest Power and Conservation Council's target for regional reliability.

To maintain regional reliability at the same level as the No Action Alternative, additional resources would have to be built, at a cost of between $34 million a year (for fossil-fuel based replacement resources) and $161 million a year (for variable renewable resources like wind and solar). For Bonneville's wholesale power rates, MO1 places upward base rate pressure of 4.5 percent to 8.6 percent over the No Action Alternative, depending upon the type of resources acquired and the source of funding for those resources. (Compared to Bonneville financing new resources, if public utilities acquire the new generation then the impact to Bonneville's wholesale power rate is generally lower, though the impact to etail customers of the public utilities is similar.) The base rate analysis only considered the costs of resources necessary to return regional reliability to the levels of the No Action Alternative and an estimate for the related structural plus fish and wildlife cost impacts. As such, it did not address other potential cost uncertainties under MO1, such as the cost of integrating new renewable resources, potentially shorter financing timeframes, and the costs and availability of firm demand response. These effects (and others) are captured in a rate sensitivity analysis performed on Bonneville's wholesale power rate. As discussed in section 3.7.3, including the rate sensitivities, MO1 could increase the wholesale rate pressure on Bonneville's power rate by up to 14.4 percent. Section 3.7.3.3 of the EIS discusses the hydropower impacts including retail rate impacts of MO1 in more detail.

Regarding the objective to **Minimize GHG Emissions**, the reduction in hydropower generation under MO1 could slightly increase GHG emissions if there is an offsetting increase in generation from fossil fuel resources. However, if the reduction in hydropower is replaced with zero-carbon resources, GHG emissions from power generation may be slightly reduced relative to the No Action Alternative.

MO1 also met the objectives to **Maximize Adaptable Water Management** and **Provide Water Supply**.

Additional Effects of MO1

Under MO1, there would likely be moderate adverse effects to water quality in the lower Snake River and resident fish in the upper Columbia River basin. This is due to the modified Dworshak flow regime that would result in a moderate increase in water temperatures to above Washington State water quality standards (68 °F) downstream. The Dworshak reservoir could be at a lower elevation in June and July (and at a higher elevation in August) compared to the No Action Alternative, resulting a moderate increase in water temperatures in the lower Snake River during August.

For cultural resources, there could be additional major effects at Hungry Horse, Lake Roosevelt, and Dworshak reservoirs due to increasing the frequency of elevation changes. Increased frequency in elevation changes typically correlates with increased erosion in reservoirs and exposure, which can displace or destroy cultural resources. An increased number of high draft events at Dworshak could also lead to major adverse effects. The Dworshak reservoir would also be at a lower elevation in June and July compared to the No Action Alternative. Changes in reservoir elevations could result in effects to the Kettle Falls sacred site due to increases in the potential for looting.

There would likely be no major or moderate economic effects above and beyond the potential electricity rate impacts described above. The co-lead agencies used the analysis in MO1 to inform the development of the Preferred Alternative that seeks to balance managing the system for all purposes while providing additional benefits for fish and other study objectives.

6 MULTIPLE OBJECTIVE ALTERNATIVE 2 (MO2)

Overview of the Alternative

MO2 was developed to prioritize hydropower production and flexibility and reduce regional GHG emissions, benefit lamprey and ESA-listed salmon through structural measures, and benefit ESA-listed salmon through increased transport, while meeting the other study objectives and avoiding or minimizing adverse impacts to other resources. It would slightly relax the No Action Alternative's restrictions on operating ranges and generation ramping rates to evaluate the potential to increase hydropower production efficiency. This would also increase operators' flexibility to respond to changes in power demand and changes in generation of other renewable resources. The measures within MO2 would increase the ability to meet power demand with hydropower production during the most valuable periods (e.g., winter, summer, and daily peak demands). The upper basin storage projects would be allowed to draft slightly deeper, allowing more hydropower generation in the winter and less during the spring.

MO2 evaluates an expanded juvenile fish transportation operation season. This alternative proposes to transport all collected ESA-listed juvenile fish for release downstream of the Bonneville project, by barge or truck. It would also reduce juvenile fish passage spill operations to a target of up to 110 percent TDG, providing the lowest end of the range of juvenile fish passage spill operations evaluated in this EIS.

Structural measures in MO2 are aimed at producing benefits for ESA-listed fish and lamprey. These measures are similar to other alternatives and include making improvements to adult fish ladders, upgrading spillway weirs, adding powerhouse surface passage, and turbine upgrades at John Day.

Chapter 2 of the EIS provides a detailed description of the measures that are included in MO2.

Does MO2 Address the EIS Objectives?

In general, MO2 is less effective than the other MOs at meeting the **Improve Juvenile Salmon**, **Improve Adult Salmon**, and **Improve Resident Fish** objectives. However, the expected effects of MO2 on anadromous species varied depending on the species, location, and by the outputs from the two distinct models (CSS and LCM) used in this analysis.

Based on the NMFS LCM, MO2 was less effective at meeting the **Improve Juvenile Salmon** and **Improve Adult Salmon** objectives for upper Columbia River Chinook salmon and steelhead. The LCM predicts

SMOLT-TO-ADULT RETURN RATIO (SAR)

is the rate at which a group of fish survive from their smolt life stage (typically measured at the first dam in their migration such as Lower Granite Dam but can also be from their fresh-water tributary or hatchery of origin) to an ending point as an adult (usually back to a dam in the CRS such as Bonneville—the first dam adults encounter—or Lower Granite Dam which is the last dam that Snake River fish can pass).

a 1 to 4 percent relative reduction in in-river survival as well as a 1 percent relative reduction in the smolt-to-adult (SAR) estimate for upper Columbia River spring Chinook. The CSS models were not available for upper Columbia fish.

For Snake River spring Chinook and steelhead, the CSS model generally predicted adverse effects, a 30 percent relative reduction in SARs for spring Chinook, while the LCM generally predicted negligible to minor beneficial effects relative to anadromous species that were modeled in the No Action Alternative. The minor beneficial effects result from increases in fish transportation rates.

MO2 also includes structural modifications at the dams to benefit passage of adult salmon, steelhead, and Pacific lamprey. While structural modifications may provide some benefit to lamprey passage, the overall shift to more powerhouse flow and passage makes this alternative less effective at meeting the **Improve Lamprey** objective than the other MOs. Greater numbers of lamprey would likely pass near fish bypass screens and would be at a higher risk of injury or impingement compared to the No Action Alternative.

MO2 is expected to have a major adverse effect to resident fish in the upper Columbia basin due to changes in reservoir operations and elevation for hydropower water storage. MO2 proposes mitigation, as appropriate, to minimize adverse effects to negligible and to meet the **Improve Resident Fish** objectives.

Compared to the other MOs, MO2 resulted in the greatest benefits to the **Provide a Reliable and Economic Power Supply** and **Minimize GHG Emissions** objectives. The additional hydropower generation produced by MO2 would increase hydropower generation by 450 average megawatts (averaged over 80 historical water years). In the most adverse water year studied, generation would also increase, leading to an additional 380 average megawatts that Bonneville would be able to offer its preference customers (primarily public power utilities) under long-term, firm power-sales contracts. Three measures had the largest impact on these increases: limiting fish passage spill to 110 percent TDG, ending fish passage spill in August, and allowing storage projects to draft slightly deeper for hydropower.

With the increase in hydropower generation, MO2 would improve regional reliability compared to the No Action Alternative. Regional generating resource costs would also likely decrease, as additional hydropower generated under MO2 could partially eliminate the need to build additional resources for reliability purposes as the region retires coal plants. For Bonneville's whole-sale power rate, MO2 would cause downward rate pressure by approximately 0.8 percent. As noted above, the base rate analysis includes the costs of resources necessary to return regional reliability to the levels of the No Action Alternative as well as related structural measures and fish and wildlife improvement costs. Rate impacts resulting from any other effects of MO2 were addressed in a rate sensitivity analysis. The high end of the rate sensitivity analysis identified rate pressure of up to 1.9 percent due to a potential increase in Fish and Wildlife Program spending of up to $53 million a year. This increased funding would be used to mitigate the possible impacts of MO2 on fish and wildlife. The low end of the sensitivity analysis found that by excluding one structural measure for fish collection at the McNary project (fish collection there could be accomplished more cost-effectively through other means), power rates could experience downward rate pressure of about 4 percent compared to the No Action Alternative. Section 3.7.3.4 of the EIS discusses the hydropower impacts of MO2 in more detail.

The increase in hydropower generation under MO2 would displace fossil fuel generation (such as natural gas or coal-based generation) in the current resource mix, thus reducing electricity sector GHG emissions. Section 3.8.3.4 discusses the GHG emissions impacts in further detail. Furthermore, as the region seeks to rely less on fossil fuel resources, the additional hydropower capability from MO2 would also support the integration of more variable renewable resources, which rely on balancing services provided by flexible generating plants. Currently, hydropower and natural gas power plants provide the majority of integration services for variable renewable resources. As the Northwest increases its reliance on new variable renewable resources, increasing hydropower production and flexibility in MO2 would help reduce the reliance on natural-gas generation. In addition to hydropower flexibility, technical advances in storage and other options may become viable to help integrate the variable renewable generation.

MO2 met the objectives for **Maximize Adaptable Water Management**. However, MO2 only partially met the **Provide Water Supply** objective. Specifically, MO2 met the existing contractual water supply obligations, but did not provide for authorized additional regional water supply. MO2 did not include the additional water supply because the co-lead agencies wanted to analyze a range of alternatives, including one without the additional water supply. Because water withdrawal for irrigation decreases hydropower production, exclusion of the water supply measure from MO2 was consistent with the broader theme of the measure.

Additional Effects of MO2

MO2 would have major beneficial economic effects to power if the measure for powerhouse surface passage with fish collection at the McNary project is excluded. The McNary project was not carried forward into the preferred alternative because the final estimated cost for the structure was over $850 million yet only provided negligible biological benefits for salmon and steelhead. Those same biological benefits could be obtained at much lower costs using alternate measures.

There would be ongoing major adverse social effects to cultural resources and tribal interests at Lake Roosevelt and Dworshak Dam due to changes in reservoir elevations. There could also be major adverse effects to the Kettle Falls sacred site if changed reservoir elevations results in looting.

Information gained from the analysis of this alternative was used by the co-lead agencies to inform and improve the development of the Preferred Alternative that seeks to balance managing the system for all purposes while providing additional benefits for fish and other study objectives.

7 MULTIPLE OBJECTIVE ALTERNATIVE 3 (MO3)

Overview of the Alternative

MO3 was developed to evaluate the effects of breaching the four lower Snake River dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) along with actions for water management flexibility, limited increases in hydropower generation in certain areas of the basin at specific times, and altered water supply (small increases in volume and small change in timing). In addition to breaching these four projects, MO3 differs from the other alternatives by carrying out a spring juvenile fish passage spill operation that sets flow through the spillways up to a target of 120 percent TDG in the tailrace of the four lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville). This alternative also proposes an earlier end to summer juvenile fish passage spill operations than the No Action Alternative. Instead, reduced spill levels would allow for increased hydropower production during August when low numbers of juvenile fish are typically present.

Structural measures in this alternative include breaching the four lower Snake River dams by removing the earthen embankment at each dam, resulting in a controlled drawdown.

Operational measures in MO3 are intended to improve juvenile and adult fish travel times, improve conditions for resident fish in the upper basin, increase hydropower generation flexibility in certain portions of the basin in order to begin to offset the lost generation from dam breaching, provide more flexibility to water managers, and provide additional water supply. A detailed description of measures that are included in MO3 is provided in Chapter 2 of the EIS.

MO3 would only partially meet the Purpose and Need and some of the objectives for the EIS to various levels. Additionally, breaching the dams would not allow the co-lead agencies to operate and maintain the dams for their congressionally authorized purposes of navigation, hydropower, envisioned recreational benefits, and water supply for irrigation purposes. It also has the highest adverse impacts to other resources, especially social and economic effects. However, it predicts the highest benefits for several of the ESA-listed juvenile and adult salmon and provides additional riverine type recreational opportunities. It also returns access and opportunities to some of the traditional cultural resources and properties for tribal purposes.

Many tribes have commented that the economic impacts of implementing this alternative must be viewed in the context of the ongoing and disproportionate social, cultural, and socioeconomic effects to Indian tribes and tribal communities from present and cumulative effects of the current System. They note that these effects, along with impairment of Indian treaty-reserved rights, would be reduced under MO3.

MO3 was carried forward in the analysis to align with the District of Oregon's Opinion and Order, and in response to comments received during public scoping that requested this alternative be evaluated. Breaching the four lower Snake River dams also received substantial interest by several tribes who believe that this alternative is the best option to offset some of the substantial adverse impacts of the CRS. New congressional authority and funding would be required to implement the dam breaching measures in MO3.

Does MO3 Address the EIS Objectives?

MO3 would meet the objectives of **Improve Juvenile Salmon**, **Improve Adult Salmon**, **Improve Resident Fish**, and **Improve Lamprey**.

Model estimates for MO3 showed the highest predicted potential smolt-to-adult returns (SARs) for Snake River salmon and steelhead among the alternatives. Quantitative model results from both the CSS and LCM were available and indicated a range of potential long-term benefits largely due to how the models address latent mortality, the delayed death of salmon following passage through the CRS. The CSS model predicts that outmigrants from Lower Granite that return to Lower Granite (SARs) would increase by 170 percent relative to the No Action Alternative. The NMFS LCM predicted that SARs from Lower Granite to Bonneville would improve by 14 percent relative to the No Action Alternative. The LCM also assessed SARs under several levels of assumed latent mortality reductions (10, 25, and 50 percent). For these scenarios, the LCM also predicted that if latent mortality were further reduced, additional improvement in SARs would be expected. These results highlight the importance of how latent mortality is considered in the analysis and the strong effect it has on the predicted results. The degree to which latent mortality is affecting salmon and steelhead is one of the critical uncertainties in this EIS analysis. The CSS model also predicted similar improvements for Snake River steelhead to those described for Snake River Chinook. The LCM was not available for use on Snake River steelhead in this EIS.

Results from the NMFS LCM indicate that the level of improvement to upper Columbia Chinook SARs is dependent on the level to which latent mortality affects this stock. If increased spill in the lower Columbia River does not improve ocean survival, (i.e. reduce latent mortality) the LCM model predicts negligible to minor improvements in SARs (one percent relative increase). Larger reductions in latent mortality would result in larger predicted increases in both SARs and abundance for Upper Columbia stocks (4 to 147 percent relative increase in abundance).

These changes are primarily due to increased spill levels (120 percent TDG) in the lower Columbia River. The CSS model was not available for use on upper Columbia River species in this EIS.

MO3 is also expected to provide a long-term benefit to species that spawn or rear in the mainstem Snake River habitats, such as fall Chinook. By breaching the four lower Snake River dams, major short-term adverse impacts to fish, riparian and wetland habitat in the Snake River and confluence of the Columbia River would occur. These impacts would be associated with the initial breaching of the dams, drawing down the reservoirs, and the time required for the river to move sediment and stabilize. These effects are expected to diminish over time. MO3 also includes structural modifications to infrastructure at the dams to benefit passage of adult salmon, steelhead, and Pacific lamprey.

Breaching of the lower Snake River projects would have major long-term beneficial effects to resident fish in the Snake River due to improved rearing and migration conditions. During the breaching, major short-term adverse effects would occur as described above for anadromous fish. In general, effects outside of the Snake River would be similar to MO1.

MO3 would not meet the objective to **Provide a Reliable and Economic Power Supply**. Under MO3, hydropower generation would decrease by 1,100 aMW under average water conditions, and 730 aMW under low water conditions compared to the No Action Alternative.

The lower Snake River projects provide more than 2,000 MW of sustained peaking capabilities during the winter, and a quarter of the federal power system's current reserves holding capability. The dams play an important role in maintaining reliability, and their flexibility and dispatchability are valuable components of the CRS. MO3 would more than double the region's risk of power shortages compared to the No Action Alternative—from 6.6 percent risk of a year having power shortages in the No Action Alternative (roughly one year in 15) to 13.9 percent in MO3 (or nearly one year in 7) for the base case (current operation of coal-fired power plants). The loss of power generation at the lower Snake River dams accounts for most of this decrease. Increases in spring spill for juvenile fish passage at the lower Columbia River projects and increases in water withdrawal for irrigation included in the alternative further reduce hydropower generation while the end of summer spill in August increases generation in that month.

Significant quantities of replacement resources would have to be built to maintain regional power reliability at the No Action Alternative levels. As referenced above, without such a resource build-out, the region would face the likelihood of a loss of load event, e.g. a power blackout, nearly one in every seven years in MO3 for the base case including the current fleet of regional coal plants. Two potential resource replacement portfolios were developed for this approach. The first was a conventional least-cost portfolio. Based on co-lead agency analysis (including a review of other publicly available information), the conventional, least-cost resource replacement would include 1,120 megawatts (MW) of combined cycle natural gas turbines at an overall cost of about $200 million a year. For Bonneville's wholesale power rate, MO3's conventional least-cost resource portfolio, along with related structural and fish and wildlife spending adjustments, places upward rate pressure of between 8.2 percent and 9.6 percent over the No Action Alternative, depending upon the source of funding for those resources. The second resource portfolio was a zero-carbon replacement portfolio. Understanding the development of the zero-carbon portfolio requires some additional context about the rapidly evolving energy policy environment in the western U.S. as well as how renewable energy resources interact with the broader power system.

Several states in the western U.S. have passed, or are likely to pass, legislation directed at decarbonizing the electric grid. California began implementing an economy-wide cap-and-trade program in 2013. In 2018, the California legislature passed a law seeking to achieve 100 percent carbon-free electricity by 2045 (Senate Bill 100). Washington enacted the Clean Energy Transformation Act (CETA) in 2019, requiring that Washington utilities eliminate coal costs from their retail rates by 2025. CETA also directs Washington retail utilities to serve loads with 100 percent carbon-neutral power by 2030, and 100 percent carbon-free power by 2045 (RCW 19.405). Oregon has been considering a cap-and-trade program similar to California's program. Additionally, Nevada (Senate Bill 358, 2019) and New Mexico (Senate Bill 489, 2019) both adopted 100 percent carbon-free goals for the electricity sector. The province of British Columbia has had a carbon tax in place since 2008.

In light of this legislative and policy trend, the co-lead agencies assumed that no new gas-fired generation would be built to replace the lost generation from the lower Snake River dams in developing the least-carbon replacement portfolio; only zero-carbon resources could be selected. At the utility-scale, the current zero-carbon options are solar and wind resources, batteries, and demand response programs. For MO3, the EIS analysis started with an effort to restore the loss of load probability to the No Action Alternative level of 6.6 percent. This analysis identified a potential zero-carbon replacement portfolio consisting of 2,550 MW of solar resources and 600 MW of demand response to restore the LOLP. This portfolio relies on using the existing regional system to help make up for some of the lost capabilities of the lower Snake River projects—primarily by operating thermal plants more frequently to meet regional load.

These initial modeling results were based on assumptions embedded in the No Action Alternative and raised two important additional considerations. First of all, the models used to determine this initial zero-carbon replacement portfolio do not adequately capture the flexibility and dispatchable peaking capabilities that the lower Snake River dams bring to the regional power system. In order to partially reflect the permanent loss of sustained dispatchable hydropower peaking capacity, reserve capability and flexibility at the lower Snake River projects, an additional 1,275 MW of battery storage were added to the zero-carbon portfolio for the base case analysis (in addition to 2,550 MW of solar and 600 MW of demand response). The estimated cost of this base case portfolio was $419 million per year. For Bonneville's wholesale power rate, MO3's zero-carbon resource portfolio, along with related structural and fish and wildlife spending adjustments, place upward rate pressure of between 9.5 percent and 19.3 percent over the No Action Alternative, depending upon the source of funding for those resources. (If public utilities acquire the new generation directly, the impact to Bonneville's wholesale power rate is generally lower than if Bonneville acquires the resources. In either case, though, the impact to retail customers of the public utilities is fairly similar.) While this portfolio with the addition of batteries continues to rely on regional thermal resources to make up for lost energy, capacity and reserves, it lessens that reliance. This portfolio is captured in the Base Case section of the rate analysis described in Section 3.7.3.5 together with retail rate impacts.

The second issue concerning the base case zero-carbon replacement portfolio is that the composition of the regional power system is undergoing rapid change, and will continue to do so over the coming years with increased coal plant retirements and restrictions on the use of natural gas generation. The base case portfolio implicitly assumes that other regional resources would be used to make up for any deficiencies in the power system's sustained peaking, storage, and dispatchable capability caused by the loss of generation from the lower Snake River dams. As a result, given the expected coal plant retirements and restrictions on natural gas generation, replacing the full flexibility and capability of the lower Snake River dams with zero-carbon resources would require substantially more resources, such as additional dispatchable battery technology, than estimated in the base case analysis. To reflect these additional costs, a rate sensitivity analysis was performed for MO3 to estimate the rate pressure effect of an expanded zero-carbon resource portfolio on Bonneville's wholesale power rate. As described in Section 3.7.3.5, this expanded zero-carbon resource portfolio would include power capabilities similar to those lost with the breaching of the lower Snake River projects.

The costs of an expanded zero-carbon resource portfolio designed to replace the full capability of the lower Snake River dams would be significant: up to $527 million a year above the resource costs assumed in the base case analysis. Additional variables such as resource financing uncertainties and the uncertainty in the cost and availability of demand response add to this rate sensitivity. Selecting this portfolio would represent a very large investment in the regional power system, equal to roughly a billion dollars a year or one-third of Bonneville's power revenues. If Bonneville had to replace the lower Snake River projects' full capability with zero-carbon resources, the rate pressure could be up to 50 percent on wholesale power rates. Before making such an investment, Bonneville and its regional partners would need to collaborate on identifying other viable options that could maintain reliability and meet regional carbon objectives, while also ensuring federal power remains competitively priced for Bonneville's power customers.

MO3 would also not meet the objective to **Minimize GHG Emissions**. GHG emissions were analyzed for the base case hydropower impacts discussed above without the effect of the additional coal-plant retirements. GHG emissions would increase the most if the hydropower were replaced with natural gas. This would lead to an additional 3.3 million metric tons (MMT) of CO_2, a 10 percent increase in power-related emissions across the Northwest. However, even assuming the new replacement resources are variable renewables (the base case of solar with batteries), some increase in fossil fuel-based generation from existing power plants would occur to maintain system reliability. This is because the magnitude and timing of the reduction in hydropower generation would occur in particular times seasonally or daily (e.g., during peak demand) during which flexible resources would need to increase generation in order to maintain reliability (i.e., to meet the demand for power and avoid blackouts). As discussed above, based on currently available technology, other renewable resources (e.g., solar and wind) are variable; that is, they cannot always be dispatched on demand because they are reliant on external factors, such as sun exposure or wind speed. Therefore, these sources of renewable generation must be used alongside other flexible (dispatchable) resources to maintain system reliability. With less clean hydropower to provide this flexible resource, the region would likely rely more on fossil-fuel-based resources, such as coal and natural gas, to balance renewable generation. This increased reliance on fossil-fuel-based resources is estimated to increase power-related emissions by 2.7 percent (1 MMT of CO_2) across the region even assuming the new replacement resources are other renewables. In the future, technical advances in storage and other low-carbon options may become increasingly viable to help integrate variable renewable generation. With the expanded portfolio that is intended as a full replacement of the capabilities of the lost generation from the lower Snake River dams, the GHG emissions impact would probably be lower.

The loss of hydropower generation at Ice Harbor would require that a transmission reinforcement project be in place prior to breaching of the dams. The transmission reinforcement project would cost about $94 million.

In addition, MO3 would result in shipping activities shifting from barge to road and rail transport as described below. As barge transportation is a relatively low source of GHG emissions per ton-mile of freight compared with truck or train transportation, MO3 would also increase transportation-related emissions for wheat that is currently transported along the lower Snake River by up to 53 percent (an increase of 0.056 MMT of CO_2). Section 3.8.3.5 discusses the transportation sector GHG impacts in further detail.

MO3 would meet the objectives to **Maximize Adaptable Water Management** and **Provide Water Supply**, but there would be adverse impacts to irrigation in the lower Snake River borne by other public and private entities due to dam breaching. Assuming 47,926 acres were no longer irrigated, the present value of the lost social welfare benefit under the MO3 alternative is $458 million (annual equivalent value is $17 million). Further information can be found in Chapter 3.12.

Additional Effects of MO3

MO3 would have multiple adverse and beneficial effects on environmental, socioeconomic, cultural, and river operations as described below.

Transportation

Major adverse effects would be anticipated under MO3. The lower Snake River shallow draft navigation channel would no longer be available, eliminating commercial navigation to multiple port facilities on the lower Snake River, include the four primary commercial navigation ports—the Port of Lewiston, the Port of Clarkston, the Port of Whitman County (Wilma, Almota, Central Ferry), and the Port of Garfield. As a result, the cost to transport goods to market would increase. For example, the cost to transport wheat, which accounted for 87 percent of the downbound tonnage on the lower Snake River in 2018, is estimated to increase by $0.07–$0.24/bushel. This is equivalent to an increase of 10 to 33 percent in average transportation costs. Cost increases for specific shippers would depend upon location and would vary throughout the region, depending on transportation options at each location. Farmers could also experience increased production costs associated with higher transportation costs for upriver movements (i.e., fertilizer, crops). There would be additional demands on existing road and rail infrastructure as well as at barging facilities near the Tri-Cities, Washington, increasing traffic and air pollution. Additional capacity and infrastructure improvements would likely be required, borne by public and private entities, and would vary depending on how the rail industry adjusted its rates with reduced competition from the barge industry.

If increased rail rates are low or non-existent, then significant increased demand on rail infrastructure would occur that would likely exceed current capacities (which could also cause rail rates to increase), as tonnage demand for rail would increase by 86 percent. Assuming new facilities would be required to accommodate the increase in capacity, costs could range from a total of $25 million to $50 million. In addition, upgrades to existing shortline rail lines of approximately $30 million to $36 million, or approximately $2 million annually may be needed.

If rail rates increase by 25 percent, there would be a 22 percent increase in average transportation costs. With a 25 percent rail rate increase, increased rail demands would likely exceed current shortline rail capacity, but somewhat less than if rail rates did not increase. Costs to increase capacity could be as high as $25 million under this scenario. Truck use would increase moderately, which would increase wear and tear on roadways and could result in additional road repair costs of up to $4 million annually.

If rail rates increase by 50 percent following dam breach, average transportation costs would increase by 33 percent. Under this scenario, rail infrastructure demand increases would not be anticipated. Instead, a substantial increase in truck use would occur (an increase of 84 percent compared to the No Action Alternative). Under this scenario, increases in vehicular accident rates, highway traffic and congestion would occur. In addition, additional wear and tear on roadways could result in additional road repair costs of up to $10 million annually.

Adverse regional economic effects would occur as the jobs and income provided by the four primary commercial navigation ports would be curtailed, including the Port of Lewiston, the Port of Clarkston, the Port of Whitman County (Wilma, Almota, Central Ferry), and the Port of Garfield. Commercial cruise lines that operate on the lower Columbia and lower Snake River, providing voyage to approximately 18,000 cruise line passengers per year, would be adversely affected by reduced numbers and distance of trips, with adverse effects to tourism revenues and associated jobs and income. Communities affected, such as Clarkston, Lewiston and Asotin, would lose their 'river port' community identity. Some port facilities within Lake Wallula, the reservoir behind McNary Dam, would require additional dredging to maintain access to the navigation channel following dam breach.

Environmental

Major adverse short-term effects to other environmental resources along the lower Snake River and confluence of the Columbia River and lower Snake River would occur from the initial dam breaching and river drawing down, but there are anticipated to be major long-term beneficial effects to vegetation, wildlife, wetlands, and floodplains in the lower Snake River. For water quality, water temperatures would be warmer in the summer (during the day) that may exceed water quality standards, but spring and fall water temperature improvements are anticipated.

Cultural resources

In the lower Snake River, MO3 could result in additional major adverse effects to archaeological sites due to potential exposure of 14,000 acres that are currently inundated. Following the drawdown, the long-term goal

would be for the river to return to as natural a condition as possible which is expected to have a beneficial effect to traditional cultural practices such as fishing, gathering, and occupation. Conversion to a more natural riverine system would allow improved access for tribal communities to areas currently inundated. There is also the potential for additional major adverse effects to archaeological sites at Hungry Horse Reservoir due to the increased frequency and size of draw-downs to compensate for the removal of the Lower Snake River dams.

Recreation

In terms of economic effects, major long-term adverse effects to lower Snake River barge navigation and reservoir-based recreation in the lower Snake River would occur. Major adverse effects would occur to reservoir-based recreation because these reservoirs and associated boat ramp access would cease to exist. However, there would likely be major long-term beneficial effects to river-based recreation, and improved recreational and tribal fishing.

Despite the major benefits to fish expected from MO3, this alternative was not identified as the Preferred Alternative due to the adverse impacts to other resources such as transportation, power reliability and affordability, and greenhouse gas emissions. The region's understanding of the impacts, both beneficial and adverse, of the Columbia River System will improve over time just as the perspectives and values of the people living in the Columbia Basin will continue to change as well. This EIS is not expected to end the regional debate on the future of the four lower Snake River dams. On the contrary, this EIS provides information and analysis to inform that future dialogue.

The co-lead agencies used the analysis in MO3 to inform and improve the development of the Preferred Alternative that seeks to balance managing the system for all purposes while providing additional benefits for fish and other study objectives.

8 MULTIPLE OBJECTIVE ALTERNATIVE 4 (MO4)

Overview of the Alternative

MO4 was developed with a primary focus on measures to benefit ESA-listed fish, integrated with measures for water management flexibility, hydropower production, and additional water supply. This alternative includes the highest level of spill in the range considered in this EIS, dry-year augmentation of spring flow with water stored in upper basin reservoirs, and annually drawing down the lower Snake River and Columbia River reservoirs to their minimum operating pools. This alternative also includes changes to juvenile fish transportation operations, operations to help establish riparian vegetation in the Upper Basin, and improved surface passage spill for adult steelhead. The structural measures in this alternative are primarily focused on improving passage conditions for ESA-listed salmonids and Pacific lamprey. The inclusion of a measure for spillway weir notch inserts for adult steelhead downstream passage is unique to the MO4 alternative; the rest of the structural measures are variations of other measures described in the other MOs, including structural measures for Pacific lamprey.

The operational measures would make improvements to meet project objectives. In MO4, Juvenile fish passage spill is set up to 125 percent TDG during the spring and summer, which is the highest volume and longest duration of spill included in any of the alternatives. This is intended to decrease travel time and improve juvenile downstream fish passage. The juvenile fish transport program would operate primarily in the spring and fall. This alternative also contains a measure for restricting winter flows from the Libby project to protect newly established downstream riparian vegetation, and to improve conditions for ESA-listed resident fish, bull trout, and Kootenai River White Sturgeon in the upper Columbia River basin. Chapter 2 of the EIS describes the measures that are included in MO4 in more detail.

Does MO4 Address the EIS Objectives?

Similar to MO3, the potential benefits of MO4 for **Improve Juvenile Salmon and Improve Adult Salmon** varies greatly depending on which model is used (see Fish Modeling discussion above). The CSS model predicts large increases in all salmon and steelhead returns, to both the Columbia and Snake Rivers. These increases are predicted based on increased spill levels that would increase the number of fish passing via the spillways and avoiding powerhouses, which the CSS models predicts would reduce latent mortality associated with CRS passage. Snake River spring Chinook and steelhead SARs are predicted to improve by 70 to 75 percent relative to the No Action Alternative.

The LCM predicts minor benefits to Upper Columbia spring Chinook and steelhead, with 2 percent relative increases in SARs and downstream survival. However, for Snake River Chinook, the model predicts that unless changes in passage through the CRS can increase ocean survival by 10 percent (i.e. latent mortality effects are decreased by 10 percent), the net impact to Snake River Chinook salmon would be adverse, a relative decrease in SARs of 12 percent. This potential decrease in overall adult returns is primarily driven by reductions in fish transport rates due to high spill, a relationship that could be similar for Snake River steelhead. MO4 also includes structural modifications to infrastructure at the dams to benefit passage of adult salmon, steelhead, and Pacific lamprey.

MO4 causes minor to major adverse effects to resident fish due to deep drafts of the upper basin storage projects. Resident fish in the lower basin would also be exposed to elevated TDG levels in the lower basin. MO4 proposes mitigation to reduce resident fish adverse effects to negligible, as appropriate, and the objective for **Improving Resident Fish** would be met.

MO4 would not meet the **Provide a Reliable and Economic Power Supply** objective. Under MO4, hydropower generation decreases by 1,300 aMW under average water conditions, and 870 aMW under low water conditions compared to the No Action Alternative, the largest impacts on hydropower generation of any of the alternatives. The reason for the reduced generation is the increase in juvenile fish passage spill, up to 125 percent total dissolved gas levels 7 days a week, 24 hours a day from March 1 to August 31, with most lower Snake and lower Columbia River projects operating at minimum generation levels in the majority of water conditions. This increase in spill, together with a measure that provides dry-year augmentation of spring flow with water stored in upper basin reservoirs, contributes to MO4 having the highest probability of power shortages of any of the MOs, with blackouts or emergency conditions in roughly one in three years.

Substantial additional resources would be needed to maintain regional reliability at the No Action Alternative levels. The conventional least-cost resource replacement portfolio would include 3,240 MW of simple cycle natural gas turbines at an annual cost of $156 million (excluding fuel). Replacing the lost hydropower generation with variable renewable resources would require around 5,000 MW of solar (occupying nearly 47 square miles of land) and 600 MW of demand response at an estimated annual cost of $350 million. For Bonneville's wholesale power rates, MO4 places upward base rate pressure of 23.5 percent to 25.3 percent over the No Action Alternative, depending upon the type of resources acquired and the source of funding for those resources. Additional rate sensitivities around this base analysis, discussed in Chapter 3.7.3.6, could lead to upward rate pressure as high as 41 percent in the Bonneville wholesale power rate. Chapter 3 also provides additional sensitivity analyses of impacts of M04 on reliability and cost given the higher expectations of coal plant retirements and restrictions on natural gas generation resulting from recent policy and planning changes. Retail rate impacts are also discussed in Chapter 3.7.3.6.

MO4 would not meet the **Minimize GHG Emissions** objective. GHG emissions would increase the most if the hydropower is replaced with natural gas (an 8.4 percent, or 3.1 MMT of CO_2 increase in power-related emissions across the Pacific Northwest). However, as with MO3, even assuming the new replacement resources are variable renewables (solar with demand response), some increase in fossil-fuel-based generation from existing power plants would occur to maintain system reliability. This seems counter-intuitive, but adding wind and solar, which are variable resources (not always available) requires a base source of dispatchable capacity to maintain reliability when they are not available. The region currently relies on the CRS to provide much of this back-up source of generation. If a significant amount of hydroelectric generation is reduced, given the region's current resource portfolio, additional generation from coal and gas would likely be used to balance for the variable nature of renewable resources. Consequently, replacing lost hydropower generation with variable renewable resources would still increase power-related GHG emissions by 0.8 percent (0.31 MMT of CO_2) across the region. Section 3.8.3.6 discusses the GHG impacts of MO4 in further detail.

This analysis is based largely on existing technology and the region's existing resource portfolio. Future technology developments—such as advances in utility-scale storage, demand management, adding voltage support capabilities to wind or solar, other emerging renewable options like tidal or wave power, small modular nuclear reactors, pumped storage, and technologies not yet in the public eye—may reduce the need to rely on fossil-fuel power for integrating variable renewable resources.

MO4 would meet the objectives to **Maximize Adaptable Water Management** and **Provide Water Supply** because the CRS would be operated to meet the flood risk management measures and does not remove authorized water supply.

Additional Effects of MO4

Overall, major adverse economic effects would occur under MO4. For irrigation on the lower Columbia River, particularly at John Day, reservoir levels may be lowered to the point where pumping could no longer be possible. Additionally, in low water years, major adverse effects to water-based recreational access at Lake Pend Oreille could occur.

MO4 would result in major adverse effects to resident fish in the Upper Basin that could require mitigation.

Finally, major social effects to cultural resources at Lake Roosevelt, John Day, and Hungry Horse reservoirs could occur. Lake Roosevelt would be at a lower elevation primarily in the spring and summer in dry years due to providing spring flow augmentation downstream. Hungry Horse reservoir would provide dry-year flow augmentation in the summer, and may not recover to the No Action elevation in some of the years. The overall result would be increased exposure and erosion of cultural resources. At John Day, the elevation of the reservoir is drawn down to minimum navigation pool during the juvenile fish passage season. There would be additional moderate effects to cultural resources at the remaining lower Columbia River Projects due to additional drawdown. There could be major effects to Kettle Falls (sacred site) if changes in reservoir elevations lead to increased potential for looting. Changes in reservoir elevation at Albeni Falls may result in reduced access to Bear Paw Rock (sacred site), which may result in less tribal visitation.

As with the other alternatives, the co-lead agencies used this analysis to inform and improve the Preferred Alternative that seeks to balance managing the system for all purposes while providing additional benefits to fish and other study objectives.

9 ALTERNATIVES CONSIDERED BUT NOT EVALUATED IN DETAIL

Initially, several important issues were identified during scoping for consideration in this EIS. This included the reintroduction of salmon above Chief Joseph and Grand Coulee Dams into the upper Columbia Basin, where passage is currently blocked. Additionally, the co-lead agencies received requests to integrate the ongoing Columbia River Treaty negotiations between the United States and Canada into the analysis. Following the CRT Sovereign Review process, the CRT Regional Recommendation stated that Pacific Northwest states and tribes support the pursuit of a comprehensive flood risk management study to re-evaluate usage of flood plains and potential changes to current levels of protection. All of these concerns or measures were considered but removed from further analysis in the EIS for the reasons detailed in Section 2.5.

In addition, a preliminary suite of single objective focused alternatives were developed to maximize certain project purposes or benefit specific resources without attempting to minimize averse effects on other resources. As information on how suites of measures from these alternatives preformed became better understood, they were used to develop the MOs in order to meet the objectives in a more comprehensive manner. None of the single objective alternatives were retained for detailed analysis in the EIS. Additional information on these alternatives can be found in Appendix A—Alternative Development.

10 PREFERRED ALTERNATIVE

Overview of the Preferred Alternative

The Preferred Alternative provides flexibility to adapt to changing conditions in the Columbia River Basin, ensures that human life and safety can be protected through flood risk management, protects valuable fish and wildlife resources, supplies water to farmers and cities, and ensures adequate, affordable, and reliable power. Throughout this process, the co-lead agencies endeavored to identify a way to best meet the multiple purposes and objectives of the Columbia River System, and build on recent progress in establishing a more collaborative, creative approach to river operations and salmon protection. Each co-lead agency has different criteria for the outcome of the EIS, but worked together to select one alternative that seeks to balance the multiple purposes of the federal projects, while complying with the relevant environmental laws and regulations.

The five multiple purpose alternatives met the study's Purpose and Need Statement and objectives to varying degrees and with varying levels of beneficial and adverse effects. Because of this, the co-lead agencies selected a combination of suites of measures from the alternatives to develop the Preferred Alternative based on how well the measures met the Purpose and Need Statement and EIS objectives, with consideration of environmental, economic, and social effects. Developing the Preferred Alternative allowed the co-lead agencies to refine several measures based on information learned during the process of modeling and evaluating the alternatives.

After the alternatives were initially developed, the implementation of spring spill operations in 2018 and the development of the fish operations plan for 2019 led to new information regarding spill for juvenile fish passage to benefit downstream migration of juvenile anadromous fish. With this information, the co-lead agencies modified the juvenile fish spill operation for the Preferred Alternative using the analysis from the range of spill levels evaluated in the MOs. The intent was to create an opportunity for a major potential benefit to salmon and steelhead through increased spill, as indicated by the CSS model, while avoiding many of the adverse effects to power generation and reliability associated with juvenile spill operations analyzed in MO4. The primary method to accomplish this in the Preferred Alternative is a flexible spill operation that spills more for fish passage when power generation is less valuable and spills less when power generation is more valuable. The Preferred Alternative also acknowledges the range of potential outcomes predicted by the models used to estimate impacts to anadromous fish, and therefore includes a study to evaluate the potential benefits and unintended consequences of significantly higher spill levels. The underlying principles and model of constructive collaboration established through the 2018 flexible spill agreement have been carried forward in the Preferred Alternative.

All measures included in the Preferred Alternative are either carried forward from the No Action Alternative, or are original measures or refined measures that were evaluated in MOs 1 through 4. The exceptions are an added measure for lamprey passage (closeable floating orifice gates) and measures identified as part of the associated CRS ESA consultation processes. This led to a Preferred Alternative that seeks a balanced approach to enable the co-lead agencies to meet the multiple purposes of the System and requirements for fish and wildlife including ESA-listed species. Following the initial development of the Preferred Alternative, the co-lead agencies shared it with the National Marine Fisheries Service, U.S. Fish and Wildlife Service, tribes, and cooperating agencies to solicit feedback and further input. The feedback received from the Services and the Cooperating Agencies was highly valuable and despite the sizable volume of comments, the co-lead agencies addressed and incorporated this feedback wherever possible.

Tribal partners provided valuable input and expertise throughout the development of the EIS and tribal interests and perspectives played an important role in how the co-lead agencies shaped the Preferred Alternative. The importance of healthy salmon and steelhead populations to tribal cultures and economies are a central part of the rationale for selecting fish passage spill measures that have the potential to provide major improvements in SARs. Continued investment in structural improvements for lamprey passage also reflects consistent feedback received from numerous tribes. The affirmation and refinement of the Montana Operation, measures designed to carefully balance resident fish needs with other projects purposes, is the result of close coordination with tribal partners in the Upper Basin.

Does the Preferred Alternative Address the Objectives?

The Preferred Alternative meets the Purpose and Need Statement and objectives developed for the EIS for operation of the CRS. Where appropriate, mitigation measures have been incorporated into the Preferred Alternative to address adverse impacts when compared to the No Action Alternative. For example, the Preferred Alternative includes a mitigation measure to address the potential for access to blocked tributaries for bull trout due to operations at Libby dam. Ongoing programs and operation and maintenance activities would continue from the time this EIS was initiated in 2016 unless otherwise described. Preliminary measures proposed

by the co-lead agencies for compliance with the ESA are also included. These may be modified or added to as the ESA consultation process is still underway. Many of the measures in the Preferred Alternative are intended to improve conditions for ESA-listed fish and lamprey. Other measures are intended to provide more flexible ways for the co-lead agencies to meet water needs for fish and wildlife, flood risk management, water supply, and hydropower in the Columbia Basin. A detailed description of the measures included in the Preferred Alternative is included in Chapter 7 of the EIS.

The Preferred Alternative would meet the **Improve Juvenile Salmon**, **Improve Adult Salmon**, and **Improve Lamprey objectives**. According to the CCS model, Snake River Chinook and steelhead are expected to see relative improvements in SARs of 35 and 28 percent respectively. If latent mortality effects are reduced, the LCM models also predict that levels of SARs would increase. However, if latent mortality effects are not reduced, the LCM predicts that SARs for Snake River spring Chinook may also be lower than the No Action Alternative (range of minus 7.5 to plus 28 percent change relative to the No Action Alternative) due to reduced rates of transportation. Results for upper Columbia River stocks are beneficial based on LCM estimates. In-river survival and SARs are anticipated to increase. The ranges in potential effects are due to the different assumptions made by each of the fish models.

The Preferred Alternative is expected to address the adult migration delay caused by high spill predicted in MO4 analysis through the inclusion of periods of reduced spill. The Preferred Alternative is anticipated to, and is specifically designed to, test and evaluate whether increased spill will ultimately lead to an increase in adult fish. Spill operations would be managed adaptively, building off of the established Regional Forum processes, to address unexpected challenges, such as potential delays to adult migration, effects to navigation, and other challenges or opportunities that may require either a temporary or permanent change. As noted above, anadromous fish from regions other than the Snake River are expected to have minor improvements or similar effects compared to the No Action Alternative.

The Preferred Alternative includes modification of the John Day Reservoir for predator disruption. Reservoir levels would be increased before Caspian tern nesting season to dissuade nesting on islands in John Day's reservoir, and then dropped back down to the minimum operating pool range in June as is normal during the juvenile fish migration season. Ramp rates at John Day Dam limit the rate of change in reservoir elevations and would be similar to the No Action Alternative. The effect of the John Day Reservoir Predation Disruption measure would have negligible effects on larval lamprey (such as stranding) compared to the No Action Alternative

The Preferred Alternative is expected to have similar effects as the No Action Alternative on water temperature. TDG levels in the lower Snake and lower Columbia in the spring are expected to increase relative to the No Action Alternative due to increased spill intended for juvenile fish passage. These TDG levels are expected to be lower than MO4 spill in the spring due to the inclusion of periods of reduced spill for hydropower generation under a flexible spill operation.

The Preferred Alternative would also meet the **Improve Resident Fish** objective. Effects to resident fish vary by region and by species but are generally minor relative to the No Action Alternative. For example, at Libby Dam, effects to resident fish are expected to have both minor adverse effects due to higher river elevations during the winter and minor beneficial effects due to the changes in reservoir elevation, downstream water temperatures, and restoration of native riparian vegetation. Effects at

Hungry Horse are expected to be minor beneficial due to higher reservoir levels in late summer. Resident fish in Lake Roosevelt at Grand Coulee are expected to experience minor adverse effects because of changes in reservoir levels, but this would be mitigated for by augmenting spawning habitat. The slightly deeper drafts at Dworshak resulting from a more formal calculation of winter drawdown are expected to have minor adverse effects to bull trout and kokanee because of increased entrainment risk and increased drawdown that may isolate fish from tributaries. In the lower Columbia River and lower Snake River, the Preferred Alternative could have minor adverse effects on resident fish due to the higher TDG levels and minor beneficial effects from increased fish passage spill resulting in decreased powerhouse passage at dams.

The Preferred Alternative would meet the **Provide a Reliable and Economic Power Supply** objective. Hydropower generation decreases under the Preferred Alternative by 160 aMW assuming average water, and 300 aMW assuming low water, in large part due to the increased spring spill for juvenile fish passage. While overall hydropower generation would decrease under the Preferred Alternative, reliability is comparable to that of the No Action Alternative because other measures increase hydropower generation slightly in the winter, and more substantially in late August, and increase hydropower flexibility in some locations and periods. Therefore, no additional resources are needed to maintain regional reliability at the No Action Alternative level.

For Bonneville's wholesale power rates, the Preferred Alternative places additional rate pressure of 2.7 percent relative to the No Action Alternative. Additional rate sensitivities not included in the base analysis could lower the rate pressure to 0.4 percent. This rate pressure is within a range that may be offset by cost reductions. For instance, over the past two years, Bonneville and its partners took steps to offset the costs of reduced hydropower generation resulting from the Opinion and Order from the U.S. District Court for the District of Oregon. The spill operations contained in the Preferred Alternative are designed to test the potential biological benefits of increased spill while maintaining cost neutrality for regional electricity ratepayers relative to the 2018 spill injunction.

The Preferred Alternative marginally meets the **Minimize GHG Emissions** objective. Due to the reduction in hydropower generation, air quality would most likely be degraded slightly and greenhouse gas emissions in the Northwest would likely increase by an estimated 0.26 MMT (or 0.70 percent) compared to the No Action Alternative. Other emissions sources (e.g., navigation, construction, fugitive dust) are most likely to have a negligible effect on air quality and greenhouse gas emissions relative to the No Action Alternative across the basin.

The Preferred Alternative also meets the **Maximize Adaptable Water Management** and **Meet Water Obligations** objectives.

Additional Effects of the Preferred Alternative

Many of the tribal cooperating agencies provided valuable input on the broader historical context of cultural resource impacts resulting from the construction and operation of the CRS prior to 2016. Relative to the No Action Alternative, the effects of the Preferred Alternative generally have negligible effects on cultural resources. The current FCRPS Cultural Resource Program would continue under the Preferred Alternative.

Overall, the Preferred Alternative would result in less adverse effects to archaeological resources than the other action alternatives. Except for Lake Koocanusa, the Preferred Alternative is neutral or even slightly better than the No Action Alternative. This does not mean that the Preferred Alternative would eliminate the ongoing adverse effects of operating the reservoirs, but there may be a slight reduction in the rate at which archaeological sites decay. The adverse effects at Libby to archaeological resources resulting from the Preferred Alternative are minor.

As with the other alternatives, and similar to archaeological resources, traditional cultural properties would continue to experience major adverse effects associated with the operations and maintenance of the CRS. These effects that have occurred and would continue to occur under the Preferred Alternative are summarized in Chapter 3.16 and listed in Table 3-299. However, based on available information, and with reference to the assumptions and constraints previously described for traditional cultural properties, the Preferred Alternative would likely not result in an appreciable increase in adverse effects relative to the No Action Alternative.

Consistent with the sacred sites identified for Chapter 3, the Preferred Alternative evaluates effects to two sacred sites. Operational changes at Grand Coulee and Albeni Falls as described for the Preferred Alternative would be negligible when compared to the No Action Alternative. The quantitative analysis discussed above shows that the period of site exposure at Kettle Falls and Bear Paw Rock would not increase. Based on the similarity between the Preferred Alternative and the No Action Alternative, the effects to sacred sites under the Preferred Alternative are expected to be negligible.

MAJOR CONCLUSIONS

The co-lead agencies developed the Preferred Alternative as part of an iterative process. The Preferred Alternative is a combination of measures included in the five multiple objective alternatives using the information that was learned during their evaluation. In some instances, measures were modified to improve their ability to meet the Purpose and Need or objectives, or refined to avoid, reduce or minimize adverse environmental, economic, and social impacts. The co-lead agencies expect that the Preferred Alternative would allow them to meet the EIS intent as expressed in the Purpose and Need and the EIS objectives, including those to benefit ESA-listed species, while also continuing to meet the congressionally authorized purposes of the system. In conclusion, the Preferred Alternative seeks to balance the multiple purposes of the federal projects, while complying with the applicable federal environmental laws, implementing regulations, and executive orders. The applicable environmental statutes, regulations, and executive orders are summarized and a status of compliance is detailed in Chapter 8.1.

FEBRUARY 2020

EXECUTIVE SUMMARY: COLUMBIA RIVER SYSTEM OPERATIONS DRAFT ENVIRONMENTAL IMPACT STATEMENT

U.S. Army Corps of Engineers **Bureau of Reclamation** **Bonneville Power Administration**

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ACRONYMS AND ABBREVIATIONS

ACS	U.S. Census Bureau American Community Survey
ADFG	Alaska Department of Fish and Game
AEP	annual exceedance probability
AF/AT	average flow/average temperature
AF/LT	average inflow/low temperature
amsl	above mean sea level
aMW	average megawatt
AQI	Air Quality Index
AR	atmospheric river
ASW	adjustable spillway weir
BA	balancing authority
BiOp	biological opinion
BMP	best management practice
Bonneville	Bonneville Power Administration
BP-18	Current (2018) Bonneville Power Administration rate case
CAA	Clean Air Act
Census	U.S. Census Bureau
Census of Agriculture	U.S. Department of Agriculture Census of Agriculture
CEM	conceptual ecological models
CEQ	Council on Environmental Quality
C.F.R.	Code of Federal Regulations
cfs	cubic feet per second
CH_4	methane
CIAA	Cumulative Impact Analysis Area
cm	centimeters
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
COMPASS	Comparative Passage model
Corps	U.S. Army Corps of Engineers
CRITFC	Columbia River Inter-Tribal Fish Commission
CRS	Columbia River System
CRSO	Columbia River System Operations
CRT	Columbia River Treaty
CRWMP	Columbia River Water Management Program
CSKT	Confederated Salish and Kootenai Tribes
CSNS	Columbia-Snake Navigation System

CSS	Comparative Survival Study model
CTCR	Confederated Tribes of the Colville Reservation
Cultural Resources Program	Federal Columbia River Power System Cultural Resources Program
CWA	Clean Water Act
CYE	Cabinet-Yaak Ecosystem
dBA	decibels on the A-weighted scale
DM	Departmental Manual
DMMP	Dredged Material Management Plan
DO	dissolved oxygen
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DPS	distinct population segment
DSI	direct service industry
Ecology	Washington State Department of Ecology
EIA	U.S. Energy Information Administration
EIS	environmental impact statement
EJSCREEN	Environmental Justice Mapping and Screening Tool
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
F&W Program	Bonneville Power Administration's Fish and Wildlife Program
FCRPS	Federal Columbia River Power System
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FONSI	Finding of No Significant Impact
FOP	fish operations plan
FR	Federal Register
FRM	flood risk management
ft/s	feet per second
FY	fiscal year
GAP	Gap Analysis Program
GBT	gas bubble trauma
GHG	greenhouse gas
GIS	geographic information system
GWP	global warming potential
H&H	hydrology and hydraulics

HAP	hazardous air pollutant
HCNRA	Hells Canyon National Recreation Area
H. Doc.	U.S. Congress House Document
HEC-RAS	Hydraulic Engineering Center River Analysis System
HF/LT	high inflow/low temperature
HMU	Habitat Management Unit
Hydsim	Hydro System Simulator
IAPMP	Inland Avian Predator Management Plan
IBA	Important Bird Area
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
IDPR	Idaho Department of Parks and Recreation
IFP	improved fish passage
IOU	investor-owned utility
IPCC	Intergovernmental Panel on Climate Change
ISAB	Independent Scientific Advisory Board
ITA	Indian Trust Asset
IWG	Interagency Working Group
kaf	thousand acre-feet
kcfs	thousand cubic feet per second
kg	kilogram
km	kilometers
KTOI	Kootenai Tribe of Idaho
kW	kilowatt
kWh	kilowatt hour
Lakes Commission	Lakes Commission
LCM	Life Cycle Model
LCR FNC	Lower Columbia River Federal Navigation Channel
LF/AT	low flow/average temperature
LOLP	loss of load probability
LRFEP	Lake Roosevelt Fishery Enhancement Program
m	meters
M&I	municipal and industrial
Maf	million acre-feet
Mcy	million cubic cards
MDEQ	Montana Department of Environmental Quality
MFWP	Montana Fish, Wildlife and Parks

mg/L	milligrams per liter
MIP	minimum irrigation pool
MMPA	Marine Mammal Protection Act
MMT	Million metric tons
MO	Multiple Objective Alternative
MOP	minimum operating pool
MOU	memorandum of understanding
MPG	major population group
MW	megawatt
MWh	megawatt per hour
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NASS	National Agricultural Statistics Service
NAVD88	North American Vertical Datum of 1988
NCDE	Northern Continental Divide Ecosystem
NCE	Northern Cascades Ecosystem
nDPS	northern distinct population segment of green sturgeon
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Corporation
NGO	non-governmental organization
NGVD29	National Geodetic Vertical Datum of 1929
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
Northwest Power Act	Pacific Northwest Electric Power Planning and Conservation Act
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NPV	net present value
NRC	Nuclear Research Council
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NT	network integration
NTDE	National Tidal Datum Epoch
NW Council	Northwest Power and Conservation Council

NWFSC	Northwest Fisheries Science Center
NWHI	Northwest Habitat Institute
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
NWRFC	Northwest River Forecast Center
O_3	ozone
OAR	Oregon Administrative Rule
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OPRD	Oregon Parks and Recreation Department
ORS	Oregon Revised Statute
PAD-US	Protected Areas Database of the United States
PCBs	polychlorinated biphenyls
PFMC	Pacific Fishery Management Council
PIT	passive integrated transponder
PITPH	probability of passing powerhouses
PM	particulate matter
ppm	parts per million
PSC	Pacific Salmon Commission
PSMP	Lower Snake River Programmatic Sediment Management Plan
PTP	point-to-point
PUD	public utility district
RCP	Resource Concentration Pathway
REC	renewable energy certificate
Reclamation	U.S. Bureau of Reclamation
ResSim	Hydrologic Engineering Center Reservoir System Simulation
RF	radiative forcing
RFFA	reasonably foreseeable future actions
RHWM	rate period high water mark
RM	river mile
RM&E	research, monitoring, and evaluation
RMJOC	River Management Joint Operating Committee
ROD	Record of Decision
RPA	reasonable and prudent alternative
RPS	Renewable Portfolio Standard
RSLC	relative sea level change
RUVD	Recreation Use Valuation Database

SAR	smolt to adult return rate
SCC	social cost of carbon
SCENT	Snake Columbia Economic Navigation Tool
sDPS	southern distinct population segment of green sturgeon
SIP	state implementation plan
SKQ	Seli'š Ksanka Qlispe'
SO2	sulfur dioxide
SOR	Columbia River System Operation Review
SRD	storage reservation diagram
SWS	selective withdrawal system
Systemwide PA	2009 Systemwide Programmatic Agreement for the Management of Historic Properties Affected by the Multipurpose Operations of Fourteen Projects of the Federal Columbia River Power System
TCL	traditional cultural landscape
TCP	traditional cultural property
TDG	total dissolved gas
TEV	total economic value
TIR	transport to in-river SAR ratio
TMDL	total maximum daily load
TMT	Technical Management Team
TRM	tiered rate methodology
UDV	unit day value
URC	upper rule curve
USC	United States Code
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
VarQ	variable discharge storage regulation procedure
VOC	volatile organic compound
W/D	width to depth
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WECC	Western Electricity Coordination Council
WQS	water quality standard
WMA	Wildlife Management Area
WNWCB	Washington Noxious Weed Control Board

WSE	water surface elevation
WSPRC	Washington State Parks and Recreation Commission
WTP	willingness-to-pay

GLOSSARY

Access point: A place where people access a site for recreation. An access point might include a boat launch, a campground, a parking area, etc. A recreation area may contain one or more access points.

Acre-foot: The volume of water that will cover an area of 1 acre to a depth of 1 foot.

Ambient air: Ambient air is the air surrounding a particular spot, such as a powerplant.

Anadromous fish: Fish, such as salmon or steelhead trout, that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.

Annual operating plan: A yearly plan for operating projects on the Columbia River. Such a plan is specifically required by the Columbia River Treaty and by the Pacific Northwest Coordination Agreement.

Aquifer: Any geological formation containing water, especially one that supplies water to wells, springs, etc.

Artifact: An object of any type made by human hands. Tools, weapons, pottery, and sculptured and engraved objects are artifacts.

Augment: Increase; in this application, to increase river flows above levels that would occur under normal operation by releasing more water from storage reservoirs.

Average megawatt (aMW): A unit of energy that represents 1 megawatt of electric power capacity continuously over a year. One aMW is equal to 8,760 megawatts per hour.

British Columbia Hydro and Power Authority: This Canadian Crown corporation was formed in 1962 following the merger of an expropriated private utility and the B.C. Power Commission.

Balancing authority: The responsible entity that integrates resource plans ahead of time, maintains load interchange-generation balance within a balancing authority area, and supports interconnection frequency in real time.

Balancing authority area: The collection of generation, transmission, and loads within the metered boundaries of the balancing authority. The balancing authority maintains load-resource balance within this area.

Baseload: In a demand sense, a load that varies only slightly over a specified time period. In a supply sense, a plant that operates most efficiently at a relatively constant level of generation.

Bypass system: Structure in a dam that provides a route for fish to move through or around the dam without going through the turbines.

Capacity: The maximum load that a generator, piece of equipment, substation, transmission line, or system can carry under existing service conditions. Baseload capacity is the power output that can be continuously produced to run at least 70 percent of the time. Firm capacity is the capacity whose availability is ensured to the purchaser.

Columbia River Treaty (CRT): A treaty signed by the United States and Canada on September 16, 1964, for joint development of the Columbia River. Under the treaty Canada built three large storage dams (Duncan, Keenleyside, and Mica) on the upper reaches of the Columbia River, which originates in Canada. It is a U.S.-Canadian agreement for bilateral development and management of the Columbia River to achieve flood control and increased power production.

Consumer surplus: Economic value received by the consumer of a good, service, or resource (e.g., by a recreational user) that is above the price actually paid.

Cubic feet per second (cfs): A unit of measurement pertaining to flow or discharge of water. One cfs is equal to 449 gallons (1.7 cubic meters) per minute.

Cultural resources: The non-renewable evidence of human occupation or activity as seen in any district, site, building, structure, artifact, ruin, object, work of art, architecture, or natural feature that was part of human history at the national, state, or local level.

Demand: For electrical energy, the rate at which it is used, whether at a given instant or averaged over any designated period of time.

Depletion: Withdrawal of water from a stream, thereby reducing the volume of instream flow.

Discharge: Volume of water flowing at a given time, usually expressed in cubic feet per second.

Dissolved gas concentrations: The amount of chemicals normally occurring as gases, such as nitrogen and oxygen, which are held in solution in water, expressed in units such as milligrams of the gas per liter of liquid.

Draft: Release of water from a storage reservoir.

Draft rate: The rate at which water, released from storage behind a dam, reduces the elevation of the reservoir.

Drawdown: The distance that the water surface of a reservoir is lowered from a given elevation as water is released from the reservoir. Also refers to the act of lowering reservoir levels.

Economic value: The difference between the maximum amount a recreationist would be willing to pay to participate in a recreational activity and the actual cost of participating in that activity. This is referred to by economists as consumer surplus or net economic value.

Electricity: Electric current used or regarded as a source of power.

Endangered: A plant or animal species which is in danger of extinction throughout all or a significant portion of its range because its habitat is threatened with destruction, drastic modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors; federally endangered species are officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the *Federal Register.*

Endemic: Native or limited to a certain region.

Energy: As commonly used in the electric utility industry, electric energy means kilowatt-hours, or joules (the level of power delivered multiplied by the amount of time that the level of power is delivered). Used interchangeably with, although technically not a synonym of, power.

Entrainment: The drawing of fish and other aquatic organisms into tubes or tunnels carrying water for cooling purposes into thermal plants, or for power generating purposes into hydroelectric plants. Entrainment increases mortality rates for those organisms.

Firm energy: Energy considered ensurable to the customer to meet all agreed-upon portions of the customer's load requirements over a defined period. As defined in Bonneville Power Administration's system, electric energy produced under critical water conditions.

Fishery: Generally defined as a group of individuals or vessels that catch finfish or harvest shellfish, with specific commonalities in activity, including the fish species or stock targeted, the gear used, the location of activity, and the season of activity.

Fish hatchery: A facility in which fish eggs are incubated and hatched and juvenile fish are reared for release to rivers or lakes.

Fish ladders: A series of ascending pools constructed to enable salmon or other fish to swim upstream around or over a dam.

Fish passage facilities: Features of a dam that enable fish to move around, through, or over without harm. Generally an upstream fish ladder or a downstream bypass system.

Flow: The volume of water passing a given point per unit of time.

Flowgates: Flowgates are points along a transmission system through which the power flow is measured.

Forebay: The portion of the reservoir at a hydroelectric plant which is immediately upstream of the generating station.

Freshet: A rapid temporary rise in streamflow caused by heavy rains or rapid snowmelt.

Full pool: The maximum level of a reservoir under its established normal operating range.

Generation: The act of producing electricity from other forms of energy or the amount of electrical energy produced.

Historical streamflow record: The unregulated streamflow database of the 50 years beginning in July 1928; data is modified to adjust for factors such as irrigation depletions and evaporations for the particular operating year being studied.

Hydraulic head: The vertical distance between the surface of the reservoir and the surface of the river immediately downstream from the turbines and dam.

Hydroelectric: The production of electric power through use of the gravitational force of falling water.

Hydrology: The science of dealing with the continuous cycle of evapotranspiration, precipitation, and runoff.

Hydroregulation model: A computer-based mathematical model that simulates the regulation of water in the coordinated operation of a river system.

Inflow: Water that flows into a reservoir or forebay during a specified period.

Intake: The entrance to a conduit through a dam or water facility.

Interruptible: A supply of power which, by agreement, can be shut off on relatively short notice (from minutes to a few days).

Intertie: A transmission line or system of transmission lines permitting a flow of energy between major power systems. The Bonneville Power Administration transmission grid has interties to British Columbia, Canada; California; and eastern Montana.

Jobs: Combined full- and part-time jobs on an annualized basis.

Juvenile: The early stage in the life cycle of anadromous fish when they migrate downstream to the ocean.

kcfs: Thousand cubic feet per second; a measurement of water flow equivalent to 1,000 cubic feet of water passing a given point in one second.

Labor income: includes employee compensation and proprietary income. Employee compensation consists of wage and salary payments as well as benefits (e.g., health and retirement benefits) and employer paid payroll taxes (e.g., employer social security contributions and unemployment taxes). Proprietary income consists of payments received by self-employed individuals (such as doctors and lawyers) and unincorporated business owners.

Levee: An embankment constructed to prevent a river from overflowing.

Littoral zone: The shallower waters near the shore of a reservoir or lake.

Load: The amount of electric power or energy delivered or required at any specified point or points on a system. Load originates primarily at the energy-consuming equipment of customers.

Load shaping: The adjustment of storage releases so that generation and load are continuously in balance.

Lock: A chambered structure on a waterway closed off with gates for the purpose of raising or lowering the water level within the lock chamber so ships can move from one elevation to another along the waterway.

Low pool: At or near the minimum level of a reservoir under its established normal operating range.

Macrophytes: Aquatic plants that are macroscopic, or large enough to be seen with the naked eye.

Mainstem: The principal river in a basin, as opposed to the tributary streams and smaller rivers that feed into it.

Megawatt (MW) and kilowatt (kW): A watt is a measure of a unit of power. One megawatt represents 1,000 kilowatts or 1 million watts. MW is a standard metric describing electric power generating capacity.

Megawatt hours (MWh) and kilowatt hours (kWh): MWh and kWh are energy measurements denoting electricity production or consumption. One MWh equals 1,000 kWh. In the electricity context, power (MW) is the rate of producing, transferring, or using energy, and energy (MWh) is power used over a period of time.

Middle Columbia: The section of the Columbia River from the U.S.-Canada border to its confluence with the Snake River.

Model: A mathematical function with parameters that can be adjusted so that the function closely describes a set of empirical data. A "mathematical" or "mechanistic" model is usually based on biological or physical mechanisms and has model parameters that have real-world interpretations. In contrast, "statistical" or "empirical" models involve curve-fitting to data where the math function used is selected for its numerical properties. Extrapolation from mechanistic models (e.g., pharmacokinetic equations) usually carries higher confidence than extrapolation using empirical models (e.g., logic).

Minimum operating pool (MOP): The minimum elevation of the established normal operating range of a reservoir.

Operating limits: Limits or requirements that must be factored into the planning process for operating reservoirs and generating projects. (Also see operating requirements, below.)

Operating requirements: Guidelines and limits that must be followed in the operation of a reservoir or generating project. These requirements may originate in authorizing legislation, physical plant limitations, or other sources. Non-power operating requirements pertain to navigation, flood control, recreation, irrigation, and other non-power uses of a river.

Operating rule curve: A curve, or family of curves, indicating how a reservoir is to be operated under specific conditions and for specific purposes.

Operating year: The 12-month period from August 1 through July 31.

Outages: Periods, both planned and unexpected, during which the transmission of power stops or a particular power-producing facility ceases to provide generation.

Outflow: The volume of water per unit of time discharged at a hydroelectric project.

Pacific Northwest Coordination Agreement: A binding agreement among Bonneville Power Administration, the U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and the major generating utilities in the Pacific Northwest that stemmed from the Columbia River Treaty. The agreement specifies a multitude of operating rules, criteria, and procedures for coordinating operation of the system for power production. It directs operation of major generation facilities as though they belonged to a single owner.

Pacific Northwest Electric Power Planning and Conservation Act: In December 1980, Congress passed this Act, Public Law 96-501 (referred to as the Northwest Power Act). This act authorized the four Pacific Northwest States— Idaho, Montana, Oregon, and Washington—to enter into an interstate compact for long-range planning and protection of shared resources. As a result of the act, each of the four states passed enabling legislation to create the Northwest Power Planning Council in April 1981.

Particulates: Substances that consist of minute separate particles, such as dust or soot.

Peak load: The maximum load in a stated period of time. It may be the maximum load at a given instant in the stated period or the maximum average load within a designated interval of the stated period of time. Peak can also be used to refer to the maximum capacity or energy.

Peaking or peaking capacity: The generating capacity available to assist in meeting that portion of the load that is above baseload. Alternatively, the maximum output of a generating plant or plants during a specified peak-load period.

Phytoplankton: The plant portion of floating or weakly swimming organisms, often microscopic in size, in a body of water.

Pool: Reservoir; a body of water impounded by a dam.

Power: The rate of energy production or transfer. Power is expressed in watts and used interchangeably with energy, although it is technically not a synonym of energy. Power delivered to a load is also called demand.

Project outflow: The volume of water per unit of time discharged from a project.

Record of Decision (ROD): A document notifying the public of a decision made, together with the reasons for making that decision. Records of Decision are published in the *Federal Register.*

Recreation area: A reservoir, river reach between reservoirs, or the Pacific Ocean off the coast of Oregon and Washington, used for recreation. A recreation area may have one or more access points.

Redds: Salmon spawning nests in gravel.

Refill: The point at which the hydro system is considered "full" from the seasonal snowmelt runoff. Also refers to the annual process of filling a reservoir.

Regional economic contributions: These reflect economic activity within a specific geographic region supported by expenditures for a particular economic sector (e.g., recreational visitation). Contributions are often measured in terms of sales (spending), jobs, income, and value added, though other measures may be used.

Reliability: For a power system, a measure of the degree of certainty that the system will continue to meet load for a specified period of time.

Reservoir elevations: The levels of the water stored behind dams.

Reservoir storage: The volume of water in a reservoir at a given time.

Resident fish: Fish species that reside in fresh water throughout their lives.

Residualize: When migrating juvenile salmonid smolts lose their urge to migrate, physiologically revert to their freshwater life form, and remain in fresh water rather than migrate to sea.

Riprap: Broken rock, cobbles, or boulders placed on the bank of a stream or river for protection against the erosive action of water.

Rule curves: Water levels, represented graphically as curves, that guide reservoir operations.

Run-of-river dams: Hydroelectric generating plants that operate based only on available streamflow and some short-term storage (hourly, daily, or weekly).

Run-of-river reservoirs: The pools or impoundments formed behind run-of-river dams.

Salmonids: Fish of the family Salmonidae, such as salmon, trout (including steelhead), char, and whitefish.

Scoping: The process of defining the scope of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with environmental documents prepared under the National Environmental Policy Act.

Secondary energy: Hydroelectric energy in excess of firm energy, often used to displace thermal resources. Sometimes called non-firm energy.

Sedimentation: The settling of material (such as dust or other particles) into water and eventual deposition on the bottoms of streams and rivers.

Shaping: The scheduling and operating of generating resources to meet changing load levels. Load shaping on a hydro system usually involves the adjustment of reservoir releases so that generation and load are continuously in balance.

Simulation: The representation of an actual system by analogous characteristics of a device that is easier to construct, modify, or understand, or by mathematical equations.

Smolt: A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater to a saltwater environment.

Spawning: The releasing and fertilizing of eggs by fish.

Spending: Equivalent to the sales by firms in the region. This can be expressed in terms of (1) recreation expenditures, and/or (2) final demand, which is the total sales by firms in the region from all buyers, including recreationists, as well as businesses and households in subsequent rounds of spending.

Spill: Water passed over a spillway without going through turbines to produce electricity. Spill can be forced, when there is no storage capability and flows exceed turbine capacity, or planned, for example, when water is spilled to enhance juvenile fish passage.

Spillway: Overflow structure of a dam

Stochastic: Involving chance or probability.

Storage reservoirs: Reservoirs that have space for retaining water from springtime snowmelts. Retained water is released as necessary for multiple uses: power production, fish passage, irrigation, and navigation.

Streamflow: The rate at which water passes a given point in a stream, usually expressed in cubic feet per second.

Subyearlings: Juvenile fish less than 1 year old.

Surplus energy: Energy generated that is beyond the immediate needs of the producing system. This energy may be sold on an interruptible basis or as firm power.

System flood control: Flood protection for the Portland, Oregon, and Vancouver, Washington, metropolitan area that is coordinated among all of the storage reservoirs in the Columbia River system.

Tailrace: The canal or channel that carries water away from a dam.

Tailwater: The water surface immediately downstream from a dam or hydroelectric powerplant.

Threatened: Legal status afforded to plant or animal species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Transmission path: A path refers to a route over which the power flows from one point to another (i.e., the direction power flows across a transmission line).

Tules: The name commonly applied to fall chinook salmon originating on the lower Columbia River.

Turbidity: A measure of the optical clarity of water, which depends on the light scattering and absorption characteristics of suspended and dissolved material in the water.

Turbine: Machinery that converts kinetic energy of a moving fluid, such as falling water, to mechanical or electrical power.

Upper rule curve (URC): The flood control rule curve for a storage reservoir which typically is the uppermost of the family of rule curves used to guide reservoir operations.

Upriver brights: The name commonly applied to fall chinook salmon originating on the middle Columbia River, primarily in the area below Priest Rapids Dam.

Velocity: Speed; the rate of linear motion in a given direction.

Water conditions: The overall supply of water to operate the Pacific Northwest hydroelectric generating system at any given time, taking into account reservoir levels, snowpack, any needs to provide water or retain water to meet various operating constraints (such as the water budget, flood control, flow constraints, etc.), weather conditions, and other factors.

Water particle travel time: The theoretical time that a water particle would take to travel through a given reservoir or river reach. It is calculated by dividing the flow (volume of water per unit time) by the cross-sectional area of the channel.

Water retention time: The length of time that a particle of water is resident in a lake or reservoir, based on rates of inflow, outflow, and circulation within the waterbody.

Water rights: Priority claims to water. In Western states, water rights are based on the principle “first in time, first in right,” meaning older claims take precedence over newer ones.

Water year: One hydrologic cycle corresponding to Bonneville Power Administration’s fiscal year, October 1 through September 30. Depending on streamflows a water year may be defined as high, low, or average, or *critical*. The **critical water year** is a sequence of streamflows under which the regional hydro system could produce an amount of power equal to that which could have been produced during the historical critical period, given today’s generating facilities and constraints.

Yearlings: One-year-old juvenile salmon and steelhead.

Zooplankton: Aquatic animals that cannot actively swim against the current and cannot make their own food by photosynthesis.

DATUM CONVERSION

This table shows the vertical datum adjustment from NGVD29 to NAVD88 for the fourteen CRS projects.

Vertical Datum Adjustment

Location	Datum Adjustment (feet)
Albeni Falls Dam	3.9
Bonneville Dam	3.3
Chief Joseph Dam	4.0
Dworshak Dam	3.3
Grand Coulee Dam	3.9
Hungry Horse Dam	3.9
Ice Harbor Dam	3.4
John Day Dam	3.2
Libby Dam	3.9
Little Goose Dam	3.2
Lower Granite Dam	3.4
Lower Monumental Dam	3.3
McNary Dam	3.3
The Dalles Dam	3.3

CHAPTER 1 - INTRODUCTION

1.1 BACKGROUND

The Columbia River is one the greatest natural resources in the western United States. The river and its tributaries impact nearly every resident of the Northwest in some way, by providing hydroelectric power, recreation opportunities, navigation, irrigation for crops, and more. The Columbia River System's Federal and non-Federal dams also provide hydroelectric energy production for about half of regional demands. For thousands of tribal members whose societies have been shaped over millennia by their proximity to and relationship with the Columbia River and its tributaries, these water bodies are also an essential source of life and a foundation of tribal spiritual and cultural connections. Many tribes have not only lost access to traditional places on the river, but have lost access to the one thing that all these places had in common, which bound them together—the salmon.

Today, a variety of projects in The Northwest waterways are operated for hydropower and other purposes. There are approximately 375 major projects; 141 are owned by Federal agencies, and 221 are owned by non-Federal entities. Of the 141 Federal projects, 31 generate hydropower in addition to serving other purposes. These 31 multi-purpose dam and reservoir projects make up the Federal Columbia River Power System (FCRPS), constructed and operated by the U.S. Army Corps of Engineers (Corps) and the U.S. Bureau of Reclamation (Reclamation). The Bonneville Power Administration (Bonneville) markets and delivers electric power from the FCRPS. Each project within the FCRPS is operated to meet various congressionally authorized purposes and other system-wide purposes.

Fourteen of the FCRPS projects are operated as a coordinated system known as the Columbia River System within the interior Columbia River Basin in the states of Idaho, Montana, Oregon, and Washington. The 14 CRS projects ("project" is used to collectively refer to a dam and its associated reservoir) are 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. Projects in the upper Snake, Willamette, and Rogue River Basins are excluded from the CRS because these are coordinated and operated separately. Projects in Canada are not operated by the co-lead agencies. Figure 1-1 shows the geographic locations of the 14 CRS projects. The CRS consists of subbasins, each having distinct topographic, meteorological, and/or hydrologic characteristics. These subbasins are grouped into four regions, A to D, shown in Figure 1-1, that are referred to throughout this environmental impact statement (EIS). The Corps, Reclamation, and Bonneville are preparing this EIS, as co-lead agencies, under the requirements of the National Environmental Policy Act (NEPA), to identify the environmental impacts associated with the operation, maintenance, and configuration (management) of the CRS.

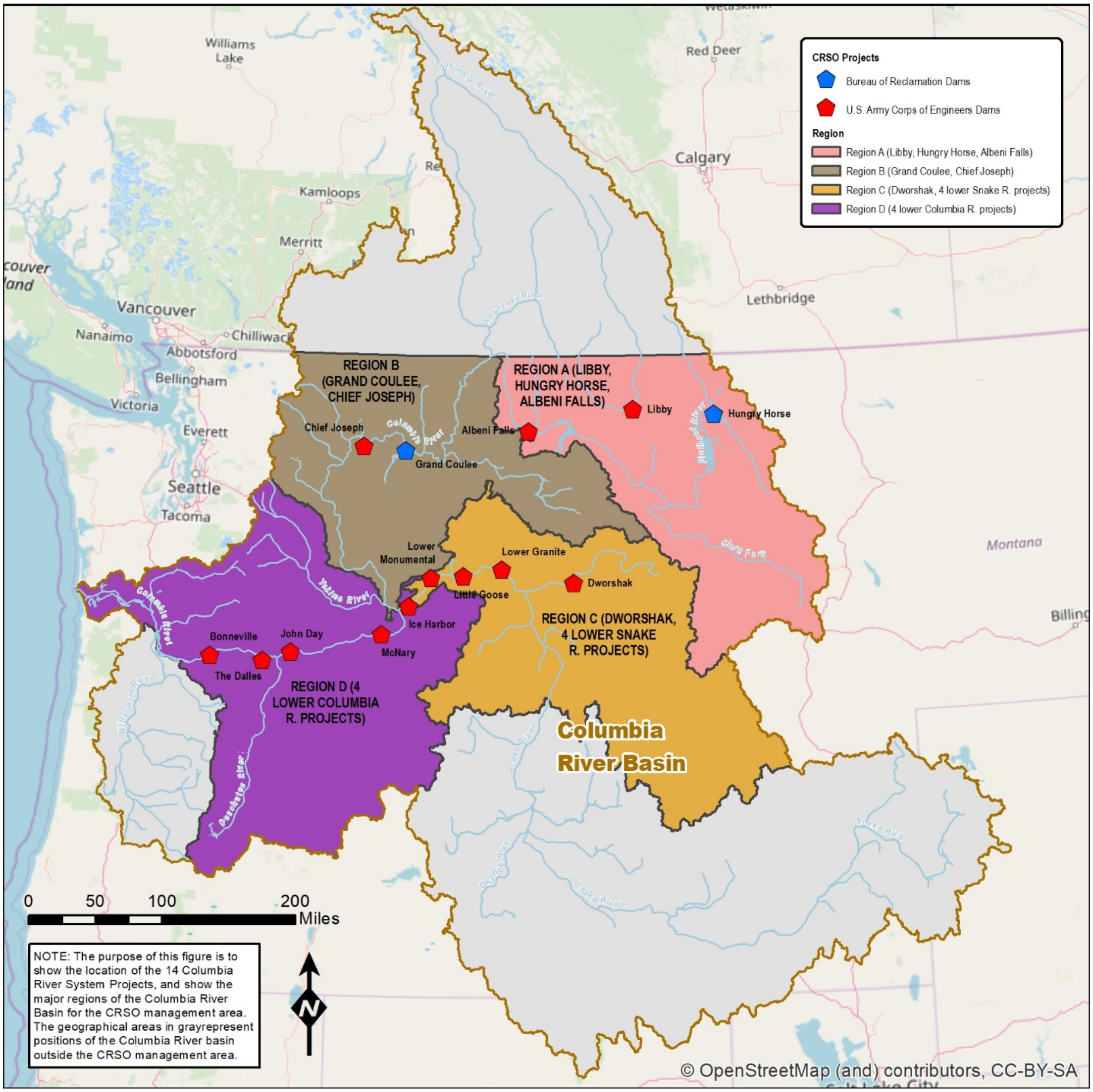

Figure 1-1. Geographic Locations of the Columbia River System Projects

The U.S. Congress authorized the Corps and Reclamation to construct, operate, and maintain the CRS projects to meet multiple specified purposes, including flood risk management (FRM), navigation, hydropower production, irrigation, fish and wildlife conservation, recreation, and municipal and industrial (M&I) water supply. However, not every project is authorized for all of these purposes. Bonneville is authorized to market and transmit the power generated by these coordinated system operations. The following list provides more detail about these purposes:

- Flood Risk Management (FRM). Storage projects allow water managers to store water in times of high flow volume to reduce the likelihood of flooding throughout the system.
- Water Supply/Irrigation. Some projects are operated for the storage and delivery of irrigation and municipal and industrial (M&I) water. For example, water pumped from Lake Roosevelt behind Grand Coulee Dam is delivered downstream to Banks Lake for irrigation and M&I. John Day is operated to meet elevation requirements to allow for pumping water for irrigation. Other projects, such as the lower Snake River projects, provide the incidental benefit of pumping by maintaining elevations for other purposes, such as navigation.
- Hydroelectric Power Generation. The Federal dams in the Northwest supply about 27 percent of the region's power under average water conditions (Bonneville 2019c).
- Navigation. The four lower Columbia River dams and four lower Snake River dams have navigation locks that allow passage for boats and barges to facilitate the transport of goods to and from the Pacific Ocean and inland ports as far upstream as Lewiston, Idaho.
- Recreation. The reservoir and adjacent public (or park) lands provide recreational opportunities for boaters, anglers, swimmers, wind and kite surfers, hunters, hikers, and campers throughout the year.
- Fish and Wildlife. The Corps and Reclamation operate the system to support the protection and conservation of fish and wildlife species in the Columbia River Basin. Bonneville supports efforts to mitigate for the effects of development and operation of the FCRPS. This includes the impacts of the CRS on fish and wildlife in the mainstem Columbia River and its tributaries, pursuant to the Pacific Northwest Power Act, in a manner consistent with the Northwest Power and Conservation Council's Fish and Wildlife Program.[1]

An overview of the CRS is provided in Section 1.9, *Introduction to Columbia River System Operations*.

In the 1990s, the co-lead agencies analyzed the environmental impacts of operating the system in the Columbia River System Operation Review (SOR) EIS, and issued respective records of decision (RODs) in 1997 that adopted a system operation strategy. This strategy included operations supporting fish listed under the Endangered Species Act (ESA), while fulfilling all other congressionally authorized purposes. Operational changes have been adopted under subsequent ESA consultations and project-specific NEPA documents. Changed environmental conditions in the Columbia River Basin, and new scientific information since the release of the SOR EIS, have triggered a reevaluation of the coordinated CRSO. In preparing this EIS, the co-lead agencies are also responding to the Opinion and Order issued by the U.S. District Court for the District of Oregon[2] (see Section 1.2 for more information).

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[1] Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act) (16 U.S.C § 839b (h)(10)(A)).
[2] *National Wildlife Federation, et al. v. National Marine Fisheries Service, et al.*, 184 F. Supp. 3d 861 (D. Or. 2016).

1.2 PURPOSE AND NEED FOR ACTION

The ongoing action that requires evaluation under NEPA is the long-term coordinated operation and management of the CRS projects for the multiple purposes identified above. An underlying need to which the co-lead agencies are responding, is to review and update the management of the CRS, including evaluating measures to avoid, offset, or minimize impacts to resources affected by managing the CRS in the context of new information and changed conditions in the Columbia River Basin since the SOR EIS was released. 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 (District Court) which states that the EIS should evaluate how to ensure that the prospective management of the CRS 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. This includes evaluating mitigation measures to address impacts to listed species from CRS operations. The EIS evaluates actions within the current authorities of the co-lead agencies, as well as certain actions that are not within their authorities, based on the District Court's observations about alternatives that could be considered and comments received during the scoping process. The EIS also allows 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 CRS.

The co-lead agencies will use the information garnered through this process to guide future decisions, and allow for a flexible approach to meeting multiple responsibilities including resource, legal, and institutional purposes of the action.

- Resource Purposes:
    - Provide for a reliable level of FRM by operating the CRS 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 throughout the environment affected by CRS operations
    - Consider and plan for climate change impacts on resources, and on the management of the CRS
    - Provide opportunities for recreation at CRS 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 CRS 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 United States Code [U.S.C.] § 839b(11)(A))
  - Protect Native American treaty and reserved rights and fulfill trust obligations for natural and cultural resources throughout the environment affected by CRS operations
  - Continue to use a collaborative Regional Forum framework to allow for flexibility and adaptive management of the CRS
  - Ensure project Water Control Manuals adequately reflect the management of the CRS

1.3 SCOPE OF THE PROJECT

1.3.1 Geographic and Temporal Scope

The Columbia River is one of the largest rivers in North America. With its tributaries, it forms the dominant water system in the Northwest Region. It is the fourth largest river in the United States, as measured by average annual flow. The Columbia River originates in British Columbia, at Columbia Lake on the west slope of the Rocky Mountains. The river enters the United States in the northeastern corner of the state of Washington. It then flows south and west, then southeasterly to its confluence with the Snake River near Pasco, Washington. It turns westward, forming the Washington-Oregon border before flowing into the Pacific Ocean near Astoria, Oregon. Four of the major tributaries to the Columbia River in the United States are the Kootenai, Clark Fork, Pend Oreille, and Snake rivers.

The specific geographic scope of the CRS proposed alternatives encompasses the 14 Federal projects on the Columbia River and its major tributaries (Figure 1-1). The other Federal projects in the Columbia River Basin (e.g., the Willamette Valley projects, the Yakima Valley projects, and other Federal projects on the Snake River) and non-Federal projects in the basin, are not included in the specific geographic scope for the effects analysis because operation of those other projects are separate actions carried out under different legal authorities.[3] In addition, three Canadian projects in the Canadian portion of the basin are partially coordinated with the CRS under the Columbia River Treaty (CRT). These other projects may be included in the

[3] For example, the Willamette Basin System, operated by the Corps, is authorized in part by several of the same Flood Control Acts as some of the CRS projects. However, as outlined in these authorizations, the Willamette System was designed as a comprehensive plan of development specific to the Willamette Basin, which would be operated as a separate system from the CRS.

cumulative effects analysis, as appropriate (refer to Chapter 6, *Cumulative Effects*). The potential for any significant effects of the alternatives that could arise in Canadian portions of the basin were reviewed in general as a matter of policy.

The temporal scope of this analysis is assumed to be 25 years from the signing of the Records of Decision (RODs), with the exception of the socioeconomic-related resource analysis. For the socioeconomic analysis, a 50-year period of analysis is used to better capture the full array of costs, benefits, and tradeoffs being evaluated in the alternatives. The 50-year period of analysis provides a long-term perspective, and enables the socioeconomic analysis to distinguish between short-term impacts that may occur during the implementation of alternatives and long-term effects that would occur after implementation is completed. The assumption for analysis in the draft EIS is that any alternative would be implemented immediately after the ROD is signed. Recognizing the uncertainty around particular structural and mitigation measures and the time required for implementation, a sensitivity analysis was completed to determine the effect of construction timing on costs and is provided in the cost analysis.

1.4 COLUMBIA RIVER SYSTEM OPERATIONS INTERAGENCY TEAM

1.4.1 Co-Lead Agencies

The co-lead agencies (the Corps, Reclamation, and Bonneville) share responsibility and legal authority for managing the Federal elements of the CRS. These three co-lead agencies coordinate the operation of the CRS and have worked together to develop this EIS.

The Corps and Reclamation develop operating requirements for their projects. These are the limits within which a reservoir or dam must be operated. Some requirements are established by Congress when a project is authorized, while others are established by the agencies based on operating experience. Within these operating limits, Bonneville schedules and dispatches power. This process requires continuous communication and coordination among the three agencies.

1.4.1.1 The U.S. Army Corps of Engineers

The Corps operates and maintains 12 of the 14 projects being evaluated as part of the CRSO EIS. Nine of these projects are operated on the lower Snake and Columbia rivers, while three provide storage in the upper reaches of the Columbia River Basin. The Corps has a major role in coordinating multiple uses in the system. It is responsible for system FRM in the basin, maintaining navigation locks and channels to accommodate river passage, producing hydropower, maintaining recreation facilities, and operating fish passage facilities.

1.4.1.2 The U.S. Bureau of Reclamation

Reclamation operates two CRS storage projects: Grand Coulee and Hungry Horse. Grand Coulee Dam Project plays a prominent role in the coordinated CRS because of its size (approximately 5.4 million acre-feet [Maf] of storage in Lake Roosevelt) and key location. Grand Coulee is the largest CRS project used for FRM and is a key generator and regulator for hydropower. Additionally, Grand Coulee Dam serves as the primary water diversion facility for the Columbia Basin Project and its irrigation system. Storage at Hungry Horse is very valuable because of its headwaters location. The water released from Hungry Horse passes through many downstream dam and reservoir projects—both Federal and non-Federal. Hungry Horse provides local and system FRM and hydropower. Additionally, flow augmentation delivered from Hungry Horse benefits both resident and anadromous fish as it passes downstream.

1.4.1.3 Bonneville Power Administration

Bonneville markets and distributes power generated at the Federal dams on the Columbia River and its tributaries. The not-for-profit agency sells power from the dams and other generating plants to public and private utilities and large industries. The agency also owns and operates over 15,000 miles of high voltage transmission lines to deliver the electricity. Federal law requires Bonneville, when providing electricity produced at the Federal dams, to give preference to publicly owned utilities and entities in the Northwest.

1.4.2 Co-Lead Agency Framework

The co-lead agencies established a project organizational structure to analyze the broad range of alternatives for this EIS. Multiple interagency technical teams, consisting of co-lead agency staff and cooperating agencies, represented the resources analyzed. The technical teams provided subject matter expertise in the preparation of the draft EIS and interacted with the other technical teams.

1.4.3 Cooperating Agency Involvement

The co-lead agencies asked tribes and Federal, state, and local agencies to participate as cooperating agencies based on their jurisdiction by law, or their special expertise with respect to any environmental issue evaluated in this EIS. The agencies and tribes listed in Table 1-1 accepted the request and are cooperating agencies for this project. These cooperating agencies contributed to the draft EIS by providing information, participating on technical teams, and reviewing draft documents. A more in-depth discussion is located in Chapter 9, *Coordination and Public Involvement Process*.

Table 1-1. Columbia River System Operations Environmental Impact Statement Cooperating Agencies

Cooperating Agencies
Federal Agencies
U.S. Environmental Protection Agency, Region 10
U.S. Coast Guard, 13th Coast Guard District
U.S. Department of the Interior, Bureau of Indian Affairs
State Agencies
Idaho
Governor's Office of Species Conservation[1/]

Cooperating Agencies
Governor's Office of Energy and Mineral Resources
Department of Fish and Game
Department of Agriculture
Department of Lands
Department of Environmental Quality
Historic Preservation Office
Department of Parks and Recreation
Department of Water Resources
Idaho Department of Transportation
Oregon
Department of Fish and Wildlife[1/]
Department of Energy
Water Resources Department
Department of Agriculture
Department of Environmental Quality
Montana
Montana Office of the Governor [1/]
Montana Fish, Wildlife and Parks
Washington
Department of Ecology
Department of Fish and Wildlife[1/]
Department of Agriculture
County Agencies
Lake County, Montana
Tribes
Confederated Salish and Kootenai Tribes of the Flathead Reservation
Confederated Tribes of the Colville Reservation
Confederated Tribes of the Grand Ronde
Confederated Tribes of the Umatilla Indian Reservation
Confederated Tribes and Bands of the Yakama Nation
Cowlitz Indian Tribe
Kootenai Tribe of Idaho
Nez Perce Tribe
Burns Paiute Tribe
Fort McDermitt Paiute and Shoshone Tribes of the Fort McDermitt Indian Reservation
Shoshone-Paiute Tribes of the Duck Valley Reservation
Shoshone-Bannock Tribes of the Fort Hall Reservation
Spokane Tribe of Indians[2/]
Intertribal Organization
Upper Snake River Tribes Foundation on behalf of Burns Paiute Tribe, Fort McDermitt Paiute-Shoshone Tribe, and Shoshone-Paiute Tribes of the Duck Valley Reservation.

214 1/ Lead for that state's Memorandum of Understanding.
215 2/ Continued discussions concerning the Spokane Tribe of Indian's cooperating agency status are ongoing.

1.5 NATIONAL ENVIRONMENTAL POLICY ACT PROCESS AND PUBLIC INVOLVEMENT

1.5.1 Overview of the National Environmental Policy Act Process

Two major purposes of the NEPA process are better-informed decisions and public involvement. This EIS provides information necessary for decision-makers to fully evaluate a range of alternatives and adopt a long-term operation strategy for the CRS. It fully addresses the potential impacts of alternatives, as required under the NEPA of 1969, as amended (42 U.S.C. § 4321 et seq.); Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations [C.F.R.] §§ 1500–1508); Corps Engineer Regulation (ER) 200-2-2 (33 C.F.R. § 230); Department of Energy's NEPA Implementing Procedures (10 C.F.R. § 1021); Department of the Interior (DOI) NEPA Regulations (43 C.F.R. § 46); and the DOI Departmental Manual Chapter 516. A brief description of public involvement can be seen in Section 1.5.2, while a more in-depth discussion is located in Chapter 9, *Coordination and Public Involvement Process*. Figure 1-2 illustrates the EIS NEPA Overview Process and where the co-lead agencies are in the process.

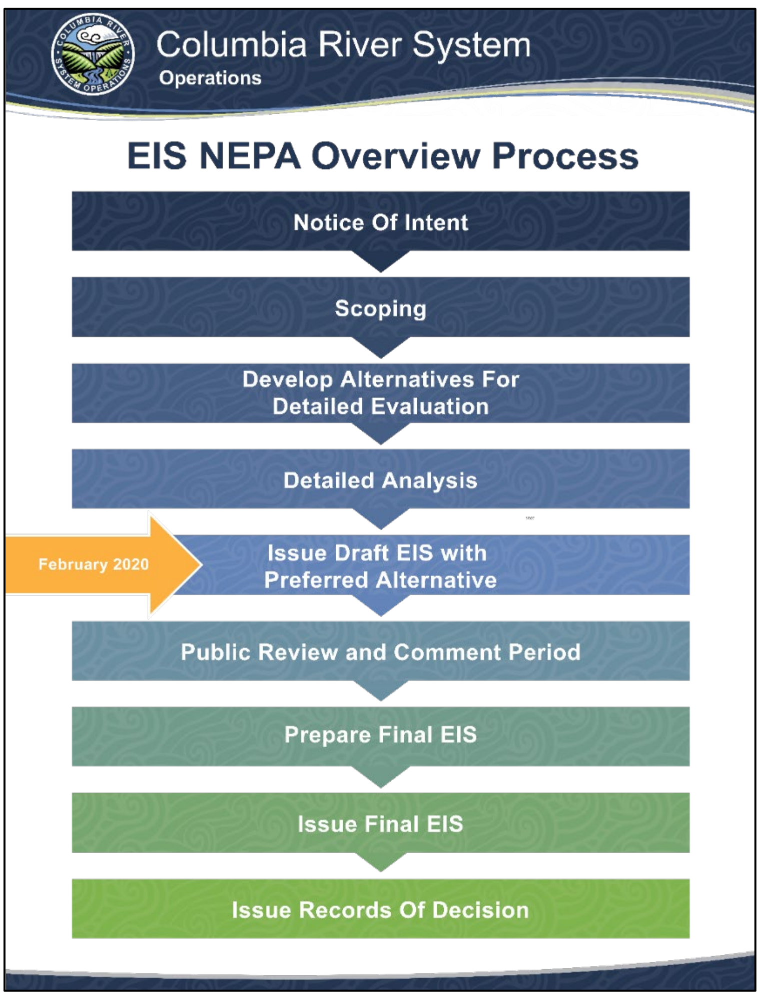

Figure 1-2. The Environmental Impact Statement National Environmental Policy Act Overview Process

1.5.2 Public Involvement

Public involvement is required by NEPA before a Federal agency undertakes an action affecting the environment. The purpose of public involvement is to support informed decision-making. This section gives an overview of the public involvement process for this project, including public scoping and tribal coordination. Chapter 9, *Coordination and Public Involvement Process*, provides a more in-depth discussion.

1.5.2.1 Public Scoping

One of the first steps in the NEPA process is to establish the scope of the project, and one component of accomplishing this step is the public scoping process. The co-lead agencies implemented a robust public scoping process intended to provide ample opportunity for the public to engage. The public was invited to provide assistance in defining the issues, concerns, and scope of alternatives to be addressed. The Notice of Intent (NOI) was published in the *Federal Register* on September 30, 2016 (81 Federal Register [FR] 67382). The public comment period was scheduled to end January 17, 2017, and a schedule was announced for 15 public meetings and two webinars. In addition, a public scoping letter was sent to interested parties on September 30, 2016. On November 4, 2016, the co-lead agencies issued a *Federal Register* notice of an additional public meeting to be held in Pasco, Washington (81 FR 76962). On January 3, 2017, the comment period was extended to February 7, 2017 (82 FR 137).

In addition, the co-lead agencies issued a series of press releases and newspaper advertisements announcing the public meetings. A public website (www.crso.info) was established at the time of the NOI to communicate and share information about the CRSO EIS. The 16 open-house public meetings were held across the region (Figure 1-3). Two webinars were held on December 13, 2016.

The co-lead agencies received more than 400,000 comments during the scoping period and these were summarized into the *Public Scoping Report for the Columbia River System Operations Environmental Impact Statement*, October 2017, which can be found at www.crso.info and is incorporated by reference herein. Members of the public, tribes, local and state governmental agencies, non-governmental organizations, and other stakeholders provided these comments.

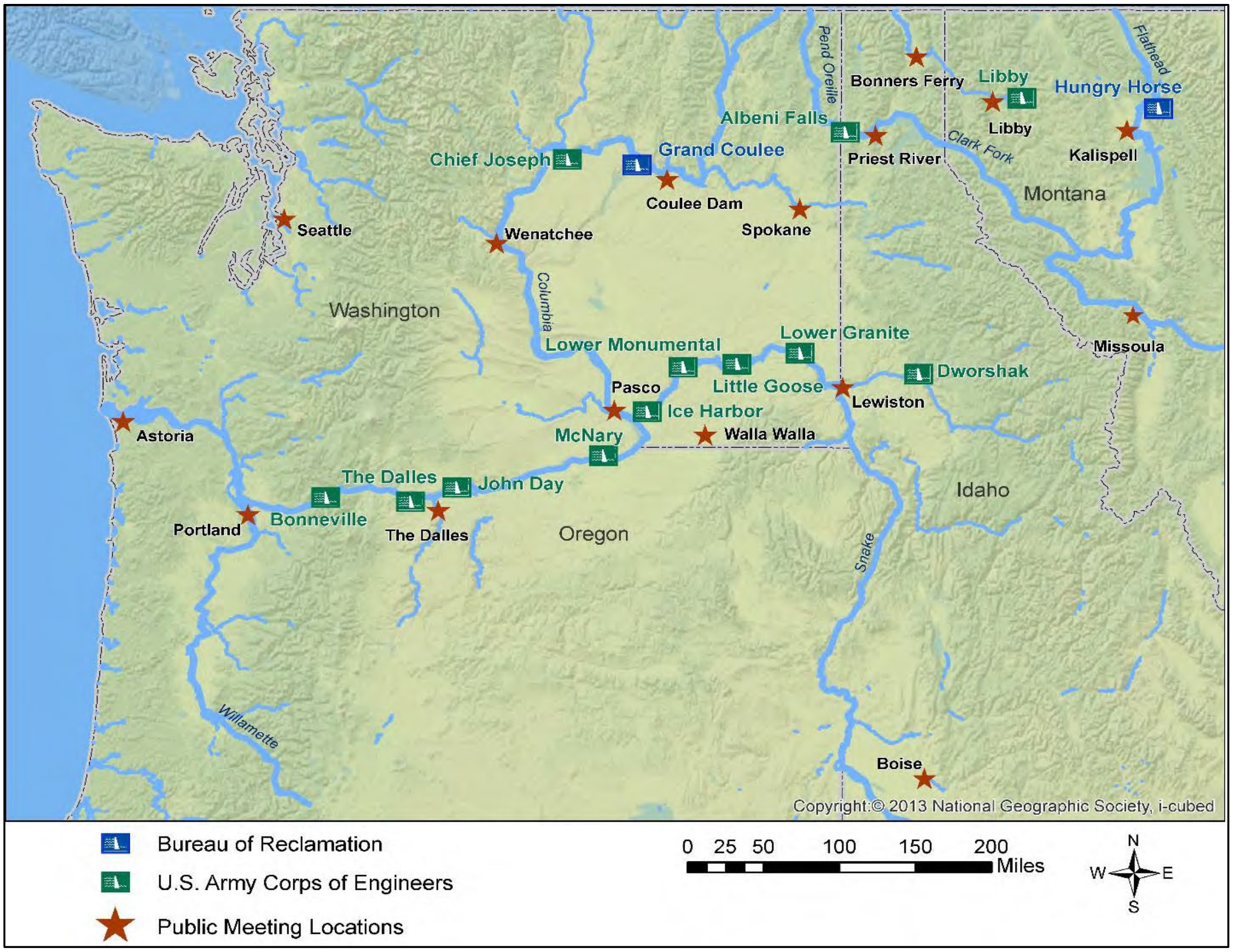

Figure 1-3. Map of Public Scoping Meeting Locations

1.5.2.2 Public Involvement on the Draft Environmental Impact Statement

The public comment period, during which any person or organization may comment on the draft EIS, is mandated by Federal laws. For the CRSO Draft EIS, the public comment period will be open for 45 days. The purpose of this review is to seek input on the alternatives considered, effects of the alternatives, and associated mitigation. The co-lead agencies will consider all comments received during the comment period. The complete list of comments regarding the draft EIS and co-lead agencies' responses will be included as an appendix to the CRSO Final EIS. The co-lead agencies will host multiple public meetings throughout the region during the public comment period. In addition to accepting comments during the public meetings, comments will be accepted via mail or the CRSO website.

1.5.2.3 Tribal Coordination and Government-to-Government Consultation

Since time immemorial, Native American tribes have inhabited the Columbia River Basin. These tribes successfully subsisted on the abundant natural resources of the area, and built thriving communities that relied on the lands to sustain their way of life. Through treaties, executive orders, judicial decisions, and legislation, tribes ceded most of their aboriginal territory to the

United States. Tribes retained smaller portions of land for their reservations. Many tribes, through treaties, retained the right to hunt, fish, and gather in their usual and accustomed locations, including areas outside of their reservations. The potentially affected area of the CRS includes portions of tribal reservations, trust lands, and ceded lands of 19 federally recognized tribes. Reservoirs that are part of the CRS system inundate parts of three existing Indian reservations: the Colville and Spokane reservations, which are partially inundated by Lake Roosevelt, and the Nez Perce Reservation, which is partially inundated by Dworshak Reservoir. In fact, half of Grand Coulee Dam's reservoir, Lake Roosevelt, lies within the Colville Reservation. In some cases, the U.S. Government has entered into special agreements with these tribes regarding management of the reservoirs because of their location within reservations.

The co-lead agencies have a unique legal and political relationship with tribal governments as sovereigns. This Federal trust responsibility is established through, and confirmed by, the U.S. Constitution, treaties, statutes, executive orders, and judicial decisions. The co-lead agencies have regulations and tribal policies regarding the trust responsibility (refer to Chapters 8 and 9). In recognition of the Federal government's trust responsibility, the co-lead agencies engage in regular and meaningful government-to-government consultation and collaboration with tribal governments when a proposed action may affect a tribe or its resources. In an effort to ensure regular engagement and participation in the CRSO EIS, multiple avenues were identified for tribal engagement:

- Participation in the NEPA process as a Cooperating Agency (see Section 1.4.3, *Cooperating Agency Involvement*).
- Tribal engagement and consultation on a government-to-government level.
- Through existing processes developed under the Columbia Basin Fish Accords.

Before the public scoping notice was published in the *Federal Register* on September 30, 2016, the co-lead agencies initiated an engagement and consultation process with the 19 federally recognized Native American tribes and three tribal organizations in the Columbia River Basin that are potentially impacted by proposed actions being evaluated in the EIS. The co-lead agencies took a three-tiered approach to ensure successful tribal engagement and consultation throughout the development of the CRSO EIS. The co-lead agencies also indicated that, upon request, one-on-one, government-to-government consultation with any individual tribe was available at any time throughout the CRSO EIS process.

The three-tiered strategic approach to tribal engagement and government-to-government consultation was intended to emphasize information sharing and communication with tribal technical staff to ensure policy staff and leadership were regularly and sufficiently informed throughout the CRSO EIS process. At the first tier, technical issues were raised by technical or policy tribal staff and resolved, whenever possible. Unresolved issues were then raised to the second tier—Deputy Level Meetings. The third tier, Executive Level Meetings, was intended to ensure tribal leadership were informed of the EIS development and to address any issues not resolved at the Technical or Deputy level, as well as to consult on major decision points in the CRSO EIS process directly with the co-lead agency Executives.

Tier 1 – Technical Level Meetings: Attended by the technical staff of the three co-lead agencies and key subject matter experts. These meetings were held quarterly at a staff level throughout the NEPA process or more frequently to meet the needs of tribal participants. These meetings provided tribal staff with information critical to preparing tribal leadership for Deputy and Executive level meetings. The co-lead agencies conducted technical level meetings in person and via webinars and conference calls.

Tier 2 – Deputy Level Meetings: Attended by deputies and appropriate support staff from the three co-lead agencies. A morning session was held to provide meaningful dialog and updates on the project, with time set aside in the afternoon for consultation sessions with individual tribes. The co-lead agencies held the Deputy level meetings in various locations around the region to make it as convenient as possible to tribal participants to attend; the locations usually included Boise, Idaho; Spokane, Washington; and Portland, Oregon. These regional meetings were held in person at appropriate intervals, prior to Executive level meetings, or as requested by tribal leaders.

Tier 3 – Executive Level Meetings: These sessions were attended by executives and appropriate support staff from the three co-lead agencies. Time was set aside in the afternoon for consultation sessions with individual tribes. As with the Deputy level meetings, the co-lead agencies held Executive level meetings in multiple locations around the region to make it as convenient as possible for tribal leaders to participate. These regional meetings were held in person when significant project milestones were achieved. Executive level meetings occurred once a year, or as requested by tribal leaders.

Individual tribes were also afforded consultation meetings with appropriate co-lead agency staff or Executives when requested. Additionally, co-lead agency staff and tribal liaisons contacted each tribe’s designated points of contact.

1.5.2.4 Tribal Perspectives

The co-lead agencies have included a “Tribal Perspectives” section in the CRSO EIS to provide an opportunity for tribes to offer their unique perspective on the impacts of the CRS specific to their respective tribe. This section can be found in Chapter 3.17, *Indian Trust Assets, Tribal Perspectives, and Tribal Interests*. This Tribal Perspectives narrative is intended to convey impacts to non-property based cultural resources. Each of the 19 tribes had an opportunity to provide their narrative to address the Tribal Perspectives section in a holistic manner. Eleven tribes provided tribal perspectives.

The evaluation of CRSO EIS alternatives and impacts on many of the resources important to tribes throughout the Columbia River Basin (e.g., salmon, resident fish, and lamprey, as well as cultural resources) were analyzed in the alternatives of the CRSO EIS. For example, many tribes share overlapping interests in the Columbia River Basin. However, potential CRS impacts may be unique to individual tribes based on many factors, including where they were historically located, where they are currently located, and which resources are impacted in those locations. In most instances, the CRSO EIS analysis focused on impacts to specific resources affected by a proposed alternative.

1.6 KEY ISSUES AND RESOURCE CONCERNS

During the NEPA public scoping process, the cooperating agencies, tribes, the public, and stakeholders identified issues and concerns to the co-lead agencies. Section 1.6.1, *Issues Identified during Scoping,* points out three issues that repeatedly were brought up during the scoping process. Section 1.6.2, *Resource Concerns*, provides an overview of various public concerns, presented by resource, which arose in the scoping process.

1.6.1 Issues Identified During Scoping

During scoping, much of the discussion focused on the specific needs of individual river issues or resources. For a more in-depth discussion, refer to Chapter 9, *Coordination and Public Involvement Process*. Several key issues identified were ESA-listed fish, climate change, and socioeconomics.

Many comments regarding ESA-listed fish were received. These comments were specifically directed at the relationship between ESA-listed fish species (e.g., salmon, steelhead, bull trout, and white sturgeon) and dam configuration and operations. The effects of the CRS on both anadromous and resident ESA-listed fish, as well as non-ESA-listed fish, have been debated in the region over the last several decades. The implementation of fish improvement technologies and structures, and ways to optimize the system for fish is an ongoing discussion for Federal, state, local, and tribal entities in the Columbia River Basin. In addition to ESA-listed fish, many scoping comments were received regarding ESA-listed Southern resident killer whales and how they will be addressed through this process when assessing impacts to salmon populations.

Another key issue expressed in scoping comments was the need for climate change to be addressed in the EIS, particularly with respect to how the system would be affected by a changing environment, as well as water quantity and quality (particularly stream and reservoir temperatures), salmonid survival and recovery, hydropower production, and groundwater recharge. Increasing temperatures, reduced snowpack, altered amounts and timing of runoff, drought, and low water conditions were of specific concern, as were how factors contributing to climate change (e.g., greenhouse gas emissions) could potentially be affected by actions in the Columbia River Basin.

Socioeconomic scoping comments were directed primarily at the positive and negative effects of the proposed action to tourism, recreation, fisheries, hydropower generation, flood control, industry, transportation, and agriculture. Potential impacts to the existing Columbia and Snake river navigation system are of concern to many in the Columbia River Basin. In addition, the scoping comments expressed concerns regarding potential effects to recreation (boating, fishing, etc.) as a result of actions impacting fish and wildlife.

Tribal Issues Identified During Scoping

During scoping for the CRSO EIS, tribes expressed concerns about the impacts the system has had on natural resources, cultural resources and ways of life. The tribes in the Basin expressed concerns about impacts on tribal economics with regards to fishing, hunting, and their culture, such as preserving their language and tribal way of life. In addition, some tribes had comments about how they cope with levels of poverty, ill health, and unemployment at significantly higher proportional rates than any other ethnic group in the country, which in turn leads to significantly higher mortality rates in comparison to non-native communities. Throughout the document, the co-lead agencies have considered effects to tribal interests that were provided in their Tribal Perspectives.

1.6.2 Resource Concerns

A variety of interests are represented throughout the Columbia River Basin, and not all of those interests are compatible; thus, tradeoffs between resources must occur. The following is a short description of each major resource and a summary of concerns about each expressed during scoping.

1.6.2.1 Navigation

The key navigation interests on the CRS are those people and businesses with economic ties to ships, barges, and port facilities that rely on Federal facilities in the CRS to provide the waterway infrastructure. People concerned about the ability to navigate the waters of the CRS emphasized the importance of waterborne commerce as an element of the regional economy and the need to maintain adequate channel depths for navigation.

1.6.2.2 Flood Risk Management

People in flood-prone areas have an interest in FRM in the Northwest. Maintaining existing FRM levels is important to those interests, as are accurate flood forecasting efforts for efficient reservoir storage and water releases. Some have expressed concerns regarding impacts experienced in the upper Columbia River Basin from reservoir FRM operations aimed at protecting flood-prone areas along the lower Columbia River.

1.6.2.3 Water Supply and Irrigation

The primary irrigation customers of the system are those farmers who divert or pump water from rivers and reservoir pools to irrigate their crops. These customers emphasize the economic benefits of agriculture to the region, and are concerned with maintaining adequate reservoir elevations to accommodate irrigation pumps and ensure the continued availability of stored water for irrigation.

1.6.2.4 Power Generation

Hydropower provides low cost electricity, helps meet state and local carbon emission goals, provides resiliency to the interconnected power system and, when available, is a low-cost flexible resource that can be used to integrate alternative energy resources into the power grid. At times both Federal CRS dams and non-Federal dams produce large quantities of excess electricity that is surplus to meeting regional firm power load demands. Such surplus power is regularly offered for sale to purchasers throughout the western United States and Canada. Many parties stressed how vitally important hydropower is to the regional economy. Numerous commenters expressed concern that clean, historically affordable hydropower might be replaced with other energy resources like fossil-fuel powered generation such as natural gas power or small modular nuclear reactors. These other types of energy may be more expensive, unproven, or more ecologically damaging. Commenters expressed concern that this EIS process may result in decisions that would compromise the region's historic hydropower resource base. Other power-related concerns included energy conservation, increased generating efficiency, and keeping electricity rates low.

1.6.2.5 Anadromous Fish

Tribes, states, the public, commercial and sport fishing groups, and Federal fishery management agencies are concerned about how the projects affect, and will continue to affect, anadromous fish survival and recovery. Many expressed the importance of the salmon and lamprey contribution to the environment, regional economy, and ecosystem of the Pacific Northwest.

1.6.2.6 Resident Fish and Resident Fish Habitat

The primary interests related to resident fish and their habitat includes the tribes, state and Federal fishery management agencies, anglers, and businesses that serve the anglers. These interests believe resident fish should be considered just as important as anadromous fish in CRS operations. They would like to see storage reservoirs operated to benefit resident fish or limit the effects of storage operations on resident fish.

1.6.2.7 Wildlife and Wildlife Habitat

Tribes, resource managers, hunters, and sightseers are important interest groups for wildlife and wildlife habitat. For the tribes, wildlife is important to cultural and ecological integrity. They seek to place more emphasis on wildlife in system operations by preserving and restoring habitat and wetlands, improving water quality, and changing river flows to benefit wildlife. During scoping, many people expressed how much they value orcas, including ESA-listed Southern resident killer whales.

1.6.2.8 Recreation

CRS projects provide recreational opportunities for the public in a variety of ways. Outfitters, guides, boaters, marina owners, and tribal, local, state, and Federal agencies providing recreation-related services, represent these interests. They emphasize the economic and social impacts reservoir operations have on regions and communities dependent on recreation and tourism. Some river recreational interests would like more opportunities for whitewater recreation. In addition, recreational fishing groups have concerns about effects on fish and what improvements have been or could be made.

1.6.2.9 Cultural Resources

The Columbia River Basin has been home to humans for over 12,000 years. Many of the tribes trace the history of the region back to time immemorial. Many, if not all, of the region's tribes have oral traditions telling of their creation in the places where they were and are along the Columbia River. The pre-contact and historic-period artifacts and sites along the river are an important source of information about the past, and they supplement other sources of information, such as written records and oral history. Traditional cultural properties (defined in Chapter 3.16), highly valued by Native Americans, include fishing sites at usual and accustomed places, hunting and traditional hunting sites, and natural resources important to contemporary tribal life. Native Americans, archaeologists, historians, members of the general public, and state and Federal agencies are interested in protecting the cultural resources of the region. These interests would like to minimize damage to cultural resources from the effects of reservoir operations, which include but are not limited to water level fluctuations, wave and wind action, inundation, irrigation, transportation, and recreation, among others. In addition, there is a concern about losses caused by vandalism and looting.

1.6.2.10 Water Quality

The primary water quality issues related to reservoir operations are total dissolved gas (TDG), water temperature, and sediment. TDG is a concern at dams that provide juvenile fish passage spill at many locations in the Columbia River Basin. Elevated water temperature, above state water quality criteria of 20 °C (68 °F) exist within much of the Columbia River Basin. Sediment transport through many of the reservoirs is also a concern; dams disrupt the longitudinal continuity of the river system, which often results in armoring riverbeds, which are less suitable for spawning. These concerns are represented through actions brought by environmental groups, regulations, and policy actions by Federal, state, and local agencies, and tribes.

1.6.2.11 Economics

Virtually everyone in the Northwest has an economic stake in the CRS. Low-cost, affordable hydropower is an important element in the economic life of the region. Comments expressed concern about the economic effects of changes to recreation, navigation, irrigation, and water supply as a result of changes to river operations.

1.6.3 Climate Change Consideration for the Columbia River System Operations

Based on recent research, increasing temperatures due to climate change will likely lead to declining snowpack and earlier peak seasonal snowmelt. Though less certain, there is also potential for increased fall and summer streamflows and longer periods of low summer flows (RMJOC 2018). Many comments received during the scoping process reflected concerns about how these changes may impact individual resources, air quality and greenhouse gasses. The basis for the climate assessment in this EIS includes findings on projected regional temperature, precipitation, snowpack, and streamflow changes resulting from a 4-year research project completed by the University of Washington and Oregon State University for the River Management Joint Operating Committee, and in collaboration with regional stakeholders. The discussion in Chapter 3 of the environmental consequences to resources from the measures and alternatives reflect modeling and analysis based on observed climate in the region over the 80-year period of 1929 to 2008. Chapter 4 builds on that analysis by providing a discussion of how the projected changes in regional climate through 2050 may impact the resources and effectiveness of alternatives for the CRS.

1.7 RELATIONSHIP TO OTHER FEDERAL NATIONAL ENVIRONMENTAL POLICY ACT EFFORTS, AND OTHER FEDERAL STUDIES, DOCUMENTS, AND REPORTS

The following projects and programs occur within the Columbia River Basin and are interrelated with, but independent from, this EIS.

- Final Environmental Impact Statement to Inform Columbia River Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs, September 2014, National Marine Fisheries Service (NMFS). This EIS examines alternatives designed to reduce or minimize the adverse effects, or increase the benefits, of hatchery operations on natural-origin salmon and steelhead populations. Hatchery operators would continue to pursue not only the conservation or harvest goals that currently apply to each hatchery program, but also different or additional conservation and harvest goals.
- Lower Snake River Programmatic Sediment Management Plan (PSMP) Final EIS, August 2014, Corps. The PSMP provides a programmatic framework to evaluate and implement sediment management measures to address the accumulation of sediment that interferes with existing authorized project purposes in the lower Snake River projects. The PSMP process includes triggers, actions for long-term and short-term planning, actions to address sediment, as well as monitoring and regional engagement.
- The Double-Crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, Final Environmental Impact Statement, 2015. This plan had two phases: Phase 1: Reduce colony size to baseline population (as identified in NMFS Biological Opinion [BiOp] Reasonable and Prudent Action 46) to between 5,380 and 5,939 breeding pairs on East Sand Island. Phase 2: Modify terrain at East Sand Island to limit breeding habitat to maintain colony size in the long term; support with hazing and egg take as needed to ensure colony does not exceed 5,380 to 5,939 breeding pairs. The Corps reduced the colony below the 5,380 to 5,939 threshold, and then moved into early

implementation of Phase 2 in 2018. The Corps has implemented the terrain modification at East Sand Island during winter of 2018 and will monitor population at East Sand Island for 3 years (2019 is year 1) to determine success of the project. The Corps will use hazing as needed to maintain population size.

- Caspian Tern Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, Final Environmental Impact Statement, 2005, U.S. Fish and Wildlife Service (USFWS). Management has reduced habitat on East Sand Island to a minimum of 1 acre, while enhancing or creating habitat out of the Columbia River Basin (southern Oregon/northern California) to support breeding pairs, creating 2 acres for every 1 acre reduced on East Sand Island. It was assumed that reducing habitat at East Sand Island to 1 acre would support 3,125 to 4,375 breeding pairs, which would support a population growth rate. The Corps created approximately 8 acres of alternative nesting habitat and reduced the breeding habitat at East Sand Island to 1 acre. However, there are still a greater number of birds because they nested in densities higher than anticipated. The Corps will continue to maintain 1 acre of habitat at East Sand Island and use hazing to prevent birds from establishing satellite colonies on the beaches.

- Columbia Basin Project (CBP). Grand Coulee, operated by Reclamation, stores water for the CBP. The water is pumped approximately 300 feet from Lake Roosevelt to Banks Lake where it is distributed by canal to irrigators within the CBP. The CBP currently has water rights and previous NEPA compliance to deliver 3.318 Maf of water for irrigation of 720,000 acres and for M&I purposes. Water for the Odessa Subarea and Lake Roosevelt Incremental Storage agreement are included in the 3.318 Maf.

- Lower Columbia River Dredged Material Maintenance Plan. The most recent dredged material management plan (DMMP) is from 1998 for the continued operation and maintenance of the federally authorized Lower Columbia River Federal Navigation Channel (43 feet deep with 5 feet of advanced maintenance dredging, by 600 feet wide with 100 feet advanced maintenance dredging) with minimized draft restriction days. Currently, an integrated DMMP EIS is being developed for a 20-year DMMP for the lower Columbia River from river mile 105.5 to 3 for the continued maintenance of the congressionally authorized Federal navigation channel (Water Resources Development Act of 1999, Consolidated Appropriations Act of 2004).

- John Day Mitigation Program. The John Day Mitigation program was originally authorized to offset mainstem fall Chinook salmon production losses that resulted from construction of The Dalles and John Day Dams and is implemented by the Corps. Mitigation for these losses is particularly important to regional tribes that historically depended on these salmon for ceremonial, subsistence and economic support. The scope of this mitigation program consists of a combination of adult (broodstock) collection, adult egg take (spawning), egg incubation, juvenile rearing and acclimation, and release of hatchery fall Chinook salmon using a combination of hatchery facilities on the mid-Columbia River. The purpose of this mitigation program is to identify facilities for the production and release of hatchery smolts in numbers sufficient to achieve in-kind mitigation: that is, a total adult production of 107,000 adult fall Chinook salmon at a ratio of 25 percent tule fall Chinook salmon and

75 percent upper river fall Chinook salmon. Upriver brights should be released from sites above the Bonneville Project to achieve in-place mitigation.

- Bonneville's Fish and Wildlife Program. Bonneville provides funding to multiple local, state, tribal and Federal entities as part of its Fish and Wildlife Program to implement offsite mitigation actions listed in various biological opinions for ESA-listed species. The Bonneville Fish and Wildlife Program also funds efforts to protect, mitigate, and enhance fish and wildlife, including non-listed species, affected by the development and operation of the FCRPS, which includes the CRS under the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act) (16 U.S.C. § 839b (h)(10)(A)). These efforts are consistent with the recommendations developed through the Northwest Power and Conservation Council's Fish and Wildlife Program. These projects would continue to undergo site-specific environmental compliance prior to implementation. This analysis includes review under applicable laws and regulations, such as NEPA.
- Odessa Subarea Special Study Project. The need to address declining groundwater supply in the Odessa Subarea and avoid economic loss to the region's agricultural sector led Reclamation and Washington Department of Ecology (Ecology) to conduct the Odessa Subarea Special Study. The purpose identified by Reclamation and Ecology to guide the proposed action is: ". . . to maintain economic viability by providing surface water from the CBP to replace groundwater from declining wells currently used for irrigation in the Odessa Subarea." This purpose is consistent with the intent of the CBP Act by encouraging "settlement and development of the project, and for other purposes." Surface water would be provided as part of the continued, phased development of the CBP, and would come from existing CBP diversion and storage water rights from the Columbia River. The Odessa Subarea Special Study was completed in 2012 and the ROD signed in 2013 (Reclamation 2012 and 2013).
- 2019 to 2021 Flexible Spill Operation Agreement. The 2019 to 2021 Flexible Spill Operation Agreement outlines implementation of the spring flexible spill operations in 2019 and 2020 at the lower Snake River projects and lower Columbia River projects. Spill operations in 2019 included spill up to the 120 percent TDG cap under the applicable state water quality standards. The Spill Operation Agreement also identified a spring flexible spill scenario for implementation in 2020 to 2021 up to the 125 percent TDG cap at most of the dams, which the parties later collaboratively worked to finalize. The state processes necessary to modify the state water quality standards are ongoing. Flexible spill refers to a 24-hour variable spill operation for juvenile fish passage at the four lower Snake River and four lower Columbia River projects. The flexible spill operation takes advantage of peak and off-peak load hours throughout the day to vary juvenile fish passage spill to complement periods of power demand. During peak load hours, spill for juvenile fish passage is provided at Performance Standard spill levels for up to 8 hours per day. Performance Standard spill is juvenile fish passage spill at the eight fish passage dams (initially developed under the NOAA 2008 BiOp and implemented under the NOAA 2008, 2010 and 2014 BiOps to achieve 96 percent juvenile dam passage survival for spring migrants and 93 percent juvenile dam passage survival for summer migrants. During the remaining 16 hours throughout the day, spill for

juvenile fish passage is provided up to the TDG cap, defined as spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under the applicable state water quality standard. The 2019 flexible spill operation was implemented.

- ESA Section 7(a)(2) 2019 BiOp, Consultation for Continued Operation and Maintenance of the CRS, conducted by NMFS for the Corps, Bonneville, and Reclamation, March 29, 2019. This BiOp addresses the continued operation and maintenance of the CRS with the inclusion of the 2019 to 2021 Flexible Spill Operation Agreement for spill and hydropower operations.
- Lower Snake River Fish and Wildlife Compensation Program. This program was initiated to provide fish and wildlife compensation for construction of the four lower Snake River projects (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite). The program was first described in a 1975 report, Special Report, Lower Snake River Fish and Wildlife Compensation Plan, Lower Snake River, Washington and Idaho. This report was developed by the Corps, in consultation with the USFWS, to assure compliance with the Fish and Wildlife Coordination Act. With the exception of riparian habitat development, the Lower Snake River Fish and Wildlife Compensation Program mitigation requirements for both fisheries and terrestrial wildlife, as laid out in the authorizations and subsequent clarifying reports, are complete. The construction of fish hatcheries and hatchery facility transfers are complete, but operating and maintaining a number of hatcheries continues. The terrestrial wildlife mitigation program, including the development of lands along the lower Snake River, acquisition of new lands for hunting opportunity, and the game farm alternative, is also complete. The Corps will continue to maintain and enhance wildlife habitat developed under the Lower Snake Compensation Plan into the foreseeable future through the Natural Resource Management program.
- Sovereign Review Process during the Treaty Review. *While the following process is not related to the CRSO process and has been officially concluded, it is noted here for historical informational purposes only.* The purpose of the Columbia River Treaty 2014/2024 Review (Treaty Review) was to enable the United States Entity, working in collaboration with regional sovereigns and stakeholders, to make an informed recommendation to the U.S. Department of State as to whether it is in the best interest of the U.S. to continue the Treaty, terminate the Treaty, or seek to negotiate with Canada to amend or modify the Treaty. The Treaty Review included extensive engagement within the region. Regional sovereigns participated through the Sovereign Review Team (SRT) and included representatives from four northwestern states (Oregon, Washington, Montana, and Idaho), 15 Native American tribes, and representatives from 10 Federal agencies with responsibilities related to the Columbia River. The SRT's primary responsibility was in the policy and recommendation development arena. The Sovereign Technical Team (STT), composed of technical experts representing the sovereigns, provided expertise to design the analytical work with STT workgroups providing more specialized technical expertise in specific areas. Non-sovereign stakeholders in the region participated through listening sessions, workshops, and other public meetings. Non-sovereigns included electric utilities, irrigators, commercial navigation interests, recreation interests, and others. Government-to-government level sessions were also held with regional tribal leadership and

congressional and national leaders and committees. The Sovereign Review process resulted in a Regional Recommendation that was delivered to the U.S. Department of State in December 2013.

1.8 RELEVANT NATIONAL ENVIRONMENTAL POLICY ACT AND ENDANGERED SPECIES ACT DOCUMENTS AND REPORTS

Key relevant documents used in this EIS are listed below:

- Columbia River System Operations Review Final EIS, November 1995. Preparations for this EIS began to take shape as soon as the first petition was made for Columbia River salmonids to be listed under the ESA. It was a joint project between Reclamation, the Corps, and Bonneville to consider changes in the operation of the FCRPS to benefit salmon runs.
- Biological Opinion: Effects to Listed Species from Operation of the Federal Columbia River Power System, consultation conducted by USFWS, December 20, 2000. The BiOp came in response to a draft feasibility report/environmental impact statement (FR/EIS) on operation of the FCRPS by Bonneville, Reclamation, and the Corps. It essentially addressed three non-breaching alternatives: major system improvements, existing conditions, and maximum transport of juvenile salmon. A fourth alternative, breaching the lower Snake River dams or natural river drawdown, was not analyzed in the BiOp, but would be addressed if the implementation of this alternative came to fruition.
- Lower Snake River Juvenile Salmon Migration Feasibility Report and Final EIS, Corps, Walla Walla District, February 2002. This FR/EIS examines only the four dams on the lower Snake River: Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. It comes in response to the 2000 National Oceanic and Atmospheric Administration (NOAA) NMFS BiOp on operation of the FCRPS. It addresses four alternatives: major system improvements, existing conditions, maximum transport of juvenile salmon, and natural river drawdown. Major system improvements, with adaptive management, were the preferred alternative of the study.
- Endangered Species Act Section 7(a)(2) 2008 Biological Opinion, Consultation for Operation of the Federal Columbia River Power System, conducted by NMFS for the Corps, Bonneville, and Reclamation, May 5, 2008. This BiOp was later supplemented, May 20, 2010, to incorporate the Adaptive Management Implementation Plan and January 17, 2014 to: (1) address specific issues raised by the District Court for the District of Oregon; (2) consider effects to newly designated critical habitat for eulachon and green sturgeon, and to proposed critical habitat for lower Columbia River coho salmon; and (3) address updated scientific information in 2010 and 2014.
- Upper Columbia Alternative Flood Control and Fish Operations Final EIS, April 2006 and Corps and Reclamation Records of Decisions, June 2008, and September 2009, respectively; the Corps as lead and Reclamation as cooperating agency. This EIS examined the implementation of alternative flood operations at Libby Dam on the Kootenai River and Hungry Horse Dam on the South Fork Flathead River, with an operation known as "variable

discharge storage regulation procedure," or VARQ, and flow augmentation for ESA-listed fish populations in the Kootenai River, the Flathead River, and mainstem Columbia River. Flow augmentation (i.e., fish flows) includes release of water for bull trout, salmon, and, at Libby Dam, white sturgeon. The actions addressed in this EIS are in direct response to reasonable and prudent actions contained in the 2000 USFWS FCRPS BiOp; the 2006 USFWS BiOp regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout and Kootenai Sturgeon Critical Habitat, and in the 2004 Updated Proposed Action; and the 2004 NMFS FCRPS BiOp.

- Biological Opinion regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout, and Kootenai Sturgeon Critical Habitat. Consultation conducted by USFWS, February 18, 2006, with a 2008 clarified RPA. This BiOp addressed implementation of VARQ, ramping rates and daily shaping, minimum flows, and flow augmentation for fish.
- Albeni Falls Flexible Winter Power Operations Final Environmental Assessment October 2011, and Finding of No Significant Impact, November 2011, Corps and Bonneville. This is a winter management operation at Albeni Falls Dam that more actively uses storage behind Albeni Falls Dam for power generation.

1.9 INTRODUCTION TO COLUMBIA RIVER SYSTEM OPERATIONS

Dam development in the Columbia River Basin began in the 1800s. Mainstem dam development began with Rock Island Dam (a non-Federal project) on the Columbia River in 1933, and continued through 1975 with the completion of Lower Granite Dam on the Snake River. Most of the dams were constructed from the 1950s through the 1970s. This section provides brief descriptions of Federal projects and non-Federal projects, and an overview of how the CRS is operated.

1.9.1 Federal Dams and Reservoirs

Federal agencies operate a series of 31 multipurpose dams known as the Federal Columbia River Power System on the Columbia River and its tributaries, 14 of which are operated as a coordinated system, referred to as the Columbia River System. The 14 CRS projects are described below. The other FCRPS projects, such as those in the Willamette subbasin, the Yakima subbasin, or the Boise River Basin, operate more independently. The output at the projects with hydropower facilities is used in meeting the region's electricity demand. However, the multi-purpose operation of these other FCRPS projects is generally not factored into the coordinated planning scenarios of the CRS.

Project features of the CRS include dams and reservoirs, navigation channels and locks, hydroelectric powerhouses, associated transmission infrastructure , spillways, sluiceways, fish ladders and bypass facilities, irrigation diversions and pumps, parks and recreation facilities, boat launches, lands dedicated to the projects, and areas set aside for mitigation of wildlife habitat losses.

Bonneville, the Corps, and Reclamation each have a role in coordinating the CRS. The Corps operates 12 of the 14 projects, and has responsibilities for FRM, recreation, fish and wildlife conservation, navigation, power production, irrigation and M&I water supply at these 12 reservoirs (although responsibilities for several resources, , such as fish and wildlife conservation and power generation, are shared with other agencies). The Corps also maintains navigation channels and has FRM responsibilities throughout the Columbia River Basin. Reclamation operates Grand Coulee and Hungry Horse projects, and has responsibility for federally financed water development and irrigation programs, hydropower, and water quality at these two projects. Bonneville Power Administration markets and distributes the power generated at all Federal projects in the Columbia River Basin, and builds and operates transmission lines to deliver the electricity. Bonneville also mitigates the impacts on fish and wildlife from the federally owned hydroelectric projects from which Bonneville markets power. The Corps and Reclamation develop multiple purpose operating requirements for their projects and, within these limits, Bonneville schedules and dispatches power. The CRS alternatives (referred to in this EIS as No Action Alternative and Multiple Objective Alternatives 1 through 4 and the Preferred Alternative) only include specific actions at these 14 Federal projects, and do not include any actions at the other FCRPS or non-Federal projects.

The general characteristics of each of these 14 Federal projects are summarized in Table 1-2, and more detailed descriptions of these projects can be found at www.CRSO.info.

Table 1-2. General Characteristics of the Columbia River System Projects

Project	Reservoir / Lake	Project Type	Approximate Normal Operating Range NGVD29	Number of Turbine Units (Nameplate Capacity-MW)[3/]	Number of Spillbays and Other Tubes	Navigation Locks	Fish Passage
Libby	Koocanusa	Storage	2,287–2,459 feet[1/]	5 (605)	2 spillbays	N/A	N/A
Hungry Horse	Hungry Horse	Storage	3,336–3,560 feet[1/]	4 (428)	1 ring gate (spillbay) 3 outlet tubes	N/A	N/A
Albeni Falls	Pend Oreille	Storage	2,051–2,062.5 feet[1/]	3 (49)	10 spillbays	N/A	N/A
Grand Coulee	Roosevelt	Storage	1,208–1,290 feet[1/]	33 (6,735 + pumped storage)	11 spillbays 40 outlet tubes	N/A	N/A
Chief Joseph	Rufus Woods	Run-of-river	950–956 feet	27 (2,614)	19 spillbays	N/A	N/A
Dworshak	Dworshak	Storage	1,445–1,600 feet[1/]	3 (465)	2 spillbays	N/A	N/A
Lower Granite	Lower Granite	Run-of-river	733–738 feet	6 (930)	8 spillbays	Yes	Yes
Little Goose	Bryan	Run-of-river	633–638 feet	6 (930)	8 spillbays	Yes	Yes
Lower Monumental	Herbert G. West	Run-of-river	537–540 feet	6 (930)	8 spillbays	Yes	Yes
Ice Harbor	Sacajawea	Run-of-river	437–440 feet	6 (693)	10 spillbays	Yes	Yes
McNary	Wallula	Run-of-river	337–340 feet	14 (1,120)	22 spillbays	Yes	Yes
John Day[2/]	Umatilla	Storage	January 1–March 14: 262.0–265.0 feet March 15–April 9: 262.5–265.0 feet April 10–September 30: 262.5–264.0 feet October 1–31: 262.5–265.0 feet November 1–December 31: 262.0–266.5 feet	16 (2,480)	20 spillbays	Yes	Yes

Project	Reservoir / Lake	Project Type	Approximate Normal Operating Range NGVD29	Number of Turbine Units (Nameplate Capacity-MW)[3/]	Number of Spillbays and Other Tubes	Navigation Locks	Fish Passage
The Dalles	Celilo	Run-of-river	155–160 feet	22 (2,052), plus 2 fish units	23 spillbays	Yes	Yes
Bonneville	Bonneville	Run-of-river	71.5–76.5 feet	PH1: 10 PH2: 8 (1,195) plus 2 fish units	18 spillbays	Yes	Yes

Note: N/A = not applicable; NGVD29 = National Geodetic Vertical Datum of 1929.

1/ For storage reservoirs, the minimum possible elevation is based on location of the project intakes. Actual reservoir levels may reach these elevations only rarely.

2/ The normal operating range for John Day varies seasonally to support multiple objectives including irrigation, navigation, ESA-listed fish recovery, hydropower, and FRM.

3/ https://www.bpa.gov/p/Generation/White-Book/wb/2018-WBK-Loads-and-Resources-Summary-20190403.pdf.

1.9.2 Storage and Run-of-River Projects

The 14 Federal projects examined in detail in the CRS fall into two major categories: storage and run-of-river projects. It is important to understand the difference between the two, which is graphically illustrated in Figure 1-4, and explained in the following paragraphs. The six Federal projects classified as storage projects in the CRS are Libby, Hungry Horse, Albeni Falls, Grand Coulee, Dworshak, and John Day. The eight Federal projects considered to be run-of-river projects in the CRS are Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, and Bonneville. While John Day may be characterized as a storage project and is authorized for FRM, it has limited storage capacity and is operated more like a run-of-river project where the project does not store incoming flow.

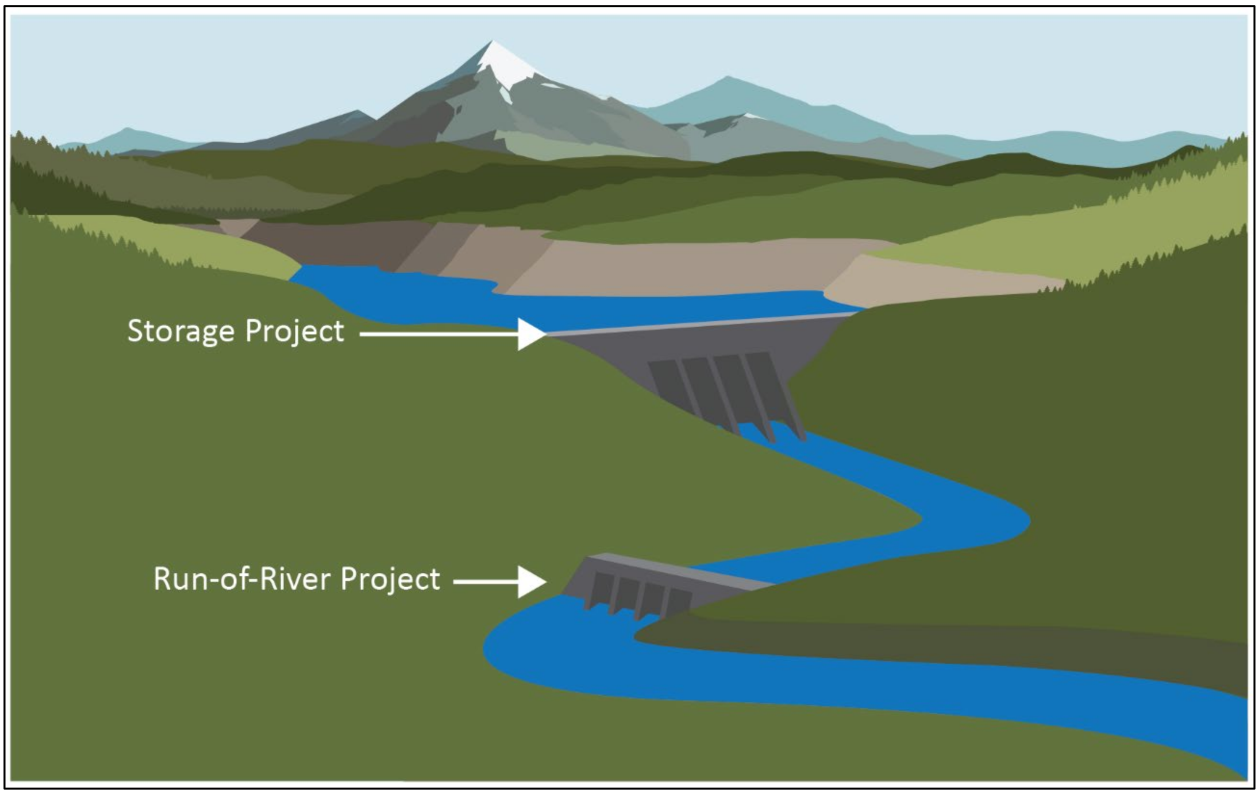

Figure 1-4. Graphic Representation of Storage and Run-of-River Projects

1.9.2.1 Storage Projects

Storage is the key to operation of the multiple-use river system. The storage reservoirs adjust the river's natural flow patterns to conform more closely to water use patterns, storing water from rain and snowmelt to reduce flood risk and generate power when needed. Water in storage reservoirs is also called upon throughout the year to support flows for fish. More water enters the river system during the spring snowmelt than is required at the time for power production, irrigation, and other uses. Reservoirs capture some of this runoff and store it until the late summer, fall, and winter, when it is released.

The system storage capacity represents the system's capability to “shape” flows for a variety of purposes. Shaping refers to the operating agencies' ability to control river flow by timing the storage and release of water from the storage reservoirs to meet specific purposes. Water is held in storage and released for multiple authorized purposes, including hydropower and for fish. In addition, shaping helps reduce downstream flows during the flooding season. Balancing the various uses of system storage can be challenging as demands increase because only a finite amount of water and storage space is available in the system to meet competing needs.

The total system storage capacity in the Columbia Basin is approximately 55 million acre-feet (Maf) of which approximately 20 Maf is in Canada, approximately 17 Maf in the CRS, and approximately 18 Maf in other Federal and non-Federal reservoirs. Of the total storage capacity, approximately 40 Maf is available for system FRM. This is an enormous amount of water, but it is only about 30 percent of an average year's runoff, as measured at The Dalles. While there is a large amount of storage on the Columbia River, there is a relatively low degree of control on the Columbia compared to other large river systems in the United States (e.g., the Missouri and Colorado River systems). Figure 1-5 illustrates the average annual and usable reservoir storage in the Columbia, Colorado, and Missouri River basins.

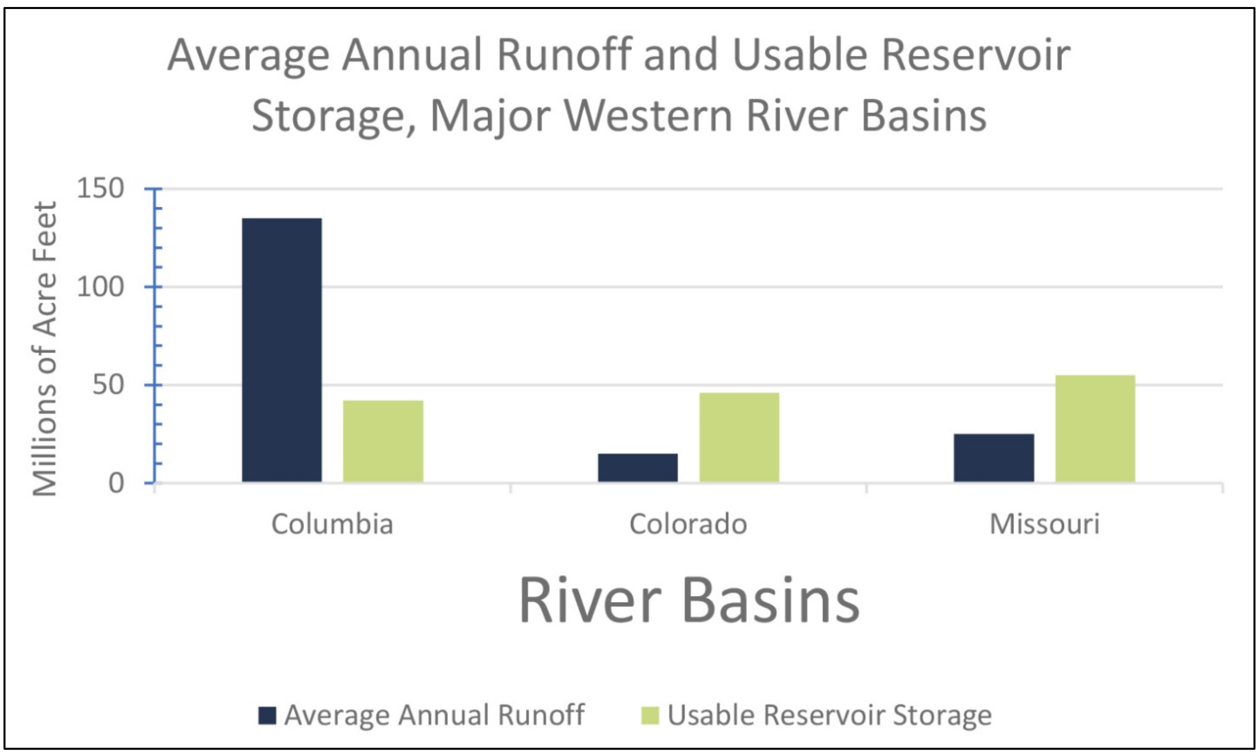

Figure 1-5. Comparison of Major Western River Basins

The combined storage in the reservoirs of the five Federal storage projects considered in the CRSO EIS is approximately 17 Maf. Active storage capacity of the five storage projects ranges from about 1.2 Maf at Albeni Falls to nearly 5.4 Maf at Grand Coulee (Table 1-3). While John Day is authorized for FRM, it has limited storage capacity and is operated primarily like a run-of-river project where the project does not store incoming flow. Three Canadian dams, Mica, Duncan, and Arrow, add up to another 20.5 Maf of storage. These eight projects are strategically located in the throughout the Columbia River Basin to capture runoff for later release.

Table 1-3. Active Storage Capacity at Columbia River System Storage Projects

Project	River	Operator	Active Storage Approximate (Maf)	Authorized System FRM (Maf)
Projects Authorized and Operated for System Flood Control			17.0	16.5
Libby	Kootenai	Corps	5.0	5.0
Hungry Horse	South Fork Flathead	Reclamation	3.0	3.0
Albeni Falls	Pend Oreille	Corps	1.2	0.6
Dworshak	North Fork Clearwater	Corps	2.0	2.0
Grand Coulee	Columbia	Reclamation	5.4	5.4
John Day	Columbia	Corps	0.5	0.5

Note: Maf = the volume of water that would cover 1 million acres to a depth of 1 foot.

Reservoir levels at storage projects typically vary greatly during normal operations and with changes in year-to-year water conditions. Libby operates over a range of 172 feet; Hungry Horse, 224 feet; Albeni Falls, 11.5 feet; Grand Coulee, 82 feet; and Dworshak, 155 feet. Although Albeni Falls operates over a relatively small range, it controls a large volume of stored water because of the large surface area of Lake Pend Oreille. Variations between full pools and lowered pools tend to occur seasonally. Just prior to the spring snowmelt, pools are generally kept low to provide enough space for increasing flows and FRM. When possible, operators try to operate pools near full during the summer, when recreation demand is the highest. Figure 1-6 illustrates elevation patterns for Libby under median hydrographs of dry, average, and wet years. The figure groups years into “dry,” “average,” and “wet” years based on the May water supply forecast for the April to August runoff period into Libby, and then calculates the median elevation for each day within the group. The dry grouping represents the lowest 20 percent of forecasted years, the average grouping represents years in the middle 60 percent of forecasted years, and wet grouping represents the highest 20 percent of forecasted years. This type of figure is explained further in Chapter 3, but is shown here to demonstrate how reservoir levels at storage projects can vary depending on water year type.

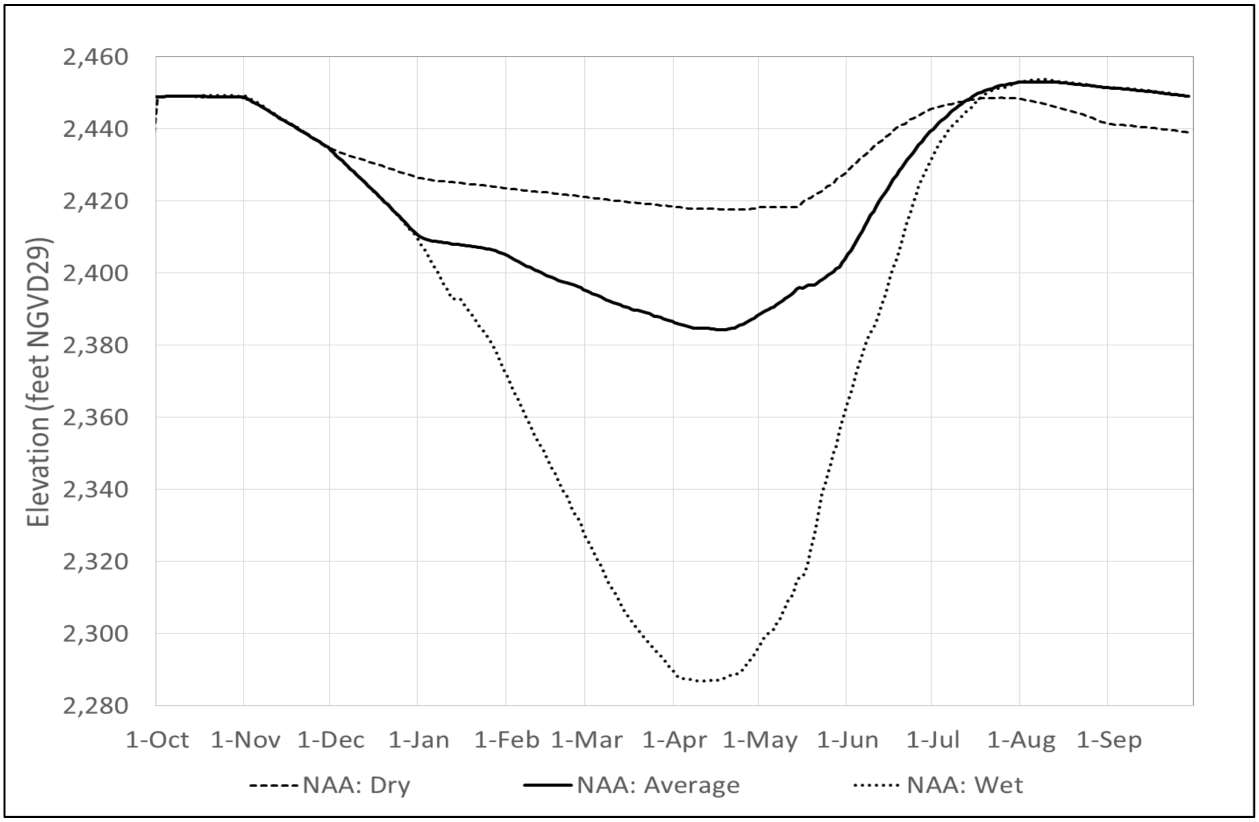

Figure 1-6. Median Hydrographs of Dry, Average, and Wet Years at Libby Project

Note: NAA = No Action Alternative.

1.9.2.2 Run-of-River Projects

The Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, and Bonneville projects are run-of-river projects with limited storage capacity. They were developed primarily for navigation and/or hydropower generation. All run-of-river projects provide hydraulic head for power generation. The eight Federal projects on the lower Snake and Columbia rivers also form enough channel depth to permit barge navigation. Run-of-river projects pass water at the dam at nearly the same rate it enters. The water that backs up behind run-of-river projects is referred to as pondage. The pondage at these projects is sufficient to control flows on only a daily or weekly basis, and use of the pondage causes frequent, small fluctuations in water levels. Reservoir levels behind these projects typically vary only 3 to 5 feet in normal operations (see Table 1-2). Maintaining the reservoir within the normal operating range in the pool allows the facilities at the dams (e.g., navigation locks, hydropower turbines, fish ladders, and juvenile fish bypass facilities) to function properly, in accordance with the engineering design. Irrigation has developed in the run-of-river projects utilizing the pool elevations that exist due to hydropower and navigation operations.

1.9.3 Non-Federal Dams and Reservoirs

In addition to the 14 Federal projects described above, 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. Major dams in the Columbia Basin are shown in Figure 1-7. A brief description of these non-Federal facilities and how they relate to the CRS is contained in the following paragraphs.

Figure 1-7 Columbia River Watershed System

1.9.3.1 Canadian Projects

Projects located in the Canadian portion of the Columbia River watershed play a key role in overall system operation and coordination, although the co-lead agencies do not operate these Canadian projects. There is a total of 11 major dams in the Canadian portion of the basin, shown in Figure 1-7. Of the 11 dams, 7 are downstream of CRS projects, including Libby or Hungry Horse and Albeni Falls; the Kootenai River below Libby and the Pend Oreille River below Albeni Falls and two non-Federal US dams both flow north into Canada. Three Canadian projects (Mica, Duncan, and Arrow Lakes) are Columbia River Treaty (CRT) storage projects located in the headwaters of the Columbia and Kootenay River system and are particularly important to overall system storage coordination. The CRT, ratified in 1964, cleared the way for the construction of storage capacity at these three Canadian storage projects and at Libby Dam. This more than doubled the storage capacity of the CRS. The CRT provides for coordination of operations of the three CRT Canadian storage projects with U.S. projects for power production, FRM, and other purposes as mutually agreed upon.

In evaluating CRSO alternatives, the CRT projects in Canada (Mica, Duncan, and Arrow Lakes) are assumed to operate consistent with practices in effect at the time the CRSO NOI was published in the *Federal Register* on September 30, 2016 (81 FR 67382). Assumptions about CRT storage are necessary to analyze CRS operations, and the best available information is the current operations. This assumption, and any other assumptions, procedures, or methodologies in this EIS regarding the Canadian projects or the effect of Canadian projects and their operations are for EIS analytical purposes only and does not establish, create, or imply any position or interpretation of the CRT. This EIS evaluated the effects in the four NEPA sub regions in the United States, while recognizing the CRS projects operate within a transboundary basin. The potential for any significant effects of the alternatives that could arise in Canadian portions of the basin were reviewed in general as a matter of policy.

1.9.3.2 Mid-Columbia River Projects

After Rock Island Dam was completed in 1933, four more run-of-river dams were constructed on the middle Columbia River (Region B in Figure 1-7) in Washington during the 1950s and 1960s by three different Public Utility Districts (PUDs). These projects are operated under licenses from the Federal Energy Regulatory Commission (FERC). They include:

- 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

Flow patterns at the mid-Columbia River projects are influenced by operations at the Canadian and Federal projects upstream, particularly Grand Coulee Dam. While releases from Grand Coulee Dam are regulated by Chief Joseph Dam, the Federal project located upstream from Wells Dam, Federal storage project operations still affect the size and timing of flows at the five

PUD dams. The CRSO alternatives do not include any specific actions that would require the mid-Columbia River projects to operate outside their normal ranges.

1.9.3.3 Middle Snake River Dams

Idaho Power Company operates three FERC-licensed dams, collectively known as the Hells Canyon Complex, located on the middle Snake River between Oregon and Idaho. The Hells Canyon, Oxbow, and Brownlee Projects are hydropower facilities that affect flows into the lower Snake River. Hells Canyon and Oxbow are run-of-river projects downstream of Brownlee Dam. Brownlee Dam is the most significant project for FRM in the Hells Canyon Complex with an active storage capacity of 980,000 acre-feet that is used jointly for FRM and power production. Operations at Brownlee Dam control inflows to Oxbow and Hells Canyon, which operate as run-of-river dams passing flows through to the lower Snake River projects. The Hells Canyon Complex has a significant effect on flows in the lower Snake River, especially in the vicinity of Lewiston, Idaho, with Brownlee Reservoir helping to reduce flooding in the lower Columbia River Basin. The CRS alternatives do not include any specific actions that would require the Hells Canyon Complex to operate outside its normal ranges.

1.9.3.4 Pend Oreille, Clark Fork, and Flathead River Dams

Major non-Federal projects in the U.S. on the Pend Oreille and Clark Fork River systems are shown on Figure 1-7 in Region A. All of these dams are downstream of Hungry Horse Dam, and two are downstream of Albeni Falls Dam. The CRSO EIS alternatives do not include any specific actions that would require these non-Federal projects to operate outside their normal ranges. These projects are operated under licenses from the Federal Energy Regulatory Commission (FERC).

- Pend Oreille River Dams:
  - Box Canyon, operated by Pend Oreille County PUD
  - Boundary, operated by Seattle City Light
- Clark Fork River Dams:
  - Thompson Falls, operated by Northwestern Corporation
  - Noxon Rapids and Cabinet Gorge, operated by Avista Corporation
- Flathead River Dams:
  - Seli'š Ksanka Qlispe' (SKQ), operated by operated by Energy Keepers, Inc.

1.9.3.5 Other Tributary Dams

There are many other dams located on tributaries of the Columbia River and upstream of CRS projects and outside of the study area. Major dams are shown in Figure 1-7 and include dams in the following sub-basins.

- The Middle Snake River includes 3 non-Federal dams.
- The Upper Snake River Basin includes 23 Federal and non-Federal dams.
- The Yakima River Basin includes 6 Federal dams.
- The Spokane River Basin includes 5 non-Federal dams.
- The Wenatchee River Basin includes Chelan Dam, a non-Federal dam.
- The Priest River Basin includes Priest Lake Dam, a non-Federal dam.
- Tributaries of the Lower Columbia River include 34 Federal and non-Federal dams.

1.9.4 System Planning and Operations

Each Federal project within the scope of the CRSO EIS was constructed under specific congressionally authorized legislation identifying the major intended uses. All of the projects were specifically authorized for hydropower production, most were authorized for navigation, and some were also authorized for FRM and irrigation. The seasonal abundance of water, and the predictability of its use, allows a project to support other uses as well, but only incidentally. General congressional authorization allows for such uses as fish and wildlife conservation, recreation, and M&I water supply.

While the authorizing legislation stipulated intended use, it seldom contained explicit provisions for operating the individual projects or for their coordinated operation within the total system. The Corps and Reclamation are largely responsible for deciding how to operate their projects based on the principles of multiple-use operation, agency statutes, operations experience, and public input. Project operations are guided by water control manuals prepared for most projects.

Congressional authorization, multiple-use operating principles, water control manuals, and public interest provide overall guidance for system planning and management. Within this overall framework, planning is needed to guide system operations in response to actual hydrologic conditions. As a result, several annual planning processes guide system operations from year to year.

1.9.5 Annual Planning

The Corps, Reclamation and non-Federal utilities update their operating plans throughout the year to optimize power operations within the constraints for FRM, fish operations, navigation, and other constraints (specified in their FERC licenses for non-Federal utilities; specified by the Corps and Reclamation for Bonneville power operations).

The annual planning process starts each February and incorporates non-power considerations. Each reservoir owner submits multiple-use operating requirements (e.g., required minimum outflows) that must be accommodated in the resulting plan. Utility parties also submit forecasts of their electricity loads, the output of their non-hydro generating resources, and planned maintenance outages for their resources. Studies are conducted to determine how much power can be produced from the whole system and by each Pacific Northwest Coordination Agreement (PNCA) party. The PNCA is an agreement involving 16 entities in the Northwest, including Federal water and power agencies and electric utilities. Through the PNCA, major hydroelectric generating plants and electric systems that serve the Pacific Northwest, including dams on the Columbia River in the United States, operations are planned as if they are controlled by a single entity. This is important because the power generation benefits of the Columbia River Treaty are based on an assumption that the operation of the Columbia River dams will be coordinated between the United States and Canada. The PNCA studies are updated throughout the operating year and guide reservoir operations that produce the planned power capability while meeting numerous other operating requirements. Although reservoirs are not required to operate in accordance with the plan, rights and obligations under the PNCA provide for exchanges of power between utilities to assure each utility can achieve the benefits of a coordinated plan.

Annual planning processes are also developed for purposes other than power. The Technical Management Team (TMT) is an inter-agency technical group comprised of sovereign representatives responsible for making in-season recommendations to the co-lead agencies (Corps, Bonneville, and Reclamation) on dam and reservoir operations in an effort to meet the expectations of the applicable BiOps and accommodate changing conditions, such as water supply, fish migration, water quality, new information, and maintenance issues. The TMT consists of representatives from the co-lead agencies, NMFS, USFWS, the states of Oregon, Washington, Idaho, and Montana, and tribal sovereigns.

Each fall, the co-lead agencies prepare an annual Water Management Plan (WMP) consistent with applicable BiOps that describes the planned operations of the CRS dams and reservoirs for the water year (October 1 through September 30). The WMP is designed by the co-lead agencies to meet specific purposes:

- Implement water management measures consistent with actions considered in their respective BiOps.
- Assist in meeting the biological performance standards specified in the BiOps in combination with other actions or operations identified in the BiOps.
- Meet other CRS project requirements and purposes such as FRM, hydropower generation, irrigation, navigation, recreation, and conservation of fish and wildlife.
- Take into account recommendations contained in the applicable Northwest Power and Conservation Council’s Fish and Wildlife Program and amendments.

The WMP also includes special operations planned for the year (e.g., special tests, maintenance, construction activities, etc.) known at the time the WMP is developed. Throughout the season, the co-lead agencies use the TMT forum to provide the region with seasonal updates on water supply forecasts and specific project operations.

The Corps coordinates with regional agencies to prepare an annual Fish Passage Plan (FPP) that provides detailed operating criteria for project fish passage facilities, powerhouses, and spillways to facilitate the safe and efficient passage of migratory fish. The FPP contains appendices that describe special operations for fish research studies, the juvenile fish transportation program, operation of turbine units within operational constraints, spill for fish passage, TDG monitoring, and dewatering procedures. The FPP is coordinated through the inter-agency Fish Passage Operations and Maintenance Coordination Team.

1.9.6 Annual and Short-Term Operation

Current operation of the Federal system throughout the year is based on meeting several related, but sometimes conflicting, objectives. These include providing adequate flood storage space for controlling spring runoff; providing sufficient water levels for navigation, recreation, and fish and wildlife; maintaining an acceptable probability that reservoirs will refill to provide water for next year's operation; providing adequate water supply for irrigation; providing flows to aid the downstream migration of anadromous juvenile fish; and maximizing power generation, within the requirements imposed by other objectives.

Annual operation of the Federal system follows a three-season cycle (fall/winter, spring, and summer) graphically represented in Figure 1-8.

- For the fall/winter season, approximately October to mid-March, the general hydrologic condition is the start of the new water year, and the building of a snowpack and future water supply. 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) so high flows in the spring can be captured. During this fall/winter season, operators must also provide a safe navigation corridor, generate power, and protect wildlife habitat.

  In the fall and winter, rivers are flowing at low, base-flow levels. Little is known at this time of year about how much snow will accumulate throughout the winter and how much water will come down the river in the upcoming spring. Winter storms may also bring rises in the river during this season.

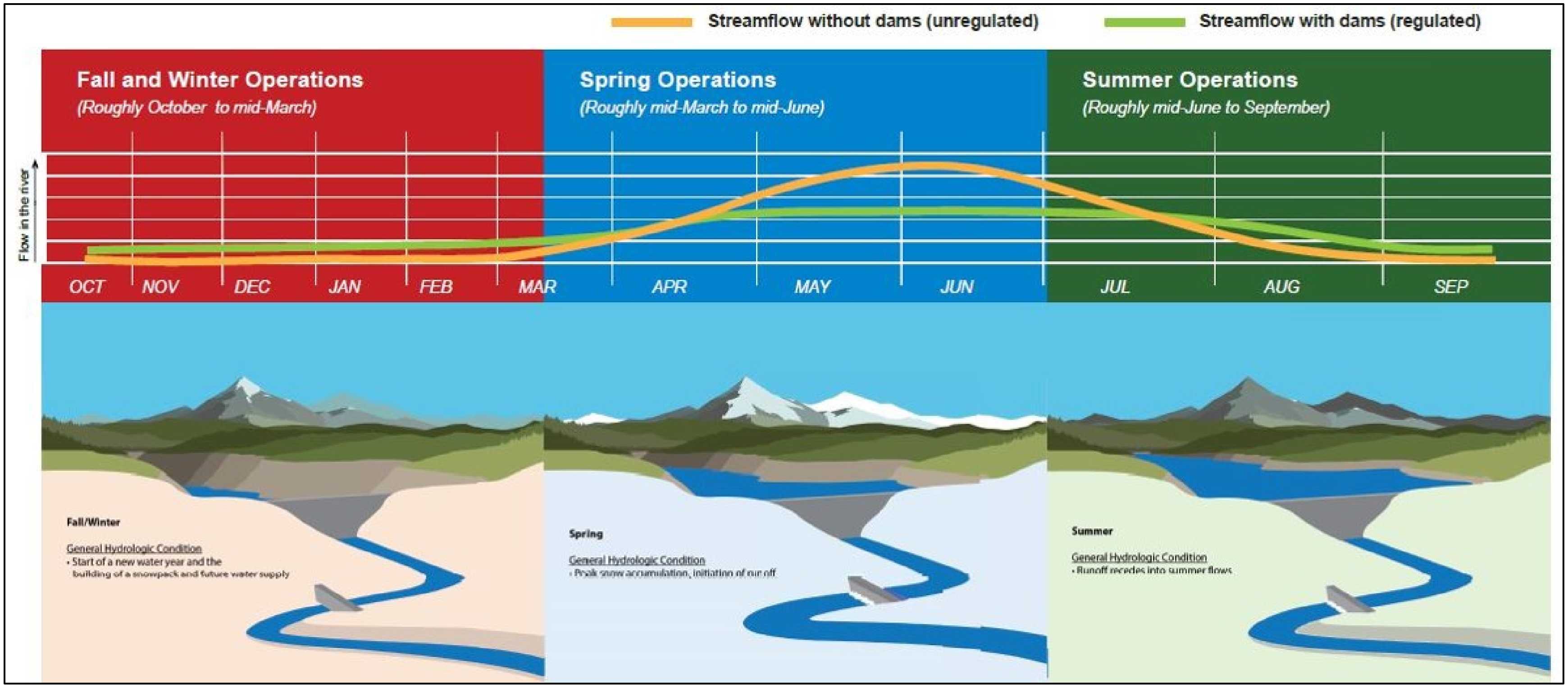

Figure 1-8. Seasonal Operations of Columbia River System

- During the spring season, the general hydrologic condition is peak snow accumulation sometime between mid-March and mid-May, depending on location in the Columbia River Basin and elevation. Water supply forecasts provide context to the type of runoff anticipated in the spring and provide information about the space required for FRM operations. Runoff can occur earlier in lower elevation subbasins because of earlier snowmelt and low elevation rains. Once runoff begins, the storage projects reduce outflow and begin refilling the reservoirs. The co-lead agencies balance FRM requirements and refill by attempting to operate no lower than the FRM elevation as of April 10th.

  The CRS is operated in the spring primarily to manage spring runoff for FRM to the extent possible, store water for irrigation use later in the season, and provide conditions to aid juvenile and adult fish migration. During this time, operators must also provide a safe navigation corridor, generate power, and protect wildlife habitat.

- For the summer season, which runs from approximately mid-June through September, spring runoff recedes into lower summer flows. Storage reservoirs reach their highest elevation in the summer months, often reaching full pool. 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 power production. By summer, the peak flows from spring runoff transition to lower summer flows.

  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 must also provide a safe navigation corridor, support recreation interests, and protect wildlife habitat.

The co-lead agencies have some flexibility in CRS operations as they attempt to meet the diverse and changing needs of the region based on information that becomes available over the course of the operating year. Many factors cause short-term operational adjustments. For example, sometimes periods of heavy rain causes higher flows in the fall. This water can be used to produce additional or surplus energy, which can be offered and sold into the wholesale electricity market. Alternatively, depending on conditions at the dams, water can be stored for future use if storage space is available. In a poor snowpack year, minimum fish flows, navigation, and other constraints dictate how much water the projects must discharge, allowing as much water as possible to be used to fill the reservoir. In a poor snowpack year, there may not be enough water to provide power to meet firm energy demand in the region, and Bonneville might need to purchase power on the wholesale market to meet its obligations.

The actual operations take place in what is described as “real time,” that is, decisions must be made in a few minutes, days, or at most, a few weeks. Operators regulate the system in an effort to satisfy all the various purposes contained in the annual operating plan. They may need to respond to in-stream conditions for fish or navigation, or take advantage of an opportunity to generate extra power to sell as surplus when economically beneficial. Boating accidents, generator outages, the weather, and even the timing of recreational events can influence operational decisions. From time to time, there are also periodic maintenance activities that drive reservoir levels. For example, Reclamation has established a periodic maintenance schedule for the drum gates that regulate flow into the spillway at Grand Coulee Dam, and this requires the reservoir to be drawn down to elevation 1255 feet National Geodetic Vertical Datum of 1929 (NGVD29).[4] Please see Chapter 2 for more details on maintenance-driven elevation changes.

1.9.7 Operational Strategies to Meet Other System Uses, Planning and Operations

Preceding sections summarized key operational strategies to effectively manage and plan CRS operations, including but not limited to water supply, hydropower generation, and FRM. The following sections summarize key operational strategies to effectively manage other resources including navigation, water quality, and fish resources.

1.9.7.1 Navigation

Navigation in the Columbia River Basin is both commercial and recreational. Section 3.10 provides detailed information on navigation. Commercial use takes place primarily along the Columbia-Snake Navigation System (CSNS). The CSNS covers the entire 470-mile-long water highway formed by the eight mainstem dams and lock facilities on the lower Columbia and Snake rivers. The CSNS follows the navigable reaches of the lower Snake River beginning near Lewiston, Idaho, and Clarkston, Washington, to its confluence with the Columbia River near Pasco, Washington, and then down another 330 miles on the Columbia River to its junction with the Pacific Ocean near Astoria, Oregon. The CSNS consists of three primary segments: (1) a 43-foot-deep draft segment between the Pacific Ocean and Portland, Oregon, and Vancouver, Washington (river mile (RM) 106); (2) a 28-foot segment (maintained at 17 feet) of the Columbia River between Vancouver, Washington and The Dalles, Oregon; and (3) a 14-foot shallow draft section of the Columbia River, which stretches from The Dalles to Pasco, Washington to the Snake River RM 140 at Lewiston, Idaho, and Clarkston, Washington. Traditionally, locks are taken out of service for approximately two weeks each year for maintenance, which generally occurs in the spring. The shallow draft channel accommodates Corps and U.S. Coast Guard vessels, shallow-draft tugs, barges, and recreational boats; and connects the interior of the Columbia River Basin with deep-water ports on the lower Columbia River.

Commercial barges and other river traffic need minimum water depths to navigate successfully. Unlike other river uses, navigation has depth requirements that do not vary seasonally. Dam operators must regulate water releases and maintain reservoir levels to provide minimum navigation depths throughout the year. Operating requirements for navigation differ between the waterway's deep draft and shallow draft segments.

From the Pacific Ocean to The Dalles, Oregon, navigation requirements can usually be met by natural river flows, without any special releases of water from the CRS projects. Periodic dredging maintains this channel’s depth to support navigation even at normal low flows, most

[4] More information on NGVD29 can be found in Chapter 3, Hydrology and Hydraulics, Section 3.2.4.1.

notably near Pillar Rock, which is located in the middle of the channel at Columbia RM 27 near Brookfield, Washington.

In the portion of the shallow-draft channel from Pasco, Washington, to Lewiston, Idaho, maximum and minimum reservoir elevations have been established to maintain an authorized 14-foot channel depth. The authorized channel depth can be maintained physically, by dredging, most notably in Lower Granite Reservoir at the confluence of the Snake and Clearwater Rivers, or operationally by raising reservoir levels. At times, the navigation channel is controlled operationally for specific purposes. For example, the McNary Reservoir needs to be above a minimum of 338 feet and held within a half-foot range and Priest Rapids Dam discharges need to be held within a specified range to facilitate periodic shipments of nuclear reactor compartment disposal packages to the Port of Benton by the U.S. Navy. Thus, navigation requirements are fully met within the flexibility provided under normal CRS operations.

Between 1996 and 2016, an average of 54.1 million tons of freight per year was moved on the CSNS, of which 4.8 million tons of freight was moved on the lower Snake River (Corps Waterborne Commerce Statistics 2018). The top ten commodities transported are wheat, soybeans, corn, wood, sodium carbonate, pebbles and gravel, potassium chloride fertilizers, gasoline, other light oils, and scrap metal (Corps Waterborne Commerce Statistics 2018).

Many types of recreational motorized and non-motorized pleasure crafts are used throughout the Columbia River Basin. Commercial tour guide and transportation services also exist in some locations. Several cruise companies offer cruises along the lower Columbia River and on the lower Snake River to Clarkston, Washington.

Two ferries operate on Lake Roosevelt, the reservoir behind Grand Coulee Dam. The Keller Ferry is operated by the Washington Department of Transportation as a link on rural State Route 21 and provides access to the Colville Indian Reservation. It can run throughout the entire operating range of the reservoir, from elevation 1,208 to 1,290 feet. The Inchelium-Gifford Ferry provides access to the Colville Indian Reservation from Washington State Highway 25. This ferry cannot operate below elevation 1,229 feet. Both ferries carry normal highway traffic.

1.9.7.2 Fish

Prior to dam construction, some populations of salmon, steelhead, lamprey, and other anadromous species migrated as far as 1,200 miles up the Columbia River to Lake Windermere, Canada, and 600 miles up the Snake River to Shoshone Falls, near Twin Falls, Idaho. As part of the Independent Science Advisory Board (ISAB) review of density dependence, the ISAB estimated that a range of 5 to 9 million salmon and steelhead once returned to the Columbia River Basin in the pre-development era (prior to 1850) with the primary evidence (i.e., probable harvest rates) supporting an estimate of around 6 million fish per year (ISAB 2015). Other published estimates of pre-development abundance range from 7.5 to 8.9 million fish (Chapman 1986) or 10 to 16 million fish (NW Council 1986), assuming that all species could reach maximum abundance in the same year. Current returns of salmon and steelhead are well below the pre-development estimates of abundance. NMFS' 2016 5-year status review notes that:

> "Many West Coast salmon and steelhead (*Oncorhynchus* spp.) stocks have declined substantially from their historical numbers and now are at a fraction of their historical abundance. Several factors contribute to these declines, including: overfishing, loss and degradation of freshwater and estuarine habitat, hydropower development, poor ocean conditions, and hatchery practices. These factors collectively led to the National Marine Fisheries Service's (NMFS) listing of 28 salmon and steelhead stocks in California, Idaho, Oregon, and Washington under the Federal Endangered Species Act (ESA)." (NOAA 2016)

Dams without fish passage block anadromous fish access to much of the upstream portions of the Columbia and Snake rivers and their tributaries. As juveniles, anadromous fish migrate from fresh water to marine environments and then return to fresh water as adults to spawn. Over 550 miles of mainstem Columbia River habitat (and many more miles of tributaries) have no returning anadromous fish above Chief Joseph Dam, which is the current upstream limit of salmon and steelhead in the Columbia River. Over 50 percent of the originally inhabited mainstem of the Snake River is no longer accessible to anadromous fish, as the Hells Canyon Complex limits access to the upper 247 miles of this river, plus access to tributaries. Dworshak Dam blocks upstream migration on the North Fork of the Clearwater River. Additional historical background information is included in Section 3.5.

The kinds and numbers of resident fish vary considerably across the Columbia River Basin. Many species interact with each other and their habitats to form local/regional fish communities. Some of these species are important for cultural, recreational, and commercial harvest. Some resident fish populations, including bull trout and Kootenai River white sturgeon are listed under the ESA. Others, such as burbot, westslope cutthroat trout, and kokanee, are not listed. Many habitats in the Columbia River Basin are fragmented by Federal and non-Federal dams for native resident fish. Dams and associated reservoirs have created more opportunities for the expansion of non-native game fish introduced into the basin.

Within the Columbia River Basin, various actions, plans, agreements, and programs have been implemented by Federal, state, local, and tribal entities to contribute to the survival and recovery of ESA-listed species and to the maintenance of other stocks. These actions, plans, and programs aim to improve water quality, habitat, up- and down-stream migrations, and address predation, among other goals.

Water quality improvements include the installation of flow deflectors to reduce the amount of TDG at Chief Joseph, all four lower Snake projects (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams), McNary, John Day, and Bonneville dams, and multilevel outlets to release water at certain temperatures at some projects, including Libby, Hungry Horse, and Dworshak dams.

Throughout the Columbia River Basin, fish and wildlife habitat protection, mitigation, and enhancement projects have been constructed with funding from a wide variety of programs, including programs implemented through by the state agencies like the Washington Salmon Recovery Funding Board and the Oregon Watershed Enhancement Board as well as Federal programs such as Bonneville's Fish and Wildlife Program, Corps' authorities like the section 536 program, BOR's ESA Recovery Program, NOAA's Pacific Coastal Salmon Recovery Fund, USFWS Partners for Fish and Wildlife Program, NRCS Conservation Easement Recovery Program, North American Wetlands Conservation Act. These interagency groups work collaboratively to better integrate, organize, and coordinate fish recovery and water quality efforts in support of protecting and restoring the Columbia River Basin aquatic ecosystem.

HABITAT ACTIONS

Bonneville works with states, tribes and watershed groups to protect, mitigate, and enhance spawning and rearing habitat, targeting factors that limit fish survival throughout the Columbia River Basin. Bonneville has funded hundreds of actions across the basin to restore natural stream channels, reconnect estuarine tidal channels, enhance flow volume and timing, expand cold water refuges and open access to habitat (www.cbfish.org). These habitat improvement actions provide both near-term and long-term benefits, including those that will help address the effects of climate change. Actions that improve connectivity and stream flow will provide a buffer against the effects of climate change.

In addition to habitat improvement actions, Bonneville works with willing landowners to protect land and water by putting it under permanent conservation easement to further support habitat and fish conservation in the short and long term.

All eight Federal projects on the lower Columbia and lower Snake Rivers provide fish passage to accommodate anadromous fish migration. Some fish facilities were included in the initial design of the projects, while others were added at a later date. Facilities and operations designed to benefit fish include ladders for adults and diversion screens for juveniles; a transportation program consisting of collection facilities, barges, and trucks for juvenile migration; hatcheries to supplement harvest and wild stocks; and in-stream flow management for both juveniles and adults. Actions to address predation on salmon and steelhead have ranged from lethal removal to non-lethal dissuasion and hazing. Avian wires at the CRS projects and higher water levels during nesting seasons are techniques to deter birds from using a particular area. For seals and sea lions (pinnipeds), exclusion devices have been installed at the projects as a dissuasion method. Hazing has been carried out to deter both birds and pinnipeds from preying on migrating salmonids.

UPSTREAM FISH PASSAGE

Fish ladders, which allow adult salmon and other fish species including lamprey to migrate upstream, were built during the original construction of all eight Federal run-of-river projects on the lower Columbia and Snake rivers. (The five PUD dams on the middle Columbia River also have fish ladders to maintain anadromous fish access to the Wenatchee, Methow, Entiat, and

Okanogan rivers.) Each of these projects has one to three ladders operating continuously, except during winter maintenance outages. Even though the fish ladders were not originally designed for lamprey passage, several ladder modifications have been made since the early 2000s and more are expected in the future to improve lamprey passage. Resident fish passage is blocked by Libby, Hungry Horse, and Albeni Falls dams. The Grand Coulee, Chief Joseph, and Dworshak dams effectively block the upstream migration of anadromous fish. All six of these projects were not designed with fish passage facilities and so effectively block the upstream access for both resident and anadromous fish.

The Bonneville Dam has three fish ladders; The Dalles, John Day, McNary, Ice Harbor, and Lower Monumental Dams each have two fish ladders; and the Little Goose and Lower Granite Dams each have one fish ladder. Adult fish enter a ladder through collection systems that run along the entire front of a dam's powerhouse, as well as at other key locations. Specific flow conditions near the ladder entrances are needed to attract adult fish into the ladders. The attraction water is provided by pumps, small turbines, or gravity flow from the reservoir behind the dam, depending on the design of the individual system. The fish swim upstream to the base of the fish ladder, where they migrate up the ladder and exit into the reservoir above the dam. Each ladder contains a fish-counting station where the fish pass an underwater viewing window, allowing them to be counted and identified by species.

DOWNSTREAM FISH PASSAGE

Currently, juvenile fish can migrate past the dams via several routes: over the spillway, through the turbines, or through the juvenile fish bypass systems, sluiceways or corner collector (Table 1-4). In addition, some fish are transported past the dams by barge or truck.

Table 1-4. Types of Downstream Fish Passage

Project	Type of Downstream Fish Passage
Lower Granite	spillway, spillway weir, juvenile bypass system, turbines, barges, and trucks
Little Goose	spillway, spillway weir, juvenile bypass system, turbines, barges, and trucks
Lower Monumental	spillway, spillway weir, juvenile bypass system, turbines, barges, and trucks
Ice Harbor	spillway, spillway weir, juvenile bypass system, and turbines
McNary	spillway, two spillway weirs, juvenile bypass system, turbines, and improved fish passage turbines
John Day	spillway, two spillway weirs, juvenile bypass system, and turbines
The Dalles	spillway, sluiceway, and turbines
Bonneville	corner collector, spillway, sluiceway, juvenile bypass system, turbines, and improved fish passage turbines

Spillway passage occurs through either conventional spill or spillway weirs (Figure 1-9). Conventional spill requires juvenile fish, which generally travel near the surface of the river, to dive to find passage at the bottom of the spill gates, while spillway weirs provide conditions that are more favorable and more effective surface passage. Spillway weirs are mounted onto the face of a dam and use surface flows to draw fish toward the structure. This route allows juvenile salmon and steelhead to pass the dam near the water surface under lower accelerations and lower pressures, providing a more efficient and faster dam passage route.

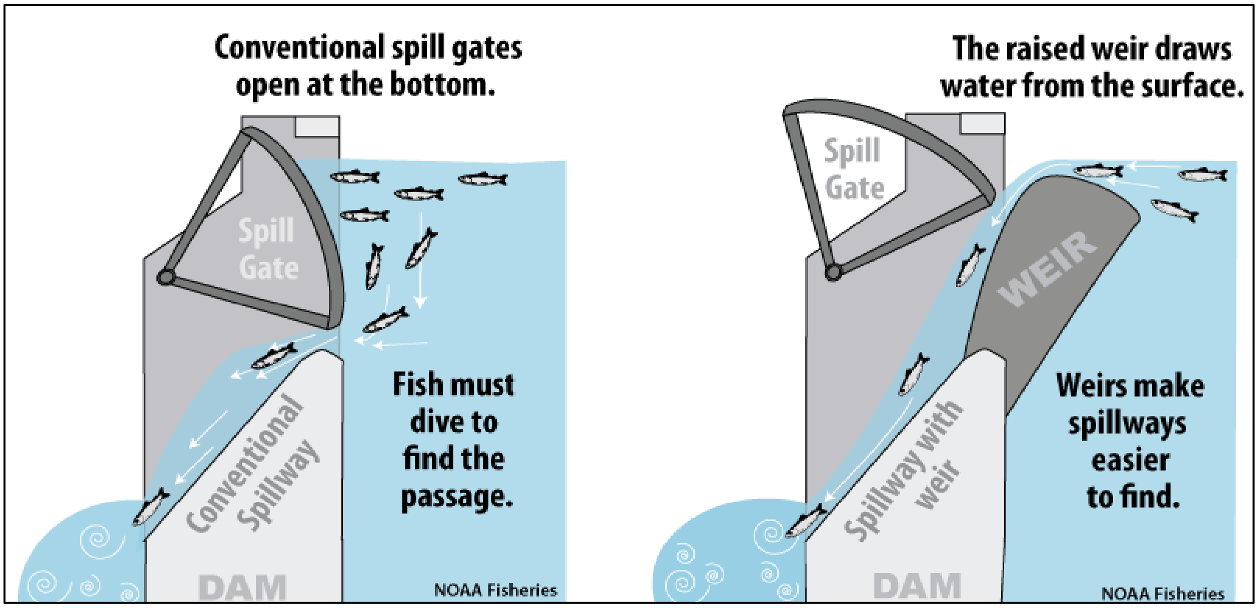

Figure 1-9. Passage Routes of Juvenile Salmon for Conventional Spill and Spillway Weir Routes

Powerhouse passage for juvenile salmonids is also broken into multiple routes, including turbines, juvenile bypass, sluiceways, and corner collector passage. Juvenile bypass systems divert juvenile anadromous fish away from the turbine intakes and through a bypass system to raceways, where they are collected for transport or bypassed directly back into the river. The juvenile bypass system guides 60 to 90 percent of juvenile salmon and steelhead that enter the powerhouse away from the turbines and into the bypass. Fish collected for transport are placed in either barges or trucks and transported around multiple dams and released downstream of Bonneville Dam.

At The Dalles Dam, turbine units are not screened. As a result, powerhouse fish passage consists of turbines or the ice-and-trash sluiceway, a rectangular channel extending along the upstream side of the powerhouse. When the sluiceway gates are open, water and juvenile migrants are skimmed from the forebay into the sluiceway, and bypassed to the tailrace.

At Bonneville Dam, turbine units are only screened at the second powerhouse because juvenile fish turbine passage was found to be better without screens at the first powerhouse. The first powerhouse also has an ice-and-trash sluiceway. The corner collector at Bonneville Dam was the ice and trash sluiceway at the second powerhouse that was transformed into a juvenile bypass route that was extended to release the fish back into the river further downstream.

1.9.7.3 Water Quality

State water quality standards are developed to ensure the protection of the water's beneficial uses. Minimum outflow requirements, which generally vary by season, are specified for each project to help maintain desired downstream conditions. The co-lead agencies recognize Federal, state, and EPA-approved tribal water quality standards, and manage a variety of programs and facilities intended to maintain water quality throughout the Columbia River Basin. Two main water quality parameters affected by CRS operations are water temperature and TDG. See Section 3.4 for detailed water quality information.

TEMPERATURE

It is understood that the creation of reservoirs can cause a change in the natural thermal regime of a river. Reservoirs tend to create thermal responses that lag behind that found in unregulated rivers, creating outflow temperatures that are cooler in the spring and warmer in the fall compared to natural or pre-dam thermal conditions. Dams and reservoirs tend to reduce the within-day warming and cooling processes typically observed in free-flowing rivers. For more information, refer to Chapter 3.4, Water Quality.

The CRS storage projects, which include Hungry Horse, Libby, and Dworshak dams are deep storage reservoirs that retain water for several months, allowing for temperature stratification (water arranged in layers that vary in temperature). This stratification provides the ability to operate these dams, through selective withdrawal, to meet downstream water temperature objectives. Cold-water releases from Dworshak Dam have been used successfully to reduce water temperatures at Lower Granite Dam. However, the cooling effects of the Dworshak releases are attenuated, as the Snake River flows toward the confluence with the Columbia River. Water temperatures in the lower Snake River are primarily determined by a combination of the temperature of the water originating from the middle Snake River and the Clearwater River. Lower and middle Snake River maximum summer temperatures exceeded the current 68 °F (20 °C) Washington standard before the dams were constructed (Corps 2002, Peery et al. 2003). Grand Coulee is also considered a storage project, but it is unique in the fact that it has relatively low retention times due to the large amount of flow through the project. This short retention time results in very weak thermal stratification, and homogenous temperatures at penstock intake depths. The lack of strong thermal stratification results in Grand Coulee Dam releasing the coolest water possible during hot summer months. The other CRS dams are run-of-river projects with short retention times (only a few days or weeks) with more uniform water temperatures from the surface to the bottom (not stratified); selective withdrawal is not possible at these dams.

TOTAL DISSOLVED GAS

Spilling water at a dam results in increased TDG levels in downstream waters when aerated water plunges to depths where pressure increases the solubility of atmospheric gases. Water that contains high levels of dissolved gases (e.g., nitrogen and oxygen) can be harmful to fish. The TDG saturation in water below CRS dams often exceed state and tribal water quality standards of 110 percent during the juvenile fish passage season, generally April to August; however, this criterion does not apply to flows above the 7-day, 10-year frequency flow (7Q10) flood flow. In addition, special waiver or rule modifications from Oregon Department of Environmental Quality and a criteria adjustment from the Washington Department of Ecology have been established as a special condition during the juvenile fish passage periods of spill for downstream fish migration (April 1 to August 31), allowing for the exceedance of the 110 percent TDG water quality standard at the lower Columbia River and lower Snake River dams up to a specified tailwater or forebay percent TDG maximum. The co-lead agencies have made major efforts to reduce TDG generation during the juvenile fish passage season by regulating flow and installing structures such as flow deflectors to reduce the plunge of water that reduces the amount of entrained air. Although the co-lead agencies have made major efforts to reduce TDG generation during high-flow years, there are situations where TDG water quality criteria are exceeded. For example, TDG can be in excess of 120 percent in the Columbia River at the International Boundary. Spillway releases can improve downstream juvenile fish migration, so balancing these releases and TDG production is important.

TDG and water temperature data are monitored in real time through a network of fixed monitoring stations operated by the Corps, Reclamation, and Grant and Douglas County PUD to provide information about dam operations during the juvenile fish passage and migration season. These monitors are used to measure compliance with state and tribal water quality standards.[5] The data collected through this monitoring network provides information used to adjust spill on a real-time basis through the system.

[5] Tribal water quality standards exist for the mainstem Columbia River and tributaries per each tribe's jurisdiction. Certain tribes in the basin have water quality standards that have been approved by EPA.

CHAPTER 2 - ALTERNATIVES

2.1 INTRODUCTION

This chapter describes the No Action Alternative and the four Multi-Objective (MO) alternatives which make up the initial range of alternatives considered in the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS). A sixth alternative, the Preferred Alternative, includes many of the measures described in this chapter. The Preferred Alternative is described and evaluated in Chapter 7.

The U.S. Army Corps of Engineers (Corps), U.S. Bureau of Reclamation (Reclamation), and Bonneville Power Administration (Bonneville), co-lead agencies for the EIS, developed a range of alternatives for the future physical configuration, operation, and maintenance of the 14 projects of the Columbia River System (CRS) to achieve a reasonable balance of competing resource demands for the available water and meet the purpose and need for this EIS.

The co-lead agencies defined eight objectives (section 2.2.1) to meet the purpose and need statement for the EIS and to direct the development of the alternatives. A suite of eight preliminary draft alternatives were developed to focus on individual resources. These Single Objective Alternatives (SOs) provided information regarding how well measures might perform when combined, and helped identify any conflicts between resources, actions, or locations. These SO Alternatives informed the next iteration of alternatives development. The resulting range of alternatives consists of the No Action Alternative and four Multiple Objective Alternatives (MOs). The No Action Alternative is a description of continuing current practices, whereas the MOs modify one or more aspects of the operation, maintenance, and configuration of the projects.

The MOs include a range of spill levels for juvenile fish passage, varying levels of hydropower production, and differing actions to support the needs of Endangered Species Act (ESA)-listed anadromous and resident fish. The MOs also include proposed means to support future delivery of water for irrigation and municipal and industrial purposes as well as increased water management flexibility to react to unanticipated changes in river flow and increase the likelihood of achieving refill of storage reservoirs. After evaluating the potential effects of the alternatives on flood risk management (FRM), irrigation, hydropower generation, navigation, fish and wildlife conservation, cultural resources, recreation and other environmental and socioeconomic resources, the Preferred Alternative was developed to achieve a reasonable balance of competing resource needs (Chapter 7, Preferred Alternative) while meeting the purpose and need statement (Section 1.2). This chapter describes the five alternatives and the process used to develop and evaluate them.

2.2 OVERVIEW OF ALTERNATIVES DEVELOPMENT PROCESS

The three co-lead agencies developed alternatives for the CRSO EIS to focus on changes to operations, maintenance, and configuration of the 14 identified projects in the CRS. Several other scopes that include regional efforts for consideration were suggested for the EIS which the co-lead agencies did not develop alternatives to address. These are identified in Section 2.4. Alternatives were developed to meet the purpose and need statement, identified objectives, and congressionally authorized purposes of the projects within the CRS. The process used to develop the No Action Alternative and MOs is summarized in this chapter, and fully detailed in Appendix A, *Alternatives Development*.

The co-lead agencies used an iterative process to build alternatives. They began by identifying objectives for future management of the CRS. Actions that could be taken to meet those objectives, called measures, were then identified. Finally, the measures were combined into alternatives and refined over time to produce a reasonable range of alternatives for analysis. In support of the alternatives development process, technical subject matter experts were convened from the three co-lead agencies, cooperating agency staffs, and multiple Native American tribes. These subject matter experts were assigned to technical teams based on their respective area of expertise. Many in-person workshops and web-based meetings were conducted by the technical teams to ensure a collaborative alternatives development process. Reviews of early draft alternatives, comment resolution, and refinement of alternatives were also conducted via web-based meetings to include large numbers of team members across the geographic region. The co-lead agencies used the input from the scoping process, technical teams, cooperating agencies, and tribes as the alternatives were developed. They also considered the Purpose and Need Statement and objectives. While there were broad efforts to collaboratively build and evaluate the alternatives, the co-lead agencies are ultimately responsible for the decisions made in the EIS process, including decisions on scope of the analysis. The co-lead agencies retain final responsibility for the analysis in the draft and final EISs and the decision made in each agency’s respective Records of Decision (ROD). The participation of the cooperating agencies and their collaboration with the lead agencies does not infer that they agree with the conclusions in the analysis or that they are waiving any rights to review and comment on the draft and final EIS during the public comment period.

Multiple Objective Alternatives Terminology
Objectives are what the Federal agencies are trying to accomplish (the “why”). They are statements of the desired outcome of the EIS, as identified by the Federal agencies and scoping comments. An example of an objective is to improve ESA-listed anadromous salmonid adult fish migration within the project area. A **measure** is the action the agencies would take to achieve an objective (the “how”). It describes an action, usually in a precise location, that meets an objective, in whole or in part. Using the objective mentioned above, a measure could be to provide structural enhancements for fish passage, such as improving fish ladders. An **alternative** is a combination of one or more measures that, together, would address one or more of the objectives. In this EIS, the co-lead agencies designed the action alternatives to address several objectives and are therefore calling them Multiple Objective Alternatives (MOs).

2.2.1 Objectives

Objectives are statements of the desired outcome of various resource conditions that are expected to result by taking Federal action(s). The eight objectives presented below, along with the EIS Purpose and need statement (Section 1.2), guided the development of a reasonable range of alternatives:

- Objective 1: 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.
- Objective 2: 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.
- Objective 3: 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.
- Objective 4: Provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River Power System.
- Objective 5: Minimize greenhouse gas emissions from power production in the Northwest by generating carbon-free power through a combination of hydropower and integration of other renewable energy sources.
- Objective 6: Maximize operating flexibility by implementing updated, adaptable water management strategies to be responsive to changing conditions, including hydrology, climate, and the environment.
- Objective 7: Meet existing contractual water supply obligations and provide for authorized additional regional water supply.
- Objective 8: Improve conditions for lamprey within the CRSO project area through actions potentially including but not limited to project configurations, flow management, spill operations, and water quality management.

2.2.2 Measures

As stated previously, a measure describes an action that could be taken to meet one or more objectives. Measures are typically specific to a discrete action in a precise location. For example, a measure could be to improve adult ladder passage through modification of the adult trap at the Lower Granite Project. An alternative is usually constructed of a number of measures that are combined to meet the objectives.

Many measures were considered to address objectives and build a reasonable range of alternatives during the development of this EIS. Potential measures were submitted by the public, stakeholders, and tribes during the scoping process. Additional measures were developed by technical team members from co-lead and cooperating agencies. Before combining measures into alternatives, they were evaluated to determine if they met the EIS purpose and need statement and at least one objective. Those measures that did not meet at least one objective were eliminated from further consideration. Remaining measures were further evaluated to determine whether the measures were technically feasible, or whether they constituted a risk to human life and safety (including increasing flood risk). Additional detail of this process can be found in Appendix A, *Alternatives Development*.

Measures remaining after screening fall under two categories: structural or operational. Structural measures are those involving a physical change to the project such as installation of a feature in the spillway or modifying fish ladders. Operational measures are those involving a change in how water is stored or released at the projects or how juvenile fish are transported around the projects. Examples of operational measures include a change in timing of drawdown or refill of a water storage reservoir and a change in how much water is released through the spillway versus the powerhouse. Further, the operational measures of each alternative are categorized as follows:

- **Fish Passage Spill** – Fish passage spill refers to the use of flow released through spillway gates to allow juvenile fish to migrate downstream from the forebay of a reservoir to the tailrace of the dam.
- **Juvenile Fish Transportation** – Juvenile fish transportation refers to the collection of ESA-listed juvenile fish at collector projects for relocation downstream of the Bonneville project via barges or trucks.
- **Water Management** – Water management refers to the planned release of flow from the projects to either draft or refill reservoirs. Water management also refers to operations to meet project purposes such as FRM, hydropower production, and irrigation as well as fish and wildlife purposes.
- **Water Supply** – Water supply refers to the withdrawal of water for the purpose of irrigation and municipal and industrial use.
- **Other Operational** – Other operational measures include actions taken to support fish and wildlife. For example, the drawdown of reservoirs to reduce juvenile salmon outmigration time.

2.3 ALTERNATIVE SCREENING

To achieve a broad range of alternatives, the co-lead agencies collaborated with cooperating agencies in teams of technical experts through several iterations to create 12 alternatives that could meet the CRSO EIS purpose and need statement: first, eight single objective alternatives, and then four MOs. After completing the effort to develop the single and MO alternatives, the co-lead agencies evaluated all 12 alternatives against screening criteria of completeness and efficiency.

- **Completeness** was used to evaluate the extent to which a given alternative provides and accounts for all actions to meet most or all objectives, and thereby satisfying the purpose and need statement.
- **Efficiency** was considered as how well (without duplication of effort) an alternative would meet objectives. Usually, cost effectiveness is part of this consideration, but costs were not available at the early screening of alternatives. In this case, efficiency was based on efficiency of analysis of measures and the elimination of duplication of effort.

The evaluation of the 12 alternatives against these two criteria found that the MOs were more complete than the single objective alternatives. The MOs were also determined to be more efficient, as MOs were composed of combinations of measures from the single objective alternatives. Retaining the single objective alternatives would have resulted in duplication of analyses which otherwise are included in the MOs. This resulted in the finding that the four MOs presented the most complete and efficient way to achieve identified objectives, and these represented a reasonable range of alternatives that included the suites of measures the technical teams identified. The single objective alternatives were eliminated from further consideration. The complete detailed descriptions of the single objective alternatives and their measures are located in Appendix A, *Alternatives Development*. A brief description of the alternatives removed from further consideration is in Section 2.5.

2.4 RANGE OF ALTERNATIVES

2.4.1 Introduction

The analysis in this chapter focuses on five alternatives, which include the No Action Alternative, Multiple Objective Alternative 1 (MO1), Multiple Objective Alternative 2 (MO2), Multiple Objective Alternative 3 (MO3), and Multiple Objective Alternative 4 (MO4). An important note is that the descriptions of the MOs only include how they differ from the No Action Alternative. For example, under the No Action Alternative, Libby and Hungry Horse Dams operate to daily and hourly ramping up and down restrictions as per the 2006 USFWS BiOp. Two MOs include ramping rate measures that would allow project operators to increase or decrease the rate of flow released from the dam more quickly than under the No Action Alternative. The other two MOs would continue to adhere to the No Action Alternative ramping rates and their descriptions do not restate the No Action Alternative operation for the sake of brevity.

MOs are so named in that they attempt to incorporate measures that would address more than one of the eight CRSO objectives. However, these alternatives do not attempt to balance all of the objectives equally. Rather, the MOs explore a range of structural and operational changes in order to determine impacts of potential new solutions and analyze the trade-offs of combining ideas under one alternative.

The sections below provide summarized descriptions of the five alternatives, which include an explanation of the measures within the alternative. The descriptions begin with an overall summary of the alternative and include the distinction amongst the four MOs. The structural measures of each alternative are characterized first, followed by the operational measures. The complete detailed descriptions of the alternatives and their measures are located in Appendix A, *Alternatives Development*.

2.4.2 No Action Alternative

For this EIS, the No Action Alternative describes the operation, maintenance, and configuration of the CRS, from September 30, 2016, the date the Notice of Intent to complete the CRSO EIS was published in the Federal Register. The No Action Alternative is required by the National Environmental Policy Act (NEPA), in accordance with the Council on Environmental Quality regulations (40 Code of Federal Regulations [CFR] 1502.14). The No Action Alternative considers what would happen if the CRS continued to be operated, maintained, and configured with no change. The EIS assumes that, to the extent possible, all ongoing, scheduled, and routine maintenance activities for the Federal infrastructure and all structural features, including those recently constructed or reasonably foreseeable, are included in the No Action Alternative.

The No Action Alternative provides a baseline condition for comparing environmental effects of the MOs. The No Action Alternative assumes the CRS will continue to be operated for all congressionally authorized purposes, requiring a balancing of operations across the 14 projects within the CRS. Current operations include actions agreed to in previous ESA consultations among the co-lead agencies, National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service (USFWS).

The No Action Alternative also assumes structural measures already budgeted and scheduled would be implemented. The majority of these structural/construction projects are modifications to the dams intended to improve conditions for ESA-listed fish or improve safety for operators and the public. A general description of the No Action Alternative is located in Section 2.4.2. Additional discussion of the No Action Alternative is contained in Appendix A, *Alternatives Development*.

As described in Chapter 1, Introduction, the CRS is operated to meet multiple authorized purposes, and consider other regional priorities. The volume of water in the CRS in any given year is variable and finite, and not all operations to benefit various resources may be achieved in a given year. In coordinating system water management, the co-lead agencies generally prioritize FRM and environmental responsibilities, such as conservation actions for ESA-listed fish species and other species of concern, before Bonneville shapes any remaining flexibility to manage water flow for hydropower generation to meet daily and seasonal power demands.

Information described in the No Action Alternative is drawn from a number of documents, including the Fish Operations Plan (Corps 2016a), Fish Passage Plan (Corps 2016b), biological opinions (BiOps) from NMFS and USFWS (NMFS 2008b; USFWS 2006), Water Management Plans (Corps 1992), and other sources.

2.4.2.1 No Action Alternative Description of Measures

This section provides a brief description of the way the CRS is operated, and would be expected to operate, if no other changes are implemented. A more comprehensive description of current system operations is contained in Appendix A, *Alternatives Development*.

STRUCTURAL MEASURES

In addition to investments that meet the structural measures criteria described in Section 2.4.2, the co-lead agencies will continue to invest in power-related capital improvements, additions, replacements, and non-routine extraordinary maintenance/expense as needed to meet reliability standards, availability requirements, regional adequacy guidelines, efficiency needs, environmental requirements, safety and security standards, and other requirements.

Hungry Horse Project Power Plant Modernization

The power plant at Hungry Horse Project began an extensive modernization effort in Fiscal Year (FY) 2018. This work will bring the facilities to current industry standards. It will include the full overhaul or replacement of governors, exciters, fixed-wheel gates, and turbines; a generator rewind; overhaul of the selective withdrawal system; and recoating the penstocks. In addition, cranes that service the power plant will be refurbished or replaced, and the power plant will be brought up to modern fire protection standards. For one of the years of the project, the power plant overhaul would limit the number of turbines available to generate power during the overhaul. This would not affect the amount of water released from the dam because outlets will be used. The full effort is expected to take 10 years to complete.

Third Powerplant Overhaul Project

Third Powerplant Overhaul Project includes work on the six generating units, turbines, shafts, and auxiliary equipment at the Grand Coulee Dam Third Powerplant. The main portion of the overhaul work is being completed within the confines of the third powerplant.

John W. Keys III Pump-Generating Plant Modernization Project

John W. Keys III Pump-Generating Plant Modernization Project at Grand Coulee Dam includes pump-generating and auxiliary equipment. Work will be within the confines of the plant and completed in 2034.

Lower Granite Project Juvenile Facility Bypass Improvements

This action modified the existing bypass system to construct an open channel with increased orifice size, intended to move fish from the collection channel to the existing juvenile fish collection facility. The work is intended to reduce the time fish spend in the system, moving them more quickly and reducing stress and delays. The project includes an enlarged collection channel, flow reduction through the transport channel, improved water supply to the location downstream of the collection channel, and a relocation of the primary outfall to reduce predation. Construction was complete and the system became fully operational in FY 2019.

Lower Granite Project Spillway Passive Integrated Transponder Monitoring System

A passive integrated transponder (PIT)-tag monitoring system was installed over spillbay 1, the location of the removable spillway weir. The system includes a set of antennas mounted in the surface of the spillway and connected to an electrical transceiver located on the tailrace deck. These antennas support collection of data so numbers of juvenile fish migrating over the spillway can be compared with using the bypass system or other routes. This system was installed in FY 2020.

Little Goose Project Adjustable Spillway Weir Closure

An adjustable spillway weir (ASW) was fabricated and installed in spillbay 1 at Little Goose Dam. The project included a mechanical system to adjust the crest elevation of the spillway to allow juvenile salmon and steelhead to pass the dam near the water surface. This allows operators to adjust quickly to changing conditions, thus increasing the likelihood of juvenile salmon and steelhead survival under the No Action Alternative spill operation.

Little Goose Project Adult Ladder Temperature Improvements

This structural measure includes a 90-foot-deep chimney attached to the face of the dam to pull cool water from lower reservoir elevations and release it into the fish ladder. In the ladder, the cold water mixes with surface water from the forebay to lower water temperatures. The cold water is also sprayed onto the surface water in the forebay to cool water at the ladder exit. This project is intended to keep ladder water temperatures within an acceptable range and prevent delays in fish passage during periods of high water and air temperatures. Construction was completed in FY 2018.

Little Goose Project Boat Barrier

This structure is comprised of a set of anchors and lines holding a string of booms and cables in the forebay of the Little Goose Project. It is a safety measure intended to keep boats from approaching the spillway. The cables have bird spikes to keep fish-eating birds off the structure in an attempt to reduce predation in the forebay. Construction was completed in FY 2018.

Little Goose Project Trash Shear Boom Repair

This is a repair of an existing boom. The action included replacement of longitudinal cable to reconnect 20 concrete floats. The floats are 40 feet long and 8 inches wide. This boom is intended to direct debris away from the powerhouse to protect powerhouse infrastructure.

Ice Harbor Project Turbines 1 to 3 Replacement and Generator Rewind[1]

The Ice Harbor turbine replacement and rewind will replace existing turbine runner blades on units 1, 2, and 3, with state-of-the-art improved fish passage runners. The project will also rewind the electrical components and replace the distributors. Collectively, these changes will improve hydraulic conditions for fish and increase hydropower generating efficiency. Units 1 and 3 will be replaced with adjustable blades for increased operating flexibility to adjust to changing river conditions. Unit 2 will remain a fixed-blade unit. The turbine replacement is scheduled to be completed in FY 2021, with some turbines being installed sooner than FY 2021.

McNary Project Turbine Replacement

This action includes full replacement of all 14 turbines at McNary with new turbines. This includes replacement of runners, discharge rings, windings, wicket gates, and potential draft tube modifications, pending final design. The replacement will increase reliability, increase generating efficiency, increase hydraulic capacity, and improve hydraulic conditions for fish. The turbine replacement project is presently in its design phase. Construction is expected to be completed within FY 2033.

Adult Passive Integrated Transponder Tag Monitoring System at John Day Project

PIT antennas were installed in both the north and south adult fish ladders during the 2016/2017 winter maintenance period. A PIT detection system at John Day Project will allow biologists to track and monitor adult upstream migration and assist in development of more accurate estimates of adult salmon survival through the CRS.

Bonneville Project Gatewell Orifice Modifications

Biological testing in 2008, 2009, and 2013 showed elevated mortality for juvenile salmon in the gatewells when the units are operating at the upper end of the peak efficiency range (>15

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[1] As part of ongoing litigation on the Columbia River System, the Corps, in coordination with Bonneville, is providing information to National Wildlife Federation on certain planned projects at the four lower Snake River dam and reservoir projects through the end of the CRSO EIS process. The four lower Snake River dam and reservoir projects are Ice Harbor, Lower Monumental, Little Goose and Lower Granite. The Corps, in coordination with Bonneville, is providing information on three categories: (1) Capital Hydropower Improvement Projects; (2) Columbia River Fish Mitigation Projects; and (3) Other Non-Power Capital Projects (e.g., navigation). The Capital Hydropower Improvement Project information provided to National Wildlife Federation is available here: https://www.bpa.gov/Finance/AssetMgmt/lsrdp/Pages/Lower-Snake-River-Dam-Projects.aspx.
The Corps' Engineering Regulations (ER) provide that the evaluation of alternatives does not include past costs (or benefits) (ER 1105-2-100 Section 2-4). The Corps considers any expenditures, including capital, at any of its dam and reservoir projects that occur prior to completion of the EIS as "sunk" costs, and therefore, these expenditures would not be relevant to a recommendation on whether the dam and reservoir projects should be breached or not. Sunk costs have already been expended and are not material in the evaluation of alternatives that will be implemented after those expenditures have been made. Rather, in evaluating alternatives for the CRSO EIS, the co-lead agencies are evaluating future benefits and costs.

thousand cubic feet per second [kcfs]). This project is to improve juvenile salmon survival in the gatewells at the Bonneville Project's second powerhouse.

OPERATIONS

The CRS is operated for a number of purposes: to reduce flood risk, generate hydropower, provide water for irrigation and water supply, to provide navigation, for recreation, and to meet fish and wildlife purposes. The current operations are described below.

OPERATIONS FOR FLOOD RISK MANAGEMENT

The CRS is authorized to provide FRM in the Columbia River Basin. It is the responsibility of the Corps and Reclamation to protect the general safety and welfare of the public by managing risks and consequences associated with flooding. The CRS operates storage dams and reservoirs to balance inflow and outflow and meet the authorized purposes. All CRS storage projects generally operate in a coordinated manner to minimize flood consequences in local areas and in the lower Columbia River below Bonneville Project. Operations are developed collaboratively by co-lead agency water managers and are described in the Water Control Manual for each project. Operations may vary from year to year based on forecasted water conditions and are adjusted throughout the year to meet changing conditions caused by weather. A gage located at The Dalles, Oregon, is the reference gage for the Columbia River Basin.

Water managers from the co-lead agencies operate the system to make the best use of flood space (capacity in the reservoirs to store inflows) and flood storage (the actual volume of water stored in a reservoir for future use) across the FRM season. The FRM season includes three operational regimes developed to provide flood protections throughout the Columbia River Basin. These regimes are described in the following paragraphs:

- **Fall Operations: September through December.** Minimal system FRM operations occur during this period, although specific projects have maximum reservoir elevations to meet FRM objectives or other goals and agreements. For example, Albeni Falls meets maximum reservoir elevation in mid-November to provide power generation flexibility, manage winter floods and to protect kokanee spawning incubation. Maximum reservoir elevations are set for the Libby, Hungry Horse, and Dworshak Projects for December.
- **Storage Evacuation Operations: January through April.** During storage evacuation operations, the storage projects are drafted based on precipitation and snow accumulation in the basin in order to prepare for high spring flows and reduce the potential for flooding. The projects operate to a storage reservoir diagram (SRD) that is specific to each reservoir. The SRD describes the minimum flood space requirement for each project and is adjusted monthly based on current water supply conditions.
- **Refill Operations: May through August.** Although CRS reservoir operations generally achieve refill by June 30, the actual refill date may vary depending on the timing and shape of the spring runoff. For example, a late snowmelt runoff may result in a later refill in order

to avoid excessive spill. During the refill period, outflow from the reservoir is kept lower than inflow, allowing the water level in the reservoir to increase and refill. In this manner, the reservoir eventually reaches its refill elevation when flood risk has significantly decreased. FRM refill at Hungry Horse and Libby dams are operated based on variable flow operating criteria. This criterion provides a more normal spring flow regime that benefits listed species and increases the likelihood of full reservoirs and water supplies for summer flow needs.

Fall Operations at the Libby Project

Libby Project typically releases the minimum outflow (4 kcfs) through the month of October in order to maintain the reservoir elevation prior to the start of the FRM draft in November. The maximum elevation requirement for November 30 is elevation 2,448 feet National Geodetic Vertical Datum of 1929 (NGVD29), which allows 0.5 million acre-feet (Maf) of space. However, Libby is often drafted as low as 2,435 feet NGVD29 in November to ensure that the December 31 flood space elevation requirements can be achieved without exceeding the powerhouse capacity at Libby Project.

Downstream Control Points at the Hungry Horse Project

Columbia Falls, Montana, serves as the control point for local FRM operations at the Hungry Horse Project. In 2014, the official flood stage for the Flathead River at Columbia Falls was modified to 13 feet (an approximate flow of 44 kcfs) when the Flathead Lake elevation is in the top 1 foot (elevation 2,892 to 2,893 feet NGVD29). The flood stage is 14 feet (approximately 51 kcfs) when the elevation of Flathead Lake is more than 1 foot below full pool (elevation 2,892 feet NGVD29 or lower).

When the Flathead River at Columbia Falls is at or above flood stage or forecasted to be at or above flood stage, outflows from the Hungry Horse Project will be adjusted as necessary (to a minimum discharge of 300 cfs) as long as enough space exists in the reservoir to manage remaining runoff. The Hungry Horse Project generally starts reducing discharges when flood stage at Columbia Falls begins to exceed 12.5 feet when flood stage criteria is 13 feet, and 13 feet when flood stage criteria is 14 feet. Depending on the remaining runoff volume and available reservoir space, however, the project may not begin reducing discharges until Columbia Falls reaches levels higher than these criteria.

Allowable Rate of Change of Release at the John Day Project

Safety precautions prohibit sudden changes in flow from the John Day Reservoir during normal operating conditions. However, unusual or emergency conditions may require rapid evacuation of stored water to achieve maximum flood storage space (between 257.0 feet and 268.0 feet NGVD29). The maximum permissible rate of change in tailwater elevation is 3 feet per hour, which corresponds to a change of approximately 200 kcfs per hour. This restriction is necessary to provide navigation safety at the downstream approach to the navigation lock. The maximum rate of change will not be used on a routine basis due to potentially severe effects on navigation, recreation, and fish, including ESA-listed salmonids.

OPERATIONS TO BENEFIT ANADROMOUS FISH

Fish and Wildlife Operations

The CRS is authorized to operate in a manner that provides benefits to fish and wildlife. The co-lead agencies coordinate fish and wildlife management with a number of other Federal, State, and tribal entities. In addition to operations intended to benefit ESA-listed anadromous fish and their designated critical habitat, the co-lead agencies operate the CRS projects to benefit ESA-listed resident fish (e.g., bull trout [*Salvelinus confluentus*] and Kootenai River White Sturgeon [*Acipenser transmontanus*]) and their designated critical habitat. The co-lead agencies, in coordination with NMFS and USFWS, make adjustments in CRS operations based on the best available science, knowledge about current conditions in the system, and any effects from management actions. Under the No Action Alternative, the analysis assumes that the system will continue to be operated for fish and wildlife purposes per the terms of the 2016 Fish Passage Plan and the Fish Operations Plan, both of which are developed annually by the Corps, in coordination with Bonneville, regional Federal, State, and tribal fish agencies, and other partners from the Fish Passage Operations and Maintenance work group. Operations to benefit ESA-listed resident fish are also described. Specific operations for fish and wildlife are designated in the following paragraphs and would continue as described under the No Action Alternative.

Total Dissolved Gas Management

The co-lead agencies use several different methods to manage total dissolved gas (TDG) across the basin, including monitoring, structures, and operations, which are described here. Specific actions are further described in future sections related to operations for fish benefits.

The co-lead agencies implement a TDG monitoring program, with monitoring locations at all 14 CRS projects, as well as the middle Columbia River dams (Wells Dam, Rocky Reach, Rock Island, and Priest Rapids), and other locations on the Snake and Columbia Rivers. The monitoring stations are operated by the Corps, Reclamation, and the Grant and Douglas County Public Utility Districts. Data collected at these locations is used to inform project operations and adjust spill on a real-time basis during fish migration season, and to monitor compliance with state and tribal water quality standards.

Spillway flow deflectors have been installed at all of the 14 CRS projects except at The Dalles and Grand Coulee (see Chapter 3, Affected Environment and Environmental Consequences, for further discussion). Flow deflectors are structures that are installed at the base of the spillway. They deflect spillway flows horizontally at the water surface, away from the dam, rather than allowing the water discharged over the spillway to plunge vertically in the stilling basin and increase concentrations of TDG. In addition to flow deflectors, the Corps has installed a training wall at The Dalles to increase survival of juvenile fish that pass over the spillways and limit TDG.

The Corps develops and implements specific spill patterns for each of the lower Snake and lower Columbia projects. These patterns dictate how much water is discharged through each spillway during fish passage season, and are defined in the Fish Passage Plan, developed annually. The spill patterns are developed to respond to the unique configuration of fish passage facilities, spillways, flow deflectors, and downstream bathymetry at each project. Spill patterns are managed to adapt to changing conditions, such as flow volumes, in the river (see Spill Operations Section).

Flow Augmentation

The Libby, Hungry Horse, Dworshak, and Grand Coulee Projects are managed to provide water for downstream flow augmentation to benefit ESA-listed fish in spring and summer. Spring flow augmentation generally begins in April, after the storage reservoirs have filled to the spring elevation objectives per the annual Water Management Plan for that year[2] (FRM refill generally runs from December through April.). Specific operations and elevations for are outlined in the Water Control Manual for each project. Dworshak operations are described below. These operations would continue under the No Action Alternative.

Storage projects provide summer flow augmentation after refilling to their maximum elevation, usually around the end of June or July. Libby and Hungry Horse summer flow augmentation draft benefits anadromous fish but is also shaped to benefit ESA-listed resident bull trout and other sensitive, native fish species downstream of the projects. The intent is to maintain steady or gradually declining flows until they reach the end of September elevation objectives. Grand Coulee is also drafted to provide summer flow augmentation to benefit ESA-listed salmonids in the Columbia River. Drafts for flow augmentation from Grand Coulee typically begin in July, while summer flow augmentation at the other projects generally begins in either June or July, depending on water supply and stream flow conditions.

Spring and Summer Flow Objectives

The co-lead agencies, in collaboration with NMFS, USFWS, and state and tribal fish and wildlife agencies across the Columbia River Basin, have developed flow objectives for the spring and summer fish passage seasons on the lower Snake and lower Columbia Rivers. These flow objectives are intended to benefit ESA-listed fish. In some years, the flow objectives may not be met throughout the entire migration season because flows in the lower Snake and Columbia Rivers depend on the volume and shape of natural runoff, combined with the flow augmentation volumes. Due to annual water year variability, these volumes may not meet the flow objectives in spite of water managers' efforts to meet them as much as possible.

For the lower Snake River, the spring flow objective is determined by the final April water forecast for Lower Granite Dam; the summer flow objective is determined by the June water

[2] The water management plan for each year is available at https://pweb.crohms.org/tmt/.

forecast. In the lower Columbia River, the flow objectives are determined by the April and June forecasts at The Dalles.

Spring and Summer Operations at Dworshak Project

Dworshak Project is operated in the spring to maximize the probability of refilling the reservoir to support summer flow augmentation, and also to provide the flows needed to meet spring objectives in the lower Snake River during the downstream migration of juvenile salmon and steelhead. If both these objectives cannot be achieved, the (TMT) will make an in-season recommendation, weighing considerations unique to each particular year. During the spring, Dworshak releases approximately 4 to 6 kcfs, if necessary, to help move fish from the Dworshak and Clearwater fish hatcheries, located directly downstream, into the mainstem of the Clearwater River.

Summer flow augmentation provided from Dworshak increases the survival of ESA-listed fish by moderating river temperatures and increasing water velocities in the lower Snake River. During the summer (July and August), the co-lead agencies operate Dworshak to help meet the flow/temperature objectives identified, in coordination with the TMT. The co-lead agencies plan to draft to elevation 1,535 feet NGVD29 by the end of August and elevation 1,520 feet NGVD29 by the end of September each year, unless modified per the agreement between the United States government and the Nez Perce Tribe for water use in the Dworshak Reservoir. Portions of Dworshak Reservoir lie within the exterior boundaries of the Nez Perce Reservation. The extension of the draft limit into September assures water will be released consistent with the Snake River Basin Adjudication Agreement.

Flood Risk Management Shift

Periodically, the co-lead agencies look for opportunities to shift system FRM space requirements from Brownlee Reservoir (owned by Idaho Power) and Dworshak to Grand Coulee from January through April in order to provide more water for flow augmentation in the lower Snake River during spring migration of anadromous fish. The shift allows operators to draft Grand Coulee deeper in the winter in order to keep the Brownlee and Dworshak reservoirs at higher levels. The reservoirs must be back to their specific upper rule curve (URC) by April 30. These shifts are implemented only after coordination with the TMT and are intended to increase the probability for increased spring flows in the lower Snake River. Consideration of these FRM shifts by the Corps and Reclamation will include an analysis of impacts to FRM, and the shift would not occur if FRM would be compromised.

Spill Operations

Planned annual spring and summer spill operations at the lower Snake and lower Columbia River projects are designed to improve downstream fish passage for juvenile salmonids. Spill levels and patterns of spill across the spillways are defined by regional fish managers and agencies in the annual Fish Operations Plan . State agencies, such as Oregon Department of Environmental Quality and Washington Department of Ecology, each set TDG water quality standards for their respective areas of jurisdiction . The co-lead agencies are required to comply with state water quality standards . In 2016, the co-lead agencies implemented performance standard spill levels for fish passage that did not exceed 120 percent TDG in project tailraces, and 115 percent TDG in the forebay of the next project downstream. At the lower Snake River projects, spring spill is implemented from April 3 to June 20, and summer spill occurs from June 21 to August 31. At the lower Columbia River projects, spring spill is implemented from April 10 to June 15, and summer spill occurs from June 16 to August 31. Spill would continue at the same levels and timing under the No Action Alternative.

Under certain circumstances, such as during high flow events, the CRS projects may need to release water using the spillways to maintain sufficient storage capacity in the reservoirs for FRM . When this occurs, it is referred to as involuntary spill . When an involuntary spill operation is implemented, the co-lead agencies utilize the Spill Priority List that establishes the order and amount of spill to be released by the CRS projects . The Spill Priority List is developed in a regional forum and published in each year's Water Management Plan . Table 2-1 provides the order and cap for spill above the Fish Operation Plan spill levels . The Spill Priority List defines the project priority order for lack-of-load spill in order to manage TDG on a system-wide basis . If necessary, to spill above Fish Operation Plan rates due to lack-of-load, spill will be allocated to projects in the following priority order.

Table 2-1. Spill Priority List

Priority Order	Project	TDG Cap (%)	Example Spill Caps (kcfs)
Level 1 (State TDG Standards[1/])			
1	LWG	120% / 115%	41
2	LGS	120% / 115%	40
3	LMN (bulk)	120% / 115%	28
4	LMN (uniform)	120% / 115%	36
5	IHR (night)	120%[2/]	95[3/]
6	IHR (day)	120%[2/]	75[3/]
7	MCN	120% / 115%	146
8	JDA	120% / 115%	90
9	TDA	120% / 115%	135
10	BON	120%[2/]	130
11	CHJ	110%	20
12	GCL[4/]	110%	OT = 0; DG = 5
13	DWR	110%	30%
Level 2			
14	LWG	120%	45
15	LGS	120%	52
16	LMN (uniform)	120%	44
17	MCN	120%	146
18	JDA	120%	146
19	TDA	120%	135
20	CHJ	120% / 115%[5/]	60

Priority Order	Project	TDG Cap (%)	Example Spill Caps (kcfs)
21	GCL[4/]	115%	OT = 5; DG = 15
Level 3 (Levels 4–7: same order as Level 3)			
22	LWG	122%	52
23	LGS	122%	59
24	LMN (uniform)	122%	60
25	IHR (night)	122%	95[3/]
26	IHR (day)	122%	85[3/]
27	MCN	122%	152
28	JDA	122%	177
29	TDA	122%	160
30	BON	122%	160
31	CHJ	120%	100
32	GCL[4/]	120%	OT = 15; DG = 40

Note: This priority list was effective April 1, 2016, until further notice (no later than August 31, 2016). BON = Bonneville; IHR = Ice Harbor; JDA = John Day; LGS = Little Goose; LMN = Lower Monumental; LWG = Lower Granite; MCN = McNary; TDA = The Dalles.

1/ Apr 1-Aug 31 (FOP Spring and Summer Spill) TDG standards are in effect at LWG, LGS, LMN, IHR, MCN, JDA, TDA, BON for ≤120% in the tailrace (Oregon, Washington) and ≤115% in next downstream forebay (Washington), except BON which does not have a downstream forebay standard. Current spill caps are online: http://www.nwd-wc.usace.army.mil/tmt/documents/ops/spill/caps/.

2/ No downstream forebay standard.

3/ IHR spill caps based on: Night 1800–0500 (11 hours) = FOP spill; Day 0500–1800 (13 hours) = lack of load spill (>FOP Day 45 kcfs).

4/ GCL spill is via outlet tubes (OT) or drumgates (DG). Transition to DG at forebay elevation 1,267–1,270 feet.

5/ Assumes spill duration ≤6 hrs.

Over-capacity spill is another type of involuntary spill and occurs when flows exceed the hydraulic capacity of the available power generation facilities at a specific dam. Over-capacity spill can be affected by high river flows, planned and unplanned unit outages, planned and unplanned transmission outages, and other transmission constraints. Any of these conditions physically limit the potential for hydropower production. Over-capacity spill will generally be the amount of project outflow in excess of the maximum amount that can be released through all available generators and other outlet structures (e.g., sluiceways and fish ladders). In general, when this condition occurs, the affected project will be operating at maximum generation, but within the Fish Passage Plan turbine operating criteria capability to minimize the amount of spill.

Temperature Control

Operations to improve water temperatures to benefit ESA-listed fish are conducted at 11 of the 14 CRS projects. Temperature control operations are conducted to benefit both anadromous and resident fish. Temperature control operations described here benefit anadromous fish and bull trout. Temperature operations to benefit resident fish are described later in this chapter.

During late spring and summer, water is released from lower levels of the Dworshak Reservoir using selective withdrawal gates. The water is used to help cool water temperatures in the lower Snake River downstream of the confluence of the Clearwater and Snake Rivers. These cooler waters improve thermal conditions for bull trout, salmon, and steelhead in the lower Snake River (Cook and Richmond 2004). At the Lower Granite and Little Goose Projects, the cooler water is supplied to fish ladders at the dams to allow upstream migration for adult salmonids.

At the Lower Granite and Little Goose Projects, the forebay tends to stratify, with warm water near the surface and cool water from the Dworshak Project deeper in the water column. When temperatures in the fish ladders are equal to or greater than 68 degrees Fahrenheit (°F), the Corps operates pumps to supply the fish ladders with cool water pumped from deep in the reservoir. The pumps are typically operated from mid- to late summer, depending on climatic conditions.

From June 1 to September 30, water temperature data is collected at adult ladder entrances and exits at each Corps project in the lower Snake and lower Columbia Rivers. This serves to monitor for temperature differentials in the ladder that could act to block adult fish from ascending the fish ladders to migrate upstream of each dam.

Variable Draft Limits

The variable draft limits (VDL) are end of period draft limits at Grand Coulee and Hungry Horse in January through March. The VDL is not a mandatory draft elevation but rather provides lower limit for hydropower generation flexibility. The VDL defines the lower operating limit based on an inflow probability that would be sufficient to refill Grand Coulee and Hungry Horse to the April 10 elevation objective with 85% and 75% confidence respectively, pursuant to the 2008 NMFS BiOp[3] and the Hanford Reach Fall Chinook Protection Program. The VDL elevation calculation does not guarantee 85% and 75% chance of refill but provides flexibility while considering the spring flow objective-based April 10 elevation. Operation above the VDL is desirable but must also not exceed the maximum elevation allowed for FRM.

Minimum Flows and Draft Limitations at Grand Coulee Project

The minimum daily average flow from the Grand Coulee Project is related to the minimum discharge below Priest Rapids Dam, which is owned by Grant County Public Utility District and located on the middle Columbia River. Generally, minimum outflow from Grand Coulee, 30 kcfs, is enough to provide the 36 kcfs minimum discharge required below Priest Rapids Dam.

The current operational draft rate limit for Lake Roosevelt is 1.5 feet per 24 hours, a rate intended to help protect against potential landslides and the erosion caused by rapidly drawing

[3] NMFS, 2008. Remand of 2004 Biological Opinion on the Federal Columbia River Power System; NMFS, 2010. Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System; NMFS, 2014. Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System.

down the reservoir. Bonneville may request an exceedance to this draft rate in order to meet increased power demand (e.g., during a winter cold snap), or the Corps may make a request to meet FRM requirements. In all cases, draft rate exceedance requests must be approved by Reclamation, and additional monitoring for erosion and landslides is required. Draft rates should not exceed 2 feet per 24 hours even if a draft rate exceedance is granted. Additional monitoring, including aerial surveillance is required when the reservoir is drafting more than 1.5 feet per 24 hours. Monitoring at more frequent intervals is required as the reservoir elevation drops. Below 1,240 feet NGVD29, no draft greater than 1.5 feet in 24 hours should be considered and all other reasonable actions should be exhausted prior to requesting approval from Reclamation for exceedance.

Lake Roosevelt Incremental Storage Release Project

The Lake Roosevelt Incremental Storage Release Project is a component of the Columbia River Water Management Program (CRWMP). It is intended to improve municipal and industrial water supply, provide water to replace some groundwater use in the Odessa Subarea, enhance stream flows in the Columbia River to benefit fish, and provide water to interruptible water right holders in drought years. A memorandum of understanding regarding the Lake Roosevelt Incremental Storage Release Project was signed by the State of Washington, Reclamation, and the Columbia Basin Irrigation Districts in December 2004. In December 2007, Water Resource Management Agreements supporting the incremental storage releases from Lake Roosevelt were signed by the State of Washington, the Confederated Tribes of the Colville Reservation, and the Spokane Tribe of Indians.

The Lake Roosevelt Incremental Storage Release Project does not reduce flows during the salmon flow objective period (April through August). This project provides for Lake Roosevelt to be drafted an additional 1.0 foot in non-drought years and up to 1.8 feet in drought years by the end of August. One-third of this water will go to instream flows.

Hanford Reach Fall Chinook Protection Program

Naturally spawning fall Chinook salmon in the Hanford Reach of the Columbia River, which are not listed under the ESA, spawn from October through the third week in November. Similar to the chum operations described below, a minimum flow is set during the spawning period and must be maintained to avoid dewatering redds. Though not listed under the ESA, these fish are an important resource to the region. During spawning, the Hanford Reach Fall Chinook Protection Program Agreement requires that Priest Rapid outflows are not higher than 70 kcfs and not lower than 55 kcfs for a continuous period of at least 12 hours of each day. Grand Coulee is operated to help support the minimum flow required below Priest Rapids Dam. Emergence occurs at the point where the eggs in the redds have accumulated 800 to 1000 degree-day C temperature units after the initiation of spawning, this typically occurs over a four-week period beginning in April and ending in early May.

Chum Flows and Operations

The Grand Coulee and Bonneville Projects are operated to support chum spawning and protections at the Ives Island complex below the Bonneville Project. There are two phases of the chum operations: spawning (typically in early November to late December) and incubation/egress (typically from late December to early April). The yearly operation is coordinated through the TMT and described in the annual Water Management Plan and seasonal updates, using the process described in Section 1.9.5, *Annual Planning*.

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 to support the chum spawning operation and winter power generation.

Beginning in November, the Bonneville Project operates to maintain the tailwater elevation in the range of 11.5 feet to 13.0 feet until chum spawning ends in late December. If it becomes necessary to operate the tailwater at elevations above 13.0 feet because of precipitation events, tidal influences, etc.), chum still have the ability to spawn at higher elevations. However, as tailwater elevations increase above 13.5 feet, some habitat in the lower elevations (11.3 feet to 12.0 feet) becomes unsuitable for chum due to higher water velocities. In addition, eggs spawned at higher elevations may risk being dewatered later in the year if there is an insufficient water supply.

After chum spawning is complete in late December, the co-lead agencies coordinate with the TMT to establish the minimum tailwater elevation necessary to protect the incubating eggs until fry have emerged from the gravel, or by April 10, whichever comes first.

Priest Rapids Spring Flow Objective

The Grand Coulee Project is operated from April 10 to June 30 to help meet the spring flow objective at Priest Rapids Dam, a public utility dam in the middle Columbia River. Grand Coulee provides flow to help meet the 135 kcfs flow objective for anadromous salmon and steelhead. If water year conditions do not allow operators to meet the 135 kcfs objective, a flow lower than the objective is used and gradually increased when possible. During dry years, the initial flow typically begins at around 90 kcfs and ramps up incrementally based on the water supply forecast, the timing of the juvenile fish migration, and streamflow conditions.

Turbine Operations

To potentially improve the survival of fish that pass through the powerhouse at a project, turbines at all projects on the lower Snake and lower Columbia Rivers target an operation within ±1 percent of peak turbine efficiency (referred to as the “1 percent range”) during the juvenile and adult migration seasons, from April 1 to October 31 (Corps 2016a, Chapters 2–9 and Appendix C). This ability to adjust unit operations for optimal performance potentially helps reduce fish injury and cavitation damage to the turbines.

Minimum Operating Pool

The four lower Snake River projects operate to minimize water travel time for juvenile fish migration by operating the forebays in the minimum operating pool (MOP) 1-foot range from April 3 until approximately September 1. Elevations may be adjusted to meet other authorized project purposes (primarily navigation), however.

Minimum Irrigation Pool

From April 10 to September 30, John Day Project is operated to minimize water travel time for downstream-migrating juvenile salmon by operating the forebay within the minimum irrigation pool (MIP) range (262.5 to 264.0 feet). The MIP is the lowest pool elevation that allows irrigation withdrawals. Irrigation withdrawals from the John Day pool typically begin in early March and extend through mid-November.

The normal operating ranges, MOP elevation ranges, and MIP elevation ranges for the four lower Snake River and four lower Columbia River projects are included here for reference (Table 2-2).

Table 2-2. Operating Range Elevations for the Lower Snake River and Lower Columbia River Projects

Location	Normal Operating Elevation Range (NGVD29) Minimum–Maximum	MOP/MIP Elevation Range (NGVD29) Minimum–Maximum
Lower Granite	733.0–738.0	733.0–734.0
Little Goose	633.0–638.0	633.0–634.0
Lower Monumental	537.0–540.0	537.0–538.0
Ice Harbor	437.0–440.0	437.0–438.0
McNary	337.0–340.0	N/A[1/]
John Day	262.0–266.5	262.5–264.0[2/]
The Dalles	155.0–160.0	N/A[1/]
Bonneville	71.5–76.5	N/A[1/]

Note: N/A = not applicable.
1/ McNary, The Dalles, and Bonneville Projects have no MOP or MIP restriction and operate within Normal Elevation Range.
2/ John Day is restricted by a MIP rather than a MOP.

Juvenile Fish Transportation Program

The Juvenile Fish Transportation Program is implemented by the Corps. Juvenile fish are collected at the Lower Granite, Little Goose, and Lower Monumental Projects for transport via barge or truck. They are moved downriver to a location below Bonneville Project, where they are released to continue their migration to the ocean. Juvenile fish collection starts no later than May 1, and barging begins the day after collection begins. Fish are transported daily or every other day throughout the migration season. Transportation operations may be adjusted due to research, conditions at fish collection facilities (e.g., overcrowding or temperature extremes), or through the adaptive management process with the Fish Passage Operations and Maintenance work group and/or the TMT (e.g., as a response to expected environmental conditions, or recent transport vs. in-river research results). Timing and operations are coordinated with regional fish managers.

OPERATIONS TO BENEFIT RESIDENT FISH

Flow Augmentation

Libby is drafted in the summer to benefit resident fish in the Kootenai River and salmonids in the Columbia River. To meet the needs of Kootenai River white sturgeon and bull trout, operations ensure minimum flows in the rivers downstream to support both species and these flows are prioritized over summer refill for recreation. The Hungry Horse Project maintains minimum flows for resident fish. To the extent possible, the intent is to maintain steady or gradually declining summer flows below the project in consideration of resident fish needs.

Temperature Control

At Libby, discharge temperatures are adjusted using a selective withdrawal system to provide thermal conditions in the Kootenai River to promote spawning, migration, and egg and larval development for Kootenai River white sturgeon and burbot, a popular game fish. To the extent possible, natural river conditions for biological productivity are provided.

At the Hungry Horse Project, per an agreement with Montana Fish, Wildlife & Parks, selective withdrawal gates are required to be operated from June to the end of September, but are typically operated into November when the reservoir temperatures become uniform and isothermal, and the benefits of the selective withdrawal system operations are negated. The goal is to provide water temperatures to the river to improve productivity for native fish species and prevent non-native lake trout from moving upstream from Flathead Lake.

Sturgeon Operations at the Libby Project

Operations at the Libby Project include the release of flows to benefit Kootenai River white sturgeon. These operations are developed annually by regional biologists (led by USFWS), based on May water supply forecasts described in the 2006 Libby BiOp (as clarified in 2008) (USFWS 2006). Release of this water falls within FRM authorities and is equal to or greater than VarQ (variable discharge) flow.

Libby operates to release tiered Kootenai River white sturgeon flow augmentation volumes to provide for the habitat needs during spawning and recruitment in April, May, June, and July. The intent of sturgeon flow augmentation is to augment lower basin runoff from tributaries of the Kootenai River downstream of the Libby Project. Sturgeon flow augmentation operations are consistent with the current version of the *Kootenai River Ecosystem Function Restoration Flow Plan Implementation Protocol* (Bonneville 2007) and USFWS's 2006 BiOp for the Libby Project (as clarified in 2008) (USFWS 2006).

Lake Pend Oreille Elevations for Kokanee and Bull Trout

Lake elevations at the Albeni Falls Project are managed to support the survival of kokanee, a critical food source for ESA-listed bull trout. During the spring, the project is operated to fill Lake Pend Oreille in accordance with FRM criteria. During the summer, the project is operated to maintain Lake Pend Oreille at a minimum elevation of 2,062.0 feet NGVD29 for recreation through Labor Day. In recent years, the start of drawdown has been delayed to the third Sunday in September, or September 18, whichever is later. Starting October 1, the project begins drafting to an elevation within a half-foot of 2,051.0 feet NGVD29 by mid-November, prior to when kokanee is expected to begin spawning. Flows released during the draft also support ESA-listed salmon in the Columbia River, particularly chum salmon downstream of Bonneville Project.

Operations to Limit TDG Production at the Hungry Horse and Chief Joseph Projects

The Hungry Horse Project is operated to minimize spill and the resultant generation of TDG. Although the generation capacity of Hungry Horse Project is about 428 megawatts (MW), there is a transmission limit at the Hungry Horse Project of 310 MW (about 9,000 cfs). Releases in excess of approximately 9,000 cfs must be put through the hollow jet flow valves, which can generate TDG. Empirical data and estimates show that limiting spill to a maximum of 15 percent of total outflow will help avoid exceeding the Montana State TDG standard of 110 percent saturation. When spill is anticipated to exceed 15 percent of total outflow, Reclamation attempts, to the extent possible, to pre-draft or reshape drawdown and refill operations to minimize spill and excess TDG generation.

In 2008, the Chief Joseph Project was fitted with spillway flow deflectors to reduce levels of TDG downstream of the project when water passes over the spillway. Throughout the year, spill is allocated to the Chief Joseph Project as needed to manage TDG on a system-wide basis to reduce TDG effects to aquatic species, including ESA-listed fish species (see Table 2-1 for the Spill Priority List relative to system-wide TDG management).

HYDROPOWER GENERATION

The CRS projects are authorized to generate hydropower for electricity using large turbines at each of the projects. While the generation of hydropower does not consume water, water must be positioned to enable generation. When power is generated that water is passed from one project to the next or downstream to the ocean. The coordinated water management of the CRS therefore includes managing the amount of water used for hydropower generation. In conjunction with the Corps and Reclamation carrying out project-specific requirements, Bonneville plans system operations to meet both power and non-power objectives and shapes any remaining flexibility to manage water flow for power generation. These plans prioritize BiOps commitments over hydropower. However, in emergency situations or when managing the system to avoid an impending emergency, power system operations can be prioritized to protect human health and safety as well as the safety and reliability of the power grid.

Hydropower generation is based on a variety of factors at each project: the type of project (storage vs. run-of-river), and generator and reservoir capacity at each project. In addition, the future CRS objectives and constraints must be accounted for in determining the distribution of generation in a current period. Storage projects typically release water based on non-power objectives, such as fish objectives or flood control. When there is flexibility for hydropower, storage projects may hold water until there is a need to generate electricity, whether for a week, a month, or even another season. The amount of electricity generated depends on available storage capacity and overall system flexibility, given other constraints.

The run-of-river projects generate electricity based on inflows, with minimal ability to store water to shape flows. Therefore, these projects also have minimal ability to control the timing of electrical generation. Some generation can be adjusted from one hour to the next, and perhaps to the subsequent day, but long-term storage for later generation is limited.

Both the lower Snake and lower Columbia River projects have minimum generation requirements to support power system reliability. The Corps has identified minimum generation powerhouse outflow values derived from actual generation records when turbines were operating within ±1 percent of best efficiency. Varying pool elevations or system disturbances may result in minor variations.

All lower Snake and lower Columbia River powerhouses may be required to keep one or more generating units online at all times for power system reliability under low river flow conditions. Low flow operations at lower Snake and lower Columbia River projects are triggered when inflow is not sufficient to meet both minimum generation requirements and planned operations to benefit ESA-listed fish. Under low flow conditions, the lower Snake River projects will operate one turbine at minimum generation and spill the remaining outflow. Minimum generation at the lower Columbia River projects is determined by grid reliability needs and generally require more than one turbine to be operating.

Power System Operation

The amount of electricity generated at the 14 CRS projects depends on a variety of factors, including operational constraints, ESA obligations, regional load,[4] and river flows. Seasonally, river flow determines when power is generated. For example, peak hydroelectric generation typically coincides with spring runoff, while low flows and low generation generally occur in late summer and fall. Energy supply (including generation, imports, and exports) must equal demand (load) at all times. Bonneville participates in the wholesale electricity market, where they buy and sell electricity to ensure demand and supply on the Federal system are always balanced. Bonneville is a North American Electric Reliability Corporation (NERC)-registered balancing authority. [5] As such, Bonneville is responsible for maintaining the balance between

[4] *Load,* or *demand,* refers to electricity being consumed in the region.
[5] A balancing authority is the entity responsible for scheduling generation on transmission paths ahead of time, maintaining a load-interchange-generation balance within a balancing authority area, and supporting

generation and load within the Bonneville Balancing Authority Area, which includes portions of the states of Washington, Oregon, Idaho, Montana, and California.

Bonneville conducts daily load shaping which means that generation is adjusted to meet load. These adjustments take place day-to-day, hour-to-hour, and even second-to-second. Bonneville uses various CRS projects (when and where there is flexibility within the FRM, environmental responsibilities, and other constraints) to increase and decrease generation to match that demand. Often, if there is not enough flexibility to meet changes in demand, Bonneville augments its generation flexibility with purchases or sales in the wholesale power market for optimized power production, while providing protection for resident fish and maintaining FRM. In some conditions, most often but not exclusively during spring runoff in high-water years, there may be more water flowing through the system than would be ideal for environmental and power needs. In these situations, even after setting some water aside for juvenile fish spill, the generation from that water supply may exceed both the regional demand and the ability to export (sell) the power to other regions like California. This excess power cannot be generated or sold, and some water is spilled for lack of market.

To ensure adequate supply to meet demand, 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. These unexpected changes in generation can come from variable sources such as wind power, sudden generation outages, or transmission constraints.

Bonneville also maintains the transmission grid for safety and reliability. The ability of the transmission system to reliably accommodate generation from the projects may impact water management functions at the projects (e.g., the location and amount of power generation required to maintain system reliability, and the best location to generate to meet the need). Transmission facilities owned and operated by Bonneville interconnect and integrate electric power generated at the Federal projects to the regional transmission grid. Certain transmission system needs can impact 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, which impacts when, where, and through which outlets the co-lead agencies pass river flows at the dams.

At times, the combined output of generation at Libby and Hungry Horse exceeds the ability of the local transmission system to reliably deliver the output of these projects to the wider transmission system. Bonneville has implemented maximum generation limits to maintain stability and meet required standards. Bonneville sets the allowable generation from Libby and Hungry Horse to balance the amount of generation that can be used to both serve load within

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interconnection frequency in real time. A balancing authority area is the collection of generation, transmission, and loads within the metered boundaries of the designated balancing authority. The balancing authority maintains load-resource balance within this area.

the Flathead Valley and transfer generation to the wider transmission system at the same time. There could be ongoing variations in allowable generation based on loads in the Flathead Valley that changes throughout the day. Currently, the combined maximum generation limit is 920 MW for heavy load hours and 860 MW for light load hours for the Libby and Hungry Horse Projects.

IRRIGATION AND WATER SUPPLY

Irrigation accounts for most surface water withdrawals in the Columbia River Basin, which is about 5 percent of total river flow.[6] Annually, about 13 Maf of water, 7 Maf from the rivers considered in this EIS, is supplied for irrigation, drinking water, and other municipal and industrial needs. The total acreage in the United States portion of the basin irrigated by Reclamation projects (including the Columbia Basin Project, Chief Joseph Dam Project, and Yakima, Umatilla, The Dalles, Deschutes, upper Snake River, and Crooked River facilities) is about 4.3 million acres. Of this, about 680,000 acres are irrigated from river reaches potentially impacted by changes in operations evaluated in this EIS.

Of the 14 Federal projects included in this EIS, only Grand Coulee (Lake Roosevelt) and John Day have operations specific to water supply purposes. Other CRS projects do supply water for irrigation or municipal and industrial purposes, but the other projects are not operated explicitly to provide that water. The irrigation season generally extends from mid-March to November 1, but some water is also pumped through the winter months.

Grand Coulee is the largest water supply provider within the study area. Each year the John W. Keys Pumping Plant can pump up to 3,318 thousand acre-feet (kaf) of water to Banks Lake for use on 720,000 acres within the Columbia Basin Project (CBP), based on water rights and completed NEPA analyses (Reclamation 2009, 2012). Under current operations, water is pumped through six pump/generators and six pumps from Lake Roosevelt (behind the Grand Coulee Project), to Banks Lake through the John W. Keys Pumping Plant, located at the left abutment of Grand Coulee Project. Banks Lake then delivers water to the Columbia Basin Project for irrigation and municipal and industrial water use.

The Columbia Basin Project Act (57 Statute 14) authorized the Secretary of Interior to construct, operate, and maintain the CBP pursuant to the Reclamation Project Act of 1939. The Secretary subsequently directed Reclamation to construct, operate, and maintain the project in House Document 172 (October 30, 1944), according to the terms of the 1939 Reclamation Project Act. In that report, the Secretary directed Reclamation to provide water for irrigation of up to 1,029,000 acres. Grand Coulee, operated by Reclamation, stores water for the CBP. The water is pumped approximately 300 feet from Lake Roosevelt to Banks Lake where it is distributed by canal to irrigators within the CBP. The CBP currently has water rights and previous NEPA compliance to deliver 3.318 Maf of water for irrigation of 720,000 acres and for M&I purposes.

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[6] Calculated using a 30-year average (1981 to 2010) inflow to The Dalles of 133 Maf (Northwest River Forecast Center 2018) and 7.1 Maf of diversion (Bonneville 2011b).

Water for the Odessa Subarea and Lake Roosevelt Incremental Storage agreement are included in the 3.318 Maf.

Odessa Subarea Special Study Project. The need to address declining groundwater supply in the Odessa Subarea, and avoid economic loss to the region's agricultural sector led Reclamation and Washington Department of Ecology (Ecology) to conduct the Odessa Subarea Special Study. The purpose identified by Reclamation and Ecology to guide the proposed action is: ". . . to maintain economic viability by providing surface water from the CBP to replace groundwater from declining wells currently used for irrigation in the Odessa Subarea." This purpose is consistent with the intent of the CBP Act by encouraging "settlement and development of the project, and for other purposes." Surface water would be provided as part of the continued, phased development of the CBP, and would come from existing CBP diversion and storage water rights from the Columbia River. The Odessa Subarea Special Study was completed in 2012 and the ROD signed in (Reclamation 2012 and 2013).

The lower Snake and lower Columbia River projects also provide water to support irrigation and municipal and industrial water supply, which is delivered via a number of pumping stations. This is an incidental use and these reservoirs are not operated specifically to provide water supply of this sort. Operations at John Day on the lower Columbia River are operated specifically to maintain elevations for the operation of water supply pumps.

MAINTENANCE OPERATIONS

Routine Maintenance

The co-lead agencies will continue to implement a maintenance program at each CRS project, consisting of routine inspection and maintenance of both power and non-power assets. The co-lead agencies conduct annual routine maintenance at all projects. Preventive and corrective maintenance coordinated and planned to occur at regular intervals is referred to as scheduled, or routine, maintenance. This type of routine maintenance would continue to be performed on all fish facilities, spillway components, navigation locks, generating units, and supporting systems to ensure project safety and reliability and to comply with North American Electric Reliability Corporation (NERC)/Western Electricity Coordinating Council (WECC) regulatory requirements.

Unscheduled and Non-Routine Maintenance

Unplanned maintenance is referred to as unscheduled maintenance. It may occur any time a problem, unforeseen maintenance issue, or emergency requires a project feature (e.g., a generating unit), be taken offline in order to resolve. Unscheduled maintenance, if it occurs in combination with ongoing scheduled maintenance, may significantly reduce the generating capability and hydraulic capacity of a project. The timing, duration, and extent of these events cannot be forecasted, however. The co-lead agencies inform regional water managers and fish managers when changes to regular operations are required for unscheduled and/or emergency non-routine maintenance.

Maintenance that is planned but not performed at regular intervals (e.g., turbine unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance is not performed at regular, pre-determined frequency, and includes tasks more significant in nature than routine scheduled maintenance. These Federal actions would be evaluated under a separate NEPA document. Non-routine maintenance examples include power plant modernization and major rehabilitation of CRS project features. Additionally, any work conducted either by the project operator or Bonneville that takes a powerhouse line out of service will generally affect several generators at one time. These types of outages, planned and coordinated in advance where possible, would continue under the No Action Alternative.

Drum Gate Maintenance at Grand Coulee Project

Reclamation's Operations and Maintenance Program requires annual inspections and dam safety maintenance for the 11 drum gates at Grand Coulee Project. A drum gate is a hinged overflow spill gate at the top of the dam, consisting of a horizontal cylindrical section that can be raised from its compartment to increase the spillway height. Each drum gate is 135 feet long and 30 feet high. Lake Roosevelt must be at or below elevation 1,255 feet NGVD29 for a minimum of 8 weeks in order to complete drum gate maintenance. Drum gate maintenance is scheduled annually during March, April, and May to take advantage of the FRM draft. However, the water conditions in the basin (dry, average, wet), and in-season conditions may affect or delay maintenance activities. To adjust for this uncertainty, and to ensure that the drum gates are maintained, Reclamation requires that, at a minimum, drum gate maintenance must be completed at least one time in a 3-year period, two times in a 5-year period, and three times in a 7-year period. The in-season criteria for accomplishing drum gate maintenance is based on the FRM requirement for the April 30 maximum Grand Coulee elevation as determined by water supply forecasts produced in February.

The February forecast is used to allow sufficient time to draft the reservoir below 1,255 feet NGVD29 by March 15. If the February forecast sets the Grand Coulee April 30 FRM elevation at or below 1,255 feet NGVD29, Grand Coulee will be drafted to perform drum gate maintenance. When the February forecast sets the April 30 FRM requirement above 1,265 feet NGVD29, drum gate maintenance will require a "forced" draft only if needed to meet the requirements of the criteria described in the previous paragraph. If the April 30 FRM requirement is between 1,255 and 1,265 feet NGVD29, maintenance will only be done if the following year would be a "forced" drum gate maintenance year. For example, if maintenance is deferred in one year due to dry conditions and the forecasted FRM elevation is between 1,255 feet and 1,265 feet NGVD29 the next year, drum gate maintenance would be accomplished in the second year in order to avoid "forced" drum gate maintenance in the third year.

In addition to the annual drum gate maintenance, an annual inspection and maintenance activity is planned for the 57-inch butterfly drum gate intake valves. Some inspection and maintenance on these valves can occur regardless of water levels, but some maintenance requires water levels at or below 1,219 feet NGVD29. The external inspection and maintenance that requires water levels at or below 1,219 feet NGVD29, for a week's duration, is scheduled to occur once every 10 years. This inspection takes advantage of spring drafts for FRM, but in some years may require an additional draft below FRM requirements to conduct this maintenance.

Third Powerplant Overhaul Project

On April 28, 2010, a FONSI was signed authorizing the third powerplant overhaul and modernization, which includes work on the six generating units, turbines, shafts, and auxiliary equipment at the Grand Coulee Third Powerplant. The main portion of the overhaul work is being completed within the confines of the third powerplant. The Third Power Plant Overhaul Project was updated with a second EIS and FONSI in February 2019. Documents and information regarding the Third Powerplant Overhaul Project are available online (Reclamation 2019e).

John W. Keys III Pump-Generating Plant Modernization Project

On March 12, 2012, a FONSI was signed authorizing the overhaul and modernization of the John W. Keys III Pump-Generating Plant. The main portion of the overhaul work will be completed within the confines of the John W. Keys III Pump-Generating Plant. The overhaul and modernization are scheduled for completion in 2034. Documents and information regarding the modernization are available online (Reclamation 2017).

Grand Coulee G1 through G18 Modernization and Overhaul Project

Reclamation is implementing this project to modernize and overhaul the power-generating units G1 through G18 in the left and right power houses at Grand Coulee Dam, by refurbishing or replacing key components. Reclamation would maintain current operations for FRM to protect communities and generate hydropower while the project is being implemented. Under the G1 through G18 Modernization and Overhaul Project, current hydrologic operations would be maintained, and, therefore, the project is not expected to have any impacts on water, or fisheries resources in the Columbia River or Lake Roosevelt. Reclamation completed an EA and FONSI in August 2018 for the Grand Coulee G1 through G18 modernization and overhaul (Reclamation 2018b).

FISH RESEARCH

Research studies may require special operations that differ from the routine operations otherwise described in the applicable and the current Fish Passage Plan. Variations in normal operations for research actions are coordinated with the TMT.

COORDINATION WITH REGIONAL TRIBES

Regional tribes participate in the development of fish-related plans such as the Fish Passage Plan and the Fish Operations Plan, and the co-lead agencies coordinate the operation of CRS reservoirs with these tribes. In addition to operations to support anadromous and resident fish and other resources important to the tribes, the co-lead agencies coordinate when CRS operations may directly impact resources or operations of tribally owned or operated facilities (e.g., at the Dworshak or Grand Coulee Projects). In some cases, the co-lead agencies operate specifically to support tribal activities, such as holding the reservoirs at certain elevations to support tribal fishing in the summer and fall. This is regularly done at the John Day, The Dalles, and Bonneville Projects.

NAVIGATION

The Corps maintains a shallow-draft navigation channel for barge transport, with a minimum depth of 14 feet, on the lower Snake and lower Columbia Rivers. For these projects, water managers in the Columbia River Basin adjust reservoir levels and spill patterns, reduce spill, or implement short-term spill curtailment, as needed to maintain safe navigation on the lower Snake River and lower Columbia River. Annual maintenance of the navigation facilities at the projects takes place in March. Major maintenance of the navigation system, including activities that may cause a temporary outage of barge traffic (e.g., gate maintenance or dredging) is conducted as needed and scheduled based on risk. These extended outages are coordinated regionally to reduce impacts to shippers and minimize economic disruption. Under the No Action Alternative, navigation operations and maintenance and operations for safety will continue.

RECREATION

The co-lead agencies operate projects to support recreation in various ways. In some instances, the change in operation might involve holding a specific reservoir at a specific elevation to support a short-term activity (e.g., boat races or weekend festivals). In other locations (Albeni Falls, Dworshak, and Grand Coulee), operations may plan to achieve refill elevations and hold them to support recreation pools over a longer season. Recreation is an authorized purpose of the CRS projects, and the co-lead agencies would continue current operational adjustments to support recreation, as needed, as long as operations do not negatively impact higher priority operations (e.g., FRM or fish and wildlife purposes).

MEASURES PREVIOUSLY COMMITTED TO BY THE CO-LEAD AGENCIES TO BENEFIT ENDANGERED SPECIES ACT–LISTED FISH

The co-lead agencies have coordinated with regional stakeholders to design and implement several measures to benefit ESA-listed fish species. The majority of these measures originate from USFWS or NMFS BiOp reasonable and prudent alternatives (RPAs). Measures include construction of habitat projects and are often coupled with research, monitoring, and evaluation (RM&E) efforts to inform trends, successful achievement of benefits and/or next-phase project details. Operational measures include guidelines for extensive regional stakeholder coordination such as annual water management plans and fish passage plans. Measures to benefit ESA-listed fish also include hatchery programs, predator management programs, and nutrient enhancement. Table 2-3 provides specific measures to benefit ESA-listed fish implemented under the No Action Alternative and lists the source of the measure (e.g., RPA).

Table 2-3. No Action Alternative Measures to Benefit Endangered Species Act–Listed Fish Species

Measure	Measure Name	Description
Habitat Measures	Tributary Habitat Implementation 2010–2018 for both Chinook salmon and steelhead	Specified construction projects, Research Monitoring and Evaluation (RM&E) actions, and species status and trend data collection habitat and survival improvement
	Kootenai White Sturgeon Habitat Restoration	Implementation of habitat project at a Tier 1 habitat restoration location
	Estuary Habitat Implementation 2010–2019	Specified construction projects, RM&E actions, and species status and trend data collection habitat and survival improvement
	Kootenai River White Sturgeon Nutrient Enhancement	Continued BPA support of nutrient enhancement in the Kootenai River through FY 2025
	Dworshak Reservoir Long-Term Nutrient Supplementation Program	Continued nutrient enhancement in the Dworshak Reservoir to enhance biological productivity of the reservoir for kokanee and reduction of algal blooms.
Operational Measures	Storage Project Operations (Upper Columbia Basin)	Develop **Annual Water Management Plan and Fish Operations Plan** for flow to aid juvenile fish passage
	Lower Columbia and Snake River Operations	Develop **Annual Water Management Plan and Fish Operations Plan** for flow to aid juvenile fish passage
	Sturgeon Operations at the Libby Project	Ongoing, seasonal flow augmentation from Libby Dam for Kootenai River white sturgeon, consistent with the **Flow Plan Implementation Protocol**; **Real-Time Management**
	Kootenai River Operations for Bull Trout	Libby Dam minimum flow to aid bull trout
	In-Season Water Management	Seasonal updates to the **Annual Water Management Plan**
	Operational Emergencies	**Real-Time Management** for unforeseen events
	Fish Emergencies	**Real-Time Management** for unforeseen events coordinated with Regional Forum
	Dry Year Operations	**Real-Time Management** when a dry water year is declared
	Water Quality Plan for TDG and Water Temperature	Maintain **Water Quality Plan** for TDG and water temperature in the mainstem Columbia and Snake Rivers
	Chum Spawning Flow	Coordination of operations via the TMT; **Real-Time Management**
	Turbine Unit Operations	Operate turbine units to achieve best fish passage survival (operate within 1 percent of best efficiency)
	Spill Operations to Improve Juvenile Passage	Define, and adjust within season, juvenile fish passage spill within the **Annual Fish Operations Plan** and **Fish Passage Plan**; **Real-Time Management**
	Juvenile Fish Transportation in the Columbia and Snake Rivers	Collect and transport juvenile fish from three Snake River dams to below Bonneville Dam per **Annual Fish Operations Plan** and **Fish Passage Plan**; **Real-Time Management**
	Fish Passage Plan	The Corps develops an **Annual Fish Passage Plan**

Measure	Measure Name	Description
Hatcheries	Federal Columbia River Power System (FCRPS) Mitigation Hatcheries – Programmatic	Continue support of hatcheries and adopt programmatic criteria for funding decisions on mitigation programs for the FCRPS that incorporate best management practices
	Kootenai River White Sturgeon Conservation Aquaculture	Continued BPA support of hatchery-raised Kootenai River white sturgeon for supplementation of lack of wild, natural recruitment
	Implement Safety Net Programs	Continue to identify and plan for ongoing "safety net" programs to provide benefits to ESA-listed stocks at high risk of extinction
	Conservation Programs to Build Genetic Resources	Continue to fund conservation programs that assist in recovery
Predator Management Measures	Northern Pikeminnow Management Program	Ongoing base program and general increase in northern pikeminnow sport-reward fishery reward structure
	Reduce Caspian Terns on East Sand Island in the Columbia River Estuary	Annual site preparations and hazing/dissuasion to maintain 1.0 acre of suitable habitat at East Sand Island and prevent birds from establishing satellite colonies outside of 1.0-acre colony site
	Double-Crested Cormorant	Plan implementation completed March 2019. Annual hazing ongoing with limited egg-take to maintain colony size objectives, as necessary.
	Inland Avian Predation	Plan implementation concluded in 2018. Ongoing monitoring of tern colony during nesting season through 2021 breeding season.
	Other Avian Deterrent Actions	Monitor avian predator activity, continue avian deterrent programs at all lower Snake and Columbia River dams. Part of annual **Fish Passage Plan**.
	Marine Mammal Control Measures	Install and improve, as needed, sea lion excluder gates at all main adult fish ladder entrances at Bonneville Dam annually

Measure	Measure Name	Description
Habitat Program	Lower Snake River Fish & Wildlife Compensation Plan	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 dams. A major component of the authorized plan was the design and construction of fish hatcheries and satellite facilities. Administered through the USFWS, the 25 LSRCP hatcheries and satellite facilities are operated by Idaho Department of 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). The LSRCP hatcheries and satellite facilities produce and release more than 19 million salmon and steelhead as part of the program's mitigation responsibility. Bonneville directly funds USFWS for the annual operation and maintenance of these LSRCP facilities. Corps also provides annual funding to implement other components of the LSRCP such as the management units for upland and riparian habitat (woody riparian initiative), a game bird farm, and other ongoing habitat management at locations across the lower Snake River basin.

BONNEVILLE'S FISH AND WILDLIFE PROGRAM AND DIRECT FUNDING AGREEMENTS WITH THE CORPS AND RECLAMATION

Bonneville's Fish and Wildlife Program funds hundreds of projects each year to mitigate the impacts of the development and operation of the Federal hydropower system on fish and wildlife. Bonneville began this program to fulfill mandates set by Congress in the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act), 16 U.S.C. § 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 BiOps 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 and climate variability on fish and wildlife. For example, Fish and Wildlife 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.

In their management and operation of the CRS, Bonneville, the Corps, and Reclamation have together fulfilled the other primary fish and wildlife mitigation mandate in the Northwest Power Act, providing fish and wildlife "equitable treatment" with the other congressionally authorized purposes of the FCRPS (16 U.S.C. § 839b(h)(11)(A)(i)). Since the 1990s, the Federal agencies have overhauled the system, achieving juvenile dam passage survival that meets or exceeds performance standards of 96 and 93 percent for spring and summer migrants, respectively,[7] a marked improvement as compared to when Congress passed the Act and the estimated average juvenile mortality at each mainstem dam and reservoir project was 15 to 20 percent, with losses recorded as high as 30 percent.[8] Travel time also improved for yearling Chinook and juvenile steelhead through the system, even in low flow years such as 2015.[9] And, total in-river survival has improved for migrating juvenile salmon and steelhead. Comparing two time periods reported in the National Oceanic and Atmospheric Administration's (NOAA) reach study, (1997–2007 and 2008–2016; Faulkner et al. 2017), there has been a 10 percent survival increase for hatchery and wild sockeye salmon, a 2 percent increase in hatchery and wild Chinook (4 percent for wild), and a 25 percent survival increase for hatchery and wild steelhead (13 percent for wild).

The Federal agencies achieved these results by installing turbine intake screens and bypass systems, modifying spillways (e.g., flow deflectors, surface spill weirs, and modified surface spill structures), and installing improved fish passage turbines while also experimenting with and adjusting flow and spill regimes to benefit salmon, steelhead, and sturgeon. Additional modifications to fish ladders have also been underway to increase passage of adult lamprey, including the installation of specialized lamprey passage structures at Bonneville, The Dalles and McNary Dams. These structural and operational improvements help fulfill ESA and Clean Water Act mandates while also harkening back to one of the original purposes of the Northwest Power Act—to mitigate for fish by providing suitable environmental conditions that are substantially obtainable from the management, operation, and configuration of the system (16 U.S.C. § 839(6)).

Habitat actions

Bonneville works with states, tribes, and watershed groups to protect, mitigate, and enhance spawning and rearing habitat, targeting factors that limit fish survival throughout the Columbia River Basin. Bonneville has funded hundreds of projects across the basin to restore natural stream channels, reconnect estuarine tidal channels, enhance flow volume and timing, and expand cold water refuges and open access to habitat (www.cbfish.org). These habitat improvement actions provide both near-term and long-term benefits, including those that will help address the effects of climate change. Actions that improve connectivity and streamflow will provide a buffer against the effects of climate change.

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[7] *See* Endangered Species Act Federal Columbia River Power System 2016 Comprehensive Evaluation – Section 1, at 17, t.2 (Jan. 2017).
[8] *See Nw. Res. Info. Ctr. v. Nw. Power Planning Council*, 35 F.3d 1371, 1374 (9th Cir. 1994) (*citing* the U.S. General Accounting Office, *Impacts and Implications of the Pacific Northwest Power Bill*, at 22 (Sept. 4, 1979)).
[9] 2016 Comprehensive Evaluation at page 20.

In addition to habitat improvement actions, Bonneville works with willing landowners to protect land by putting it under permanent conservation easement to further support habitat and fish conservation in the short and long term.

Hatchery actions

Bonneville constructed and now funds the operation and maintenance of over 20 compensation, conservation, and supplementation hatchery programs throughout the Columbia and Snake River basins to preserve, rebuild, and reduce extinction risk for ESA-listed fish species as well as to meet Northwest Power Act objectives to protect, mitigate, and enhance fish and wildlife affected by the FCRPS. The conservation hatchery programs help rebuild and enhance the naturally reproducing ESA-listed fish in their native habitats using locally adapted broodstock, while maintaining genetic and ecologic integrity, and supporting harvest where and when consistent with conservation objectives. These hatchery programs include captive propagation for critically endangered Snake River sockeye, Snake River spring/summer Chinook supplementation, Snake River fall Chinook supplementation, reintroduction of spring Chinook in the Okanagan Basin, coho salmon reintroduction and supplementation in the middle and upper Columbia basins, reconditioning of middle and upper Columbia and Snake River steelhead kelts, Kootenai River white sturgeon, burbot, and westslope cutthroat trout.

Predation

Bonneville's Fish and Wildlife Program funds efforts to address the mortality of ESA-listed and non-listed fish caused by predators including birds, fish, and mammals. Certain types of fish in rivers are voracious consumers of juvenile salmon and steelhead. Predation by introduced fish species in reservoirs is also a concern. Other predators are known to consume substantial numbers of adult spring Chinook salmon and winter steelhead below Bonneville Dam, and injure adult fish that migrate upstream. Bonneville funds projects to reduce the impact of these predator species on native fish.

Lamprey

Several lamprey species, both anadromous and resident, are native to the Columbia River Basin, which historically supported productive populations. Much of the research and mitigation effort in the basin is currently focused on the anadromous Pacific lamprey due to its cultural importance to tribes and vital role in the ecosystem. At present, Bonneville funds six lamprey projects to improve understanding of Pacific lamprey status and limiting factors, implement high-priority habitat restoration actions, increase populations through reintroduction and translocation efforts, and conduct artificial propagation research with plans to release hatchery juveniles in select areas pending an environmental assessment.

Wildlife Mitigation for Construction, Inundation, and Operations

When the CRS dams were built and the reservoirs behind them filled, they inundated about 308,996 acres, much of it important fish and wildlife habitat. To calculate the area affected by CRS development—dam construction and inundation by the reservoirs behind them—Bonneville relied on either the amounts agreed upon in negotiated mitigation agreements with state and tribal entities or the loss assessments prepared by Federal, state, and tribal wildlife managers.[10]

To date, Bonneville has implemented numerous wildlife habitat projects to address the impact of the development of the FCRPS, many of which included acquisition and permanent protection of wildlife habitat. Bonneville also provides operations and maintenance funding for these projects.

The loss assessments relating to dam construction and inundation considered all habitat losses up to and including full reservoir pool levels. As such, mitigation for those losses can also serve to address the effects of reservoir operations on wildlife habitat, to the extent that such operational impacts occur below full pool level.

While much of the mitigation work was implemented through annual contracts, Bonneville and its partners negotiated “settlement agreements” to complete the wildlife mitigation for construction and inundation impacts, and some operational impacts, for Dworshak, Libby, Hungry Horse and part of the impacts from the Albeni Falls Dams. These settlements allowed Bonneville and the affected states or tribes to agree on an appropriate amount of mitigation to be done and the funding or other consideration Bonneville would provide.

- ***Albeni Falls Dam.*** In the 2018 Albeni Falls Dam Wildlife Mitigation Agreement, Bonneville and the State of Idaho established that 14,087 acres had been mitigated through the efforts of the state and three tribes to address wildlife impacts from the construction and inundation of the dam (6,617 acres were impacted as a result of the construction and inundation of Albeni Falls Dam).[11] In addition, Bonneville agreed to fund the State of Idaho to protect and enhance 1,279 acres of wetland habitat at the Clark Fork Delta and an additional 99 acres at the Priest River Delta to address the upriver effects of Albeni Falls operations. This is in addition to the 624 acres of wetland protected and enhanced on the Clark Fork Delta by IDFG, which was funded by Bonneville through a letter agreement in 2012.

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[10] Bonneville funded but did not control the production of wildlife habitat loss assessments by wildlife managers in the mid-1980s and early 1990s. These documents, also called “Brown Books,” are on file with Bonneville. The Brown Books generally reflect the acres inundated by the FCRPS as determined by the surface area of the reservoirs created behind each dam (e.g., USFWS 1990).

[11] Northern Idaho Memorandum of Agreement Between the State of Idaho and the Bonneville Power Administration for Wildlife Habitat Stewardship and Restoration section II.C, page 5 (2018) (on file with Bonneville).

- ***Dworshak Dam*.** The 1992 Dworshak Wildlife Mitigation Agreement with the State of Idaho and the Nez Perce Tribe, frequently referred to as the "Dworshak Settlement," fully mitigated the impacts to wildlife from the construction and inundation of Dworshak Dam estimated at 16,970 acres.[12] To determine this acreage, Bonneville relied on the Dworshak Wildlife Agreement reports from the tribe. The tribe's 2018 annual report indicates it has purchased 7,576 acres and still has over $9.5 million remaining in its mitigation fund established under the agreement (Nez Perce Tribe 2018). The State of Idaho also has a $3 million fund provided by Bonneville to manage the 60,000-acre Peter T. Johnson Unit of the Craig Mountain Wildlife Management Area (formerly known as Craig Mountain), which Bonneville purchased and transferred to the State of Idaho (IDFG 2014). All told, Bonneville has already funded 67,576 acres of mitigation for Dworshak Dam.
- ***Montana Dams*.** As with Dworshak, Bonneville fully addressed the construction and inundation mitigation for wildlife occurring around Libby and Hungry Horse dams using a comprehensive long-term agreement. To determine acreage protected, Bonneville relied on reports from Montana Fish, Wildlife, and Parks. Under the 1989 Montana Wildlife Mitigation Trust Agreement (MFWP 2013), Montana has protected or enhanced 272,104 acres (the Northwest Power Planning Council's program called for a total of 55,837 acres for Libby and Hungry Horse Dams split between 29,171 acres of enhancement and 26,666 acres of protection; MFWP 2019).[13]

DIRECT FUNDING AGREEMENTS WITH THE CORPS AND RECLAMATION

In addition to Bonneville's fish and wildlife mitigation described above, there are also fish and wildlife mitigation costs that are direct funded by Bonneville to the Corps and Reclamation for mitigation activities, such as hatchery operations, fish stocking, elk habitat maintenance, and others. The specifics of these programs are described below.

Lower Snake River Compensation Plan

In addition to the hatchery operations that are funded through the Fish and Wildlife Program, Bonneville directly funds the annual operations and maintenance of the 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. The LSRCP is administered through the USFWS. The LSRCP hatcheries and satellite facilities produce and release more than 19 million salmon and steelhead as part of the program's mitigation

[12] Crediting Forum, Final Report 3.
13 See Northwest Power Planning Council, 1987 Columbia River Basin Fish and Wildlife Program § 1000 138–39 tbl.4, https://www.nwcouncil.org/media/6843101/1987Program.PDF; see also, Montana Fish, Wildlife and Parks, Program for Mitigating Wildlife Impacts Caused by construction of Libby and Hungry Horse Dams: Five-Year Operating Plan 3 (July 1, 2009) (citing Yde and Olsen (1984)), http://fwp.mt.gov/fwpDoc.html?id=53780 [hereinafter Program for Libby and Hungry Horse].

responsibility. Corps also provides annual funding to implement other components of the LSRCP such as the management units for upland and riparian habitat (woody riparian initiative), a game bird farm, and other ongoing habitat management at locations across the lower Snake River basin. LSRCP would be continued, consistent with the No Action Alternative, under all of the Multiple Objective Alternatives except for MO3.

2.4.3 Multiple Objective Alternative 1

MO1 was developed to integrate actions that would benefit both juvenile and adult life stages of ESA-listed anadromous fish, as well as measures to benefit ESA-listed resident fish. At the same time, this alternative incorporates measures for water management flexibility, hydropower production, and additional water supply.

MO1 differs from the other alternatives by carrying out a juvenile fish passage spill operation referred to as a block spill design. The block spill design alternates between a base operation that releases surface flow, where juvenile fish are most present, over the spillways using different flows at each project versus the same target at all projects. For the block that uses the same target at all projects, the operators would release flow through the spillways up to a target of no more than 120 percent TDG in the tailrace of projects and 115 percent TDG in the forebay of those projects. In addition, MO1 sets the duration of this juvenile fish passage spill to end based upon a fish count trigger rather than a predetermined date. MO1 proposes to initiate transport operations for juvenile fish approximately 2 weeks earlier than under the No Action Alternative.

After establishing the juvenile fish passage spill measure, MO1 incorporated measures to increase hydropower generation flexibility in the lower basin projects and use stored water at Dworshak for downstream water temperature control in the summer. MO1 then includes measures similar to the other action alternatives, which include increased water management flexibility, water supply, opportunities for disruption of ESA-listed fish predators, and optimize inclusion of local forecasts for upper basin projects into whole-basin planning.

All measures included in MO1 are listed in Table 2-4, and a brief description of those measures is contained in the following section.

Table 2-4. Measures of Multiple Objective Alternative 1

Measure Description	Abbreviated Measure Name
Structural Measures	
Construct additional powerhouse surface passage routes at McNary and Ice Harbor Dams	Additional Powerhouse Surface Passage
Upgrade spillway weirs to ASWs	Upgrade to Adjustable Spillway Weirs
Improve adult ladder passage through modification of adult trap at Lower Granite Dam	Lower Granite Trap Modifications
Modify the upper ladder serpentine flow control ladder sections at Bonneville Dam	Modify Bonneville Ladder Serpentine Weir

Measure Description	Abbreviated Measure Name
Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Dams	Lower Snake Ladder Pumps
Expand network of LPSs to bypass impediments	Lamprey Passage Structures
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Install improved-fish passage turbines at John Day	Improved Fish Passage Turbines
Operational Measures	
Fish Passage	
Operate spill to evaluate latent mortality hypothesis; alternate base spill and spill cap 120/115 percent TDG	Block Spill Test (Base + 120/115%)
Modify summer juvenile fish passage spill operations to end based on fish collection numbers	Summer Spill Stop Trigger
Change start of juvenile fish transportation during spring juvenile fish passage spill operations	Early Start Transport
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
Water Management	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee
Operational constraints for ongoing Grand Coulee maintenance of power plants	Grand Coulee Maintenance Operations
Develop draft requirements/assessment approach to protect against rain-induced flooding	Winter System FRM Space
Water Supply	
Increase volume of water pumped from Lake Roosevelt during annual irrigation season	Lake Roosevelt Additional Water Supply
Increase water managers' flexibility to store and release water from Hungry Horse Reservoir	Hungry Horse Additional Water Supply
Increase water diversion from the Columbia River for the Chief Joseph Dam Project	Chief Joseph Dam Project Additional Water Supply
Hydropower	
Increase forebay operating range flexibility at the lower Snake River and John Day projects for hydropower generation flexibility.	Increased Forebay Range Flexibility

Measure Description	Abbreviated Measure Name
Other Operational	
Implement modified timing of Lower Snake Basin reservoir draft for additional cooler water	Modified Dworshak Summer Draft
Implement sliding scale summer draft at Libby and Hungry Horse	Sliding Scale at Libby and Hungry Horse
Manipulate lower Columbia reservoir elevations to disrupt juvenile salmonid predator reproduction	Predator Disruption Operations

2.4.3.1 Multiple Objective Alternative 1 Description of Measures

STRUCTURAL MEASURES

Construct additional powerhouse surface passage routes at Ice Harbor and McNary Dams

This measure will be referred to as "Additional Powerhouse Surface Passage" throughout the remainder of this EIS. This measure would reestablish the operation of existing ice and trash sluiceways for fish passage, which had been ceased to accommodate updated fish collection procedures. To implement this measure, existing bulkheads would be replaced with telescoping weirs. This would also require modifications to the existing juvenile fish facility and to the floor elevation at McNary Project. Operation of these sluiceways would divert 8 kcfs from the powerhouse at McNary. The diversion at Ice Harbor would amount to 4 kcfs from the powerhouse. The surface passage would be used March 1 to August 31.

Upgrade existing spillway weirs to adjustable spillway weirs

This measure will be referred to as "Upgrade to Adjustable Spillway Weirs" throughout the remainder of this EIS. This measure would replace those existing spillway weirs that are not adjustable with adjustable spillway weirs, which will provide better operational flexibility based on river flows. Two dams, McNary and John Day, would receive the upgrades. One weir would be upgraded at McNary and two weirs would be upgraded at John Day. This measure would contribute to meeting objective 1 to improve passage for ESA-listed juvenile anadromous fish.

Improve adult ladder passage through modification of adult trap and adult trap bypass loop at Lower Granite Dam

This measure will be referred to as "Lower Granite Trap Modifications" throughout the remainder of this EIS. This measure would reconfigure the existing adult trap bypass at the Lower Granite Project to reduce the height that adult fish must ascend, reduce deployment of the main fish ladder diversion gate, and to use a vacuum tube to move adult fish that are handled for monitoring and research at the trap. This measure would contribute to meeting objective 2 to improve passage for adult ESA-listed anadromous fish.

Modify the upper ladder serpentine flow control ladder sections at Bonneville Project

This measure will be referred to as "Modify Bonneville Ladder Serpentine Weir" throughout the remainder of this EIS. This measure would modify the upper serpentine flow control fish ladder sections at the Bonneville Project, 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. This measure is intended to benefit adult fish passage and would contribute to meeting objective 2 for adult ESA-listed anadromous fish.

Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Projects

This measure will be referred to as "Lower Snake Ladder Pumps" throughout the remainder of this EIS. This measure would install pumping systems for the fish ladders at Lower Monumental and Ice Harbor projects. The pumps would pull water from elevations deep in the reservoir to provide cooling water to fish ladders and at fish ladder entrances to reduce thermal barriers to adult fish passage for adult salmon migrating upstream. This measure would contribute to meeting objective 2 to improve adult ESA-listed anadromous fish migration.

Expand network of lamprey passage structures to bypass impediments in existing fish ladders

This measure will be referred to as "Lamprey Passage Structures" throughout the remainder of this EIS. Existing fish ladders at the John Day and Bonneville Projects would be modified 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 passage structures 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 the 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 the John Day Project, a lamprey passage structures would be constructed on the south fish ladder and the existing lamprey passage structures on the north ladder would be extended from the tailrace deck to the forebay.

This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Modify turbine cooling water strainer systems to safely exclude Pacific lamprey

This measure will be referred to as "Turbine Strainer Lamprey Exclusion" throughout the remainder of this EIS. This measure would install structures to prevent juvenile lamprey and all other fish from being entrained into the turbine unit cooling water source. A hood would be installed over the existing intake grating and allow sweeping flows to move fish past the opening, making entrainment unlikely, and keeping all fish out of the cooling water piping. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Modify turbine intake bypass screens that cause juvenile lamprey impingement

This measure will be referred to as "Bypass Screen Modifications for Lamprey" throughout the remainder of this EIS. This measure would replace existing fish screens used to divert fish into the collection channel of the juvenile bypass system. The co-lead agencies would replace existing extended-length bar screens with submerged traveling screens to reduce juvenile lamprey entanglement at the McNary, Little Goose, and Lower Granite Projects. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Modify existing fish ladders, incorporating lamprey passage features and criteria

This measure will be referred to as "Lamprey Passage Ladder Modifications" throughout the remainder of this EIS. This measure would modify existing fish ladders at the lower Snake and lower Columbia River projects as follows:

- **Install ramps to salmon orifices at Bonneville Project** 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 Project (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. The diffuser adds water to the fish ladder to increase flows in the ladder, but existing grating and water velocities make it difficult for lamprey to pass through the wall passage orifices. This 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 Project** 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 Project** Install a metal wall in the serpentine section of the Washington shore fish ladder at Bonneville Project (similar to that already installed in the Bradford Island ladder). This would provide an alternate upstream passage route for migrating adult lamprey and allow the lamprey to escape the higher water velocities in the fish 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. Rounding these edges would provide lamprey a constant attachment surface to

overcome the high water velocities encountered at the entrance of the fish ladders. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Install improved fish passage turbines at John Day

This measure will be referred to as "Improved Fish Passage Turbines" throughout the remainder of this EIS. This measure would install improved fish passage (IFP) turbines at the John Day Project to improve hydraulic conditions for fish passing through the turbines. These IFP turbines are designed to improve hydropower turbine efficiency and hydraulic conditions for fish passing through the turbines, similar to the IFP turbines at the Ice Harbor Project. The existing 16 turbines would be replaced two at a time over a period of approximately 8 to 12 years. This measure would contribute to meeting objectives 4 and 5 by installing new turbines for an efficient and reliable power supply that minimizes greenhouse gas emissions, indirectly improve water quality by reducing total dissolved gas (TDG). Because the turbines are designed to minimize negative impacts to fish passing through the powerhouse, it would also contribute to meeting objective 1, which strives to improve passage and survival for ESA juvenile anadromous fish.

OPERATIONAL MEASURES

Operate spill test to evaluate latent mortality hypothesis; alternate base spill and spill cap 120/115 percent TDG

This measure will be referred to as "Block Spill Test (Base + 120/115%)" throughout the remainder of this EIS. This measure is to operate the lower Snake River and lower Columbia River projects in a manner that allows comparison of two different fish passage spill operations by alternating between a base spill operation and a test spill operation. The details of the two spill operations are contained in Table 2-5. The base spill would be implemented first in year one, and the test block operations implemented first the following year. These operations would be implemented annually from April 3 to June 20 for the lower Snake River projects and from April 10 to June 15 for the lower Columbia River projects. The block spill operations would exchange specific dates biannually while holding overall spill dates constant. This measure would contribute to meeting objective 1, as it is intended to improve passage for ESA-listed anadromous fish.

Table 2-5. Juvenile Fish Passage Spill Measure for Multiple Objective Alternative 1

Location	Spring Base Spill Operation: (Volume/Percent of Total Flow Routed to Spillway)	Spring Test Spill Operation: (Volume/Percent of Total Flow Routed to Spillway)
Lower Granite	20 kcfs	120/115% Gas Cap[1/]
Little Goose	30%	120/115% Gas Cap[1/]
Lower Monumental	120/115% Gas Cap[1/]	120/115% Gas Cap[1/]
Ice Harbor	30%	120/115% Gas Cap[1/]
McNary	48%	120/115% Gas Cap[1/]

Location	Spring Base Spill Operation: (Volume/Percent of Total Flow Routed to Spillway)	Spring Test Spill Operation: (Volume/Percent of Total Flow Routed to Spillway)
John Day	32%	120/115% Gas Cap[1/]
The Dalles	40%	120/115% Gas Cap[1/]
Bonneville	100 kcfs	120/115% Gas Cap[1/]

1/ 120/115% Gas Cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state law in 2017. Co-lead agencies would manage juvenile fish passage spill on a daily 24-hour basis. Implementation of the daily spill averaging would facilitate integration of renewable power, including solar and wind power.

Modify summer juvenile fish passage spill operations to end based on fish collection numbers

This measure will be referred to as "Summer Spill Stop Trigger" throughout the remainder of this EIS. The existing spill regime at the lower Snake and lower Columbia River projects would be modified to curtail fish passage spill when fish collection numbers at the projects remain below 300 juvenile fish for four consecutive days. This has potential to end summer spill at one or more of the lower Snake River projects as early as August 1, and all spill operations would cease by August 31. This operation would begin annually June 21, and end when the criteria described here is met. This measure would modify current spill operations, which are undertaken to improve ESA-listed juvenile fish passage . Thus, it contributes to meeting objective 1.

Change start of juvenile fish transportation during spring juvenile fish passage spill operations

This measure will be referred to as "Early Start Transport" throughout the remainder of this EIS. The transport of juvenile salmon collected at the Lower Granite, Little Goose, and Lower Monumental Projects would begin on April 15, approximately two weeks earlier than current fish transport operations described in the No Action Alternative, to potentially increase the total number of juvenile fish transported. 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 the Bonneville Project 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 was developed to contribute to meet objective 1, which is intended to improve survival and passage of ESA-listed juvenile anadromous fish.

Allow contingency reserves to be carried within juvenile fish passage spill

This measure will be referred to as "Contingency Reserves Within Juvenile Fish Passage Spill" throughout the remainder of this EIS. This measure would allow operations to change fish spill for short durations during fish passage spill season. The change would be implemented to meet energy demands that are caused by unexpected events such as transmission interruption or the failure of a generator. These events are rare and, when they occur, the co-lead agencies may be able to cover the contingencies without temporarily reducing spill. This measure would provide operating flexibility to allow Bonneville to carry required reserves on the turbines to ensure grid reliability. This measure would be implemented at all lower Snake River and lower Columbia

River projects during the fish spill season. This measure would contribute to meeting objective 4 to provide an adequate, efficient, and reliable power supply.

Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less

This measure will be referred to as "Modified Draft at Libby" throughout the remainder of this EIS. This measure would base the date for initiation of refill of Lake Koocanusa on the local forecast of water volume in the Kootenai River Basin of the CRS during lower water years, rather than on the No Action Alternative practice of initiating refill based upon water volume forecast in the lower Columbia River at The Dalles. This would modify water operations at Libby to provide water managers more flexibility to respond to local conditions in the upper basin. The measure would change flow management so that local flood durations and the start of refill operations are tied to Kootenai Basin runoff. The new procedure will also take into consideration other planned releases for resources such as resident fish.

This measure would provide more flood space for local high spring flow, and lower the risk of filling the reservoir early, which can result in a need to spill to create more flood space before the end of the FRM operations season. This measure was developed to contribute to meet objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions. As this operation is implemented, adjustments to provide more space in the reservoir may be made in coordination with interested parties if new information emerges about nutrient flushing and temperature impacts that could not be captured with the current modeling tools.

Eliminate end-of-December variable draft at Libby and replace with single draft target

This measure will be referred to as "December Libby Target Elevation" throughout the remainder of this EIS. This measure would change current operations at Libby from a variable draft implemented at the end of December to a fixed draft target of elevation 2,420 feet NGVD29 to prevent over-drafting of the reservoir in years that have less precipitation than forecasted. In most years, this operation would allow the reservoir draft to be shifted from November/December to January/February, holding more water in the reservoir longer to meet demand in drier years, and providing flexibility for water managers to adapt to a wide range of runoff conditions throughout the water year. It would support delivery of nutrients and water temperatures that support sturgeon during the sturgeon flow augmentation operation. This measure was developed to contribute to meet objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Update the upstream Storage Corrections Method as applied to the Grand Coulee Storage Reservoir Diagram

This measure will be referred to as "Update System FRM Calculation" throughout the remainder of this EIS. This measure would change the end-of-month maximum flood space elevation of Lake Roosevelt at Grand Coulee based on whether the storage reservoirs upstream of Grand Coulee had drafted to reach their required flood space elevations at the end of the months of January, February, March, and April. If one or more upstream storage reservoirs were unable to draft down to their required flood space elevations at the end of each of those months, then Lake Roosevelt would be used to provide additional flood storage space for the CRS. This measure differs from the No Action Alternative by allowing the Grand Coulee Project to better respond to changing conditions in the upstream storage reservoirs. There would be no change to the current level of FRM, but rather, a shift in where flood space is held. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Decrease the Grand Coulee Project draft rate used in planning drawdown

This measure will be referred to as "Planned Draft Rate at Grand Coulee" throughout the remainder of this EIS. This measure would change the way that Lake Roosevelt is drawn down to reach flood space elevations in winter and spring at Grand Coulee. Under the proposed operation, the reservoir drawdown would begin earlier, and the reservoir elevations would be lowered more slowly in order to reduce the risk of landslides along the shoreline. The current rate would be reduced in the Planned Draft Rate at Grand Coulee from 1 ft/day to 0.8 ft/day. Ultimately, the deepest lake elevations for system FRM are not changed by this measure, but the timing and rate for reaching those lower reservoir elevations would change. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Operational constraints for ongoing Grand Coulee maintenance of power plants

This measure will be referred to as "Grand Coulee Maintenance Operations" throughout the remainder of this EIS. This measure would expedite the maintenance schedule for the power plants and spillways of the Grand Coulee Project relative to the No Action Alternative schedule. The maintenance on the power plants would reduce the number of units available, requiring additional spill in some situations. The project would keep 27 of the 40 regulating gates and/or eight drum gates in service and take the others out of service to perform spillway maintenance activities at an accelerated rate. The expedited maintenance schedule has the potential to complete maintenance activities sooner; this could increase reliability and hydraulic capacity through powerplants while decreasing the risk of unplanned maintenance that often leads to non-fish passage spill. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions. This measure would also contribute to meeting objective 4 to provide a reliable power supply by supporting maintenance of the turbines at Grand Coulee.

Develop draft requirements/assessment approach to protect against rain-induced flooding

This measure will be referred to as "Winter System FRM Space" throughout the remainder of this EIS. This measure would increase flood space in Grand Coulee by 650,000 acre-feet to protect against rain-induced flooding downstream. In order to provide the necessary space, Grand Coulee would be drafted more deeply from mid-December through March. All other existing winter operations described in the No Action Alternative would remain the same. This measure is intended to increase operational flexibility to maintain flood risk protection for the lower Columbia River. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Increase volume of water pumped from Lake Roosevelt during annual irrigation season

This measure will be referred to as "Lake Roosevelt Additional Water Supply" throughout the remainder of this EIS. This measure would deliver 4,472,138 acre-feet of water, the amount of water required to irrigate the full number of authorized acres for the CBP, by increasing the amount of water pumped from Lake Roosevelt for irrigation and municipal and industrial water supply. This is an increase of 1,154,138 acre-feet over current withdrawals. This water volume could be delivered annually, generally during the irrigation season (April through October), from Lake Roosevelt at Grand Coulee, as the demand arises. Additionally, this measure would change the timing of delivery of recently developed water supplies for the Odessa Subarea of the CBP (164,000 acre-feet for irrigation and 15,000 acre-feet for M&I of the current supplies) from September and October to when the water is needed, on demand. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Increase water managers' flexibility to store and release water from Hungry Horse Reservoir

This measure will be referred to as "Hungry Horse Additional Water Supply" throughout the remainder of this EIS. This measure would change water management operations at Hungry Horse to ensure that an additional 90,000 acre-feet of water is available for delivery annually to fulfill the water rights settlement with the Confederated Salish and Kootenai Tribes. Operations would prioritize maintaining enough water to meet flow augmentation requirements and the delivery of 90,000 acre-feet of water to the Confederated Salish and Kootenai Tribes for irrigation and municipal and industrial purposes, as outlined in the settlement. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Increase water diversion from the Columbia River for the Chief Joseph Dam Project

This measure will be referred to as "Chief Joseph Dam Project Additional Water Supply" throughout the remainder of this EIS. This measure would prioritize annual delivery of 9,600 acre-feet of irrigation water to the Chief Joseph Dam Project. Deliver the full congressionally authorized amount of water for the irrigation of lands downstream of Chief Joseph Dam using water from the Chief Joseph Project. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Increase forebay operating range flexibility at the lower Snake River and John Day Projects for hydropower generation flexibility

This measure will be referred to as "Increased Forebay Range Flexibility" throughout the remainder of this EIS. This measure would provide operating flexibility during the fish passage season (April 3 to August 31) by changing the operating elevation range restriction at the lower Snake and John Day projects. The lower Snake projects would operate within a 1.5-foot MOP range, and John Day would operate within a 2-foot MIP range (262.5 to 264.5 feet NGVD29), except from April 1 to May 31 when the John Day forebay operating range would remain between elevations 263.5 and 265 feet NGVD29. This operating range restriction would end when spill is reduced or ends. Safety-related restrictions would continue, including, but not limited to, maintaining ramp rates to minimize shoreline erosion and maintain power grid reliability. This measure is intended to increase flexibility for water management, shaping hydropower production to meet energy demand and maintain power grid reliability. This measure would contribute to meeting objective 4, with the goal of providing an adequate, efficient, economical, and reliable power supply that supports the Columbia River power system.

Implement modified timing of the lower Snake Basin reservoir draft for additional cooler water

This measure will be referred to as "Modified Dworshak Summer Draft" throughout the remainder of this EIS. This measure would alter the current draft schedule at Dworshak to provide more cooling water in the lower Snake River to benefit migrating adult salmonids at different times than described in the No Action Alternative. The draft would be tied to water temperatures from year to year, but generally, drafting from Dworshak Reservoir would begin June 21 to August 1 for migrating sockeye salmon and summer Chinook. The later draft (September 1 to September 30) would provide cooling water for fall Chinook and steelhead. This measure would contribute to meeting objective 2, which is intended to improve passage and migration for adult ESA-listed anadromous fish.

Implement a sliding-scale summer draft at Libby and Hungry Horse

This measure will be referred to as "Sliding Scale at Libby and Hungry Horse" throughout the remainder of this EIS. The trigger for summer draft from the Libby and Hungry Horse Projects for downstream fish will be changed from a system forecast point to a local forecast point. The Libby and Hungry Horse Projects would be operated based on local water supply conditions to allow water managers more flexibility to balance local resident fish priorities in the upper basin with downstream flow augmentation for the middle and lower basin. In addition, the change in draft elevation would occur over a range, a "sliding scale," rather than an abrupt point when the water supply forecast changes. This measure would contribute to meeting objective 3 to improve resident fish survival and spawning success at CRS projects.

Manipulate lower Columbia River reservoir elevations to disrupt juvenile salmonid predator reproduction

This measure will be referred to as "Predator Disruption Operations" throughout the remainder of this EIS. This measure would manipulate reservoir elevations on the John Day Reservoir to disrupt avian nesting on islands in the reservoir. The action would dissuade colonies of species known to consume high numbers of outmigrating juvenile salmon and steelhead from nesting . The measure would allow water managers to fluctuate pool elevations between 263.5 and 265 feet NGVD29, a 1.5-foot operating range, during the months of April and May. This measure would contribute to meeting objective 1, intended to improve the survival and passage of ESA-listed juvenile anadromous fish.

2.4.4 Multiple Objective Alternative 2

MO2 was developed to increase hydropower production and reduce regional greenhouse gas emissions while avoiding or minimizing negative impacts to other authorized project purposes and co-lead agency missions. It would slightly relax the No Action Alternative's restrictions on operating ranges and ramping rates to evaluate the potential to increase hydropower production efficiency and increase operators' flexibility to respond to changes in power demand and changes in generation of other renewable resources. The measures within MO2 would increase the ability to meet power demand with hydropower production during the most valuable periods (e.g., winter, summer, and daytime peak demands). The upper basin storage projects would be allowed to draft slightly deeper, up to 10 feet below Upper Rule Curve (URC) values (Appendix I, *Hydroregulation*, modeling data sheets), allowing more hydropower generation in the winter and less during the spring.

MO2 also differs from the other alternatives by excluding the water supply measures and evaluating an expanded juvenile fish transportation operation season. This alternative proposes to transport all collected ESA-listed juvenile fish for release downstream of the Bonneville Project by barge or truck and reducing juvenile fish passage spill operations to a target of near 110 percent TDG. Inclusion of the target near 110 percent TDG spill operation provides the lowest end of the range of juvenile fish passage spill operations evaluated in this EIS.

Structural measures of MO2 are aimed at benefits for ESA-listed fish and lamprey. These measures are similar to other alternatives and include making improvements to adult fish ladders, upgrading spillway weirs, adding powerhouse surface passage, and turbine upgrades at John Day. A brief description of the measures contained in MO2 are provided in Table 2-6 and listed below.

Table 2-6. Measures of Multiple Objective Alternative 2

Measure Descriptions	Abbreviated Measure Name
Structural Measures	
Install improved fish passage turbines at John Day	Improved Fish Passage Turbines
Construct powerhouse and/or spill surface passage routes at John Day, McNary and Ice Harbor Dams	Additional Powerhouse Surface Passage
Cease installation of fish screens at Ice Harbor, McNary and John Day Projects	Fewer Fish Screens
Upgrade spillway weirs to ASWs	Upgrade to Adjustable Spillway Weirs
Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Dams	Lower Snake Ladder Pumps
Expand network of LPSs to bypass impediments	Lamprey Passage Structures
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Operational Measures	
Fish Passage	
Limit fish passage spill to near 110 percent TDG	Spill to 110% TDG
Juvenile fish transportation at Lower Granite, Little Goose, Lower Monumental, and McNary down to Bonneville Dam April 25 to August 31	Increase Juvenile Fish Transportation
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
Water Management	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee
Operational constraints for ongoing Grand Coulee maintenance of power plants	Grand Coulee Maintenance Operations
Develop draft requirements/assessment approach to protect against rain-induced flooding	Winter System FRM Space
Hydropower	
Ramping rate limitations at all projects will be defined only for safety or engineering	Ramping Rates for Safety
At the four lower Snake River projects, operate within the full reservoir operating range year-round	Full Range Reservoir Operations
At John Day, allow project to operate up to full pool except as needed for FRM	John Day Full Pool

Measure Descriptions	Abbreviated Measure Name
The storage projects may be drafted slightly deeper for hydropower	Slightly Deeper Draft for Hydropower
Operate turbines across their full range of capacity year-round	Full Range Turbine Operations
Zero generation operations may occur on lower Snake River projects November through February	Zero Generation Operations
Other Operational	
Implement sliding scale summer draft at Libby and Hungry Horse Dams	Sliding Scale at Libby and Hungry Horse

2.4.4.1 Multiple Objective Alternative 2 Description of Measures

STRUCTURAL MEASURES

Improved Fish Passage Turbines

This measure is the same as described in MO1. This measure would contribute to meeting objectives 4 and 5 by installing new turbines for an efficient and reliable power supply that minimizes greenhouse gas emissions. Because the turbines are designed to minimize negative impacts to fish passing through the powerhouse, it would also contribute to meeting objective 1, which strives to improve passage and survival for ESA juvenile anadromous fish.

Additional Powerhouse Surface Passage

This measure is the same as described in MO1, though it also includes the John Day Project. This measure would contribute to meeting objective 1 to improve passage for ESA-listed juvenile anadromous fish.

Cease installation of fish screens at Ice Harbor, McNary, and John Day Projects

This measure will be referred to as "Fewer Fish Screens" throughout the remainder of this EIS. This measure would potentially cease installation of fish screens to increase the efficiency of hydropower turbines at the Ice Harbor, McNary, and John Day Dams once IFP turbines are installed. This measure is intended to consider running the new IFP turbines unscreened if warranted biologically similar to the process implemented once turbines were replaced at the first powerhouse at Bonneville Dam. The co-lead agencies would collaborate with NMFS and USFWS to develop a Turbine Intake Bypass Screen Management and Future Strategy process to monitor success of the improved fish passage turbines and determine when best to remove fish screens at these projects.

Upgrade to Adjustable Spillway Weirs

Removal of fish screens would make hydropower production more efficient . Thus, this measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply.

Lower Snake Ladder Pumps

This measure is the same as described in MO1. This measure would contribute to meeting objective 2 to improve adult ESA-listed anadromous fish migration.

Lamprey Passage Structures

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for pacific lamprey.

Turbine Strainer Lamprey Exclusion

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for pacific lamprey.

Bypass Screen Modifications for Lamprey

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for pacific lamprey.

Lamprey Passage Ladder Modifications

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for pacific lamprey.

OPERATIONAL MEASURES

Limit fish passage spill to 110 percent TDG

This measure will be referred to as "Spill to 110% TDG" throughout the remainder of this EIS. This measure would decrease spill for juvenile fish passage from the current operational levels, and limit fish passage spill to near the 110 percent TDG levels, as measured in-river (including tailraces and downstream forebays), except when minimum spill levels are higher, including spill needed for the powerhouse surface passage routes, for the spillway weirs, and/or for adult attraction to fish ladders. These operations would be implemented at the four lower Snake River and the four lower Columbia River projects. Spill during high flow and flood events would not be constrained to a cap of 110 percent TDG, but would be set to levels necessary to ensure public safety. Lack of market spill would follow the spill priority list set by TMT. These spill operations would be implemented annually beginning April 3 at the lower Snake River projects and April 10 at the lower Columbia River projects. Juvenile fish passage spill at all projects would cease at midnight July 31 each year. This measure would improve hydropower production, and thus, contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply.

Juvenile fish transportation at Lower Granite, Little Goose, Lower Monumental, and McNary Dams down to Bonneville Dam April 25 to August 31

This measure will be referred to as "Increase Juvenile Fish Transportation" throughout the remainder of this EIS. This measure would transport all juvenile fish that enter juvenile fish bypasses at Lower Granite, Little Goose, Lower Monumental, and at the powerhouse surface passage facility at McNary for release below Bonneville Dam. Juvenile salmon would be transported by barge or by truck, and transport would be conducted from April 25 to August 31. This would extend the current juvenile transport season, starting slightly earlier than the No Action Alternative, and ending at a fixed end date, which is later in the summer than current transport operations. This measure would contribute to meeting objective 1 and is intended to benefit ESA-listed juvenile anadromous fish.

Contingency Reserves Within Juvenile Fish Passage Spill

This measure is the same as described in MO1. This measure would contribute to meeting objective 4 to provide an adequate, efficient, and reliable power supply.

Modified Draft at Libby

This measure is the same as described in MO1. This measure was developed to meet objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

December Libby Target Elevation

This measure is the same as described in MO1, but the target elevation is 2,400 feet, not 2,420 feet NGVD29. feet NGVD29. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Update System FRM Calculation

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Planned Draft Rate at Grand Coulee

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Grand Coulee Maintenance Operations

This measure is the same as described in MO1. This measure was developed to contribute to meeting t objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions. This measure would also contribute to meeting objective 4 to provide a reliable power supply by supporting maintenance of the turbines at Grand Coulee.

Winter System FRM Space

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Ramping rate limitations at all projects will be defined only for safety or engineering

This measure will be referred to as "Ramping Rates for Safety" throughout the remainder of this EIS. This measure would provide operational flexibility for hydropower generation by applying ramping rates only for safety or engineering purposes (e.g., erosion in the tailrace), relaxing all other ramping rate constraints such as those implemented to benefit fish and wildlife. This would allow operators to change flow operations within a 24-hour period to meet changes in hydropower demand. The measure would apply at all 14 CRS projects. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical and reliable power supply, by allowing additional flexibility to generate hydropower.

At all four lower Snake River projects, operate within the full reservoir operating range year-round

This measure will be referred to as "Full Range Reservoir Operations" throughout the remainder of this EIS. This measure would allow the four lower Snake River projects (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) to operate within their full normal operating range to provide greater flexibility to meet demand for hydropower generation. This would remove the current requirement that the projects operate within a 1-foot MOP range during fish passage season (April through August). This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

At John Day, allow project to operate up to full pool, except as needed for flood risk management

This measure will be referred to as "John Day Full Pool" throughout the remainder of this EIS. This measure would remove current restrictions on seasonal pool elevations at the John Day Project, allowing more operating flexibility for hourly and daily shaping of hydropower generation. The measure would allow for operation of the reservoir across the full range possible, between 262.5 and 266.5 feet NGVD29 all year, except as needed for FRM. By providing additional operating flexibility this measure would contribute to meeting objective 4 for an adequate, efficient, economical, and reliable power supply.

The storage projects may be drafted slightly deeper for hydropower

This measure will be referred to as "Slightly Deeper Draft for Hydropower" throughout the remainder of this EIS. This measure would provide slightly more operational flexibility (up to 10 feet below URC values [Appendix I, *Hydroregulation*]) for hydropower generation by relaxing restrictions on seasonal pool elevations at the storage projects (Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak). The operations in this measure would allow deeper drafting of the FRM pool to meet hydropower demand. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Operate turbines across their full range of capacity year-round

This measure will be referred to as "Full Range Turbine Operations" throughout the remainder of this EIS. This measure would lift the requirement to operate hydropower turbines within 1 percent of peak efficiency during fish passage season at the lower Snake and lower Columbia projects: Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. This would allow the turbines to operate across the full range of their generating capacity and provide more flexibility to generate hydropower to meet demand. Removing the limitation would allow more water to pass through the turbines during periods of high flow, potentially reducing TDG levels in the river. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Zero generation operations may occur on lower Snake River projects November through February

This measure will be referred to as "Zero Generation Operations" throughout the remainder of this EIS. This measure would allow the lower Snake River projects to cease hydropower generation when there is little demand, unless limited by grid stability requirements. Currently, these projects are allowed to operate at zero generation mid-December through mid-February. This measure would extend that period to begin in September and extend through March. This would allow operators to save water in low-demand periods to use during high-demand periods in order to meet demand for hydropower. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Sliding Scale at Libby and Hungry Horse

This measure is the same as described in MO1. This measure would contribute to meeting objective 3 to improve resident fish survival and spawning success at CRS projects.

2.4.5 Multiple Objective Alternative 3

MO3 was developed to integrate actions for water management flexibility, hydropower production, and water supply with measures that would breach the four lower Snake River dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor). In addition to breaching these four projects, MO3 differs from the other alternatives by carrying out a juvenile fish passage spill operation that sets flow through the spillways up to a target of no more than 120 percent TDG in the tailrace of the four lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville). The alternative also proposes an earlier end to summer juvenile fish passage spill operations than the No Action Alternative. Instead, flows would transition to increased hydropower production when low numbers of juvenile fish are anticipated.

Structural measures in this alternative include breaching the four lower Snake River dams by removing the earthen embankment at each dam location, resulting in a controlled drawdown.

Operational measures in MO3 are intended to improve juvenile fish travel times, improve conditions for resident fish in the upper basin, increase hydropower generation flexibility, provide more flexibility to water managers, and provide additional water supply.

A brief description of the measures contained in MO3 is listed in Table 2-7 and the following paragraphs.

Table 2-7. Measures of Multiple Objective Alternative 3

Measure Descriptions	Abbreviated Measure Name
Structural Measures	
Construct additional powerhouse and/or spill surface passage routes at McNary Dam	Additional Powerhouse Surface Passage
Cease installation of fish screens at McNary Dam and John Day	Fewer Fish Screens
Upgrade spillway weirs to ASWs	Upgrade to Adjustable Spillway Weirs
Modify the upper ladder serpentine flow control ladder sections at Bonneville Dam	Modify Bonneville Ladder Serpentine Weir
Expand network of LPSs to bypass impediments	Lamprey Passage Structures
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Install improved fish passage turbines at John Day	Improved Fish Passage Turbines
Dam Breach	
Remove earthen embankments and adjacent structures, as required, at each lower Snake River dam	Breach Snake Embankments
Modify equipment and infrastructure to adjust to drawdown conditions at each lower Snake River dam	Lower Snake Infrastructure Drawdown

Measure Descriptions	Abbreviated Measure Name
Operational Measures	
Dam Breach	
Develop procedures to operate existing equipment during reservoir drawdown	Drawdown Operating Procedures
Develop contingency plans to address unexpected issues with drawdown operations	Drawdown Contingency Plans
Fish Passage	
Limit fish passage spill to 120 percent TDG at McNary, John Day, The Dalles, and Bonneville Dams	Spring Spill to 120% TDG
Reduce the duration of summer juvenile fish passage spill	Reduced Summer Spill
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
Water Management	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD with flat spot retained	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee
Operational constraints for ongoing Grand Coulee maintenance of power plants	Grand Coulee Maintenance Operations
Water Supply	
Increase volume of water pumped from Lake Roosevelt during annual irrigation season	Lake Roosevelt Additional Water Supply
Increase water managers' flexibility to store and release water from Hungry Horse Reservoir	Hungry Horse Additional Water Supply
Increase water diversion from the Columbia River for the Chief Joseph Dam Project	Chief Joseph Dam Project Additional Water Supply
Hydropower	
Ramping rate limitations at all projects will be defined only for safety or engineering	Ramping Rates for Safety
At John Day, allow project to operate up to full pool except as needed for FRM	John Day Full Pool
Operate turbines within and above 1 percent peak efficiency in juvenile fish passage season	Above 1% Turbine Operations
Other Operational	
Implement sliding scale summer draft at Libby and Hungry Horse Dams	Sliding Scale at Libby and Hungry Horse

2.4.5.1 Multiple Objective Alternative 3 Description of Measures

STRUCTURAL MEASURES

Remove earthen embankments and adjacent structures, as required, at each lower Snake River dam

This measure will be referred to as "Breach Snake Embankments" throughout the remainder of this EIS. This measure would breach the lower Snake River dams. The demolition would remove the earthen embankments, abutments, and portions of existing structures at the dams to eliminate the reservoirs behind the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Projects. In order to minimize impacts to migrating salmon and ensure safety, the removal of the embankments would be conducted in two phases during the low water period in the river. Drawdown would begin in August, with the removal of structures during October, months when few ESA-listed salmon would be present in the Snake River. To do this, the north embankments at the Lower Granite and Little Goose Projects would be removed the first year, and the south embankment at Lower Monumental and north embankment at Ice Harbor would be removed the second year. The co-lead agencies would implement a controlled drawdown, at a rate of 2 feet per day, beginning in August and continuing through December, in order to safely evacuate the reservoir and minimize damages to infrastructure (highways, bridges, railroads) adjacent to the reservoirs. In-water structures such as anchored concrete blocks would be installed at Ice Harbor to produce resting pools and hydraulic conditions needed for fish passage. This measure was developed to contribute to meeting objective 1 for improvements to ESA-listed juvenile salmonid rearing, passage, and survival.

Modify equipment and infrastructure to adjust to drawdown conditions at each lower Snake River dam

This measure will be referred to as "Lower Snake Infrastructure Drawdown" throughout the remainder of this EIS. In order to implement breaching, the reservoirs would be drawn down to spillway elevations. In order to evacuate the reservoirs below this level, three turbines at each of the four lower Snake River dams would be modified so that they could be used as low-level water outlets to support a controlled drawdown of the reservoirs. The turbines would be modified to operate over a range of low head conditions, requiring modification to the cooling water systems, and removal of the turbine blades. This would allow maximum discharge of water through the turbine passages at low head. These actions would be taken several months in advance of initiation of drawdown. This measure was developed to contribute to meeting objective 1 for improvements to ESA-listed juvenile salmonid rearing, passage, and survival.

Additional Powerhouse Surface Passage

This measure is the same as described in MO1, but without inclusion of the Ice Harbor Project on the lower Snake River. This measure would contribute to meeting objective 1 to improve passage for ESA-listed juvenile anadromous fish.

Fewer Fish Screens

This measure is the same as described in MO2, but without inclusion of the Ice Harbor Project on the lower Snake River. Removal of fish screens would make hydropower production more efficient . Thus, this measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply.

Upgrade to Adjustable Spillway Weirs

This measure is the same as described in MO1 but applies only to the lower Columbia River projects and does not include the lower Snake River projects. This measure was developed to contribute to meeting objective 1 for improvements to ESA-listed juvenile salmonid rearing, passage, and survival.

Modify Bonneville Ladder Serpentine Weir

This measure is the same as described in MO1. This measure is intended to benefit adult fish passage and would contribute to meeting objective 2 for adult ESA-listed anadromous fish.

Lamprey Passage Structures

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Turbine Strainer Lamprey Exclusion

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Bypass Screen Modifications for Lamprey

This measure is the same as described in MO1 but would only be implemented at McNary. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Lamprey Passage Ladder Modifications

This measure is the same as described in MO1 but would not be implemented at the lower Snake River projects. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Improved Fish Passage Turbines

This measure is the same as described in MO1. This measure would contribute to meeting objectives 4 and 5 by installing new turbines for an efficient and reliable power supply that minimizes greenhouse gas emissions. Because the turbines are designed to minimize negative impacts to fish passing through the powerhouse, it would also contribute to meeting objective 1, which strives to improve passage and survival for ESA juvenile anadromous fish.

OPERATIONAL MEASURES

Develop procedures to operate existing equipment during reservoir drawdown

This measure will be referred to as “Drawdown Operating Procedures” throughout the remainder of this EIS. This measure would be implemented in conjunction with the structural measures described above. Under this measure, equipment at the dams to be used for drawdown would be tested and calibrated to establish operational limits. Engineers, and powerhouse and transmission operators would establish manual operations and procedures using the modified equipment to facilitate a controlled and safe reservoir evacuation to support dam breaching. This measure was developed to contribute to meeting objective 1 for improvements to ESA-listed juvenile salmonid rearing, passage, and survival.

Develop contingency plans to address unexpected issues with drawdown operations

This measure will be referred to as “Drawdown Contingency Plans” throughout the remainder of this EIS. Corps staff that operate the dams would develop plans for unexpected operations or emergency shutdown during reservoir drawdown. To address the risks of breaching such large dams, training would be provided to dam and transmission system operators to implement emergency actions during unanticipated circumstances to ensure the safety of the general public and construction and dam personnel during reservoir drawdown. This measure was developed to contribute to meeting objective 1 for improvements to ESA-listed juvenile salmonid rearing, passage, and survival.

Limit fish passage spill to 120 percent TDG at McNary, John Day, The Dalles, and Bonneville Dams

This measure will be referred to as “Spring Spill to 120 Percent TDG” throughout the remainder of this EIS. This measure would modify spring juvenile fish passage spill to allow spill up to 120 percent tailrace gas cap. Juvenile fish passage spill to 120 percent TDG would be implemented annually at the McNary, John Day, The Dalles, and Bonneville Projects from April 10 to June 15. McNary, John Day, and The Dalles would spill to 120 percent in the tailrace, while Bonneville would spill to 120 percent in the tailrace not to exceed a 150 kcfs spill constraint. The juvenile fish spill volumes at each project are described in Table 2-8. This measure is intended to contribute to meeting objective 1 to improve the passage and survival of juvenile ESA-listed salmonids.

Table 2-8. Juvenile Fish Passage Spill Measure for Multiple Objective Alternative 3

Location	Spill Regime
McNary	120% tailrace Spill Cap[1/]
John Day	120% tailrace Spill Cap[1/]
The Dalles	120% tailrace Spill Cap[1/]
Bonneville	120% tailrace Spill Cap[1/], not to exceed 150 kcfs spill

1/ The term "spill cap" refers to the maximum spill level at each project that is estimated to meet, but not exceed, the gas cap in the tailrace unless the spill cap is constrained (e.g.,150 kcfs maximum spill for Bonneville Dam). In this measure, spill caps will be set to meet, but not exceed, the gas cap of 120% TDG as measured at the tailrace fixed monitoring stations. This gas cap is consistent with the current Oregon TDG water quality standard modification and with Washington State's current short-term modification to its TDG water quality standard (2019), which removed the 115% TDG criteria.

Reduce the duration of summer juvenile fish passage spill

This measure will be referred to as "Reduced Summer Spill" throughout the remainder of this EIS. This measure would reduce the period of fish passage spill in the summer, ending all summer spill operations at midnight July 31 at McNary, John Day, The Dalles, and Bonneville Dams to allow for an increase in hydropower production during periods when low numbers of juvenile fish are migrating. This measure would contribute to meeting objective 4, and is intended to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Ramping Rates for Safety

This measure is the same as described in MO2. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply, by allowing additional flexibility to generate hydropower.

John Day Full Pool

This measure is the same as described in MO2. By providing additional operating flexibility this measure would continue to meet objective 4 for an adequate, efficient, economical, and reliable power supply.

Operate turbines within and above 1 percent peak efficiency during juvenile fish passage season

This measure will be referred to as "Above 1 Percent Turbine Operations" throughout the remainder of this EIS. This measure would lift the requirement to operate hydropower turbines only within a 1 percent peak efficiency during the fish passage season at McNary, John Day, The Dalles, and Bonneville Dams. This would allow turbine operation within and above the current 1 percent peak efficiency limit to increase flexibility for hydropower generation to meet demand during high flow periods. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Sliding Scale at Libby and Hungry Horse

This measure is the same as described in MO1. This measure would contribute to meeting objective 3 to improve resident fish survival and spawning success at CRS projects.

Contingency Reserves Within Juvenile Fish Passage Spill

This measure is the same as described in MO1. This measure would contribute to meeting objective 4 to provide an adequate, efficient, and reliable power supply.

Modified Draft at Libby

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

December Libby Target Elevation

This measure is the same as described in MO1, but with a target elevation of 2,400 feet NGVD29. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Update System FRM Calculation

This measure is the same as described in MO1, except that the SRD maintains what is known as the "flat spot" from the No Action Alternative. The flat spot is a range of water supply conditions that doesn't require additional draft, but rather requires a consistent draft ("flat") of 1,222.7 feet NGVD29 over those conditions. This slight adjustment to the flood risk draft elevation reduces impacts to water supply operations. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Planned Draft Rate at Grand Coulee

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Grand Coulee Maintenance Operations

This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions. This measure would also contribute to meeting objective 4 to provide a reliable power supply by supporting maintenance of the turbines at Grand Coulee.

Lake Roosevelt Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Hungry Horse Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Chief Joseph Dam Project Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

2.4.6 Multiple Objective Alternative 4

MO4 was developed to examine an additional combination of measures to benefit ESA-listed fish integrated with measures for water management flexibility, hydropower production, and additional water supply. The additional combination of fish measures that differ from the other alternatives include proposing spillway weir notch inserts, changes to the juvenile fish transportation operations, the highest spill target in the range considered in this EIS. Annually drawing down the lower Snake River and Columbia River reservoirs to their minimum operating pools, a measure for establishment of riparian vegetation, dry-year augmentation of spring flow with water stored in upper basin reservoirs, and increased powerhouse surface passage for kelt and overshoots.

The structural measures in this alternative are primarily focused on improving passage conditions for ESA-listed salmonids and Pacific lamprey. The inclusion of spillway weir notch inserts is the only structural measure difference from the other action alternatives. The operational measures are focused on making improvements and providing flexibility across authorized project purposes. In MO4, the juvenile fish transport program is proposed to operate only in the spring and fall, while juvenile fish passage spill is set to a target of no more than 125 percent TDG during the spring and summer spill season. The alternative also contains a measure for flows from the Libby Project targeted for downstream riparian vegetation establishment that is intended to improve conditions for ESA-listed resident fish, bull trout, and Kootenai River white sturgeon in the upper Columbia River Basin.

A brief description of the measures contained in MO4 is listed in Table 2-9 and the following paragraphs.

Table 2-9. Measures of Multiple Objective Alternative 4

Measure Descriptions	Abbreviated Measure Name
Structural Measures	
Construct additional powerhouse surface passage routes to meet system-wide PITPH target	Additional Powerhouse Surface Passage
Improve adult ladder passage through modification of adult trap at Lower Granite Dam	Lower Granite Trap Modifications
Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Dams	Lower Snake Ladder Pumps
Install improved fish passage turbines at John Day	Improved Fish Passage Turbines
Expand network of LPSs to bypass impediments	Lamprey Passage Structures
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Addition of spillway weir notch gate inserts	Spillway Weir Notch Inserts
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Operational Measures	
Fish Passage	
Spill through surface passage structures for steelhead overshoots, overwintering steelhead, and kelt	Spill for Adult Steelhead
Set juvenile fish passage spill to not exceed 125 percent TDG	Spill to 125% TDG
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
Implement juvenile fish transportation during spring and fall periods at Lower Granite, Little Goose, and Lower Monumental Dams	Spring & Fall Transport
Cease juvenile transport during portions of summer spill period at Lower Granite, Little Goose, and Lower Monumental Dams	No Summer Transport
Water Management	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee
Operational constraints for ongoing Grand Coulee maintenance of power plants and spillways	Grand Coulee Maintenance Operations
Develop draft requirements/assessment approach to protect against rain-induced flooding	Winter System FRM Space
Water Supply	
Increase volume of water pumped from Lake Roosevelt during annual irrigation season	Lake Roosevelt Additional Water Supply

Measure Descriptions	Abbreviated Measure Name
Increase water managers' flexibility to store and release water from Hungry Horse Reservoir	Hungry Horse Additional Water Supply
Increase water diversion from the Columbia River for the Chief Joseph Dam Project	Chief Joseph Dam Project Additional Water Supply
Operate turbines within and above 1 percent peak efficiency in juvenile fish passage season	Above 1% Turbine Operations
Other Operational Measures	
Strive to hold minimum 220 kcfs spring flow/200 kcfs summer flow at McNary Dam using upstream storage	McNary Flow Objective
Reservoir drawdown to Minimum Operating Pool to reduce outmigration travel time	Drawdown to MOP
Implement sliding scale summer draft at Libby and Hungry Horse	Sliding Scale at Libby and Hungry Horse
Support establishment of vegetation at Libby Dam by limiting Bonners Ferry stage height November through March	Winter Stage for Riparian

2.4.6.1 Multiple Objective Alternative 4 Description of Measures

STRUCTURAL MEASURES

Additional Powerhouse Surface Passage

This measure is the same as described in MO1, but under MO4, the additional powerhouse surface passage route would be used to measure probability of passing powerhouses (PITPH). As stated in the May 13, 2019 Fish Passage Center Memorandum, "PITPH is an index that describes the probability that an average juvenile fish will experience powerhouse passage under specific project operations. PITPH is an index used to characterize the effects of spill in CSS analyses. CSS analyses have shown that the probability of passing powerhouses (PITPH) influences juvenile travel time, juvenile survival, and smolt-to-adult return rates" (Fish Passage Center 2019). This measure would contribute to meeting objective 1 to improve passage for ESA-listed juvenile anadromous fish.

Lower Granite Trap Modifications

This measure is the same as described in MO1. This measure would contribute to meeting objective 2 to improve passage for adult ESA-listed anadromous fish.

Lower Snake Ladder Pumps

This measure is the same as described in MO1. This measure would contribute to meeting objective 2 to improve adult ESA-listed anadromous fish migration.

Improved Fish Passage Turbines

This measure is the same as described in MO1. This measure would contribute to meeting objectives 4 and 5 by installing new turbines for an efficient and reliable power supply that minimizes greenhouse gas emissions. Because the turbines are designed to minimize negative impacts to fish passing through the powerhouse, it would also contribute to meeting objective 1, which strives to improve passage and survival for ESA juvenile anadromous fish.

Lamprey Passage Structures

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Bypass Screen Modifications for Lamprey

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Lamprey Passage Ladder Modifications

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Turbine Strainer Lamprey Exclusion

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Add spillway weir notch gate inserts.

This measure will be referred to as "Spillway Weir Notch Inserts" throughout the remainder of this EIS. Modify existing spillway weirs at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, and John Day Dams. A notch gate would be installed in one spillway weir at each dam to create a smaller opening in the weir and enable reduced spill flow velocities. The notched weirs would be operated October 1 to November 31 at all dams. This measure would contribute to meeting objective 1 and is intended to improve the passage and survival of ESA-listed juvenile anadromous fish.

OPERATIONAL MEASURES

Spill through surface passage structures for steelhead overshoots, overwintering steelhead and kelt

This measure will be referred to as "Spill for Adult Steelhead" throughout the remainder of this EIS. Implementation of this measure would require modification of the spillway weirs as described above for the Spillway Weir Notch Inserts measure to facilitate downstream passage of adult salmon, steelhead, and kelt. Flows would be directed through the weirs at the Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary and John Day Projects from October 1 to November 31. The measure is intended to increase adult salmon and steelhead survival by decreasing passage mortality of adult steelhead. This measure would contribute to meeting objective 2, intended to benefit adult ESA-listed anadromous fish.

Set juvenile fish passage spill to not exceed 125 percent TDG

This measure will be referred to as "Spill to 125 Percent TDG" throughout the remainder of this EIS. This measure would set the target for juvenile fish passage spill up to 125 percent TDG, as measured in the tailrace, at the four lower Snake River and four lower Columbia River projects. Juvenile fish passage spill to this level would be dependent upon availability of sufficient flow to meet minimum generation requirements for hydropower. Upstream storage reservoirs would not be drafted specifically to reach 125 percent TDG spill levels. This juvenile fish passage spill regime would be implemented March 1 to August 31 at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville Dams. This measure is intended to improve passage for juvenile ESA-listed salmonids, and as such, would contribute to meeting objective 1.

Allow contingency reserves to be carried within juvenile fish passage spill

This measure will be referred to as "Contingency Reserves Within Juvenile Fish Passage Spill" throughout the remainder of this EIS. This measure is the same as described in MO1. This measure would contribute to meeting objective 4 to provide an adequate, efficient, and reliable power supply.

Implement juvenile fish transportation during spring and fall periods at Lower Granite, Little Goose, and Lower Monumental Dams

This measure will be referred to as "Spring & Fall Transport" throughout the remainder of this EIS. Juvenile fish transportation on barges and trucks would be implemented in two timeframes, April 25 to June 14, and August 16 to November 15, rather than transport beginning no later than May 1 through the migration season. During these two transport seasons, all juvenile salmonids that enter the juvenile fish bypass systems at Lower Granite, Little Goose, and Lower Monumental Dams would be collected and transported to a location downstream of Bonneville Dam for release. This measure would contribute to meeting objective 1 to improve passage and survival of juvenile ESA-listed salmonids.

Cease juvenile transport during portions of summer spill period at Lower Granite, Little Goose, and Lower Monumental Dams

This measure will be referred to as "No Summer Transport" throughout the remainder of this EIS. The juvenile transport program at Lower Granite, Little Goose, and Lower Monumental Dams would be suspended during the full summer timeframe (June 15 to August 15). Instead of collection for transport, all juvenile fish entering the fish bypasses at these projects would be returned to the river to migrate during the June 15 to August 15 window. This measure is a variation of the current and proposed transport program, which is intended to improve passage and survival of juvenile ESA-listed salmonids . As such, it would contribute to meeting objective 1.

Modified Draft at Libby

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions

December Libby Target Elevation

This measure is the same as described in MO1, with a target elevation of 2,420 feet NGVD29. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Update System FRM Calculation

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Planned Draft Rate at Grand Coulee

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Grand Coulee Maintenance Operations

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions . This measure would also contribute to meeting objective 4 to provide a reliable power supply by supporting maintenance of the turbines at Grand Coulee.

Winter System FRM Space

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Lake Roosevelt Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Hungry Horse Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Chief Joseph Dam Project Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Above 1 Percent Turbine Operations

This measure is the same as described in MO3, but would include the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Projects. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Strive to hold minimum 220 kcfs spring flow/200 kcfs summer flow at McNary using upstream storage

This measure will be referred to as "McNary Flow Target" throughout the remainder of this EIS. This measure would augment flows in the lower Columbia River during the juvenile salmon outmigration period in low water years. The summer flow objective at McNary is supported by various flow augmentation measures in the No Action Alternative that would continue, however, this measure would provide additional flow augmentation. Even with this additional water, there is a limited amount of water available for flow augmentation and flow objectives are provided as a biological guideline. To meet this minimum flow objective for the lower Columbia River, up to 2.0 Maf of storage water from the Hungry Horse, Libby, Albeni Falls, and Grand Coulee Projects would be provided above that provided currently, in order to meet spring or summer flow objectives established for the McNary Project. Grand Coulee would be drafted from first to meet the flow objective, with no more than 40 kcfs being released in a single day and drafting the reservoir to no more than the minimum pool elevation. Then, Hungry Horse, Libby, and Albeni Falls reservoirs would be drafted to support the augmented flow target as well as to refill Grand Coulee's reservoir, but to a reduced refill elevation. Local resident fish operations in the upper basin, such as minimum flows for resident fish, would be maintained. In the event that all 2.0 Maf of water has not been used by June 15, then the remaining volume of water would be released to meet a reduced minimum flow objective of

200 kcfs at McNary through to July 31. This measure is not anticipated be implemented every year, but rather only when the system-wide April to August water supply forecast is below 87.5 Maf, the current 30-year average for the period 1981 to 2008, which will be updated after 2020. This measure is intended to benefit ESA-listed juvenile anadromous fish migration, and as such, would contribute to meeting objective 1.

Reservoir drawdown to Minimum Operating Pool to reduce outmigration travel time

This measure will be referred to as "Drawdown to MOP" throughout the remainder of this EIS. The lower Snake River and lower Columbia River projects would be operated at lower elevations to reduce travel times for juvenile fish out-migration while providing slightly increased operating range flexibility at the lower Snake River projects. These operations would be implemented at the lower Snake River projects from March 15 to August 15, and at the lower Columbia projects from March 25 to August 15. The projects would be drafted down to the following reservoir elevations (Table 2-10).

Table 2-10. Drawdown to MOP Measure for Multiple Objective Alternative 4

Location	MO4 MOP Forebay Elevation
Lower Granite	733.0 + 1.5 ft range
Little Goose	633.0 + 1.5 ft range
Lower Monumental	537 + 1.5 ft range
Ice Harbor	437 + 1.5 ft range
McNary	337.0 + 1.0 ft range
John Day	261.0 + 1.5 ft range
The Dalles	155.0 + 1.5 ft range
Bonneville	71.5 + 1.5 ft range

This measure is intended to benefit ESA-listed juvenile anadromous fish migration, and as such, would contribute to meeting objective 1.

Sliding Scale at Libby and Hungry Horse

This measure is the same as described in MO1. This measure would contribute to meeting objective 3 to improve resident fish survival and spawning success at CRS projects.

Support establishment of vegetation at Libby Dam by limiting Bonners Ferry stage height November through March

This measure will be referred to as "Winter Stage for Riparian" throughout the remainder of this EIS. Operate to limit the Bonners Ferry river elevations to a maximum of 1,753 feet NGVD29 from November through March to create conditions that would increase survival of riparian vegetation downstream of Libby Dam. The riparian vegetation is considered an important factor in creating good conditions for Kootenai white sturgeon and bull trout (Table 2-9). This measure would contribute to meeting objective 3 to improve resident fish survival and spawning success at CRS projects.

2.5 ALTERNATIVES CONSIDERED BUT REMOVED FROM FURTHER CONSIDERATION

Initially, eight single objective-focused alternatives were developed to maximize certain project purposes and emphasize specific resources, in a hypothetical condition where other purposes do not constrain the possibility of actions that could be taken. These single objective alternatives provided the framework for the exchange of expertise across technical disciplines throughout the Columbia River Basin. The technical teams collaborated to determine where measures would be most effective and if they were compatible across the 14 projects in the CRS. If measures were determined to be conflicting, or experts felt one measure would perform better at accomplishing the objective as compared to a similar measure, the team decided which measure to retain or modify to meet the intended single objective. In some cases, measures were suggested, either through scoping or by technical team members, but were not selected for further consideration. This unrestrained development of single objective-focused alternatives helped the co-lead agencies understand which measures the technical teams prioritized and understood to be most effective and formed the basis for framing the MO process with a manageable suite of measures.

As information was exchanged, redundancies between alternatives and conflicts between proposed measures became more clearly understood, leading to refinement of the draft alternatives. The MOs were then developed to meet a blend of actions and benefits across project authorities.

The single objective-focused alternatives (Table 2-11) are summarized in the following sections, with additional detail in Appendix A, *Alternatives Development*.

Table 2-11. List of Draft Single Objective-Focused Alternatives

Single Objective Alternatives
Spill to 125% TDG with Extended Duration
Juvenile Anadromous Fish Survival
Adult Anadromous Fish Survival
ESA-Listed Resident Fish Survival
Hydropower Generation
Water Management
Water Supply
Lower Snake River Dam Breach

2.5.1 Single Objective Focus Alternative for Increased Spill to 125 Percent TDG with Extended Duration

The Single Focus Alternative for Increased Spill to 125 Percent TDG with Extended Duration was not an objective-focused alternative. Rather, it was developed based on scoping comments specifically requesting analysis of an increased juvenile fish passage spill target level. This alternative is comprised of two operational measures but has no associated structural measures. The first operational measure involves increasing the proportion of flow released over the spillway (referred to as "spill"), relative to the No Action Alternative, at the lower

Snake and lower Columbia River dams. Juvenile fish passage spill levels would be increased to a target not to exceed 125 percent TDG, as measured in the tailrace of each project. The second operational measure to cease summer transportation was added because flows associated with this level of spill results in very few fish entering the fish collection facilities at the Lower Granite, Little Goose, and Lower Monumental Projects. The Single Focus Alternative for Increased Spill to 125 Percent TDG with Extended Duration was intended to benefit juvenile fish migration during the March 1 to August 31 timeframe each year.

This alternative was refined and became part of MO4 for analysis.

2.5.2 Single Objective Focus Juvenile Anadromous Fish Survival Alternative

The Single Objective Focus Juvenile Anadromous Fish Survival Alternative was designed to maximize juvenile salmonid survival through the CRS by prioritizing juvenile-focused actions above some of the other congressionally authorized project purposes and above other salmonid life stages. Although juvenile anadromous fish do not experience the CRS separately from their adult counterparts, this alternative emphasizes how actions to benefit the survival of juvenile salmonids affects both the adult life stage and other co-lead agency missions (e.g., FRM, hydropower production, and water quality).

The measures from this alternative were refined and became part of the MOs.

2.5.3 Single Objective Focus Adult Anadromous Fish Survival Alternative

The Single Objective Focus Adult Anadromous Fish Survival Alternative contains a mix of structural and operational measures intended to improve the migration and survival of anadromous adult steelhead and salmon. Structural measures are focused on improving conditions for adult salmon migrating upstream through the fish ladders. Under this alternative, the adult fish trap and bypass loop at Lower Granite Dam would be modified to shorten the time it takes an adult salmon to travel through the bypass. Pumps would be installed at Lower Monumental and Ice Harbor Dams to provide cooling water for the fish ladders. The Washington shore and Bradford Island fish ladders at Bonneville Dam would be modified to a vertical slot fishway to reduce upstream travel times for adult salmon and steelhead. In addition, the alternative includes a measure to transport all juvenile salmonids from the collector projects, which includes Lower Granite, Little Goose, Lower Monumental, and McNary Dams. Juvenile salmonids collected at these projects would be transported downstream via barge or truck for release below Bonneville Project. Spill would be reduced to provide only fish attraction spill and spill for steelhead overshoots, overwintering steelhead, and downstream passage for kelt.

The majority of measures from this alternative were refined and became part of the MOs.

2.5.4 Single Objective Focus ESA-Listed Resident Fish Survival Alternative

The Single Objective Focus ESA-Listed Resident Fish Survival Alternative was intended to improve river and reservoir habitat conditions for the two ESA-listed resident fish in the Columbia River Basin, bull trout and Kootenai River white sturgeon, through improving water temperature management, creating conditions for higher reservoir productivity during the summer months, and improving the likelihood of releasing instream flow objectives for resident fish in the CRS. This alternative focused on the upper Columbia River dams and did not include changes to the lower Columbia or Snake River operations. The Single Objective Focus ESA-Listed Resident Fish Survival Alternative emphasized the survival of resident fish juveniles and adults in CRS reservoirs through measures developed for improving condition for spawning, egg-hatching success, and food resource availability.

The measures from this alternative were refined and became part of the MOs.

2.5.5 Single Objective Focus on Hydropower Generation Alternative

The Single Objective Focus on Hydropower Generation Alternative describes action that would maximize hydropower generation at CRS projects. The proposed measures would create circumstances similar to conditions that existed prior to implementation of the Northwest Power Act and actions implemented for BiOps and other agreements. Restrictions on ramping rates, turbine operating ranges, reservoir operating ranges, and similar measures have reduced the flexibility needed for enough hydropower generation to serve hourly, daily, and seasonal power demands. The Single Objective Focus on Hydropower Generation Alternative includes relaxing current restrictions on operating ranges and ramping rates found in the No Action Alternative in order to evaluate the potential to increase hydropower production efficiency and increase flexibility to respond to changing power demands. This alternative does not provide spill for juvenile fish passage.

Most of the measures from this alternative were modified or refined and became part of the MOs. The majority of the measures became part of MO2.

2.5.6 Single Objective Focus Water Management Alternative

The Single Objective Focus Water Management Alternative would provide water managers with the increased flexibility to react to unanticipated changes in river flow and forecast runoff volume, as well as prepare for the operational constraints of implementing ongoing maintenance at Grand Coulee Project. This alternative does not include any structural measures or operational changes to the lower Columbia and Snake River dams. The operational measures at Grand Coulee, Libby, Hungry Horse, and Dworshak Projects included in this alternative are intended to update FRM and improve the likelihood of achieving storage project refill. This, in turn, would provide downstream flow augmentation and recreational benefits, faster turnover of the Libby reservoir to support downstream nutrient delivery, and better management of outflow temperature during Kootenai River white sturgeon spawning.

As storage reservoirs are drafted for FRM, situations can occur where rapid and large water releases are required in the March to April timeframe to achieve FRM draft goals (e.g., high runoff during late winter/early spring or years with rapidly increasing water supply forecasts). Drafting large volumes in a short timeframe can require increased spill (lack of market/lack of turbine) to achieve the maximum FRM elevation or a deviation from FRM draft requirements, which could result in high TDG levels or slight increases in flood risk in a given year. In addition, heavy rain often results in near-term high runoff that cannot be forecasted in the same way as longer-term, snowmelt-induced runoff. Water management operating procedures that more explicitly account for the rain component of runoff would afford greater flexibility and adaptability in reservoir operations. The Single Objective Focus Water Management Alternative is expected to maintain the current level of flood risk, meet contractual water supply obligations, maintain infrastructure to ensure safe and reliable operations, and maintain commercial navigation.

The measures from this alternative were refined and became part of the MOs.

2.5.7 Single Objective Focus Water Supply Alternative

The Single Objective Focus Water Supply Alternative was formulated to assess providing additional water to authorized, but not yet developed, lands within the Columbia Basin Project and the Chief Joseph Dam Project. In addition, the alternative assesses delivering 90,000 acre-feet of water from Hungry Horse Dam for currently undefined use by the Confederated Salish and Kootenai Tribes. The scope for this alternative is limited to the diversion of water from the Columbia and South Fork Flathead Rivers and does not describe how that water is used or where. To clarify, the scope of this alternative as related to the Columbia Basin Project is limited to the diversion of water from Grand Coulee's Lake Roosevelt into Banks Lake using the John W. Keys Pumping Plant and does not include pumping that water from Banks Lake to the additional acres of land.

The Single Objective Focus Water Supply Alternative is focused on upper basin dams and river segments, including Lake Roosevelt and the Columbia River above Grand Coulee Dam, Hungry Horse Dam and reservoir on the Flathead River, and Chief Joseph Dam on the Columbia River and proposes to maintain the No Action Alternative's configuration and general operations. This alternative was developed with the assumption that there would be a warranted, future demand to irrigate the remaining authorized acreage within the Columbia River Basin, which would require delivery of the total authorized volume of water.

The Single Objective Focus Water Supply Alternative included only operational measures. These measures were focused on water diversion from Grand Coulee's Lake Roosevelt via the John W. Keys Pumping Plant, delivery of water from Hungry Horse, and diversion of water for the Chief Joseph Dam Project. At Lake Roosevelt, water diverted to Banks Lake would be increased to supply an additional 1,154,138 acre-feet of water to irrigate an additional 256,475 acres of land as authorized under the Columbia Basin Project. Presently, only 772,525 acres have been developed for delivery. Hungry Horse Reservoir was originally authorized for irrigation but has never been used for that purpose. The release of 90,000 acre-feet for the Confederated Salish and Kootenai Tribes could be used for irrigation, municipal and industrial, or in-stream uses. Since the use of the water is not currently defined, the entire 90,000 acre-feet of water is assumed to be diverted from the river at Flathead Lake so as to evaluate the most extreme impact of using this water. Finally, 9,600 acre-feet of water would be diverted from the Columbia River into the Chief Joseph Dam Project (a Reclamation irrigation project not to be confused by the Corps' dam of the same name). However, the John W. Keys Pumping Plant would not be reconfigured under this alternative, because the existing design is capable of pumping the increased volume proposed. Instead, monthly volumes of diversion flow from Lake Roosevelt would be reshaped to prevent substantial drafting of Banks Lake as an operational measure.

The measures from this alternative were refined and became part of MO1, MO3, and MO4.

2.5.8 Single Objective Focus Lower Snake River Dam Breaching Alternative

The Single Objective Focus Lower Snake River Dam Breaching Alternative was not an objective-focused alternative. It was developed based on formal scoping comments specifically requesting analysis of this action. The hypothesis for this alternative was that habitat conditions for 4 of the 13 listed anadromous species in the Columbia River Basin could potentially be restored. The alternative proposed breaching the four lower Snake River dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) by removing the earthen embankments at each location. The reservoirs behind the dams would be drawn down slowly to avoid damage to adjacent infrastructure (e.g., roads, bridges, and railroads) and ensure life safety of downstream populations. The concrete portions of the dams would remain in place, but the powerhouses would be mothballed. The generators would be modified for use as outlets during a controlled reservoir drawdown. The breaching would occur over a 2-year period, with the two upstream dams (Lower Granite and Little Goose) breached first and followed the next year by Lower Monumental and Ice Harbor. Spreading the breaching over 2 years allows the work to occur during the in-water work window, when very few ESA-listed fish are present in the reservoirs and inflows are relatively small.

This alternative was refined and included in MO3 for analysis in this EIS.

2.5.9 Multiple Objective Alternative Crosswalk

Table 2-12 represents how the measures of the Single Objective Focus Alternatives were distributed in the MOs.

Table 2-12. Multiple Objective Alternative Crosswalk

CRSO Measure Name	Spill to 125% TDG	Juvenile Anadrom. Focus	Adult Anadromous Focus	Resident Fish Focus	Hydropower Focus	Water Management	Water Supply Focus	LSR Dam Breach Focus	MO1	MO2	MO3	MO4	Measure source from Alternatives
Structural Measures													
Additional Powerhouse Surface Passage	–	Juv	–	–	–	–	–	–	Juv	Juv	Juv	Juv	Juvenile
Upgrade to Adjustable Spillway Weirs	–	Juv	–	–	–	–	–	–	Juv	Juv	Juv	–	Juvenile
Lower Granite Trap Modifications	–	–	Adu	—	–	–	–	–	Adu	–	–	Adu	Adult
Modify Bonneville Ladder Serpentine Weir	–	–	Adu	—	–	–	–	–	Adu	–	Adu	–	Adult
Lower Snake Ladder Pumps	–	–	Adu	—	–	–	–	–	Adu	Adu	–	Adu	Adult
Spillway Weir Notch Inserts	–	–	–	–	–	–	–	–	–	–	–	X	MO4
Fewer Fish Screens	–	–	–	–	Hyd	–	–	–	–	Hyd	Hyd	–	Hydropower
Improved Fish Passage Turbines	–	–	–	–	–	–	–	–	X	X	X	X	MO1,2,3,4
Lamprey Passage Structures	–	–	–	–	–	–	–	–	X	X	X	X	MO1,2,3,4
Turbine Strainer Lamprey Exclusion	–	–	–	–	–	–	–	–	X	X	X	X	MO1,2,3,4
Bypass Screen Modifications for Lamprey	–	–	–	–	–	–	–	–	X	X	X	X	MO1,2,3,4
Lamprey Passage Ladder Modifications	–	–	–	–	–	–	–	–	X	X	X	X	MO1,2,3,4

CRSO Measure Name	Spill to 125% TDG	Juvenile Anadrom. Focus	Adult Anadromous Focus	Resident Fish Focus	Hydropower Focus	Water Management	Water Supply Focus	LSR Dam Breach Focus	MO1	MO2	MO3	MO4	Measure source from Alternatives
Dam Breach													
Breach Snake Embankments	–	–	–	–	–	–	–	LSR	–	–	LSR	–	LSR Breach
Lower Snake Infrastructure Drawdown	–	–	–	–	–	–	–	LSR	–	–	LSR	–	LSR Breach
Operational Measures													
Dam Breach													
Drawdown Operating Procedures	–	–	–	–	–	–	–	LSR	–	–	LSR	–	LSR Breach
Drawdown Contingency Plans	–	–	–	–	–	–	–	LSR	–	–	LSR	–	LSR Breach
Fish Passage													
Block Spill Test (Base + 120/115%)	–	–	–	–	–	–	–	–	X	–	–	–	MO1
Summer Spill Stop Trigger	–	–	–	–	–	–	–	–	X	–	–	–	MO1
Early Start Transport	–	–	–	–	–	–	–	–	X	–	–	–	MO1
Contingency Reserves Within Juvenile Fish Passage Spill	–	–	–	–	–	–	–	–	X	X	X	X	MO1,2,3,4
Spill to 110% TDG	–	–	–	–	–	–	–	–	–	X	–	–	MO2
Spring & Fall Transport	–	–	–	–	–	–	–	–	–	–	–	X	MO4
No Summer Transport	–	–	–	–	–	–	–	–	–	–	–	X	MO4
Reduced Summer Spill	–	–	–	–	–	–	–	–	–	–	X	–	MO3
Spill to 125% TDG	125	–	–	–	–	–	–	–	–	–	–	125	125%
Spring Spill to 120% TDG	–	Juv	–	–	–	–	–	–	–	–	Juv	–	Juvenile
Spill for Adult Steelhead	–	–	Adu	–	–	–	–	–	–	–	–	Adu	Adult

CRSO Measure Name	Spill to 125% TDG	Juvenile Anadrom. Focus	Adult Anadromous Focus	Resident Fish Focus	Hydropower Focus	Water Management	Water Supply Focus	LSR Dam Breach Focus	MO1	MO2	MO3	MO4	Measure source from Alternatives
Increase Juvenile Fish Transportation	–	–	Adu	–	–	–	–	–	–	Adu	–	–	Adult
Water Management													
Modified Draft at Libby	–	–	–	–	–	WM	–	–	WM	WM	WM	WM	Water Mgmt
December Libby Target Elevation	–	–	–	Res	–	WM	–	–	WM	WM	WM	WM	Water Mgmt
Update System FRM Calculation	–	–	–	–	–	WM	–	–	WM	WM	WM	WM	Water Mgmt
Planned Draft Rate at Grand Coulee	–	–	–	–	–	WM	–	–	WM	WM	WM	WM	Water Mgmt
Grand Coulee Maintenance Operations	–	–	–	–	–	WM	–	–	WM	WM	WM	WM	Water Mgmt
Winter System FRM Space	–	–	–	–	–	WM	–	–	WM	WM	–	WM	Water Mgmt
Water Supply													
Lake Roosevelt Additional Water Supply	–	–	–	–	–	–	WS	–	WS	–	WS	WS	Water Supply
Hungry Horse Additional Water Supply	–	–	–	–	–	–	WS	–	WS	–	WS	WS	Water Supply
Chief Joseph Dam Project Add'l Water Supply	–	–	–	–	–	–	WS	–	WS	–	WS	WS	Water Supply
Hydropower													
Increased Forebay Range Flexibility	–	–	–	–	Hyd	–	–	–	Hyd	–	–	–	Hydropower
Slightly Deeper Draft for Hydropower	–	–	–	–	Hyd	–	–	–	–	Hyd	–	–	Hydropower

CRSO Measure Name	Spill to 125% TDG	Juvenile Anadrom. Focus	Adult Anadromous Focus	Resident Fish Focus	Hydropower Focus	Water Management	Water Supply Focus	LSR Dam Breach Focus	MO1	MO2	MO3	MO4	Measure source from Alternatives
Ramping Rates for Safety	–	–	–	–	Hyd	–	–	–	–	Hyd	Hyd	–	Hydropower
John Day Full Pool	–	–	–	–	Hyd	–	–	–	–	Hyd	Hyd	–	Hydropower
Full Range Reservoir Operations	–	–	–	–	Hyd	–	–	–	–	Hyd	–	–	Hydropower
Full Range Turbine Operations	–	–	–	–	Hyd	–	–	–	–	Hyd	–	–	Hydropower
Above 1% Turbine Operations	–	–	–	–	Hyd	–	–	–	–	–	Hyd	Hyd	Hydropower
Zero Generation Operations	–	–	–	–	Hyd	–	–	–	–	Hyd	–	–	Hydropower
Other Operational Measures													
McNary Flow Target	–	Juv	–	–	–	–	–	–	–	–	–	Juv	Juvenile
Drawdown to MOP	–	Juv	–	–	–	–	–	–	–	–	–	Juv	Juvenile
Predator Disruption Operations	–	Juv	–	–	–	–	–	–	Juv	–	–	–	Juvenile
Modified Dworshak Summer Draft	–	–	Adu	–	–	–	–	–	Adu	–	–	–	Adult
Sliding Scale at Libby and Hungry Horse	–	–	–	Res	–	–	–	–	Res	Res	Res	Res	Resident
Winter Stage for Riparian	–	–	–	Res	–	–	–	–	–	–	–	Res	Resident

2273 Note: – = not applicable; LSR = lower Snake River.
2274

2.5.10 Other Proposals and Measures Considered but Removed from Further Consideration

Within this EIS, other proposals and measures were considered but removed from consideration early in the alternative development process. These measures were removed from further consideration for several reasons: because they had been previously studied or considered and found to be ineffective; because the measures were already being examined under a separate NEPA effort; or because they were outside of the scope of this EIS. Examples and brief rationale of specific measures considered but removed from further consideration include:

- Reintroduction of salmon above Grand Coulee Dam and installation of fish passage at Grand Coulee and Chief Joseph Dams. Reintroduction is an important and complex, large-scale concept. Its consideration, evaluation, and implementation should involve multiple tribal, federal, state, and other entities. A coordinated approach among water users, tribes, states, multiple federal agencies, and others would be necessary. To allow so many differing interests to coordinate on such a complex topic, which may include international considerations, a decision-making framework and a series of regional workshops would be necessary just to approach the first step of defining reintroduction objectives. Given the incompatibility of such a wildlife management decision-making framework with an analysis of the operation of the CRS, it is not feasible to proceed with a detailed consideration of reintroduction in this EIS. Moreover, to meaningfully analyze reintroduction as a measure, the details of the proposal would need to be understood well enough to include in hydrologic, water quality, and fish models. That information is not presently available, and development of those details was not possible in the timeframe of this NEPA process. Nevertheless, the agencies and interested regional sovereigns are developing a framework to address critical information gaps.
- Creation of "natural rivers" to mimic pre-dam construction conditions, which was previously studied and found to be infeasible. The co-lead agencies concluded that breaching all 14 dams would be unreasonable for several reasons, including that this action would either preclude or significantly alter the co-lead agencies' ability to meet their congressionally authorized purposes in the system and it would likely result in significant human health and safety concerns. In addition, the co-lead agencies have no existing data for breaching the remaining dams such that completion of necessary analysis would take years to gather data and develop a model.
- A comprehensive FRM study for the Columbia River Basin. The scope of analysis of this EIS is limited to analyzing those measures that are part of the water management operations, associated maintenance, and structural configuration of the 14 Federal dam and reservoir projects. The Purpose and Need Statement includes a necessary constraint on the alternatives development to provide for a reliable level of flood risk by operating the Columbia River System to afford safeguards for public safety, infrastructure, and property. This screened out re-evaluating system flood risk management from further consideration in this EIS. However, FRM is an authorized project purpose and is assessed for each alternative in this EIS. Interest from states and tribes in a process to assess potential

changes to the current level of flood risk protection was identified during the Columbia River Treaty (CRT) Sovereign Review Process completed in December 2013. The Regional Recommendation stated that the Pacific Northwest states and tribes support the pursuit of Congressional authorization and appropriations for a region-wide public process to assess potential changes to the current level of flood risk protection in the Columbia River Basin to enhance spring and summer flows. However, no such authorization or appropriation was provided and, as such, a study for this purpose was determined to be outside of the scope of this EIS.

- The Columbia Basin spans the United States and Canada. The Columbia River's flow at the U.S.-Canada border is affected in part by how the Columbia River Treaty operations in Canada are managed. The 2016 CRT-related operations, were applied in the EIS analysis, as the best-available information. If CRT-related operations change in a manner that presents new information or circumstances resulting in significant changes that were not previously addressed, those changes will be addressed by this NEPA process if they are identified in time or subsequently in another NEPA process, if necessary.