Upper Columbia Alternative Flood Control and Fish Operations

Columbia River Basin

Final Environmental Impact Statement

US Army Corps of Engineers®
Seattle District

April 2006

EXECUTIVE SUMMARY

Introduction

In accordance with the National Environmental Policy Act of 1969 (NEPA), 42 USC §§ 4321-4370e, this Final Environmental Impact Statement (EIS) assesses the effects of a proposed Federal action and alternatives, which have the potential to significantly affect the human environment. The proposed Federal action consists of:

1. Implementation of alternative flood control operations at Libby Dam on the Kootenai River and Hungry Horse Dam on the South Fork Flathead River. Called variable discharge flood control, this alternative action is known as "VARQ FC," with VAR representing variable, Q representing engineering shorthand for discharge, and FC representing flood control.
2. Flow augmentation that such alternative flood control would facilitate in the Kootenai River, the Flathead River, and mainstem Columbia River for fish populations listed as threatened or endangered under the Endangered Species Act (ESA). Flow augmentation (i.e., fish flows) includes release of water for bull trout, salmon, and, at Libby Dam, white sturgeon.

The U.S. Army Corps of Engineers (Corps) is the lead agency for this EIS, with the Bureau of Reclamation (Reclamation) acting as a cooperating agency.

Purpose of the Proposed Action

The purpose of the proposed action is to provide reservoir and flow conditions at and below Libby and Hungry Horse dams for anadromous (mainstem Columbia River) and resident fish listed as threatened or endangered under the ESA, consistent with authorized project purposes, including maintaining the current level of flood control benefits.

Need for the Proposed Action

Multiple use project operations[1] at Libby, Hungry Horse, and other dams have altered the natural river hydrology of the Columbia River and some of its major tributaries. These

[1] These include flood control, hydropower, fish and wildlife, recreation, navigation, irrigation, water supply, and water quality.

dams store the spring snowmelt runoff to control floods, and release water for multiple uses. Populations of threatened and endangered fish in the Columbia River Basin (Kootenai River white sturgeon, Columbia Basin bull trout, and several Columbia River salmon and steelhead stocks) benefit from certain high flow periods, which historically were determined by natural runoff patterns driven by snowmelt and rainfall. While the status of bull trout populations in the Kootenai and Flathead rivers is generally better than some others in the Columbia River Basin, long-term monitoring has shown that bull trout populations in both watersheds have declined since construction of Libby and Hungry Horse dams. Kootenai River white sturgeon numbers are estimated at fewer than 500, down from numbers of 5,000 to 6,000 in the 1980s, and are declining at approximately 9 percent per year. Several salmon and steelhead populations in the Columbia River Basin are in various states of decline.

In accordance with the ESA, the Corps, Reclamation and the Bonneville Power Administration (the Action Agencies) have engaged in formal consultation on the effects of the operation of the Federal Columbia River Power System (FCRPS) on anadromous and resident fish species listed as threatened or endangered. In December 2000, the National Marine Fisheries Service (NMFS, also referred to NOAA Fisheries) and the U.S. Fish and Wildlife Service (USFWS), issued biological opinions on the effects of the operation of the FCRPS on the species under their jurisdiction. The NMFS and USFWS 2000 biological opinions both included a Reasonable and Prudent Alternative (RPA), with a recommendation to implement VARQ FC at Libby and Hungry Horse dams. In response, the Corps and Reclamation began the process to ensure the recommended flood control and fish flow operations at Libby and Hungry Horse dams were consistent with our responsibilities under the NEPA as represented in the purpose and need for this EIS. The recommendations carried over into the NMFS 2004 BiOp and the USFWS 2006 BiOp. For more details on ESA consultations and biological opinions from the NOAA Fisheries and USFWS, refer to Sections 1.4.1 and 1.4.2, respectively, of the Final EIS.

Columbia River System and Local Flood Control

The basic objective of Columbia River system flood control operations is to regulate the total reservoir system to, when possible, minimize flood damages in Canada and the United States in areas that are prone to potential flooding; and, in years with very high runoff, to regulate flows at The Dalles, Oregon, for the protection of Portland, Oregon, and Vancouver, Washington. Storage dam operations are designed to manage for flood control while increasing probability of refill of storage reservoirs at the end of the spring runoff.

In the context of system flood control operations, storage reservoirs throughout the Columbia River Basin release water from January through April using guidance provided by a storage reservation diagram (SRD) to create flood control storage space. A SRD shows how much water storage space is required on a certain date in each reservoir for the most current seasonal water supply forecast. In early January, water supply forecasts (WSFs) are developed for each subbasin and for the Columbia River system to The Dalles. Based on the WSF, and using the SRD as guidance, the Corps calculates the end-of-January reservoir target elevation required to provide storage space to meet flood control objectives at The Dalles. In early February, a new WSF is used to develop updated end-of-February reservoir target elevations. This process is repeated for each month through April. Reservoirs typically reach their maximum flood control draft on or about May 1. Reservoir refill in May and June is based on the calculated natural flow at The Dalles, the remaining water supply forecast, available reservoir space, and the weather forecast.

In addition to providing water storage for system flood control, Libby and Hungry Horse dams also provide local flood control for downstream river reaches in the vicinity of the dams.

Standard and VARQ Flood Control

In the past, Libby and Hungry Horse dams operated using Standard FC. Under Standard FC, the dams would generally release high flows from January through April in order to make space to capture the spring runoff in May, June, and July; from January through April, reservoir levels typically drop. This process of reducing reservoir levels by releasing water is called "drafting." Because the reservoirs drafted a large amount of storage under Standard FC, they historically released little water during the May through July period in order to refill. An assumption of the Standard FC procedure was that each dam could minimize outflow during the refill period.

The Corps and Reclamation now release water from Libby and Hungry Horse dams to augment flows for fish. At Hungry Horse Dam, for example, these releases occur during the summer months for salmon flow augmentation and year-round in the form of minimum flows for bull trout. Libby Dam provides flow augmentation for white sturgeon in addition to summer bull trout minimum flows and salmon flow augmentation. Because these fish flow releases are higher than those originally designed into Standard FC, the reservoirs have a noticeably reduced likelihood and frequency of refilling.

Variable discharge flood control was developed to improve the multipurpose operation of Libby and Hungry Horse dams while maintaining the level of local or mainstem flood protection in the Columbia River. Implementation of VARQ FC at Libby and Hungry Horse Dams enables the Corps and Reclamation to more reliably supply spring and summer flows for fish while simultaneously better ensuring higher reservoir elevations in the summer. The USFWS and NOAA Fisheries support VARQ FC because of the improved probability of providing flows for listed fish in spring while also ensuring a higher probability of reservoir refill for summer fish flow releases.

Generally, VARQ FC provides less system flood control space at Libby and Hungry Horse dams prior to spring runoff. The flood control space needed in a given year varies based on each dam's seasonal water supply forecast (WSF) for that year. In years where the April to August seasonal WSF is between about 80 and 120 percent of average at Libby Dam and between 80 and 130 percent at Hungry Horse Dam, the VARQ FC reservoir elevation would be higher than the Standard FC reservoir elevation during the January through April drawdown period. For forecasts greater than 120 percent of average, Libby Dam typically does not draft to the VARQ FC or Standard FC reservoir elevations because outflows must be reduced to comply with the IJC Order of 1938 concerning Kootenay Lake levels. In years where the seasonal water supply forecast is higher than about 120 percent of the average volume at Libby Dam and 130 percent at Hungry Horse Dam, storage space for flood control would be the same for either VARQ FC or Standard FC.

During reservoir refill, VARQ FC and Standard FC also differ. Standard FC may reduce dam releases to minimum flows during the refill period from May through July. In contrast, in years where the WSF at Libby and Hungry Horse dams are about 80 to 120 percent of average, the VARQ FC refill outflow is generally greater than minimum flows. The basic premise of VARQ FC is that the dam releases during the refill period can vary based on the seasonal WSF, actual reservoir elevation, and the estimated duration of flood control. Some of the water that would be stored during the refill period under Standard FC is instead passed through the dam under VARQ FC.

Since the flood control draft at Grand Coulee Dam is based, in part, on the available storage space upstream from The Dalles, VARQ FC at Libby and Hungry Horse dams influences operations for system flood control at Grand Coulee Dam. In years when VARQ FC operations result in higher reservoir elevations and less flood control storage space at Libby and Hungry Horse dams, Grand Coulee Dam may draft deeper to maintain system flood protection at The Dalles. In practice, Grand Coulee Dam may draft deeper for flood control in years with seasonal WSFs between 86 and 100 percent of average. The increase in flood control draft at Grand Coulee Dam is less than the net decrease in draft at Libby and Hungry Horse dams.

Interim Implementation of VARQ FC

Based on analyses of the effects of interim (short-term) implementation of VARQ FC operation at Hungry Horse and Libby dams, Reclamation began implementation of VARQ FC at Hungry Horse Dam in winter 2002 and the Corps began implementation of VARQ FC at Libby Dam in winter 2003. This Final EIS addresses the long-term implementation of VARQ FC at both dams. In addition, this Final EIS evaluates potential effects of fish flow operations at Libby Dam involving discharges greater than the existing powerhouse capacity, actions which were beyond the scope of the interim decision-making process.

Libby Dam Alternatives

The alternatives for Libby Dam are referred to by the abbreviations shown in Table S-1. The alternative operations vary in terms of the flood control operation and recommended fish flow augmentation.

Table S-1. Alternative abbreviations used in this EIS.

Abbreviation	Project Feature or Alternative Operation
L	Libby Dam
H	Hungry Horse Dam
S	Standard FC
V	VARQ FC
1	sturgeon flows up to powerhouse capacity (25 kcfs)
2	sturgeon flows up to 10 kcfs above powerhouse capacity (35 kcfs)
B	sturgeon flows up to 10 kcfs above powerhouse capacity for up to 14 days, using spill when reservoir, inflow and temperature conditions are suitable

kcfs = thousand cubic feet per second

The Corps, Reclamation and the Bonneville Power Administration (the Action Agencies) have engaged in several ESA consultations on the effects of the operation of the Federal Columbia River Power System (FCRPS) on anadromous and resident fish species listed as threatened or endangered under the ESA. With the designation of Kootenai River white sturgeon critical habitat, the Corps and BPA reinitiated consultation with the USFWS on the effects of the operation of Libby Dam on the Kootenai River white sturgeon, its designated critical habitat, and bull trout. On February 18, 2006, the USFWS issued a biological opinion (USFWS 2006), which included a Reasonable and Prudent Alternative (RPA) recommending continued implementation of VARQ FC at Libby Dam and flow augmentation for sturgeon in the spring.

The RPA from the 2006 USFWS Biological Opinion recommends a range of releases from Libby Dam up to 35 kcfs for up to 14 days, pending appropriate water conditions, providing for a normative hydrograph to achieve the desired habitat attributes of depth, velocity and temperature. The USFWS identified these habitat attributes to support successful sturgeon spawning and recruitment. Currently, the only means available to provide up to 10 kcfs above the powerhouse capacity (approximately 25 kcfs) for a total release of 35 kcfs from Libby Dam is by spill. Spill of up to 10 kcfs will increase total dissolved gas (TDG) above the Montana water quality standard of 110%. The Corps, BPA, and the USFWS are coordinating with the State of Montana on the TDG effects of spilling up to 10 kcfs.

The 2006 USFWS Biological Opinion RPA recognizes that there are several ways to achieve the desired habitat attributes and allows the Corps and BPA the flexibility to select the means to provide for these attributes. This is called a performance-based adaptive management approach. While release of flows up to 35 kcfs out of Libby is the method currently available to achieve the desired attributes in the near term, the Corps and BPA are pursuing habitat actions that may reduce the need for such releases in the future. As information is gained on the biological response to providing the habitat attributes, flows may be adjusted under the adapative management approach provided for in the 2006 USFWS Biological Opinion.

In response to the RPA in the USFWS 2006 Biological Opinion, additional alternatives concerning the operation of Libby Dam were added to this Final EIS. These alternatives, LSB and LVB, identify the use of the spillway as the mechanism for achieving flows up to 35 kcfs (10 kcfs above powerhouse capacity), which is an operational component of the USFWS 2006 RPA. Because the use of the spillway to provide flows up to 35 kcfs had not been included in the Draft EIS, as analysis of the effects associated with this operation, including the TDG levels and the condition of the spillway surface, has been incorporated in the Final EIS. Other impacts associated with the additional alternatives fall within the range of the impacts associated with the alternatives analyzed in the Draft EIS.

Detailed descriptions of the Libby Dam alternatives and benchmarks follow.

Alternative LS1 – Standard FC with fish flows up to powerhouse capacity (No Action Alternative)

Alternative LS1, the no action alternative for Libby Dam, consists of Standard FC with sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate up to the existing powerhouse capacity (about 25 kcfs). Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

Alternative LV1 – VARQ FC with fish flows up to powerhouse capacity (Preferred Alternative)

As of 2003, Alternative LV1 is the current interim operation for Libby Dam and consists of VARQ FC with sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate up to the existing powerhouse capacity (about 25 kcfs). Dam releases would be timed and optimized to provide for temperatures of 50^o F with no more than a 3.6^o F drop.

With the release of the 2006 USFWS Biological Opinion and its Reasonable and Prudent Alternative, Alternative LV1 is no longer the preferred alternative for Libby Dam.

Alternative LS2 – Standard FC with fish flows up to powerhouse capacity plus 10 kcfs

Alternative LS2 is the same as Alternative LS1, except that sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate at some level up to 10,000 cfs above the approximately 25,000-cfs powerhouse capacity. Dam releases would be timed and optimized to provide for temperatures of 50^o F with no more than a 3.6^o F drop.

LS2 differs from LSB in that LS2 does not identify a specific mechanism to achieve the 10 kcfs of additional flow and the corresponding analysis presumes that the additional 10 kcfs of flow would be provided for all sturgeon flow augmentation events except when limited to avoid exceeding flood stage of 1,764 feet at Bonners Ferry, Idaho. Impacts of the flows and reservoir elevations are addressed on that basis for LS2. This would contrast with LSB, where the additional 10 kcfs of flow would be provided when the reservoir elevation is at or above 2415 feet and reservoir inflows are sufficient to maintain that reservoir elevation during spill operations for sturgeon. Dam releases would be timed and optimized to provide for temperatures of 50^o F with no more than a 3.6^o F drop.

Alternative LV2 – VARQ FC with fish flows up to powerhouse capacity plus 10 kcfs

In years when sturgeon flows are requested and conditions are met (see Section 1.1), Alternative LV2 is the same as Alternative LV1, except that sturgeon flow augmentation would provide tiered sturgeon volumes as adopted in the 2006 USFWS FCRPS Biological Opinion using a maximum Libby Dam release rate at some level up to 10,000 cfs above the approximately 25,000-cfs powerhouse capacity. Dam releases would be timed and optimized to provide for temperatures of 50^o F with no more than a 3.6^o F drop.

LV2 differs from LVB in that LV2 does not identify a specific mechanism to achieve the 10 kcfs of additional flow and the corresponding analysis assumes that the additional 10 kcfs of flow would be provided for all sturgeon flow augmentation events except when limited to avoid exceeding flood stage of 1,764 feet at Bonners Ferry, Idaho. As with LS2, impacts from flows and reservoir elevations are addressed based on that assumption.

This contrasts with LVB, where the additional 10 kcfs of flow would be provided only when the reservoir elevation is about 2415 feet and reservoir inflows are sufficient to maintain that reservoir elevation during spill operations for sturgeon. Dam releases would be optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop.

Alternative LSB – Standard FC with fish flows up to powerhouse capacity plus 10 kcfs, using spill when reservoir and inflow conditions make this possible

Alternative LSB consists of Standard FC with sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes consistent with the 2006 USFWS FCRPS Biological Opinion. Annual operations would be based on a scientific approach for testing different releases from Libby Dam and determining the effectiveness for achieving the habitat attributes and meeting the conservation needs established for sturgeon as described in the 2006 USFWS Biological Opinion. Maximum peak augmentation flows up to 35kcfs would be provided for up to 14 days, when water supply conditions are conducive, during the peak of the spawning period. After the peak augmentation flows, remaining water would be provided to maximize flows for up to 21 days with a gradually receding hydrograph. As before, sturgeon augmentation flows would include no dedicated sturgeon flows during a Tier 1 water year (see Section 1.4.2); otherwise, LSB would provide either dam releases up to existing powerhouse capacity, or dam releases to powerhouse capacity plus up to 10 kcfs via the Libby Dam spillway.

Specific details for determining appropriate flows in any given year are being developed in a Flow Plan Implementation Protocol in collaboration with the states, tribes and other Federal agencies.

For this alternative, the reservoir elevation would have to be no lower than about 2415 feet in order to release 10 kcfs via the Libby Dam spillway (which has a spillway crest elevation of 2405 feet); and, reservoir inflows would need to be sufficient to maintain the reservoir at or above elevation 2415 feet to maintain these releases for up to two weeks. Dam releases would be timed and optimized to provide for temperatures of 50^{o} F with no more than a 3.6^{o} F drop. When the reservoir elevation is not high enough to allow spillway releases in the spring, sturgeon flow augmentation would be provided using adaptive management consistent with the Flow Plan Implementation Protocol, with a maximum release rate of about 25 kcfs (the existing powerhouse capacity at Libby Dam). Under Standard FC, review of the monthly modeling data shows that the appropriate conditions to allow for releases of sturgeon flows through the Libby Dam spillway occurs for some period of time in approximately 25% of years. Actual duration and quantity of spill operations would vary in any given year.

Alternative LVB - VARQ FC with fish flows up to powerhouse capacity plus 10 kcfs, using spill when reservoir and inflow conditions make this possible (Preferred Alternative)

Alternative LVB is the preferred alternative. LVB is similar to LSB, but with VARQ FC rather than Standard FC. It includes sturgeon, bull trout, and salmon flow augmentation. Sturgeon flow augmentation would provide tiered sturgeon volumes as specified in the 2006 USFWS FCRPS Biological Opinion. Annual operations would be based on a scientific approach for testing different releases from Libby Dam and determining the effectiveness for achieving the habitat attributes and meeting the conservation needs established for sturgeon as described in the 2006 USFWS Biological Opinion. Maximum peak augmentation flows up to 35 kcfs would be provided for up to 14 days, when water supply conditions are conducive, during the peak of the spawning period. After the peak augmentation flows, remaining water would be provided to maximize flows for up to 21 days with a gradually receding hydrograph. Consistent with the 2006 USFWS Biological Opinion, during a Tier 1 water year, dedicated sturgeon augmentation flows are not provided (see Section 1.4.2); otherwise, dam releases would range from within existing powerhouse capacity up to an additional 10 kcfs using the Libby Dam spillway for up to 14 days depending on water supply conditions. Specific details for determining appropriate flows in any given year are being developed in a Flow Plan Implementation Protocol in collaboration with the states, tribes and other Federal agencies.

For this alternative, the reservoir elevation would have to be no lower than about 2415 feet in order to release 10 kcfs via the Libby Dam spillway (which has a spillway crest elevation of 2405 feet); and, reservoir inflows would need to be sufficient to maintain the reservoir at or above elevation 2415 feet in order to maintain these release for up to two weeks during sturgeon flow augmentation. Dam releases would be timed and optimized to provide temperatures of approximately 50^{o} F with no more than a 3.6^{o} F drop. When the reservoir elevation is not high enough to allow spillway releases in the spring, sturgeon flow augmentation would be provided using adaptive management consistent with the Flow Plan Implementation Protocol, with a maximum release rate of about 25 kcfs (the existing powerhouse capacity at Libby Dam). Under VARQ FC, review of the monthly modeling data shows that conditions to allow for releases of sturgeon flows from the Libby Dam spillway for some period of time occur in approximately 50% of years. Actual duration and quantity of spill operations would vary in any given year.

LVB is consistent with the Reasonable and Prudent Alternative for Libby Dam operations included in the 2006 USFWS Biological Opinion.

LS and LV Benchmarks

The LS and LV benchmarks are descriptive of Libby Dam operations that do not include fish flows. These benchmark operations discuss additional information that became available after publication of the 1995 Columbia River System Operation Review (SOR) EIS (BPA *et al*. 1995) on potential effects associated with fish flows up to existing Libby Dam powerhouse capacity, and are included for that purpose.

This new information also provides an opportunity to update the evaluation of groundwater seepage in the Kootenai River valley in Idaho and assist in evaluating the effects of flows on sturgeon reproduction. The benchmarks are not included as alternatives because they do not meet the purpose and need of the proposed action.

Hungry Horse Dam Alternatives

The alternatives for Hungry Horse Dam operations vary in terms of flood control and both alternatives provide bull trout minimum flows and salmon flow augmentation. The effects of bull trout minimum flows and drafts for salmon flow augmentation were addressed in the 1995 Columbia River SOR EIS.

Alternative HS – Standard FC with fish flows (No Action Alternative)

Alternative HS, the no action alternative for Hungry Horse Dam is Standard FC with bull trout and salmon augmentation flows. Standard FC operations are the historic operations and are based on the principle of deep winter drafts of the reservoir for flood control then minimizing outflow during the refill period from May through June 30.

Alternative HV – VARQ FC with fish flows (Preferred Alternative)

Alternative HV, the preferred alternative for Hungry Horse Dam, consists of flood control using VARQ FC with bull trout and salmon augmentation flows. This is the current interim operation at Hungry Horse Dam and is based on less winter reservoir draft for flood control during years with 80% to 130% normal forecast and increases releases during the refill period in May and June.

Mainstem Columbia River Alternative and Benchmark Combinations

The effects of Libby Dam and Hungry Horse Dam alternatives and benchmarks are evaluated in the mainstem Columbia River downstream from the Kootenai River and Pend Oreille River tributary systems. Thus, for analysis of the environmental effects in the Columbia River upstream and downstream from Grand Coulee Dam for power generation and related economic values, alternative and benchmark combinations are derived by combining Libby Dam and Hungry Horse Dam alternatives and benchmarks

(Table S-2). As with Libby Dam benchmarks LS and LV, benchmark combinations LS+HS and LV+HV are included as a tool to derive the effects of fish flows from Libby Dam on the mainstem Columbia River.

Table S-2. Mainstem Columbia River alternative combinations and benchmarks.

	Flood Control Method at Libby and Hungry Horse Dams		**Fish Flows Provided at Libby Dam**				**Fish Flows Provided at Hungry Horse Dam**	
Alternative Combinations	Standard FC	VARQ FC	Sturgeon up to ~25 kcfs	Sturgeon up to ~35 kcfs	Bull trout	Salmon	Bull trout	Salmon
LS1+HS	X		X		X	X	X	X
LV1+HV		X	X		X	X	X	X
LS2+HS	X			X	X	X	X	X
LV2+HV		X		X	X	X	X	X
LSB+HS	X		X[a]	up to 25% of years	X	X	X	X
LVB+HV		X	X[a]	up to 50% of years	X	X	X	X
Benchmark Combinations								
LS+HS	X		none				X	X
LV+HV		X	none				X	X

a. Sturgeon flows provided in years with sturgeon volume Tiers 2-6 (see Fig. 1-2). Depending upon reservoir elevation, reservoir inflow, and/or water temperatures, releases may vary from 25 kcfs to 35 kcfs. Duration of the release would also vary year to year.

Issues Addressed in this EIS

The Corps and Reclamation initiated a joint NEPA process to analyze the effects of long-term implementation of the VARQ FC strategies at Libby and Hungry Horse dams with publication in the Federal Register of the Notice of Intent to prepare an EIS on October 1, 2001.

Public scoping meetings were held at Grand Coulee, Washington; Sandpoint, Idaho; Bonners Ferry, Idaho; Portland, Oregon; Libby, Montana; Eureka, Montana; Kalispell, Montana; and in Creston, British Columbia, Canada. In addition to the meeting comments, comment forms and letters from tribes, agencies, and interested parties were also received.

Through scoping and interdisciplinary analysis, the following issues were identified for consideration in this Final EIS.

Issue 1: Flood control and related impacts

Libby Dam and Hungry Horse Dam are important facilities for management of local and system flooding and related impacts. The Final EIS addresses how the alternatives would modify flood control operations and fish flows.

Issue 2: Fisheries and other biological impacts and benefits

The proposed modifications to flood control operations and fish flows are primarily intended to benefit fish stocks listed under the ESA, including Kootenai River white sturgeon (endangered), bull trout (threatened), and various stocks of Chinook, chum, coho, and sockeye salmon, and steelhead (threatened and endangered). The Final EIS addresses how the alternatives would affect the fisheries resource.

Issue 3: Water and air quality impacts

The Final EIS addresses how the changes in flood control operations and fish flows influence water quality and may have indirect effects on air quality.

Issue 4: Cultural resource protection and related impacts

The Final EIS addresses how changes in reservoir elevations and shoreline erosion and exposure can influence the likelihood of discovery, looting, and vandalism of prehistoric artifacts and human remains along Lake Roosevelt (the reservoir behind Grand Coulee Dam) and elsewhere.

Issue 5: Recreation impacts

The Final EIS addresses how changes in reservoir levels and streamflows can influence the quality and availability of water-based recreation opportunities.

Issue 6: Power generation impacts

The Final EIS addresses how changes in flood control operations and fish flows can affect power generation at Hungry Horse Dam, Libby Dam, and numerous dams downstream.

Issue 7: Economic impacts

The Final EIS addresses how changes in flood control operations and fish flows can directly or indirectly influence local and regional economies.

Cumulative Impacts

Cumulative impacts for the Kootenai and Pend Oreille subbasins and along the mainstem Columbia River were analyzed based on the incremental consequences of the different alternatives when added to other past, present, and reasonably foreseeable future actions. Notable potential cumulative impacts are summarized below.

Kootenai River Basin

Adaptive management of dam operations would consider multiple uses to provide more normative flow conditions and help maintain Lake Koocanusa levels during the summer. While the flow patterns that are possible under the alternatives would provide a semblance of normative river conditions, over the course of any given year, they would still be significantly different from pre-dam conditions in terms of magnitude, duration, and timing. Due to heat storage in Lake Koocanusa as a result of Libby Dam construction, the addition of fish flows would tend to increase the possibility of temperature fluctuations in the river downstream of the dam. The expansion of Brilliant Dam on the Kootenay River downstream of Kootenay Lake may serve to decrease the duration or degree of high TDG levels resulting from fish flows or VARQ FC operations.

Physical modification of riparian and floodplain areas and various operational requirements (Kootenay Lake operations, flood control requirements) can, under certain circumstances, constrain opportunities for ecosystem and species recovery actions that rely solely on operational flexibility that would be provided by the various alternatives. Such constraints could prevent or diminish effectiveness of the suite of actions that are possible under the different alternatives and likely necessary to successfully recover and sustain ecosystem functions. All of the alternatives would provide a degree of flexibility to provide more normative river flows during the spring and summer, with resultant synergistic benefits to ecosystem functions (i.e. riparian habitat development, habitat connectivity) and sensitive, threatened, and endangered species such as sturgeon, bull trout, burbot, and bald eagles. The VARQ FC alternatives and higher fish flows possible under LS2. LV2, LSB, and LVB provide the greatest flexibility to manage river flows in concert with ecosystem recovery efforts to generate higher relative ecosystem benefits.

Benefits to the regional ecosystem under the VARQ FC alternatives could provide long-term recreational opportunities to anglers and eco-tourists, with resulting benefits to local economies. However, together with other factors that have adversely affected the local economy, adverse impacts to businesses relying on angling would further impact the potential for economic growth in the vicinity of Libby. Future expansion of hops or other crops that tend to be more sensitive to shallow groundwater could further worsen agricultural impacts from groundwater seepage linked to higher river flows during the spring and summer.

Climate change could result in changes in the temperature regime of Lake Koocanusa, which could assist in optimizing spring release temperatures for benefit of sturgeon spawning and reproduction. Libby Dam construction and the resulting creation of Lake Koocanusa has placed some cultural resources out of reach of looters and vandals, but has allowed exposure of others in wave-affected zones. All known sites around Lake Koocanusa have been impacted by reservoir operations since 1972. The better the chance of refill under the VARQ FC alternatives would reduce exposure.

Pend Oreille River Basin

Cumulatively, implementation of VARQ FC at Hungry Horse Dam would work in concert with the proposed Flathead Lake Drought Management Plan to improve lake refill while meeting minimum flow requirements below Kerr Dam..

The various state programs such as the 1998 Watershed Planning Act in Washington, the water quality restoration plans and new TMDL program in Montana and the establishment of TMDLs in Idaho are intended to improve water quality, water supply, and habitat.

Cumulatively, ongoing stream and riparian restoration measures, TMDL processes, state agency programs, and other conservation activities in conjunction with Federal recovery efforts, could help preserve and possibly improve habitat conditions for bull trout populations.

Mainstem Columbia River

Climate changes may alter runoff patterns. Since system flood control under all alternative combinations is essentially equivalent, cumulative impacts under all the alternative combinations would also be comparable.

Alternative combinations with VARQ FC would assist in efforts to provide more normative hydrographs in the mainstem Columbia River which would likely provide a cumulative benefit to overall ecosystem health. At Grand Coulee Dam and Lake Roosevelt, small changes in the timing and degree of reservoir fluctuation that would result from the various alternative combinations will not substantially alter the character, scope, or nature of Lake Roosevelt, particularly since any observed changes will be within the current operating range.

Alternative combinations that result in lower annual or monthly generation may result in more power generation from sources such as fossil fuel-powered generators. Changes in flow patterns resulting from climate changes may force additional changes in system operations to better balance power generation with ecosystem recovery objectives. Any reduction in flows from drought or climate shifts may lead to relatively lower ecosystem recovery capability. No cumulative impacts on the electrical transmission system are anticipated.

Actions now being undertaken, such as flow deflector construction at Chief Joseph Dam, expansion of Brilliant Dam, and operational shifts of generation and spill between Grand Coulee and Chief Joseph dams, would enhance the ability of the system to manage spill and TDG generation. Further population growth in the region might cause development of greater power generating and transmission capacity with potential of reducing involuntary spill and resulting TDG impacts.

The provision of more normative flows for fish and aquatic life presents opportunities for successful maintenance of habitat conditions. Fish flows in all alternative combinations would cumulatively improve the ability of the system to meet flow objectives at Priest Rapids and McNary dams for anadromous fish migration and would provide more options to achieve recovery of threatened and endangered fish stocks over the long term. Demands for water, and impacts to watersheds would continue to be a factor in determining the health of aquatic species. It is conceivable that aquatic species would continue to be adversely affected in the long run as development and mitigation balance against each other.

Continued regional growth is expected to add to demand for recreational use. Further degradation of water quality, loss of fish and wildlife habitat and visual resources and esthetic values might also decline. To the extent that habitat is maintained or enhanced, and to the extent that fish and wildlife resources can be maintained and recovered in the face of competing interests, then cumulative impacts to recreation would be decreased.

All known historic properties at Lake Roosevelt have undergone impacts from the operation of Lake Roosevelt over the past 70 years, including loss of site integrity and of individual items. Cumulative effects from past, present, and foreseeable future actions include increased weathering to organic materials, artifact movement or damage from human and animal use of the shoreline, and loss from illegal collecting activities.

Mitigation

All alternatives in this EIS are formulated with the primary intent of avoiding or minimizing impacts. Some impacts cannot be avoided while meeting the purpose and need of the proposed action.

Potential mitigation measures are identified in this EIS, even if they are outside the jurisdiction of the Corps or Reclamation. Some of the identified measures may be undertaken by other entities or individuals. No commitments are made in this EIS to any mitigation action, particularly those that are not currently authorized, programmed, and funded. Notable potential mitigation measures are summarized below.

Kootenai River Basin

Mitigation for occasional flooding has not been identified, because the alternatives are not considered to increase flood risk. Levee repairs and upgrades, structural relocation, and individual structural floodproofing are potential measures that local landowners may consider to further decrease flood risk above that provide by Libby Dam operations. Potential mitigation for agricultural impacts due to high groundwater includes upgrades to drainage and pumping systems or removing affected areas from agricultural production. The cost-effectiveness of mitigation for agricultural seepage may be low. Bank stabilization work of vulnerable shoreline sections (ranging from bioengineering techniques to placement of riprap) would prevent or minimize potential bank erosion that may occur primarily in areas upstream of Bonners Ferry under alternatives with generally higher flows.

Modification of the dam to provide for spillway deflectors, additional discharge capacity via the powerhouse, or other options could reduce TDG loadings resulting from spill and resulting adverse impacts to aquatic life. The Corps is currently studying temperature stratification in the Libby Dam forebay to determine if it is possible to improve selective withdrawal system use, including possible water withdrawals closer to the surface, to more accurately provide desired downstream temperatures in the spring and consequently aid sturgeon migration and spawning. Ongoing fertilization of the Kootenai River and Kootenay Lake will help minimize effects from any increased nutrient flushing. Options to reduce potential adverse effects from flooding of waterfowl and shorebird nesting areas, as well as reptile and amphibian reproductive sites, could include increased pumping capacity or increasing the height of levees protecting sensitive nesting areas, in the Creston Valley Wildlife Management Area. Other possible mitigation may include connection to the river for nesting areas which are currently behind dikes, so that water level rises in nesting areas are more synchronous with onset of lowland runoff.

Appropriate mitigation for adversely affected cultural resources sites is being formulated in Site Treatment Plans and Site Protection Plans by the Corps, and mitigation planning will continue under the current cultural resources management program at Libby Dam—Lake Koocanusa. Mitigation may include documentation, surface collection of artifacts and features, site stabilization, or more intensive data recovery. The Corps, BPA, Kootenai National Forest, Confederated Salish and Kootenai Tribes, and the Montana SHPO will continue to coordinate to mitigate impacts as needed under the current program.

Pend Oreille River Basin

No mitigation needs were identified based on the impact analysis.

Mainstem Columbia River

Coordinated operation of the system is to minimize TDG. Flow deflector construction at Chief Joseph Dam and operational shifts of generation and spill between Chief Joseph and Grand Coulee dams would cumulatively reduce the magnitude of high TDG levels below Grand Coulee Dam.

Mitigation for cultural resources could include appropriate additional management actions for historic properties affected by implementation of VARQ FC including erosion monitoring targeted to affected sites, completion of the evaluation process for affected sites to determine appropriate mitigation efforts, and public outreach/education. Protective patrols are already in place during the April drawdown, and Reclamation would work with patrolling agencies and tribes to make any needed adjustments in spatial focus.

Discovery of new sites or site components, or impacts to known sites, would be managed through the current cultural resources program at Lake Roosevelt. No specific mitigation is needed or planned for cultural resources impacts below Grand Coulee Dam.

Reduction in hydropower generation in Canada and consequent compensation issues are matters appropriately addressed through established Columbia River Treaty processes.

Effects on other resources are expected to be beneficial, minor, or not capable of being mitigated.

Unavoidable Adverse Effects

The various alternatives may create some unavoidable and adverse effects on some resources in some impact areas. Notable unavoidable adverse effects are summarized below.

Kootenai River Basin

Potential unavoidable adverse impacts in the Kootenai River basin include:

- Possible flooding under any of the alternatives since Libby and Hungry Horse dams were not designed to prevent flooding under all circumstances.

- Spill at Libby Dam up to 10,000 cfs for up to 14 days under appropriate conditions under the Preferred Alternative, with TDG saturations over 130% below the dam.
- Increased likelihood of forced spill, in terms of frequency and duration, at Libby Dam with the VARQ FC alternatives compared to the Standard FC alternatives. Spill would increase TDG concentrations in the river downstream, between the dam and Kootenai Falls, which could adversely affect aquatic life (including sensitive and threatened fish species).
- Possible entrainment of fish through the turbines and/or over the spillway at Libby Dam.
- Increased nutrient flushing from Kootenay Lake.
- Fish stranding in the Duncan River delta.
- Adverse effects on spawning burbot due to relatively high winter water temperatures under all alternatives.
- Adverse effects to wetland vegetation under Standard FC due to relatively lower spring and summer river levels and resulting poor hydrologic connectivity between the river and riparian areas.
- Adverse effects to amphibians, and nesting waterfowl and shorebirds in the Creston Valley Wildlife Management Area due to high water levels under VARQ FC.
- Reduction in recreational use and access along Lake Koocanusa, and reduction in swimming and shore fishing days on the Kootenai River downstream of Libby Dam.
- Impacts to archaeological sites and other historic properties along the reservoir shoreline due to their static and perishable nature.
- Increased costs for agricultural drainage pumping along the Kootenai River.
- Economic losses due to impacts from groundwater seepage in agricultural lands.
- Economic losses due to less-reliable Lake Koocanusa refill under Standard FC or alternatives with fish flows to 10 kcfs above current Libby powerhouse capacity.

Pend Oreille River Basin

- Existing potential for adverse flooding effects under the implementation of either alternative.
- Occasional TDG levels above 120% saturation, with a high incidence under VARQ FC alternative combinations, at Cabinet Gorge Dam, which may adversely affect aquatic life, including threatened and endangered fish, in the Clark Fork.

- Impacts arising from implementation of either alternative to archaeological sites or other historic properties along the reservoir shoreline, because of the static nature of historic properties.

Mainstem Columbia River

Potential unavoidable adverse impacts along the mainstem Columbia River include:

- Potential flooding as the storage capacity of the FCRPS was not designed to prevent all flooding.
- Under VARQ FC alternative combinations, reduction in power generation in winter.
- TDG levels above 120% saturation under VARQ FC alternative combinations, at Priest Rapids, Wanapum, Rock Island, and Rocky Reach dams, which may adversely affect aquatic life, including threatened and endangered fish, in the mainstem Columbia River.
- Some increased vandalism, erosion, and looting arising from VARQ FC alternative combinations at archaeological sites and other historic properties along the Lake Roosevelt shoreline, primarily because of the static nature of these resources.
- Reduction in power generation in the winter under VARQ FC alternative combinations.

Summary Comparison of Alternatives

The following tables provide summary comparisons of the alternatives and benchmarks at Libby Dam, alternatives at Hungry Horse Dam, and alternative and benchmark combinations in the mainstem Columbia.

Table S-3. Summary comparison of the no action and action alternatives and benchmarks at Libby Dam.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Hydrology and Flood Control								
Lake Koocanusa	Median draft 2370'; median July elevation 2440'; within 5' of full in 12% of years.	Median draft 2396'; median July elevation 2446'; within 5' of full in 31% of years.	Median draft 2370'; median July elevation 2440'; within 5' of full in 10% of years.	Median draft 2396'; median July elevation 2445'; within 5' of full in 31% of years.	Median draft and refill range between LS1 and LS2.	Median draft and refill range between LV1 and LV2.	Median draft 2370'; median July elevation 2458'; within 5' of full in 98% of years.	Median draft 2396'; median July elevation 2458'; within 5' of full in 98% of years.
Kootenai River downstream from Libby Dam	Libby Dam peak releases at about 25 kcfs. Fish flows eliminate need for flood control spills above powerhouse capacity.	Libby Dam peak releases similar to LS1. Highest average outflow during July/Aug. of any alternative. Increased likelihood of 1' higher river stage at Bonners Ferry than LS1 (below 1764').	Libby Dam peak releases at about 35 kcfs. Peak stages at Bonners Ferry are the second highest of any alternative 20% of time, but lowest river stage 80% of time.	Libby Dam peak releases slightly higher than LS2 (35 kcfs) during drier years, similar to LS2 in wetter years. Peak stages at Bonners Ferry are the highest of any alternative.	Peak dam releases range between LS1 and LS2. Bonners Ferry maximum daily elevation and stage-duration range between LS1 and LS2.	Peak dam releases range between LV1 and LV2. Bonners Ferry maximum daily elevation and stage-duration range between LV1 and LV2.	Average Libby Dam releases and Bonners Ferry stages during May, June, and August are the lower than all alternative and LV. Peak releases are distinctly lower than all alternatives for most years below flood stage.	Libby Dam peak releases are lower than all alternatives. Below flood stage, tends to produce peak Bonners Ferry stages higher than LS, but below all of the alternatives.
Kootenay Lake to confluence with Columbia River	Lowest lake levels of all alternatives.	Peak lake elevation tends to be slightly higher than LS1, but lower than LS2 or LV2.	Peak lake elevation tends to be higher than any alternative other than LV2.	Produces the highest likelihood of any given Kootenay Lake peak stage.	Median lake elevation, month-end average stages, and maxim um daily elevations range between LS1 and LS2. Elevation-duration would be similar to or within the range of LS1 and LS2.	Median lake elevation, month-end average stages, and maximum daily elevations range between LV1 and LV2. Elevation-duration would be similar to or within the range of LV1 and LV2.	Tends to produce lower Kootenay Lake peak stages than any alternative.	Produces lower Kootenay Lake peak stages than any alternative.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Water Quality								
Lake Koocanusa	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives,	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives	Similar temperatures to other alternatives
Kootenai River downstream from Libby Dam	Similar release temperatures to other alternatives. TDG saturation >110% in 1 out of 52 yrs, >120%&>125% in 0 out of 52 yrs	Similar release temperature to other alternatives. TDG saturation >110% in 3 out of 52 yrs, > 120%&>125% in 2 out of 52 yrs, > 130% in 1 out of 52 yrs	Similar release temperature as other alternatives except possibly slightly cooler in spring. No evaluation of TDG since mechanism to achieve add'l 10 kcfs of flow not known.	Similar release temperature as other alternatives except possibly slightly cooler in spring. No evaluation of TDG since mechanism to achieve add'l 10 kcfs of flow not known	Similar release temperature to LS1 except possibly slightly warmer in spring. TDG levels up to about 125% saturation near dam, and 112% at 8 mi. downstream, in 25% of years; otherwise about 100% saturation throughout.	Similar release temperature to LV1 except possibly slightly warmer in spring. TDG levels up to about 125% saturation near dam, and 112% at 8 mi. downstream, in 50% of years; otherwise about 100% saturation throughout.	TDG saturation >110% in 11 out of 52 yrs, >120%&>125% in 6 out of 52 yrs, >130% in 3 out of 52 yrs	TDG saturation > 110% in 13 out of 52 yrs, >120%&>125% in 7 out of 52 yrs, > 130% in 5 out of 52 yrs
Kootenay Lake to confluence with Columbia River	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	Some unquantified increase in TDG levels from dams below Kootenay Lake due to fish flows from Libby in spring.	No anticipated increase in TDG levels from dams below Kootenay Lake.	No anticipated increase in TDG levels from dams below Kootenay Lake.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Aquatic Life								
Lake Koocanusa	Relative to VARQ FC alternatives, reduced primary productivity; lower zooplankton production; lower benthic production; lower terrestrial insect deposition; lower kokanee growth. Possible entrainment of fish and plankton through turbines.	Relative to Standard FC alternatives, higher primary productivity; higher zooplankton production; higher benthic production; higher terrestrial insect deposition; high kokanee growth. Possible entrainment of fish and plankton through turbines	Lake productivity similar to LS1. Possible entrainment of fish and plankton through turbines	Lake productivity similar to LV1. Possible entrainment of fish and plankton through turbines	Primary productivity, entrainment of primary producers, zooplankton production, benthic insect production, benthic biomass production, terrestrial insect deposition, fish entrainment, and fish growth would range between LS1 and LS2.	Primary productivity, entrainment of primary producers, zooplankton production, benthic insect production, benthic biomass production, terrestrial insect deposition, fish entrainment, and fish growth would range between LV1 and LV2.	In lake, second highest primary productivity and zooplankton production; low benthic production; mostly high terrestrial insect deposition; high kokanee growth.	In lake, highest primary productivity and zooplankton production; high benthic production; highest terrestrial insect deposition; highest kokanee growth.
Kootenai River downstream from Libby Dam	Mixed benthic production; low TDG risk; less likelihood of low winter flow for burbot; flow benefits for sturgeon. Low probability of involuntary spill with TDG impacts.	High benthic production; somewhat higher TDG risk; greater likelihood of low winter flow for burbot; flow benefits for sturgeon. Some probability of involuntary spill with TDG impacts.	Productivity similar to LS1; less likelihood of low winter flow for burbot; higher flow benefits for sturgeon.	Productivity similar to LV1; greater likelihood of low winter flow for burbot; higher flow benefits for sturgeon.	Benthic biomass would range between LS1 and LS2. Possible TDG impacts to aquatic life in 25% of years, especially at spill levels above 2-3kcfs	Benthic biomass would range between LS1 and LS2. Possible TDG impacts to aquatic life in 50% of years, especially at spill levels above 2-3kcfs.	Mixed benthic production; relatively high TDG risk; less likelihood of low winter flow for burbot; no flow benefits for sturgeon.	Relatively high benthic production; highest TDG risk; greater likelihood of low winter flows for burbot; no flow benefits for sturgeon.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Kootenay Lake to confluence with Columbia River	Possible washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Possibly higher washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Possible washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Possible washout of nutrients and plankton; possible fish stranding in Duncan delta. Possible TDG impacts to fish between Kootenay Lake and the Columbia River in spring.	Biological effects would range between LS1 and LS2.	Biological effects would range between LV1 and LV2	Possibly lower washout of nutrients and plankton; possible fish stranding in Duncan delta (Note: Potential for fish stranding a result of low lake levels that may not be significantly affected by the different alternatives)	Lower washout of nutrients and plankton; possible fish stranding in Duncan delta.
Sensitive, Threatened and Endangered Species								
	No likely effect on terrestrial species exc. bald eagle; moderate flow benefits for sturgeon, moderate flexibility for research, monitoring, & evaluation (RM&E) of sturgeon responses; relatively low likelihood of winter low flows for burbot; minimum flows maintained for bull trout. Low probability of involuntary spill with TDG impacts.	No likely effect on terrestrial species exc. bald eagle; flow benefits for sturgeon same as LS1, slightly higher flexibility for RM&E of sturgeon responses than LS1; relatively high likelihood of low flows in winter for burbot; minimum flows maintained for bull trout. Some probability of involuntary spill with TDG impacts.	No likely effect on terrestrial species exc. bald eagle; high flow benefits for sturgeon, high flexibility for RM&E of sturgeon responses; same winter flows as LS1 for burbot; minimum flows maintained for bull trout. No TDG evaluation because mechanism to pass flows above powerhouse capacity not known.	No likely effect on terrestrial species exc. bald eagle; highest flow benefits for sturgeon, highest flexibility for RM&E of sturgeon responses; same winter flows as LV1 for burbot; minimum flows maintained for bull trout. No TDG evaluation because mechanism to pass flows above powerhouse capacity not known.	Most biological effects of flow would range between LS1 and LS2. Higher flow benefits for sturgeon than LS1 or LV1, moderate flexibility for RM&E of sturgeon responses. TDG impacts to fish below Libby Dam in years of spill (about 25% of years), especially when spill exceeds 2-3 kcfs.	Most biological effects of flow would range between LV1 and LV2. Higher flow benefits for sturgeon than LS1 or LV1, moderate flexibility for RM&E of sturgeon responses. TDG impacts to fish below Libby Dam in years of spill (about 50% of years)—especially when spill exceeds 2-3 kcfs.	No likely effect on terrestrial species exc. bald eagle; no flow benefits for sturgeon; same winter flows as LS1 for burbot; no minimum flows for bull trout.	No likely effect on terrestrial species exc. bald eagle; no flow benefits for sturgeon; same winter flows as LV1 for burbot; no minimum flows for bull trout.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Vegetation and Wildlife								
Lake Koocanusa	Little or no riparian vegetation below full reservoir level. Minimal effect on wildlife.	Similar to LS1 around L. Koocanusa.	Similar to LS1 around L. Koocanusa.	Similar to LS1 around L. Koocanusa.	Effects would range between LS1 and LS2.	Effects would range between LV1 and LV2	Similar to LS1 around L. Koocanusa.	Similar to LS1 around L. Koocanusa.
Kootenai River downstream from Libby Dam	Some riparian vegetation enhancement due to fish flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Some riparian vegetation enhancement due to fish flows; possible enhancement due to lower winter flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Some riparian vegetation enhancement due to fish flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Some riparian vegetation enhancement due to fish flows; possible enhancement due to lower winter flows. Wildlife benefit from this, but may be impacted by high water in Creston Valley Wildlife Mgmt. Area. Possible Duck Lake overfilling.	Effects to wildlife and vegetation would range between LS1 and LS2.	Effects to wildlife and vegetation would range between LV1 and LV2.	Little or no benefit to riparian vegetation; possible loss, with corresponding effects on wildlife.	Little or no benefit to riparian vegetation; possible loss, with corresponding effects on wildlife.
Kootenay Lake to confluence with Columbia River	Little or no change in existing lakeshore vegetation, which should remain extensive.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.	Similar to LS1.
Recreation								
Lake Koocanusa in United States	1,340 boat ramp days May-Sep; 107 swimming days Jun-Aug; 45 camping days above elev. 2439' May-Sep; 113 camping days above 2409' May-Sep	1,467 boat ramp days May-Sep; 150 swimming days Jun-Aug; 65 camping days above elev. 2439' May-Sep; 126 camping days above 2409' May-Sep	1,351 boat ramp days May-Sep; 92 swimming days Jun-Aug; 42 camping days above elev. 2439' May-Sep; 112 camping days above 2409' May-Sep	1,454 boat ramp days May-Sep; 142 swimming days Jun-Aug; 61 camping days above elev. 2439' May-Sep; 124 camping days above 2409' May-Sep	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	1,627 boat ramp days May-Sep; 217 swimming days Jun-Aug; 102 camping days above elev. 2439' May-Sep; 122 camping days above 2409' May-Sep	1,665 boat ramp days May-Sep; 221 swimming days Jun-Aug; 104 camping days above elev. 2439' May-Sep; 130 camping days above 2409' May-Sep

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Lake Koocanusa in Canada	352 boat ramp days May-Sep, and 29 swimming days Jun-Aug.	414 boat ramp days May-Sep, and 51 swimming days Jun-Aug	343 boat ramp days May-Sep, and 24 swimming days Jun-Aug	404 boat ramp days May-Sep, 24 swimming days Jun-Aug	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	503 boat ramp days May-Sep, and 131 swimming days Jun-Aug	522 boat ramp days May-Sep, and 133 swimming days Jun-Aug
Kootenai River downstream of Libby Dam	May-Sep: 77 shore-fishing days and 88 boating days.	May-Sep: 50 shore-fishing days and 101 boating days.	May-Sep: 80 shore-fishing days and 88 boating days.	May-Sep: 54 shore-fishing days and 105 boating days.	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	May-Sep 74 shore-fishing days and 85 boating days.	May-Sep: 48 shore-fishing days and 115 boating days.
Kootenay Lake to confluence with Columbia River	135 days in preferred range May-Sep; 52 boat moorage days Jan-May; 83 fishing days above elev. 1744' May-Sep; 77 swimming days below lake elev. 1749' Jun-Aug	132 days in preferred range May-Sep; 52 boat moorage days Jan-May; 90 fishing days above elev. 1744' May-Sep; 76 swimming days below lake elev. 1749 Jun-Aug	134 days in preferred range May-Sep; 52 boat moorage days Jan-May; 82 fishing days above elev. 1744' May-Sep; 76 swimming days below lake elev. 1749 Jun-Aug	132 days in preferred range May-Sep; 52 boat moorage days Jan-May; 89 fishing days above elev. 1744' May-Sep; 75 swimming days below lake elev. 1749' Jun-Aug	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	142 days in preferred range May-Sep; 51 boat moorage days Jan-May; 79 fishing days above elev. 1744' May-Sep; 84 swimming days below lake elev. 1749' Jun-Aug	139 days in preferred range May-Sep; 52 boat moorage days Jan-May; 86 fishing days above elev. 1744' May-Sep; 82 swimming days below lake elev. 1749' Jun-Aug
Environmental Health								
Lake Koocanusa	Elev. at or below 2404' (exposed dust could become windblown) 90% of time Jan-Apr, 87% of time May, & 32% of time June	Elev. at or below 2404' (exposed dust could become windblown) 63% of time Jan-Apr, 60% of time May, and 13% of time June	Elev. at or below 2404' (exposed dust could become windblown) 90% of time Jan-Apr, 88% of time May, & 37% of time June	Elev. at or below 2404' (exposed dust could become windblown) 63% of time Jan-Apr, 62% of time May, & 18% of time June	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	Elev. at or below 2404' (exposed dust could become windblown) 90% of time Jan-Apr, 83% of time May, & 14% of time June	Elev. at or below 2404' (exposed dust could become windblown) 63% of time Jan-Apr, 56% of time May, & 7% of time June
Cultural Resources								
Lake Koocanusa in United States	268 sites possibly exposed to erosion, looting, and vandalism	247 sites possibly exposed to erosion, looting, and vandalism	Similar to LS1	Similar to LV1	Similar to LS1	Similar to LV1	Similar to LS1 Note: This exposure is due to FC operations and not a factor of fish flows	Similar to LV1
Kootenai River below Libby Dam	Possible erosion at 6 sites within 5 miles of Libby Dam	Same as LS1.	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Lowest likelihood of erosion at sites downstream from dam.	Relatively low likelihood of erosion at sites downstream from dam.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Indian Sacred Sites								
	During informal consultations with the CSKT, they have chosen not to discuss sacred sites at Libby Dam-Lake Koocanusa. Therefore, the possible effects on TCPs are not assessed in this analysis.	Same as LS1.	Same as LS1.	Same as LS1.	Same as LS1	Same as LS1.	Same as LS1.	Same as LS1.
Other Affected Tribal Interests								
	No impacts	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1
Socioeconomics								
Lake Koocanusa	Adverse impacts on employment and income from recreation and tourism.	Potential positive effects on employment and income from recreation/ and tourism.	Adverse socioeconomic impacts slightly greater than LS1.	Socioeconomic benefits slightly lower than LV1.	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	Positive effects on employment and income from recreation/tourism.	Positive effects on employment and income from recreation/tourism.
Kootenai River downstream of Libby Dam	Avg. annual flood damages of $21,780; 455,600 kW-hr of ag. pumping; moderate ag. losses from high groundwater (i.e. seepage).	Avg. annual flood damages same as LS1. 452,500 kW-hr of ag. pumping; relatively high ag. losses from high groundwater.	Avg. annual flood damages same as LS1. 456,100 kW-hr of ag. pumping; ag. losses from high groundwater similar to LS1.	Avg. annual flood damages same as LS1. 453,000 kW-hr of ag. pumping; highest ag. losses from high groundwater.	Avg. annual flood damages same as LS1. ag. pumping costs and losses from high groundwater between LS1 and LS2. Also likely TDG impacts to game fish in 25% of years, affecting recreation economy.	Avg. annual flood damages same as LS1. ag. pumping costs and ag. losses from high groundwater between LV1 and LV2. Also likely TDG impacts to game fish in 50% of years, affecting recreation economy.	Avg. annual flood damages same as LS1. 457,100 kW-hr of ag. pumping; lowest ag. losses from high groundwater.	Avg. annual flood damages of $22,950 in Idaho. 455,300 kW-hr of ag. pumping; ag. losses from high groundwater higher than LS, but tend to be lower than fish flow alternatives.

Reach	Alternative LS1 (No Action)	Alternative LV1	Alternative LS2	Alternative LV2	Alternative LSB	Alternative LVB (Preferred)	Benchmark LS	Benchmark LV
Kootenay Lake	Moderate likelihood of flood damages around Kootenay Lake.(Damages would occur below established zero-damage elevation)	Likelihood of flood damages around Kootenay Lake similar to LS1	Highest likelihood of flood damages around Kootenay Lake.	Likelihood of flood damages around Kootenay Lake similar to LS2	Values would range between LS1 and LS2.	Values would range between LV1 and LV2.	Lowest likelihood of flood damages around Kootenay Lake.	Relatively low likelihood of flood damages around Kootenay Lake.
Municipal Water and Wastewater Treatment								
	No impacts identified.	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1
Transportation								
	No impacts identified.	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1	Same as LS1
Dam Structural Condition								
	Minor add'l deterioration of spillway surface. Repairs would remain relatively low urgency	Same as LS1	No analysis since mechanism to achieve add'l 10 kcfs of flow not known	Same as LS2	Accelerated deterioration of spillway surface. Repairs would become a higher priority maintenance activity.	Same as LSB	Lowest rate of add'l deterioration of spillway surface.	Rate of deterioration of the spillway surface would be low, but slightly higher than LS1 or LV1.

Table S-4. Summary comparison of the no action and preferred alternatives at Hungry Horse Dam.

	Alternatives	
Resource and River Reach	**HS (No Action)**	**HV (Preferred)**
Hydrology and Flood Control		
Hungry Horse Reservoir	Hungry Horse Reservoir would continue to have deeper winter flood control drafts in slightly below average to slightly above average water years. The average winter draft would be to elevation 3501 feet. The average June 30 refill would be to elevation 3558.17 feet.	Hungry Horse Reservoir would have shallower winter flood control drafts in slightly below average to slightly above average water years. The average winter draft would be to elevation 3512 feet. This would allow for a slight improvement in probability of refill; the average maximum refill would be to elevation 3558.5 feet.
Hungry Horse Outflows	Due to deeper winter flood control drafts, average outflows would be higher under HS during the January to April period. Average outflows would be about: January – 4995 cfs February – 4930 cfs April – 5648 cfs May – 3423 cfs June – 3054cfs Average outflows for flow augmentation would be about: July – 5174 cfs August - 5474 cfs	Given shallower winter flood control drafts, more water would be released later in the spring in order to maintain the same level of flood protection. Average outflows would be about: January – 4151cfs February – 3906 cfs April – 3560 cfs May – 5637 cfs June – 4243 cfs Average out flows for flow augmentation would be about: July – 5302 cfs August – 5476 cfs Releases for flow augmentation are higher under HV because of the improved probability of refill.
Columbia Falls	During slightly below average to slightly above average water years, HS flows would be higher during the January to April period. Average outflows would be about: January – 6594 cfs February – 6486 cfs April – 12681 cfs May – 23874 cfs June – 23650 cfs Under both alternatives there would continue to be an 18% probability of reaching or exceeding flood stage at Columbia Falls (14 feet).	During slightly below average to slightly above average water years, HV flows would be higher in May and June. Average outflows would be about: January – 5751 cfs February – 5461 cfs April – 10592 cfs May – 26088 cfs June – 24839 cfs Under both alternatives there would continue to be an 18% probability of reaching or exceeding flood stage at Columbia Falls (14 feet).
Flathead Lake	Under HS, there is a 7% probability of exceeding Flathead Lake's full pool elevation of 2893 feet.	Under HV there is 10% probability of exceeding Flathead Lake's full pool elevation of 2893 feet.

Resource and River Reach	Alternatives HS (No Action)	HV (Preferred)
Lake Pend Oreille	Due to the attenuation of flows in the river reaches downstream from Hungry Horse Dam and reregulation of flows through Flathead Lake and Kerr Dam, water surface elevations at Lake Pend Oreille would be essentially identical.	Same as HS.
Downstream from Albeni Falls Dam	Average outflows from Lake Pend Oreille would lower in June. Average outflows would be about: January – 17411 cfs February – 19434 cfs April – 28588 cfs May – 53,678 cfs June – 54518 cfs There would continue to be a 27% probability of exceeding the flood stage of 100,000 cfs below Albeni Falls Dam.	Average outflows from Lake Pend Oreille would be slightly lower in January to April period. The slight reduction in April flows could provide flood relief in the Cusick area when Calispell and Trimble Creeks are high. Average outflows would be about: January – 16981 cfs February – 18033 cfs April – 28020 cfs May – 53,536 cfs June – 56578 cfs There would continue to be a 27% probability of exceeding the flood stage of 100,000 cfs below Albeni Falls Dam.
Water Quality		
	Under simulated releases, there is less chance of HS exceeding TDG standards.	Under simulated releases, the chance of HV exceeding the 15 percent spill is 1 % in June. Overall, spill analysis indicates that implementation of HV could result in increases in TDG saturation levels from May through July. Changes in the saturation levels are not quantifiable with the available data, but appear to be minor. Based on modeling, HV operations would generally increase benthic biomass production in the Flathead River because the natural temperature regime and other physical properties of the river would be more closely mimicked.
Aquatic Life		
	Deep drafts implemented under HS would continue to limit food availability and habitat quality at Hungry Horse Reservoir and the Flathead River. Modeling results showed minimal differences between alternatives from Flathead Lake downstream.	Implementation of HV would likely benefit resident fish, especially those in Hungry Horse Reservoir and immediately downstream in the Flathead River. Hungry Horse releases would follow a more normative hydrograph and would be higher in March, May, and June. Reduced winter drafts would help achieve refill at Flathead Lake, especially in dry years. Higher late-spring releases would help meet Kerr Dam minimum outflow requirements, thus providing minor benefits to aquatic resources in Flathead Lake and downstream from Kerr Dam.

	Alternatives	
Resource and River Reach	**HS (No Action)**	**HV (Preferred)**
Sensitive, Threatened and Endangered Species		
	Deep drafts implemented under HS would continue to limit food availability and habitat quality at Hungry Horse Reservoir and the Flathead River. Modeling results showed minimal differences between alternatives from Flathead Lake downstream.	Implementation of HV would benefit bull trout through general improvements in biological conditions at Hungry Horse Reservoir and immediately downstream in the Flathead River. Below Flathead Lake, HV would result in a slightly more normative hydrograph and minor increases in TDG saturation levels. Neither alternative is likely to appreciably affect existing conditions within designated bull trout critical habitat HV may result in minor benefits to the fish prey base for bald eagles at Hungry Horse Reservoir and Flathead Lake and neither alternative is likely to affect bald eagle nesting, roosting, and feeding habitats.
Wildlife		
	Existing riparian and wetlands habitat would remain unchanged.	May provide minor benefits to riparian and wetland habitats and associated wildlife along Flathead Lake and immediately upstream on the Flathead River. Otherwise, existing wildlife habitats generally would not be affected.
Vegetation		
	Existing riparian and wetlands would remain unchanged.	May provide minor benefits to riparian areas and wetlands along Flathead Lake and immediately upstream on the Flathead River.
Recreation		
	Slightly more fishing and kayaking days on the Flathead River downstream from Hungry Horse Dam in the early summer due to optimal flows.	May result in minor improvements in boater access to Hungry Horse Reservoir and Flathead Lake owing to higher average water surface elevations during the recreation season and an increase in the usability of boat ramps. Slightly better aesthetics due to higher surface water elevations.
Environmental Health		
	No measurable effect on human or environmental health within the affected area.	Same as HS.
Cultural Resources		
	Some erosion and slumping would continue at archaeological sites within Hungry Horse Reservoir.	Likely would be a minor increase in the potential for winter erosion and ice impacts to cultural resources. HV also may provide minor benefits to cultural resources during the summer recreation season owing to the increased probability of reservoir refill. Once full, the reservoir helps protect cultural sites below the high water line which otherwise would be exposed to impacts from summer erosion and visitor use.
Indian Sacred Sites		
	No Indian sacred sites have been identified.	Same as HS.

	Alternatives	
Resource and River Reach	**HS (No Action)**	**HV (Preferred)**
Other Affected Tribal Interests		
	No effect on other interests	Same as HS.
Transportation		
	No effect on existing transportation systems	Same as HS.
Municipal Water and Wastewater Treatment		
	No effect likely on existing municipal water sources or treatment/disposal facilities.	Same as HS.
Socioeconomics		
	Existing levels of flood protection would continue.	Results in a minor (4%) increase in potential flood effects at Flathead Lake, primarily for damage to waterfront land and docks. HV would also result in a 12% increase in potential flood effects below Albeni Falls Dam, primarily for damages to agricultural and residential property.

Table S-5. Summary comparison of alternative and benchmark combinations on the mainstem Columbia River.

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Hydrology and Flood Control								
Grand Coulee Dam-upstream	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies no greater than LS+HS	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies same as LV+HV	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies no greater than LS+HS	Of 10 years modeled, only 1948 exceeds 280 kcfs flood stage at Birchbank; exceedance frequencies same as LV+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Birchbank: 99% exceedance frequency 93.6 kcfs, 50% exceedance. frequency 162.5 kcfs; 1% exceedance frequency 250 kcfs	Birchbank: 99% exceedance frequency 95.1 kcfs, 50% exceedance frequency 167 kcfs; 1% exceedance frequency 251 kcfs
Lake Roosevelt	2nd half of April elevations (feet): Minimum 1208.0 Maximum 1280.0 Average 1244.0	2nd half of April elevations (feet): Minimum 1208.0 Maximum 1280.0 Average 1242.4	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Apr2 same as LV1+HV Lower Jan-May elevations during some years

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam – downstream	Peak 1-day release exceedance frequencies for The Dalles no more than for LS+HS. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly lower than for LV1+HV, and above flood stage In 2 of the 10 years.	Peak 1-day release exceedance frequencies for The Dalles no more than for LV+HV. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly higher than for LS1+HS, and above flood stage In 2 of the 10 years.	Peak 1-day release exceedance frequencies for The Dalles no more than for LS+HS. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly lower than for LV2+HV, and above flood stage In 2 of the 10 years.	Peak 1-day release exceedance frequencies for The Dalles no more than for LV+HV. Of 10 years modeled, 4 would exceed the 450 kcfs flood flow threshold and only 1948 would exceed the major damage level of 600 kcfs. Out of 10 years modeled, peak 1-day elevations at Vancouver mostly slightly higher than for LS2+HS, and above flood stage In 2 of the 10 years.	Similar to LS1+HS and LS2+HS. For peak daily releases at The Dalles, values would be between LS1+HS and LS2+HS. Peak 1-day elevations at Vancouver would fall between LS1+HS and LS2+HS.	Similar to LV1+HV and LV2+HV. For peak daily releases at The Dalles, values would be between LV1+HV and LV2+HV. Peak 1-day elevations at Vancouver would fall between LV1+HV and LV2+HV.	The Dalles: 99% exceedance frequency: 205 kcfs 50% exceedance frequency: 401 kcfs; 1% exceedance frequency: 670 kcfs	The Dalles: 99% exceedance frequency: 211 kcfs 50% exceedance frequency: 411 kcfs; 1% exceedance frequency: 670 kcfs
System Power								
Winter (Jan-Apr)	Monthly average winter generation (aMW): 16,556 System; 8,252 Federal; 3,812 non-Federal; Canadian monthly average generation 631 on Pend d'Oreille, 702 on Kootenay.	Monthly average winter generation (aMW): 16,220 System; 8,008 Federal; 3,718 non-Federal Canadian monthly average generation 616 aMW on Pend d'Oreille 626 on Kootenay	Monthly average winter generation (aMW): 16,555 system; 8,252 Federal; 3,812 non-Federal Canadian monthly average generation 631 on Pend d'Oreille, 702 on Kootenay	Monthly average winter generation (aMW): 16,219 System; 8,008 Federal; 3,718 non-Federal Canadian monthly average generation 616 on Pend d'Oreille, , 626 on Kootenay	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly average winter generation (aMW): 16,556 System; 8,259 Federal; 3,813 non-Federal Canadian monthly average generation 631 on Pend d'Oreille, 704 aMW on Kootenay	Monthly average winter generation (aMW): 16,226 System; 8012 Federal; 3,718 non-Federal; Canadian monthly average generation 616 on Pend d'Oreille, 627 on Kootenay

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Spring/summer (May-Aug)	Monthly average generation (aMW): 16,993 System; 9,011 Federal; 4,272 non-Federal; Canadian monthly average generation 795 on Pend d'Oreille, 922 aMW on Kootenay	Monthly average generation (a MW): 17,252 System; 9,237 Federal; 4,317 non-Federal; Canadian monthly average generation 794 aMW on Pend d'Oreille, 948 on Kootenay	Monthly average generation (aMW): 16,977 System; 9,009 Federal; 4,273 non-Federal; Canadian monthly average generation 795 on Pend d'Oreille, 921 aMW on Kootenay	Monthly average generation (aMW): 17,235 System; 9,235 Federal; 4,317 non-Federal; Canadian monthly average generation 795 on Pend d'Oreille, 947 aMW on Kootenay	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly average generation (aMW): 16,716 System; 8,763 Federal; 4,219 non-Federal; Canadian monthly average generation 797 on Pend d'Oreille, 886 aMW on Kootenay	Monthly average generation (aMW): 16,993 System; 9,003 Federal; 4,269 non-Federal; Canadian monthly average generation 798 on Pend d'Oreille, 901 on Kootenay
Fall (Sept-Dec)	Monthly average generation (aMW): 11,500 System; 5,780 Federal; 2,821 non-Federal; Canadian monthly average generation 507 on Pend d'Oreille, 477 on Kootenay	Monthly average generation (aMW): 11,550 System; 5,805 Federal; 2,836 non-Federal; Canadian monthly average generation 510 on Pend d'Oreille, 483 on Kootenay	Monthly average generation (aMW): 11,493 System; 5,775 Federal; 2,820 non-Federal; Canadian monthly average generation 507 on Pend d'Oreille, 476 on Kootenay	Monthly average generation (aMW): 11,545 System; 5,803 Federal; 2,834 non-Federal; Canadian monthly average generation 509 on Pend d'Oreille, 483 on Kootenay	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly average generation (aMW): 11,863 System; 6,805 Federal; 2,906 non-Federal; Canadian monthly average generation 504 on Pend d'Oreille, 580 on Kootenay	Monthly average generation (aMW): 11,888 System; 6,092 Federal; 2,910 non-Federal; Canadian monthly average generation 505 on Pend d'Oreille, 580 on Kootenay
Water Quality								
Grand Coulee Dam – upstream TDG	Existing seasonally-elevated TDG levels in the Columbia River at the international border and in Lake Roosevelt would continue, as would ongoing efforts to ameliorate them.	TDG levels in the Columbia River at the international border likely would be marginally higher than at present at times, primarily due to minor increases in involuntary spill at Canadian hydropower facilities on the Kootenay River.	Same as LS1+HS	Same as LV1+HV	Values would range between LS1+HS and LS2+HS.	Values would range between LV1+HV and LV2+HV.	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Temperature	Operational changes at Hungry Horse and Libby Dams are unlikely to affect Columbia River temperatures because of the large intervening distance involved.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Grand Coulee Dam – downstream TDG	Slightly increase spill cap exceedance index and the amount of spill in excess of the spill cap compared to benchmarks which indicates the potential to increase TDG levels.	Highest spill cap exceedance index and the amount of spill in excess of the spill cap.	Same as LS1+HS	Same as LS1+HS and has a higher spill cap exceedance index at Rock Island and Priest Rapids Dams than LV1+HV.	Values would range between LS1+HS and IS2+HS.	Values would range between LV1+HV and LV2+HV.	Spill cap exceedance index and spill in excess of spill cap would be lower than Standard FC alternative combinations.	Spill cap exceedance index and spill in excess of spill cap would be lower than VARQ FC alternative combinations.

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Aquatic Life								
Grand Coulee Dam - upstream	The present habitat characteristics, species assemblages, and population dynamics at Lake Roosevelt generally would remain unchanged. Large annual flood control drafts would continue to limit natural reproduction of many fish species in the reservoir and would continue to facilitate entrainment. Nutrient flushing and low spring water surface elevations would continue to limit the growth of some species.	Minor increases in spring drawdowns at Lake Roosevelt could result in periodic, small reductions in present levels of spawning success for smallmouth bass, yellow perch, and shoreline spawning kokanee. Minor reductions in water retention times may result in small increases in the loss of nutrients from the reservoir which in turn may lead to minor decreases in growth rates for some species. Minor increases in entrainment would occur in some years.	Same as LS1+HS	Same as LV1+HV	Similar to LS1+HS and LS2+HS	Similar to LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam – downstream	Continued similar influence on the timing and magnitude of flows in the Columbia River. The present habitat characteristics, presence/ absence and migration patterns of species generally would remain unchanged.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Sensitive, Threatened and Endangered Species								
Grand Coulee Dam - upstream	The present habitat characteristics, species presence, and population dynamics at Lake Roosevelt and upstream generally would remain unchanged. Large annual flood control drafts would continue to limit benthic productivity and may also continue to limit the juvenile-growth potential of bull trout in the reservoir. Bald eagle numbers and distribution would likely remain unchanged.	Minor increases in spring drawdowns at Lake Roosevelt could result in small reductions in present levels of benthic productivity. Primary impacts to bull trout would most likely be growth-related. The fish prey base for bald eagles would not likely be noticeably affected, and bald eagle numbers and distribution would likely remain unchanged.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam - downstream	River flows and reservoir elevations would remain within the current range of operations. In general, related ongoing effects to threatened and endangered species would remain unchanged from those previously consulted upon and addressed in biological opinions.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LV1+HV
Anadromous Fish –Priest Rapids Dam	Monthly flow objectives met in 32-49 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.	Values would be similar to LS1+HS and LS2+HS	Values would be similar to LV1+HV and LV2+HV	Monthly flow objectives met in 32-47 of 52 years.	Monthly flow objectives met in 32-49 of 52 years.
Anadromous Fish -McNary Dam	Monthly flow objectives met in 4-42 of 52 years.	Monthly flow objectives met in 4-42 of 52 years.	Monthly flow objectives met in 4-42 of 52 years.	Monthly flow objectives met in 3-42 of 52 years.	Values would range between LS1+HS and LS2+HS	Values would range between LV1+HV and LV2+HV	Monthly flow objectives met in 3-42 of 52 years.	Monthly flow objectives met in 2-42 of 52 years.

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Spill	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this alternative combination results in slightly lower potential TDG levels and durations as compared to the VARQ FC alternative combinations.	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this alternative combination results in a slight potential increase in TDG levels and durations as compared to the Standard FC alternative combinations.	Same as LS1+HS	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this alternative combination results in the highest potential TDG levels and durations as compared to all other alternative combinations.	Values would range between LS1+HS and LS2+HS	Values would range between LV1+HV and LV2+HV	Some risk of forced spill with elevated TDG. Incremental effects on anadromous fish should be minimal, but this benchmark combination results in the lowest potential TDG levels and durations.	Same as LV1+HV
Vegetation								
	River flows and reservoir elevations would remain within the current range of river and reservoir operations, and; therefore, related effects on vegetation would be similar. Riparian and wetland areas within the influence of the Columbia River and its impoundments generally would remain unchanged.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Wildlife								
	Riparian and wetland habitats within the influence of the Columbia River and its impoundments generally would remain unchanged. Associated terrestrial wildlife populations also are not likely to be affected.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Recreation								
Grand Coulee Dam - upstream	Current levels of recreation access and scenic quality at Lake Roosevelt generally would remain unchanged. There would be no change in usable boat ramp days during the summer.	There would be a minor decrease (less than 5%, primarily in May) in average usable boat ramp days at Lake Roosevelt. Otherwise, there would be no change in the present function of boat ramps or marinas, particularly during the summer. A slight degradation in visual resources may be noticeable in May due to slightly lower reservoir elevations.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam - downstream	No change in present levels and quality of boating and shoreside recreation.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Environmental Health								
Grand Coulee Dam - upstream	There would be no change in the timing, duration, or magnitude of annual flood control drawdowns at Lake Roosevelt. Similarly, there would be no change in the annual exposure of lake bed sediments, or in the exposure of humans and other organisms to contaminants present in those sediments. Preliminary results of an ongoing air quality study indicate that none of the samples taken at Lake Roosevelt study sites have exceeded established standards.	There would be slightly lower reservoir surface elevations and thus slightly increased exposure of lake bed sediments during the spring flood control draft in average to moderately dry water years. When compared to present conditions, the likelihood of measurable impacts to environmental and human health through inhalation, ingestion, or direct contact with contaminated bed-sediments is expected to be extremely low.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam - downstream	There are no identified flow-related environmental health concerns below Grand Coulee. All alternative combinations would continue to similarly influence the timing and magnitude of flows in the Columbia River.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Cultural Resources								
Grand Coulee Dam – upstream	There would be no change in the timing, duration, or magnitude of annual flood control drawdowns at Lake Roosevelt. Similarly, there would be no change in the periodic exposure of cultural resources to wave action, erosion, displacement, weathering, or collection/looting.	There would be slightly lower reservoir surface elevations and thus slightly increased exposure of cultural resources during the spring flood control draft in average to moderately dry water years. When compared to present conditions, the likelihood of impacts to cultural resources is expected to be minor.	Same as LS1+HS	Same as LV1+HV	Same as LS1+HS and LS2+HS	Same as LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Grand Coulee Dam – downstream	There would be essentially no change in management or protection of cultural resources downstream from Grand Coulee Dam. Effects to cultural resources (primarily erosion and site exposure) from river flows and reservoir operations would be similar for all alternative combinations.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Indian Sacred Sites								
	No sacred sites have been identified.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Other Affected Tribal Interests								
	Tribal interests in fishing would be affected by all alternative combinations to the extent that salmon and steelhead survival and recovery are affected. The analysis for anadromous fish discusses how the flow objectives at McNary and Priest Rapids dams are achieved by the various alternative combinations. Fish flows from Libby and Hungry Horse in July and August are intended to assist salmon outmigration. Spring flow augmentation for Kootenai River white sturgeon also can assist in meeting flow objectives in the lower Columbia River. No discernible effect on lamprey is expected.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Socioeconomics								
Flood Damages	No increase in economic losses from floods to areas protected by major levee systems. Fish flows may cause minor increase in levee maintenance costs.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Agriculture	No impacts identified.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS
Hydropower	Annual hydropower values (billions): $4.946 System; $2.516 Federal; $1.211 non-Federal	Annual hydropower values (billions): $4.932 System; $2.504 Federal; $1.202 non-Federal	Annual hydropower values (billions): $4.944 System; $2.525 Federal; $1.212 non-Federal	Annual hydropower values (billions): $4.931 System; $2.508 Federal; $1.202 non-Federal	Values would range between LS1+HS and LS2+HS	Values would range between LV1+HV and LV2+HV	Annual hydropower values (billions): $4.967 System; $2.533 Federal; $1.213 non-Federal	Annual hydropower values (billions): $4.948 System; $2.520 Federal; $1.203 non-Federal
Transportation and Navigation	No effects to Keller or Inchelium ferries	Keller Ferry north landing would be used more frequently.	Same as LS1+HS	Same as LV1+HV	Similar to LS1+HS and LS2+HS	Similar to LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV
Municipal Water and Wastewater Treatment								
	No effect on municipal water sources, wastewater treatment or disposal.	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS

Resource & River Reach	LS1+HS (No-Action)	LV1+HV	LS2+HS	LV2+HV	LSB+HS	LVB+HV (Preferred)	LS+HS	LV+HV
Transportation								
Grand Coulee Dam – upstream	The Keller and Inchelium Ferries would continue normal operations within the current range of reservoir levels. Lake Roosevelt end-of-April elevation would be less than 1248 feet approximately 60% of all years. Keller Ferry North landing must be used when elevation is below 1248 feet	The Keller and Inchelium ferries would continue normal operations within the current range. Lake Roosevelt end-of-April elevation would be less than 1248' approximately 70% of all years, therefore, the Keller Ferry's alternative north landing would have to be used more frequently than at present.	Same as LS1+HS	Same as LV1+HV	Similar to LS1+HS and LS2+HS	Similar to LV1+HV and LV2+HV	Same as LS1+HS	Same as LV1+HV
Grand Coulee Dam – downstream	No effect	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS	Same as LS1+HS