



**Columbia River System Operations
Final Environmental Impact Statement**

Appendix W, Clean Water Act Section 404(b)(1) Evaluation

*Columbia River System Operations Environmental Impact Statement
Appendix W, Clean Water Act Section 404(b)(1) Evaluation*

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ACRONYMS AND ABBREVIATIONS

Bonneville	Bonneville Power Administration
BPM	best management practice
C.F.R.	Code of Federal Regulations
Corps	U.S. Army Corps of Engineers
CRS	Columbia River System
CRSO	Columbia River System Operations
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FRM	flood risk management
kcfs	thousand cubic feet per second
LCM	Life Cycle Model
Maf	million acre-feet
MO	Multiple Objective Alternative
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NWR	National Wildlife Refuge
OHW	ordinary high water
Reclamation	U.S. Bureau of Reclamation
RFFA	Reasonably Foreseeable Future Actions
SRD	Storage Reservoir Diagram
TCP	Traditional Cultural Property
TDG	total dissolved gas
USFWS	U.S. Fish and Wildlife Service

CLEAN WATER ACT SECTION 404(b)(1) EVALUATION

COLUMBIA RIVER SYSTEM OPERATIONS PROJECT

May 2020

CHAPTER 1 - INTRODUCTION

The purpose of this document is to record the U.S. Army Corps of Engineers' (Corps) evaluation and findings regarding the Columbia River System Operations (CRSO) Project pursuant to Section 404 of the Clean Water Act. Figure 1 shows the geographic locations of the 14 Columbia River System (CRS) projects. The CRS consists of subbasins, each having distinct topographic, meteorological, and/or hydrologic characteristics. These subbasins are grouped into four regions, A to D, shown in Figure 1, and are referred to throughout this document and the CRSO Final Environmental Impact Statement (EIS).

The operational measures in the Preferred Alternative do not result in the discharge of dredged or fill material. However, the following activities in the Preferred Alternative include mitigation components that may need excavation, or discharge of dredged or fill materials: potential placement of dredged material, planting of riparian vegetation, in-channel excavation of material, and placement of spawning gravel below the jurisdictional ordinary high water (OHW) line within the waters of the United States. The implementation of any of these activities would require further refinement for site-specific analysis. As design details are developed to implement the Preferred Alternative, additional site-specific activities associated with discharge of dredged or fill materials below the OHW may be realized.

The information contained in this document reflects the findings of the project record. Specific sources of information included the following:

CRSO Final EIS

404(b)(1) Evaluation (see below)

Public Interest Review (see below)

This document addresses the substantive compliance issues of the Clean Water Act 404(b)(1) Guidelines (40 Code of Federal Regulations [C.F.R.] § 230.12(a)) and Public Interest Factors (33 C.F.R. § 320.4 as reference).

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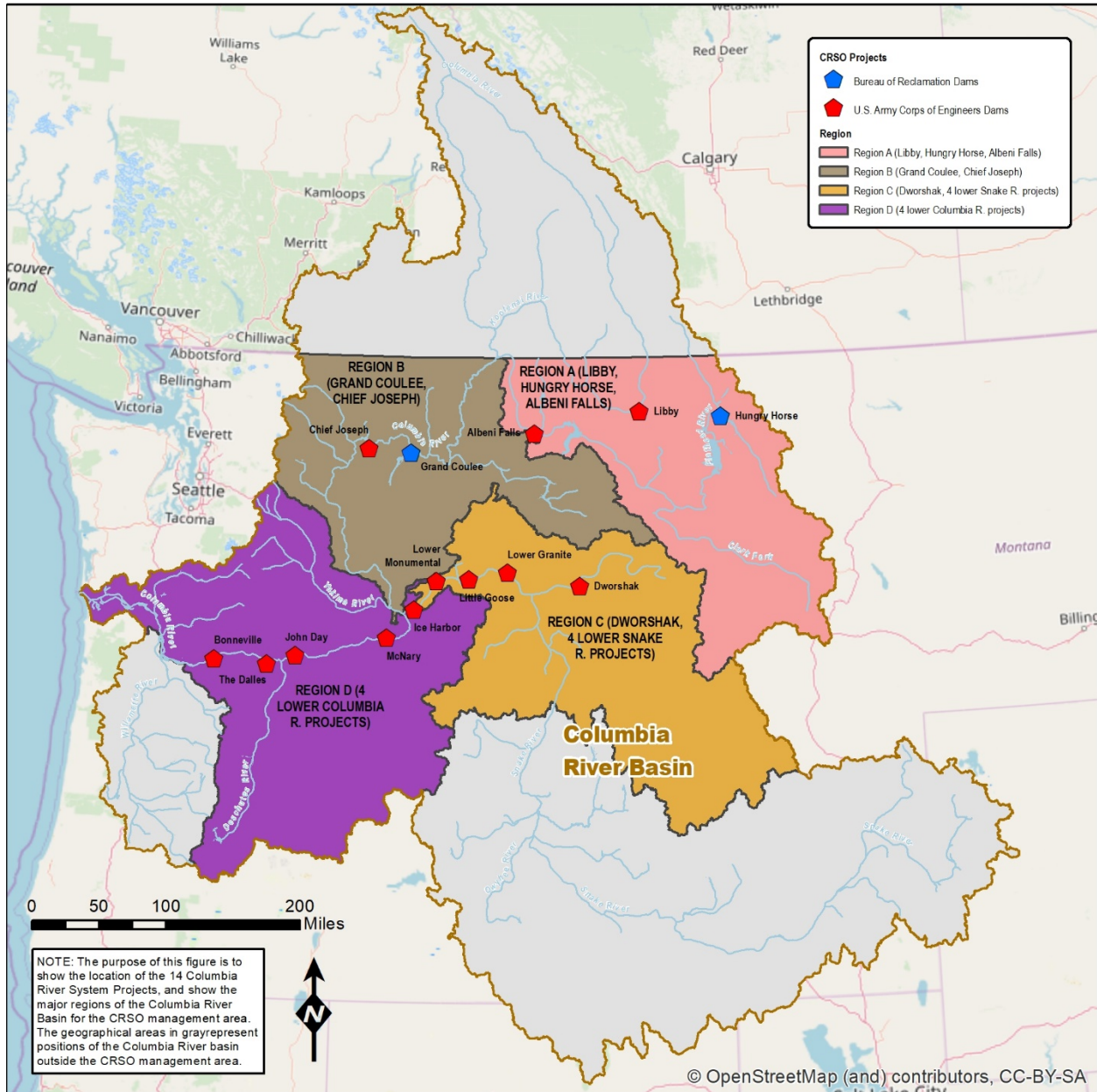


Figure 1. Geographic Locations of the Columbia River System Projects

CHAPTER 2 - PROJECT PURPOSE AND NEED

The ongoing action that requires evaluation under the National Environmental Policy Act (NEPA) is the long-term coordinated operation and management of the CRS projects for the multiple purposes identified above. An underlying need to which the co-lead agencies are responding, is to review and update the management of the CRS, including evaluating measures to avoid, offset, or minimize impacts to resources affected by managing the CRS in the context of new information and changed conditions in the Columbia River Basin since the 1995 System Operation Review EIS was released. In addition, the co-lead agencies are responding to the Opinion and Order issued by the U.S. District Court for the District of Oregon (District Court), which states that the EIS should evaluate how to ensure that the prospective management of the CRS is not likely to jeopardize the continued existence of any endangered or threatened species, or result in the destruction or adverse modification of designated critical habitat. This includes evaluating mitigation measures to address impacts to listed species from CRS operations. The EIS evaluates actions within the current authorities of the co-lead agencies, as well as certain actions that are not within their authorities, based on the District Court's observations about alternatives that could be considered and comments received during the scoping process. The EIS also allows the co-lead agencies and the region to evaluate the costs, benefits, and tradeoffs of various alternatives as part of reviewing and updating the management of the CRS.

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

Resource Purposes:

- Provide for a reliable level of flood risk management (FRM) by operating the CRS to afford safeguards for public safety, infrastructure, and property
- Provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River Power System
- Provide water supply for irrigation, municipal, and industrial uses
- Provide for waterway transportation capability
- Provide for the conservation of fish and wildlife resources, including threatened, endangered, and sensitive species throughout the environment affected by CRS operations
- Consider and plan for climate change impacts on resources, and on the management of the CRS
- Provide opportunities for recreation at CRS lakes and reservoirs
- Protect and preserve cultural resources

Legal and Institutional Purposes:

- Act within the authorities granted to the agencies under existing statutes, and when applicable, identify where new statutory authority may be needed
- Comply with environmental laws and regulations and all other applicable Federal statutory and regulatory requirements, including those specifically addressing the CRS such as requirements under the Northwest Power Act “to adequately protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, affected by such projects or facilities in a manner that provides equitable treatment for such fish and wildlife with the other purposes for which such system and facilities are managed and operated.” (16 United States Code § 839b(11)(A))
- Protect Native American treaty and reserved rights and fulfill trust obligations for natural and cultural resources throughout the environment affected by CRS operations
- Continue to use a collaborative Regional Forum framework to allow for flexibility and adaptive management of the CRS
- Ensure project Water Control Manuals adequately reflect the management of the CRS

CHAPTER 3 - PROPOSED ACTION ALTERNATIVES

Chapter 2 of the EIS describes five alternatives, which include the No Action Alternative, Multiple Objective Alternative 1 (MO1), Multiple Objective Alternative 2 (MO2), Multiple Objective Alternative 3 (MO3), and Multiple Objective Alternative 4 (MO4). A sixth alternative, the Preferred Alternative, includes many of the measures described in these multiple objective alternatives. The Preferred Alternative is described and evaluated in Chapter 7 of the EIS. An important note is that the descriptions of the Multiple Objective Alternatives (MOs) and Preferred Alternative only include how they differ from the No Action Alternative. For example, under the No Action Alternative, Libby and Hungry Horse Dams operate to daily and hourly ramping up and down restrictions as per 2006 U.S. Fish and Wildlife Service (USFWS) Biological Opinion. After the Record of Decision is signed, the mitigation measures of the Preferred Alternative would be further refined and fully developed during implementation phases.

3.1 NO ACTION ALTERNATIVE

The No Action Alternative describes the operation, maintenance, and configuration of the CRS, from September 30, 2016, the date the Notice of Intent to complete the CRSO EIS was published in the Federal Register. The No Action Alternative considers what would happen if the CRS continued to be operated, maintained, and configured with no change from planned operations at that point in time. The EIS assumes that, to the extent possible, all ongoing, scheduled, and routine maintenance activities for the Federal infrastructure and all structural features, including those recently constructed or will be in the reasonably foreseeable future, are included in the No Action Alternative. Under the No Action Alternative, mitigation currently being implemented would continue. With implementation of any of the proposed MOs, there are nine mitigation programs that the co-lead agencies currently implement that would be incorporated, with certain modifications, in the respective alternatives. These mitigation programs are the Bonneville Power Administration (Bonneville) Fish and Wildlife Program, the Lower Snake River Compensation Plan, the Corps Columbia River Fish Mitigation Program, the U.S. Bureau of Reclamation (Reclamation) Columbia River Tributary Habitat Program, the Federal Columbia River Power System Cultural Resources Program, Predator Management, Invasive Species Management, Pest Management Programs, and Nutrient Supplementation Program.

3.2 MULTIPLE OBJECTIVE ALTERNATIVE 1

MO1 was developed to integrate actions that would benefit both juvenile and adult life stages of Endangered Species Act (ESA)-listed anadromous fish, as well as measures to benefit ESA-listed resident fish. At the same time, this alternative incorporates measures for water management flexibility, hydropower production, and allocation of previously authorized water supply. The existing mitigation programs identified in the No Action Alternative would be carried forward in MO1. Brief descriptions of the measures contained in MO1 are listed in Table 1. and mitigation measures for MO1 are listed in Table 2.

Table 1. Measures of Multiple Objective Alternative 1

Measure Description	Abbreviated Measure Name
STRUCTURAL MEASURES	
Construct additional powerhouse surface passage routes at McNary and Ice Harbor Dams	Additional Powerhouse Surface Passage
Upgrade spillway weirs to Adjustable Spillway Weirs	Upgrade to Adjustable Spillway Weirs
Improve adult ladder passage through modification of adult trap at Lower Granite Dam	Lower Granite Trap Modifications
Modify the upper ladder serpentine flow control ladder sections at Bonneville Dam	Modify Bonneville Ladder Serpentine Weir
Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Dams	Lower Snake Ladder Pumps
Expand network of Lamprey Passage Structures to bypass impediments	Lamprey Passage Structures
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Install improved-fish passage turbines at John Day	Improved Fish Passage Turbines
OPERATIONAL MEASURES	
Fish Passage	
Operate spill to evaluate latent mortality hypothesis; alternate base spill and spill cap 120/115 percent total dissolved gas (TDG)	Block Spill Test (Base + 120/115%)
Modify summer juvenile fish passage spill operations to end based on fish collection numbers	Summer Spill Stop Trigger
Change start of juvenile fish transportation during spring juvenile fish passage spill operations	Early Start Transport
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
Water Management	
Modify Libby draft and refill operations when water supply forecast is 6.9 million acre-feet (Maf) or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation

Measure Description	Abbreviated Measure Name
Update the upstream Storage Corrections Method as applied to the Grand Coulee Storage Reservoir Diagram (SRD)	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee
Operational constraints for ongoing Grand Coulee maintenance of power plants	Grand Coulee Maintenance Operations
Develop draft requirements/assessment approach to protect against rain-induced flooding	Winter System FRM Space
Water Supply	
Increase volume of water pumped from Lake Roosevelt during annual irrigation season	Lake Roosevelt Additional Water Supply
Increase water managers' flexibility to store and release water from Hungry Horse Reservoir	Hungry Horse Additional Water Supply
Increase water diversion from the Columbia River for the Chief Joseph Dam Project	Chief Joseph Dam Project Additional Water Supply
Hydropower	
Increase forebay operating range flexibility at the lower Snake River and John Day projects for hydropower generation flexibility.	Increased Forebay Range Flexibility
Other Operational	
Implement modified timing of Lower Snake Basin reservoir draft for additional cooler water	Modified Dworshak Summer Draft
Implement sliding scale summer draft at Libby and Hungry Horse	Sliding Scale at Libby and Hungry Horse
Manipulate lower Columbia reservoir elevations to disrupt juvenile salmonid predator reproduction	Predator Disruption Operations

Table 2. Mitigation Summary for MO1

Resource	Proposed Mitigation Action
Water Quality	On the lower Snake River, increase harmful algal bloom monitoring at recreational areas; if algal blooms produce toxins, post public advisories at recreational areas to protect the public.
Anadromous Fish	Temporarily extend performance standard spill levels in coordination with the Regional Forum to assist fish migration.
Resident Fish - ESA Kootenai River White Sturgeon	Plant 1–2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon by providing a food source. This would complement ongoing habitat actions already being taken in the region.

Resource	Proposed Mitigation Action
Resident Fish – ESA Bull Trout	On the Hungry Horse Reservoir, install structural components like woody debris, and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, and possibly more) to stabilize channels, increase cover for migrating fish, and improve the varial zone.
Resident Fish - Burbot, Kokanee, and Redband Rainbow Trout	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.
Vegetation, Wildlife, Wetlands & Floodplains	In Region A, update and implement the Invasive Plant Management Plan for the shoreline at Libby. Region B mitigation includes habitat for fish mitigation (see Resident Fish).
Vegetation, Wildlife, Wetlands & Floodplains	On the Kootenai River downstream of Libby, plant native wetland and riparian vegetation up to ~100 acres along river.
Navigation & Transportation	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it is available at lower water elevations.
Cultural Resources	Use the Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other alternative mitigation to address impacts to Traditional Cultural Properties (TCP).

3.3 MULTIPLE OBJECTIVE ALTERNATIVE 2

MO2 was developed to increase hydropower production and reduce regional greenhouse gas emissions while avoiding or minimizing negative impacts to other authorized project purposes and co-lead agency missions. The existing mitigation programs identified in the No Action Alternative would be carried forward in MO2, except where described below. Brief descriptions of the measures contained in MO2 are provided in Table 3, and mitigation measures for MO2 are listed in Table 4.

Table 3. Measures of Multiple Objective Alternative 2

Measure Descriptions	Abbreviated Measure Name
STRUCTURAL MEASURES	
Install improved fish passage turbines at John Day	Improved Fish Passage Turbines
Construct powerhouse and/or spill surface passage routes at John Day, McNary, and Ice Harbor Dams	Additional Powerhouse Surface Passage
Cease installation of fish screens at Ice Harbor, McNary, and John Day Projects	Fewer Fish Screens
Upgrade spillway weirs to Adjustable Spillway Weirs	Upgrade to Adjustable Spillway Weirs
Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Dams	Lower Snake Ladder Pumps
Expand network of Lamprey Passage Structures to bypass impediments	Lamprey Passage Structures
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
OPERATIONAL MEASURES	
Fish Passage	
Limit fish passage spill to near 110 % TDG	Spill to 110% TDG
Juvenile fish transportation at Lower Granite, Little Goose, Lower Monumental, and McNary down to Bonneville Dam April 25 to August 31	Increase Juvenile Fish Transportation
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
Water Management	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee

Measure Descriptions	Abbreviated Measure Name
Operational constraints for ongoing Grand Coulee maintenance of power plants	Grand Coulee Maintenance Operations
Develop draft requirements/assessment approach to protect against rain-induced flooding	Winter System FRM Space
Hydropower	
Ramping rate limitations at all projects will be defined only for safety or engineering	Ramping Rates for Safety
At the four lower Snake River projects, operate within the full reservoir operating range year-round	Full Range Reservoir Operations
Allow John Day to operate up to full pool, except as needed for FRM	John Day Full Pool
The storage projects may be drafted slightly deeper for hydropower	Slightly Deeper Draft for Hydropower
Operate turbines across their full range of capacity year-round	Full Range Turbine Operations
Zero generation operations may occur on lower Snake River projects November through February	Zero Generation Operations
Other Operational	
Implement sliding scale summer draft at Libby and Hungry Horse Dams	Sliding Scale at Libby and Hungry Horse

Table 4. Mitigation Summary of MO2

Resource	Proposed Mitigation Action
Water Quality	Initiate a nutrient supplementation program at Hungry Horse.
Anadromous, Resident Fish, and Wildlife	Increase the Bonneville Fish and Wildlife Program to mitigate additional impacts to fish and wildlife.
Resident Fish – ESA Kootenai River White Sturgeon	Plant –2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon by providing a food source. This would complement ongoing habitat actions already being taken in the region.
Resident Fish – ESA Bull Trout	On the Hungry Horse Reservoir, install structural components like woody debris, and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, and possibly more) to stabilize the channels, increase cover for migrating fish, and improve the varial zone.
Resident Fish - Burbot, Kokanee, and Redband Rainbow Trout	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. Place

Resource	Proposed Mitigation Action
	appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.
Vegetation, Wildlife, Wetlands & Floodplains	On the Kootenai River downstream of Libby, plant native wetland and riparian vegetation up to ~100 acres along river.
Vegetation, Wildlife, Wetlands & Floodplains	In Region A, update and implement the Invasive Plant Management Plan for the shoreline at Libby. Region B mitigation includes habitat for fish mitigation (see Resident Fish).
Navigation & Transportation	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it is available at lower water elevations.
Recreation	Extend the boat ramp at Dworshak State Park (Freeman Creek) to make it accessible in April, when it is used by hunters and fishermen.
Cultural Resources	In Regions A, B, and C, increase Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other mitigation to address impacts to TCPs.

3.4 MULTIPLE OBJECTIVE ALTERNATIVE 3

MO3 was developed to integrate actions for water management flexibility, hydropower production, and water supply with measures that would breach the earthen portion of four the lower Snake River dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor). The existing mitigation programs identified in the No Action Alternative would be carried forward in MO3, with the exception of the Lower Snake River Compensation Plan. Brief descriptions of the measures contained in MO3 are listed in Table 5, and mitigation measures for MO3 are listed in Table 6.

Table 5. Measures of Multiple Objective Alternative 3

Measure Descriptions	Abbreviated Measure Name
STRUCTURAL MEASURES	
Construct additional powerhouse and/or spill surface passage routes at McNary Dam	Additional Powerhouse Surface Passage
Cease installation of fish screens at McNary Dam and John Day	Fewer Fish Screens
Upgrade spillway weirs to Adjustable Spillway Weirs	Upgrade to Adjustable Spillway Weirs
Modify the upper ladder serpentine flow control ladder sections at Bonneville Dam	Modify Bonneville Ladder Serpentine Weir
Expand network of Lamprey Passage Structures to bypass impediments	Lamprey Passage Structures

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Measure Descriptions	Abbreviated Measure Name
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Install improved fish passage turbines at John Day	Improved Fish Passage Turbines
Dam Breach	
Remove earthen embankments and adjacent structures, as required, at each lower Snake River dam	Breach Snake Embankments
Modify equipment and infrastructure to adjust to drawdown conditions at each lower Snake River dam	Lower Snake Infrastructure Drawdown
OPERATIONAL MEASURES	
Dam Breach	
Develop procedures to operate existing equipment during reservoir drawdown	Drawdown Operating Procedures
Develop contingency plans to address unexpected issues with drawdown operations	Drawdown Contingency Plans
Fish Passage	
Limit fish passage spill to 120 % TDG at McNary, John Day, The Dalles, and Bonneville Dams	Spring Spill to 120% TDG
Reduce the duration of summer juvenile fish passage spill	Reduced Summer Spill
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
Water Management	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD with flat spot retained	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee
Operational constraints for ongoing Grand Coulee maintenance of power plants	Grand Coulee Maintenance Operations
Water Supply	
Increase volume of water pumped from Lake Roosevelt during annual irrigation season	Lake Roosevelt Additional Water Supply

Measure Descriptions	Abbreviated Measure Name
Increase water managers' flexibility to store and release water from Hungry Horse Reservoir	Hungry Horse Additional Water Supply
Increase water diversion from the Columbia River for the Chief Joseph Dam Project	Chief Joseph Dam Project Additional Water Supply
Hydropower	
Ramping rate limitations at all projects will be defined only for safety or engineering	Ramping Rates for Safety
At John Day, allow project to operate up to full pool except as needed for FRM	John Day Full Pool
Operate turbines within and above 1 percent peak efficiency in juvenile fish passage season	Above 1% Turbine Operations
Other Operational	
Implement sliding scale summer draft at Libby and Hungry Horse Dams	Sliding Scale at Libby and Hungry Horse

Table 6. Mitigation Summary of MO3

Resource	Proposed Mitigation Action
Anadromous Fish	Temporarily extend performance standard spill levels in coordination with the Regional Forum.
Anadromous Fish	Construct a trap-and-haul facility at McNary and conduct at least 2 years of trap-and-haul operations for Snake River fish (Chinook salmon, Sockeye, Steelhead) to allow removal and transport of these fish from the lower Snake River prior to breaching.
Anadromous Fish	Raise additional hatchery fish to help to address 2 lost year classes of anadromous fish prior to the initiation of each phase of breaching (2 phases) of the lower Snake River dams.
Resident Fish – ESA Kootenai River White Sturgeon	Plant 1–2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon by providing a food source. This would complement ongoing habitat actions already being taken in the region.
Resident Fish – ESA Bull Trout	On the Hungry Horse Reservoir, install structural components like woody debris, and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, and possibly more) to stabilize the channels, increase cover for migrating fish, and improve the varial zone.
Resident & Anadromous Fish	Modify the Tucannon River channel at the delta to allow bull trout, salmon, and steelhead passage after Snake River water elevations decrease from breaching.

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Resource	Proposed Mitigation Action
Resident Fish – White Sturgeon	On the Snake River, trap-and-haul White Sturgeon from impacted areas prior to dam breaching. Relocate trapped sturgeon to locations in Hells Canyon on the Snake River, and downstream of McNary project on the Columbia River.
Vegetation, Wildlife, Wetlands & Floodplains	On the Kootenai River downstream of Libby, plant native wetland and riparian vegetation up to ~100 acres along river.
Vegetation, Wildlife, Wetlands & Floodplains	Update and implement the existing Invasive Plant Management Plan at Libby to prevent establishment of invasive plant species.
Vegetation, Wildlife, Wetlands & Floodplains	Develop and implement a planting plan to restore arid, native plant communities on approximately 13,000 acres of lands along the lower Snake River.
Vegetation, Wildlife, Wetlands & Floodplains	Develop and implement a planting plan for approximately 1,500 acres of wetland and riparian species along the exposed shorelines.
Vegetation, Wildlife, Wetlands & Floodplains	Develop and implement a restoration plan for approximately 155 acres of wetlands downstream of Ice Harbor. The plan may include excavation of sediments deposited after breaching.
Navigation & Transportation	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it is available at lower water elevations.
Navigation & Transportation	Armor piers of up to 25 bridges to protect them from erosion caused by higher velocity flows in the river after breaching.
Navigation & Transportation	Armor approximately 80 miles of railroad and highway embankments previously designed or constructed by the Corps to protect them from erosion caused by the breaching measure.
Navigation & Transportation	At the confluence of the lower Snake River in Region D the Corps would dredge the Federal navigation channel post-breaching until the river equilibrium is achieved, as needed, to maintain the Federal channel.
Cultural Resources	In Regions A and B, an increase the Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other mitigation to address impacts to TCPs.
Cultural Resources	Develop a new Programmatic Agreement under the existing Federal Columbia River Power System Cultural Resource Program for cultural resources exposed in the four reservoir areas.
Public Safety	After breaching the lower Snake River dams, modify the gas lines to withstand the velocities due to breach.

3.5 MULTIPLE OBJECTIVE ALTERNATIVE 4

MO4 was developed to examine an additional combination of measures to benefit ESA-listed fish integrated with measures for water management flexibility, hydropower production, and additional water supply. The existing mitigation programs identified in the No Action Alternative would be carried forward in MO4. Brief descriptions of the measures contained in MO4 are listed in Table 7, and mitigation measures for MO4 are listed in Table 8.

Table 7. Measures of Multiple Objective Alternative 4

Measure Descriptions	Abbreviated Measure Name
STRUCTURAL MEASURES	
Construct additional powerhouse surface passage routes to meet system-wide PITPH target	Additional Powerhouse Surface Passage
Improve adult ladder passage through modification of adult trap at Lower Granite Dam	Lower Granite Trap Modifications
Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Dams	Lower Snake Ladder Pumps
Install improved fish passage turbines at John Day	Improved Fish Passage Turbines
Expand network of Lamprey Passage Structures to bypass impediments	Lamprey Passage Structures
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Addition of spillway weir notch gate inserts	Spillway Weir Notch Inserts
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
OPERATIONAL MEASURES	
Fish Passage	
Spill through surface passage structures for steelhead overshoots, overwintering steelhead, and kelt	Spill for Adult Steelhead
Set juvenile fish passage spill to not exceed 125 % TDG	Spill to 125% TDG
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
Implement juvenile fish transportation during spring and fall periods at Lower Granite, Little Goose, and Lower Monumental Dams	Spring & Fall Transport

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Measure Descriptions	Abbreviated Measure Name
Cease juvenile transport during portions of summer spill period at Lower Granite, Little Goose, and Lower Monumental Dams	No Summer Transport
Water Management	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee
Operational constraints for ongoing Grand Coulee maintenance of power plants and spillways	Grand Coulee Maintenance Operations
Develop draft requirements/assessment approach to protect against rain-induced flooding	Winter System FRM Space
Water Supply	
Increase volume of water pumped from Lake Roosevelt during annual irrigation season	Lake Roosevelt Additional Water Supply
Increase water managers' flexibility to store and release water from Hungry Horse Reservoir	Hungry Horse Additional Water Supply
Increase water diversion from the Columbia River for the Chief Joseph Dam Project	Chief Joseph Dam Project Additional Water Supply
Operate turbines within and above 1 % peak efficiency in juvenile fish passage season	Above 1% Turbine Operations
Other Operational Measures	
Strive to hold minimum 220 thousand cubic feet per second (kcfs) spring flow/200 kcfs summer flow at McNary Dam using upstream storage	McNary Flow Objective
Reservoir drawdown to Minimum Operating Pool to reduce outmigration travel time	Drawdown to MOP
Implement sliding scale summer draft at Libby and Hungry Horse	Sliding Scale at Libby and Hungry Horse
Support establishment of vegetation at Libby Dam by limiting Bonners Ferry stage height November through March	Winter Stage for Riparian

Table 8. Mitigation Summary of MO4

Resource	Proposed Mitigation Action
Water Quality	Implement and expend the existing Invasive Aquatic Plant Removal program at Albeni Falls.
Water Quality	In Region A, initiate a nutrient supplementation program at Hungry Horse Reservoir.
Anadromous Fish	Temporarily extend performance standard spill levels in coordination with the Regional Forum
Anadromous Fish	Modify the Little Goose Raceway infrastructure to de-gas the water in the raceway during collection for transport. This would allow the fish to be transported in water with lower TDG than that in the river.
Resident Fish – ESA Bull Trout	On the Hungry Horse Reservoir, install structural components like woody debris, and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, and possibly more) to stabilize the channels, increase cover for migrating fish, and improve the varial zone.
Resident Fish - Burbot, Kokanee, & Redband Rainbow Trout	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.
Navigation & Transportation	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it is available at lower water elevations.
Navigation & Transportation	Conduct regular monitoring of tailrace conditions. If any discovery of adverse or damaging effects, install coffer cells at Lower Monumental, Lower Granite, McNary, and John Day to dissipate energy from higher spill levels.
Navigation & Transportation	Conduct monitoring of scour and infill at John Day, McNary, Ice Harbor, Lower Monumental, and Lower Granite projects and increase dredging maintenance, as needed, to maintain navigation channel. This is predicted to be needed every 4–7 years.
Cultural Resources	In Regions A, B and C, increase Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other alternative mitigation to address impacts to TCPs.

3.6 PREFERRED ALTERNATIVE

The Preferred Alternative includes a description of measures that would be implemented, in addition to components of the No Action Alternative, to operate the CRS to better meet the Purpose and Need Statement and objectives developed for the EIS. Operations, maintenance,

and programs that were ongoing or planned as of 2016 are carried forward into the Preferred Alternative unless described otherwise. Ongoing operations and maintenance measures are described in more detail in Chapter 2.4.2.1 of the EIS.

This section describes a complete list of structural and operational measures that are being carried forward, modified, or added to the Preferred Alternative from those described as part of the MO alternatives in Chapter 2 of the EIS. The existing mitigation programs identified in the No Action Alternative would be carried forward in the Preferred Alternative. These measures are listed in Table 9. Mitigation measures and ESA measures for the Preferred Alternative are listed in Tables 10 and 11, respectively.

Table 9. List of Measures that were Carried Forward, Modified, or Added to the Preferred Alternative from Alternatives in Chapter 2 of the EIS

Description
STRUCTURAL MEASURES
Hungry Horse Project Powerplant Modernization ^{1/}
Third Powerplant Overhaul Project
John W. Keys III Pump-Generating Plant Modernization Project
Grand Coulee G1 through G18 Plant Modernization Project
Lower Granite Trap Modifications
Lower Granite Juvenile Facility Bypass Improvements ^{1/}
Lower Granite Spillway Passive Integrated Transponder (PIT) Monitoring System ^{1/}
Little Goose Adjustable Spillway Weir Closure ^{1/}
Little Goose Adult Ladder Temperature Improvements ^{1/}
Little Goose Boat Barrier ^{1/}
Little Goose Trash Shear Boom Repair ^{1/}
Ice Harbor Turbines 1–3 Replacement and Generator Rewind ^{1/}
McNary Turbine Replacement ^{1/}
John Day Adult Passive Integrated Transponder (PIT) Tag Monitoring System ^{1/}
John Day Improved Fish Passage Turbines
Bonneville Gatewell Orifice Modifications ^{1/}
Bonneville Ladder Serpentine Weir Modifications
Closeable Floating Orifice Gates for Lamprey
Bypass Screen Modifications for Lamprey
Lamprey Passage Ladder Modifications
Turbine Strainer Lamprey Exclusion
Fewer Fish Screens

Description
OPERATIONAL MEASURES
Sliding Scale at Libby and Hungry Horse
Modified Draft at Libby
Planned Draft Rate at Grand Coulee
Grand Coulee Maintenance Operations
Update System FRM Calculation at Grand Coulee
Lake Roosevelt Additional Water Supply
Fall Operational Flexibility for Hydropower (Grand Coulee)
Slightly Deeper Draft for Hydropower (Dworshak)
Juvenile Fish Passage Spill Operations
Contingency Reserves within Juvenile Fish Passage Spill
Above 1% Turbine Operations
Increased Forebay Range Flexibility
Early Start Transport
Zero Generation Operations
Predator Disruption Operations
John Day Full Pool

1/ Carried forward from No Action Alternative.

Table 10. Mitigation Summary for the Preferred Alternative

Resource	Proposed Mitigation Action
Resident Fish – ESA Kootenai River White Sturgeon	Plant 1–2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon by providing a food source. This would complement ongoing habitat actions already being taken in the region.
Vegetation, Wildlife, Wetlands & Floodplains	On Kootenai River downstream of Libby, plant native wetland and riparian vegetation up to ~100 acres along river.
Anadromous Fish	Temporarily extend performance standard spill levels in coordination with the Regional Forum to assist fish migration.
Resident Fish – Burbot, Kokanee, and Redband Rainbow Trout	If study evaluations and other available data indicate resident fish spawning habitat areas are impacted by changes in reservoir elevations, the co-lead agencies would work with regional partners to determine where to augment spawning habitat at locations along the reservoir and in the tributaries (up to 100 acres).

Resource	Proposed Mitigation Action
Navigation & Transportation	Conduct regular monitoring of tailrace conditions. If any discovery of adverse or damaging effects, install coffer cells at Lower Granite, Lower Monumental and McNary projects to dissipate energy from higher spill levels.
Navigation & Transportation	Increase the frequency and total volume of dredging at McNary, Ice Harbor, Lower Monumental, and Lower Granite at a 4- to 7-year interval.
Navigation & Transportation	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it is available at lower water elevations.
Cultural Resources	Use the Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other alternative mitigation to address impacts to TCPs.

Table 11. Final Measures Incorporated into the Preferred Alternative as a Result of Informal and Formal Endangered Species Act Consultation

Measure
Bull Trout Access to Perched Tributaries in the Kootenai River
Surface Spill to Reduce Take of Overshooting Adult Steelhead
Maintenance Improvements to Little Goose Dam Jetty and Retaining Wall
Enhanced Debris Management at Lower Snake River Dams and McNary
Investigate Shad Deterrence at Lower Granite Dam
Reduce Mortality Associated with Dworshak Dam Turbine Maintenance and Testing
Adult Fish Ladder Temperature Differentials
Adjust Refill at Grand Coulee to Offset Reclamation Water Withdrawal Request
Adult Separator at the Lower Granite Dam Juvenile Bypass System

Operational measures for all the alternatives are not expected to result in discharge of dredged or fill materials. If implemented, MO3 would need an engineering and design report to identify quantity of dredged material and location of disposal. All the action alternatives, MO1–MO4 and the Preferred Alternative, have proposed mitigation measures where discharge of dredged or fill materials below OHW may occur. All the action alternatives propose placement of spawning gravel and extension of the ramp at the Inchelium-Gifford Ferry, both at Lake Roosevelt. In MO1–MO3 and the Preferred Alternative, installation of riparian and wetland plantings, including cottonwoods, are proposed downstream of Libby Project and near Bonners Ferry, Idaho. A potential increase in dredging frequency and total volume at McNary, Ice Harbor, Lower Monumental, and Lower Granite may occur as mitigation under MO3, MO4, and the Preferred Alternative, depending on scour and sediment monitoring. To address potential river channel inaccessibility for fish passage, channel modifications such as channel excavation

are proposed in MO3 and the Preferred Alternative. With MO3, modifying the Tucannon River channel at the delta to allow bull trout, salmon, and steelhead passage after Snake River water elevations decrease from breaching is proposed. Similarly, the Preferred Alternative would implement channel modifications at two tributaries of the Kootenai River to address upstream passage for bull trout concerns. These exact tributary sites would be determined at a later date when the implementation plan is further refined. All of these proposed activities would involve work below OHW with the placement of materials and possibly excavation. This list of activities potentially occurring below OHW is not comprehensive. As site-specific implementation plans are developed to implement the Preferred Alternative, additional site-specific activities occurring below OHW may be realized, and site-specific environmental compliance would be performed. For any of the proposed measures, typical best management practices (BMPs) and in-water work windows would be implemented to minimize potential effects to water quality such as turbidity.

3.7 FINDINGS

Operational measures for all the alternatives would not result in discharge of dredged or fill materials. The proposed mitigation components would need a site-specific implementation plan and environmental compliance, including Section 404. Compared to MO1, MO2, MO4, and the Preferred Alternative, dam breaching measures, along with the proposed mitigation measures in MO3 associated with fill and discharge, would have major short-term effects, including high sediment and low oxygen concentrations for 2 to 7 years following breaching, and potential migration barriers at tributaries that may become perched during reservoir drawdown; however, they would also result in long-term gain in aquatic ecosystem function.

As described in Chapter 7 of the CRSO EIS, following the evaluation of the No Action Alternative and MOs, the co-lead agencies selected a combination of measures for the Preferred Alternative based on how well the measures met the Purpose and Need Statement and study objectives, with consideration of environmental, economic, and social effects. Development of the Preferred Alternative allowed the co-lead agencies to refine several measures based on information learned during the modeling and evaluation process of the alternatives detailed in Chapter 3 of the EIS. In addition, new information on juvenile fish passage from the 2018 and 2019 operations for spring juvenile fish spill that benefit downstream migration of juvenile anadromous fish became available after the alternatives were developed. Using this information, the co-lead agencies modified the juvenile fish spill operation for the Preferred Alternative using the analysis from the range of spill levels evaluated in the MOs. This modification was an attempt to provide a high potential benefit to salmon and steelhead through increased spill while avoiding many of the adverse impacts to power generation and reliability associated with MO4. Exact design details and locations of site-specific actions, such as proposed mitigation measures with work below OHW, are not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, site-specific details will be available, and environmental compliance, including Section 404, would be performed. Typical construction avoidance and minimization measures such as standard operating procedures, BMPs such as minimizing ground disturbance, and industry standards would be employed.

CHAPTER 4 - SIGNIFICANT DEGRADATION, EITHER INDIVIDUALLY OR CUMULATIVELY, TO THE AQUATIC ENVIRONMENT OF THE PREFERRED ALTERNATIVE

- a) **Impacts on Ecosystem Function.** The Preferred Alternative would result in a mix of beneficial and minor to moderate adverse localized effects to both anadromous and resident fish species and aquatic habitat. The degree to which the Preferred Alternative affects anadromous fish varies between the two models used to evaluate benefits. The CSS model predicts the Preferred Alternative would result in a substantial improvement in returning Snake River species that migrate in the spring, while the Life Cycle Model (LCM) predicts slightly reduced survival and adult returns as compared to the No Action Alternative in the absence of latent mortality. The LCM also assessed survival and adult returns under several levels of assumed latent mortality reductions (10, 25, and 50 percent). As latent mortality is decreased by more than 10 percent, the LCM predicts increased survival and adult returns compared to the No Action Alternative. In Region A, there would be minor to moderate beneficial food availability and habitat effects, especially in dry years. In Region B, there would be minor to moderate adverse effects to resident fish, primarily in above average water years, with minor beneficial effects from mitigation. In Region C, there would be minor adverse effects from increased winter entrainment (Dworshak reservoir) and increased TDG exposure (lower Snake River). In Region D, there would be negligible to minor adverse effects from TDG exposure and John Day reservoir changes. When the impacts from the Preferred Alternative are added to the Reasonably Foreseeable Future Actions (RFFAs), effects to anadromous and resident fish could be adverse, but it is uncertain to what degree. Some of these adverse effects could be partially alleviated by other actions that have the goal of benefiting anadromous and resident species (i.e., Tribal, State, and Local Fish and Wildlife Improvement projects).

Negligible to minor effects to wetlands in Regions A–D associated with proposed operations in the Preferred Alternative are anticipated, primarily due to transition from wetlands to a more upland habitat type. In Region A, reservoir elevation changes in Lake Koocanusa would cause minor shifts in transition zones between uplands and emergent and forested wetlands. In addition, proposed operations during wet years would reduce outflows to the Kootenai River from June to September, potentially reducing ecological productivity in the river. To reduce these effects, native wetland and riparian vegetation (up to ~100 acres) would be planted along the Kootenai River downstream of Libby Dam. At Hungry Horse and Flathead River, summer water levels change would have negligible effects to minor beneficial effects to vegetation and wetlands. At Lake Pend Oreille, negligible impacts to vegetation wetlands are expected.

In Region B, the frequency and duration of drying conditions could slightly increase for areas with emergent herbaceous and forested and scrub-shrub wetlands, and these habitats could transition into upland habitats, or plant communities in these habitats would transition to predominantly species more tolerant of dry conditions, reducing the overall quantity of wetlands. The effect, however, are very likely to be minor, given the small percentage of water elevation changes throughout an average year.

Downstream of Dworshak in Region C, there would be no net loss or reduction in the quality and distribution of existing emergent herbaceous and forested and scrub-shrub wetlands. Along the four Lower Snake River dams, there would be no reduction in the quality and distribution of existing emergent herbaceous and forested and scrub-shrub wetlands.

In Region D, increasing the duration and extent of inundation could shift wetland species composition from facultative species to a greater dominance by obligate species. Despite the increased duration of inundation, the temporary nature of inundation is not expected to result in functional changes to wetland habitats in Lake Umatilla.

Actions that have the potential to cause cumulative impacts to wetlands when added to the direct and indirect impacts from the Preferred Alternative include climate change and increased water withdrawals if they cause lower water levels and cause habitat conversion from existing vegetation types to drier habitat types (e.g., convert wetlands to uplands).

- b) **Impacts on Recreational, Aesthetic, and Economic Values.** No major adverse effects on recreation, aesthetics, or the economy are anticipated from the Preferred Alternative. Effects to these resources from the Preferred Alternative, cumulatively, with the RFFAs are not anticipated to result in major adverse effects, as discussed in Chapter 7 of the EIS.

Across the study area, total recreational visitation and associated social welfare effects are anticipated to decrease by a negligible amount in a typical year due to changes in boat ramp access. Expenditures associated with non-local visitation would decrease by \$12,000 annually across the study area, a change of less than 0.1 percent compared to the No Action Alternative. Regional economic effects of this change in expenditures would be negligible. Effects to the quality of hunting, wildlife viewing, swimming, and water sports at river recreation sites in the study area would be generally negligible under the Preferred Alternative. In the future, there could be reduced boat ramp accessibility for some periods of time during the year due to an overall reduced volume of available water from increased demand and from the effects of climate change, causing lower summer volumes. When the impacts from the Preferred Alternative are added to RFFAs, there is a potential for the impacts to recreation to increase from negligible to minor to minor to moderate.

Effects to visual resources from structural measures for Regions A and B would be negligible because they would not substantially differ from the No Action Alternative. There would be minor, short-term visual effects for viewers in the vicinity of projects in Regions C and D because of increased construction activity from implementing structural measures, but these measures would not contribute to a substantial visual change in the landscape surrounding those projects. Because operational measures across all regions would result in minor changes in pool elevation management, carrying out those measures would have a minor effect on the viewshed and viewers in the vicinity of changes in duration and timing of reservoir elevations compared to the No Action Alternative. Minor adverse visual effects from the Preferred Alternative due to deeper drafts at reservoirs could be exacerbated by cumulative actions such as climate change; increased water withdrawals to support municipal, agricultural, and

industrial uses; and ongoing land-based activities; however, the cumulative impact to visual resources would likely be minor.

Effects to the economy are expected to be negligible to minor with regards to hydropower generation and navigation. Under the Preferred Alternative, hydropower generation would decrease relative to the No Action Alternative. This decrease in hydropower generation across the Pacific Northwest is anticipated to result in social welfare costs ranging between \$6.7 million and \$25 million. These values are estimates of the net economic cost of the Preferred Alternative from a national societal perspective. In addition, the Preferred Alternative would result in additional cost of compliance with greenhouse gas emission reduction programs in the region of between \$9 and \$47 million per year. Cumulative effects in combination with the power and transmission impacts analyzed under the Preferred Alternative are expected to be similar to that of the No Action Alternative.

In Region A, there would likely be no effects to navigation from reservoir elevation changes. In Region B, the effects to the operation of the Inchelium-Gifford Ferry would result in minor effects and would be addressed by extending the boat ramp for the Inchelium-Gifford Ferry in Lake Roosevelt. With regards to commercial navigation, the Preferred Alternative could result in approximately a 1-day decrease in navigable days annually under low-flow conditions when compared to the No Action Alternative, and approximately a 1-day increase during normal flow conditions. In all other flow conditions, there would be negligible or no effect compared to the No Action Alternative. Overall, there would likely be negligible to minor cumulative effects when the effects to navigation from the Preferred Alternative are added to impacts from other RFFAs, such as climate change.

Findings. The Corps has determined that there would be no major adverse effects to aquatic ecosystem functions and values throughout the CRS from the Preferred Alternative. The Preferred Alternative would not cause significant degradation, either individually or cumulatively to the aquatic environment. As mitigation measures are implemented, site-specific environmental compliance would be performed, including Section 404.

CHAPTER 5 - APPROPRIATE AND PRACTICABLE MEASURES TO MINIMIZE POTENTIAL HARM TO THE AQUATIC ECOSYSTEM.

- a) **Impact Avoidance Measures.** The co-lead agencies would avoid and minimize impacts to waters of the U.S. to the maximum extent practicable. Implementation would involve multiple potential sites with construction near ecological resources. Each specific location would have short-term construction-related effects with varying spatial and temporal scales and degrees of intensity. Construction would include practices that avoid and minimize effects to affected significant resources. Some of these avoidance measures may include, but not limited to the following:
- Construction would be schedule during designated in-water work windows.
 - Each construction contractor would be required to prepare an Environmental Protection Plan to anticipate and avoid impacts and submit it to the co-lead agencies for approval.
 - Construction sequencing would avoid exposing the entire site at one time and would avoid having bare soils during rainy months.
 - Construction methods would include stabilizing erodible surfaces with mulch, compost, seeding, or sod to avoid causing turbid runoff.
 - Methods would include the use of isolation devices such as silt fences, for interception and dissipation of turbid runoff water to avoid contributing turbid water to a water body.
 - All hazardous, toxic, and radioactive waste sites would be avoided.
 - Impacts to wetlands would be avoided to the maximum extent practicable.
- b) **Impact Minimization Measures.** When avoidance is not feasible, the co-lead agencies should employ efforts to minimize impacts. The following is a list of standard methods to minimize adverse construction effects.
- Use water and other dust suppressants to control fugitive dust and minimize erosion during construction.
 - Develop and implement storm water prevention, erosion and sediment control, and spill prevention control and countermeasure plans.
 - Implement secondary containment for fuel and hazardous chemicals used in construction and operational implementation of measures.
 - Adhere to fish passage guidelines during in-water work and construction of ladders, weirs, and other in-water structures, and coordinate with the National Marine Fisheries Service (NMFS) and the USFWS if ESA-listed species are impacted.
 - Implement standard fish handling techniques to minimize stress, and acquire the necessary Federal and state scientific take permits for fish handling.
 - Minimize spread and establishment of invasive species by implementing control measures for construction equipment.

- c) **Compensatory Mitigation Measures.** Additional compensatory mitigation is not anticipated to be required. However, as the site-specific designs are further developed, the need for compensatory mitigation measures will also be evaluated.

Findings. Avoidance, minimization, and mitigation measures are conceptual at this stage. Further development would be made during the implementation of site-specific mitigation. Co-lead agencies have determined that all appropriate and practicable measures would be taken to minimize potential harm to the environment.

CHAPTER 6 - OTHER FACTORS IN THE PUBLIC INTEREST

- a) **Fish and Wildlife.** The co-lead agencies have coordinated with State and Federal agencies, as well as the tribes in the Columbia basin, to ensure careful consideration of fish and wildlife resources. The co-lead agencies have been coordinating with both NMFS and USFWS throughout the development of this project. The biological assessment was submitted to NMFS and USFWS for formal Section 7 consultation, dated December 20, 2019. NMFS and USFWS determined that the proposed action would not likely jeopardize the continued existence of ESA-listed species, and would not likely destroy or adversely modify designated critical habitat for the same species. NMFS and USFWS also concurred with the co-lead agencies' "may effect, not likely to adversely affect" determinations for several species. These biological opinions were received in July 2020 and can be found in Appendix V of the EIS. In compliance with Magnuson-Stevens Fishery Conservation and Management Act, effects to essential fish habitat are consulted on in conjunction with the ESA Section 7 consultation and included in the NMFS biological opinion. As site-specific project designs are developed, they will be coordinated with all applicable natural resource agencies.
- b) **Water Quality.** The co-lead agencies would obtain a Water Quality Certification under Section 401 of the Clean Water Act for site-specific actions requiring a Federal permit, license, or authorization, if not already included.
- c) **Historic and Cultural Resources.** After reviewing the changes in operations, maintenance, and configuration proposed as a part of the Preferred Alternative, the co-lead agencies have determined that the existing Systemwide Programmatic Agreement (SWPA) would cover the co-lead agencies' responsibilities under Section 106 of the National Historic Preservation Act for all proposed operations, and many structural measures, under the Preferred Alternative. For proposed structural measures not covered by the SWPA, separate Section 106 compliance would be completed prior to construction, when sufficient site-specific information on the undertaking becomes available.
- d) **Environmental Benefits.** The Preferred Alternative would benefit salmon and steelhead, through improved migration and in-river survival, and resident fish, and it would maintain the conservation goals of other fish and wildlife. Additionally, it would improve lamprey passage at the Federal projects and reduce the need for lethal take of migratory birds by using nesting dissuasion techniques. The Preferred Alternative would also improve summer flow augmentation for anadromous migration, while improving resident fish habitat at Libby and Hungry Horse. Additionally, proposed mitigation would offset adverse effects to reservoir levels in Lake Roosevelt and waters around Libby to maintain spawning grounds and tributary access.
- e) **Navigation.** A negligible disruption of navigation traffic may result from the proposed operational measures. If dredging was needed as a mitigation measure, that dredging activity would be similar to the ongoing Lower Snake River Programmatic Sediment Management Plan. A determination of whether a Section 9 permit would be required

would be made prior to construction of the project-specific structural measures. It is not anticipated that the co-lead agencies would need to obtain a Section 9 permit from the U.S. Coast Guard.

Findings. The co-lead agencies have determined that the Preferred Alternative is within the public interest based on review of the public interest factors.

CHAPTER 7 - CONCLUSIONS

Based on the analyses presented in project NEPA and ESA documents, as well as the following 404(b)(1) Evaluation and General Policies for the Evaluation of Permit Applications analysis, the Corps finds that the operational measures of the Preferred Alternative comply with the substantive elements of Section 404 of the Clean Water Act because those measures would not result in discharge of dredged or fill materials. As the proposed mitigation components are implemented, a site-specific implementation plan would be developed and environmental compliance, including Section 404, would be performed.

7.1 CLEAN WATER ACT SECTION 404(B)(1) EVALUATION [40 C.F.R. § 230]

The potential effects of the Preferred Alternative are described below. Exact design details and locations of site-specific actions, such as proposed mitigation measures with work below OHW, are not known at this time. As site-specific designs are developed for the implementation of the mitigation for the Preferred Alternative, site-specific details will be available. Typical construction avoidance and minimization measures, such as standard operating procedures; BMPs, such as minimizing ground disturbance; and industry standards would be employed. Applicable permitting will be obtained as needed prior to implementation of any site-specific measures.

7.2 POTENTIAL IMPACTS ON PHYSICAL AND CHEMICAL CHARACTERISTICS (SUBPART C)

1. **Substrate [230.20].** Substrate composition varies widely throughout the study area. Site-specific details regarding substrate are not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, details about the substrate at the specific locations will be available.
2. **Suspended Particulate/Turbidity [230.21].** Site specific effects regarding suspended particulate and turbidity are not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, details will be available to evaluate site-specific effects. Typical construction avoidance and minimization measures for sediment control would be used throughout construction to minimize any potential turbidity issues.
3. **Water [230.22].** Generally speaking basin-wide, minimal changes to the physical, chemical, or biological processes of water would occur. However, localized site-specific effects to water are not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, details will be available to evaluate site-specific effects. Typical construction avoidance and minimization measures for sediment control would be used throughout construction to minimize any potential turbidity issues.
4. **Current Patterns and Water Circulation [230.23].** Site-specific effects regarding current patterns and water circulation are not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, these details will be available to evaluate site-specific effects.

5. **Normal Water Fluctuations [230.24].** Normal water level fluctuations in the reservoirs are controlled at the dams. The Preferred Alternative does not change the fluctuations outside of the normal operational range.
6. **Salinity Gradients [230.25].** The Preferred Alternative is unlikely to affect salinity gradients due to negligible effects to hydrology and hydraulics downstream of Bonneville Project.

7.3 POTENTIAL IMPACTS ON BIOLOGICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM (SUBPART D)

1. **Threatened and Endangered Species [230.30].** The co-lead agencies have been coordinating with both NMFS and USFWS throughout the development of this project. The biological assessment was submitted to NMFS and USFWS for formal Section 7 consultation, dated December 20, 2019. NMFS and USFWS determined that the proposed action would not likely jeopardize the continued existence of ESA-listed species, and would likely not destroy or adversely modify designated critical habitat for the same species. NMFS and USFWS also concurred with the co-lead agencies' "may effect, not likely to adversely affect" determinations for several species. These biological opinions were received in July 2020 and can be found in Appendix V of the EIS. In compliance with Magnuson-Stevens Fishery Conservation and Management Act, effects to essential fish habitat are consulted on in conjunction with the ESA Section 7 consultation and included in the NMFS biological opinion. As site-specific project designs are developed, they will be coordinated with all applicable natural resource agencies.
2. **Aquatic Food Web [230.31].** The Preferred Alternative would result in a mix of beneficial effects and negligible to minor adverse localized effects to aquatic food availability and habitat throughout Regions A–D. Details are provided in Chapter 7 of the EIS.
3. **Wildlife [230.32].** In Region A, larger transition zone devoid of vegetative cover would expose wildlife to increased rates of predation. Changes in reservoir elevation in Lake Koocanusa during summer may have minor impacts to nesting waterfowl. The Preferred Alternative is not expected to impact nesting birds in the Albeni Falls Dam study area.

The Preferred Alternative in Region B would only slightly influence reservoir elevations in Lake Roosevelt and downstream reaches of the Columbia River through the run of river past Chief Joseph Dam, resulting in only potentially minor changes to the quantity, quality, and distribution of habitats in the study area. However, even minor changes to wildlife habitats could have a corresponding effect on wildlife populations in the study area.

In Region C, changes to wildlife habitats at Dworshak Reservoir would have a corresponding effect on wildlife populations in the study area. However, lower water levels in January, February, and March would have a minor adverse effect on elk migration patterns, when ice is present on the reservoir. Downstream of Dworshak Reservoir, the Preferred Alternative would not result in changes to the quantity, quality, and distribution of habitats in the Clearwater River. Changes to wildlife habitats have a corresponding effect on wildlife populations in the study area. Existing wetlands would continue to be productive habitats supporting breeding amphibians, reptiles, mammals, and birds during the spring and summer breeding season.

In Region D, existing wetlands would continue to be productive habitats supporting breeding amphibians, reptiles, mammals, and birds during the spring and summer breeding season. These wetland habitats would continue to support regionally important migratory waterfowl overwintering in the Umatilla National Wildlife Refuge by providing forage opportunities and prey resources.

In Regions C and D, the *Early Start Transport* and *Predator Disruption Operations* measures would have effects on the birds throughout these regions. In Regions C and D, the *Early Start Transport* measure would reduce the number of juvenile salmonids between collection points in the lower Snake River and release points below Bonneville Dam, thus decreasing overall prey resources supporting a variety of wildlife populations at higher trophic levels above Bonneville Dam, specifically colonial nesting terns, gulls, and pelicans.

Because the *Predator Disruption Operations* measure could reduce the overall quantity and availability of habitat in Lake Umatilla, including the Blalock Islands, prior to the breeding season, nesting waterbirds would likely delay nest initiation until late June and July, forego nesting, or relocate to other areas. Avian predators displaced from nesting habitat in Lake Umatilla would be expected to relocate to other islands and continue to forage within the Columbia River Basin.

The estimated increase in adult salmonid returns would have a moderately beneficial effect on marine mammals that feed on salmon and steelhead downstream of Bonneville Dam and in the ocean. For special status species, there would be negligible effects. In addition, it is assumed that the abundance and condition of juvenile salmon and steelhead entering the estuary would similarly increase in the prey base available to nesting waterbirds, which would be a moderately beneficial impact to the size and reproductive success of these colonies.

7.4 POTENTIAL IMPACTS TO SPECIAL AQUATIC SITES (SUBPART E)

1. **Sanctuaries and Refuges [230.40].** There are numerous National Wildlife Refuges (NWR) within the geographic scope of the EIS. The proposed operational measure at Libby would create higher flows in the summer, resulting in a minor adverse effect on the Kootenai NWR. In Lake Umatilla, despite the increased duration of inundation under the Preferred Alternative, the temporary nature of inundation is not expected to result in functional changes to wetland habitats at Umatilla NWR. Similarly, at Franz Joseph, Pierce, Steigerwald, Ridgefield, Julia-Butler Hansen, and Lewis and Clark NWRs, wetland habitats would remain consistent with existing conditions despite minor changes in water surface elevations
2. **Wetlands [230.41].** In Regions A–D, negligible to minor adverse effects to wetlands associated with proposed operations in the Preferred Alternative are anticipated, primarily due to transition from wetlands to more upland habitat type.
3. **Mudflats [230.42].** Due to some of the operational measures, reservoirs in Regions A–C may be drawn down further seasonally, resulting in a minor increase in the barren zone where mudflats could occur.

4. **Vegetated Shallows [230.43].** As mentioned above, a potential increase in the barren zone due to proposed reservoir operations in Regions A–C could result in a minor adverse effect to vegetated shallows, as these areas could be dewatered.
5. **Coral Reefs [230.44].** Not applicable.
6. **Riffle and Pool Complexes [230.45].** Not applicable.

7.5 POTENTIAL EFFECTS ON HUMAN USE CHARACTERISTICS (SUBPART F)

1. **Municipal and Private Water Supplies [230.50].** The Preferred Alternative is not expected to change the ability to deliver existing water supply as compared to the No Action Alternative, because the changes in flow and reservoir elevations are expected to be negligible. In addition, the operation of withdrawals is timed to minimize impacts to flows. The additional 45,000 acre-feet from Lake Roosevelt proposed for storage in this measure is expected to increase water supply in Region B, but is not expected to affect other regions.
2. **Recreational and Commercial Fisheries [230.51].** The effects from the Preferred Alternative on fisheries (anadromous) are expected to be negligible in Region B downstream of Chief Joseph Dam due to minor changes in operations. The effects to fisheries (anadromous) in Regions C and D have the potential to range from moderate adverse impacts to major beneficial impacts. However, effects from the Preferred Alternative are expected to improve fish survival and abundance (both anadromous and resident fish) through the combination of operational and mitigation measures. To the extent that increases in fish abundance occur, this would increase opportunities for tribal, commercial, and recreational fishing throughout the Columbia River Basin.
3. **Water-Related Recreation [230.52].** Effects to the quality of swimming and water sports at river recreation sites in the study area would be generally negligible under the Preferred Alternative.
4. **Aesthetics [230.53].** Effects to visual resources from structural measures for Regions A and B would be negligible because they would not substantially differ from the No Action Alternative. There would be minor, short-term visual effects for viewers in the vicinity of projects in Regions C and D because of increased construction activity from implementing structural measures, but these measures would not contribute to a substantial visual change in the landscape surrounding those projects. Because operational measures across all regions would result in minor changes in pool elevation management, carrying out those measures would have a minor effect on the viewshed and viewers in the vicinity of changes in duration and timing of reservoir elevations compared to the No Action Alternative.
5. **Parks, National and Historic Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves [230.54].** The Preferred Alternative is not expected to adversely affect parks, National and Historic Monuments, National Scenic Areas, National Seashores, Wilderness Areas, research sites, or similar preserves, either because none of these sites are in the study area or the proposed operations would result in no or negligible change from the existing condition.

7.6 EVALUATION AND TESTING (SUBPART G)

1. **General Evaluation of Dredged or Fill Material [230.60].** No specific sediment testing has occurred associated with this project, but may be done during the construction phase. No contaminated material would be used as fill, nor would it be sidecast after excavation if found to contain contaminants. Sources of fill would be examined to ensure that any material imported to sites to be used as fill is clean material free of contaminants.
2. **Chemical, Biological, and Physical Evaluation and Testing [230.61].** No specific sediment testing has occurred associated with this project, but may be done during the construction phase.

7.7 ACTION TO MINIMIZE ADVERSE EFFECTS (SUBPART H)

1. **Actions Concerning the Location of the Discharge [230.70].** Exact information about location of discharge is not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, site-specific details will be available. Typical construction avoidance and minimization measures such as standard operating procedures, BMPs such as minimizing ground disturbance, and industry standards would be employed.
2. **Actions Concerning the Material to be Discharged [230.71].** Exact information about material to be discharged is not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, site-specific details will be available. Typical construction avoidance and minimization measures such as standard operating procedures, BMPs such as minimizing ground disturbance, and industry standards would be employed.
3. **Actions Controlling the Material after Discharge [230.72].** Exact information about how the material will be controlled after discharge is not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, site-specific details will be available. Typical construction avoidance and minimization measures such as standard operating procedures, BMPs such as minimizing ground disturbance, and industry standards would be employed.
4. **Actions Affecting the Method of Dispersion [230.73].** Exact information about method of dispersion is not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, site-specific details will be available. Typical construction avoidance and minimization measures such as standard operating procedures, BMPs such as minimizing ground disturbance, and industry standards would be employed.
5. **Actions Related to Technology [230.74].** Exact information about machinery and methods of transport is not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, site-specific details will be available. Typical construction avoidance and minimization measures such as standard operating procedures, BMPs such as minimizing ground disturbance, and industry standards would be employed.
6. **Actions Affecting Plant and Animal Populations [230.75].** Site-specific effects to plant and animal populations are not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, site-specific details will be available. Typical

construction avoidance and minimization measures such as standard operating procedures, BMPs such as minimizing ground disturbance, and industry standards would be employed.

7. **Actions Affecting Human Use [230.76].** Site specific effects to human use are not known at this time. As site-specific designs are developed for the implementation of the Preferred Alternative, site-specific details will be available. Typical construction avoidance and minimization measures such as standard operating procedures, BMPs such as minimizing ground disturbance, and industry standards would be employed.
8. **Other Actions [230.77].** Not applicable.

7.8 APPLICATION BY ANALOGY OF THE GENERAL POLICIES FOR THE EVALUATION OF PUBLIC INTEREST [33 C.F.R. § 320.4 FOR REFERENCE]

1. **Public Interest Review [320.4(a)].** The co-lead agencies find these actions to be in compliance with the 404(b)(1) guidelines and not contrary to the public interest.
2. **Effects on Wetlands [320.4(b)].** Effects to wetlands have been determined to be negligible to minor. As site-specific designs are developed for the implementation of the Preferred Alternative, details will be available to evaluate site-specific effects.
3. **Fish and Wildlife [320.4(c)].** The co-lead agencies consulted with Federal and State agencies and tribes to ensure that direct and indirect loss and damage to fish and wildlife resources attributable to the proposed work would be minimized. The co-lead agencies would continue to coordination with Federal and State agencies and tribes as site-specific designs are developed.
4. **Water Quality [320.4(d)].** The co-lead agencies would obtain a Water Quality Certification under Section 401 of the Clean Water Act for site-specific projects, as needed, prior to construction.
5. **Historic, Cultural, Scenic, and Recreational Values [320.4(e)].** After reviewing the changes in operations, maintenance, and configuration proposed as a part of the Preferred Alternative, the co-lead agencies have determined that the existing Systemwide Programmatic Agreement would cover the co-lead agencies' responsibilities under Section 106 of the National Historic Preservation Act for all proposed operations, and many structural measures, under the Preferred Alternative. For proposed structural measures not covered by the SWPA, separate Section 106 compliance would be completed prior to construction, when sufficient site-specific information on the undertaking becomes available.
6. **Effects on Limits of the Territorial Sea [320.4(f)].** Not applicable.
7. **Consideration of Property Ownership [320.4(g)].** Not applicable.
8. **Activities Affecting Coastal Zones [320.4(h)].** Not applicable.
9. **Activities in Marine Sanctuaries [320.4(i)].** The Preferred Alternative would not affect any marine sanctuaries.

10. **Other Federal, State, or Local Requirements [320.4(j)].** The co-lead agencies have analyzed the Preferred Alternative under all applicable Federal, State, and local requirements and documented this compliance in Chapter 8 of the EIS.
11. **Safety of Impoundment Structures [320.4(k)].** Not applicable.
12. **Floodplain Management [320.4(l)].** The Preferred Alternative would not alter floodplain areas.
13. **Water Supply and Conservation [320.4(m)].** The Preferred Alternative is not expected to change the ability to deliver existing water supply or conservation.
14. **Energy Conservation and Development [320.4(n)].** Not applicable.
15. **Navigation [320.4(o)].** A negligible disruption of navigation traffic may result from the proposed operational measures. If dredging was needed as a mitigation measure, that dredging activity would be similar to the ongoing activities under the Lower Snake River Programmatic Sediment Management Plan.
16. **Environmental Benefits [320.4(p)].** The Preferred Alternative would benefit salmon and steelhead through improved migration and in-river survival, resident fish, and maintain the conservation goals of other fish and wildlife. It would improve lamprey passage at the Federal projects and reduce the need for lethal take of migratory birds by using nesting dissuasion techniques. The Preferred Alternative also improves summer flow augmentation for anadromous migration while improving resident fish habitat at Libby and Hungry Horse. Additionally, proposed mitigation would offset adverse effects to reservoir levels in Lake Roosevelt and waters around Libby to maintain spawning grounds and tributary access.
17. **Economics [320.4(q)].** No major economic effects are expected (see Table 7-1 for more details).
18. **Mitigation [320.49(r)].** Site-specific designs will incorporate all available impact avoidance and minimization measures to the extent practicable. Compensatory mitigation is not anticipated to be required. However, as the site-specific designs are further developed, the need for compensatory mitigation measures will also be evaluated.



Columbia River System Operations Environmental Impact Statement

Appendix X, Independent External Peer Review Report

Note: The Section 508 amendment of the Rehabilitation Act of 1973 requires that the information in federal documents be accessible to individuals with disabilities. The Agency has made every effort to ensure that the information in *Appendix X: Independent External Peer Review Report* is accessible. However, if readers have any issues accessing the information in this appendix, please contact the *U.S. Army Corps of Engineers* at (800) 290-5033 or info@crso.info so additional accommodations may be provided.

The four Independent External Peer Reviews (IEPRs) that were performed on the Columbia River System Operations Environmental Impact Statement, or models used therein, are in various stages of progress as indicated below. The final reports for all IEPRs will be available at <https://www.nwd.usace.army.mil/CRSO> prior to the signing of the Record of Decision. The current status of the four IEPR reports are:

- Environmental Impact Statement IEPR: panel comments were received by the co-lead agencies, responses to the panel were drafted, and a draft back check of the co-lead agencies' responses has been performed by the panel. The co-lead agencies have revised responses, but a final back check of the co-lead agencies' responses has not yet been performed by the panel.
- Ecological Model IEPR: complete; final report attached in this Appendix.
- Economic Model IEPR: panel comments were received by the co-lead agencies, responses to the panel were drafted, but a back check of the co-lead agencies' responses has not yet been performed by the panel.
- Power Analysis Model IEPR: panel comments were received by the co-lead agencies, responses to the panel were drafted, but a back check of the co-lead agencies' responses has not yet been performed by the panel.

*Columbia River System Operations Environmental Impact Statement
Appendix X, Independent External Peer Review Report*

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Final Independent External Peer Review Report Columbia River System Operations Environmental Impact Statement

Prepared by
Battelle Memorial Institute

Prepared for
Department of the Army
U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Mississippi Valley Division

Contract No. W912HQ-15-D-0001
Task Order: W912HQ20F0008

May 19, 2020

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CONTRACT NO. W912HQ-15-D-0001
Task Order: W912HQ20F0008

Final Independent External Peer Review Report Columbia River System Operations Environmental Impact Statement

Prepared by

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U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Mississippi Valley Division

May 19, 2020

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Final Independent External Peer Review Report Columbia River System Operations Environmental Impact Statement

Executive Summary

Project Background and Purpose

The U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and Bureau of Reclamation (Co-lead Agencies) are jointly developing a comprehensive Environmental Impact Statement (EIS), referred to as the Columbia River System Operations (CRSO) Draft EIS (DEIS), to evaluate long-term system operations and configurations of 14 multiple-purpose projects that are operated as a coordinated system within the interior Columbia River Basin in Idaho, Montana, Oregon, and Washington. USACE was authorized by Congress to construct, operate, and maintain 12 of these projects for flood risk management, navigation, power generation, fish and wildlife conservation, recreation, and municipal and industrial water supply purposes. USACE projects that will be included in the EIS are Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. The Bureau of Reclamation was authorized to construct, operate, and maintain the other two projects—Hungry Horse and Grand Coulee—for the purposes of irrigation, flood risk management, navigation, power generation, recreation, and other beneficial uses. The BPA is responsible for marketing and transmitting the power generated by these dams. Together, these Co-lead Agencies are responsible for managing the system for these various purposes, while meeting their other statutory and regulatory obligations.

The Co-lead Agencies will use this EIS to assess and update their approach for long-term system operations and configurations through the analysis of alternatives and evaluation of potential effects to the human and natural environments. The scope and scale of this project, its potential to impact human life safety, interest on the part of the Governors of Montana, Idaho, Washington, and Oregon and of 19 Federally recognized tribes, connection to ongoing litigation on the Federal Columbia River Power System, as well as the likelihood for the project to result in public dispute, drive a requirement for a heightened level of review and meet the criteria of a highly influential scientific assessment in Office of Management and Budget (OMB) and Bureau of Reclamation peer review policies.

Independent External Peer Review Process

Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analysis. USACE is conducting an Independent External Peer Review (IEPR) of the CRSO Draft EIS (hereinafter: CRSO DEIS IEPR). As a 501(c)(3) non-profit science and technology organization, Battelle is independent, free from conflicts of interest (COIs), and meets the requirements for an Outside Eligible Organization (OEO) per guidance described in USACE (2018). Battelle has experience in establishing and administering peer review panels for USACE and was engaged to coordinate this IEPR. The IEPR was external to the agency and conducted following USACE and OMB guidance described in USACE (2018) and OMB (2004). This final report presents the Final Panel Comments of the IEPR Panel (the Panel). Details regarding the IEPR (including the process for selecting panel members, the panel

members' biographical information and expertise, and the charge submitted to the Panel to guide its review) are presented in appendices.

Based on the technical content of the decision documents and the overall scope of the project, Battelle identified potential candidates for the Panel in the following key technical areas: economics, environmental resources/water quality (dual role), cultural resources, hydrology and hydraulic (H&H) engineering/climate change (dual role), hydropower operations and water supply, civil/geotechnical engineering, and cost engineering. Battelle screened the candidates to identify those most closely meeting the selection criteria and evaluated them for COIs and availability. USACE was given the list of all the final candidates to independently confirm that they had no COIs, and Battelle made the final selection of the seven-person Panel from this list.

The Panel received electronic versions of the decision documents (6,790 pages in total), along with a charge that solicited comments on specific sections of the documents to be reviewed. Following guidance provided in USACE (2018) and OMB (2004), USACE prepared the charge questions, which were included in the draft and final Work Plans.

The USACE Project Delivery Team (PDT) briefed the Panel and Battelle during a kick-off meeting held via teleconference at the start of the review to provide the Panel an opportunity to ask questions of USACE and clarify uncertainties. Other than Battelle-facilitated teleconferences, there was no direct communication between the Panel and USACE during the peer review process.

IEPR panel members reviewed the decision documents individually and produced individual comments in response to the charge questions. The panel members then met via teleconference with Battelle to review key technical comments and reach agreement on the Final Panel Comments to be provided to USACE. Each Final Panel Comment was documented using a four-part format consisting of (1) a comment statement; (2) the basis for the comment; (3) the significance of the comment (high, medium/high, medium, medium/low, or low); and (4) recommendations on how to resolve the comment. Overall, 23 Final Panel Comments were identified and documented. Of these, two have been identified as having medium/high significance, nine have medium significance, ten have medium/low significance, and two have low significance.

Results of the Independent External Peer Review

The panel members agreed on their “assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used” (USACE, 2018) in the CRSO DEIS review documents. Table ES-1 lists the Final Panel Comment statements by level of significance. The full text of the Final Panel Comments is presented in Section 4.2 of this report. The following summarizes the Panel's findings.

Based on the Panel's review, the report is well-written, is organized, and provides supporting documentation on the project's goals, objectives, and constraints, as well as the environmental, economic and engineering issues related to CRSO. The report provided a balanced assessment of the economic, engineering, and environmental issues of the overall project; however, the Panel identified several elements of the report that should be reviewed, documented, or revised.

Environmental: The CRSO is an extremely complex interaction of natural processes, Federal law, regional and international agreements, and environmental goals and objectives. Given the complexity of

this project and the plan to incorporate adaptive management to ensure that the project goals are met, the Panel believes that implementation of adaptive management in the CRSO would benefit from a more robust, science-based adaptive management model that can be used to guide program development and support future decision making. The large number of tradeoffs, conflicts, viewpoints, and dynamically interacting subsystems make it difficult to define any one uniquely qualified alternative for the CRSO. The Panel thus believes that an effective CRSO will have to adapt and respond to new information and changing conditions over time. Traditional adaptive management often results in an extended field-based, build-test-adapt sequence of projects with inherent long project times, high costs, and limited programmatic success, whereas a more science-based adaptive management process may accelerate ecosystem response and recovery.

Another critical concern identified by the Panel was the description and assessment of impacts on the built resources. The CRSO DEIS does not identify which built resources are eligible for listing in the National Register of Historic Places (NRHP), and what effects project actions would have on such resources. The effects of project actions on built resources can only be addressed by knowing their NRHP eligibility status. A built resource that is 50 years or older is not automatically eligible for listing in the NRHP. The replacement of original components of a NRHP-eligible built resource would be considered an adverse effect if the characteristics that make the property eligible are compromised by the project action. An alteration or modification to a historic property, however, does not necessarily adversely affect the characteristics that make a property eligible for the NRHP. A modification or alteration can be compatible with the original operation and appearance of the property (i.e., in-kind replacement, a common maintenance activity, and/or technological upgrade). In addition, the approach used to determine what constitutes a built resource versus an archaeological property is too narrow and subjective.

The Panel identified additional issues that need to be discussed or clarified in the CRSO DEIS, including the assessment of impacts due to increases in extreme climate events and the ability of fish to adapt to changing climatic conditions. Several Panel comments also focus on misunderstandings and incorrect information provided in the CRSO DEIS regarding total dissolved gas (TDG) and gas bubble disease (GBD) in relation to the CRSO.

Economics: For the most part, the economic analyses were done thoroughly, utilizing secondary, and in some cases primary, data to assess the complex impacts of potential changes to the CRSO. However, the Panel noted several inconsistencies that should be corrected. Examples of some inconsistencies include the definition of local versus non-local visitors used for the aggregation of economic impacts from changes in recreation. By basing the regional recreational impacts on a summation of individual site-level impacts, non-local visits may be overestimated because site impacts include local regional impacts that should not be included. In another instance, the use of averages from a USACE nation-wide database for expenditure data may not accurately represent averages expenditures on a regional scale.

The Panel also noted that the CRSO DEIS assumes that all new power generation and transmission infrastructure would be immediately available for all Multiple Objective (MO) alternatives. This clearly is not the case; in fact, the CRSO DEIS states in several places that building the necessary infrastructure could take a decade or more. More importantly, this assumption misrepresents the estimated costs and benefits. Assuming that all MO alternatives would be fully implemented instantly systematically misrepresents the present value of estimated benefits, while assuming that all structural measures would occur over 2 years with evenly spread costs systematically misrepresents the present value of estimated costs.

The economic analysis relies on two different models to assess the impacts of the alternatives on the shipping costs of various commodities. However, the inconsistent use of datasets for the commodities models Snake Columbia Economic Navigation Tool (SCENT) and Transportation Optimization Model (TOM) distorts the comparisons of results for shipment costs. The Panel noted that the CRSO DEIS does not explain how the risk associated with disruptions and delays due to high-water conditions in the Columbia River System (CRS) is incorporated into the SCENT model, and based on the information provided, the TOM does not appear to include any sort of risk assessment at all.

Engineering: The CRSO DEIS with its supporting appendices provides a high level of detail, rationally explained, that allows review of the stated goals, system operation, and modeled effects within the system. However, the Panel noted some areas where the assumptions made for the various alternatives need to be clarified. For example, it is unclear why the MO1, MO3, and MO4 alternatives were burdened with new irrigation diversions that are 25 times greater than those used for the Preferred Alternative. Further, in evaluating the loss of Lower Snake River (LSR) hydro generation (part of MO3), regional development of new renewable generation resources is not considered as the most likely replacement energy source.

Table ES-1. Overview of 23 Final Panel Comments Identified by the CRSO DEIS IEPR Panel

No.	Final Panel Comment
Significance – Medium/High	
1	The implementation of adaptive management in the CRSO would benefit from a more robust, science-based adaptive management model that can be used to guide program development and support future decision making.
2	The CRSO DEIS does not identify which built resources are eligible for listing in the NRHP, and what effects project actions would have on such resources.
Significance – Medium	
3	The assessment of climate change does not consider the impacts of increases in extreme climate events.
4	The approach used to determine what constitutes a built resource versus an archaeological property is too narrow and subjective.
5	The definition of local versus non-local visitors is not appropriate for the aggregation of economic impacts from changes in recreation.
6	The inconsistent use of datasets for the commodities modeled by SCENT and TOM distorts the comparisons of results for shipment costs.

Table ES-1. Overview of 23 Final Panel Comments Identified by the CRSO DEIS IEPR Panel (continued)

No.	Final Panel Comment
7	The CRSO DEIS does not explain how the risk associated with disruption/delay due to high-water conditions is incorporated into the SCENT model, and this risk does not appear to be included in the TOM at all.
8	The assumption that all new power generation and transmission infrastructure would be immediately available for all MO alternatives misrepresents the estimated costs and benefits.
9	The conclusion that TDG levels exceeding 110% produce an increased risk of fish mortality is misleading.
10	A percent change in the 5-year average maximum TDG as compared to the No Action Alternative does not reflect the degree of GBD impact to the fish.
11	It is unclear why MO1, MO3, and MO4 were burdened with new irrigation diversions that are 25 times greater than those used for the Preferred Alternative.
Significance – Medium/Low	
12	The use of monthly and weekly flows in the H&H models does not replicate local hydraulic conditions that would impact aspects of the quality and use of the CRSO environment by adult and juvenile fish during passage.
13	The assessment of climate changes does not consider the adaptability of fish to changing climatic conditions.
14	In evaluating the loss of LSR hydro generation (part of MO3), regional development of new renewable generation resources is not considered as the most likely replacement energy source.
15	The use of averages from a USACE nation-wide database for expenditure data may not accurately represent the average expenditures on a regional scale.
16	The system cost models do not communicate risk under the MO alternatives.
17	The IMPLAN analysis for the power generation and transmission model was not modeled properly.

Table ES-1. Overview of 23 Final Panel Comments Identified by the CRSO DEIS IEPR Panel (continued)

No.	Final Panel Comment
18	The CRSO DEIS does not include any information on the potential for earthquakes and any resulting impacts to the Columbia River area under the No Action Alternative or the action alternatives assessed.
19	It is unclear how risk and uncertainty have been integrated into the complex adaptive system managed under the CRSO.
20	It is unlikely that the relatively small-scale habitat restorations proposed will restore historic levels of the fish stocks on the Columbia River tributaries due to large watershed impacts from various human activities prior to and since dam construction.
21	Several definitions, terms, and comparisons used in the CRSO DEIS in regard to TDG supersaturation are incorrect and misleading.
Significance – Low	
22	Chapter 2 of the CRSO DEIS does not discuss increased access by white sturgeon to upstream habitat due to removal of the LSR dams.
23	Discussions of some topics seem fragmented and distributed throughout the CRSO DEIS in a way that makes it difficult to capture and appreciate details and reach full understanding of the impacts.

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LIST OF ACRONYMS

BPA	Bonneville Power Administration
cfs	Cubic Foot per Second
COI	Conflict of Interest
COMPASS	Comprehensive Passage
CRS	Columbia River System
CRSO	Columbia River System Operations
CSS	Comparative Survival Study
DEIS	Draft Environmental Impact Statement
DOE	United States Department of Energy
DOS	Department of State (Washington State)
DrChecks	Design Review and Checking System
EC	Engineer Circular
ECB	Engineering and Construction Bulletin
EDR	Engineering Documentation Report
EIS	Environmental Impact Statement
ELAM	Eulerian-Lagrangian-Agent Method
ERDC	Engineer Research and Development Center
ETL	Engineer Technical Letter
FERC	Federal Energy Regulatory Commission
ft	Foot
GBD	Gas Bubble Disease
H&H	Hydrology and Hydraulic
HEC	Hydrologic Engineering Center
HMS	Hydrologic Modeling System
IEPR	Independent External Peer Review
IFIM	Instream Flow Incremental Methodology
IWR	Institute for Water Resources
kaf	Kilo Acre-Feet
LCM	Life-Cycle Modeling
LOLP	Loss of Load Probability

LSR	Lower Snake River
Maf	Million Acre-Feet
MO	Multiple Objective
MPNHP	Manhattan Project National Historical Park
NED	National Economic Development
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NRHP	National Register of Historic Places
O&M	Operation and Maintenance
OEO	Outside Eligible Organization
OMB	Office of Management and Budget
PCX	Planning Center of Expertise
PDT	Project Delivery Team
RAS	River Analysis System
SCENT	Snake Columbia Economic Navigation Tool
TDG	Total Dissolved Gas
TOM	Transportation Optimization Model
USACE	United States Army Corps of Engineers
VE	Value Engineering

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1. INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and Bureau of Reclamation (Co-lead Agencies) are jointly developing a comprehensive Environmental Impact Statement (EIS), referred to as the Columbia River System Operations (CRSO) Draft EIS (DEIS), to evaluate long-term system operations and configurations of 14 multiple-purpose projects that are operated as a coordinated system within the interior Columbia River Basin in Idaho, Montana, Oregon, and Washington. USACE was authorized by Congress to construct, operate, and maintain 12 of these projects for flood risk management, navigation, power generation, fish and wildlife conservation, recreation, and municipal and industrial water supply purposes. USACE projects that will be included in the EIS are Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. The Bureau of Reclamation was authorized to construct, operate, and maintain the other two projects—Hungry Horse and Grand Coulee—for the purposes of irrigation, flood risk management, navigation, power generation, recreation, and other beneficial uses. The BPA is responsible for marketing and transmitting the power generated by these dams. Together, these Co-lead Agencies are responsible for managing the system for these various purposes, while meeting their other statutory and regulatory obligations.

The Co-lead Agencies will use this EIS to assess and update their approach for long-term system operations and configurations through the analysis of alternatives and evaluation of potential effects to the human and natural environments. The scope and scale of this project, its potential to impact human life safety, interest on the part of the Governors of Montana, Idaho, Washington, and Oregon and of 19 Federally recognized tribes, connection to ongoing litigation on the Federal Columbia River Power System, as well as the likelihood for the project to result in public dispute, drive a requirement for a heightened level of review and meet the criteria of a highly influential scientific assessment in Office of Management and Budget (OMB) and Bureau of Reclamation peer review policies.

Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analysis. The objective of the work described here was to conduct an Independent External Peer Review (IEPR) of the draft CRSO EIS (hereinafter: CRSO DEIS IEPR) in accordance with procedures described in the Department of the Army, USACE, Engineer Circular (EC) *Review Policy for Civil Works* (EC 1165-2-217) (USACE, 2018) and the OMB *Final Information Quality Bulletin for Peer Review* (OMB, 2004). Supplemental guidance on evaluation for conflicts of interest (COIs) was obtained from the *Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports* (The National Academies, 2003).

This final report presents the Final Panel Comments of the IEPR Panel (the Panel) on the existing engineering, economic, and environmental analyses contained in the CRSO DEIS IEPR documents (Section 4). Appendix A describes in detail how the IEPR was planned and conducted, including the schedule followed in executing the IEPR. Appendix B provides biographical information on the IEPR panel members and describes the method Battelle followed to select them. Appendix C presents the final charge to the IEPR panel members for their use during the review; the final charge was submitted to USACE in the final Work Plan according to the schedule listed in Table A-1. Appendix D presents the organizational COI form that Battelle completed and submitted to the Institute for Water Resources (IWR) prior to the award of the CRSO DEIS IEPR.

2. PURPOSE OF THE IEPR

To ensure that USACE documents are supported by the best scientific and technical information, USACE has implemented a peer review process that uses IEPR to complement the Agency Technical Review, as described in USACE (2018).

In general, the purpose of peer review is to strengthen the quality and credibility of the USACE decision documents in support of its Civil Works program. IEPR provides an independent assessment of the engineering, economic, and environmental analyses of the project study. In particular, the IEPR addresses the technical soundness of the project study's assumptions, methods, analyses, and calculations and identifies the need for additional data or analyses to make a good decision regarding implementation of alternatives and recommendations.

In this case, the IEPR of the CRSO DEIS was conducted and managed using contract support from Battelle, which is an Outside Eligible Organization (OEO) (as defined by EC 1165-2-217). Battelle, a 501(c)(3) organization under the U.S. Internal Revenue Code, has experience conducting IEPRs for USACE.

3. METHODS FOR CONDUCTING THE IEPR

The methods used to conduct the IEPR are briefly described in this section; a detailed description can be found in Appendix A. The IEPR was completed in accordance with established due dates for milestones and deliverables as part of the final Work Plan; the due dates are based on the award/effective date and the receipt of review documents.

Battelle identified, screened, and selected seven panel members to participate in the IEPR based on their expertise in the following disciplines: economics, environmental resources/water quality (dual role), cultural resources, hydrology and hydraulic (H&H) engineering/climate change (dual role), hydropower operations and water supply, civil/geotechnical engineering, and cost engineering. The Panel reviewed the CRSO DEIS documents and produced 23 Final Panel Comments in response to 13 charge questions provided by USACE for the review. This charge also included two overview questions added by Battelle, for a total of 15 questions. Battelle instructed the Panel to develop the Final Panel Comments using a standardized four-part structure:

1. Comment Statement (succinct summary statement of concern)
2. Basis for Comment (details regarding the concern)
3. Significance (high, medium/high, medium, medium/low, or low; in accordance with specific criteria for determining level of significance)
4. Recommendation(s) for Resolution (at least one implementable action that could be taken to address the Final Panel Comment).

Battelle reviewed all Final Panel Comments for accuracy, adherence to USACE guidance (EC 1165-2-217), and completeness prior to determining that they were final and suitable for inclusion in the Final IEPR Report. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The Panel's findings are summarized in Section 4.1; the Final Panel Comments are presented in full in Section 4.2.

4. RESULTS OF THE IEPR

This section presents the results of the IEPR. A summary of the Panel's findings and the full text of the Final Panel Comments are provided.

4.1 Summary of Final Panel Comments

The panel members agreed on their "assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used" (USACE, 2018) in the CRSO DEIS IEPR review documents. The following summarizes the Panel's findings.

Based on the Panel's review, the report is well-written, is organized, and provides supporting documentation on the project's goals, objectives, and constraints, as well as the environmental, economic and engineering issues related to CRSO. The report provided a balanced assessment of the economic, engineering, and environmental issues of the overall project; however, the Panel identified several elements of the report that should be reviewed, documented, or revised.

Environmental: The CRSO is an extremely complex interaction of natural processes, Federal law, regional and international agreements, and environmental goals and objectives. Given the complexity of this project and the plan to incorporate adaptive management to ensure that the project goals are met, the Panel believes that implementation of adaptive management in the CRSO would benefit from a more robust, science-based adaptive management model that can be used to guide program development and support future decision making. The large number of tradeoffs, conflicts, viewpoints, and dynamically interacting subsystems make it difficult to define any one uniquely qualified alternative for the CRSO. The Panel thus believes that an effective CRSO will have to adapt and respond to new information and changing conditions over time. Traditional adaptive management often results in an extended field-based, build-test-adapt sequence of projects with inherent long project times, high costs, and limited programmatic success, whereas a more science-based adaptive management process may accelerate ecosystem response and recovery.

Another critical concern identified by the Panel was the description and assessment of impacts on the built resources. The CRSO DEIS does not identify which built resources are eligible for listing in the National Register of Historic Places (NRHP), and what effects project actions would have on such resources. The effects of project actions on built resources can only be addressed by knowing their NRHP eligibility status. A built resource that is 50 years or older is not automatically eligible for listing in the NRHP. The replacement of original components of a NRHP-eligible built resource would be considered an adverse effect if the characteristics that make the property eligible are compromised by the project action. An alteration or modification to a historic property, however, does not necessarily adversely affect the characteristics that make a property eligible for the NRHP. A modification or alteration can be compatible with the original operation and appearance of the property (i.e., in-kind replacement, a common maintenance activity, and/or technological upgrade). In addition, the approach used to determine what constitutes a built resource versus an archaeological property is too narrow and subjective.

The Panel identified additional issues that need to be discussed or clarified in the CRSO DEIS, including the assessment of impacts due to increases in extreme climate events and the ability of fish to adapt to changing climatic conditions. Several Panel comments also focus on misunderstandings and incorrect

information provided in the CRSO DEIS regarding total dissolved gas (TDG) and gas bubble disease (GBD) in relation to the CRSO.

Economics: For the most part, the economic analyses were done thoroughly, utilizing secondary, and in some cases primary, data to assess the complex impacts of potential changes to the CRSO. However, the Panel noted several inconsistencies that should be corrected. Examples of some inconsistencies include the definition of local versus non-local visitors used for the aggregation of economic impacts from changes in recreation. By basing the regional recreational impacts on a summation of individual site-level impacts, non-local visits may be overestimated because site impacts include local regional impacts that should not be included. In another instance, the use of averages from a USACE nation-wide database for expenditure data may not accurately represent averages expenditures on a regional scale.

The Panel also noted that the CRSO DEIS assumes that all new power generation and transmission infrastructure would be immediately available for all Multiple Objective (MO) alternatives. This clearly is not the case; in fact, the CRSO DEIS states in several places that building the necessary infrastructure could take a decade or more. More importantly, this assumption misrepresents the estimated costs and benefits. Assuming that all MO alternatives would be fully implemented instantly systematically misrepresents the present value of estimated benefits, while assuming that all structural measures would occur over 2 years with evenly spread costs systematically misrepresents the present value of estimated costs.

The economic analysis relies on two different models to assess the impacts of the alternatives on the shipping costs of various commodities. However, the inconsistent use of datasets for the commodities models Snake Columbia Economic Navigation Tool (SCENT) and Transportation Optimization Model (TOM) distorts the comparisons of results for shipment costs. The Panel noted that the CRSO DEIS does not explain how the risk associated with disruptions and delays due to high-water conditions in the Columbia River System (CRS) is incorporated into the SCENT model, and based on the information provided, the TOM does not appear to include any sort of risk assessment at all.

Engineering: The CRSO DEIS with its supporting appendices provides a high level of detail, rationally explained, that allows review of the stated goals, system operation, and modeled effects within the system. However, the Panel noted some areas where the assumptions made for the various alternatives need to be clarified. For example, it is unclear why the MO1, MO3, and MO4 alternatives were burdened with new irrigation diversions that are 25 times greater than those used for the Preferred Alternative. Further, in evaluating the loss of Lower Snake River (LSR) hydro generation (part of MO3), regional development of new renewable generation resources is not considered as the most likely replacement energy source.

4.2 Final Panel Comments

This section presents the full text of the Final Panel Comments prepared by the IEPR panel members.

Final Panel Comment 1

The implementation of adaptive management in the CRSO would benefit from a more robust, science-based adaptive management model that can be used to guide program development and support future decision making.

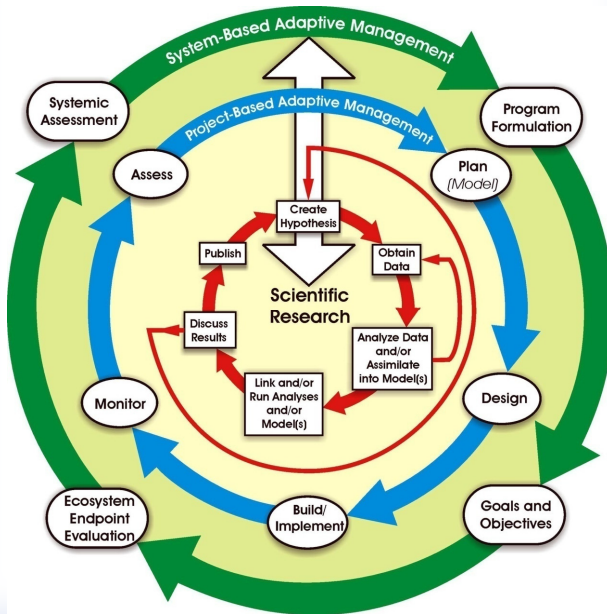
Basis for Comment

Because the two fish population models vary widely in the predicted effect on juvenile passage mortality, especially as it is related to spill, the Co-lead Agencies propose to use adaptive implementation of the flexible spill operation to test the assumptions in the models. Although this is a good, standard implementation of adaptive management, clearly, there are too many tradeoffs, conflicts, viewpoints, and dynamic interacting subsystems to define any one uniquely qualified alternative for the CRSO. The Panel thus believes that an effective CRSO will have to adapt and respond to new information and changing conditions over time. To detect important conditions, adaptive management requires appropriate data collection and monitoring, followed by data analysis, synthesis, and evaluation consistent with explicit contingency action plans. An effective learning process is required.

Traditional adaptive management often results in an extended field-based, build-test-adapt sequence of projects with inherent long project times, high costs and limited programmatic success, whereas a more science-based adaptive management process may accelerate ecosystem response and recovery.

The Panel thus believes that the CRSO DEIS would benefit from a more robust, science-based, adaptive management model that includes: defining assumed knowns/unknowns; coupling laboratory, field and numerical experimentation; developing data needs and data collection programs; and defining feedback loops into both detailed scientific studies and higher-level programmatic decisions. This more science-based adaptive management (see figure below) approach 1) recognizes the role of fundamental and applied scientific research to answer basic unresolved questions, 2) uses a traditional project-based adaptive management at each dam to prototype preferred alternatives, 3) integrates the research and project-based learning in the overall program, and 4) typically uses models (like Comprehensive Passage [COMPASS]/Life-Cycle Modeling [LCM] and/or Comparative Survival Study [CSS]) to integrate knowledge and understanding across the three levels of adaptive management. Additionally, uncertainties in the system-scale model often drive the need for additional research or field-based experimentation and/or prototype testing.

Final Panel Comment 1



Significance – Medium/High

Implementation of a practically optimal CRSO will require a timely, robust, scientific adaptive management model to confirm, test, or modify management operations and effectively deal with changing conditions and new information over time.

Recommendations for Resolution

1. Improve the adaptive management discussion in the CRSO DEIS based on the issues and concerns summarized above.
2. Develop a rigorous, science-based adaptive management framework to promote a better understanding of general fish passage models and specific models related to TDG.
3. Develop a responsive, science-based adaptive management framework for maintaining or improving CRSO effectiveness and efficiency over time as conditions change and new information is obtained.

Final Panel Comment 2

The CRSO DEIS does not identify which built resources are eligible for listing in the NRHP, and what effects project actions would have on such resources.

Basis for Comment

To determine the effects of a project action or undertaking on a built resource, the CRSO DEIS would need to identify whether the built resource is eligible for listing in the NRHP. Specifically, the CRSO DEIS would need information on the “determination of effects” process as defined under 36 CFR 800.5 of the NHPA, and the “determination of NRHP eligibility” process under 36 CFR Part 60. The CRSO DEIS also would need to explain how both processes are applied to built resources.

A built resource that is 50 years or older is not automatically eligible for listing in the NRHP. A cultural resource needs to possess enough physical integrity to be able to convey its historic significance and obtain the level of importance under at least one of the four eligibility criteria (A-D), as defined in the NRHP Criteria for Evaluation (36 CFR Part 60).

The CRSO DEIS states that any modification/alteration of a historic property would be considered an adverse effect to the characteristics that make a property eligible for listing in the NRHP. A historic property means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the NRHP, as defined in 36 CFR 800.16(l)(1) of the National Historic Preservation Act (NHPA) of 1966, as amended, 16 U.S.C. 470-470w-6. Under the MO2 alternative, the project would upgrade the historic spillway weirs at McNary, Ice Harbor, and Lower Monumental Dams to newer, adjustable weirs. This undertaking or project action would have an effect, but the effect would not necessarily be adverse unless the dams and the original spillway weirs were determined eligible for the NRHP. The replacement of original components of a NRHP-eligible built resource would be considered an adverse effect if the characteristics that make the property eligible are compromised by the project action. An alteration or modification to a historic property, however, does not necessarily adversely affect the characteristics that make a property eligible for the NRHP. A modification or alteration can be compatible with the original operation and appearance of the property (i.e., in-kind replacement, a common maintenance activity, and/or technological upgrade).

The CRSO DEIS refers to adverse, moderate, or minor/negligible effects of CRSO structural measures on cultural resources. The CRSO DEIS would benefit from more information on the approach used to make such determinations. For example, on page 7-7, under MO1, the CRSO DEIS states that there would be “...additional major effects at Hungry Horse, Lake Roosevelt and Dworshak Reservoirs.” On page 7-15, the CRSO DEIS states that “...there would be major social effects, including impacts to cultural resources at Lake Roosevelt, John Day, and Hungry Horse Reservoirs...”. The next sentence then states that “There would be additional moderate effects to cultural resources at the remaining Columbia River projects due to additional drawdown.” Additional information describing the major and moderate effects to cultural resources, the extent of project actions and impacts, and the process for arriving at the conclusions presented would be beneficial.

Final Panel Comment 2

Significance – Medium/High

The effects of the operational and structural measures presented, as well as the effects of project actions, on the built resources under the various alternatives cannot be fully addressed without knowledge of their NRHP eligibility.

Recommendations for Resolution

1. Add the NRHP eligibility status of CRSO built resources so the effects of the operational and structural measures on the built resources can be determined.
2. Describe the NRHP Criteria of Evaluation (36 CFR Part 60) process and how it is applied to built resources.
3. Describe the process used to determine the effects of operational and structural measures on NRHP-eligible built resources under the various alternatives, including a determination of “adverse effects,” “no adverse effects,” or “no historic properties affected” due to project actions.

Final Panel Comment 3

The assessment of climate change does not consider the impacts of increases in extreme climate events.

Basis for Comment

In addition to increases in annual and seasonal average temperatures and precipitation, it is expected that the number of extreme events (for both temperature and precipitation) will increase based on the most recent climate assessments. It is unclear how those extremes were factored into the alternative assessments. If USACE considered potential changes to the standard project flood or the probable maximum flood as a result of climate change, it does not appear to be clearly documented in the CRSO DEIS or supporting documentation. In addition, the DEIS does not explain how future updates to the Intergovernmental Panel on Climate Change reports will be incorporated into the CRSO program over the duration of the project life. The Panel notes that in each climate assessment report, the general information indicates that the climate is changing faster than previously projected.

Significance – Medium

Developing a robust method to update the CRSO as a result of the latest climate assessments will be important to the successful implementation of the CRSO project.

Recommendation for Resolution

1. Develop and describe a science-based adaptive management process for the incorporation of the latest data from the National Climate Assessment and other credible climate reports.

Final Panel Comment 4

The approach used to determine what constitutes a built resource versus an archaeological property is too narrow and subjective.

Basis for Comment

For the purposes of this CRSO DEIS, a built resource over 50 years of age, no longer in use, and deteriorating is considered an archaeological property. However, there are numerous built resources around the country, including in the Pacific Northwest, that are vacant, are not in use, and show signs of deterioration but are still considered a built resource rather than an archaeological property.

This CRSO DEIS would benefit from a broader, more flexible approach in what constitutes a built resource versus an archaeological property. While the criteria used to determine NRHP eligibility are the same for both built resources and archaeological properties, the NRHP eligibility criteria (and status) of both built resources and archaeological properties are important barometers in describing their different physical condition, historical integrity, and cultural significance. These criteria could provide a more definitive standard for describing what is a built resource versus an archaeological property.

Significance – Medium

A broader, more objective approach that clearly defines what constitutes a built resource versus an archaeological property would provide clarity for understanding the differences and treatment of both types of resources under the various alternatives.

Recommendations for Resolution

1. Adopt a clear standard (or a set of benchmarks) for what constitutes a built resource versus an archaeological property that reflects a more flexible but definitive approach, using NRHP eligibility criteria (and status) as one barometer in defining the two types of resources.
2. Develop a standard that reflects the definition used by State Historic Preservation Officers in the States of Washington, Oregon, Montana, and Idaho to determine what is a built resource versus an archaeological property.

Final Panel Comment 5

The definition of local versus non-local visitors is not appropriate for the aggregation of economic impacts from changes in recreation.

Basis for Comment

The methodology for estimating regional economic impacts using IMPLAN is based on the distinction between local and non-local visitors. Non-local visitors are considered those traveling more than 60 miles *to the site*. The regions in the recreation analysis are very large, extending more than 60 miles from most sites. So, it seems a visitor could be counted as a non-local, thereby including their trip expenditures in the regional IMPLAN analysis, when those expenditures should be counted as local *to the region*, in which case their expenditures should be excluded from the IMPLAN analysis. This methodology is applied inappropriately. The CRSO DEIS needs to clearly reconcile the apparent misuse of non-local visits in the regional economic impact analyses.

Site-level Analysis - As an example, all visitors from Seattle would be considered non-local visitors to Regions A, B, C, and D. Therefore, all lost visits to every site in Region A from people who live in Seattle should be counted as lost economic activity to Region A. Similarly, all lost visits to every site in Region B from people who live in Seattle should be counted as lost economic activity to Region B, and so on for Regions C and D.

To aggregate the economic impact to Region A from these lost Seattle-resident visits, simply add up the economic impact at each site in Region A, and so on for Regions B, C, and D. To aggregate the economic impact across the CRSO area, simply add up the economic impact across all regions.

Region-level Analysis - Portland, Oregon, however, is located in Multnomah County, which is considered part of Region D in the recreation analysis (see Table 2-5 of Appendix M). Portland is close enough to Bonneville to be considered local to the site, but Portland visitors to John Day would be considered non-local to the site even though they reside within the same economic region (Region D). So, lost visits from Portland residents to John Day should be included in an IMPLAN analysis of the economic impacts *at John Day site*. But lost visits from Portland to John Day are *local to Region D*. Therefore, it is inappropriate to include those lost visits in an IMPLAN analysis of the economic impacts *to the region*—the money the Portland visitors would have spent at John Day is still being spent within Region D. To correctly assess the economic impact to each region, one must define local versus non-local visits *to the region*. It is inappropriate to simply add up each of the site-level impacts across the region.

CRSO Area-level Analysis - The same issue arises when estimating the impacts to the entire CRSO. A new definition of local versus non-local *to the CRSO* must be employed. It is inappropriate to simply add up each of the region-level impacts. For example, lost visits in Region B from visitors who reside in Region A should be included in an IMPLAN analysis of Region B; those lost visits should not be included in an IMPLAN analysis of the entire CRSO because the Region A visitors are local to the CRSO.

Final Panel Comment 5**Significance – Medium**

Accurately aggregating the economic impacts to each sub-region and the CRSO area as a whole is necessary to assess the impacts of each alternative.

Recommendations for Resolution

1. Define local versus non-local visitors to each site clearly.
2. Define local versus non-local visitors to each economic region clearly.
3. Define local versus non-local visitors to the CRSO area clearly.
4. Run IMPLAN models for each region using the appropriate definition of local versus non-local visits to the region to aggregate the economic impacts from changes in recreation within Regions A, B, C, and D properly.
5. Run an IMPLAN model for the entire CRSO area using the appropriate definition of local versus non-local visits to the CRSO area to aggregate the economic impacts from changes in recreation across Regions A, B, C, and D properly.

Final Panel Comment 6

The inconsistent use of datasets for the commodities modeled by SCENT and TOM distorts the comparisons of results for shipment costs.

Basis for Comment

The SCENT and TOM models use different years for commodities volumes. SCENT uses 2016 shipment volumes; however, it is unclear what year of shipments are modeled in TOM. Page L-3-4 states that TOM models 202 million bushels of grain based on 2014-2018 average, but page L-3-8 states that TOM models 204 million bushels of grain based on 2018 production.

More importantly, SCENT models all commodities based on 2016 volumes for MO1, MO2, MO4, the No Action Alternative, and the Preferred Alternative. TOM, however, only models wheat shipments for MO3 and the No Action Alternative. Because the SCENT and TOM models generate estimates of the extra shipping costs of each MO alternative relative to the No Action Alternative, this difference may or may not matter, depending on the relative cost of shipping wheat compared to the other commodities and whether the No Action Alternative has binding capacity constraints along any route. Both SCENT and TOM are cost minimization models, so in the face of binding capacity constraints along any route, both models will re-route the least costly commodities first.

To estimate the extra shipping costs for MO1, for example, SCENT calculates the MO1 costs for wheat combined with the MO1 costs for the other commodities, and then subtracts the No Action Alternative costs for wheat combined with the No Action Alternative costs for the other commodities. So, the extra shipping costs for MO1, MO2, MO4, and the Preferred Alternative generated by SCENT represent the extra costs of shipping wheat and the other commodities.

Now, the decision to model only wheat in the TOM is based on the fact that wheat represents a large majority of the total volume of commodities moving out of the Lower Snake (possibly 87%, depending on the year being modeled). Modeling wheat only, however, may not reflect the full impacts on transportation costs under MO3.

To estimate the extra shipping costs for MO3, TOM calculates the MO3 shipping costs for wheat and subtracts the No Action Alternative shipping costs for wheat. If wheat is the highest-cost commodity to re-route, it would be the last to be re-routed by TOM in cases of binding capacity constraint(s); all the other commodities would be re-routed before any wheat. If the No Action Alternative has binding capacity constraints when modeling only wheat, then TOM would have re-routed all other commodities under both the No Action Alternative and MO3. In that case, the TOM calculation of the extra shipping costs under MO3 (MO3 wheat shipping costs minus the No Action Alternative wheat shipping costs) would effectively be the same as the calculations made using SCENT, because the shipping costs of other commodities in TOM would be moot, having canceled out through the subtraction.

If, however, wheat is not the highest-cost commodity to re-route, the shipping costs of the other commodities would not cancel out in TOM through the subtraction. Here, if there are binding capacity constraints under MO3, then excluding those other commodities from the TOM would underestimate the amount of wheat that would be re-routed, thereby underestimating the extra shipping costs of MO3.

Final Panel Comment 6

Significance – Medium

The discrepancies in the use of datasets could affect the relative cost of MO3 compared to the other MO alternatives.

Recommendations for Resolution

1. Use the same year of data for the SCENT and TOM models.
2. Provide information on the relative cost of rerouting wheat compared to the other commodities leaving the LSR.
3. Discuss the effect to shipping costs under MO3 relative to the other MO alternatives that arises from modeling only wheat in the TOM.

Final Panel Comment 7

The CRSO DEIS does not explain how the risk associated with disruption/delay due to high-water conditions is incorporated into the SCENT model, and this risk does not appear to be included in the TOM at all.

Basis for Comment

Because four-barge tows may be unable to safely navigate certain high-water conditions, shippers will have to either delay the movement of their four-barge tows until after high-water conditions pass or break the four-barge tow into multiple smaller tows. This is referred to as the risk of disruption/delay and represents very real risks to shippers in the CRSO. Appendix L, Section 2.4 of the CRSO DEIS states that the SCENT model addresses this risk but does not explain how it does so. More importantly, the TOM does not address this risk at all.

The SCENT model is used to estimate the extra shipping costs associated with MO1, MO2, MO4, and the Preferred Alternative. The TOM is used to estimate the extra shipping costs associated with MO3. Because TOM does not incorporate the risk of disruption/delay while SCENT does, the estimates of MO3 relative to the other MO alternatives and the Preferred Alternative are systematically biased.

Significance – Medium

The inconsistent treatment of risk in the SCENT and TOM models could affect the relative cost of MO3.

Recommendations for Resolution

1. Explain how the risk of disruption/delay is incorporated into the SCENT model.
2. Incorporate the risk of disruption/delay into the TOM so all MO alternatives are evaluated using the same risk framework.

Final Panel Comment 8

The assumption that all new power generation and transmission infrastructure would be immediately available for all MO alternatives misrepresents the estimated costs and benefits.

Basis for Comment

The CRSO DEIS assumes that all new power generation and transmission infrastructure would be immediately available for all MO alternatives. This clearly is not the case; in fact, the CRSO DEIS states in several places (see Appendix H, Sections 3.2.2 and 3.2.3) that building the necessary infrastructure could take a decade or more.

The timing of costs and benefits is an exceptionally important factor when calculating the net present value of the MO alternatives and the Preferred Alternative. With discounting, future benefits and costs are valued lower than current benefits and costs. In reality, the time required to fully implement each MO alternative has a direct impact on the net present value of each alternative. As an example, imagine two MO alternatives which, when fully implemented, generate the exact same benefits each year. Now imagine one of those MO alternatives can be fully implemented 5 years earlier than the other. Over the life of the project, the MO alternative that is completed sooner would have a higher level of benefits because it is able to start generating those benefits 5 years earlier.

Now imagine two MO alternatives that cost the exact same amount in nominal dollars but have different construction schedules, with one MO alternative taking longer to construct than the other. The present value of costs for the MO alternative that spends more further into the future will be lower than the one that spends more money sooner, due to discounting. The CRSO DEIS, however, assumes that all structural measures would occur over 2 years, and the costs were divided evenly over those 2 years for all alternatives.

Assuming that all MO alternatives would be fully implemented instantly systematically misrepresents the present value of estimated benefits, while assuming that all structural measures would occur over 2 years with evenly spread costs systematically misrepresents the present value of estimated costs. Together, these could affect the net present value of each MO alternative relative to each other and to the Preferred Alternative.

Significance – Medium

Changes to the net present value of each MO alternative and the Preferred Alternative due to these construction delays could result in changes to the overall viability of each assessed alternative.

Recommendations for Resolution

1. Include build-out times into the power generation and transmission cost analysis.
2. Provide a relative measure of time-to-full implementation across each MO alternative and the Preferred Alternative in the CRSO DEIS if Recommendation 1 is not possible.

Final Panel Comment 9

The conclusion that TDG levels exceeding 110% produce an increased risk of fish mortality is misleading.

Basis for Comment

The 110% of saturation criterion was established based primarily on data produced by laboratory investigations of GBD, with some support from live cage studies. This information is pertinent only for fish restrained in shallow water, not for migrants that occupy a range of depths such as in the deep reservoirs of the lower Snake and Columbia Rivers.

TDG levels would be “relatively high” or increase “risk” if the fish were restrained in shallow water, such as less than 1 meter deep. Levels of 115% to 120% of saturation are not high for fish occupying the range of available depths within the project reservoirs. This distinction is important because the CRSO DEIS gives the impression that 120% of TDG saturation would produce a high incidence of GBD and substantial mortality, which is not the case. Oregon and Washington States have regularly provided a TDG criterion of 115% in forebays and 120% at tailrace monitoring locations during the spring and summer migration periods, with no apparent deleterious effect to migrants (Whitman, 2020).

Exceeding the 110% of saturation level does not equate to GBD or mortality. Even at 120% of saturation and higher, empirical evidence has demonstrated a rare incidence of GBD within the project area. Even in the relatively shallow Kootenai River, Dunnigan (2002) observed that less than 1% of the fish collected by electrofishing showed GBD signs following exposure during June and July with TDG supersaturation (120 to >125%) during spill events that lasted from less than 1 hour to 58 hours in duration. By contrast, all captive fish held in cages showed GBD signs. This finding clearly indicates that laboratory and cage investigations do not replicate the depth behavior of fish in natural river conditions. The criterion of 110% was originally based on experiments that exposed fish to TDG supersaturation in shallow water (0.25 to 0.5 meter). These laboratory conditions do not represent the real-world conditions encountered by fish in the lower Columbia and Snake.

The TDG Average Exposure (TDG Tool) criteria are not likely to be useful in predicting biological effects of TDG supersaturation in the lower Snake and Columbia Rivers. The Panel suggests that an exposure duration of 16 hours or more to TDG levels exceeding 125% of saturation would be more useful in predicting a recognizable incidence of GBD in migrants.

Significance – Medium

The inclusion of an accurate representation of the TDG and GBD issues in the CRSO DEIS will allow decision makers to understand the issues and resulting alternative impacts when deciding on a preferred alternative. The 110% criterion is commonly superseded by the States of Oregon and Washington annually establishing a 115% forebay and 120% tailrace criterion during the juvenile migration period.

Final Panel Comment 9

Recommendations for Resolution

1. Remove references to the 110% of saturation criterion other than to identify the historical regulatory standards.
2. Remove statements regarding “risk” for the TDG supersaturation analyses due to the inaccuracy of these statements. A useful risk analysis would need to evaluate fish depth conditions for migrants.
3. Document the current spill season criteria established by the states of Oregon and Washington, which allow 115% in the forebays and 120% in the tailraces of lower Snake and Columbia River dams (Whitman, 2020).
4. Review Dunnigan (2002) and report on the findings as they directly relate to the CRSO project.

Literature Cited

Dunnigan, J. L. (2002). Kootenai River fisheries monitoring results from the spill events at Libby Dam, June-July 2002. Montana Fish, Wildlife and Parks, Helena, Montana. 30 pp.

Whitman, R. (2020). Agenda Item I: Proposed modification to the total dissolved gas water quality standard on the Columbia River for fish passage (Action). Memorandum to Environmental Quality Commission, by Department of Environmental Quality, State of Oregon.
https://www.oregon.gov/deq/EQCdocs/01242020_I_TotalDissolvedGas.pdf

Final Panel Comment 10

A percent change in the 5-year average maximum TDG as compared to the No Action Alternative does not reflect the degree of GBD impact to the fish.

Basis for Comment

The 5-year average maximum TDG level has not been demonstrated to produce a useful measure of the biological effects of elevated TDG levels in the natural conditions of the Columbia and Snake Rivers. At best, this criterion provides a weak comparison among CRSO alternatives and is likely to indicate an effect where none would occur.

A change in saturation of 2% at a No Action Alternative level of 120% TDG would be unlikely to produce an observable effect in overall GBD, while a 2% increase at a No Action Alternative level of 130% might produce a substantial observable effect. However, with the TDG levels generally being maintained at a 5-year average maximum TDG of 120% or lower, this issue would likely be insignificant (an exception would be situations such as Libby Dam where the downstream reach tends to be relatively shallow, making TDG levels exceeding 120% a concern). The net effect is likely to be an overestimate of the negative impact of any predicted increase in 5-year average maximum TDG levels.

Significance – Medium

An accurate representation of the TDG and GBD issues in the CRSO DEIS will allow decision makers to understand the issues and resulting impacts under the alternatives when deciding on a preferred alternative.

Recommendations for Resolution

1. Delete references to the 5-year average maximum TDG level, which does not accurately reflect GBD impacts.
2. Employ the 115% forebay and 120% tailrace criteria for TDG during the spring-summer migration period when determining potential effects to salmonid migrants in the lower Snake and Columbia Rivers, as suggested by the States of Oregon and Washington (Whitman, 2020).

Literature Cited

Whitman, R. (2020). Agenda Item I: Proposed modification to the total dissolved gas water quality standard on the Columbia River for fish passage (Action). Memorandum to Environmental Quality Commission, by Department of Environmental Quality, State of Oregon.
https://www.oregon.gov/deq/EQCdocs/01242020_I_TotalDissolvedGas.pdf

Final Panel Comment 11

It is unclear why MO1, MO3, and MO4 were burdened with new irrigation diversions that are 25 times greater than those used for the Preferred Alternative.

Basis for Comment

The MO1, MO3, and MO4 alternatives each include new irrigation diversions of 1.15 million acre-feet (Maf) per year from Lake Roosevelt. The Preferred Alternative includes a much smaller new diversion volume of 45,000 kilo acre-feet (kaf) per year, which is 4% of the added diversion volume included in the MO alternatives. The added irrigation flows for the MOs represent an expansion of approximately 254,000 acres of irrigated cropland in the Bureau of Reclamation Columbia Basin Project. The positive economic effects of this increase in irrigated cropland are not discussed in the analyses of the MO alternatives. However, the negative socioeconomic effects of the loss of 47,800 acres of cropland associated with MO3 are evaluated in detail in the analysis of that alternative. This is an unequal treatment of the water supply benefits between the Preferred Alternative and the MO alternatives.

The new 1.15 Maf irrigation diversion under the MO alternatives would result in a 0.5% to 1% reduction in river flow volumes below Grand Coulee Dam. This reduced river flow would cause a small but readily quantified reduction in power generation, system reliability, and socioeconomic benefits under the MO1, MO3 and MO4 alternatives. These negative effects are not discussed in the analyses of MO1, MO3 and MO4. Concurrently, the Preferred Alternative enjoys the incremental generation, reliability, and socioeconomic benefits of not diverting this added 1.1 Maf from the river. This benefit under the Preferred Alternative is not discussed in the CRSO DEIS.

The Panel believes it is important to quantify the amount of this difference between alternatives, which the Panel understands to be in the range of 0.5% to 1.0% of the Federal Projects' annual power generation.

Significance – Medium

The unequal examination of new irrigation diversions between the alternatives disregards positive benefits under the MO alternatives and overstates the relative benefits under the Preferred Alternative. As a result, this uneven treatment appears to inflate the economic justification of the Preferred Alternative and ignores likely benefits under the MO alternatives.

Recommendations for Resolution

1. Describe in Chapter 3 the benefits that would accrue from the added irrigation diversions at Lake Roosevelt under MO1, MO3, and MO4. Explain why socioeconomic and regional benefits were not examined.
2. Explain in Chapter 3 that the power generation, regional cost of power, and related socioeconomic benefits would be slightly higher if the large irrigation expansion did not occur under MO1, MO3, and MO4.

Final Panel Comment 11

3. Explain in Chapter 7 that the smaller new irrigation diversions from Lake Roosevelt would provide a small increase in CRS electric generation, loss of load probability (LOLP), and socioeconomic benefits due to about 1.1 Maf remaining in the river below Grand Coulee.
4. Quantify in Chapter 7 the difference in power generation, LOLP, and socioeconomic benefits that the 1.1 Maf difference in river flow represents.
5. Explain in Chapter 7 that this same small benefit would accrue under the MO alternatives if they also had irrigation diversions similar to that proposed under the Preferred Alternative.

Final Panel Comment 12

The use of monthly and weekly flows in the H&H models does not replicate local hydraulic conditions that would impact aspects of the quality and use of the CRSO environment by adult and juvenile fish during passage.

Basis for Comment

Overall, the H&H models focus on hydroregulation and flood risk management, where monthly and weekly flows are adequate for analysis. However, these flow periods are often inadequate to describe local hydraulic or hydrodynamic conditions that fish experience during both adult and juvenile fish passage where they continually make swim path decisions based on their local hydrodynamic conditions.

The CRSO DEIS and supporting documents do not discuss impacts from changes in spillway flows to adult and juvenile fish passage; exposure to TDG; potential for bed rock scour with increased spill levels; changes in powerhouse to spillway flow entrainment; and impact on overall downstream flow conditions, including near boat ramps, adult ladder entrances, and along shoreline protections such as rock revetment and stabilization structures.

Significance – Medium/Low

Both numerical and laboratory models are required in order to develop detailed project designs, shape spillway operations for flexible spill conditions, and evaluate changes in downstream flow conditions, which are important factors for analyzing the CRSO environment.

Recommendation for Resolution

1. Use a couple projects as “index” locations to more thoroughly assess the detailed hydrodynamic conditions near fish passage structures, spillway stilling basins, boat ramps, etc., and the impact of the changing flow conditions under the Preferred Alternative.

Final Panel Comment 13

The assessment of climate changes does not consider the adaptability of fish to changing climatic conditions.

Basis for Comment

The early life history of Columbia River salmonids is closely tied to the water temperatures they experience during incubation and intergravel rearing. However, salmonids and other fishes have been known to adapt to extended ranges of temperature.

The CRSO DEIS evaluation does not consider the adaptability of salmonid species to altered climatic and other habitat conditions. The various salmonid subspecies show substantial indication that species have historically adapted to fringe conditions to expand their occupation of adjacent habitats. The movement of salmonids to reoccupy the northern part of their existing range that provided no aquatic habitat during the Ice Age is one clear indication of the adaptability of these species.

Water temperatures do strongly influence reproductive timing as well as the development and survival of salmonid embryos and alevins. A degree or two increase in temperature beginning at the time of spawning may result in earlier hatching, emergence, and migration timing (possibly by several weeks). Times from spawning to emergence of alevins and subsequent migration are closely tied to the accumulation of degree-days by each fish. An increase in the accumulation of degree-days at the initiation of embryo development is likely to result in substantially earlier emergence of alevins, also perhaps by several weeks.

Increased temperatures may result in either earlier or later spawning dates, depending on species and other conditions. Higher temperatures can result in delayed adult migration to spawning areas, producing delayed spawning. If adult migrations are increased by slightly higher temperatures, earlier spawning together with a higher temperature (by a degree) at the time of spawning will result in the embryos accumulating substantially more degree-days by the historic date of spawning, followed by earlier emergence and migration.

Furthermore, changes in river flow (total discharge) are likely to occur with climate change. These changes may be sufficient to reduce juvenile migrant survival and delay adult migrations.

Also, the greatest effects of climate change may be the result of changes in ocean-rearing temperatures that influence the survival and growth of salmonids over one to three years. Ocean conditions are outside the area that can be influenced by the CRSO.

Significance – Medium/Low

Adding information on the adaptability of fish will add useful considerations to the basic issue of climate change and make the analysis less susceptible to criticism. This additional information would also help demonstrate that the CRSO has limited capacity to alter the effects of climate change in the CRS.

Final Panel Comment 13

Recommendations for Resolution

1. Document the potential for the native species to adapt to changes in water temperatures with climate changes in the CRSO DEIS.
2. Document the potential substantive changes in ocean conditions that may produce greater population changes than the CRSO area changes, and clarify that these changes are outside the capability of the CRSO to control.

Final Panel Comment 14

In evaluating the loss of LSR hydro generation (part of MO3), regional development of new renewable generation resources is not considered as the most likely replacement energy source.

Basis for Comment

As part of regional climate change policies, multiple state government and corporate initiatives are now developing new renewable electric generating resources. This new generation capacity will hasten the retirement of fossil fuel generation in the region. It also would likely replace the LSR hydro generation that would be lost as part of MO3.

The grid reliability and regional power system effects analysis for MO3 presents one very unlikely scenario where LSR hydro generation is replaced by conventional gas-fired generation. Given government/corporate mandates and the pace of new renewable generation sources, these fossil-fired replacements seem highly unlikely.

The replacement energy discussion in the MO3 analysis also suggests that BPA might be the developer of whatever replacement energy source is needed to replace the LSR hydro generation. That discussion confirms that a new Federal congressional authorization would be needed for BPA to develop such resources. Given ongoing resource development by others and the need for an act of Congress to allow BPA development, it seems also quite unlikely that BPA would carry out this energy development program.

Significance – Medium/Low

The analysis of power generation impacts for MO3 would be more complete if it acknowledged that replacement energy sources for the lost LSR hydro generation would most likely be developed by others. Specifically, this replacement generation would likely be renewable energy developed according to an economic framework and schedule largely independent of the CRSO.

Recommendations for Resolution

1. Edit the grid reliability and regional power system effects analyses to better describe the current regional development of renewable electric generation by entities external to the CRS.
2. State more clearly in the cost and LOLP analyses that replacement resources are likely to be developed by entities external to the CRS lead agencies.

Final Panel Comment 15

The use of averages from a USACE nation-wide database for expenditure data may not accurately represent the average expenditures on a regional scale.

Basis for Comment

The expenditure data used in the recreation model are national averages. All the sites in the CRSO area are located in the northwestern United States. Ideally, the expenditure data should reflect the expenditures at the sites being evaluated. The nation-wide data should be stratified by region and expenditure types so that sites in the northwestern United States could be used. This approach would more accurately reflect the economic impacts of changes to recreation sites in the CRSO area.

Significance – Medium/Low

Using expenditure data specific to the northwest region will yield the most accurate estimates possible of the economic impact of changes to recreation sites.

Recommendation for Resolution

1. Stratify the national expenditure data by region and use the northwest region averages in the recreation model.

Final Panel Comment 16

The system cost models do not communicate risk under the MO alternatives.

Basis for Comment

The estimated system costs under each alternative are divided into four categories: construction costs, capital costs, operation and maintenance costs (O&M), and mitigation costs (see Appendix Q, Table 7-2). All of these costs, with the exception of the mitigation costs, are presented as point estimates. The cost parameters in the models, however, are subject to fluctuations. Because each alternative employs different levels of inputs for construction, capital, and O&M, fluctuations in the cost of inputs will have different effects on the alternatives. The system cost models in the CRSO DEIS do not communicate how those parameter fluctuations would affect the system cost estimates.

As an example, O&M costs include the costs of dredging for navigation. To estimate the annual cost of dredging activity, the CRSO DEIS uses the average cost from 2011 to 2018, inflated to 2019 prices (Appendix Q, pages Q-5-2 and Q-5-3). It would not be difficult to use that same information to calculate the variance of the dredging costs and construct a confidence interval for the annual dredging costs.

Significance – Medium/Low

Including parameter fluctuations in the models will provide decision makers a better understanding of the perceived accuracy of the point estimates.

Recommendation for Resolution

1. Develop confidence intervals for the system costs of each alternative and report them in the CRSO DEIS.

Final Panel Comment 17

The IMPLAN analysis for the power generation and transmission model was not modeled properly.

Basis for Comment

The IMPLAN analysis was done at the state level and then aggregated to the study region. IMPLAN allows for models to be run at various spatial scales—single county, multi-county regions within a state, multi-county regions across states, state-level, multi-state regions, etc. The IMPLAN analysis for the CRSO DEIS ran separate state-level analyses and then totaled the results. This approach does not account for the economic inter-connection across state lines. The proper approach would be to run a regional IMPLAN model incorporating all counties in the study area into a single region.

Significance – Medium/Low

Changing the structure of the IMPLAN analysis from separate state-level analyses to a single regional analysis will provide more accurate estimates of the economic impacts under each alternative.

Recommendation for Resolution

1. Run a regional IMPLAN model for the power generation and transmission model.

Final Panel Comment 18

The CRSO DEIS does not include any information on the potential for earthquakes and any resulting impacts to the Columbia River area under the No Action Alternative or the action alternatives assessed.

Basis for Comment

Earthquakes are known to occur in the study area. The CRSO DEIS does not address potential adverse effects if earthquakes were to impact the Columbia River area. The potential for earthquakes causing ground shaking and increased shoreline slope instability, including landslides and erosion, is not discussed. The resulting shoreline instability could increase sediment supply, transport, and turbidity, as well as trigger reservoir surge waves. Potential adverse effects from the combined effect of climate change (e.g., affecting reservoir drawdowns and soil and groundwater conditions per Chapter 4, Table 4-8) and earthquake loading are not addressed in the CRSO DEIS, nor are potential adverse effects to major structures (dams, locks, or other large structures) discussed.

The Panel believes that the CRSO DEIS should include explicit discussion, including recognition and consideration, of potential earthquake effects. Adequate discussion could be limited to expert geotechnical engineering and geologic interpretation with reference to regional seismicity and historic earthquake effects. However, a seismic risk analysis would help in quantifying uncertainty.

Significance – Medium/Low

A discussion of potential adverse impacts due to earthquake activity would support the overall decision-making process.

Recommendations for Resolution

1. Discuss the regional seismicity and the potential for future earthquakes to adversely affect shoreline erosion (and consequential effects), CRS structures, and the CRSO.
2. Discuss how potential future earthquakes could affect the natural, social, and economic environment under the alternatives, including the Preferred Alternative.
3. Consider conducting a formal seismic risk analysis.

Final Panel Comment 19

It is unclear how risk and uncertainty have been integrated into the complex adaptive system managed under the CRSO.

Basis for Comment

The CRSO represents a complex adaptive management system that presents great challenges to usefully conceptualizing, communicating, and integrating risk and uncertainty to inform decision making. While risk and uncertainty associated with economic and power generation metrics seem to be well discussed, the Panel did not see a clear discussion of how the aggregate or overall risk and uncertainty inherent in the CRSO was characterized and considered or evaluated. The Panel did not see an explicit basis for (or explanation and summary of) an overall integration of risk and uncertainty for each alternative, including the Preferred Alternative.

Significance – Medium/Low

The aggregate risk and uncertainty associated with CRSO is important to understanding the CRSO and differences between alternatives, including the Preferred Alternative.

Recommendations for Resolution

1. Discuss the overall or aggregate risk and uncertainty associated with the CRSO, including the alternatives, differences between alternatives, and the Preferred Alternative.
2. Provide a formal basis for aggregating risk and uncertainty in the evaluation of the alternatives.

Final Panel Comment 20

It is unlikely that the relatively small-scale habitat restorations proposed will restore historic levels of the fish stocks on the Columbia River tributaries due to large watershed impacts from various human activities prior to and since dam construction.

Basis for Comment

Remedial actions supported by the CRSO would provide benefits to salmonid habitat, but such actions would not reverse the legacy effects of human modification of the Columbia River watershed. These effects began with great over-harvest of the salmonid resources in the 1800s. In fact, changes to the salmonid populations occurred in the 1800s prior to any substantial alteration of the Columbia River Basin by dams and other human impacts to the Columbia River Basin. Prior to 1890, fish stocks in a number of Columbia River tributaries had been depleted by various human actions prior to dam construction:

- Intense commercial, recreational, and subsistence fishing and mixed stock fishing.
- Habitat degradation caused by farming, logging, ranching, and urban growth.
- Water withdrawal for agricultural, municipal, and commercial uses.
- Tributary channel alteration, diking, and riparian corridor modifications.

The following are several examples of documented early historic large-scale changes to the salmonid populations.

“A remarkable deficiency in the yield of salmon in the Clackamas River in 1876 aroused the persons employed in the canning trade on the river to use all practicable measures of relief” (Baird, 1879).

“While salmon used to ascend the Yakima and its tributaries in large numbers, they have fallen off of late years.” (Gilbert & Evermann, 1895).

“It is now very doubtful whether a hatchery located at any point on this stream could depend for spawn on the fish which ascend the stream itself” (Gilbert & Evermann, 1895).

“...salmon were abundant in the Columbia at Kettle Falls as late as 1878. Since then there has been a great decrease. They have been scarce since about 1882; since 1890 there have been scarcely any at Kettle Falls.” (Gilbert & Evermann, 1895).

The small-scale habitat restoration actions now available to the CRSO are not adequate to deal with the large-scale impacts of early Columbia River watershed degradation.

Significance – Medium/Low

The suggested additions will help reviewers understand the limited ability of the river managers to reverse the historic alterations to the salmon populations and their habitat by basic and widespread effects of the human population in the Columbia River Basin and the historic over harvest.

Final Panel Comment 20

Recommendation for Resolution

1. Discuss pre-1930 changes to Columbia River salmonid populations to provide understanding that the CRSO actions have limited capacity to restore historic conditions.

Literature Cited

Baird, S. F. (1879). Report of the Commissioner of fish and fisheries. Part B-The propagation of food-fishes in the waters of the United States. United States Commission of Fish and Fisheries. p. 31-32.

Gilbert, C. H., and B. W. Evermann (1895). A report upon investigations in the Columbia River basin, with descriptions of four new species of fishes. Pages 169-207 in: Bulletin of the United States Fish Commission XIV, for 1894.

Final Panel Comment 21

Several definitions, terms, and comparisons used in the CRSO DEIS in regard to TDG supersaturation are incorrect and misleading.

Basis for Comment

The definition of TDG supersaturation provided in the Executive Summary (text box, page 14; Chapter 1, page 14) is not correct. TDG supersaturation is not an “amount”; it is the level of dissolved air that the water would hold relative to equilibrium at the water body’s surface pressure under the recorded temperature and barometric pressure conditions. A range of amounts of dissolved air can produce the same level of TDG supersaturation under various temperature and atmospheric pressure conditions.

Further, the correct term for the biological malady produced by TDG supersaturation is gas bubble *disease*, not gas bubble *trauma*. Both of these terms have been used in recent literature dealing with TDG supersaturation, but use of the term trauma is incorrect.

Significance – Medium/Low

The suggested changes will correct errors that perpetuate misunderstandings regarding TDG supersaturation.

Recommendation for Resolution

1. Correct these definitions in the CRSO DEIS.

Final Panel Comment 22

Chapter 2 of the CRSO DEIS does not discuss increased access by white sturgeon to upstream habitat due to removal of the LSR dams.

Basis for Comment

Chapter 2, Alternatives, of the CRSO DEIS does not mention white sturgeon for the LSR dam removal alternative. The analysis of the effects of dam removal on white sturgeon, found later in the CRSO DEIS, should be summarized here and in the MO3 summary. Dam breaching would restore connections to the functionally isolated reservoir reaches of the LSR and increase access to upstream habitat, an important benefit likely of interest to many readers of the MO3 summary who may not read the entire CRSO DEIS.

Significance – Low

Although the suggested addition to Chapter 2 and the MO3 summary will not alter the alternatives analysis, it may avoid unnecessary controversy among those who only read that far.

Recommendation for Resolution

1. Summarize the analysis of the effects of dam removal on white sturgeon found in Chapter 2 of the CRSO DEIS.

Final Panel Comment 23

Discussions of some topics seem fragmented and distributed throughout the CRSO DEIS in a way that makes it difficult to capture and appreciate details and reach full understanding of the impacts.

Basis for Comment

The CRSO DEIS presents an enormous volume and complexity of information to digest and understand. Comprehension was difficult for some topics (e.g., H&H, environmental and cultural resources) because discussions seemed out of balance or inconsistent between the main text and supporting appendices. For example, the Panel noticed less detail or different emphasis in the appendices than in the main text, or inconsistent discussions on the same topic in different sections of the main text. The appendices did not provide enough supporting information to assist in determining project impacts to resources identified in the various alternatives. The incompleteness of the Table of Contents added to the sense of fragmented discussions because lower-level headings were not included (or were invisible in the Adobe PDF version available to the general public), making it difficult to pinpoint the locations of related discussions and consolidate understanding.

Significance – Low

The fragmented discussions undermine the clarity and comprehensibility of the CRSO DEIS.

Recommendations for Resolution

1. Expand the Table of Contents to include all enumerated headings in the main text and appendices.
2. Edit the main text and appendices to provide a consistent and balanced level of detail and discussion, and consolidate fragmented discussions where and as appropriate.

5. REFERENCES

Baird, S. F. (1879). Report of the Commissioner of fish and fisheries. Part B-The propagation of food-fishes in the waters of the United States. United States Commission of Fish and Fisheries. p. 31-32.

Dunnigan, J. L. (2002). Kootenai River fisheries monitoring results from the spill events at Libby Dam, June-July 2002. Montana Fish, Wildlife and Parks, Helena, Montana. 30 pp.

Gilbert, C. H., and B. W. Evermann (1895). A report upon investigations in the Columbia River basin, with descriptions of four new species of fishes. Pages 169-207 in: Bulletin of the United States Fish Commission XIV, for 1894.

OMB (2004). Final Information Quality Bulletin for Peer Review. Executive Office of the President, Office of Management and Budget, Washington, D.C. Memorandum M-05-03. December 16.

The National Academies (2003). Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports. The National Academies (National Academy of Science, National Academy of Engineering, Institute of Medicine, National Research Council). May 12.

USACE (2018). Water Resources Policies and Authorities: Review Policy for Civil Works. Engineer Circular (EC) 1165-2-217. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. February 20.

Whitman, R. (2020). Agenda Item I: Proposed modification to the total dissolved gas water quality standard on the Columbia River for fish passage (Action). Memorandum to Environmental Quality Commission, by Department of Environmental Quality, State of Oregon.

https://www.oregon.gov/deq/EQCdocs/01242020_I_TotalDissolvedGas.pdf

APPENDIX A

IEPR Process for the CRSO DEIS Project

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A.1 Planning and Conduct of the Independent External Peer Review (IEPR)

Table A-1 presents the major milestones and deliverables of the Independent External Peer Review (IEPR) of the Columbia River System Operations (CRSO) Draft Environmental Impact Statement (DEIS) (hereinafter: CRSO DEIS IEPR). Due dates for milestones and deliverables are based on the award/effective date listed in Table A-1. The review documents were provided by U.S. Army Corps of Engineers (USACE) on February 28, 2020. Note that the actions listed under Task 6 occur after the submission of this report. Battelle anticipates submitting the pdf printout of the USACE's Design Review and Checking System (DrChecks) project file (the final deliverable) on July 24, 2020. The actual date for contract end will depend on the date that all activities for this IEPR are conducted and subsequently completed.

Table A-1. Major Milestones and Deliverables of the CRSO DEIS IEPR

Task	Action	Due Date
1	Award/Effective Date	1/8/2020
	Review documents available	2/28/2020
	Battelle submits draft Work Plan ^a	1/15/2020
	USACE provides comments on draft Work Plan	1/30/2020
	Battelle submits final Work Plan ^a	1/30/2020
2	Battelle submits list of selected panel members ^a	1/30/2020
	USACE confirms the panel members have no COI	2/6/2020
3	Battelle convenes kick-off meeting with USACE	1/27/2020
	Battelle convenes kick-off meeting with panel members	3/3/2020
	Battelle convenes kick-off meeting with USACE and panel members	3/3/2020
4	Panel members complete their individual reviews	4/21/2020
	Panel members provide draft Final Panel Comments to Battelle	5/1/2020
	Panel finalizes Final Panel Comments	5/11/2020
5	Battelle submits Final IEPR Report to USACE ^a	5/19/2020
6 ^b	Battelle convenes Comment Response Teleconference with panel members and USACE	7/9/2020
	Battelle submits pdf printout of DrChecks project file ^a	7/24/2020
	Contract End/Delivery Date	1/31/2021

^a Deliverable.

^b Task 6 occurs after the submission of this report.

At the beginning of the Period of Performance for the CRSO DEIS IEPR, Battelle held a kick-off meeting with USACE to review the preliminary/suggested schedule, discuss the IEPR process, and address any questions regarding the scope (e.g., terminology to use, access to DrChecks, etc.). Any revisions to the schedule were submitted as part of the final Work Plan. The final charge consisted of 13 charge questions provided by USACE, and two overview questions added by Battelle (all questions were

included in the draft and final Work Plans), and general guidance for the Panel on the conduct of the peer review (provided in Appendix C of this final report).

Prior to beginning their review and after their subcontracts were finalized, all the members of the Panel attended a kick-off meeting via teleconference planned and facilitated by Battelle in order to review the IEPR process, the schedule, communication procedures, and other pertinent information for the Panel. Battelle planned and facilitated a second kick-off meeting via teleconference during which USACE presented project details to the Panel. Before the meetings, the IEPR Panel received an electronic version of the final charge, as well as the review documents and reference/supplemental materials listed in Table A-2.

Table A-2. Documents to Be Reviewed and Provided as Reference/Supplemental Information

Review Documents	Number of Pages
Draft Environmental Impact Statement	2,371
Hydrology and Hydraulics	726
Water Quality	499
Fish, Aquatic Invertebrates and Aquatic Habitat	484
Air Quality	50
Power Generation and Transmission	136
Flood Risk Management	24
Navigation and Transportation	64
Recreation	118
Water Supply	82
Environmental Justice	31
Cost Analysis	90
River Mechanics	275
Vegetation, Wetlands, and Wildlife	142
Hydroregulation	118
Hydropower	198
Monitoring and Adaptive Management	382
CRSO Biological Assessment	1,000
Actual Total Review Pages	6,790
Supplemental Information^a	
Tribal Perspectives	96
Fish and Wildlife Coordination Act Report	242
Public Involvement Notices	502
Alternatives Development Appendix	336
Actual Total Number of Reference Pages	1,176

^a Supporting documentation only. These documents are not for Panel review and should be used as information sources only. They are not included in the total page count.

In addition to the materials provided in Table A-2, the panel members were provided the following USACE guidance documents.

- Review Policy for Civil Works (EC 1165-2-217, February 20, 2018)
- Office of Management and Budget's Final Information Quality Bulletin for Peer Review (December 16, 2004)
- USACE Climate Change Adaptation Plan (2015)
- Procedures to Evaluate SLR Change Impacts Responses Adaptation (ETL 1100-2-1 – June 30, 2014)
- Incorporating SLR Change in CW Programs (ER 1100-2-8162 – December 31, 2013).

About halfway through the review, a teleconference was held with USACE, Battelle, and the Panel so that USACE could answer any questions the Panel had concerning either the review documents or the project. Prior to this teleconference, Battelle submitted 21 panel member questions to USACE. USACE was able to provide responses to all the questions prior to the teleconference.

A.2 Review of Individual Comments

The Panel was instructed to address the charge questions/discussion points within a charge question response form provided by Battelle. At the end of the review period, the Panel produced individual comments in response to the charge questions/discussion points. Battelle reviewed the comments to identify overall recurring themes, areas of potential conflict, and other overall impressions. At the end of the review, Battelle summarized the individual comments into a preliminary list of overall comments and discussion points. Each panel member's individual comments were shared with the full Panel.

A.3 IEPR Panel Teleconference

Battelle facilitated a teleconference with the Panel so that the panel members could exchange technical information. The main goal of the teleconference was to identify which issues should be carried forward as Final Panel Comments in the Final IEPR Report and decide which panel member should serve as the lead author for the development of each Final Panel Comment. This information exchange ensured that the Final IEPR Report would accurately represent the Panel's assessment of the project, including any conflicting opinions. The Panel engaged in a thorough discussion of the overall positive and negative comments, added any missing issues of significant importance to the findings, and merged any related individual comments. At the conclusion of the teleconference, Battelle reviewed each Final Panel Comment with the Panel, including the associated level of significance, and confirmed the lead author for each comment.

A.4 Preparation of Final Panel Comments

Following the teleconference, Battelle distributed a summary memorandum for the Panel documenting each Final Panel Comment (organized by level of significance). The memorandum provided the following detailed guidance on the approach and format to be used to develop the Final Panel Comments for the CRSO DEIS IEPR:

- **Lead Responsibility:** For each Final Panel Comment, one panel member was identified as the lead author responsible for coordinating the development of the Final Panel Comment and submitting it to Battelle. Battelle modified lead assignments at the direction of the Panel. To assist

each lead in the development of the Final Panel Comments, Battelle distributed a summary email detailing each draft final comment statement, an example Final Panel Comment following the four-part structure described below, and templates for the preparation of each Final Panel Comment.

- Directive to the Lead: Each lead was encouraged to communicate directly with the other panel members as needed and to contribute to a particular Final Panel Comment. If a significant comment was identified that was not covered by one of the original Final Panel Comments, the appropriate lead was instructed to draft a new Final Panel Comment.
- Format for Final Panel Comments: Each Final Panel Comment was presented as part of a four-part structure:
 1. Comment Statement (succinct summary statement of concern)
 2. Basis for Comment (details regarding the concern)
 3. Significance (high, medium/high, medium, medium/low, and low; see description below)
 4. Recommendation(s) for Resolution (see description below).
- Criteria for Significance: The following were used as criteria for assigning a significance level to each Final Panel Comment:
 1. **High:** There is a fundamental issue within study documents or data that will influence the technical or scientific basis for selection of, justification of, or ability to implement the recommended plan.
 2. **Medium/High:** There is a fundamental issue within study documents or data that has a strong probability of influencing the technical or scientific basis for selection of, justification of, or ability to implement the recommended plan.
 3. **Medium:** There is a fundamental issue within study documents or data that has a low probability of influencing the technical or scientific basis for selection of, justification of, or ability to implement the recommended plan.
 4. **Medium/Low:** There is missing, incomplete, or inconsistent technical or scientific information that affects the clarity, understanding, or completeness of the study documents, and there is uncertainty whether the missing information will affect the selection of, justification of, or ability to implement the recommended plan.
 5. **Low:** There is a minor technical or scientific discrepancy or inconsistency that affects the clarity, understanding, or completeness of the study documents but does not influence the selection of, justification of, or ability to implement the recommended plan.
- Guidelines for Developing Recommendations: The recommendation section was to include specific actions that USACE should consider to resolve the Final Panel Comment (e.g., suggestions on how and where to incorporate data into the analysis, how and where to address insufficiencies, areas where additional documentation is needed).

Battelle reviewed and edited the Final Panel Comments for clarity, consistency with the comment statement, and adherence to guidance on the Panel's overall charge, which included ensuring that there were no comments regarding either the appropriateness of the selected alternative or USACE policy. At the end of this process, 23 Final Panel Comments were prepared and assembled. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The full text of the Final Panel Comments is presented in Section 4.2 of the main report.

A.5 Final IEPR Report

After concluding the review and preparation of the Final Panel Comments, Battelle prepared a final IEPR report (this document) on the overall IEPR process and the IEPR panel members' findings. Each panel member and Battelle technical and editorial reviewers reviewed the IEPR report prior to submission to USACE for acceptance.

A.6 Comment Response Process

As part of Task 6, Battelle will enter the 23 Final Panel Comments developed by the Panel into USACE's DrChecks, a Web-based software system for documenting and sharing comments on reports and design documents, so that USACE can review and respond to them. USACE will provide responses (Evaluator Responses) to the Final Panel Comments, and the Panel will respond (BackCheck Responses) to the Evaluator Responses. All USACE and Panel responses will be documented by Battelle. Battelle will provide USACE and the Panel a pdf printout of all DrChecks entries, through comment closeout, as a final deliverable and record of the IEPR results.

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APPENDIX B

Identification and Selection of IEPR Panel Members for the
CRSO DEIS Project

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B.1 Panel Identification

The candidates for the Independent External Peer Review (IEPR) of the Columbia River System Operations (CRSO) Draft Environmental Impact Statement (DEIS) (hereinafter: CRSO DEIS IEPR) Panel were evaluated based on their technical expertise in the following key areas: economics, environmental resources/water quality (dual role), cultural resources, hydrology and hydraulic (H&H) engineering/climate change (dual role), hydropower operations and water supply, civil/geotechnical engineering, and cost engineering. These areas correspond to the technical content of the review documents and overall scope of the CRSO DEIS project.

To identify candidate panel members, Battelle reviewed the credentials of the experts in Battelle's Peer Reviewer Database, sought recommendations from colleagues, contacted former panel members, and conducted targeted Internet searches. Battelle evaluated these candidate panel members in terms of their technical expertise and potential conflicts of interest (COIs). Of these candidates, Battelle chose the most qualified individuals, confirmed their interest and availability, and ultimately selected seven experts for the final Panel. The remaining candidates were not proposed for a variety of reasons, including lack of availability, disclosed COIs, or lack of the precise technical expertise required.

Candidates were screened for the following potential exclusion criteria or COIs. These COI questions were intended to serve as a means of disclosure in order to better characterize a candidate's employment history and background. Battelle evaluated whether scientists in universities and consulting firms that are receiving USACE-funding have sufficient independence from USACE to be appropriate peer reviewers. Guidance in OMB (2004, p. 18) states,

“...when a scientist is awarded a government research grant through an investigator-initiated, peer-reviewed competition, there generally should be no question as to that scientist's ability to offer independent scientific advice to the agency on other projects. This contrasts, for example, to a situation in which a scientist has a consulting or contractual arrangement with the agency or office sponsoring a peer review. Likewise, when the agency and a researcher work together (e.g., through a cooperative agreement) to design or implement a study, there is less independence from the agency. Furthermore, if a scientist has repeatedly served as a reviewer for the same agency, some may question whether that scientist is sufficiently independent from the agency to be employed as a peer reviewer on agency-sponsored projects.”

The term “firm” in a screening question referred to any joint venture in which a firm was involved. It applied to any firm that serves in a joint venture, either as a prime or as a subcontractor to a prime. Candidates were asked to clarify the relationship in the screening questions.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS)

1. Previous and/or current involvement by you or your firm in the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS) (hereinafter: CRSO EIS) and related projects.
2. Previous and/or current involvement by you or your firm in salmonid projects in the Columbia River Basin.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS)

3. Previous and/or current involvement by you or your firm in the conceptual or actual design, construction, or operation and maintenance (O&M) of any projects in the Columbia River Basin.
4. Current employment by the U.S. Army Corps of Engineers (USACE), Bonneville Power Administration, or Bureau of Reclamation.
5. Previous and/or current involvement with paid or unpaid expert testimony related to Columbia River Basin projects.
6. Previous and/or current employment or affiliation with members of the following Federal, State, County, local and regional agencies, environmental organizations, and interested groups (*for pay or pro bono*):
 - Governor of Washington State
 - Governor of Oregon
 - Governor of Idaho
 - Governor of Montana
 - Burns Paiute Tribe
 - Confederated Salish and Kootenai Tribes
 - Confederated Tribes and Bands of the Yakama Nation
 - Confederated Tribes of the Colville Reservation
 - Confederated Tribes of Grand Ronde
 - Confederated Tribes of the Chehalis Reservation
 - Confederated Tribes of Siletz
 - Confederated Tribes of the Umatilla Indian Reservation
 - Confederated Tribes of the Warm Springs Reservation of OR
 - Coeur D'Alene Tribe
 - Cowlitz Indian Tribe
 - Fort McDermitt Paiute-Shoshone Tribe
 - Kalispel Tribe of Indians
 - Kootenai Tribe of Idaho
 - Nez Perce Tribe
 - Shoalwater Bay Tribe
 - Shoshone Bannock Tribes of the Fort Hall Reservation
 - Shoshone-Paiute Tribes of the Duck Valley Reservation
 - Spokane Tribe of Indians
 - Upper Columbia United Tribes
 - Center for Whale Research
 - Save Our Wild Salmon
 - National Resources Defense Council
 - Sierra Club
 - Earth Justice
 - Dam Sense
 - Defenders of Wildlife
 - Trout Unlimited

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS)

- Wild Orca Center
- Earth Economics
- Bluefish.org
- Columbia Riverkeepers
- Northwest River Partners
- Audubon Society
- American Rivers
- Oceana

7. Past, current, or future interests or involvements (financial or otherwise) by you, your spouse, or your children related to Columbia River Basin.

8. Current personal involvement with other USACE projects, including whether involvement was to author any manuals or guidance documents for USACE. If yes, provide titles of documents or description of project, dates, and location (USACE district, division, Headquarters, Engineer Research and Development Center [ERDC], etc.), and position/role. Please highlight and discuss in greater detail any projects that are specifically with the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation.

9. Previous or current involvement with the development or testing of models that were used for, or in support of, the CRSO EIS project.

Note that the Comprehensive Passage Model (COMPASS), Interior Columbus Basin Lifecycle Model (LCM), Comparative Survival Study (CSS) Model, Total Dissolved Gas – University of Washington Model, CRSO Recreation Analysis Model, Snake Columbia Economic Navigation Tool (SCENT), and Transportation Optimization Model (TOM) are just some of the models used in this project.

10. Current firm involvement with other projects, specifically those projects/contracts that are with the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation. If yes, provide title/description, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Please also clearly delineate the percentage of work you personally are currently conducting for the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation. Please explain.

11. Any previous employment by USACE as a direct employee, notably if employment was with the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.

12. Any previous employment by USACE, Bonneville Power Administration, or Bureau of Reclamation as a contractor (either as an individual or through your firm) within the last 10 years, notably if those projects/contracts are with the USACE Northwest Division, and Bonneville Power Administration, or Bureau of Reclamation associated with the Columbia River Basin. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS)

13. Previous experience conducting technical peer reviews. If yes, please highlight and discuss any technical reviews concerning salmonids and include the client/agency and duration of review (approximate dates).
14. Pending, current, or future financial interests in contracts/awards from USACE, Bonneville Power Administration, or Bureau of Reclamation related to the CRSO EIS project.
15. Significant portion of your personal or office's revenues within the last three years came from USACE Bonneville Power Administration, or Bureau of Reclamation contracts.
16. Significant portion of your personal or office's revenues within the last three years came from contracts with any of the organizations listed in Screening Question 6.
17. Any publicly documented statement (including, for example, advocating for or discouraging against) related to the CRSO EIS project.
18. Participation in relevant prior and/or current Federal studies related to the CRSO EIS project.
19. Previous and/or current participation in prior non-Federal studies related to the CRSO EIS project.
20. Has your research or analysis been evaluated as part of the CRSO EIS project?
21. Is there any past, present, or future activity, relationship, or interest (financial or otherwise) that could make it appear that you would be unable to provide unbiased services on this project? If so, please describe.

Providing a positive response to a COI screening question did not automatically preclude a candidate from serving on the Panel. For example, participation in previous USACE technical peer review committees and other technical review panel experience was included as a COI screening question. A positive response to this question could be considered a benefit.

B.2 Panel Selection

In selecting the final members of the Panel, Battelle chose experts who best fit the expertise areas and had no COIs. Table B-1 provides information on each panel member's affiliation, location, education, and overall years of experience. Battelle established subcontracts with the panel members when they indicated their willingness to participate and confirmed the absence of COIs through a signed COI form. USACE was given the list of candidate panel members, but Battelle selected the final Panel.

Table B-1. CRSO DEIS IEPR Panel: Summary of Panel Members

Name	Affiliation	Location	Education	P.E.	Exp. (yrs)
Economics					
Jeff Mullen	Independent Consultant	Athens, GA	Ph.D., Applied Economics	N/A	24+
Environmental Resources/Water Quality (Dual Role)					
Don Weitkamp	LEON Environmental, LLC	Seattle, WA	Ph.D., Fisheries Biology	No	45+
Cultural Resources					
David Harvey	Northwest Cultural Resources Services	Richland, WA	M.A., History	No	35+
H&H Engineering/Climate Change (Dual Role)					
Larry Weber	Independent Consultant	Iowa City, IA	Ph.D., Civil Engineering	Yes	30+
Hydropower Operations and Water Supply					
Paul Carson	Currents Consulting Water & Power Services	Seattle, WA	M.S., Mechanical Engineering	Yes	41
Civil/Geotechnical Engineering					
Charles "Chuck" Vita	Independent Consultant	Seattle, WA	Ph.D., Civil Engineering	Yes	45
Cost Engineering					
Robert Hepler	RC Engineering and Construction Management	Richland, WA	B.S., Civil Engineering	Yes	27

Table B-2 presents an overview of the credentials of the final seven members of the Panel and their qualifications in relation to the technical evaluation criteria. More detailed biographical information on the panel members and their areas of technical expertise is given in Section B.3.

Table B-2. CRSO DEIS IEPR Panel: Technical Criteria and Areas of Expertise

Technical Criterion	Mullen	Weitekamp	Harvey	Weber	Carson	Vita	Hepner
Economist							
M.S. degree or higher	X						
At least 10 years of demonstrated experience in evaluating socioeconomic and economic-related resource impacts for complex, regional projects	X						
Extensive experience with inland navigation and transportation modeling, fisheries evaluations, utility modeling, and power rate modeling is required	X						
Experience with analysis and evaluation of socioeconomic impacts (e.g., recreation and environmental justice impacts) is required	X						
Environmental Resources/Water Quality (Dual Role)							
M.S. degree or higher in a related field		X					
At least 10 years of experience directly related to environmental evaluation or review as well as compliance with environmental laws, policies, and regulations including the National Environmental Policy Act (NEPA)		X					
Familiarity with impact assessments, including cumulative effects analysis for complex operating project systems with competing trade-offs		X					
Extensive knowledge of fish passage issues at dams on large river systems		X					
Extensive experience in life cycle models and ecological models of anadromous salmonid and resident fisheries with a strong background in statistics		X					
Experience with Instream Flow Incremental Methodology (IFIM) and related concepts		X					
Should be a water quality modeler, limnologist, or sediment quality expert with a minimum of 10 years of experience		X					
Experience evaluating large river systems, limnologic or freshwater ecological processes, temperature and dissolved gas modeling, and water quality modeling		X					
Knowledge of contaminated sediment issues (e.g., mobilization) related to dam breaching		X					

Table B-2. CRSO DEIS IEPR Panel: Technical Criteria and Areas of Expertise (continued).

Technical Criterion	Mullen	Weitkamp	Harvey	Weber	Carson	Vita	Hepler
Cultural Resources							
M.S. degree or higher in a related field			X				
At least 10 years of experience and should meet the Secretary of the Interior's Professional Qualification Standards as defined and officially adopted in 1983 (48 FR 44716, September 29, 1983; 36 C.F.R. § 61) and the Secretary of the Interior's Historic Preservation Professional Qualification Standards as expanded and revised in 1997 (62 FR 33708, June 20), although not formally adopted for Federal regulatory purposes			X				
Demonstrated Tribal coordination experience including participation in Tribal consultation as well as experience in the management of specific Indian trust assets like land, water, minerals, funds, treaty-secured rights, or other properties that have been reserved by or granted to Indian tribes			X				
H&H Engineer/Climate Change							
Registered Professional Engineer				X			
A minimum of 10 years of experience in their area of expertise				X			
Experienced with all aspects of hydrology and hydraulic engineering including a thorough understanding of regulated systems as well as regional water management operations				X			
Familiar with development and application of complex open channel hydraulic models including Hydrologic Engineering Center (HEC) modeling computer software such as HEC River Analysis System (RAS) and HEC Hydrologic Modeling System (HMS)				X			
Specialized experience in river mechanics, sediment transport (including numerical mobile bed analysis of scour and deposition), and large and medium size regulated river restoration				X			
Experience with dam removal and/or dam removal impact studies				X			
M.S. degree or higher in a related field				X			

Table B-2. CRSO DEIS IEPR Panel: Technical Criteria and Areas of Expertise (continued).

Technical Criterion	Mullen	Weitekamp	Harvey	Weber	Carson	Vita	Hepler
A minimum of 10 years of experience related to climate change assessments including impact/vulnerability assessments, snowmelt hydrology (sensitivity of snowmelt systems to warming temperature), and climate change and hydrological model output data application and interpretation				X			
Familiarity with USACE ECB 2018-14 (Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects) and Bureau of Reclamation Climate Policy documents (https://www.usbr.gov/watersmart/wcra/docs/WWCRATEchnicalGuidance.pdf) is required, as well as familiarity with the current state of climate science research and impact assessment applications				X			
Hydropower Operation and Water Supply							
M.S. degree or higher in a related field					X		
A minimum of 10 years of experience in the areas of operation, generation, and transmission					X		
Experience with operations of large and complex multi-purpose hydropower systems including knowledge of large dam hydraulic components and hydropower production					X		
Experience in development of hydropower models as well as seasonal water supply forecasting is required					X		
Experience with water supply concepts is also required, including experience evaluating impacts to water deliveries due to changes in water surface elevations (i.e., ability to pump from reservoirs or rivers), impacts to groundwater due to substantial changes in surface water resources, and water rights (in particular, interruptible rights in Washington)					X		
Civil/Geotechnical Engineer							
Registered Professional Engineer						X	
A minimum of 10 years of experience in civil or geotechnical engineering						X	
M.S. degree or higher						X	

Table B-2. CRSO DEIS IEPR Panel: Technical Criteria and Areas of Expertise (continued).

Technical Criterion	Mullen	Weitkamp	Harvey	Weber	Carson	Vita	Hepler
Experience in slope stability assessments, settlement analysis, rockslides, dewatering of dams, scour and erosion analysis						X	
Experience in the design and construction (or modification) of large facilities to include dams, roads, railroads, and water systems is required						X	
Experience in the geology of the Lower Snake River is preferred						X	
Cost Engineer							
M.S. degree or higher in a related field							W ¹
Registered Cost Estimating Professional, Certified Cost Consultant, or Certified Cost Engineer							X
A minimum of 10 years of experience in scheduling and estimating costs for large construction projects involving significant earth moving and dewatering							X
Experience in evaluating cost and schedule risk is also required							X

¹ USACE accepted a waiver of this criterion for this panel member.

B.3 Panel Member Qualifications

Detailed biographical information on each panel member's credentials, qualifications, and areas of technical expertise is provided in the following paragraphs.

Name	Jeff Mullen, Ph.D.
Role	Economist
Affiliation	Independent Consultant

Dr. Mullen is an independent consultant and an associate professor in the Department of Agricultural and Applied Economics at the University of Georgia, specializing in water resource, natural resource, and environmental economics. He earned his Ph.D. in Agricultural and Applied Economics/Natural Resource Economics from Virginia Polytechnic Institute and State University in 1999. He has over 24 years of experience conducting numerous studies in the field of environmental and natural resource economics and has taught graduate courses in environmental and natural resource economics and econometrics.

Dr. Mullen recently was the Planning Formulator/Economist on an IEPR for USACE's Calumet Harbor, which was conducted for the Inland Navigation Planning Center of Expertise (PCX), previously served on the Kissimmee River Restoration Project IEPR Panel for the Ecosystem Restoration PCX, and is currently serving on the East San Pedro Bay IEPR. He has considerable experience with transportation models,

including the interconnection between inland navigation, rail and trucking systems. In his graduate level course Quantitative Methods for Agribusiness Decisions, about 25% of the course is dedicated to transportation optimization models focused primarily on the movement of agricultural products. As a resource economist, Dr. Mullen has been teaching state-of-the-art methodologies for estimating recreational demand, including travel cost, contingent valuation, choice experiments, and hedonics for 20 years. In addition to covering recreational demand in his graduate courses, he has served as an expert witness regarding the impact of water levels and water quality on reservoir benefits in Georgia. He has also been involved with the evaluation of the blue crab fishery in Georgia, and recreational sport fishing demand in the Gulf of Mexico. Dr. Mullen also teaches a course in Energy Economics covering electric utility modeling as well as wholesale and retail electricity markets in all six North American Electric Reliability Corporation regions.

Dr. Mullen has coauthored numerous peer-reviewed articles concerning economic analyses and impacts related to municipal, wastewater, irrigation, and water impoundment projects and has been a contributing author to numerous publications concerning environmental economics and evaluation, economic modeling, transportation modeling and price analysis. He has served as a consultant on a wide variety of projects related to environmental/natural resource issues. Additionally, he serves as a frequent reviewer for peer-review journals including Land Economics, Ecological Economics, Journal of Agricultural and Resource Economics, Journal of Environmental Economics and Management, and Ecosystem Services. Dr. Mullen is a past president of the Southern Natural Resource Economics Committee and a member of the American Agricultural Economics Association.

Name	Don Weitkamp, Ph.D.
Role	Environmental Resources/Water Quality
Affiliation	LEON Environmental, LLC

Dr. Weitkamp is a fisheries biologist with 45+ years of experience dealing with fish, invertebrate, and associated aquatic resource issues. He earned his Ph.D. in fisheries biology from the University of Washington in 1977 with a dissertation developing a detailed understanding of total dissolved gas (TDG) supersaturation resulting from hydroelectric projects. He has worked on various water quality (temperature, dissolved oxygen, TDG supersaturation) and juvenile salmonid passage issues at most of the larger dams (50- to 300-foot head) in the Columbia River basin from Bonneville Dam to Noxon Dam on the Clark Fork River, and Brownlee Dam on the Snake River.

Dr. Weitkamp has conducted an analysis evaluating the potential water quality effects of reservoir drawdown in the Snake and Columbia Rivers. He has developed monitoring plans to conduct routine monitoring of dissolved gases during spills at a number of Pacific Northwest dams. Recently, he assisted BC Hydro with analysis and monitoring of TDG supersaturation at several existing dams and the proposed Peace River project. He has testified at numerous state hearings regarding water quality issues, particularly those dealing with TDG supersaturation. Dr. Weitkamp has provided expert testimony in Federal Energy Regulatory Commission (FERC) and Department of Interior trial-type hearings dealing with water quality issues, as well as in Federal Court on behalf of the U.S. Environmental Protection Agency in an action brought by the National Wildlife Federation. He has evaluated the water quality impacts of salmonid hatcheries and aquaculture net pens in estuarine habitats.

Dr. Weitkamp has assessed the impacts and remedial actions for river flow conditions determined by hydropower operations in the Hanford Reach of the Columbia River and Instream Flow Incremental Methodology (IFIM) analyses of the Bureau of Reclamation's operation of the Yakima River Project. He has conducted numerous projects dealing with sediment contamination and remediation. Most of these

have been in estuarine habitats such as the Columbia River channel deepening, outfalls, and aquaculture sites. Many of these projects have included State Environmental Policy Act and National Environmental Policy Act (NEPA) analyses. Although he is not a modeler, he routinely works with modelers to address water and sediment quality concerns. He has conducted a 15-year study of fall Chinook spawning in the Columbia River to evaluate effects of dam operations.

Dr. Weitkamp has directed studies of juvenile and adult passage survival at Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids Dams for passage through spillways and turbines. Using biological information together with physical modeling, he directed the development of appropriate criteria to provide to engineers for the design of successful screens and surface-collector bypass systems. As a member of an engineering team working on a surface collection device for a Rocky Reach Dam project, Dr. Weitkamp led efforts to incorporate biological criteria in the design of a unique collector for juvenile salmon. This system incorporated hydraulic characteristics with fish behavior tendencies to provide a practical bypass solution that avoids expensive installation of intake diversion screens. His role was to help develop and evaluate alternative designs by incorporating fish behavior characteristics with hydraulic evaluations.

For the Wanapum and Priest Rapids Dams evaluation project, Dr. Weitkamp again provided biological expertise to help develop a unique intake screen and bypass system for these dams to meet FERC requirements. Prototype testing showed favorable results of very high survival and very low stress in screened fish. He was responsible for biological evaluation of orifice collection bypass gallery tests. He evaluated engineering alternatives for moving diverted fish efficiently from dam gate wells to downstream outfalls. Models were assessed using both hydraulic parameters and small fish.

As a member of an interdisciplinary team, Dr. Weitkamp helped develop an outfall design and location constructed at Wanapum Dam. This effort involved field evaluations; construction of a 1:100 scale model of the dam and three miles of the river; and videotaping of both the real site and the model to identify a location that would minimize predation. A 1:10 scale model of the outfall was constructed to evaluate the best means for discharging young salmon. Dr. Weitkamp also directed investigations to assess the current conditions of TDG supersaturation downstream from Wanapum and Priest Rapids Dams. This included biological monitoring, a routine dissolved gas monitoring program, and a program to assess the reduction in dissolved gas provided by spillway deflectors. He worked with hydraulic engineers to evaluate options and conduct field evaluations of deflector prototypes. Dr. Weitkamp has worked with experts in computational fluid dynamics in aquatic ecosystems combined with principles of engineering hydraulics, but he is not an expert in these fields.

Dr. Weitkamp has directed studies of genetics and migration survival of hatchery populations of salmonids in the mid-Columbia River. He helped to evaluate the potential effects of reservoir drawdown in the Snake and Columbia Rivers. He has provided biological expertise to interpret physical and computational hydrodynamic model results to deal with fisheries passage concerns. He also helped a multi-agency workgroup develop and conduct aquatic resource investigations for water quality issues on the Clark Fork and Spokane River Projects (five hydroelectric dams), including work with the U.S. Fish and Wildlife Service to develop a supplemental biological assessment that met license requirements. Dr. Weitkamp worked with Battelle on the Mount St. Helens Sediment Control Facility Independent External Peer Review.

Name	David Harvey
Role	Cultural Resources
Affiliation	Northwest Cultural Resources Services

Mr. Harvey is the owner/principal of Northwest Cultural Resources Services in Richland, Washington. He has over 35 years of experience in historic preservation, cultural resources management, architectural history, determinations of National Register of Historic Places (NRHP) eligibility and effects under Sections 106 of the National Historic Preservation Act (NHPA) of 1966, NEPA/Environmental Impact Statement (NEPA/EIS) assessments, and historic research in the Pacific Northwest, California, Alaska, and Montana. He earned his M.A. in history from Western Washington University in 1975 and a B.A. in American history and government from Fairleigh Dickinson University in 1970. He has assisted Federal and state agencies, local governments and utilities, and private architectural and engineering firms in carrying out their cultural resources' obligations under the NEPA and Sections 106 and 110 of the NHPA.

Mr. Harvey meets and exceeds the Secretary of Interior's Historic Preservation Professional Qualifications Standards for History, Architectural History and Historic Preservation. His considerable experience in these disciplines is further demonstrated by his eight years of service as architectural historian and Vice Chair on the Governor of Washington's Advisory Council on Historic Preservation, advising the Governor's office and the State Historic Preservation Officer on statewide historic preservation issues. In 2018, he was appointed by the U.S. Department of Energy (DOE) to serve on the Scholar's Forum for the Manhattan Project National Historical Park (MPNHP) that convened in Washington, D.C. The forum made recommendations to the National Park Service on the type of interpretive issues that the MPNHP should stress in telling the story of the Manhattan Project. He also served as Chair of the City of Kennewick's Historic Preservation Commission, as architectural historian on the Design Review Committee for the Historic Downtown Kennewick Partnership, as architectural historian and Vice Chair on the Pioneer Square Preservation Board, chair of the historical research committee for the Lewis and Clark Commemoration Commission for the Tri-Cities Visitor & Convention Bureau, and served as a board trustee for the Washington Trust for Historic Preservation, Seattle.

Mr. Harvey has extensive experience in researching histories and conducting National Register assessments of historic buildings and structures, including transportation and energy facilities, maritime resources, hydroelectric and water storage structures, and nuclear reactor facilities, for county, state, and Federal government agencies and architectural and engineering firms. Mr. Harvey has provided support to DOE for facilities in Washington, California, and New Mexico; to the Pacific Gas & Electric Company, General Services Administration, Washington State Department of Transportation, Department of State (DOS), and cities of Richland, Pasco, and Kennewick; and to the King County Road Services Division. Mr. Harvey has worked closely with the U. S. Forest Service, National Park Service, Bureau of Reclamation, Bureau of Land Management, and USACE throughout the Pacific Northwest, California, Montana, and Alaska. He has applied his expertise in determining National Register eligibility, preparing Historic American Building Survey/Historic American Engineering Record documentations, assessing agricultural/rural landscapes, and conducting studies for historic land use.

Mr. Harvey managed the architectural and archaeological documentation and environmental impact analysis/EIS of the proposed 29-mile natural gas pipeline to deliver natural gas to the waste treatment plant at the Hanford Site. He assisted DOE in Tribal and agency consultation and public involvement activities and was responsible for preparing the cultural resources sections of the draft and final EISs. Mr. Harvey was a senior co-author for cultural resource sections of the TransCanada Keystone XL Pipeline Project EIS. He assisted the DOS in Section 106 consultation meetings with approximately

100 Indian tribes and numerous agencies. He conducted a technical review of the applicant's cultural resources survey reports and co-authored a programmatic agreement, Tribal Monitoring Plans, and a Historic Trail and Archaeological Monitoring Plan. Mr. Harvey contributed to the cultural resource sections in the Enbridge Alberta Clipper Pipeline Project EIS documents and assisted the DOS in consultations with 48 Indian tribes. He conducted technical reviews of the applicant's cultural resources survey reports and coordinated interagency consultation with the Advisory Council on Historic Preservation, Bureau of Indian Affairs, U.S. Forest Service, USACE, as well as the individual State Historic Preservation Offices.

During his 12 years with the cultural resources project for the Pacific Northwest National Laboratory operated by Battelle for DOE at the Hanford Site, Mr. Harvey conducted consultations and coordination with Tribal cultural resources staff on technical research issues concerning the significance and history of archaeological resources on traditional aboriginal lands. His other research efforts as a historic preservation consultant included technical exchanges with Tribal cultural resources staff concerning the documentation of historic properties of religious and cultural significance to the tribes.

Mr. Harvey's other activities have included researching and writing historic contexts and National Register nominations, completing recordation of historic property inventory forms, and preparing Programmatic Agreements and Memoranda of Agreement for mitigating historic properties.

Name	Larry Weber, Ph.D., PE
Role	H&H Engineer/Climate Change
Affiliation	Independent Consultant

Dr. Weber earned a Ph.D. from the University of Iowa in civil and environmental engineering in 1993 and received his license in engineering in Iowa in 1996. He is an independent consultant but also currently is the Edwin B. Green Chair in Hydraulics and a full professor in the Department of Civil and Environmental Engineering at the University of Iowa. His current area of focus includes coupling computational fluid dynamics models to community and individual-based behavioral models to further understand fish behavioral decisions in the immediate vicinity of passage facilities. These models have been applied to natural river reaches and hydraulic structures both for fundamental advancement of scientific understanding of fish swim path selection and for practical application to the design of successful fish passage facilities.

From 2004 to 2017, Dr. Weber served as the Director of IIHR – Hydrosience & Engineering, the nation's oldest academic research program focused on hydraulics, hydrology, and fluid mechanics. He has extensive knowledge in community resilience and planning; flooding; flood mapping; flood mitigation; river hydraulics; fate and transport of nutrients; hydropower; coupling individual-based ecological and fluid mechanics models; fish passage facilities; environmental hydraulics; hydraulic structures; and river restoration and sustainability. Through these research programs, Dr. Weber's impact has ranged from theoretical numerical model development and scientific discovery (as demonstrated in over 60 peer-reviewed scholarly publications) to the broad application of numerical models and systems-level design approaches to solve complex large-river ecological challenges (as demonstrated in over 200 conference papers and engineering research reports for contracted projects).

In particular, Dr. Weber led the computational fluid dynamics model development for the first fully coupled Eulerian-Lagrangian-Agent Method (ELAM) model to fully predict the swim path of downstream migrating juvenile salmonids on the Columbia-Snake River system. The ELAM model, developed in partnership with scientists at the USACE Engineer Research and Development Center (ERDC), was successfully applied to develop downstream fish passage structures at several USACE projects (Walla Walla District,

Seattle District), public power utilities (Grant Public Utility District, Chelan Public Utility District) and private power utilities (Idaho Power). From 2000 to present, Dr. Weber and his team have developed the most physically accurate, computational fluid dynamics model coupled with air entrainment and gas transfer modules to predict the fully three-dimensional TDG distribution downstream of hydropower dams. This TDG model has been used extensively throughout the Pacific Northwest, Asia, and South America and has led to spillway deflector designs in the Mid-Columbia, Lower Snake, and Hells Canyon reaches in the Columbia River system.

In addition to the numerical model development described above, Dr. Weber also has over 30 years of experiences with industry-standard models such as: HEC-RAS, HEC-HMS, SWOT, WEPP, HAZUS, SWMM, MIKE 11, MIKE 21, MIKE Flood and Delft 3D applied to engineering projects for infrastructure development and flood mitigation.

Through these integrated model development and application projects, Dr. Weber has gained a deep understanding of numerical methods and algorithms, a visionary approach to systems-level integrated design and development, and a genuine understanding of the complexities of both engineering physics and ecological behavior and ecosystem response.

Name	Paul Carson, P.E.
Role	Hydropower Operation and Water Supply
Affiliation	Currents Consulting Water and Power Services

Mr. Carson is a registered professional engineer in Washington, Alaska, California, and Oregon with 41 years of mechanical engineering experience, including 39 years in design and construction management of hydroelectric, fish passage, and water resource projects. He has a master's degree in mechanical engineering from the University of Washington and a bachelor's degree in mechanical engineering from the University of Notre Dame. His experience includes design and specification of mechanical systems, shop drawing review, field inspections, turbine-generator performance testing, and operational testing of mechanical systems.

Mr. Carson has prepared final design plans, specifications, and cost estimates for a wide range of hydraulic machinery required for hydroelectric plants, navigation projects, flood control, and fish passage systems. In each of these assignments, he was directly involved in the sizing of major project features and equipment and in the development of operating plans and control schemes. Specific equipment experience includes intake, emergency closure, and outlet gates; gate operators; butterfly, spherical, polyjet, and free discharge valves; steel penstocks and branched outlets; centrifugal and mixed flow pumps; Francis, Pelton, and Kaplan-type hydraulic turbines; overhead cranes and hoisting equipment; diesel generators; compressed air; heating, ventilation, and air conditioning; and related auxiliary equipment.

Mr. Carson was the lead mechanical engineer for the design and construction or rehabilitation of 35 hydroelectric and fish passage projects. Representative projects include the Rocky Reach Juvenile Fish Bypass project on the Columbia River, where he led the mechanical design and construction management from 1996 to 2004 for four prototype systems and the final 6,000 cubic-foot-per-second (cfs) fish bypass system. He was the project startup manager and lead mechanical engineer responsible for design of mechanical and control systems for this \$110 million fish protection project. He was responsible for the design of attraction control gates, the 6,000-cfs pumping system, and controls for the juvenile fish surface collector and gatewell collector systems.

On the Deschutes River in Oregon, Mr. Carson was the engineering lead for the FERC relicensing of the Pelton Round Butte Project for the Confederated Tribes of the Warm Springs and Portland General Electric from 1996 through 2005. In this role, he developed and presented a multi-dam hydro operations model that was used to resolve competing stakeholder interests related to water quality, recreation, fisheries, and power generation. Mr. Carson presented results of the modeling effort at technical working group and stakeholder meetings.

After issuance of the new license, Mr. Carson led the concept development, design and construction management for the flow control gates and machinery in the Round Butte Selective Water Withdrawal Project. This system is a 9000-cfs capacity selective water withdrawal and fish passage system that includes a 260-foot (ft) high intake tower, constructed in the wet, with top and bottom screened selective withdrawal structures. Mechanical systems included four 42-ft x 12-ft bottom control gates operating at 200-ft depth; six 14-ft x 24-ft surface exclusion baffle sets; and flow control weirs, fish separators, a fish pumping system, floating structure buoyancy control systems, and three screen cleaning systems for the fish collection screens. Mr. Carson also served as startup manager in 2009 and lead author for the project's operation and maintenance (O&M) manual.

Mr. Carson was instrumental in developing a river basin computer simulation model which integrates seasonal inflow forecasts, basin hydrology, generating facility characteristics (flow capacities, efficiencies, travel times, etc.), operating constraints (water levels, groundwater impacts, river ramp rates, water quality, flood control, etc.) and energy market data. In the past 25 years, he led study programs which used this model to evaluate possible structural and operational changes on multiple river systems, including Lewis River, Washington; Deschutes River, Oregon; American River, California; North Umpqua, Oregon; Klamath, Oregon; and St. Louis, Minnesota.

For the Cabinet Gorge Dam Dissolved Gas Abatement Study, Mr. Carson was the project engineer supervising concept development, preliminary alternative evaluation, and performance comparison of operational and physical alternatives for reduction of TDG levels at the project. Alternatives included revised spillway gate operating policies, spillway modifications, powerhouse expansions, new side channel spillways, and closed-conduit bypass systems to reduce downstream gas levels. The study recommended several leading alternatives for final feasibility determination. Mr. Carson's experience also includes preparing test plan and gas monitoring procedures for a turbine air admission test program aimed at increasing downstream oxygen levels without increasing TDG levels beyond state standards at the Pelton Round Butte project. This test program was part of a preliminary evaluation of alternatives for water quality enhancement.

Mr. Carson has served on a variety of independent peer review panels and Boards of Consultants for hydroelectric, flood control, and navigation projects, including serving as a mechanical engineer panel member on two USACE IEPRs: the West Closure Complex – Gulf Intercoastal Hurricane and Storm Damage Risk Reduction IEPR and the Inner Harbor Navigation Canal – Lake Borgne Flood Protection IEPR.

Name	Charles “Chuck” Vita, Ph.D., P.E., G.E.
Role	Civil/Geotechnical Engineer
Affiliation	Independent Consultant

Dr. Vita, an independent consultant, has 45 years of professional civil and geotechnical engineering experience in the design and construction of large civil facilities, including dams, roads, pipelines, and water systems. His geotechnical expertise includes site exploration and characterization, foundation analyses, slope stability assessments in complex terrain including rockslides, settlement analyses, dewatering, and erosion analyses for dams and other civil infrastructure. He has an extensive background in large river processes in complex systems and in geotechnical theory and practice. He earned his B.S. in civil engineering from the University of California, Berkeley, in 1972, his M.S. in civil (geotechnical) engineering from the University of California, Berkeley, in 1973, and his Ph.D. in civil engineering (geosystems) from the University of Washington in 1985. He is a registered professional civil engineer (P.E.) in California, Washington, and Alaska and a registered geotechnical engineer (G.E.) in California.

Dr. Vita’s geotechnical engineering practice includes geomorphology and geologic factors and issues based on his Ph.D. research and project experience with the Coeur d’Alene River Basin Project, Hanford Waste Isolation and (Columbia) River Corridor Cleanup Projects, the California Levee Evaluation Program, and geotechnical evaluation associated with channel instability and river avulsions due to geotechnical instability. His work at the Bremerton Naval Complex, the Pearl Harbor Naval Base, the Duwamish River in Seattle, and the Port of Anchorage demonstrate his extensive experience in performing geotechnical evaluation and geo-civil design for deep draft navigation projects, including the classification, dredging, and disposal of material. He also has conducted IEPRs for major USACE flood control and storm damage risk reduction projects and river ecosystem restoration projects. He understands the behavior of aquifers and soils based on his extensive geotechnical and geo-environmental experience.

Dr. Vita is experienced in geotechnical risk analysis and is familiar with USACE risk registers and cost and schedule risk analysis. He has addressed safety assurance review aspects on several USACE projects, including the Greater New Orleans Hurricane and Storm Damage Risk Reduction System Design Elevation Report, the New Orleans to Venice Project, and the Morganza to the Gulf of Mexico Project. Dr. Vita is particularly skilled in the analysis and evaluation of uncertainty and risk and in the reliability of complex infrastructure systems. As part of California’s Urban Levee Geotechnical Evaluation Program, he developed a probabilistic formulation of underseepage analysis for risk and uncertainty considerations. He also initiated development of a geotechnical analysis of levee-system slope stability as part of risk and uncertainty consideration of length effects in levee system reliability. In addition, Dr. Vita investigated the use of statistical analysis to characterize the probability of undiscovered geologic and geotechnical details affecting levee stability and reviewed and commented on USACE’s draft Engineer Technical Letter (ETL) 1110 2-570, Certification of Levee Systems for the National Flood Insurance Program, with a focus on geotechnical risk and uncertainty considerations.

Dr. Vita has been active in the American Society of Civil Engineers, has published many professional papers in journals and conference proceedings, and has made many technical presentations to professional and lay audiences.

Name	Robert Hepler, P.E., CEP, CCM, CQM-C
Role	Cost Engineer
Affiliation	RC Engineering and Construction Management

Mr. Hepler is a registered civil engineer in Washington, Oregon, California, and Hawaii and Certified Estimating Professional (CEP) with 27 years of cost estimating, scheduling, project management, change order management, and quality control experience. He has a bachelor's degree in civil engineering from Oregon State University in 1991 and currently works for RC Engineering and Construction Management as a cost engineer. He specializes in cost and value engineering (VE) for civil works and construction projects for USACE, DOE, and other Federal, state, and public agencies.

Mr. Hepler's experience includes cost estimating for large earth-moving and water infrastructure improvement projects such as dams and navigational locks; water control structures; ecosystem restoration and environmental remediation; fish passage improvements and additions; and water treatment and diversion equipment installation. For USACE Portland, Mr. Hepler provided cost engineering support for the development of an Engineering Documentation Report (EDR) to develop and document a selected design alternative for the addition of temperature control and fish passage modifications to the output water from Detroit Dam. He prepared estimates utilizing MCACES MII, summary schedule, and detailed construction schedule for 60%, 90%, and final completion, and performed cost and schedule risk analysis and supported a VE study. For the Fall Creek Dam Fish Ladder, he provided cost engineering support for the development of an EDR for upgrades to the Fall Creek Dam fish collection facilities to improve upstream fish passage and protect Endangered Species Act-listed fish. Mr. Hepler prepared multiple conceptual cost estimates for the various design alternatives; evaluated designs for potential cost and schedule savings and developed risk analyses and risk registers for the proposed design alternatives with cost-variance ranges; and performed ongoing cost and schedule risk analyses as the designs evolved. For USACE Kansas City, Mr. Hepler was a cost estimator on the Missouri River Fish and Wildlife Mitigation Program, Benedictine Bottoms Mitigation Site, Atchison, Kansas. He prepared detailed 95%, 98%, and 100% design estimates to support the client's Missouri River ecosystem restoration efforts. Design elements included flow-through chutes, bench cuts, and secondary tieback channels. Mr. Hepler prepared cost estimates in the USACE-required format; utilized MCACES/III with 2010 Cost Book Library; and developed detailed backup information, assumptions, and other basis of estimate documentation.

Mr. Hepler utilizes his depth of experience and understanding of cradle-to-grave engineering, design, and construction to identify construction constraints, provide realistic and practical estimates for project costs, develop and analyze construction schedules, and provide impactful contributions to VE activities. He applies his civil engineering expertise in support of VE sessions, design development, and other planning and cost engineering activities. In support of construction of a new fish facility for Foster Dam, he performed a detailed analysis of a cost- and resource-loaded construction schedule prepared by the construction contractor; reviewed the schedule for compliance with contract requirements with respect to the manner in which the schedule was developed; evaluated resource loadings and proposed the schedule for realism; and performed detailed schedule risk analysis and provided recommendations for corrective actions.

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APPENDIX C

Final Charge for the CRSO DEIS IEPR

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Charge Questions and Guidance to the Panel Members for the Independent External Peer Review (IEPR) of the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS)

This is the final Charge to the Panel for the CRSO DEIS IEPR. This final Charge was submitted to USACE as part of the final Work Plan, originally submitted on January 30, 2020.

The dates and page counts in this document have not been updated to match actual changes made throughout the project.

BACKGROUND

The U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and Bureau of Reclamation (Co-lead Agencies) are jointly developing a comprehensive Environmental Impact Statement (EIS), referred to as the Columbia River System Operation (CRSO) EIS, to evaluate long-term system operations and configurations of 14 multiple-purpose projects that are operated as a coordinated system within the interior Columbia River Basin in Idaho, Montana, Oregon, and Washington. USACE was authorized by Congress to construct, operate, and maintain 12 of these projects for flood risk management, navigation, power generation, fish and wildlife conservation, recreation, and municipal and industrial water supply purposes. USACE projects that will be included in the EIS are Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. The Bureau of Reclamation was authorized to construct, operate, and maintain the other two projects—Hungry Horse and Grand Coulee—for the purposes of irrigation, flood risk management, navigation, power generation, recreation, and other beneficial uses. The BPA is responsible for marketing and transmitting the power generated by these dams. Together, these Co-lead Agencies are responsible for managing the system for these various purposes, while meeting their other statutory and regulatory obligations.

The Co-lead Agencies will use this EIS to assess and update their approach for long-term system operations and configurations through the analysis of alternatives and evaluation of potential effects to the human and natural environments. The scope and scale of this project, its potential to impact human life safety, interest on the part of the Governors of Montana, Idaho, Washington, and Oregon, 19 Federally recognized tribes, connection to ongoing litigation on the Federal Columbia River Power System, as well as the likelihood for the project to result in public dispute, drive a requirement for a heightened level of review and meet the criteria of a highly influential scientific assessment in OMB and Bureau of Reclamation peer review policies.

OBJECTIVES

The objective of this work is to conduct an independent external peer review (IEPR) of the Columbia River System Operations (CRSO) EIS (hereinafter: CRSO EIS IEPR) in accordance with the Department of the Army, USACE, Water Resources Policies and Authorities' *Review Policy for Civil Works* (Engineer Circular [EC] 1165-2-217, dated February 20, 2018), and the Office of Management and Budget's (OMB's) *Final Information Quality Bulletin for Peer Review* (December 16, 2004). Peer review is one of the important procedures used to ensure that the quality of published information meets the standards of the scientific and technical community. Peer review typically evaluates the clarity of hypotheses, validity of the research design, quality of data collection procedures, robustness of the methods employed, appropriateness of the methods for the hypotheses being tested, extent to which the conclusions follow from the analysis, and strengths and limitations of the overall product.

The purpose of the IEPR is to “assess the adequacy and acceptability of the economic and environmental assumptions and projections, project evaluation data, economic analyses, environmental analyses, engineering analyses, formulation of alternative plans, methods for integrating risk and uncertainty, models used in evaluation of economic or environmental impacts, and any biological opinions” (EC 1165-2-217; p. 39) for the decision documents. The IEPR will be limited to technical review and will not involve policy review. The IEPR will be conducted by subject matter experts (i.e., IEPR panel members) who meet the technical criteria and areas of expertise required for and relevant to the project.

The Panel will be “charged” with responding to specific technical questions as well as providing a broad technical evaluation of the overall project. Per EC 1165-2-217 (p. 41), review panels should identify, explain, and comment upon assumptions that underlie all the analyses, as well as evaluate the soundness of models, surveys, investigations, and methods. Review panels should be able to evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable. Reviews should focus on assumptions, data, methods, and models. The panel members may offer their opinions as to whether there are sufficient analyses upon which to base a recommendation.

DOCUMENTS PROVIDED

The following is a list of documents, supporting information, and reference materials that will be provided for the review. The review assignments for the panel members may vary slightly according to discipline.

Review Documents	No. of Review Pages	Subject Matter Experts							
		Economist	Environmental Resources/ Water Quality (Dual Role)	Cultural Resources	Hydrology and Hydraulic Engineer	Hydropower Operations and Water Supply	Climate Change	Civil/ Geotechnical Engineer	Cost Engineer
Draft Environmental Impact Statement	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Hydrology and Hydraulics	550				550	550	550		
Geomorphology, Sediment Transport, Geology and Soils	100		100			100		100	
Water Quality	600		600			600			
Fish, Aquatic Invertebrates and Aquatic Habitat	500		500	500			500		
Air Quality	30		30						
Power Generation and Transmission	200	200	200		200	200	200	200	200
Flood Risk Management	60	60	60	60	60	60	60	60	60
Navigation and Transportation	80	80	80	80					80
Recreation	75	75	75	75					
Water Supply	150	150	150	150	150	150	150	150	150
Environmental Justice	150		150	150			150		
Cultural and Tribal Resources	75		75	75					
Cost Analysis	20	20					20		20
Thermal Regime of the Columbia River at Lake Roosevelt	60		60			60	60		
Total Number of Review Pages	4,150	2,085	3,580	2,590	2,460	3,220	3,190	2,010	2,010
Reference Information									
Tribal Perspectives	550		550	550					
Fish and Wildlife Coordination Act Report	200		200	200					
Clean Water Act 404(b)(1) Analysis	75		75						
Public Involvement Notices	50		50	50					
Alternatives Development Appendix	300	300	300	300	300	300	300	300	300
Total Number of Reference Pages	1,175	300	1,175	1100	300	300	300	300	300

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Documents for Reference

- Review Policy for Civil Works (EC 1165-2-217, February 20, 2018)
- OMB's Final Information Quality Bulletin for Peer Review (December 16, 2004)
- USACE Climate Change Adaptation Plan (2015)
- ETL 1100-2-1 – Procedures to Evaluate SLR Change Impacts Responses Adaptation
- ER 1100-2-8162 – Incorporating SLR Change in CW Programs.

SCHEDULE & DELIVERABLES

This schedule is based on the receipt date of the final review documents and may be revised if review document availability changes. This schedule may also change due to circumstances out of Battelle's control such as changes to USACE's project schedule and unforeseen changes to panel member and USACE availability. As part of each task, the panel member will prepare deliverables by the dates indicated in the table (or as directed by Battelle). All deliverables will be submitted in an electronic format compatible with Microsoft® Word (Office 2003).

Task	Action	Due Date
Meetings	Subcontractors complete mandatory Operations Security (OPSEC) training	3/19/2020
	Battelle sends review documents to panel members	3/2/2020
	Battelle convenes kick-off meeting with panel members	3/3/2020
	Battelle convenes kick-off meeting with USACE and panel members	3/4/2020
	Battelle convenes mid-review teleconference for panel members to ask clarifying questions of USACE	3/16/2020
Review	Panel members complete their individual reviews	3/31/2020
	Battelle provides talking points for Panel Review Teleconference to panel members	4/2/2020
	Battelle convenes Panel Review Teleconference	4/3/2020
	Battelle provides Final Panel Comment templates and instructions to panel members	4/6/2020
	Panel members provide draft Final Panel Comments to Battelle	4/10/2020
	Battelle provides feedback to panel members on draft Final Panel Comments; panel members revise Final Panel Comments	4/11/2020 - 4/19/2020
	Panel finalizes Final Panel Comments	4/20/2020
Final Report	Battelle provides Final IEPR Report to panel members for review	4/24/2020
	Panel members provide comments on Final IEPR Report	4/30/2020
	*Battelle submits Final IEPR Report to USACE	5/4/2020
	USACE Planning Center of Expertise (PCX) provides decision on Final IEPR Report acceptance	5/11/2020

Task	Action	Due Date
Comment Response Process	Battelle inputs Final Panel Comments to Design Review and Checking System (DrChecks) and provides Final Panel Comment response template to USACE	5/13/2020
	Battelle convenes teleconference with Panel to review the Comment Response process	5/13/2020
	USACE Project Delivery Team (PDT) provides draft Evaluator Responses to USACE PCX for review	6/1/2020
	USACE PCX reviews draft Evaluator Responses and works with USACE PDT regarding clarifications to responses, if needed	6/5/2020
	USACE PCX provides draft PDT Evaluator Responses to Battelle	6/8/2020
	Battelle provides draft PDT Evaluator Responses to panel members	6/10/2020
	Panel members provide draft BackCheck Responses to Battelle	6/15/2020
	Battelle convenes teleconference with panel members to discuss draft BackCheck Responses	6/16/2020
	Battelle convenes Comment Response Teleconference with panel members and USACE	6/17/2020
	USACE inputs final PDT Evaluator Responses to DrChecks	6/24/2020
	Battelle provides final PDT Evaluator Responses to panel members	6/25/2020
	Panel members provide final BackCheck Responses to Battelle	6/30/2020
	Battelle inputs panel members' final BackCheck Responses to DrChecks	7/1/2020
	*Battelle submits pdf printout of DrChecks project file	7/2/2020

* Deliverables

CHARGE FOR PEER REVIEW

Members of this IEPR Panel are asked to determine whether the technical approach and scientific rationale presented in the decision documents are credible and whether the conclusions are valid. The Panel is asked to determine whether the technical work is adequate, competently performed, and properly documented; satisfies established quality requirements; and yields scientifically credible conclusions. The Panel is being asked to provide feedback on the economic, engineering, environmental resources, and plan formulation. The panel members are not being asked whether they would have conducted the work in a similar manner.

Specific questions for the Panel (by report section or appendix) are included in the general charge guidance, which is provided below.

General Charge Guidance

Please answer the scientific and technical questions listed below and conduct a broad overview of the decision documents. Please focus your review on the review materials assigned to your discipline/area of expertise and technical knowledge. Some sections have no questions associated with them; however, you may still comment on them. Please feel free to make any relevant and appropriate comment on any of the sections and appendices you were asked to review. In addition, please note that the Panel will be asked to provide an overall statement related to 2 and 3 below per USACE guidance (EC 1165-2-217).

1. Your response to the charge questions should not be limited to a “yes” or “no.” Please provide complete answers to fully explain your response.
2. Assess the adequacy and acceptability of the economic and environmental assumptions and projections, project evaluation data, and any biological opinions of the project study.
3. Assess the adequacy and acceptability of the economic analyses, environmental analyses, engineering analyses, formulation of alternative plans, methods for integrating risk and uncertainty, and models used in evaluating economic or environmental impacts of the proposed project.
4. If appropriate, offer opinions as to whether there are sufficient analyses upon which to base a recommendation.
5. Identify, explain, and comment upon assumptions that underlie all the analyses, as well as evaluate the soundness of models, surveys, investigations, and methods.
6. Evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable.
7. Please focus the review on assumptions, data, methods, and models.

Please **do not** make recommendations on whether a particular alternative should be implemented, or whether you would have conducted the work in a similar manner. Also, please **do not** comment on or make recommendations on policy issues and decision making. Comments should be provided based on your professional judgment, **not** the legality of the document.

1. If desired, panel members can contact one another. However, panel members **should not** contact anyone who is or was involved in the project, prepared the subject documents, or was part of the USACE Agency Technical Review.
2. Please contact the Battelle Program Manager Lynn McLeod; mcleod@battelle.org for requests or additional information.
3. In case of media contact, notify the Battelle Program Manager, Lynn McLeod (mcleod@battelle.org) immediately.
4. Your name will appear as one of the panel members in the peer review. Your comments will be included in the Final IEPR Report but will remain anonymous.

Please submit your comments in electronic form to the Project Manager, no later than 10 pm ET by the date listed in the schedule above.

Independent External Peer Review of the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS)

Charge Questions and Relevant Sections as Supplied by USACE

The following Review Charge to Reviewers outlines the objectives of the Independent External Peer Review (IEPR) for the subject study and identifies specific items for consideration for the IEPR Review Panel.

The objective of the IEPR is to obtain an independent evaluation of whether the interpretations of analysis and conclusions based on analysis are reasonable for the subject study. The IEPR Review Panel is requested to offer a broad evaluation of the overall study decision document in addition to addressing the specific technical and scientific questions included in the Review Charge. The Review Panel has the flexibility to bring important issues to the attention of decision makers, including positive feedback or issues outside those specific areas outlined in the Review Charge. The Review Panel can use all available information to determine what scientific and technical issues related to the decision document may be important to raise to decision makers. This includes comments received from agencies and the public as part of the public review process.

The Panel review is to focus on scientific and technical matters, leaving policy determinations for U.S. Army Corps of Engineers and the Army. The Panel should not make recommendations on whether a particular alternative should be implemented or present findings that become “directives” in that they call for modifications or additional studies or suggest new conclusions and recommendations. In such circumstances the Review Panel would have assumed the role of advisors as well as reviewers, thus introducing bias and potential conflict in their ability to provide objective review.

Panel review comments are to be structured to fully communicate the Panel's intent by including the comment, why it is important, any potential consequences of failure to address, and suggestions on how to address the comment.

The Review Panel is asked to consider the following items as part of its review of the decision document and supporting materials.

Broad Evaluation Review Charge Questions

1. Is the need for and intent of the EIS clear?
2. Does the EIS adequately address the stated need and intent relative to scientific and technical issues?
3. Given the need for and intent of the EIS, assess the adequacy and acceptability of the project evaluation data used in the study analyses.
4. Given the need for and intent of the EIS, assess the adequacy and acceptability of the economic, environmental, and engineering assumptions that underlie the study analyses.
5. Given the need for and intent of the EIS, assess the adequacy and acceptability of the economic, environmental, and engineering methodologies, analyses, and projections.

6. Given the need for and intent of the EIS, assess the adequacy and acceptability of the models used in the evaluation of affected environment as well as economic or environmental impacts of alternatives.
7. Given the need for and intent of the EIS, assess the adequacy and acceptability of the methods for integrating risk and uncertainty.
8. Given the need for and intent of the EIS, assess the adequacy and acceptability of the formulation of alternative plans and the range of alternative plans considered.
9. Given the need for and intent of the EIS, assess the adequacy and acceptability of the quality and quantity of the surveys, investigations, and engineering sufficient for conceptual design of alternative plans.
10. Given the need for and intent of the EIS, assess the adequacy and acceptability of the overall assessment of significant environmental impacts and any biological analyses.
11. Evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable.
12. Assess the considered and tentatively selected alternatives from the perspective of systems, including systemic aspects being considered from a temporal perspective, including the potential effects of climate change.
13. Given the number of technical models (ecological, economic, power analysis, etc.) used to support conclusions and recommendations in the EIS, are the modeling methodologies and results integrated appropriately and adequately?

Battelle Summary Charge Questions to the Panel Members¹

These questions are provided for Battelle's use in identifying the Panel's key technical issues.

Summary Questions

14. Please identify the most critical concerns (up to five) you have with the project and/or review documents. These concerns can be (but do not need to be) new ideas or issues that have not been raised previously.
15. Please provide positive feedback on the project and/or review documents.

¹ Questions 14 and 15 are Battelle-supplied questions and should not be construed or considered part of the list of USACE-supplied questions. These questions were delineated in a separate appendix in the final Work Plan submitted to USACE.

APPENDIX D

Conflict of Interest Form

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David Kaplan
USACE, Institute for Water Resources
December 11, 2019
C-2

Conflicts of Interest Questionnaire

Independent External Peer Review

Columbia River System Operations (CRSO) Environmental Impact Statement (EIS)

The purpose of this document is to help the U.S. Army Corps of Engineers identify potential organizational conflicts of interest on a task order basis as early in the acquisition process as possible. Complete the questionnaire with background information and fully disclose relevant potential conflicts of interest. Substantial details are not necessary; USACE will examine additional information if appropriate. Affirmative answers will not disqualify your firm from this or future procurements.

NAME OF FIRM: **Battelle Memorial Institute Corporate Operations**

REPRESENTATIVE'S NAME: **Courtney Brooks**

TELEPHONE: **614-424-5623**

ADDRESS: **505 King Avenue, Columbus, Ohio 43201**

EMAIL ADDRESS: **brooksc1@battelle.org**

I. INDEPENDENCE FROM WORK PRODUCT. Has your firm been involved in any aspect of the preparation of the subject study report and associated analyses (field studies, report writing, supporting research etc.) **No** **Yes** (if yes, briefly describe): Battelle managed Pacific Northwest National Laboratories (PNNL). PNNL assisted with the scoping for the EIS. However, due to contractual requirements, Battelle Corporate staff do not work with PNNL staff and are firewalled from PNNL work, therefore the Battelle staff conducting the IEPR have not had and will not have any involvement with the PNNL work and PNNL will not have any involvement with the IEPR.

II. INTEREST IN STUDY AREA OR OUTCOME. Does your firm have any interests or holdings in the study area, or any stake in the outcome or recommendations of the study, or any affiliation with the local sponsor? **No** **Yes** (if yes, briefly describe):

III. REVIEWERS. Do you anticipate that all expert reviewers on this task order will be selected from outside your firm? **No** **Yes** (if no, briefly describe the difficulty in identifying outside reviewers):

IV. AFFILIATION WITH PARTIES THAT MAY BE INVOLVED WITH PROJECT IMPLEMENTATION. Do you anticipate that your firm will have any association with parties that may be involved with or benefit from future activities associated with this study, such as project construction? **No** **Yes** (if yes, briefly describe):

V. ADDITIONAL INFORMATION. Report relevant aspects of your firm's background or present circumstances not addressed above that might reasonably be construed by others as affecting your firm's judgment. Please include any information that may reasonably: impair your firm's objectivity; skew the competition in favor of your firm; or allow your firm unequal access to nonpublic information.

No additional information to report.

Courtney M. Brooks
Courtney Brooks

December 11, 2019
Date

BATTELLE

It can be done

Comment Response Record for the Independent External Peer Review of the Columbia River System Operations Environmental Impact Statement

USACE Draft Evaluator Responses and Panel Draft BackChecks

Prepared by

Battelle
505 King Avenue
Columbus, Ohio 43201

Contract No. W912HQ-15-D-0001
Task Order: W912HQ20F0008

for

Department of the Army
U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Mississippi Valley Division

June 30, 2020

Final Panel Comment 1

The implementation of adaptive management in the CRSO would benefit from a more robust, science-based adaptive management model that can be used to guide program development and support future decision making.

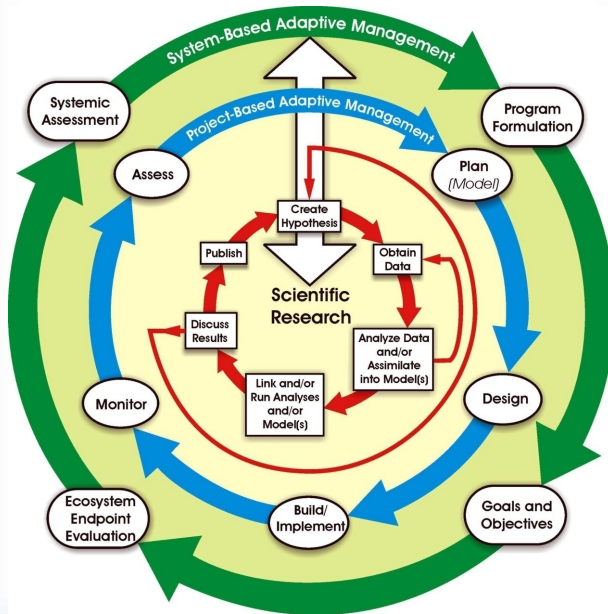
Basis for Comment

Because the two fish population models vary widely in the predicted effect on juvenile passage mortality, especially as it is related to spill, the Co-lead Agencies propose to use adaptive implementation of the flexible spill operation to test the assumptions in the models. Although this is a good, standard implementation of adaptive management, clearly, there are too many tradeoffs, conflicts, viewpoints, and dynamic interacting subsystems to define any one uniquely qualified alternative for the CRSO. The Panel thus believes that an effective CRSO will have to adapt and respond to new information and changing conditions over time. To detect important conditions, adaptive management requires appropriate data collection and monitoring, followed by data analysis, synthesis, and evaluation consistent with explicit contingency action plans. An effective learning process is required.

Traditional adaptive management often results in an extended field-based, build-test-adapt sequence of projects with inherent long project times, high costs and limited programmatic success, whereas a more science-based adaptive management process may accelerate ecosystem response and recovery.

The Panel thus believes that the CRSO DEIS would benefit from a more robust, science-based, adaptive management model that includes: defining assumed knowns/unknowns; coupling laboratory, field and numerical experimentation; developing data needs and data collection programs; and defining feedback loops into both detailed scientific studies and higher-level programmatic decisions. This more science-based adaptive management (see figure below) approach 1) recognizes the role of fundamental and applied scientific research to answer basic unresolved questions, 2) uses a traditional project-based adaptive management at each dam to prototype preferred alternatives, 3) integrates the research and project-based learning in the overall program, and 4) typically uses models (like Comprehensive Passage [COMPASS]/Life-Cycle Modeling [LCM] and/or Comparative Survival Study [CSS]) to integrate knowledge and understanding across the three levels of adaptive management. Additionally, uncertainties in the system-scale model often drive the need for additional research or field-based experimentation and/or prototype testing.

Final Panel Comment 1



Significance – Medium/High

Implementation of a practically optimal CRSO will require a timely, robust, scientific adaptive management model to confirm, test, or modify management operations and effectively deal with changing conditions and new information over time.

Recommendations for Resolution

1. Improve the adaptive management discussion in the CRSO DEIS based on the issues and concerns summarized above.
2. Develop a rigorous, science-based adaptive management framework to promote a better understanding of general fish passage models and specific models related to TDG.
3. Develop a responsive, science-based adaptive management framework for maintaining or improving CRSO effectiveness and efficiency over time as conditions change and new information is obtained.

PDT Draft/Final Evaluator Response (FPC #1)				
X	Concur		Non-Concur	
<p>Explanation: The co-lead agencies agree that “implementation of a practically optimal CRSO will require a timely, robust, scientific adaptive management model to confirm, test, or modify management operations and effectively deal with changing conditions and new information over time.” We have added additional content to Appendix R to more clearly make this point. The preferred alternative will be implemented using a robust monitoring plan to help narrow the uncertainty between the two models and to determine how effective increased spill can be towards increasing salmon and steelhead returns to the Columbia Basin. The framework for the adaptive management process is detailed in Appendix R, Part 2 Process for Adaptive Implementation of the Flexible Spill Operational Component of the Columbia River System Operations EIS. It is the intention of the co-lead agencies to engage regional state, tribal, and federal biologists in the development of an appropriate adaptive management process utilizing their respective salmonid management expertise. The goal of that adaptive management process would be to consider additional opportunities to further the effectiveness of the operation while maintaining the goals of the flexible spill operation which are: provide benefits for salmon and steelhead, maintain opportunities to operate the CRS for hydropower generation in a flexible manner that provides value to the Northwest, ensure operations are implementable by the Corps while continuing to meet all authorized project purposes, and implement the operation in a manner that reduces uncertainty while improving the learning opportunities around how operations of the CRS can influence the magnitude of latent mortality effects. The co-lead agencies have not made any determinations on what the preferred approach would be for a regionally developed study plan, and intend to develop that study jointly with regional sovereigns. Unforeseen outcomes or unintended consequences will be monitored and adjusted using current in-season management teams such as the Technical Management Team.</p>				
Recommendation 1:		X	Adopt	Not Adopt
<p>Explanation: Additional content was added to Appendix R to improve the adaptive management discussion as noted in this comment. The co-lead agencies will develop the fine-scale details of the adaptive management approach collaboratively with regional experts from federal, state, and tribal fisheries management agencies.</p>				
Recommendation 2:		X	Adopt	Not Adopt
<p>Explanation: The co-lead agencies will update the biological models used in the EIS as new information is developed based on monitoring of the preferred alternative. This will be a continual process as new information is developed under actual operations of the PA.</p>				
Recommendation 3:		X	Adopt	Not Adopt
<p>Explanation: The co-lead agencies will monitor and assess the effectiveness and efficiency of CRS operations based on monitoring associated with the PA. The co-lead agencies will update and modify operations as warranted based on monitoring results.</p>				

Panel Draft/Final BackCheck Response (FPC #1)			
X	Concur		Non-Concur

Final Panel Comment 2

The CRSO DEIS does not identify which built resources are eligible for listing in the NRHP, and what effects project actions would have on such resources.

Basis for Comment

To determine the effects of a project action or undertaking on a built resource, the CRSO DEIS would need to identify whether the built resource is eligible for listing in the NRHP. Specifically, the CRSO DEIS would need information on the “determination of effects” process as defined under 36 CFR 800.5 of the NHPA, and the “determination of NRHP eligibility” process under 36 CFR Part 60. The CRSO DEIS also would need to explain how both processes are applied to built resources.

A built resource that is 50 years or older is not automatically eligible for listing in the NRHP. A cultural resource needs to possess enough physical integrity to be able to convey its historic significance and obtain the level of importance under at least one of the four eligibility criteria (A-D), as defined in the NRHP Criteria for Evaluation (36 CFR Part 60).

The CRSO DEIS states that any modification/alteration of a historic property would be considered an adverse effect to the characteristics that make a property eligible for listing in the NRHP. A historic property means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the NRHP, as defined in 36 CFR 800.16(l)(1) of the National Historic Preservation Act (NHPA) of 1966, as amended, 16 U.S.C. 470-470w-6. Under the MO2 alternative, the project would upgrade the historic spillway weirs at McNary, Ice Harbor, and Lower Monumental Dams to newer, adjustable weirs. This undertaking or project action would have an effect, but the effect would not necessarily be adverse unless the dams and the original spillway weirs were determined eligible for the NRHP. The replacement of original components of a NRHP-eligible built resource would be considered an adverse effect if the characteristics that make the property eligible are compromised by the project action. An alteration or modification to a historic property, however, does not necessarily adversely affect the characteristics that make a property eligible for the NRHP. A modification or alteration can be compatible with the original operation and appearance of the property (i.e., in-kind replacement, a common maintenance activity, and/or technological upgrade).

The CRSO DEIS refers to adverse, moderate, or minor/negligible effects of CRSO structural measures on cultural resources. The CRSO DEIS would benefit from more information on the approach used to make such determinations. For example, on page 7-7, under MO1, the CRSO DEIS states that there would be “...additional major effects at Hungry Horse, Lake Roosevelt and Dworshak Reservoirs.” On page 7-15, the CRSO DEIS states that “...there would be major social effects, including impacts to cultural resources at Lake Roosevelt, John Day, and Hungry Horse Reservoirs...”. The next sentence then states that “There would be additional moderate effects to cultural resources at the remaining Columbia River projects due to additional drawdown.” Additional information describing the major and moderate effects to cultural resources, the extent of project actions and impacts, and the process for arriving at the conclusions presented would be beneficial.

Significance – Medium/High

The effects of the operational and structural measures presented, as well as the effects of project actions, on the built resources under the various alternatives cannot be fully addressed without knowledge of their NRHP eligibility.

Final Panel Comment 2**Recommendations for Resolution**

1. Add the NRHP eligibility status of CRSO built resources so the effects of the operational and structural measures on the built resources can be determined.
2. Describe the NRHP Criteria of Evaluation (36 CFR Part 60) process and how it is applied to built resources.
3. Describe the process used to determine the effects of operational and structural measures on NRHP-eligible built resources under the various alternatives, including a determination of “adverse effects,” “no adverse effects,” or “no historic properties affected” due to project actions.

PDT Draft/Final Evaluator Response (FPC #2)

Concur	X	Non-Concur
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Explanation: The co-lead agencies acknowledge the importance of the National Historic Preservation Act (NHPA) and implement a robust section 106 compliance program in keeping with the FCRPS Systemwide Programmatic Agreement (SWPA), as described in section 3.16.1. NEPA requires a broad comparative analysis of impacts to the known resources within a study area and across all alternatives. This is in contrast to the NHPA which only requires effects be assessed on cultural properties that are listed on, or may be eligible for listing to, the National Register of Historic Places (NRHP). The co-lead agencies respectfully disagree it is necessary for the draft EIS to identify resources that are eligible for listing in the NRHP, and what effects project actions would have on such resources. This was not possible due to the high number of known cultural resources in the study area, which exceeded 4,500 archeological sites, traditional cultural properties, and historic built resources. A very small amount of these 4,500 resources have had determinations of eligibility to the NRHP completed. Thus if the analysis were only conducted on eligible or NRHP listed sites, then the co-lead agencies would have a dramatically inadequate impact analysis based on the sites known to exist but which were not factored into the analysis due to their unknown NRHP status. Throughout section 3.16, the draft EIS conducts a comparative impact analysis across all action alternatives of the impacts to cultural resources, as required by NEPA, regardless of a specific resources' eligibility to the NRHP. The reviewers comment suggests the cultural resources impact analysis should follow the process outlined in the section 106 regulations described at 36 CFR 800. The co-lead agencies are following 36 CFR 800.14 Federal Agency Program Alternatives (b) Programmatic agreements for compliance with NHPA.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: The co-lead agencies respectfully disagree it is necessary to add the NRHP eligibility status of CRSO built resources. The impact analysis on built resources was conducted without regard to NRHP eligibility status in order to conduct the most comparative analysis possible across the range of action alternatives. In order to focus the analysis on properties potentially impacted within the NEPA study area(s), the co-lead agencies focused on known historic built resources that had the highest likelihood of being impacted. Also, as mentioned above, the co-lead agencies existing section 106 program has identified many potential historic properties but eligibility status has yet to be determined

due to the high number throughout the system. Thus completing an impact analysis to cultural resources solely based on a resources established NRHP eligibility would not be sufficient or complete.

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The co-lead agencies respectfully disagree that a description of 36 CFR Part 60 will contribute to the comparative NEPA impact analysis conducted across the action alternatives. As mentioned above, section 3.16.1 of the draft EIS describes the work of the co-lead agencies ongoing FCRPS section 106 compliance program and also the link to BPA's public website providing program information and related documents. That section 106 program does focus on historic properties and often uses the NRHP Criteria of Evaluation in furthering the co-lead agencies section 106 compliance efforts.

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The co-lead agencies respectfully disagree it is necessary to describe the process used to determine the effects of operational and structural measures on NRHP-eligible built resources under the various alternatives, including a determination of "adverse effects," "no adverse effects," or "no historic properties affected" due to project actions. This would essentially replace the NEPA analysis used in the draft EIS with the terminology and process used for section 106 compliance. The co-lead agencies describe their compliance with section 106 of the NHPA in Section 8.4.1 of the draft EIS. This section demonstrates the use of the Systemwide Programmatic Agreement to organize the co-lead agency compliance with Section 106. The SWPA describes the adverse effects of the operations and maintenance of the system on historic properties and outlines the necessary course of actions for the co-lead agencies to follow in order to resolve adverse effects.

Panel Draft/Final BackCheck Response (FPC #2)

Concur ☒ **Non-Concur**

Explanation: The Panel understands and appreciates the PDT's response, but feels that the Co-lead agency's Section 106 compliance program would be strengthened by using the National Register of Historic Places (NRHP) eligibility process in conjunction with their Sitewide Programmatic Agreement under the 36 CFR 800.14 Federal Agency Program Alternatives (b) Programmatic Agreement for compliance with the National Historic Preservation Act. Using the NRHP eligibility process to identify historic properties would streamline the Co-lead agency's ability to determine the effects of the operational and structural measures on historic properties and resolve any adverse effects. The Co-leads would only need to concentrate on those built resources that are eligible for the NRHP, or historic properties. Thus, the Co-leads could focus on those historic properties with the highest likelihood to be impacted by the operational and structural measures under the various alternatives.

Final Panel Comment 3

The assessment of climate change does not consider the impacts of increases in extreme climate events.

Basis for Comment

In addition to increases in annual and seasonal average temperatures and precipitation, it is expected that the number of extreme events (for both temperature and precipitation) will increase based on the most recent climate assessments. It is unclear how those extremes were factored into the alternative assessments. If USACE considered potential changes to the standard project flood or the probable maximum flood as a result of climate change, it does not appear to be clearly documented in the CRSO DEIS or supporting documentation. In addition, the DEIS does not explain how future updates to the Intergovernmental Panel on Climate Change reports will be incorporated into the CRSO program over the duration of the project life. The Panel notes that in each climate assessment report, the general information indicates that the climate is changing faster than previously projected.

Significance – Medium

Developing a robust method to update the CRSO as a result of the latest climate assessments will be important to the successful implementation of the CRSO project.

Recommendation for Resolution

1. Develop and describe a science-based adaptive management process for the incorporation of the latest data from the National Climate Assessment and other credible climate reports.

PDT Draft/Final Evaluator Response (FPC #3)

Concur	X	Non-Concur
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Explanation: Extreme events were included in the climate analysis. Through on-going regional climate change studies and work, the co-lead agencies evaluated potential shifts in precipitation and temperature patterns and resulting changes in unregulated Columbia Basin streamflow timing and volumes. The evaluation consisted of the full range of the latest climate change projections developed using multiple global climate models, emissions scenarios, downscaling techniques, and hydrologic models. Details of this evaluation are in chapter 4 of the EIS. This information was used to describe the potential effects (both beneficial and adverse) on the river systems and resources due to potential changes in climate for all alternatives.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: Emerging climate change information will be considered on an ongoing basis as it relates to the Preferred Alternative. A specific plan will not be included in the EIS.

Panel Draft/Final BackCheck Response (FPC #3)		
<input checked="" type="checkbox"/>	Concur	<input type="checkbox"/> Non-Concur
Explanation: The response from the PDT that emerging climate change information will be considered is satisfactory.		

Final Panel Comment 4

The approach used to determine what constitutes a built resource versus an archaeological property is too narrow and subjective.

Basis for Comment

For the purposes of this CRSO DEIS, a built resource over 50 years of age, no longer in use, and deteriorating is considered an archaeological property. However, there are numerous built resources around the country, including in the Pacific Northwest, that are vacant, are not in use, and show signs of deterioration but are still considered a built resource rather than an archaeological property.

This CRSO DEIS would benefit from a broader, more flexible approach in what constitutes a built resource versus an archaeological property. While the criteria used to determine NRHP eligibility are the same for both built resources and archaeological properties, the NRHP eligibility criteria (and status) of both built resources and archaeological properties are important barometers in describing their different physical condition, historical integrity, and cultural significance. These criteria could provide a more definitive standard for describing what is a built resource versus an archaeological property.

Significance – Medium

A broader, more objective approach that clearly defines what constitutes a built resource versus an archaeological property would provide clarity for understanding the differences and treatment of both types of resources under the various alternatives.

Recommendations for Resolution

1. Adopt a clear standard (or a set of benchmarks) for what constitutes a built resource versus an archaeological property that reflects a more flexible but definitive approach, using NRHP eligibility criteria (and status) as one barometer in defining the two types of resources.
2. Develop a standard that reflects the definition used by State Historic Preservation Officers in the States of Washington, Oregon, Montana, and Idaho to determine what is a built resource versus an archaeological property.

PDT Draft/Final Evaluator Response (FPC #4)

Concur	X	Non-Concur
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Explanation: The co-lead agencies respectfully disagree the approach used to determine what constitutes a built resource versus an archaeological property is too narrow or subjective. The co-lead agency cultural resources team leads have over approximately 70 years of combined professional cultural resources management experience and are very cognizant of the resource characteristic differences between pre-contact archeological sites, post-contact and historic archeological sites, historic built environment sites, to include buildings and structures, and multi-component sites, or sites that exhibit one or more characteristics or evidence of one or more of the aforementioned site types. The agencies provide an adequate description of what constitutes an element of the built environment

in section 3.16.2.5 of the draft EIS. In this section, the co-lead agencies list 11 specific categories of built resources that were carried forward throughout the comparative impact analysis across all the action alternatives. The different variety of built resource types within these specific 11 categories were expanded upon in a series of historic themes within the text of section 3.16.2.5. These themes included hydroelectricity development, Columbia and Snake River Transportation, Transportation, Urban Development, and Irrigation. This approach to the built environment incorporates various definitions from the SHPO's of historic resources and identifies historic themes to appropriately classify the historic buildings and structures known to exist within the study area. In addition, section 3.16.2.2 lists 18 specific archaeological resource types that are used for impact analysis. The impact analysis demonstrated the majority of impacts to historic built resources would stem from the various structural measures proposed for the different action alternatives. This impact analysis is described in 3.16.3.3 through 3.16.3.7 for the No Action Alternative through the Multiple Objective Alternative 4. Section 7.7.18 of the draft EIS provides the description of the impact analysis of the Preferred Alternative to all cultural resources, including the historic built environment.

Recommendation 1: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The co-lead agencies feel the definition of a built resource versus an archaeological property provided in sections 3.16.2.2 (archaeological resource types) and 3.16.2.5 (built environment) is adequate for the analysis required for the draft EIS. As mentioned above, the draft EIS did not use NRHP eligibility as a benchmark to include a particular cultural resources within the impact analysis. In addition, the co-lead agencies disagree using NRHP eligibility criteria (and status) as a barometer in defining two different types of resources (archaeological versus historic built resource) is an adequate approach. Current standards and practices have shown all types of historic properties can demonstrate NRHP significance under all four criteria described in 36 CFR 60.4.

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: There are varying definitions of archaeological sites and historic built resources between the State Historic Preservation Offices in the states of Washington, Oregon, Montana, and Idaho. For this reason the co-lead agencies utilized as broad a definition as possible of both archaeological site types and built environment resource types to conduct the comparative impact analysis as required by NEPA.

Panel Draft/Final BackCheck Response (FPC #4)

Concur ☒ **Non-Concur**

Explanation: The Panel still feels that the DEIS would benefit from a broader, more flexible approach on what constitutes a built resource versus an archaeological property that would provide clarity for understanding the differences and treatment of both types of resources under the various alternatives. Clearly the standard that defines a built resource that is over 50 years of age, no longer in use, and deteriorating as an archaeological property does not provide such flexibility. While the Panel appreciates that the State Historic Preservation Offices in the states of Washington, Oregon, Idaho and Montana use varying definitions of what constitutes an archaeological resource versus a built resource, the Co-lead agencies could develop an approach based on the consensus of the definitions used by those states.

Final Panel Comment 5

The definition of local versus non-local visitors is not appropriate for the aggregation of economic impacts from changes in recreation.

Basis for Comment

The methodology for estimating regional economic impacts using IMPLAN is based on the distinction between local and non-local visitors. Non-local visitors are considered those traveling more than 60 miles *to the site*. The regions in the recreation analysis are very large, extending more than 60 miles from most sites. So, it seems a visitor could be counted as a non-local, thereby including their trip expenditures in the regional IMPLAN analysis, when those expenditures should be counted as local *to the region*, in which case their expenditures should be excluded from the IMPLAN analysis. This methodology is applied inappropriately. The CRSO DEIS needs to clearly reconcile the apparent misuse of non-local visits in the regional economic impact analyses.

Site-level Analysis - As an example, all visitors from Seattle would be considered non-local visitors to Regions A, B, C, and D. Therefore, all lost visits to every site in Region A from people who live in Seattle should be counted as lost economic activity to Region A. Similarly, all lost visits to every site in Region B from people who live in Seattle should be counted as lost economic activity to Region B, and so on for Regions C and D.

To aggregate the economic impact to Region A from these lost Seattle-resident visits, simply add up the economic impact at each site in Region A, and so on for Regions B, C, and D. To aggregate the economic impact across the CRSO area, simply add up the economic impact across all regions.

Region-level Analysis - Portland, Oregon, however, is located in Multnomah County, which is considered part of Region D in the recreation analysis (see Table 2-5 of Appendix M). Portland is close enough to Bonneville to be considered local to the site, but Portland visitors to John Day would be considered non-local to the site even though they reside within the same economic region (Region D). So, lost visits from Portland residents to John Day should be included in an IMPLAN analysis of the economic impacts *at John Day site*. But lost visits from Portland to John Day are *local to Region D*. Therefore, it is inappropriate to include those lost visits in an IMPLAN analysis of the economic impacts *to the region*—the money the Portland visitors would have spent at John Day is still being spent within Region D. To correctly assess the economic impact to each region, one must define local versus non-local visits *to the region*. It is inappropriate to simply add up each of the site-level impacts across the region.

CRSO Area-level Analysis - The same issue arises when estimating the impacts to the entire CRSO. A new definition of local versus non-local *to the CRSO* must be employed. It is inappropriate to simply add up each of the region-level impacts. For example, lost visits in Region B from visitors who reside in Region A should be included in an IMPLAN analysis of Region B; those lost visits should not be included in an IMPLAN analysis of the entire CRSO because the Region A visitors are local to the CRSO.

Significance – Medium

Accurately aggregating the economic impacts to each sub-region and the CRSO area as a whole is necessary to assess the impacts of each alternative.

Final Panel Comment 5

Recommendations for Resolution

1. Define local versus non-local visitors to each site clearly.
2. Define local versus non-local visitors to each economic region clearly.
3. Define local versus non-local visitors to the CRSO area clearly.
4. Run IMPLAN models for each region using the appropriate definition of local versus non-local visits to the region to aggregate the economic impacts from changes in recreation within Regions A, B, C, and D properly.
5. Run an IMPLAN model for the entire CRSO area using the appropriate definition of local versus non-local visits to the CRSO area to aggregate the economic impacts from changes in recreation across Regions A, B, C, and D properly.

PDT Draft/Final Evaluator Response (FPC #5)

Concur	X	Non-Concur
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Explanation: The PDT does not concur that the definition of local versus non-local visitors is not appropriate for the aggregation of economic impacts from changes in recreation. The focus of the regional economic impact analysis is at the site- or project- level, which is designed to estimate the economic impacts in terms of jobs and income of changes in non-local visitor spending in gateway communities. Visitor spending profiles (from standard expenditure profiles) are estimated for spending at the site level, not the regional level. The changes in non-local visitor spending in gateway communities at each site compared to the No Action Alternative were aggregated for all projects in the region to show the total changes in jobs and income supported by non-local visitor spending across all gateway communities in the region. Region-based IMPLAN models (and not site-specific models) were used for consistency with the regional economic evaluation across resources and to simplify the modeling approach. The regional economic effects (jobs and income) would largely be experienced by communities surrounding the recreation sites and parks (i.e., in gateway communities) where the changes in visitation would occur. However, because a broader IMPLAN regional model was used, relatively larger multipliers at the regional level (versus the site-level) capture economic activity linkages across the broader region, rather than only impacts experienced at or near the gateway communities.

The reviewer suggested that the proposed methodology for estimating regional economic effects likely overstates the lost “regional” visitation and expenditures. The commenter is concerned that some non-local visits that are considered to be lost from a particular site may actually still occur elsewhere in a region. The PDT agrees that visitors could be local to some sites, while they could be considered non-local at other sites within a region. However, the available data on visitation defines visits as being either local or non-local at the site-level; it does not capture the origins and destinations of every visitor. Without the specific information on origin of visitors, the PDT has assumed that non-local visitors would forego their travel to the gateway community if a site is unavailable, which indeed is likely to overstate the actual number of visits that would be “lost”. The PDT also concurs that there may be some

substitution by visitors within sites or within other projects within a region, for example, if a particular boat ramp or area is unavailable for a period of time due to high or low water conditions. Therefore, the evaluation is likely to overestimate changes in visitation (and non-local visitation). However, it should be noted that other aspects of the recreation evaluation, such as under counting of non-reservoir based recreation (river reaches), would likely underestimate the visitation and associated economic impacts. The limitation on visitor origin and destination data could not be practically resolved for the purposes of this study.

Some of these limitations are described in Section 3.11.3.1, Recreation Methodology. The PDT has added additional caveats to describe the assumptions around the non-local visitor spending in the FEIS.

The following additions have been made to Section 3.11.3.1 (changes shown in bold italics):

Recreational Visitation

As described previously, visitation estimates are not available for all sites, and visitation data likely under-estimates river recreational visitation. The methodology presented above includes a number of assumptions due to data limitations. In particular, specific data about the behavior of recreationists when faced with varying river and reservoir conditions in the Basin is not known with certainty. The assumptions used in this analysis are conservative (i.e., they are more likely to overstate than understate effects of changes to water-based visitation), **but the methodology is the best approach available given existing information.** In particular, quantified effects do not take into account the potential for spatial substitution or temporal substitution.¹

1(foot note) That is, if a particular boat ramp is made temporarily inaccessible by changes in reservoir elevations, a recreationist might use a different ramp, pursue a shore-based activity on a given trip occasion **to the same site, or make a trip to a different site in the region.** The current methodology assumes that recreationists (local and non-local visitors) would forego that particular visit and not visit other adjacent reservoirs. Second, quantified effects do not take into account the potential for temporal substitution. That is, a recreationist may take a trip earlier or later in time to make up for a lost trip on another occasion due to an inaccessible boat ramp.

The following additions and changes have been made to section 3.11.3.1, Methodology (change shown in the italicized and bolded text):

Regional Economic Effects

Regional economic effects are measures of changes in economic activity as a result of changes in expenditures (also known as visitor spending) associated with recreational visitation. The approach to assess the regional economic effects is briefly described in this section. First, quantified changes in visitation resulting from changes in water surface elevations and boat ramp accessibility (results from the social welfare effects evaluation) are multiplied by per-day visitor spending estimates for recreation **at each river reach or reservoir.**

The change in non-local visitation was estimated based on data on visitation patterns at affected sites. The focus of the regional economic effects evaluation was on non-local visitors **to the site or project** because, while local visitors are likely to continue to spend money in the affected area even if they forgo particular recreation trips, non-local visitors may divert spending to other areas if particular trips are not taken due to access issues. A majority of visitors in the study area are considered to be non-

local (agencies define local by the distance travelled to sites, which is generally 30 or 60 miles, depending on agency). The percentage of visitors who are non-local for each reservoir/river reach are presented in Appendix M.

Second, estimates of non-local visitor spending in **each reservoir/river reach** are **aggregated for each region** to estimate the **changes in** regional economic activity in terms of jobs, income, and sales using the input-output model, IMPLAN. The regional economic effects and changes in effects would primarily be experienced in communities surrounding the recreation sites and parks (i.e., in gateway communities), although broader effects across the region could also occur. IMPLAN is a widely used industry-standard input-output data and software system that is used by many Federal and state agencies to estimate regional economic effects. The underlying data for IMPLAN is derived from multiple sources, including the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the U.S. Census Bureau. Any potential effects to regional economies associated with changes in recreation quality are discussed qualitatively.

Again, the current methodology associated with changes in water-based visitation assumes that recreationists (local and non-local visitors) when faced with reduced access would forego that particular visit and not visit other reservoirs. The specific origin of the visitor is not known for non-local visitors, precluding a regional assessment of whether the visitor spending would be local or non-local to the region.

Regional economic effects are presented by CRS region and in total for the Basin. The study area for each region includes multi-county areas as shown in Table 3-259. Region-based IMPLAN models (and not site-specific models) were used for consistency with the regional economic evaluation across resources and to simplify the modeling approach. The regional economic effects (jobs and income) would largely be experienced by communities surrounding the recreation sites and parks (i.e., in gateway communities) where the changes in visitation would occur.

However, because a broader IMPLAN regional model was used, relatively larger multipliers at the regional level (versus the site-level) capture economic activity linkages across the broader region, rather than only impacts experienced at or near the gateway communities.. A county was assigned to a CRS region if the majority of the county's area lies within the region.

Recreation Appendix M will be updated as appropriate to reflect the changes described for the EIS.

Recommendation 1:	X	Adopt		Not Adopt
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Explanation: The regional economic impact analysis has evaluated the economic impacts of changes in non-local visitor spending at a site-level; the changes in non-local visitor spending at each project or site were aggregated for all sites within the region to estimate the economic impacts. The percentage of local and non-local visitors at each site is presented in Appendix M in Table 3-11.

Recommendation 2:		Adopt	X	Not Adopt
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Explanation: The focus of the regional economic impact analysis is at the site- or project- level, which is designed to estimate the economic impact in terms of jobs and income of changes in non-local visitor spending in gateway communities at each site or project (i.e., reservoir) location. These economic

impacts are presented for each region. Data is not available on the origin of visitors in terms of within or outside the “region.”

Recommendation 3: ☐ **Adopt** ☒ **X** **Not Adopt**

Explanation: The focus of the regional economic impact analysis is at the site- or project- level, which is designed to estimate the economic impact in terms of jobs and income of changes in non-local visitor spending in gateway communities at each site or project (i.e., reservoir) location. These economic impacts are presented for each region. Data is not available on the origin of visitors in terms of within or outside the “CRSO area.”

Recommendation 4: ☐ **Adopt** ☒ **X** **Not Adopt**

Explanation: The focus of the regional economic impact analysis is at the site- or project- level, which is designed to estimate the economic impact in terms of jobs and income of changes in non-local visitor spending in gateway communities at each site or project (i.e., reservoir) location. These economic impacts are presented for each region. Data is not available on the origin of visitors in terms of within or outside the “region.”

Recommendation 5: ☐ **Adopt** ☒ **X** **Not Adopt**

Explanation: The focus of the regional economic impact analysis is at the site- or project- level, which is designed to estimate the economic impact in terms of jobs and income of changes in non-local visitor spending in gateway communities at each site or project (i.e., reservoir) location. These economic impacts are presented for each region. Data is not available on the origin of visitors in terms of within or outside the “CRSO area.”

Panel Draft/Final BackCheck Response (FPC #5)

Concur ☒ **X** **Non-Concur**

Explanation: The Panel disagrees with USACE’s response – it is inappropriate to aggregate the site-level expenditure changes to the region and then run one regional IMPLAN model as if the aggregated site-level expenditures were removed from the entire region. The same is true of the CRSO-level analysis. If your intention is to focus on the economic impact in gateway communities associated with each site, then you should run a separate IMPLAN analysis for each site that only encompasses those gateway communities (counties) for the site. You can define gateway communities by drawing a 30 (or 60) mile radius circle around each site and including all counties that lie partially or wholly within that circle. Then you can add the economic impact from each analysis within a region and say they represent the economic impacts to gateway communities across the region, but it is not appropriate to claim they represent the aggregate economic impacts to the region as a whole for two reasons.

First, the IMPLAN multipliers for recreational expenditure categories vary by county. If you include all the counties in a region as defined in Table 3-259 of Section 3.11 of the DEIS, the multipliers used in the IMPLAN analysis will be different than if you only include the counties of the gateway communities for each site. This point is even acknowledged in the notes of Tables 6-7 and 7-6 of Appendix M.

Second, while you are accurately estimating the lost expenditures within gateway communities, you are overestimating the reduction in regional expenditures because, as explained in the original FPC, there are people living within each region (i.e., local to the region) whose visits would be considered non-local to one or more sites in that region. The whole idea of the IMPLAN analysis is to account for lost expenditures to a geographic area. Imagine I live in a community within Region D that is more than 30

(or 60) miles from any of the CRSO sites in Region D. If a particular MO reduces my annual visits to all CRSO sites in Region D by 2 per year, then the money I would have spent on those trips is lost to the gateway communities as defined above, but it is not lost to Region D as a whole. Afterall, I reside in Region D, so, when I do not travel outside of my community, I spend the money in my local community instead, i.e., in Region D. The same goes for the CRSO-level economic impact analysis.

In reality, because many visitors to the CRSO sites may be non-local to the site but local to the region, and even more will be non-local to the site but local to the CRSO, the economic impacts to the gateway communities will be greater than the economic impacts to the regions which will be greater than the economic impacts to the entire CRSO. Unfortunately, the results presented in Appendix M Tables 4-6 and 5-6 have the relative magnitude of the CRSO economic impacts greater than the sum of regional economic impacts.

To conclude, it is fine to run separate IMPLAN analyses for the gateway communities at each site and then aggregate to the region and/or entire CRSO, as long as you stipulate that it is the economic impact to gateway communities. It is entirely incorrect to run the regional and CRSO level analyses as you have because you use the wrong multipliers and the wrong change in regional/CRSO expenditures.

Final Panel Comment 6

The inconsistent use of datasets for the commodities modeled by SCENT and TOM distorts the comparisons of results for shipment costs.

Basis for Comment

The SCENT and TOM models use different years for commodities volumes. SCENT uses 2016 shipment volumes; however, it is unclear what year of shipments are modeled in TOM. Page L-3-4 states that TOM models 202 million bushels of grain based on 2014-2018 average, but page L-3-8 states that TOM models 204 million bushels of grain based on 2018 production.

More importantly, SCENT models all commodities based on 2016 volumes for MO1, MO2, MO4, the No Action Alternative, and the Preferred Alternative. TOM, however, only models wheat shipments for MO3 and the No Action Alternative. Because the SCENT and TOM models generate estimates of the extra shipping costs of each MO alternative relative to the No Action Alternative, this difference may or may not matter, depending on the relative cost of shipping wheat compared to the other commodities and whether the No Action Alternative has binding capacity constraints along any route. Both SCENT and TOM are cost minimization models, so in the face of binding capacity constraints along any route, both models will re-route the least costly commodities first.

To estimate the extra shipping costs for MO1, for example, SCENT calculates the MO1 costs for wheat combined with the MO1 costs for the other commodities, and then subtracts the No Action Alternative costs for wheat combined with the No Action Alternative costs for the other commodities. So, the extra shipping costs for MO1, MO2, MO4, and the Preferred Alternative generated by SCENT represent the extra costs of shipping wheat and the other commodities.

Now, the decision to model only wheat in the TOM is based on the fact that wheat represents a large majority of the total volume of commodities moving out of the Lower Snake (possibly 87%, depending on the year being modeled). Modeling wheat only, however, may not reflect the full impacts on transportation costs under MO3.

To estimate the extra shipping costs for MO3, TOM calculates the MO3 shipping costs for wheat and subtracts the No Action Alternative shipping costs for wheat. If wheat is the highest-cost commodity to re-route, it would be the last to be re-routed by TOM in cases of binding capacity constraint(s); all the other commodities would be re-routed before any wheat. If the No Action Alternative has binding capacity constraints when modeling only wheat, then TOM would have re-routed all other commodities under both the No Action Alternative and MO3. In that case, the TOM calculation of the extra shipping costs under MO3 (MO3 wheat shipping costs minus the No Action Alternative wheat shipping costs) would effectively be the same as the calculations made using SCENT, because the shipping costs of other commodities in TOM would be moot, having canceled out through the subtraction.

If, however, wheat is not the highest-cost commodity to re-route, the shipping costs of the other commodities would not cancel out in TOM through the subtraction. Here, if there are binding capacity constraints under MO3, then excluding those other commodities from the TOM would underestimate the amount of wheat that would be re-routed, thereby underestimating the extra shipping costs of MO3.

Significance – Medium

Final Panel Comment 6

The discrepancies in the use of datasets could affect the relative cost of MO3 compared to the other MO alternatives.

Recommendations for Resolution

1. Use the same year of data for the SCENT and TOM models.
2. Provide information on the relative cost of rerouting wheat compared to the other commodities leaving the LSR.
3. Discuss the effect to shipping costs under MO3 relative to the other MO alternatives that arises from modeling only wheat in the TOM.

PDT Draft/Final Evaluator Response (FPC #6)

Concur	X	Non-Concur
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Explanation: The PDT concurs that it would be ideal to have both the SCENT and TOM models utilize identical data, but it does not concur that the effect of shipping costs under the alternatives would be significantly affected by this change. The basis for the TOM model is the regional wheat production as well as the 10-year average of downriver wheat shipments on the lower Snake River which, as the reviewer notes, is the majority of the commodities that travel on the lower Snake River.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: The PDT concurs that it would be ideal to have both the SCENT and TOM models utilize identical data, but implementing this change is not practically feasible. The SCENT used 2016 data because when the modeling effort got underway, that was the most recent data available. While somewhat aged, the 2016 data are still useful for the purpose of SCENT, which is to determine how system operational changes impact the ability of shippers/carriers to move commodities on the CSNS. The SCENT results show that hydraulically speaking, none of the alternatives (including MO3) show significant changes compared to No Action (more than one standard deviation), below Ice Harbor. Essentially, if a commodity could be on the water at Ice Harbor, it could transit the system in any alternative as it would under No Action. The TOM model and EIS refer to overall regional wheat production in the region, which uses USDA data from 2014-2018 as well, but the barged freight volumes are from Corps data that are largely aligned with the SCENT model data. The TOM model focuses on a 10-year average of downriver shipments of wheat on the lower Snake River, (using Army Corps Waterborne Commerce data). The 2016 downriver shipments of wheat are not very different from this average, suggesting that the use of 2016 data by the SCENT model is largely aligned with this data.

The commenters note that the regional bushels of wheat produced is inconsistent has been fixed in the FEIS.

Recommendation 2:	Adopt	X	Not Adopt
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Explanation: The TOM model analysis already incorporates changes in the costs to ship wheat under MO3. Commodities on the lower Snake River are not in competition with each other on this system.

The PDT does not find that other commodities need to be included as recommended, due to the fact that they do not historically compete for the capacity of the barge industry on the river and there is no known reason they would in the future. The movements of other commodities on the lower Snake River has been clarified in the FEIS. The operational changes under MO1, MO2, and MO4 are so minor that they are unlikely to affect wheat shipping costs.

Recommendation 3: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The operational changes under MO1, MO2, and MO4 are so minor that they are unlikely to affect wheat shipping costs. A statement to this affect has been added to section 3.10 to affirmatively state this.

Panel Draft/Final BackCheck Response (FPC #6)

☒ **Concur** ☐ **Non-Concur**

Explanation: It is still unclear to the Panel which data were used in the TOM model. As noted in the Basis for Comment above, the DEIS references different years for the TOM data on different pages. Now you are saying the TOM data are based on a 10-year average. Which years were used in the TOM model, 2014-2018, just 2018, or a 10-year average?

With respect to Recommendation 2, the Panel agrees the TOM model analysis incorporates the cost of wheat shipments. This recommendation, however, is to provide information on the shipping cost of wheat relative to other commodities. That has not been addressed.

Final Panel Comment 7

The CRSO DEIS does not explain how the risk associated with disruption/delay due to high-water conditions is incorporated into the SCENT model, and this risk does not appear to be included in the TOM at all.

Basis for Comment

Because four-barge tows may be unable to safely navigate certain high-water conditions, shippers will have to either delay the movement of their four-barge tows until after high-water conditions pass or break the four-barge tow into multiple smaller tows. This is referred to as the risk of disruption/delay and represents very real risks to shippers in the CRSO. Appendix L, Section 2.4 of the CRSO DEIS states that the SCENT model addresses this risk but does not explain how it does so. More importantly, the TOM does not address this risk at all.

The SCENT model is used to estimate the extra shipping costs associated with MO1, MO2, MO4, and the Preferred Alternative. The TOM is used to estimate the extra shipping costs associated with MO3. Because TOM does not incorporate the risk of disruption/delay while SCENT does, the estimates of MO3 relative to the other MO alternatives and the Preferred Alternative are systematically biased.

Significance – Medium

The inconsistent treatment of risk in the SCENT and TOM models could affect the relative cost of MO3.

Recommendations for Resolution

1. Explain how the risk of disruption/delay is incorporated into the SCENT model.
2. Incorporate the risk of disruption/delay into the TOM so all MO alternatives are evaluated using the same risk framework.

PDT Draft/Final Evaluator Response (FPC #7)

Concur	X	Non-Concur
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Explanation: While the commenter is correct that risk of disruption is included in the SCENT model, the commenter is not correct that risk is not incorporated in the TOM model. The typical risk of disruption is incorporated into shipper costs. Shipping would be entirely precluded from the lower Snake River under MO3. There would not be an increased risk of disruption on the Columbia River under MO3. As such, a change in risk is not relevant to the assessment that is conducted using the TOM model.

Recommendation 1:	X	Adopt	Not Adopt
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Explanation: Disruption and delay are modeled within SCENT using the SCEN01.prn and TN0916.prn files (described in the model documentation). SCEN01.prn is the effect of flows on shipping operations and for any flow level gives the options shippers would consider (wait, 3 barge, 2 barge light load and cease). TN0916.prn is then referenced to determine which option the shippers would take given the duration of the flow condition. In the case of high flow, the options are to wait or switch to a two barge

configuration and the option chosen depends on the dispatch date relative to disruption and the disruption duration. Additional explanation has been added to Appendix L to describe this consideration of risk.

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: While the commenter is correct that risk of disruption is included in the SCENT model, the commenter is not correct that risk is not incorporated in the TOM model. The typical risk of disruption is incorporated into shipper costs. There would not be an increased risk of disruption on the Columbia River under MO3. The disruption in service in the Lower Snake is captured in the TOM model. Shipping would be entirely precluded from the lower Snake River under MO3. As such, a change in risk is not relevant to the assessment that is conducted using the TOM model.

Panel Draft/Final BackCheck Response (FPC #7)

Concur ☒ **Non-Concur**

Explanation: The response to Recommendation 2 does not address the issue. The TOM model addresses the shipment of wheat from the Lower Snake River to Portland. The SCENT model addresses shipments throughout the CRSO to Portland. Why is it not possible to incorporate the risk of disruption/delay used by SCENT into TOM?

Final Panel Comment 8

The assumption that all new power generation and transmission infrastructure would be immediately available for all MO alternatives misrepresents the estimated costs and benefits.

Basis for Comment

The CRSO DEIS assumes that all new power generation and transmission infrastructure would be immediately available for all MO alternatives. This clearly is not the case; in fact, the CRSO DEIS states in several places (see Appendix H, Sections 3.2.2 and 3.2.3) that building the necessary infrastructure could take a decade or more.

The timing of costs and benefits is an exceptionally important factor when calculating the net present value of the MO alternatives and the Preferred Alternative. With discounting, future benefits and costs are valued lower than current benefits and costs. In reality, the time required to fully implement each MO alternative has a direct impact on the net present value of each alternative. As an example, imagine two MO alternatives which, when fully implemented, generate the exact same benefits each year. Now imagine one of those MO alternatives can be fully implemented 5 years earlier than the other. Over the life of the project, the MO alternative that is completed sooner would have a higher level of benefits because it is able to start generating those benefits 5 years earlier.

Now imagine two MO alternatives that cost the exact same amount in nominal dollars but have different construction schedules, with one MO alternative taking longer to construct than the other. The present value of costs for the MO alternative that spends more further into the future will be lower than the one that spends more money sooner, due to discounting. The CRSO DEIS, however, assumes that all structural measures would occur over 2 years, and the costs were divided evenly over those 2 years for all alternatives.

Assuming that all MO alternatives would be fully implemented instantly systematically misrepresents the present value of estimated benefits, while assuming that all structural measures would occur over 2 years with evenly spread costs systematically misrepresents the present value of estimated costs. Together, these could affect the net present value of each MO alternative relative to each other and to the Preferred Alternative.

Significance – Medium

Changes to the net present value of each MO alternative and the Preferred Alternative due to these construction delays could result in changes to the overall viability of each assessed alternative.

Recommendations for Resolution

1. Include build-out times into the power generation and transmission cost analysis.
2. Provide a relative measure of time-to-full implementation across each MO alternative and the Preferred Alternative in the CRSO DEIS if Recommendation 1 is not possible.

PDT Draft/Final Evaluator Response (FPC #8)

Concur	X	Non-Concur
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Explanation: The commenter questions the use of 2022 as the study year for the EIS and suggests including a timeline for the implementation and cost analysis. While there is merit in evaluating costs and benefits according to the comment, Bonneville feels confident in the reasons for the approach taken in the EIS.

The focus of the CRSO EIS is to measure the impacts of the proposed system operations on various identified resources, one of which is power reliability. To do that, though, there needs to be an established point-in-time from which to measure the effects of the MOs as compared to the No Action Alternative. The EIS accomplishes this comparison by assuming each MO (and its effects) were fully in place by 2022. Both practical and analytical reasons support this approach.

Practical reasons support using 2022 as the beginning year because at the time the analysis was prepared, this year coincided with the latest available data from the Northwest Power and Conservation Council's (Council) Power Plan to run the GENESYS model to calculate the Loss-of-Load Probability LOLP. In other words, 2022 is the latest date that data are available from which to calculate the effects of the MO on LOLP. Had the EIS used 2023 or any later date, the co-lead agencies would have had to develop their own data set to estimate the effects of the MOs on LOLP. Using 2022 allowed the EIS to use, in a non-biased fashion, the Council's existing data set to run the GENESYS model with no additional adjustments.

Analytical reasons also support using 2022 as the study date. Although, there would be virtually no chance that all pre-requisites for resource construction (or elimination as in MO3) would be completed by 2022, the use of 2022 as a start year does not degrade the analysis in the EIS. In fact, it enhances it because it removes the subjective variable of resource replacement timing that could have impacted the relative weighting of the MOs. By choosing a single start year applicable across MOs, the EIS provides a level playing field from which to compare the impacts and costs of each MO (See Section 3.19 and Appendix Q for additional discussion).

Had the EIS assumed "build-out times" for each MO and its replacement resource portfolios, as suggested by the Panel, the co-lead agencies would have had to speculate about when the various elements of the MOs would have been in effect. This approach would have injected a subjective timing element into the measurement of the relative impacts of differing CRS operations on each of the alternatives. The Panels' example of a five-year difference between two MOs is an excellent example of the issue the co-lead agencies wanted to avoid. As described in the comment, two MOs had the same benefits on a nominal basis. However, when adding in a five-year timing difference, the MO that is completed sooner would have a higher level of benefits because it is able to start generating those benefits earlier than the other. In reaching this conclusion, the Panel presumes that there is a basis for the five-year difference and that difference can in some way be justified. But that is where the co-lead agencies believe the EIS would separate from analytical comparisons to subjective judgments on the timing elements of each MO.

For example, MO3 – with dam breaching – requires Congressional action. Had a timing element been included in the comparison of the MOs, the power resource replacement analysis could have assumed that Congress would not act by 2022, but by 2035, or some other subjective date. This approach would mean MO3 in almost all cases would produce the least amount of benefits compared to an MO that would not require congressional action. Similarly, subjective assumptions on timing could have

been employed for the construction of replacement resources, especially for large-scale solar installations requiring environmental compliance, permitting, etc., and conventional gas-fired units, which are carbon emitting and potentially constrained by regulatory policy. These subjective timing assumptions would in turn become a driving factor in estimating the costs of the replacement analysis. All of this complexity would have been added to the power resource replacement analysis with little additional analytical benefit – and potentially a detriment – to the EIS because of the speculative nature of the timing assumptions the co-lead agencies would have had to make.

The use of a single study year allows for a comparison of before-and-after effects for each alternative, utilizing the most recently available – and vetted – models and data up and through 2022. The hypothetical start year ensured that the effects of the MOs could be compared fairly with each other and the NAA without the co-lead agencies speculating on when Congress might act, when resources would be removed, or when resources would be completed.

To address concerns about potential reductions in resource costs, publicly released draft information, such as updated prices for solar and battery storage, from development of the Council's 8th Power Plan is included as rate sensitivities in the final EIS. The final EIS will include the de-escalating cost curves prepared by the National Renewable Energy Laboratory (NREL) that will be used by the Council in the 8th Power plan.

Recommendation 1:	<input type="checkbox"/>	Adopt	<input checked="" type="checkbox"/>	Not Adopt
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Explanation: See above

Recommendation 2:	<input checked="" type="checkbox"/>	Adopt	<input type="checkbox"/>	Not Adopt
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Explanation: As described above, the EIS is unable to estimate the start or completion date of the MOs and has, therefore, not included a timing element in the analysis. In various sections, the EIS acknowledges that for the MOs that require replacement resources, additional time would be needed for permitting, siting, and construction. While the scale of resource construction described in the EIS is, in many cases, unprecedented, the EIS will contain a high-level description of estimated resource construction timelines based on existing projects and publicly available information. These estimates will only provide a broad outline of the time it may take to build replacement resources and will not include unknowable subjective timing issues (like the process for seeking Congressional approval for dam breach).

Panel Draft/Final BackCheck Response (FPC #8)

<input checked="" type="checkbox"/>	Concur	<input type="checkbox"/>	Non-Concur
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Explanation: The Panel is able to concur given the additional information and clarification provided.

Final Panel Comment 9

The conclusion that TDG levels exceeding 110% produce an increased risk of fish mortality is misleading.

Basis for Comment

The 110% of saturation criterion was established based primarily on data produced by laboratory investigations of GBD, with some support from live cage studies. This information is pertinent only for fish restrained in shallow water, not for migrants that occupy a range of depths such as in the deep reservoirs of the lower Snake and Columbia Rivers.

TDG levels would be “relatively high” or increase “risk” if the fish were restrained in shallow water, such as less than 1 meter deep. Levels of 115% to 120% of saturation are not high for fish occupying the range of available depths within the project reservoirs. This distinction is important because the CRSO DEIS gives the impression that 120% of TDG saturation would produce a high incidence of GBD and substantial mortality, which is not the case. Oregon and Washington States have regularly provided a TDG criterion of 115% in forebays and 120% at tailrace monitoring locations during the spring and summer migration periods, with no apparent deleterious effect to migrants (Whitman, 2020).

Exceeding the 110% of saturation level does not equate to GBD or mortality. Even at 120% of saturation and higher, empirical evidence has demonstrated a rare incidence of GBD within the project area. Even in the relatively shallow Kootenai River, Dunnigan (2002) observed that less than 1% of the fish collected by electrofishing showed GBD signs following exposure during June and July with TDG supersaturation (120 to >125%) during spill events that lasted from less than 1 hour to 58 hours in duration. By contrast, all captive fish held in cages showed GBD signs. This finding clearly indicates that laboratory and cage investigations do not replicate the depth behavior of fish in natural river conditions. The criterion of 110% was originally based on experiments that exposed fish to TDG supersaturation in shallow water (0.25 to 0.5 meter). These laboratory conditions do not represent the real-world conditions encountered by fish in the lower Columbia and Snake.

The TDG Average Exposure (TDG Tool) criteria are not likely to be useful in predicting biological effects of TDG supersaturation in the lower Snake and Columbia Rivers. The Panel suggests that an exposure duration of 16 hours or more to TDG levels exceeding 125% of saturation would be more useful in predicting a recognizable incidence of GBD in migrants.

Significance – Medium

The inclusion of an accurate representation of the TDG and GBD issues in the CRSO DEIS will allow decision makers to understand the issues and resulting alternative impacts when deciding on a preferred alternative. The 110% criterion is commonly superseded by the States of Oregon and Washington annually establishing a 115% forebay and 120% tailrace criterion during the juvenile migration period.

Recommendations for Resolution

1. Remove references to the 110% of saturation criterion other than to identify the historical regulatory standards.

Final Panel Comment 9

2. Remove statements regarding “risk” for the TDG supersaturation analyses due to the inaccuracy of these statements. A useful risk analysis would need to evaluate fish depth conditions for migrants.
3. Document the current spill season criteria established by the states of Oregon and Washington, which allow 115% in the forebays and 120% in the tailraces of lower Snake and Columbia River dams (Whitman, 2020).
4. Review Dunnigan (2002) and report on the findings as they directly relate to the CRSO project.

Literature Cited

Dunnigan, J. L. (2002). Kootenai River fisheries monitoring results from the spill events at Libby Dam, June-July 2002. Montana Fish, Wildlife and Parks, Helena, Montana. 30 pp.

Whitman, R. (2020). Agenda Item I: Proposed modification to the total dissolved gas water quality standard on the Columbia River for fish passage (Action). Memorandum to Environmental Quality Commission, by Department of Environmental Quality, State of Oregon.
https://www.oregon.gov/deq/EQCdocs/01242020_I_TotalDissolvedGas.pdf

PDT Draft/Final Evaluator Response (FPC #9)

Concur	X	Non-Concur
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Explanation: TDG levels of 110% saturation does, with sufficient duration, increase the risk of mortality. However the DEIS does not emphasize 110% as a standard. TDG levels among alternatives are reported as the proportion of time exceeding TDG of 120% or 125%, for modeled salmon and for steelhead only an estimated average exposure is presented. Higher TDG levels are identified as higher risk of GBT. Despite many field studies there are still many remaining uncertainties in effects in free swimming fish in general, the variety of species and life stages, so a conservative approach is prudent. The co-lead agencies did not use the TDG related mortality estimates generated by the UW TDG model in their decision making process. The co-lead agencies updated the Final EIS and clarified the description of how elevated risk of mortality associated with TDG was considered for non-salmonids.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: The DEIS only mentions the 110% TDG standard at Rufus Woods Lake, where there is no waiver, but then refers to 120% and 125%. All analysis and discussions on salmon and steelhead are presented relative to exceeding 120% and 125% TDG saturation with the exceptions of page 3-397 where chum salmon eggs and sac fry are addressed where the goal is to maintain TDG below 105% of saturation. A “minor effect” was noted as possible for bull trout in Chief Joseph to McNary relative to duration above 110%. However, reanalyzing that species and reach relative to 115% / 120% would not materially improve the EIS and would not alter any decisions.

Recommendation 2:	Adopt	X	Not Adopt
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Explanation: The TDG exposure model did incorporate depths migrating fish.

TDG is a risk to invertebrates and fish as identified in the DEIS and extensively in the scientific literature, the risk to any individual depends on the organism, its life stage, gas loading, the duration of exposure, and level of TDG saturation, and depth. In the immediate area of spillways TDG can reach extreme levels; there is significant risk for fish at relatively shallow depths, or have prolonged exposure do to tailrace eddies cycling them back into the spillway discharge. Also, MO4 and the Preferred Alternative includes maintaining TDG at 125% which, is beyond precedence for duration and lower river discharges. These levels clearly would provide risk for fish that maintains depths of less than 2 meter. We know both juvenile and adult salmon spend much of their time below compensation depth, however the dynamic of behavior is not sufficiently known to quantify the risk. Many larval fish are more sensitive relative to other life stages. The DEIS specifically mentions white sturgeon. The actual risk to fish is unknown for the reasons discussed above, but the relative risk among alternatives will be higher for alternatives with higher TDG.

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: Page 3-295 & 3-296 of the Draft EIS discussed TDG, depth compensation. Recent updates have been made to state water quality standards. In Oregon, the Environmental Quality Commission approved a spring TDG modification of 125 percent at its January 2020 Environmental Quality Commission hearing and went into effect on February 11, 2020, after it was signed by the Oregon Department of Environmental Quality Director. In Washington, a permanent rule change to facilitate the 125 percent TDG spring spill for juvenile fish passage was approved by the U.S. Environmental Protection Agency on March 5, 2020.

Recommendation 4: ☐ **Adopt** ☒ **Not Adopt**

Explanation: Depth compensation was addressed. Adding this discussion would not materially add clarity to the EIS or alter any decisions.

Panel Draft/Final BackCheck Response (FPC #9)

☐ **Concur** ☒ **Non-Concur**

Explanation: It is important to recognize that TDG supersaturation is unique among water quality parameters in that it is not a concentration or amount as is common with other water quality parameters. Employing the appropriate terminology is an essential part of maintaining an understanding of TDG supersaturation.

The explanation statement regarding 110 % of saturation is only true when fish are restrained in water depths of less than 1 m. This condition is highly unlikely in the CRSO project area and does not provide a useful means of evaluating differences among the alternatives. Attached is an annotated bibliography of TDG literature published since 1980 (Weitkamp, 2020). Many of these field and modeling investigations show an absence of adverse effects (signs of gas bubble disease) resulting from 110-120 % of saturation unless fish are restrained in shallow water (< 1 m),

In regards to the following statement in the USACE Evaluator Response to Recommendation 2: "We know both juvenile and adult salmon spend much of their time below compensation depth, however the dynamic of behavior is not sufficiently known to quantify the risk." The Panel notes that a number of investigations prior to 1980 (Weitkamp and Katz, 1980) and since (Weitkamp, 2020) have demonstrated that fish showing signs of GBD recover and lose the GBD signs as a result of spending time at or below a compensating depth (> 2 m), The two referenced documents include a substantial

number of investigations that provide evidence that Columbia River salmonids spend sufficient time at depths greater than 2 m and that they avoid gas bubble disease where shallow water laboratory studies indicate they would suffer severe GBD.

Final Panel Comment 10

A percent change in the 5-year average maximum TDG as compared to the No Action Alternative does not reflect the degree of GBD impact to the fish.

Basis for Comment

The 5-year average maximum TDG level has not been demonstrated to produce a useful measure of the biological effects of elevated TDG levels in the natural conditions of the Columbia and Snake Rivers. At best, this criterion provides a weak comparison among CRSO alternatives and is likely to indicate an effect where none would occur.

A change in saturation of 2% at a No Action Alternative level of 120% TDG would be unlikely to produce an observable effect in overall GBD, while a 2% increase at a No Action Alternative level of 130% might produce a substantial observable effect. However, with the TDG levels generally being maintained at a 5-year average maximum TDG of 120% or lower, this issue would likely be insignificant (an exception would be situations such as Libby Dam where the downstream reach tends to be relatively shallow, making TDG levels exceeding 120% a concern). The net effect is likely to be an overestimate of the negative impact of any predicted increase in 5-year average maximum TDG levels.

Significance – Medium

An accurate representation of the TDG and GBD issues in the CRSO DEIS will allow decision makers to understand the issues and resulting impacts under the alternatives when deciding on a preferred alternative.

Recommendations for Resolution

1. Delete references to the 5-year average maximum TDG level, which does not accurately reflect GBD impacts.
2. Employ the 115% forebay and 120% tailrace criteria for TDG during the spring-summer migration period when determining potential effects to salmonid migrants in the lower Snake and Columbia Rivers, as suggested by the States of Oregon and Washington (Whitman, 2020).

Literature Cited

Whitman, R. (2020). Agenda Item I: Proposed modification to the total dissolved gas water quality standard on the Columbia River for fish passage (Action). Memorandum to Environmental Quality Commission, by Department of Environmental Quality, State of Oregon.
https://www.oregon.gov/deq/EQCdocs/01242020_I_TotalDissolvedGas.pdf

PDT Draft/Final Evaluator Response (FPC #10)

Concur	X	Non-Concur
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Explanation: 5-year average maximum does not reflect to degree of risk for GBD and this information was not used for this purpose. It is an index to identify the long-term differences in TDG among alternatives to compare the water quality effects. TDG effects on fish were subjectively described due to the complexity and uncertainty in fish behavior, and differing sensitivities of different life stages.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: The 5-year average maximums were not purported to represent TDG impacts on fish, including the degree of risk for GBD. It is an index on such a scale that will show differences in dissolved gas productions among alternatives to compare the effects of water quality over the long-term.

Recommendation 2:	Adopt	X	Not Adopt
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Explanation: No change needed. For Mainstem projects, the NAA is under the 115%/120% TDG waivers, and the salmon and steelhead effects analysis qualitatively compared each alternative to gas exposures estimated for the NAA.

Panel Draft/Final BackCheck Response (FPC #10)

Concur	X	Non-Concur
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Explanation: The 5-year average maximum does not provide a useful index to distinguish differences among the alternatives evaluated by the Draft EIS. If the “5-year maximums were not purported to represent TDG impacts on fish.”, it would be of little or no value in distinguishing differences among the alternatives. The basic purpose of regulating and evaluating total dissolved gas supersaturation is to protect aquatic life.

Although there is substantial complexity in fish behavior, it is only the fish’s depth distribution that is of substantial value in determining adverse effects of total dissolved gas supersaturation. The two documents cited above (Weitkamp and Katz 1980, Weitkamp 2020) provide reference to numerous investigations that document or infer the depth of juvenile and adult salmonids that avoid gas bubble disease under reservoir and free-flowing river conditions.

Final Panel Comment 11

It is unclear why MO1, MO3, and MO4 were burdened with new irrigation diversions that are 25 times greater than those used for the Preferred Alternative.

Basis for Comment

The MO1, MO3, and MO4 alternatives each include new irrigation diversions of 1.15 million acre-feet (Maf) per year from Lake Roosevelt. The Preferred Alternative includes a much smaller new diversion volume of 45,000 kilo acre-feet (kaf) per year, which is 4% of the added diversion volume included in the MO alternatives. The added irrigation flows for the MOs represent an expansion of approximately 254,000 acres of irrigated cropland in the Bureau of Reclamation Columbia Basin Project. The positive economic effects of this increase in irrigated cropland are not discussed in the analyses of the MO alternatives. However, the negative socioeconomic effects of the loss of 47,800 acres of cropland associated with MO3 are evaluated in detail in the analysis of that alternative. This is an unequal treatment of the water supply benefits between the Preferred Alternative and the MO alternatives.

The new 1.15 Maf irrigation diversion under the MO alternatives would result in a 0.5% to 1% reduction in river flow volumes below Grand Coulee Dam. This reduced river flow would cause a small but readily quantified reduction in power generation, system reliability, and socioeconomic benefits under the MO1, MO3 and MO4 alternatives. These negative effects are not discussed in the analyses of MO1, MO3 and MO4. Concurrently, the Preferred Alternative enjoys the incremental generation, reliability, and socioeconomic benefits of not diverting this added 1.1 Maf from the river. This benefit under the Preferred Alternative is not discussed in the CRSO DEIS.

The Panel believes it is important to quantify the amount of this difference between alternatives, which the Panel understands to be in the range of 0.5% to 1.0% of the Federal Projects' annual power generation.

Significance – Medium

The unequal examination of new irrigation diversions between the alternatives disregards positive benefits under the MO alternatives and overstates the relative benefits under the Preferred Alternative. As a result, this uneven treatment appears to inflate the economic justification of the Preferred Alternative and ignores likely benefits under the MO alternatives.

Recommendations for Resolution

1. Describe in Chapter 3 the benefits that would accrue from the added irrigation diversions at Lake Roosevelt under MO1, MO3, and MO4. Explain why socioeconomic and regional benefits were not examined.
2. Explain in Chapter 3 that the power generation, regional cost of power, and related socioeconomic benefits would be slightly higher if the large irrigation expansion did not occur under MO1, MO3, and MO4.
3. Explain in Chapter 7 that the smaller new irrigation diversions from Lake Roosevelt would provide a small increase in CRS electric generation, loss of load probability (LOLP), and socioeconomic benefits due to about 1.1 Maf remaining in the river below Grand Coulee.

Final Panel Comment 11

4. Quantify in Chapter 7 the difference in power generation, LOLP, and socioeconomic benefits that the 1.1 Maf difference in river flow represents.
5. Explain in Chapter 7 that this same small benefit would accrue under the MO alternatives if they also had irrigation diversions similar to that proposed under the Preferred Alternative.

PDT Draft/Final Evaluator Response (FPC #11)

Concur	X	Non-Concur
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Explanation: This language is in Chapter 7 and explains why the CBP diversion was decreased in the PA:

This operational measure was included in MO1, MO3, and MO4 where an additional 1.15 million acre-feet could be pumped from Lake Roosevelt at Grand Coulee above what was provided in the No Action. This measure was updated for the Preferred Alternative to pump up to 45,000 acre-feet of water above the No Action due to the uncertainty over the timing and extent of the development of new water supply projects for the full volume. Additionally, this measure would change the timing of delivery of recently developed water supplies for the Odessa Subarea of the Columbia Basin Project (164,000 acre-feet for irrigation and 15,000 acre-feet for M&I of the current supplies) from September and October to when the water is needed, on demand. The 45,000 acre-feet water supports near-term additional development of authorized project acres. Water pumped from Lake Roosevelt would be delivered as the demand arises during the irrigation season (March to October).

Because multiple factors contribute to the amount of water in the river and reservoirs that then translates into changes in power generation, etc, this was not explicitly called out in the EIS, though the H&H section explains the measures that lead to changes in flow and storage in each MO.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: The increased irrigation deliveries described in MO1, M02, and M04 reflect the water needed to develop the remaining acres originally authorized for the Columbia Basin Project; only a portion of the authorized acres have been developed to date. The timing and method of development was unknown at the time of this EIS and therefore benefits of this additional water delivery were not quantified but impacts to river flows and associated resources that result from the additional water delivery were quantified. The uncertainty of the timing of water demand development and certainty of impacts contributed to the decision to decrease the amount of additional water delivery in the Preferred Alternative. Section 3.12.1.4 has been updated to acknowledge that the beneficial effects from the additional water supply measure are not analyzed. Section 3.12.1.4 and the Water Supply appendix explain the uncertainty associated with the new water deliveries.

Recommendation 2:	Adopt	X	Not Adopt
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Explanation: The No Action Alternative largely captures the benefits of not including the additional water supply measures. The analysis of MO1, MO3 and MO4 demonstrates the impacts of delivering the additional water supply to the Columbia River flows, and impact to individual resources. This is explained in the individual resource sections. Because multiple factors contribute to the amount of water in the river and reservoirs that then translates into changes in power generation, etc, this was not

explicitly called out in the EIS, though the H&H section explains the measures that lead to changes in flow and storage in each MO.

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The PA explains potential effects to these resources due to the combined effect of the measures in the PA. As with all other effects, it explains the difference to the NAA, not the other MOs.

Recommendation 4: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The PA explains potential effects to these resources due to the combined effect of the measures in the PA. As with all other effects, it explains the difference to the NAA, not the other MOs.

Recommendation 5: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The No Action Alternative largely captures the benefits of not including the additional water supply measures. The analysis of PA demonstrates the impacts of delivering the additional water supply to the Columbia River flows, and impact to individual resources. This is explained in the individual resource sections for the PA. Because multiple factors contribute to the amount of water in the river and reservoirs that then translates into changes in power generation, etc, this was not explicitly called out in the EIS, though the H&H section explains the measures that lead to changes in flow and storage in the PA.

Panel Draft/Final BackCheck Response (FPC #11)

Concur ☒ **Non-Concur**

Explanation: With respect to Recommendation 1, the text in EIS Report Section 3.12.1.1 – Future Water Supply Measures, does not adequately describe the magnitude and possible beneficial effects of the increased water supply diversion volumes. The narrative in Section 3.12.2 presents an extensive analysis of the negative physical and socioeconomic effects of the reduced water supply diversions in Region C, related to the loss of 47,800 acres of cropland. The reader is left with a conclusion that MO 3 will result in a loss of crop production in the basin, when in fact the added diversions in Region B could result in an overall net increase of 200,000 acres of cultivated cropland in the Columbia Basin.

The Panel understands that further development of cropland in the Columbia Basin Project is uncertain, both in terms of its timing and the total acreage that may ultimately be developed. However, the relative magnitude of the two water volumes begs at least some mention that benefits of the increased pumping at Grand Coulee could be significantly larger than the cropland loss in Region C. Some mention of this should be presented in 3.12.2.2 for Region B.

Final Panel Comment 12

The use of monthly and weekly flows in the H&H models does not replicate local hydraulic conditions that would impact aspects of the quality and use of the CRSO environment by adult and juvenile fish during passage.

Basis for Comment

Overall, the H&H models focus on hydroregulation and flood risk management, where monthly and weekly flows are adequate for analysis. However, these flow periods are often inadequate to describe local hydraulic or hydrodynamic conditions that fish experience during both adult and juvenile fish passage where they continually make swim path decisions based on their local hydrodynamic conditions.

The CRSO DEIS and supporting documents do not discuss impacts from changes in spillway flows to adult and juvenile fish passage; exposure to TDG; potential for bed rock scour with increased spill levels; changes in powerhouse to spillway flow entrainment; and impact on overall downstream flow conditions, including near boat ramps, adult ladder entrances, and along shoreline protections such as rock revetment and stabilization structures.

Significance – Medium/Low

Both numerical and laboratory models are required in order to develop detailed project designs, shape spillway operations for flexible spill conditions, and evaluate changes in downstream flow conditions, which are important factors for analyzing the CRSO environment.

Recommendation for Resolution

1. Use a couple projects as “index” locations to more thoroughly assess the detailed hydrodynamic conditions near fish passage structures, spillway stilling basins, boat ramps, etc., and the impact of the changing flow conditions under the Preferred Alternative.

PDT Draft/Final Evaluator Response (FPC #12)

Concur	X	Non-Concur
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Explanation: Estimated monthly and two week flows in of themselves does not describe the hydraulic characters. However, many of the key factors for differentiating among the alternatives were qualitatively described, to include adult passage delays, and tailrace eddies, that delay juveniles and increase their predation risk. They types of modeling necessary to address these factors in the tailraces is very expensive and often very difficult to validate. The Preferred Alternative includes and Adaptive Management Framework to address unintended consequences such as those that could arise from some the uncertainty in local hydraulics.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: All of the projects result in different local conditions. Modeling one or two site would have very little value in comparing system wide effects among the alternatives.

Panel Draft/Final BackCheck Response (FPC #12)		
X	Concur	Non-Concur
<p>Explanation: The PDT's choice of using an Adaptive Management Framework to address unintended consequences is a satisfactory approach.</p>		

Final Panel Comment 13

The assessment of climate changes does not consider the adaptability of fish to changing climatic conditions.

Basis for Comment

The early life history of Columbia River salmonids is closely tied to the water temperatures they experience during incubation and intergravel rearing. However, salmonids and other fishes have been known to adapt to extended ranges of temperature.

The CRSO DEIS evaluation does not consider the adaptability of salmonid species to altered climatic and other habitat conditions. The various salmonid subspecies show substantial indication that species have historically adapted to fringe conditions to expand their occupation of adjacent habitats. The movement of salmonids to reoccupy the northern part of their existing range that provided no aquatic habitat during the Ice Age is one clear indication of the adaptability of these species.

Water temperatures do strongly influence reproductive timing as well as the development and survival of salmonid embryos and alevins. A degree or two increase in temperature beginning at the time of spawning may result in earlier hatching, emergence, and migration timing (possibly by several weeks). Times from spawning to emergence of alevins and subsequent migration are closely tied to the accumulation of degree-days by each fish. An increase in the accumulation of degree-days at the initiation of embryo development is likely to result in substantially earlier emergence of alevins, also perhaps by several weeks.

Increased temperatures may result in either earlier or later spawning dates, depending on species and other conditions. Higher temperatures can result in delayed adult migration to spawning areas, producing delayed spawning. If adult migrations are increased by slightly higher temperatures, earlier spawning together with a higher temperature (by a degree) at the time of spawning will result in the embryos accumulating substantially more degree-days by the historic date of spawning, followed by earlier emergence and migration.

Furthermore, changes in river flow (total discharge) are likely to occur with climate change. These changes may be sufficient to reduce juvenile migrant survival and delay adult migrations.

Also, the greatest effects of climate change may be the result of changes in ocean-rearing temperatures that influence the survival and growth of salmonids over one to three years. Ocean conditions are outside the area that can be influenced by the CRSO.

Significance – Medium/Low

Adding information on the adaptability of fish will add useful considerations to the basic issue of climate change and make the analysis less susceptible to criticism. This additional information would also help demonstrate that the CRSO has limited capacity to alter the effects of climate change in the CRS.

Recommendations for Resolution

1. Document the potential for the native species to adapt to changes in water temperatures with

Final Panel Comment 13

climate changes in the CRSO DEIS.

2. Document the potential substantive changes in ocean conditions that may produce greater population changes than the CRSO area changes, and clarify that these changes are outside the capability of the CRSO to control.

PDT Draft/Final Evaluator Response (FPC #13)

X	Concur		Non-Concur
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Explanation: The DEIS does not address the potential for salmon and steelhead to adapt to changing conditions. The salmon are well known to be quite plastic in many life history traits and have adapted to each local habitat. Water temperature, runoff timing, etcetera are very powerful selection forces so some degree of adaption could be expected. However, much of the recognized adaption of these cold water obligates has been in migration timing to allow success in the hot arid inland Columbia River basin. Meeting the challenges of higher temperatures and longer durations of warm water will be a challenge.

Recommendation 1:	X	Adopt		Not Adopt
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Explanation: It is possible some populations may adapt to changing condition. Additional information has been added in the Cumulative Effects chapter of the Final EIS when discussing climate change on anadromous fish.

Recommendation 2:	X	Adopt		Not Adopt
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Explanation: The projected changes in ocean temperatures and acidification will likely have a greater population effects on salmon and steelhead population than any of the EIS alternatives. Additional information has been added in the Cumulative Effects chapter when of the Final EIS when discussing climate change on anadromous fish.

Panel Draft/Final BackCheck Response (FPC #13)

X	Concur		Non-Concur
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Final Panel Comment 14

In evaluating the loss of LSR hydro generation (part of MO3), regional development of new renewable generation resources is not considered as the most likely replacement energy source.

Basis for Comment

As part of regional climate change policies, multiple state government and corporate initiatives are now developing new renewable electric generating resources. This new generation capacity will hasten the retirement of fossil fuel generation in the region. It also would likely replace the LSR hydro generation that would be lost as part of MO3.

The grid reliability and regional power system effects analysis for MO3 presents one very unlikely scenario where LSR hydro generation is replaced by conventional gas-fired generation. Given government/corporate mandates and the pace of new renewable generation sources, these fossil-fired replacements seem highly unlikely.

The replacement energy discussion in the MO3 analysis also suggests that BPA might be the developer of whatever replacement energy source is needed to replace the LSR hydro generation. That discussion confirms that a new Federal congressional authorization would be needed for BPA to develop such resources. Given ongoing resource development by others and the need for an act of Congress to allow BPA development, it seems also quite unlikely that BPA would carry out this energy development program.

Significance – Medium/Low

The analysis of power generation impacts for MO3 would be more complete if it acknowledged that replacement energy sources for the lost LSR hydro generation would most likely be developed by others. Specifically, this replacement generation would likely be renewable energy developed according to an economic framework and schedule largely independent of the CRSO.

Recommendations for Resolution

1. Edit the grid reliability and regional power system effects analyses to better describe the current regional development of renewable electric generation by entities external to the CRS.
2. State more clearly in the cost and LOLP analyses that replacement resources are likely to be developed by entities external to the CRS lead agencies.

PDT Draft/Final Evaluator Response (FPC #14)

X	Concur	Non-Concur
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Explanation: The underlying premise of the comment, that natural-gas may not be the likely replacement for the four lower Snake River dams' generation in some scenarios and that Bonneville may not be the entity acquiring the new resources, are already described in the EIS.

The *Base Case Methodology, Potential Resource-Replacement Portfolios*, in Section 3.7.3.1 p. 3-820 of the DEIS, describes that two potential resource replacement portfolios were developed, one being conventional least-cost (natural gas) and the other zero-carbon to serve as bookends for the cost analysis. These portfolios were developed to provide a range of potential resources that could be acquired by Bonneville or public power utilities to meet their supply obligations and return regional reliability to the level of the No Action Alternative. The source of data for these portfolios was the Council's 7th Power Plan and Mid-Term Update, which identifies natural gas as a primary resource. The EIS acknowledges, though, that future development of natural gas may be unlikely. Section 3.7.3.1, *Cost of Carbon Compliance and Availability of Coal Resources*, (beginning on p. 3-839 of the DEIS) describes changes in legislation and policy in the Northwest that make it unlikely that carbon-based resources would be built.

As to the question of who might develop the new resources, the EIS uses the word "acquire" but not "build" in the context of new generation for Bonneville. The comment is correct that Bonneville does not have authority to own any new resources; however, Bonneville has statutory authority to contract to acquire the output of a resource. The discussion under *Step 3* in Section 3.7.3.1, (particularly p. 3-821 in the DEIS) and a footnote acknowledge the details of how Bonneville would acquire new resources. Whether Bonneville would have to exercise its acquisition authority depends, in part, on its customers' elections for service as prescribed in Bonneville's current long term power sales contracts. If customers elect Bonneville to serve their requirements, then Bonneville is obligated, if needed, to acquire sufficient resources (*i.e.*, acquire output of specific resources or power from the short-term power market) to meet its power obligations. This could include acquisitions to replace the lost capability from the four lower Snake River dams in MO3. What resources Bonneville would acquire would depend on a host of factors not within the scope of the EIS, including cost effectiveness, availability, and capability. However, nothing in existing law would prohibit Bonneville from commencing statutory proceedings to acquire the output of resources that the Administrator determines are needed to meet his obligations, which could include output from a natural gas project.

Recommendation 1:	X	Adopt	Not Adopt
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Explanation: It should be noted that in Chapter 6 – Cumulative Effects includes Reasonable and Foreseeable Future Action (RFFA) 3: "New and Alternative Energy Development" that discusses the prevalence of new renewable development in the region. In addition to this existing discussion, new language will be added to Section 3.7.2.1 to describe the growth of renewable generation. Additional language will be added to Appendix H (Section 2.2) to describe the timeline for developing new resources, and it will include language to state that independent power producers are developing new renewable resources that may be used to replace hydropower generation if not already allocated to replace coal-based generation.

Recommendation 2:	X	Adopt	Not Adopt
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Explanation: In Section 3.7.3.1 under base case methodology, Step 3, we intend to add clarifying language describing that whether Bonneville or its customers acquire replacement resources, it may entail entering into power purchase agreements with independent power producers.

Also, as noted in the Explanation for Recommendation 1, new language will be added in Appendix H to describe the timeline for developing new resources, and it will include language to state that independent power producers are developing new renewable resources that may be used to replace hydropower generation if not already allocated to replace coal-based generation.

Panel Draft/Final BackCheck Response (FPC #14)

<input checked="" type="checkbox"/>	Concur	<input type="checkbox"/>	Non-Concur
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Final Panel Comment 15

The use of averages from a USACE nation-wide database for expenditure data may not accurately represent the average expenditures on a regional scale.

Basis for Comment

The expenditure data used in the recreation model are national averages. All the sites in the CRSO area are located in the northwestern United States. Ideally, the expenditure data should reflect the expenditures at the sites being evaluated. The nation-wide data should be stratified by region and expenditure types so that sites in the northwestern United States could be used. This approach would more accurately reflect the economic impacts of changes to recreation sites in the CRSO area.

Significance – Medium/Low

Using expenditure data specific to the northwest region will yield the most accurate estimates possible of the economic impact of changes to recreation sites.

Recommendation for Resolution

1. Stratify the national expenditure data by region and use the northwest region averages in the recreation model.

PDT Draft/Final Evaluator Response (FPC #15)

Concur	X	Non-Concur
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Explanation: The PDT agrees with the commenter that expenditure data would ideally reflect the expenditure profiles that are specific to the study sites or the Pacific Northwest.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: While the PDT agrees that expenditure data would ideally reflect the expenditures at sites being evaluated in this EIS (or other similar sites in the northwestern United States), the Corps utilizes a nationwide expenditure profile for recreational visitor expenditures. The following revision has been made to Appendix M in order to clarify this point (changes shown in italics):

“The Corps’ expenditure profile was developed for six visitor segments at all projects across the country from recent surveys at a range of sites.”¹⁰

¹⁰ *The Corps does not have expenditure profiles specific to sites in the Pacific Northwest or other regions, as the underlying surveys were not designed to generate regional-level profiles.”*

Panel Draft/Final BackCheck Response (FPC #15)

X	Concur	Non-Concur
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Explanation: Given the information provided, the Panel concurs that the expenditure data cannot be stratified as recommended. We do, however, request clarification. Can you explain why it is not possible to stratify the national expenditure data by region? Is it because of the sampling methodology or because the survey instrument or something else?

Final Panel Comment 16**The system cost models do not communicate risk under the MO alternatives.****Basis for Comment**

The estimated system costs under each alternative are divided into four categories: construction costs, capital costs, operation and maintenance costs (O&M), and mitigation costs (see Appendix Q, Table 7-2). All of these costs, with the exception of the mitigation costs, are presented as point estimates. The cost parameters in the models, however, are subject to fluctuations. Because each alternative employs different levels of inputs for construction, capital, and O&M, fluctuations in the cost of inputs will have different effects on the alternatives. The system cost models in the CRSO DEIS do not communicate how those parameter fluctuations would affect the system cost estimates.

As an example, O&M costs include the costs of dredging for navigation. To estimate the annual cost of dredging activity, the CRSO DEIS uses the average cost from 2011 to 2018, inflated to 2019 prices (Appendix Q, pages Q-5-2 and Q-5-3). It would not be difficult to use that same information to calculate the variance of the dredging costs and construct a confidence interval for the annual dredging costs.

Significance – Medium/Low

Including parameter fluctuations in the models will provide decision makers a better understanding of the perceived accuracy of the point estimates.

Recommendation for Resolution

1. Develop confidence intervals for the system costs of each alternative and report them in the CRSO DEIS.

PDT Draft/Final Evaluator Response (FPC #16)

X	Concur	Non-Concur

Explanation: The PDT agrees that the risk and uncertainty surrounding the CRSO implementation and system costs could be better communicated in the EIS. The PDT will revise the EIS (Section 3.19 and Appendix Q) to better describe risk and uncertainty regarding the cost estimates. Appendix Q, Chapter 1, second to last paragraph includes some description on uncertainty related to the development of the cost analysis and cost estimates. Some of the cost estimates include uncertainty, such as construction costs of the structural measures and the additional mitigation measures and the Fish and Wildlife Program costs.

For the construction cost estimates of the structural measures and the additional mitigation measures, a 50 percent contingency was added to the construction costs due to uncertainty surrounding the estimates and the preliminary designs. This is a standard approach for the cost engineers at the Corps Mandatory Cost Center of Expertise at the Walla Walla District, which was also reviewed and approved by Bonneville. Therefore, the cost estimates for these measures reflect conservative measures. Uncertainty surrounding the fish and wildlife mitigation costs was included in the cost estimates and is

reflected as a range for the Fish and Wildlife Program costs under MO2, MO3, MO4, and the Preferred Alternative.

Capital cost estimates and non-routine extraordinary (NREX) cost estimates are based on long-range forecasts of these capital and non-routine requirements to 2068. There are multiple areas of uncertainty related to these future costs, including equipment replacement and repair needs and timing, cost estimates of the capital requirements, and execution risk (i.e., planning timing, authorizations, and appropriations). Bonneville evaluates the uncertainty around individual investments in the short-term (one year out) to understand cost and schedule risk. However, any evaluation of the magnitude of uncertainty for the long-term plan would be speculative and is beyond the scope of this evaluation.

Additional information on risk and uncertainty regarding O&M costs was included in Appendix Q (Section 5.1) was included to reflect the variation in these costs over the past 3 to 5 years, where possible. Although the commenter is correct that some of the O&M costs are based on an average of the recent historic costs (updated to current price levels), other categories of these costs (for example, routine O&M for cultural resources, routine O&M costs for the Reclamation projects, navigation non-routine costs for Walla Walla District), are based on program and budget experts reviewing the historic costs and providing an expert judgement on the annual O&M costs for these programs and activities in the future. As described previously, specific uncertainty bounds or ranges for the NREX costs, which fall in the O&M category, cannot be estimated.

As a result of the above issues and considerations described above, additional description of risk and uncertainty regarding the implementation and system costs has been added to the EIS, although confidence intervals or ranges in these costs were not included in the cost estimates in the tables in Section 3.19 and Appendix Q.

The fourth paragraph of Section 3.19 and the Chapter 1 of Appendix Q includes the following additional description on risk and uncertainty:

It should be noted that there are multiple areas of uncertainty related to the cost analysis in general. In fact, risk and uncertainty are inherent with any model that is developed and used for water resource planning. Much of the risk and uncertainty associated with modeling the costs stem from the assumptions that historic activities and costs would reflect cost estimates in the future. There are uncertainties in terms of the needs and timing of O&M, capital requirements, fish and wildlife mitigation, and construction costs of the structural measures; the cost estimates associated with those needs or requirements; and the execution risk associated with timing and the ability to obtain authorizations and appropriations to implement the alternatives, and others. Future costs can also be affected by technological advancements and cost efficiencies although any future changes in technologies are speculative. Additional descriptions on the risks and uncertainties surrounding the implementation and system cost categories are described in Appendix Q.

Additional details have also been added in each of the sub-sections (structural measures, capital, O&M, mitigation) to describe uncertainty surrounding these cost estimates.

Section 4.1.1. (Capital Costs) of Appendix Q includes the following additional description:

Capital cost estimates are based on long-range forecasts of these capital requirements to 2068. There are multiple areas of uncertainty related to these future costs, including equipment replacement and repair needs and timing, cost estimates of the capital requirements, and execution risk (i.e., planning timing, authorizations, and appropriations). Bonneville has begun

a process to evaluate how well the individual investments in the short-term (one year out) align with the cost estimates; however, any evaluation of the magnitude of uncertainty would be speculative and is beyond the scope of this evaluation.

Section 5.1.1.1 (Routine O&M) of Appendix Q includes the following additional description:

To better understand the variation and uncertainty regarding routine O&M costs, an evaluation was completed on the standard deviation and 95 percent confidence interval for the O&M costs that used 5 years of historic data. Average routine O&M costs for all of the Corps projects (updated to 2019 price levels and not including cultural resource O&M) were estimated to be \$237.1 million annually based on 5 years of cost data from 2013 to 2017. From these five years of data, the standard deviation was estimated to be \$9.2 million with a 95 percent confidence interval that ranges from \$229.0 million to \$245.2 million.

Section 5.1.1.2 (NREX) of Appendix Q includes the following additional description:

NREX cost estimates are based on long-range forecasts of these non-routine requirements to 2068. There are multiple areas of uncertainty related to these future costs, including equipment replacement and repair needs and timing, cost estimates of the non-routine requirements, and execution risk (i.e., planning timing, authorizations, and appropriations). Bonneville has begun a process to evaluate how well the individual investments in the short-term (one year out) align with the cost estimates; however, any evaluation of the magnitude of uncertainty would be speculative and is beyond the scope of this evaluation.

Section 5.1.1.3 (Navigation) of Appendix Q includes the following additional description:

To better understand the variation and uncertainty regarding navigation costs, an evaluation was completed on the standard deviation and 95 percent confidence interval for the Portland District dredging costs, which was based on 3 years of historic data. Average Portland District dredging costs were estimated to be \$67.1 million annually, with a standard deviation of \$4.1 million and a 95 percent confidence interval that ranges from \$62.5 million to \$71.7 million.

Section 6.1.1 (Fish and Wildlife Costs) of Appendix Q includes the following additional description:

Funding decisions for the Bonneville F&W Program are not being made as a part of the CRSO EIS process. However, a range of potential F&W Program costs are included to inform the broader cost analysis for each alternative in the EIS.

Section 6.1.2 (Costs for Additional Mitigation Measures) of Appendix Q includes the following additional description:

Structural mitigation measures were estimated by the cost engineers at the Mandatory Cost Center for Expertise, while on-going system annual system costs were developed with input from programs, operations and cost engineering. ***A contingency of 50 percent was added to all construction estimates based on preliminary designs, scope, and uncertainty surrounding the construction estimates and in consultation with Bonneville. A 50 percent contingency is typical for this level of scope and cost engineering estimate development.***

Recommendation 1:	<input type="checkbox"/>	Adopt	<input checked="" type="checkbox"/>	Not Adopt
Explanation: Descriptions of risk and uncertainty surrounding the implementation and system costs have been included in Section 3.19 and Appendix Q. However, confidence intervals or ranges in these costs were not included in the cost estimates in the tables in Section 3.19 and Appendix Q due to the difficulty and speculation in estimating these ranges across an array of cost data sources. It should also be noted that the decision-making associated with the EIS and selection of the Preferred Alternative considered a comparison of the costs across the alternatives, including comparing the action alternatives with the No Action Alternative. All of these costs include a level of uncertainty; it is the general relative changes across the alternatives that was considered in the decision-making process.				
Panel Draft/Final BackCheck Response (FPC #16)				
<input checked="" type="checkbox"/>	Concur	<input type="checkbox"/>	Non-Concur	

Final Panel Comment 17

The IMPLAN analysis for the power generation and transmission model was not modeled properly.

Basis for Comment

The IMPLAN analysis was done at the state level and then aggregated to the study region. IMPLAN allows for models to be run at various spatial scales—single county, multi-county regions within a state, multi-county regions across states, state-level, multi-state regions, etc. The IMPLAN analysis for the CRSO DEIS ran separate state-level analyses and then totaled the results. This approach does not account for the economic inter-connection across state lines. The proper approach would be to run a regional IMPLAN model incorporating all counties in the study area into a single region.

Significance – Medium/Low

Changing the structure of the IMPLAN analysis from separate state-level analyses to a single regional analysis will provide more accurate estimates of the economic impacts under each alternative.

Recommendation for Resolution

1. Run a regional IMPLAN model for the power generation and transmission model.

PDT Draft/Final Evaluator Response (FPC #17)

Concur	X	Non-Concur
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Explanation: Thank you for reviewing the IMPLAN modeling approach and providing thoughtful comments. It is correct that the current IMPLAN modeling analysis is conducted at the state level. This means that the power rate effects rely on state-level spending and state-specific multiplier data to quantify indirect and induced impacts, and results are then summed across states to estimate a total effect. We agree that this approach results in some unaccounted for direct and induced effects that occur due to interconnected businesses that are affected outside of the state. This is referred to as “leakage” in the context of regional economic modeling.

While we recognize there are alternative ways to model the multiplier effects, we disagree that the current approach is improper. The choice of region size in IMPLAN necessitates a tradeoff between minimizing leakage and minimizing “aggregation bias” (i.e., the loss of detail in IMPLAN when aggregating industries across regions, in this case states). Our current approach takes spending effects at the state level, apportions them to industries based on state-specific data on electricity purchases, and applies multipliers from IMPLAN that are specific to each industry in each state. This approach better targets the direct spending effects to the appropriate industries, and makes use of more precise state specific-industry multipliers to minimize aggregation bias. If we were instead to combine all the states into one region, we would reduce leakage but also reduce the precision of our estimates.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation:	See explanation above.
Panel Draft/Final BackCheck Response (FPC #17)	
X Concur	Non-Concur
Explanation:	The Panel is able to concur given the clarification provided.

Final Panel Comment 18

The CRSO DEIS does not include any information on the potential for earthquakes and any resulting impacts to the Columbia River area under the No Action Alternative or the action alternatives assessed.

Basis for Comment

Earthquakes are known to occur in the study area. The CRSO DEIS does not address potential adverse effects if earthquakes were to impact the Columbia River area. The potential for earthquakes causing ground shaking and increased shoreline slope instability, including landslides and erosion, is not discussed. The resulting shoreline instability could increase sediment supply, transport, and turbidity, as well as trigger reservoir surge waves. Potential adverse effects from the combined effect of climate change (e.g., affecting reservoir drawdowns and soil and groundwater conditions per Chapter 4, Table 4-8) and earthquake loading are not addressed in the CRSO DEIS, nor are potential adverse effects to major structures (dams, locks, or other large structures) discussed.

The Panel believes that the CRSO DEIS should include explicit discussion, including recognition and consideration, of potential earthquake effects. Adequate discussion could be limited to expert geotechnical engineering and geologic interpretation with reference to regional seismicity and historic earthquake effects. However, a seismic risk analysis would help in quantifying uncertainty.

Significance – Medium/Low

A discussion of potential adverse impacts due to earthquake activity would support the overall decision-making process.

Recommendations for Resolution

1. Discuss the regional seismicity and the potential for future earthquakes to adversely affect shoreline erosion (and consequential effects), CRS structures, and the CRSO.
2. Discuss how potential future earthquakes could affect the natural, social, and economic environment under the alternatives, including the Preferred Alternative.
3. Consider conducting a formal seismic risk analysis.

PDT Draft/Final Evaluator Response (FPC #18)

Concur	X	Non-Concur
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Explanation: Earthquake effects were not considered in evaluating any of the alternatives. The measures considered do not result in an increase in water levels that would saturate potentially liquefiable soils or increase soil pressure on the shoreline slopes, which would result in an increase in expected slope instability during an earthquake event. While this could be discussed, there is no expected change in consequences from seismic events for any of the alternatives.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: Regional seismicity was not part of the scope of this study. Each of the Columbia River System projects in this study has a current seismic analysis as a part of their respective Dam Safety program.

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: There is no expected change in consequences from seismic events for any of the alternatives.

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: None of the alternatives negatively affect or change the risk from a seismic event and the information was not included in this analysis.

Panel Draft/Final BackCheck Response (FPC #18)

☒ **Concur** ☐ **Non-Concur**

Explanation: The Panel accepts the PDT's explanations and suggests that those explanation be included in the final EIS to demonstrate that potential earthquake effects and concerns were recognized and generally considered (as stated above) and judged to not significantly affect the alternatives.

Final Panel Comment 19

It is unclear how risk and uncertainty have been integrated into the complex adaptive system managed under the CRSO.

Basis for Comment

The CRSO represents a complex adaptive management system that presents great challenges to usefully conceptualizing, communicating, and integrating risk and uncertainty to inform decision making. While risk and uncertainty associated with economic and power generation metrics seem to be well discussed, the Panel did not see a clear discussion of how the aggregate or overall risk and uncertainty inherent in the CRSO was characterized and considered or evaluated. The Panel did not see an explicit basis for (or explanation and summary of) an overall integration of risk and uncertainty for each alternative, including the Preferred Alternative.

Significance – Medium/Low

The aggregate risk and uncertainty associated with CRSO is important to understanding the CRSO and differences between alternatives, including the Preferred Alternative.

Recommendations for Resolution

1. Discuss the overall or aggregate risk and uncertainty associated with the CRSO, including the alternatives, differences between alternatives, and the Preferred Alternative.
2. Provide a formal basis for aggregating risk and uncertainty in the evaluation of the alternatives.

PDT Draft/Final Evaluator Response (FPC #19)

Concur	X	Non-Concur
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Explanation: Most of our understanding of potential changes to resources of implementing different operational measures is well understood. MO1, MO2, and MO4 operate within ranges we have historically operated within, and was used to interpret modeling results to describe the cumulative impacts. The exception is in the fish response, and in particular, response of anadromous migrating fish to spill levels, TDG, and the hypotheses of latent mortality. Structural uncertainty relates to breaching the earthen embankments of the federal dams and the short and long term impacts to natural resources as well as to regional economies and social welfare. The team used a previous reservoir drawdown pilot study on the lower Snake River and previous dam breaching activities for empirical data to identify potential short term effects along with supplemental modeling. We used the best available, current models to understand changes to hydrology, water quality, navigation and transportation, recreation, air quality, power production and fish responses. Even so, each model can introduce an element of uncertainty. There are also conditions outside of the federal actions, such as climate change, changes to power production from carbon, gas, wind, and future demands and how the region will meet those demands, changes in development, etc, which the team tried to anticipate and modeled in the analysis.

Throughout the resources discussions in the EIS, these uncertainties were discussed. We have also added a discussion to the EIS in the fish methodology section to discuss the uncertainty in the modeling. For the Preferred Alternative, we will implement an adaptive management plan to adjust operations should it be needed after monitoring fish responses and address the uncertainty in the models. This plan is in Appendix R.

For the aggregate risk and uncertainty, the MO3 alternative is the only alternative with significant uncertainty and is highest risk. The EIS describes short term, major adverse impacts to the natural environment as a result of significantly adverse water quality and sedimentation mobilization. For long term benefits to be achieved, fish would have to overcome a 2 to 7 year of adverse conditions, and other entities outside the co-leads would have to take actions to remove contaminated sediments and ground water contaminated areas for fish, wildlife and human health. For regional economy to thrive, the assumption is that different transportation routes will be expanded and permitted to meet demand; irrigators and local municipalities are assumed to extend water intake pipes and wells. State and local governments would shore up roads and maintenance for increased traffic. Boat ramps and docks would have to be constructed by local entities to access water for both recreation and tourism. Environmental conditions would depend on changes in city development, climate change, and ocean conditions. Power reliability is uncertain. Economic analysis projects greatest job loss, while at the same time could have the biggest impact to tourism for sport fishing and bring greater numbers of culturally significant salmon to the Snake River. This alternative, however, has the greatest potential for fish benefits specifically for Snake River anadromous species and resident fish, which makes it an attractive alternative. These themes of risk are discussed throughout the resource analysis, environmental justice section, and in mitigation discussions, where the agencies are clear to indicate that implementing MO3 would require a significant response of the region to take additional actions if adverse effects are to be minimized. It is because of this reliance on actions and conditions outside the co-lead agencies control and the potential biological and social impacts that this alternative has the greatest uncertainty and risk.

The preferred alternative will be implemented using a robust monitoring plan to help narrow the uncertainty between the two fish response models and to determine how effective increased spill can be towards increasing salmon and steelhead returns to the Columbia Basin. The framework for the adaptive management process is detailed in Appendix R, Part 2 Process for Adaptive Implementation

of the Flexible Spill Operational Component of the Columbia River System Operations EIS. It is the intention of the co-lead agencies to engage regional state, tribal, and federal biologists in the development of an appropriate adaptive management process utilizing their respective salmonid management expertise. The goal of that adaptive management process would be to consider additional opportunities to further the effectiveness of the operation while maintaining the goals of the flexible spill operation: additional improvements for salmon and steelhead, maintain opportunities to operate the CRS for hydropower generation in a flexible manner that provides value to the Northwest, is implementable by the dam operators, and provides opportunity to reduce uncertainty and improve the learning opportunities around how operations of the CRS can influence the magnitude of latent mortality effects. The co-lead agencies have not made any determinations on what the preferred approach would be for a regionally developed study plan, and intend to develop that study jointly with regional experts. Unforeseen outcomes or unintended consequences will be monitored and adjusted using current in-season management teams such as the Technical Management Team.

Recommendation 1:	<input type="checkbox"/>	Adopt	<input checked="" type="checkbox"/>	Not Adopt
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Explanation: See explanation above.

Recommendation 2:	<input type="checkbox"/>	Adopt	<input checked="" type="checkbox"/>	Not Adopt
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Explanation: Chapter 7 has a discussion of the choice between alternatives, how they meet the purpose and needs, and overall objectives. While we concur the risk and uncertainty is not compared in the document, it is discussed throughout the presentation of resources effects and mitigation. Additionally the plan for managing the greatest risk, benefits for fish, is described in the preferred alternative and detailed in Appendix R.

Panel Draft/Final BackCheck Response (FPC #19)

<input checked="" type="checkbox"/>	Concur	<input type="checkbox"/>	Non-Concur
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Explanation: The Panel accepts and appreciates the PDT's clarifying and summarizing explanations, and suggests that the content of the (clarifying and summarizing) discussion be added to the final EIS.

Final Panel Comment 20

It is unlikely that the relatively small-scale habitat restorations proposed will restore historic levels of the fish stocks on the Columbia River tributaries due to large watershed impacts from various human activities prior to and since dam construction.

Basis for Comment

Remedial actions supported by the CRSO would provide benefits to salmonid habitat, but such actions would not reverse the legacy effects of human modification of the Columbia River watershed. These effects began with great over-harvest of the salmonid resources in the 1800s. In fact, changes to the salmonid populations occurred in the 1800s prior to any substantial alteration of the Columbia River Basin by dams and other human impacts to the Columbia River Basin. Prior to 1890, fish stocks in a number of Columbia River tributaries had been depleted by various human actions prior to dam construction:

- Intense commercial, recreational, and subsistence fishing and mixed stock fishing.
- Habitat degradation caused by farming, logging, ranching, and urban growth.
- Water withdrawal for agricultural, municipal, and commercial uses.
- Tributary channel alteration, diking, and riparian corridor modifications.

The following are several examples of documented early historic large-scale changes to the salmonid populations.

“A remarkable deficiency in the yield of salmon in the Clackamas River in 1876 aroused the persons employed in the canning trade on the river to use all practicable measures of relief” (Baird, 1879).

“While salmon used to ascend the Yakima and its tributaries in large numbers, they have fallen off of late years.” (Gilbert & Evermann, 1895).

“It is now very doubtful whether a hatchery located at any point on this stream could depend for spawn on the fish which ascend the stream itself” (Gilbert & Evermann, 1895).

“...salmon were abundant in the Columbia at Kettle Falls as late as 1878. Since then there has been a great decrease. They have been scarce since about 1882; since 1890 there have been scarcely any at Kettle Falls.” (Gilbert & Evermann, 1895).

The small-scale habitat restoration actions now available to the CRSO are not adequate to deal with the large-scale impacts of early Columbia River watershed degradation.

Significance – Medium/Low

The suggested additions will help reviewers understand the limited ability of the river managers to reverse the historic alterations to the salmon populations and their habitat by basic and widespread effects of the human population in the Columbia River Basin and the historic over harvest.

Final Panel Comment 20**Recommendation for Resolution**

1. Discuss pre-1930 changes to Columbia River salmonid populations to provide understanding that the CRSO actions have limited capacity to restore historic conditions.

Literature Cited

Baird, S. F. (1879). Report of the Commissioner of fish and fisheries. Part B-The propagation of food-fishes in the waters of the United States. United States Commission of Fish and Fisheries. p. 31-32.

Gilbert, C. H., and B. W. Evermann (1895). A report upon investigations in the Columbia River basin, with descriptions of four new species of fishes. Pages 169-207 in: Bulletin of the United States Fish Commission XIV, for 1894.

PDT Draft/Final Evaluator Response (FPC #20)

X	Concur		Non-Concur
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Explanation: The purpose of the CRS EIS is to update operation and configuration of the 14 dams operated as a system, while meeting the fish and wildlife authorized purposes of the dams as well as relevant law, most notably, the Endangered Species Act (ESA). Recovery of salmon and steelhead population is not the purpose, nor a requirement of the EIS. Under the section 7 of the ESA, the operation and maintenance of the CRS may not jeopardize the existence of any species listed under the ESA, or destroy or adversely modify designated critical habitat of any listed species. Recovery is a shared responsibility, led by NOAA Fisheries to address the myriad factors affecting the listed species.

Recommendation 1:	X	Adopt		Not Adopt
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Explanation: Chapter 1 of the EIS will be updated to mention the broad and significant declines of salmon that occurred by 1895 due to overharvest and extensive habitat modifications throughout the Columbia River Basin as noted by Gilbert and Evermann, 1895.

Panel Draft/Final BackCheck Response (FPC #20)

X	Concur		Non-Concur
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Final Panel Comment 21

Several definitions, terms, and comparisons used in the CRSO DEIS in regard to TDG supersaturation are incorrect and misleading.

Basis for Comment

The definition of TDG supersaturation provided in the Executive Summary (text box, page 14; Chapter 1, page 14) is not correct. TDG supersaturation is not an “amount”; it is the level of dissolved air that the water would hold relative to equilibrium at the water body’s surface pressure under the recorded temperature and barometric pressure conditions. A range of amounts of dissolved air can produce the same level of TDG supersaturation under various temperature and atmospheric pressure conditions.

Further, the correct term for the biological malady produced by TDG supersaturation is gas bubble *disease*, not gas bubble *trauma*. Both of these terms have been used in recent literature dealing with TDG supersaturation, but use of the term trauma is incorrect.

Significance – Medium/Low

The suggested changes will correct errors that perpetuate misunderstandings regarding TDG supersaturation.

Recommendation for Resolution

1. Correct these definitions in the CRSO DEIS.

PDT Draft/Final Evaluator Response (FPC #21)

Concur	X	Non-Concur
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Explanation: The co-lead agencies agree that the TDG definition the commenter provides is correct and more precise. However, NEPA documents are to be written in plain language to be understood by the general public. We believe, the description is sufficiently accurate for the purposes of the EIS.

The term gas bubble trauma will be retained as both gas bubble disease and gas bubble trauma are commonly used in the literature, the condition fits within the definitions of both disease and trauma, a change will not improve clarity of the document, nor would change effect decisions.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: See Explanation above.

Panel Draft/Final BackCheck Response (FPC #21)

Concur	X	Non-Concur
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Explanation: Use of the term "amount" is simply wrong and does not promote understanding by non-technical readers. Total dissolved gas is not measured as an "amount". TDG is commonly reported as a percent of saturation at water surface pressure.

Perpetuating use of an inappropriate term such as "trauma" does not provide greater understanding than using the correct term "disease". Use of "trauma" is not justified on the basis that "trauma" has been used in some of the literature (see attached Annotated Bibliography, Weitkamp 2020). Use of more appropriate nomenclature has not enhanced the understanding of total dissolved gas supersaturation by various audiences during the prolonged history of TDG regulation. It is the Panel's experience that the use of appropriate terminology has not hindered the communication between experts and general audiences in conversations dealing with the various aspects of TDG supersaturation.

Final Panel Comment 22

Chapter 2 of the CRSO DEIS does not discuss increased access by white sturgeon to upstream habitat due to removal of the LSR dams.

Basis for Comment

Chapter 2, Alternatives, of the CRSO DEIS does not mention white sturgeon for the LSR dam removal alternative. The analysis of the effects of dam removal on white sturgeon, found later in the CRSO DEIS, should be summarized here and in the MO3 summary. Dam breaching would restore connections to the functionally isolated reservoir reaches of the LSR and increase access to upstream habitat, an important benefit likely of interest to many readers of the MO3 summary who may not read the entire CRSO DEIS.

Significance – Low

Although the suggested addition to Chapter 2 and the MO3 summary will not alter the alternatives analysis, it may avoid unnecessary controversy among those who only read that far.

Recommendation for Resolution

1. Summarize the analysis of the effects of dam removal on white sturgeon found in Chapter 2 of the CRSO DEIS.

PDT Draft/Final Evaluator Response (FPC #22)

Concur	X	Non-Concur
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Explanation: None of the resources analyzed are described in Chapter 2 - Alternatives. The alternatives only described the measures that are included in each alternative. There is no discussion of effects to any of the resources. This information is included in Chapter 3 – Affected Environment and Environmental Consequences.

Recommendation 1:	Adopt	X	Not Adopt
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Explanation: To be consistent with the format of the EIS, this information is not discussed in Chapter 2, but is included in Chapter 3. The EIS includes the necessary analysis to evaluate and compare each of the alternatives. It meets legal and policy requirements for an EIS.

Panel Draft/Final BackCheck Response (FPC #22)

Concur	X	Non-Concur
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Explanation: A brief mention of the White Sturgeon issue early in the EIS might avoid some controversy. White Sturgeon are presently a controversial species that is adversely affected due to the migration barriers provide by Columbia and Snake River dams. Currently there is not sufficient funding available to even assess the population levels in the CRSO area.

Final Panel Comment 23

Discussions of some topics seem fragmented and distributed throughout the CRSO DEIS in a way that makes it difficult to capture and appreciate details and reach full understanding of the impacts.

Basis for Comment

The CRSO DEIS presents an enormous volume and complexity of information to digest and understand. Comprehension was difficult for some topics (e.g., H&H, environmental and cultural resources) because discussions seemed out of balance or inconsistent between the main text and supporting appendices. For example, the Panel noticed less detail or different emphasis in the appendices than in the main text, or inconsistent discussions on the same topic in different sections of the main text. The appendices did not provide enough supporting information to assist in determining project impacts to resources identified in the various alternatives. The incompleteness of the Table of Contents added to the sense of fragmented discussions because lower-level headings were not included (or were invisible in the Adobe PDF version available to the general public), making it difficult to pinpoint the locations of related discussions and consolidate understanding.

Significance – Low

The fragmented discussions undermine the clarity and comprehensibility of the CRSO DEIS.

Recommendations for Resolution

1. Expand the Table of Contents to include all enumerated headings in the main text and appendices.
2. Edit the main text and appendices to provide a consistent and balanced level of detail and discussion, and consolidate fragmented discussions where and as appropriate.

PDT Draft/Final Evaluator Response (FPC #23)

Concur	X	Non-Concur
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Explanation: We agree that the overall length of the document is long and difficult to review due to the complex nature of the subject matter and broad geographic scope of the EIS. However, the document contains the necessary information to fully evaluate each alternative while meeting all policy and legal requirements.

Recommendation 1:	X	Adopt	Not Adopt
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Explanation: The Table of Contents has been expanded to include subheadings and appendices to aid in finding detailed conversations pertinent to the conclusions of the report.

Recommendation 2:	Adopt	X	Not Adopt
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Explanation: The discussions in the EIS were scaled to the appropriate level based on the significance of changes to the resources, the resource significance, or to discuss the drivers of changes to other resources, such as in the case of hydrology and hydraulics, which is the basis of understanding both

operations and changes to resources. Additionally, the technical details and reports were provided in the appendices, and pertinent information brought forward into the body of the EIS to complete the effects determination. The EIS is scaled to information pertinent for the public to understand effects analysis and basis of the decision, and not be duplicative of the back ground information. For those readers that are interested on the more technical analysis of running models and data sheets, the information is available in the appendices. The panel did not specifically identify fragmented discussions to resolve; however the EIS has been updated based on public comment and cooperating agency feedback which may have resolved this stated concern.

Panel Draft/Final BackCheck Response (FPC #23)

X	Concur	Non-Concur
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Explanation: The Panel is pleased to learn that the TOC will be expanded as recommended. The Panel is satisfied that the PDT understands its general concern with the readability and understandability of the DEIS and assumes that the updated, final EIS will have adequately resolved those shortcomings.

Comment Response Record for the Independent External Peer Review Columbia River System Operations (CRSO) Ecological Models

USACE Final Evaluator Responses and Panel Final BackChecks

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Final Panel Comment 1

Differences in the attribution of salmon survival rates to the ocean environment versus Columbia River dam/reservoir operations used in the COMPASS/LCM and CSS models result in increased uncertainty of the actual benefits attained by future changes.

Relevant Model Assessment Criteria

Model Usefulness in Selecting Alternatives

Basis for Comment

There are two contrasting modeling approaches: the COMPASS/LCM and the CSS efforts. These two modeling frameworks differ greatly in how much of the variation in salmon survival rates is assigned to the ocean environment and how much to operations of the Columbia River dam/reservoir system. Consequently, they often differ drastically in their predictions of the effect of changes in operations on salmon survival. As both models are credible efforts from competent scientists, the implication is that the effects of changes contemplated in the DEIS are highly uncertain.

As explained in the DEIS (Chapter 3, pages 3-360 to 3-362), the critical difference is in what in-river factors are assumed to affect ocean mortality—i.e., “latent” mortality. In the COMPASS/LCM approach, date of arrival at Bonneville and river temperature affect ocean survival. In the CSS approach, a variable representing the expected number of powerhouse passages is the critical driver.

Unfortunately, the current data may not be sufficient to resolve questions about how much variability in ocean survival can be attributed to these different factors. Although large quantities of high-quality observations exist, they do not stem from an experimental design to address these differences. Climate variations likely simultaneously affect in-river flow and temperatures, dam/reservoir operations, and at least the estuarine oceanic environment, making it difficult to parse out the effects of each on salmon survival. The best and most detailed survival data, from PIT tags, is restricted to the last two decades, when the configuration of the dam/reservoir system has been largely static (although some significant operational changes and some structural changes have occurred).

Independent reviews (e.g., Independent Scientific Advisory Board [ISAB]) emphasized resolving the question through tests of the mechanisms (e.g., looking at the condition of fish exiting the powerhouse) and adaptive management approaches (e.g., monitoring the effects of increased spills on future SARs). However, because of large inherent variability, learning through adaptive management is likely to be a slow process.

Significance – High

Large differences in the predicted effects of changes to the dam system’s configuration and operation from two credible models imply that the data are not informative, and that the outcome of changes is highly uncertain.

Recommendations for Resolution

1. Prepare a comprehensive model development, calibration, and validation plan for both modeling frameworks that outlines the modeling assumptions, knowns, unknowns, current

Final Panel Comment 1

limitations, additional data (field, laboratory) needs, and future laboratory and field-based experimentation.

2. Perform additional studies to resolve the relative roles of the dam/reservoir system and the estuary/ocean environment in determining salmon survival, focusing on identifying and quantifying latent effects of a fish's experience in the dam/reservoir system on later survival. This will likely take significant time and effort.
3. In the short term, develop methods to quantify the level of uncertainty in projections of the effects of any proposed structural or operational changes to the dam/reservoir system, synthesizing the predictions of both modeling approaches.

PDT Final Evaluator Response (FPC #1)

X	Concur	Non-Concur

Explanation: The co-lead agencies agree that both models couch uncertainty in different ways using different underlying assumptions that are not explicitly stated. This leaves the reader with the onerous task of searching for these assumptions and how they impact the results. Both models are computationally intensive, yet produce relative comparisons of management scenarios. Rather than increasing uncertainty, this disparity in approaches and outputs highlights the true uncertainty which may not be evident if only one model were used. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Recommendation 1:	X	Adopt	Not Adopt

Explanation: The co-lead agencies agree that a comprehensive description of the model frameworks, assumptions, uncertainties and data needs is an important step to improve the interpretability of the models. Although the full spectrum of this recommendation may not be timely to implement, much of this could be clarified with a paragraph or table that explicitly outlines assumptions, uncertainties, and outstanding data needs that could inform a justification. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Recommendation 2:	X	Adopt	Not Adopt

Explanation: There are a number of confounding factors that complicate the estimation of SARs and associated variability. Quantifying latent effects of a fish's experience in the dam/reservoir system on later survival are intractable until updated information is available regarding causal mechanisms of survival limitations. Furthermore, latent mortality should not be estimated prior to determining the sensitivity about the given uncertainties in the model. Instead, additional studies should be part of a step-wise process: Step 1, outline the assumptions and uncertainties; Step 2, develop explicit sensitivity analyses about the assumptions to determine the relative risk of making "wrong" assumptions; Step 3: Determine which uncertainties are actually crucial to driving model predictions;

PDT Final Evaluator Response (FPC #1)

and Step 4: As the preferred alternative is implemented, develop study scopes to inform crucial uncertainties as informed by the sensitivity analyses. The last step could take significant time and would be part of an evaluation process for the Preferred Alternative, the Adaptive Management Framework which is described in Appendix R of the Final EIS.

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: Prospective runs are inherently more uncertain than retrospective because retrospective analyses are calibrated with real data. For projections, it's generally understood and accepted that credibility intervals will be extremely wide and the uncertainty particularly because there is also great uncertainty in the data used to calibrate the models. This fact is, estimating the uncertainty in around all measures is not necessarily useful to capture and not intuitive to manage using additional quantitative methods. The richest dataset in the world will not necessarily narrow the uncertainty in projections, at least not in a meaningful way that could better inform management. Uncertainty in the prospective analysis could be better managed through enhancing the dataset used to calibrate the model. Ideally, this would occur through evaluation of the Preferred Alternative after implementation.

Further, the EIS schedule does not allow for development of such methods, and it is not necessary for the co-lead agencies to make an informed decision under NEPA. Decision makers and the public have the outputs from the separate models that identifies the potential effects of each alternative.

Panel Final BackCheck Response (FPC #1)

☒ **Concur** ☐ **Non-Concur**

Explanation: Recommendation #3 applies to short-term decision-making. There are two modeling approaches, and sometimes their projections of the outcomes of an alternative differ substantially. There is a natural tendency to find reasons to support one model over another, and base decisions on that model's projections. This would be a mistake, even if those reasons are valid. Until more definitive evidence is available, both projections will be plausible. The spirit of Recommendation #3 is to communicate this clearly to those responsible for near-term decisions; if quantitative approaches are not warranted, some other method should be found.

Final Panel Comment 2

The results of testing performed to determine the CSS model's sensitivity to spill and the TDG upper limit may not accurately represent TDG exposures that lead to GBD.

Relevant Model Assessment Criteria

Model Usefulness in Selecting Alternatives

Basis for Comment

The CSS model sensitivity to spill and the TDG upper limit should be further tested, especially given the following statement: "We found that the most significant benefits to in-river survival rates and SARs occurred at the highest TDG limit spill levels, and that benefits under breached conditions at BiOp spill levels were higher than under impounded conditions at 125% spill levels" (McCann et al. 2017 CSS Annual Report, Chapter 2). The CSS model predicts that by increasing the spill levels to 125%, returning adults roughly double.

The increase in gas bubble mortality with increased spill is not considered explicitly, although it may be incorporated in the statistical relationships between spill and survival. In the juvenile survival model, the examination of the TDG effects is ad hoc and statistically suspect. If TDG is to be examined, it should be as another predictor in the Bayesian Cormack-Jolly-Seber (CJS) analysis. However, the analysis is probably sufficient to cast doubt on the importance of these effects. Since TDG is a function of spill, some TDG effects may also be indirectly incorporated through other predictors.

Questions arise: Is there an upper limit to TDG where mortality increases? What if the TDG cap were raised to 130%, 140%, etc.? Does the CSS model accurately represent TDG exposures that lead to GBD? Is the model falsifiable?

Field data analyzed do not indicate an effect of TDG percentage on survival, including data for involuntary spills of TDG up to 135% of saturation. One concern to this last point is that with high river flows resulting in 135% TDG during involuntary spill, the overall passage percentages and mixing conditions downstream may be different than during lower flow conditions with an elevated gas cap.

Significance – High

The implementation of the TDG component within the CSS model appears to be entirely insensitive to levels of TDG saturation. Until the model is more fully validated, especially for elevated TDG levels, support for high spill-level alternatives may result, which may prove detrimental to juvenile fish survival and ultimately adversely affect SAR.

Recommendation for Resolution

1. Develop a field-based experimental plan to assess the impact of high levels of TDG saturation, in particular under voluntary spill conditions. This approach should include multiple dams within the system to explore local configurations.

PDT Final Evaluator Response (FPC #2)

X	Concur		Non-Concur
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Explanation: The co-lead agencies agree that the potential for GBT is not fully addressed in the models. It is indeed possible, at some level of saturation, for GBT to limit survival relative to that predicted by the CSS, or even the COMPASS model. This is why the TDG model was also used.

Recommendation 1:	X	Adopt		Not Adopt
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Explanation: A field-based experiment (using the term strictly) to fully address this concern would be impracticable at best, given the range of TDG that would be necessary, the great difficulty in estimating exposures (accounting for depth compensation), and detecting symptom and measuring mortality rates due to GBT of free swimming fish. However, in recognition of many levels of uncertainty of fish response to higher spills (many of which are highlighted in this IEPR), an Adaptive Management process will be part of implementation of higher spills to serve the intent of the recommendation within operational and technological constraints. This process is described in Appendix R of the Final EIS.

In coordination with sovereign parties with interests in CRS spill operations, the Flexible Spill Working Group/RIOG will design a long-term study plan to assess the impacts of high spill on latent mortality on Columbia and Snake River salmon and steelhead. This issue will be revisited as data is collected to evaluate the Preferred Alternative as opposed to extrapolated model predictions. The study will need to address the following criteria: (1) statistically meaningful results; (2) within a reasonable timeframe; and (3) while providing safe fish passage.

Panel Final BackCheck Response (FPC #2)

X	Concur		Non-Concur
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Explanation: Agreed, field-based experimentation relating free swimming fish to TDG exposure will be complicated. The Panel encourages the Co-lead Agencies to continue to seek learning opportunities through an active adaptive management process and robust long-term study plan.

Final Panel Comment 3

The use of large sets of predictor variables in the LCM, COMPASS, and CSS models increases the probability of either finding false relationships or exaggerating the effects of any real relationships that end up in each predictive model.

Relevant Model Assessment Criteria

Model Assumptions and Limitations
Calculations and Formulas

Basis for Comment

Several models that sought to incorporate environmental influences suffer from “data dredging” (the term for investigating a large set of predictor variables relative to the length and amount of contrast in a data series). The effect of data dredging is a high probability of finding spurious relationships or of exaggerating the effects of any real relationships that end up in the predictive model (Myers, 1998).

All models that incorporate oceanographic indices have this issue; the most extreme case is the LCM ocean survival model, where 59 predictors are applied to only 14 years of data. Another example is the COMPASS model of smolt arrival at Lower Granite Dam, where two nominal variables, flow and temperature, are expanded to 31 potential predictors by subsetting by month and by using means and ranges and maximums for each month. In this analysis, each quantile regression involved fitting 31 predictors to 26 years of data.

Model averaging is only a partial solution. The guidance from the ecological modeling literature, including guidance by the leading proponents of a model averaging approach, is to minimize the number of potential predictors to avoid this issue. Pre-screening the variables by only formally estimating the effects of some does not solve this problem, if the pre-screening is to select those with the strongest relationships with the response variable. Spurious and exaggerated effects that would have been found by examining all predictors will be retained by this method of screening. Instead, a limited set of potential predictors to examine should be chosen *a priori*, based on the plausibility of the mechanisms by which they might affect the response variable (Anderson, 2008).

One of the CSS ocean survival models (McCann et al. 2017 CSS Annual Report, Chapter 2) has the same issue, with subsetting of predictors leading to 49 candidate predictors examined. In contrast, the CSS ocean survival/SAR model used in Chapter 3 of the 2017 Experimental Spill Management document is based on Haeseker et al. (2012), which only considered three oceanographic variables, avoiding this data dredging issue.

Additionally, sometimes the relationships found between predictors and response variables are poorly described, suggesting definitive cause-effect relationships when only correlative ones have been demonstrated, or overemphasizing statistically significant relationships that have small biological effects.

Example: The discussion of SAR and transported to in-river return ratio (TIR) models in the CSS documentation (CSS Oversight Committee [CSSOC] 2017 Documentation of Experimental Spill Management Report, page 33) covers a suite of predictors that are correlated with each other and are estimated in similar ways. PITPH is correlated with flow, WTT is correlated with flow, ocean survival is correlated with arrival time below Bonneville, run timing is correlated with flow. Inferring causality to

Final Panel Comment 3

any relationships with these variables is problematic without additional data supporting their mechanism of action.

Example: In Chapter 2 of the Zabel and Jordan 2019 Life Cycle Models of Interior Columbia River Basin Spring and Summer Chinook Populations technical memorandum (henceforth Zabel and Jordan 2019 LCM Report, which discusses COMPASS modeling results, Figures 1 and 2 show extremely small survival differences among groups (less than one percentage) and large overlap in the range of survival rates among these groups. In part of the Discussion section, the authors do characterize these differences as small and try to explain this result. In another part, however, they state "...the results for the upper Columbia COMPASS runs showed that both the 120-Perf and 125-Perf scenarios had consistently higher survival...", which the Panel feels is unwarranted.

Example: The McCann et al. 2017 CSS Annual Report (page 41) states that "...lower early ocean survival of transported fish may be attributable to the [Pacific Decadal Oscillation]." The Pacific Decadal Oscillation is merely a pattern of climatic variability, not by itself a mechanism that would lead to mortality in the ocean.

Significance – Medium/High

Application of the LCM, COMPASS, and CSS models would be enhanced by 1) using fewer variables and outlining clear linkages between the variables used and biological processes, and 2) presenting hypotheses that explain why these factors would result in observed patterns (e.g., differentially affect transported fish more than those that migrated in-river).

Recommendations for Resolution

1. Rebuild the LCM and CSS ocean survival models, following the example of Haeseker et al. (2012) in using fewer and broader-scale predictors, based on a plausible mechanism for an effect and support for this effect in the literature.
2. Rebuild the dam arrival timing model(s), again using fewer predictors. Consider whether the spline-smoothing issues could be avoided with simpler models, such as a beta shape with parameters dependent on these predictors. Possibly, capturing the mean and spread of the arrival timing distribution would be sufficient for the purposes of comparing alternative system structural/operational modes.
3. Systematically quantify the effect sizes of statistically supported predictive relationships, and describe their magnitude as well as their significance. Revise text where a causal explanation might be simply correlative. Describe clear connections between predictor variables and the ecological processes they represent based on hypotheses supported by literature.

Literature Cited

Anderson, D.R. (2008). Model based inference in the life sciences: a primer on evidence. Springer, New York.

Haeseker, S.L. et al. (2012). Transactions of the American Fisheries Society 141:121–138.

Myers, R.A.M. (1998). Reviews in Fish Biology and Fisheries 8:285-305.

PDT Final Evaluator Response (FPC #3)

X	Concur		Non-Concur
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Explanation: These are valid points. Ocean indices tend to be correlative because so little is known about causation, particularly as ocean conditions relate to the CRS. To limit the possibility of spurious relationships, model fit should also weigh parsimony or provide model evaluation criteria that more strongly penalize the number of variables. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Recommendation 1:	X	Adopt		Not Adopt
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Explanation: This may not require a “rebuild” of the model, but instead a simple paring down of predictor variables such that a comparable fit could be achieved at the expense of some lost information. The NOAA LCM, ocean survival model is based on more than 285,000 individuals, and it did not include models with more than 2 ocean indicators. However, the reviews clearly could not discern that. The predictor variables should be rooted in some assumption about the causal relationships. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementing this recommendation.

Recommendation 2:	X	Adopt		Not Adopt
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Explanation: This may not require a rebuild, but a model that includes fewer predictor variables with a different error structure. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team encourage implementation of this recommendation.

Recommendation 3:	X	Adopt		Not Adopt
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Explanation: This is a reasonable request that should be common practice in modeling exercises. Where causal relationships may not be known, support assumptions about causal mechanism with available or new hypotheses/justifications. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Panel Final BackCheck Response (FPC #3)

X	Concur		Non-Concur
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Explanation: Recommendation #1: We were aware that the LCM did not consider models with more than 2 ocean variables; nonetheless, 58 potential predictor variables were considered giving a total of 1,653 potential 2-variable combinations. Because of pre-winnowing, fewer combinations were actually fit (the 2017 documentation says 29 variables and the 2019 document 24 variables, for a total of 406 and 276 fits, respectively), but it is the larger number of models potentially considered that controls the possibility of finding spurious relationships.

Panel Final BackCheck Response (FPC #3)

Likewise, the statistical relationship between the oceanographic variables and annual survival is based on a sample size of 14, which is the number of years. The 285,000 fish sampled simply gives high precision to each of the 14 survival values.

Final Panel Comment 4

The COMPASS/LCM and CSS models are being used to extrapolate beyond the range of conditions to which they have been calibrated.

Relevant Model Assessment Criteria

Model Assumptions and Limitations
Model Usefulness in Selecting Alternatives

Basis for Comment

Both sets of models are used to extrapolate beyond the range of conditions to which they have been calibrated, including major changes to the structure and operation of the system up to the removal of four major dams, and potential changes to future ocean conditions. This reduces the confidence in critical model outputs such as salmon life-cycle survival, potential changes in latent mortality, etc.

In some cases, there appear to be insufficient data for crucial aspects of forecasting. Both COMPASS and CCS have used approximate assumptions for fish passage efficiencies at projects, stating that the COMPASS team chose Powerhouse Surface Passage efficiencies of 30% and 40% for sub-yearling and yearling Chinook, respectively, and 50% for Steelhead while CSS tried values of 10%, 20%, and 30% for all juvenile salmon. For comparison, at Wanapum Dam the Attraction Flow prototype collected less than 3% of the downstream migrants, whereas at the same dam, the Future Units Fish Bypass collected over 75% of the juvenile migrants, indicative of the wide-ranging effectiveness of surface passage devices. Similar, widely variable, data exists at Federal Columbia River Power System dams (e.g., Lower Granite). The use of such widely variable project- and passage-specific data raises concerns with regard to forecasting with models calibrated to historical data.

For the CSS model, the conclusion was drawn that TDG was not impacting survival. However, the data used to form this conclusion do not include larger TDG values expected in some prospective scenario analyses. No impact will be modeled because there is no modeled detriment to increased spill, although it is certain that there are impacts at some TDG levels. Also, the treatment of TDG as a predictor variable is separate from the other variables (CSSOC 2017 Documentation of Experimental Spill Management Report, page 28) and done in an exploratory/post-hoc way. Results may have been different if TDG had been included in the main model.

Significance – Medium/High

Although extensive work has been performed to calibrate the models to historical data, concerns remain about model assumptions and inherent predictability for future Columbia River System conditions, which extend beyond the calibration conditions.

Recommendations for Resolution

1. Describe the assumptions and limitations of the models for forecast mode, and note and discuss the implications when projecting to conditions beyond the calibration datasets.

Final Panel Comment 4

2. Prepare an adaptive research and development plan that will continue to improve the model approaches and predictability as the CRSO program moves into future years.

PDT Final Evaluator Response (FPC #4)

X **Concur** ☐ **Non-Concur**

Explanation: Agree partially. The shortcomings of forecasting unobserved or unobservable conditions should be discussed at length with proper justification of assumptions. The issue of unobservable states may not be resolved within a foreseeable timeline due to the logistical problem of implementation. It is unclear how one would design an experiment or simulation about the pre-project condition without either historical data to inform it or certitude that there will ever be an unimpounded condition within the foreseeable future to observe. While comments regarding TDG are reasonable, there are similar limitations. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Recommendation 1: ☒ **Adopt** ☐ **Not Adopt**

Explanation: Although the co-lead agencies generally agree with the suggestion to clarify and justify model assumptions, particularly as they relate to projections, unobserved states are incidental to forecasting. In the absence of data to inform unobserved states, modelers calibrate based on the past. This is foundational in standard modeling practice. If the data existed to inform these unobserved conditions, there would be no need to extrapolate them; however, this should be explained. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Recommendation 2: ☒ **Adopt** ☐ **Not Adopt**

Explanation: This will be a part of the Adaptive Management Framework as high spill is implemented to 125% to support fish passage as described in the DEIS, and described in Appendix R of the Final EIS. Evaluation of the implemented Preferred Alternative will help inform the dataset used to calibrate the models, which will also narrow the uncertainty about prospective runs.

Panel Final BackCheck Response (FPC #4)

X **Concur** ☐ **Non-Concur**

Explanation: The Panel encourages the Co-lead Agencies to continue to refine model documentation of limitations, assumptions and calibration and to seek learning opportunities through an active adaptive management process and robust long-term study plan.

Final Panel Comment 5

The model documentation often does not report the results of the assessment of model assumptions, fit, or validation.

Relevant Model Assessment Criteria

Model Documentation Quality
Representation of the System
Testing/Evaluation Processes

Basis for Comment

Ecological models are simplifications of reality that can aid understanding of the natural world but require simplifying assumptions that are not always valid. The usefulness of a model for predicting the consequences of management decisions depends upon the ability of the model to match observations (fit), and more importantly, the predictive capabilities of the model (validity). When a model performs poorly, it is often because the broad assumptions necessary to form the model have not been met. Conflicting results among models can often be explained based on model fit, validation, and assumptions.

The CRSO ecological model documentation does not contain sufficient information on model fit, validation, and assumptions for individual model components to be fully evaluated. For any model fitted to data, it is important to check model fit to ensure that model behavior is reasonable and to evaluate whether the fitted parameter values can be used with confidence (thus, measures of uncertainty should be presented alongside fitted parameter estimates). This transparency is important in a complex system with a web of interacting models that are constantly being updated and calibrated in new ways.

Because the models are being used by USACE to compare future operations, model validation is critical in understanding potential weaknesses in the modeling process. Model validation differs from model fit in that it is an assessment of how well the model performs against data not used in the calibration. It provides the most relevant indication of how well predictions of the future are likely to match reality.

COMPASS/LCM

Both applications of the COMPASS model (i.e., to generate both cohort-specific estimates for Snake River Chinook and steelhead and full life cycle estimates) generally seem to capture overall trends in the observed data. However, neither approach specifically quantifies model fit or uncertainty associated with specific parameters or with overall model components in the results. The COMPASS model documentation provides little to no discussion of the many model assumptions inherent within each component model, and the level of detail provided on important modeling decisions varies. Decisions to use fixed values for some model inputs are not defended at all. Decisions to exclude data because of poor precision in Appendix 1 (PIT Tag Data) should include quantitative evidence and commentary on the implications of excluding data. There is a model diagnostics appendix (Appendix 3), but it needs expansion, more explanation, and additional assessment of assumptions and model validation. The fit of the survival models appears to be poor (specifically the McNary-to-

Final Panel Comment 5

Bonneville portion and the Lower Granite Pool), which conflicts with statements in the Zabel and Jordan 2019 LCM Report that models fit the observed data well. The CJS models are part of this model set but are not discussed in any detail. In the COMPASS documentation Appendix 7, validation methods for the models predicting arrival time at Lower Granite Dam model are included, but these do not appear to be based on standard validation methodology using predictive accuracy. The two years nominally reserved for “cross-validation” are instead used to select a model form that provides smooth shapes to the arrival distribution.

For the LCM (Zabel and Jordan 2019 LCM Report, Chapter 4), there needs to be a more thorough explanation of how models were assessed and selected. It is unclear which models were included in the complete set, which is relevant for Akaike Information Criteria (AIC) comparison. Statements that ocean survival is independent of downstream and upstream survival estimates (page 4-1) and the exploratory nature of the ocean survival models (58 potential covariates; page 4-4) need to be discussed in detail.

Cross-validation is an excellent validation technique but should be applied to capture the dominant sources of variability. In the life-cycle modeling, K(10)-fold cross-validation of PIT tag data was run, but the validation was based on subsampling fish, rather than years. This was not the best approach, as the major source of variation to explain is the yearly effect of a single value of an environmental index on the ensemble survival of all fish. Therefore, the validation methodology likely substantially underestimates the prediction uncertainty. A more realistic estimate of uncertainty would be a leave-one-out cross-validation, removing an entire year’s worth of data each time.

TDG

The TDG model assumptions should be stated and the implications of violations discussed. This documentation has inconsistent and imprecise language for listed steps in the process (bottom of page 5). The details on data used to calibrate the model for mortality as a function of TDG should be described in the model documentation (i.e., what are the “x” values used for calibration; are they independent replicates?), and standard summary fit values should be provided (e.g., sample size, R^2 , standard errors). Detail is needed on the methodology for selecting depth distribution shape and parameters, along with the potential impacts of different shapes. No model validation is provided.

CSS

For all component models, important assumptions are made without discussion of the potential influence of those assumptions on model results. Specific examples include the following:

- 1) The level of tagging effort varies among populations or subbasins, so some areas may be overrepresented by the models.
- 2) In many locations, hatchery fish dominate the samples, but these fish may exhibit vital rates and behaviors that differ from those of wild individuals.

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3) Size and mortality are explicitly linked ecologically, but this linkage is not considered in the life cycle.

In Chapter 3 of the CSSOC 2017 Documentation of Experimental Spill Management Report (pages 34-35), model results are presented with no assessment of model fit (beyond simple plots) or best model selection. Although mixed models produce both marginal (averaged across random effects) and conditional (specific to individual group) predictions, it is unclear which predictions are plotted for comparison to observed values. Post-hoc consideration of TDG effects are based on t-values and may be inadequate. Random effects were used in various models to account for lack of independence among observations, but the implications of removing random effects based on Deviance Information Criteria (DIC) are not discussed. There was no documentation of model validation.

In Chapter 2 of the McCann et al. 2017 CSS Annual Report, AIC was apparently used to select the best model; however, the standard practice of reporting AIC comparisons is not followed, and no quantitative assessment of model fit is provided. The basis for selecting three representative years for prospective models (page 34) is not supported. The life cycle model is referred to as “statistically validated” (page 56), but no evidence of such validation is presented.

Significance – Medium/High

Validation is a fundamental part of the technical soundness and quality of a model. It is likely to reveal weaknesses in models, which leads to better understanding of the system being modeled as well as differences in model results in the CRSO. If the models do not fit or predict well, a review of assumptions can reveal important caveats for interpretation and targets for research improvements.

Recommendations for Resolution

1. Include an assessment of assumptions, model fit, and validation for each model component that is consistent with standard practices and justified by literature. It is likely that most of this assessment and possibly corresponding documentation of the assessment is currently available, but it should become part of standard documentation.
2. Include all model assumptions and potential consequences of departure from assumptions in the model documentation. Assumptions include the form of the model (e.g., linear, piecewise linear, quadratic); distribution of residuals (normal, binomial, beta); all relevant independence assumptions; appropriate range of inference; all variables considered; the strength and representativeness of the underlying datasets; and more.
3. List model fitting processes and decisions with justification and provide detailed final model fit statistics and graphics, following standard practices.
4. Assess the validity of all model components through prediction of observations not included in model calibration, and discuss the impacts of bias and lack of precision on decision-making.

PDT Final Evaluator Response (FPC #5)

X	Concur		Non-Concur
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Explanation: The FEIS will include text describing that the IEPR panel reported that the model documentation often does not report the results of the assessment of model assumptions, fit, or validation. This further highlights the uncertainty in model outputs. Further, this IEPR report, and responses will be included in an appendix to the Final EIS. The co-lead agencies will work with the modelers and encourage them to produce more comprehensive model documentation, assumptions, model fit, and validations.

Recommendation 1:	X	Adopt		Not Adopt
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Explanation: The co-lead agencies do not have any direct control over the modeling teams. However, the co-lead agencies recognize great value in well organized and clear documentation of assessments of assumptions, model fit, and validation for each model component that is consistent with standard practices and justified by literature. These data will provide a better understanding for working with the modelers, better understanding of applicability, and improved understanding of outputs in a risk framework. Therefore, the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Recommendation 2:	X	Adopt		Not Adopt X
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Explanation: The co-lead agencies do not control the model teams. However, the co-lead agencies recognize great value in well organized and clear documentation of all the areas listed in recommendation 2. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Recommendation 3:	X	Adopt		Not Adopt
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Explanation: The co-lead agencies recognize great value in well organized and clear documentation that includes a list of model fitting processes and decisions with justification and provide detailed final model fit statistics and graphics, which follow standard practices. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Recommendation 4:	X	Adopt		Not Adopt
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Explanation: The co-lead agencies recognize great value in well organized and clear documentation that includes assessments of the validity of all model components through prediction of observations not included in model calibration, and discusses the impacts of bias and lack of precision on decision-making. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Panel Final BackCheck Response (FPC #5)

X	Concur	Non-Concur
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Explanation: We appreciate that the Co-lead Agencies cannot induce the modeling teams to undertake additional work. However, we wonder if it might be possible to standardize the subsections related to models in Appendix E of the DEIS to include sections labeled (for example) “Model Assumptions”, “Model Uncertainties”, “Model Validation”, to assemble any mentions of these topics into one location. Then if information is not available for these sections, the section would simply state that the model team either has not performed (e.g., validation at this time), or that the information was not available for the EIS. In the very least, this would prevent readers from searching in vain for these types of results.

Final Panel Comment 6

The methodology for use of the powerhouse passage variable (PITPH) in the CSS model is not clear and may be statistically problematic.

Relevant Model Assessment Criteria

Theory and External Model Components

Basis for Comment

Throughout the CSS documentation, PITPH is used with very little description, and reference for more information is given as the 2015 CSS Report, Appendix J. However, the term PITPH is not used in Appendix J, and there is not enough detail in that appendix to clarify exactly how this parameter was used retrospectively and prospectively at various spatial and temporal scales.

Both retrospectively and prospectively, the PITPH metric estimates the expected number of powerhouse passages within a major segment (e.g., Lower Granite to McNary Dam) by summing powerhouse passage probabilities across projects. This estimator relies on the assumption that passage through each powerhouse is independent, and that fish guidance efficiency (FGE) is constant across all conditions within projects. These are important assumptions, and they should be discussed and defended within the model documentation, including the likelihood and implications of assumption violations. For example, if the likelihood of powerhouse passage decreases with fish length at certain spills (Harnish et al., 2020), then this sum would not adequately capture the expectation across the range of fish sizes and spill levels. The assumption that FGE is constant for each project (i.e., the proportion of fish that enter the bypass facility given that they have entered the powerhouse is invariant under different environmental conditions) is justified via citation, but more detail on the strength of the assumption and implications of assumption violation is needed.

When PITPH is used prospectively, it is predicted from a statistical model as a function of total flow, % spill, and the presence or absence of a spillway weir. The model is calibrated using PIT tag counts through the collection facility and constant estimated FGE for each powerhouse. Note that flow and % spill are not independent variables (i.e., if spill were held constant, % spill would be completely determined by flow). When multi-collinearity is present, predictions can be badly biased if the relationships between the correlated predictors change, which could be the case under changed operations. There may be a better way to formulate this regression rather than including flow and % spill as independent variables (for example, by using flow as an offset variable). The approach used to formulate the model should be reviewed and defended.

The PITPH dependent variable is estimated on multiple scales for use as an independent variable in multiple models (CSSOC 2017 Documentation of Experimental Spill Management Report, Chapter 3):

- 1) for individual release cohorts within a year (fish travel time model, juvenile survival model, ocean survival model, smolt-to-adult returns);
- 2) for population groups within release cohorts (Lower Granite Reservoir survival model, also known as detection probability model); and
- 3) annually (TIR).

Final Panel Comment 6

The different estimation efforts and assumptions required to form the estimate on these different scales are confusing and should be supported by much more detailed descriptions.

For prospective use, PITPH is a model prediction with multiple sources of uncertainty, including daily environmental stochasticity, measurement error of flow and percent spill, and uncertainty associated with model fit (parameter uncertainty) (see CSS Annual Report 2015, Figures J3 and J4). The models using PITPH as a predictor of salmonid life cycle parameters include WTT, which is also a function of flow. In this case, measurement error and stochasticity are impacting these models multiple times. For example, if juvenile survival in the year 2040 is predicted as a function of WTT and PITPH, the model equation includes 1) a weighted average of reservoir volume divided by flow (WTT) over the selected time period (average across dams within the large reach); and 2) a separate sum or average of flow and spill percent (average across dams within the large reach). The Panel is concerned about the impact of variance inflation and multi-collinearity on these model predictions.

The discussion surrounding PITPH in the ocean survival model (McCann et al. 2017 CSS Annual Report) also warrants careful review, as it is used as a predictor of ocean survival and discussed as though it is an observed variable, which it is not. If it is to be used as a predictor of ocean survival, the model predicting PITPH should be presented with coefficient values and detailed explanation of specific model calibration for this purpose. The explanation should include the exact flow rates and spill rates that were used to predict PITPH. The validity of using this layered modeling approach and the statistical implications should be carefully reviewed and described.

Significance – Medium/High

The powerhouse passage variable PITPH is a central focus of the CSS modeling effort, as the main link between project operations and impacts to salmonids. This variable has not been sufficiently defended and documented, and the Panel is concerned that inferences drawn from the variable may be improper or misleading.

Recommendations for Resolution

1. Assemble and clarify documentation of PITPH to include methods for estimation at all spatial and temporal scales, assumptions, and uncertainties.
2. Assess fit of retrospective models, and report standard errors and model limitations.
3. Assess predictive capability using standard validation techniques and report prediction error and potential biases.
4. Assess the implications of using a model prediction as a predictor in a statistical regression model, including potential bias and inflation of parameter uncertainty.
5. Properly caveat conclusions based on the findings of the above analysis.

Literature Cited

Harnish, R.A., K.D. Ham, T. Fun, X. Li, J.R. Skalski, R.L. Townsend, and J. Lady (2020). Juvenile salmon and steelhead passage and survival through the Snake and Columbia River hydrosystem during spring gas cap spill, 2018. Presentation at the Upper Columbia Science Conference, January 2020, Wenatchee, Washington.

PDT Final Evaluator Response (FPC #6)			
X	Concur		Non-Concur
Explanation: The co-lead agencies concur. We also had difficulty understanding and replicating PITPH estimates for alternatives. The FEIS will include text describing that the IEPR panel reported that the methodology for use of the powerhouse passage variable (PITPH) in the CSS model is not clear and may be statistically problematic. The DEIS included discussion on the potential for size selectivity of the bypasses to result in a bias in the CSS model that would overestimate the survival benefit reduced powerhouse encounters (PITPH). Additionally, this IEPR report and responses will be included in an appendix to the final EIS. The co-lead agencies do not have direct control over the modeling, but will work with the FPC modelers to encourage them to produce more comprehensive documentation of the calculation of PITPH.			
	Recommendation 1:	X	Adopt
			Not Adopt
Explanation: The co-lead agencies recognize great value in well organized and clear documentation of PITPH to include methods for estimation at all spatial and temporal scales, assumptions, and uncertainties. These data will help better understand potential bias, compare results among models, and understand model output relative of measures. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with the CSS model team to encourage implementation of this recommendation.			
	Recommendation 2:	X	Adopt
			Not Adopt
Explanation: The co-lead agencies recognize great value in well organized and clear documentation that includes assessments of fit of retrospective models, and reports standard errors and model limitations. These data will help better understand potential bias, and understand uncertainty in decision making. The co-lead agencies will work with the CSS modelers to encourage them to produce more comprehensive model documentation.			
	Recommendation 3:	X	Adopt
			Not Adopt
Explanation: The co-lead agencies recognize great value in well organized and clear documentation that includes assessments of predictive capability using standard validation techniques and reports prediction errors and potential biases. These data will help better understand potential bias, and understand uncertainty in decision making. The co-lead agencies will strongly encourage the CSS modelers to implement this recommendation.			
	Recommendation 4:	X	Adopt
			Not Adopt
Explanation: The co-lead agencies recognize great value in well organized and clear documentation that includes assessments of the implications of using a model prediction as a predictor in a statistical regression model, including potential bias and inflation of parameter uncertainty. These data will help better understand potential bias, and understand uncertainty in decision making. The co-lead agencies will work with the CSS modelers to encourage implementation of this recommendation.			
	Recommendation 5:	X	Adopt
			Not Adopt
Explanation: The co-lead agencies do not have any direct control over the modeling teams. However, the co-lead agencies recognize great value in well organized and clear documentation properly caveat conclusions based on the findings of all analysis. These data will help better understand potential bias,			

PDT Final Evaluator Response (FPC #6)

limitations, and understand uncertainty in decision making. The co-lead agencies will work with the CSS modelers to encourage implementation of this recommendation.

Panel Final BackCheck Response (FPC #6)

X	Concur	Non-Concur
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Explanation: We appreciate that the co-lead agencies cannot induce the modeling teams to undertake additional work. However, we wonder if it might be possible to standardize the subsections related to models in Appendix E of the DEIS to include sections labeled (for example) “Model Assumptions”, “Model Uncertainties”, “Model Validation”, to assemble any mentions of these topics into one location. Then if information is not available for these sections, the section would simply state that the model team either has not performed (e.g., validation at this time), or that the information was not available for the EIS. In the very least, this would prevent readers from searching in vain for these types of results.

Final Panel Comment 7

The TDG model lacks information on model formulation, data inputs, and sensitivity and uncertainty analyses conducted on the model.

Relevant Model Assessment Criteria

Model Documentation Quality

Basis for Comment

It does not appear that spillway-specific populations are modeled to experience any additional TDG exposure beyond the reservoir exposure after the populations are reassembled downstream of the dam. Increasing the TDG cap at the dams will allow increases in the percentage of total river flow passing through the spillway, thereby increasing both the percentage of juveniles using the spillway as a passage route and the percentage of fish exposed to high local levels of TDG within the spillway tailrace region. While these exposure durations would be short, these spillway-passed fish will have a different exposure history than other populations passing the powerhouse, sluiceways, or elevated spillway weir structures. Specifically, while all fish will be exposed to TDG levels consistent with the downstream compliance monitoring location (~120% at most dams), only spillway-passed fish are likely to briefly experience the high local TDG levels (~140% to 160% at many dams) in the spillway vicinity.

Additionally, the documentation of the TDG model lacks specificity on a number of input parameters and processes. In particular, the process for estimated tailrace TDG is unclear. Assuming variable TDG is assigned based on spillway discharge-tailwater elevation combinations, how are TDG rating curves established? As part of RESSIM or as part of SYSTDG?

Sensitivity to TDG production would benefit from a more thorough sensitivity analysis. In general, the models are constructed to facilitate sensitivity, uncertainty, and risk analyses, but the TDG model team has not fully completed these studies. Given the complexity and intermodal dependencies of these models, the potential for errors is not insignificant.

The data for calibrating the model components is very sparse and could potentially be expanded. The mortality model is based on a single, limited laboratory study, and the use of the data from the study is not described well or justified. For the depth distribution, a table of numbers from literature is given, but justification for the model selected is omitted.

Significance – Medium

Because increased TDG exposures in the spillway region are not taken into account and model documentation is incomplete, the TDG model may be used improperly or yield incomplete or inaccurate results with respect to alternative selection.

Recommendations for Resolution

1. Consider developing an additional TDG exposure relationship applied to spillway-passed juveniles that are exposed to local elevated levels of TDG saturation.

Final Panel Comment 7

2. Complete a thorough sensitivity and uncertainty analysis of the TDG model.
3. Revise the model document report to include input forcing data (TDG rating curves); the basis of data used for calibration and the limitations of available data; a discussion on model assumptions and limitations; and a more thorough sensitivity and uncertainty analysis.

PDT Final Evaluator Response (FPC #7)

X	Concur	Non-Concur

Explanation: The co-lead agencies decided not to present the fish mortality rate estimates from this model due to the paucity of calibration data available and the related lack of validation. However, the TDG exposure estimates from this model were presented for each alternative.

Recommendation 1:	X	Adopt	Not Adopt

Explanation: At most of the dams, high spill proportions due to unbalanced discharge across the tailrace form strong persistent eddies. These eddies cycle fish using spillway, turbine, and sometimes the bypass routes through the spilling basin or at least the spillway plume repeatedly. However, this is not the case at The Dalles and Bonneville. Therefore, this is a legitimate concern for bias, but small on a system level. Nevertheless, the co-lead agencies will work with the modelers to encourage them to consider how to include this exposure to very high TDG levels into the model.

Recommendation 2:	X	Adopt	Not Adopt

Explanation: A sensitivity analysis to all TDG model inputs was not carried out but could be performed. The current report addressed sensitivity to the range of TDG for the reservoirs estimated in the model. The co-lead agencies will work with the modelers to design and carry out a more thorough sensitivity analysis.

Recommendation 3:	X	Adopt	Not Adopt

Explanation: The co-lead agencies originally asked the modelers to include additional indices which were not published, including reach average exposure (reflecting migration rates due to flow). It would be straightforward to include representations of TDG inputs, the TDG reach average exposure, and its relationship with computed survivals. This should accompany a more extensive sensitivity analysis to model inputs.. The co-lead agencies will work with the modeling team to encourage implementation of this recommendation.

Panel Final BackCheck Response (FPC #7)

X	Concur	Non-Concur

Final Panel Comment 8

The model documentation does not assess impacts of model uncertainty on the prospective results.

Relevant Model Assessment Criteria

Model Documentation Quality
Representation of the System
Review of Model Usefulness in Selecting Alternatives

Basis for Comment

Documentation of the source and magnitude of uncertainty is especially important when models are used for predictions that influence management decisions, so decision makers can understand the implications of imperfect deterministic estimates. Decision makers will benefit from an evaluation of uncertainty that allows them to ask questions such as: How confident can I be that this estimate falls between these two values? How likely is a result that would change our interpretation of a management scenario?

Most of the documentation for the various models reviewed by the Panel acknowledged potential sources of uncertainty but lacked an analysis or appropriate discussion of the potential for uncertainty to influence results. Important assumptions were made with little or no discussion about the potential influence of those assumptions on model results. Additionally, in many cases model outputs were provided as deterministic estimates, without an explicit acknowledgment of potential uncertainty (e.g., confidence intervals). Interpretation of all results would benefit from a discussion of major areas of uncertainty and the scale of uncertainty in projections. Acknowledgment of specific parts of the model with lower certainty or consistent bias would provide more transparency.

COMPASS

No uncertainty was included for “fixed” estimates, such as dam survival, which were treated deterministically. Annual uncertainty was not discussed. Monte Carlo simulation mode allows users to incorporate uncertainty in survival predictions and to partition variance components. This approach is valuable, and the resulting graphs demonstrated uncertainty surrounding estimates. The Panel feels it would also be helpful to provide numerical estimates of uncertainty around mean survival estimates in results (e.g., simulations run for the CRSO EIS), so managers understand the magnitude of uncertainty associated with model output. Additionally, it would be helpful if results were presented to the number of decimal places to which the model is accurate; results with a large number of decimal places imply high precision. For the prospective modeling, the researchers looked at variability across years and populations in terms of arrival time to Lower Granite Reservoir, in-river survival, and proportion of juvenile fish transported. The analysis shows substantial variability across years and across some populations. This information could be used to inform sensitivity, uncertainty, and risk analyses for the survival estimates produced by COMPASS.

LCM

There is some uncertainty included in the COMPASS outputs and the LCM outputs, including confidence intervals for most estimates and projections. Additionally, some important potential sources

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of variability and uncertainty are described in the discussions. However, there is no comprehensive discussion of uncertainty, and the results are not clearly described in terms of what types of uncertainty are included or ignored. Within the full life cycle model, environmental variability/uncertainty is incorporated by drawing model parameters from a distribution or modeling them as stochastic, and model output is presented as a range of values, which is helpful. However, these inputs represent process variation, and there is no assessment or discussion of the potential for input data errors and modeling uncertainties.

TDG

No sensitivity or uncertainty information is provided. Because model output is dependent on values input for the variable TDG_c, uncertainty should be quantified. For this modeling approach, it would be valuable to partition uncertainty into environmental stochasticity, sampling error, and model error, and to discuss the implications of each error component.

CSS

Both applications of the model (i.e., to generate cohort-specific estimates, as well as full life-cycle estimates) generally seem to capture overall trends in the observed data. However, the model appears to underestimate variability observed in the PIT tag data for both in-river survival and ocean survival estimates, but no estimates of associated uncertainty are provided. Additional information on uncertainty associated with specific parameters, as well as the overall model and potential biases in each model component, would help readers understand how reliable model outputs are. Projections from prospective modeling are shown in result figures as “sensitivity analyses” used to illustrate predicted survival, abundance, and productivity under various management scenarios, but no accompanying discussion of uncertainty associated with specific assumptions used for these projections, such as dam breaching, is presented. There is no assessment or discussion of the potential for input data errors and modeling uncertainties.

Significance – Medium

When ecological models are used for decision making, underestimating uncertainty can lead to poor decisions.

Recommendations for Resolution

1. Within model documentation, identify areas of uncertainty and the scale of uncertainty in model projections. Discuss primary underlying assumptions and associated sources of uncertainty, identify potential sources of bias or error, and provide estimates of uncertainty for model output.
2. Perform quantitative uncertainty analyses or sensitivity analyses to evaluate the degree of confidence that can be placed on model output (or model components in the full life cycle models). This can help readers assess underlying differences between the modeling approaches.

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3. Include some measure of uncertainty when evaluating the differences between modeled scenarios and how these uncertainties influence rank order of alternatives. A conceptual diagram illustrating uncertainty in each component of the LCM and the relative magnitude of each could prove useful for comparing relative sources of uncertainty within and among models.

PDT Final Evaluator Response (FPC #8)

X Concur ☐ Non-Concur

Explanation: These are reasonable requests. Although process and data errors are well known complications to many modeling efforts, they should be fully described such that the reader may understand the inherent risk of a decision.

Recommendation 1: ☒ Adopt ☐ Not Adopt

Explanation: Modelers should provide categories that relate to “process” (model fit) and “observational” (data) risks. These do not need to be resolved in this exercise but should be acknowledged so a reader may understand how error is propagated through these models. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of his recommendation.

Recommendation 2: ☒ Adopt ☐ Not Adopt

Explanation: Although sensitivity analyses are part of good modeling practice, it is notoriously difficult to adequately capture “process” (model) vs “observational” (data) uncertainty while providing informative predictions. This is outside the scope of the EIS and not appropriate here. It is important to acknowledge these known shortcomings but not necessary to resolve them. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage them to provide additional language and documentation regarding these error types.

Recommendation 3: ☒ Adopt ☐ Not Adopt

Explanation: It is reasonable to provide hypotheses about how process and observational error may impact the predictions. It is not within scope to speculate the degree to which each error type drives the predictions. The EIS is an applied exercise, not an academic one. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Panel Final BackCheck Response (FPC #8)

X Concur ☐ Non-Concur

Panel Final BackCheck Response (FPC #8)

Explanation: It is precisely because the EIS is an applied exercise, not an academic one, that the Panel feels it is important for model documentation to acknowledge sources and relative magnitude of uncertainty. Each model component inherently includes both process and observational variance, and in many cases, the modelers do have an estimate of the magnitude of that variance. However, information regarding this uncertainty was not adequately included in descriptions of the numerous models when they were combined within a complete life cycle model. Additionally, confidence intervals were not included in some of the model output. It would be particularly useful if the EIS included a summary of what is known about uncertainty associated with each major life cycle component and how those uncertainties could impact results. This information would help decision-makers better evaluate the implications of decisions regarding those specific life stages.

Final Panel Comment 9

The scaling of data and models from one timeframe to another is confusing and has the potential to affect inference of certain variables.

Relevant Model Assessment Criteria

Representation of the System

Model Calculations/Formulas

Basis for Comment

Data used in the combined life-cycle models are collected at different time scales, including daily, in two-week cohorts, annually, and possibly others (the temporal scales of some predictor variables were ambiguous). Evaluating the relationship between predictive factors and response variables of interest over a daily or weekly timeframe provides important insights into these processes—for example, that smolt travel time decreases over the migration period (CSS) and smolt migration date is a significant predictor of first-year ocean survival (LCM). When combined into full life-cycle models, which are run at an annual time step, some variables calculated at shorter time steps are scaled up to an annual metric. In both the CSS and LCM, it is unclear exactly how this is done due to limited or confusing documentation. Ecological inference may change when relationships between variables are summarized at a coarser time step than that at which data were originally collected.

LCM

Chapter 4, Ocean Survival: It is not clear how COMPASS model results produced on a daily time step were integrated into climate change scenarios that necessarily use annual predictor variables. Specifically, the description of matching the annual Multivariate Auto-Regressive State-Space (MARSS) scenario data to predicted daily COMPASS output was confusing, and thus it was difficult to evaluate the effectiveness of this approach (Zabel and Jordan 2019 LCM Report, pages 4-14 and 4-15). It is also unclear how individual adult survival was calculated using average run timing distributions (since adult upstream survival decreases above a temperature threshold, one would expect the probability of individual adult survival to have a strong seasonal effect) and how this calculation was aggregated into an annual population survival estimate, which was then evaluated relative to average June temperatures (Zabel and Jordan 2019 LCM Report, page 4-15). Better documentation would help readers understand the potential implications of moving from short timeframes to annual time steps, and from individual-level metrics to annual, population-level responses.

CSS

In the CSSOC 2017 Documentation of Experimental Spill Management Report, observed and predicted values of in-river smolt survival, ocean survival, and SARs are estimated for outmigrant cohorts grouped at two-week intervals. These same parameters are estimated and modeled on an annual time step in Chapter 2 of the McCann et al. 2017 CSS Annual Report. The documentation does not specify how observed in-river survival, SARs, and ocean survival were calculated annually. It is unclear whether these annual values represent an average value, or if cohort estimates were used and somehow weighted by the proportion of the run represented by each cohort, or some other

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approach. Each of these different approaches comes with potential pitfalls and assumptions, so it is important to include enough methodological documentation that readers can understand potential implications of the methods employed. The predictor variables WTT and PITPH are also estimated on a two-week time step for individual release cohorts within a year in the CSSOC 2017 Documentation of Experimental Spill Management Report, and as an annual variable in the McCann et al. 2017 CSS Annual Report, but there is no clarification regarding how estimation methods vary between the time steps. It is unclear whether the annual values are somehow weighted by proportion of the migration at certain times/flows or if they are simply measures of average conditions across the entire migration period. When considered at these different temporal scales, predictor variables can take on different meanings, and as an annual measure may have considerably different inference than when measured by individual dam or for a discrete cohort of fish. For example, as an annual metric that statistically represents flow and spill, PITPH may be more representative of annual hydrography than a specific measurement of powerhouse passage, since powerhouse passage varies seasonally, with fish size, and among individual dam sites.

Significance – Medium

Because ecological inference may change when relationships between variables are summarized at different time steps, it is important to understand how variables are scaled from one time step to another, and when these variables are summarized or compiled, how their interpretation might change.

Recommendations for Resolution

1. Clarify methods used to scale up from smaller time steps to annual time steps and use diagrams and equations when possible. Describe methods used to estimate key parameters. Define predictors used in models within the model documentation. If a variable is used at multiple temporal scales, specify the scale each time the variable is used in the variable name (e.g., PITPH_{cohort} vs PITPH_{annual}) or define a different metric with a different name altogether.
2. Provide enough information about variables and relationships in the documentation in the form of equations, figures, estimates, etc., for readers to understand and validate the major ecological inferences and conclusions.

PDT Final Evaluator Response (FPC #9)

X	Concur	Non-Concur

Explanation: The co-lead agencies were uncertain of these methods, and a number of public comments on the DEIS also addressed question of scaling time step date. The IEPR report and responses will be included as an appendix to the Final EIS. The co-lead agencies do not have direct control over the modeling teams; however, we will work with the teams to better describe methods, including scaling of data and models from one timeframe to other time steps, and the implications to

PDT Final Evaluator Response (FPC #9)

inference of certain variables. These improvements to models and documentation cannot be accomplished in time to benefit the FEIS. However, they would be valuable for future applications.

Recommendation 1: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The co-lead agencies recognize great value in well organized and clear documentation of all methods including those used to scale up from smaller time steps, to estimate key parameters, and keeps clear the time scale of all variables. Therefore, the co-lead agencies will work with the model teams to encourage implementation of this recommendation.

Recommendation 2: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The co-lead agencies recognize great value in well organized and clear documentation that provides enough information about variables and relationships in the documentation in the form of equations, figures, estimates, etc., for readers to understand and validate the major ecological inferences and conclusions. Therefore, the co-lead agencies will work with the model teams to encourage implementation of this recommendation.

Panel Final BackCheck Response (FPC #9)

☒ **Concur** ☐ **Non-Concur**

Final Panel Comment 10

Simplifying assumptions applied to the adult migration portion of the life cycle decrease the accuracy and interpretability of the LCM and CSS models.

Relevant Model Assessment Criteria

Representation of the System

Basis for Comment

The adult freshwater portion of the salmon-steelhead life cycle encompasses freshwater migration through the hydrosystem and up to natal tributaries, a pre-spawn holding period, and spawning itself. A substantial body of research indicates that multiple factors influence survival during this period, including harvest quotas (fisheries), pinniped predation rates, water temperature, fish travel time, and the timing of freshwater entry. Both the CSS and LCM full life cycle models include simplified adult salmonid survival relationships that are unlikely to account for the complex set of factors that can influence survival during adult upstream migration and the pre-spawning period. Both models focus considerable effort on juvenile survival across short time steps (daily or for two-week cohorts) relative to multiple predictor variables. In contrast, adult survival is modeled as an averages for each year, without accounting for variability related to known processes, thus making unsupported assumptions about how management actions within the CRSO are expected to influence adult survival. Specifically, temperature, transportation history, and spill have been shown to influence adult survival (or at least “conversion rate”, a metric used to approximate adult survival), all of which have management implications within the CRSO. For example, higher spill at Columbia River dams has been linked to increased juvenile survival but decreased adult survival. The ability to evaluate such trade-offs is a particular strength of complete life cycle models, but to the Panel’s knowledge was not explicitly included in the current application of these models.

LCM

Documentation for the LCM states that adult survival includes all adult migration mortalities from arrival at the Columbia River mouth to spawning grounds, including estimated marine mammal predation in the Lower Columbia, harvest in the mainstem, upstream mortalities, and pre-spawn mortality above Lower Granite Dam. However, not all components are defined in each chapter or scenario, and it is not always clear how the various estimates were combined into a complete adult survival estimate. Complete model documentation should include equations with coefficient estimates and sources of input data for each different use of every model.

It is also unclear how harvest was accounted for in the model(s). The upstream survival component and the prediction of this component for prospective modeling is not well-described (Zabel and Jordan 2019 LCM Report, page 4-15). Specifically, this predicted relationship between annual survival rate and mean June temperature may not adequately capture important within-year variations in adult survival.

Inclusion of additional predictors of migration survival such as spill (Crozier et al., 2017) and fish transportation history (Keefer et al., 2008), as well as a separate component for pre-spawning mortality modeled relative to holding temperatures, could improve accuracy of the model. Some of these variables might have been included in predictions of individual fish survival but were not

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described in the documentation provided. Additionally, modeling adult survival on a shorter time step (daily or weekly) would allow evaluation of seasonal trade-offs, such as higher pinniped predation rates at the start of migration for early-season migrants (Keefer et al., 2012) vs. higher migration mortality related to high stream temperatures for late-season migrants (Crozier et al., 2017).

CSS

In the CSS model, the number of spawners was defined as the sum of the run of each age class of fish not harvested that survive migration passage for a given population and year. This definition would seem to account only for survival through the migration corridor (as suggested by the equations for predicted SAR), defined as returns to Lower Granite Dam (or the current location of Lower Granite Dam under breach scenarios). By this definition, the current CSS model would not account for pre-spawning mortality that occurs above Lower Granite Dam, which would lead to underestimates in the number of adult spawners since pre-spawning mortality has been observed in the populations of interest.

In addition, the migration conversion rates were not defined, and no values were given for this derived estimate (λ). Additionally, it was not clear where these values were located in the reference provided, (the reference was listed as “US vs. OR Biological Assessment Tables” in Table 2.1, McCann et al. 2017 CSS Annual Report), or whether this reference was for adult conversion rates or harvest schedules. For prospective analyses, harvest was modeled relative to abundance, but no equation was provided showing how this was calculated.

Conversion rate values (not provided) were drawn at random from the most recent 20 years of conversion rates. The assumption that adult migration survival (known as conversion rate in the model) is random is overly simplistic, and the theoretical underpinning for this assumption should be supported with data or literature. Inclusion of predictor variables, such as those evaluated in McCann et al. 2017 CSS Annual Report, Chapter 8, may provide more insight into the ecological function of the system and will explicitly acknowledge that adult survival is not completely random (e.g., there are multiple lines of evidence suggesting that adult upstream survival is lower in years with elevated water temperatures).

In the prospective analysis, the conversion rate represents survival rate after “adult losses net of harvest,” and those losses include predation, pre-spawn mortality, and passage-related mortality, which implies consideration of the adult life stage from freshwater entry to spawning (a slightly different definition than the one provided for λ in the life-cycle equations). As such, the subsequent assumption—that under a scenario in which the four Snake River dams are breached, there would be a 50% reduction in upstream mortality throughout that entire life stage—should be backed up with data and/or literature. The supporting data should demonstrate the relative contribution of mortality related to hydrosystem passage vs. pinniped predation and pre-spawning conditions, and the effect of this assumption on overall results should be discussed.

In Chapter 8 of the McCann et al. 2017 CSS Annual Report, the authors modeled adult survival relative to variables such as water temperature and juvenile transport, although it did not appear that these relationships were included in the overall life-cycle modeling. This approach seemed somewhat exploratory, as several different approaches were tested. The authors chose models based on what

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was the most biologically plausible to them and/or the lowest AIC value. The recommended approach for model selection using AIC is to first choose models that are biologically relevant, and then compare models using AIC (Burnham and Anderson, 2002), rather than to combine the two approaches. In this assessment, too many predictors and interactions were selected to be plausible for a 14-year time series. Although year was included as a random effect (so that each year would have an intercept offset), it is likely that within-year pseudo-replication was not adequately accounted for by this term. Possibly a random year/predictor interaction with temperature or arrival date would give better results. These issues aside, there appeared to be a negative effect of temperature on adult migration survival and a potential negative effect of transport. As these results become further developed, inclusion of these relationships in the complete life cycle model could improve accuracy of prospective models.

Significance – Medium

Although survival during the adult life stage is typically higher than for other life stages, failure to account for factors that influence survival during all components of the adult life stage, including freshwater entry, upstream migration, and holding prior to spawning, could lead to inaccurate estimates of spawner abundance. Failure to evaluate the relationship between environmental conditions and adult survival in models could lead to management decisions that benefit one life stage without adequate consideration of the cost to other life stages.

Recommendations for Resolution

1. Evaluate the importance of including additional environmental predictor variables and selecting appropriate time steps in the adult survival component of life cycle models to improve predictive accuracy.
2. Provide adequate documentation of each model use, including equations with parameter estimates and source of input data.

Literature Cited

Burnham, K.P., and D.R. Anderson (2002). Model selection and multimodel inference: A practical information-theoretic approach. Springer-Verlag, New York.

Crozier, L., L. Wiesebron, E. Dorfmeier, and B. Burke (2017). River conditions, fisheries and fish history drive variation in upstream survival and fallback for Upper Columbia River spring and Snake River spring/summer Chinook salmon. Report of research by Fish Ecology Division, Northwest Fisheries Science Center.

Keefer, M.L., C.C. Caudill, C.A. Peery, and S.R. Lee (2008). Transporting juvenile salmonids around dams impairs adult migration. *Ecological Applications* 18(8): 1888-1900.

Keefer, M.L., R.J. Stansell, S.C. Tackley, W.T. Nagy, K.M. Gibbons, C.A. Peery, and C.C. Caudill (2012). Use of radiotelemetry and direct observations to evaluate sea lion predation on adult pacific salmonids at Bonneville Dam. *Transactions of the American Fisheries Society* 141:1236-1251.

PDT Final Evaluator Response (FPC #10)

X	Concur		Non-Concur
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Explanation: The co-lead agencies concur that the upstream adult models are simplified, and that better addressing factors influencing adult survival would be beneficial in future uses of these models. For example, the relative benefit of juvenile transportation if it resulted in greater straying rates. However, as the review notes, the presumption is that improvements for the juvenile outmigration have larger potential gains as the adult migration is largely successful; therefore, fewer resources have been applied to research and modeling adult migrations. Nevertheless, the co-lead agencies will work with the modeling teams to improve the models to be more realistic, accurate, and better documented.

Recommendation 1:	X	Adopt		Not Adopt
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Explanation: The co-lead agencies recognize the great value in evaluating the importance of including additional environmental predictor variables and selecting appropriate time steps in the adult survival component of life cycle models to improve predictive accuracy. Therefore, the co-lead agencies will work with the model teams to encourage implementation of this recommendation.

Recommendation 2:	X	Adopt		Not Adopt
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Explanation: The co-lead agencies recognize great value in providing adequate documentation of each model use, including equations with parameter estimates and source of input data. Therefore, the co-lead agencies will work with the model teams to encourage implementation of this recommendation.

Panel Final BackCheck Response (FPC #10)

X	Concur		Non-Concur
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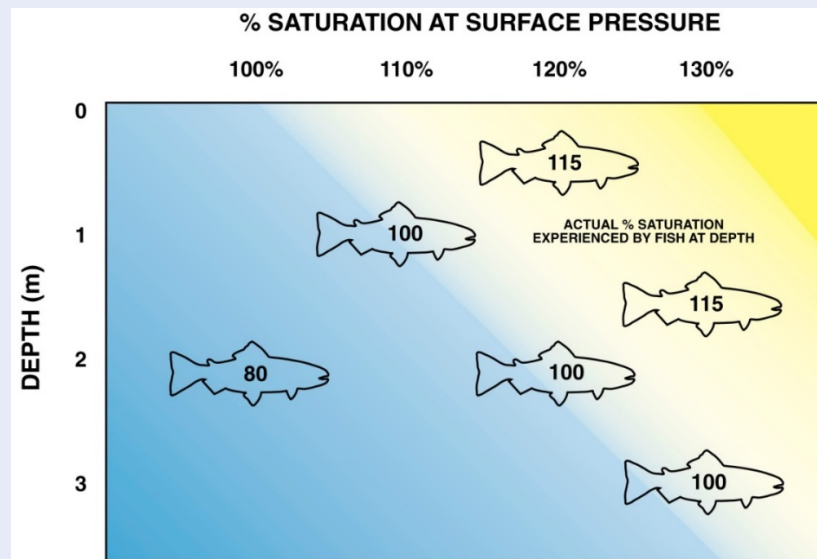
The biological effect of TDG supersaturation would be more accurately modeled if the Fish Individual-based Numerical Simulator (FINS) and/or Politano et al. models were used for the TDG analysis.

Relevant Model Assessment Criteria

Review Theory and External Model Components

Basis for Comment

Juvenile salmonids commonly occupy a range of depths during their migrations that result in varying exposure to TDG levels, as presented in the figure below. This varying exposure to supersaturation both limits the development of GBD and provides recovery from GBD when fish occupy depths at TDG levels lower than 100% saturation.



Relationship of measured and actual TDG levels experienced by fish at various depths.

The FINS (Scheibe and Richmond, 2002; Scheibe et al., 2002) and/or Politano (Politano et al., 2009, 2012, 2017) models could be used in a decoupled mode to run numerical experiments to better understand the relationship between fish behavior, depth distribution of juvenile salmonids, and their supersaturation exposure history. The results of these numerical experiments could be used to improve the simplified TDG exposure relations used in the larger system-scale population models.

The TDG model documentation provides several objections to using the FINS model that the Panel suggests be reconsidered. We recommend that the TDG modeling team explore ways to overcome these objections. The FINS and/or Politano models can be used to better understand the depth distribution, and duration at various depths, of juvenile salmonid migrants under different behavioral

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assumptions. The depth distribution / duration of exposure is the most important combination in determining the biological effects of TDG supersaturation.

Stated objections to the FINS model are as follows:

1. A three-dimensional (3-D) hydraulic model is required.
2. Information on the radio-tracked movement of fish is required.
3. FINS does not compute the mortality resulting from gas exposure.
4. Only a single reservoir is modeled.
5. FINS cannot be integrated with the other models used in the CRSO modeling system.

In response to these stated objections, the Panel offers the following counter-arguments for consideration:

1. FINS and/or the Politano model could be used as stand-alone models as they exist to explore the exposure history of radio-tracked fish, in particular, at projects with varying spill operations, subsequent levels of downstream TDG, and recorded biological data of gas bubble trauma. This has been done at a few select locations where associated model results exist. The Panel was unable to find reference to these data being reviewed or used by the TDG team in its development of the overall TDG model assumptions. Given the level of physics captured by FINS, and in particular the Politano model, a greater understanding of the driving physical mechanisms for elevated TDG can be explored, including the entrainment and entrapment of air at the plunge point of the spillway jet, the break-up and coalescence of bubbles, and the subsequent dissolution of gas into fluid (Wang et al., 2019).
2. In the absence of radio-tagged data, 3-D computational fluid dynamics models of a tailrace region along with numerical particle tracking data is a good surrogate for fish pathways and associated exposure history, as the energy and flow velocities in the spillway region far exceed the fish's swimming strength and ability for volitional movement.
3. True, neither FINS nor the Politano models directly compute mortality resulting from TDG gas exposure, but using these models along with field data should increase understanding of fish mortality and would potentially lead to more simplified causal relationships that may be later incorporated into CSS or COMPASS. However, the absence of any significant mortality and low incidence of GBD in monitored juveniles migrating within the study area indicates that an accurate model would not predict mortality.
4. True, both the FINS and Politano models only simulate a single reservoir—hence the need to run the models decoupled from CSS or COMPASS and use the results to improve understanding as stated above. As an example, the Politano model has been used at Wanapum and Well Dams (mid-Columbia), Brownlee and Hells Canyon Dams (Hells Canyon Reach) and McNary Dam (lower Columbia), providing a wide range of dam configurations, flow conditions, and reach-specific attributes.

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5. As previously stated, the Panel suggests using the models as decoupled, numerical tools to increase understanding of underlying processes and to advance more simplified relations that could be integrated into the populations dynamics models.

Incorporation of behavior (depths occupied by fish) is necessary for an accurate modeling of the supersaturation exposure fish actually receive.

Significance – Medium

Knowledge of the depths fish occupy during exposure to supersaturation is necessary to accurately predict the occurrence and severity of GBD and thus fish mortality. However, the absence of GBD observations in the fish sampled from the study area indicates that the migrants are spending sufficient time at depths adequate to compensate for up to 130% of saturation. Therefore, a more accurate model is not likely to alter conclusions or decisions.

Recommendation for Resolution

1. Develop a research plan to include these advanced technologies (FINS and/or Politano model) to improve the current TDG model and its implementation into the larger system-scale population models.

Literature Cited

Politano M., P.M. Carrica, and L. Weber (2009). A multiphase model for the hydrodynamics and total dissolved gas in tailraces. *Int. J. Multiphase Flow*, 35(11), 1036.

Politano M., A. Arenas Amado, S. Bickford, J. Murauskas, and D. Hay (2012). Evaluation of operational strategies to minimize gas saturation downstream of a dam. *Computer and Fluids*, 68, 168.

Politano, M., A. Castro, and B. Hadjerioua (2017). Modeling total dissolved gas for optimal operation of multireservoir systems. *J. Hyd. Eng.*, 143(6), 04017007.

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PDT Final Evaluator Response (FPC #11)

Concur	X	Non-Concur

Explanation: Based on assuming fish depths within the range of observed fish depths, the conclusion of the TDG model is that at some CRS spill levels, fish exposure could be near the critical threshold for GBT effects. This approach was parsimonious, giving a straight-forward way of comparing all the scenarios across 80 years. The co-lead agencies find no reason to suspect the mortality estimates, given the assumptions, were underestimated because: 1) the tailrace regions were not modeled where fish are exposed to very high TDG levels; 2) effects on fish experiencing acute rapid pressure changes in spillway and powerhouse passage were not modeled; 3) it was not possible to model the effects of cumulative exposure of CRS passage on lower river and estuary mortality; and 4) effects of TDG on smolt condition, their forage, or the interaction with temperature as might be expected with climate change were not considered.

These factors were not considered because the data are not available and the physiology mechanisms of GBT are only partially worked out and are uncalibrated. Most importantly, these types of inputs were not available for our part in the EIS process. The six-step mortality model of Scheibe, T.D., M.C. Richmond, and L.E. Fidler. (2002) noted by the Panel Review is a good first step, but as was noted in the paper and the Panel Review, more field and laboratory data are needed to move towards accurately assessing TDG effects. As acknowledged in point 3, the main issue is not addressed. Determining mortality response rates of free swimming fish would be very difficult and potentially not possible with current technology, but would also require creating TDG levels high enough to cause significant mortality. Then, for all of the modeling runs that are considered outside of historic observations and unprecedented conditions (e.g. the drawdown), the co-lead agencies would return to the more common critique of process models: that they should not be used to explore the unknown. The additional parameters required would require even further justification. More details lead to further uncertainty. The proposed approach is a reasonable avenue toward resolving the effects of TDG levels to free swimming fish; however, it does not address the most difficult portion of the problem. Such an effort is therefore unlikely to be prioritized for funding.

Recommendation 1:	Adopt	X	Not Adopt

Explanation: Due to uncertainty in TDG effects, latent mortality, etcetera, the co-lead agencies included in the Preferred Alternative, an Adaptive Management Framework to develop in conjunction with the Flexible Spill Working Group/RIOG a plan for rigorous evaluations to resolve the critical uncertainties around high spill. This process is described in Appendix R to the final EIS. The methods have not yet been determined.

Panel Final BackCheck Response (FPC #11)

X	Concur	Non-Concur

Explanation: The Review Panel recognizes the limits imposed by available research funds and the limited ability to improve this situation.

Panel Final BackCheck Response (FPC #11)

Recommendation 1: We hope that our comments are used to provide support for additional funding of investigations that will provide appropriate information to more accurately assess the role of TDG supersaturation in survival of migrating juvenile and adult salmonids.

The Review Panel continues to recommend that the modelers use or incorporate the more advance models to increase sensitivity to higher levels of TDG supersaturation and more accurately assess GBD potential at the higher levels of TDG supersaturation.

Final Panel Comment 12

An accurate TDG model requires data, or at least informed assumptions, regarding fish behavior to accurately assess the real TDG exposure migrants encounter and subsequent biological effects.

Relevant Model Assessment Criteria

Theory and External Model Components

Basis for Comment

Using a TDG model that relies on mean TDG levels perpetuates a misconception that mean TDG levels predict biological effects, namely GBD. Both fish populations and TDG levels vary with depth and spatial position in the tailrace region, resulting in unique incidence of exposure and subsequent renormalization for fish that remain at depth as they migrate downstream into areas of lower TDG levels.

Fish exposed to mean TDG levels in shallow water (e.g., hatchery troughs, raceways, or shallow tributaries) will have biological effects reasonably modeled by mean TDG levels, whereas fish exposed to mean TDG levels in conditions of substantial stream depth are not likely to be accurately assessed by mean TDG levels.

Additional research into the depth-exposure-biological response is needed to improve the TDG model. The use of coupled field/laboratory–numerical experiments, applying controlled environmental conditions and higher-order, physics-based models such as FINS (Scheibe and Richmond, 2002; Scheibe et al., 2002) or the Politano et al. and the Wang et al. (Politano et al., 2009, 2012, 2017; Wang et al., 2019) models, would result in a better understanding of actual GBD and the latent mortality from high TDG exposures.

Significance – Medium

The TDG model does not accurately model fish exposure to the TDG levels experienced by migrating juvenile salmonids. However, monitoring indicates that the levels of GBD and juvenile fish mortality occurring within the study area are sufficiently low therefore increasing the TDG model accuracy may not alter conclusions or alternative selection.

Recommendation for Resolution

1. Develop a research plan to better understand the impact of TDG exposure and depth on fish injury and mortality.

Literature Cited

Politano M., P.M. Carrica, and L. Weber (2009). A multiphase model for the hydrodynamics and total dissolved gas in tailraces. *Int. J. Multiphase Flow*, 35(11), 1036.

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Wang Y., M. Politano, and L. Weber (2019). Spillway jet regime and total dissolved gas prediction with a multiphase flow model. J. Hyd. Res., 57(1), 26.

PDT Final Evaluator Response (FPC #12)

X Concur ☐ Non-Concur

Explanation: The purpose of the current analysis was to show that **given** assumptions on fish depth and TDG exposure, the co-lead agencies expect a certain mortality rate. The TDG model was based on the limited laboratory studies showing significant mortality occurs beyond a threshold level of gas. Below that threshold, effects of gas are not detectable given the accuracy of CRS survival studies.

The co-lead agencies agree with the Review Panel that increasing the accuracy of the TDG model would not alter the alternative selection. Given the significant lack of information, it was better to proceed with a simple model compared to the alternative of developing or applying a complex model which has greater data demands. The model is accessible online and a user can vary the critical variables, fish depth, exposure time and TDG exposure to quickly realize the nature of the system and the need for additional data. The model does suggest that, if TDG levels reach levels near the threshold,, additional studies would be prudent and the first step along this path would be to develop a research plan to monitor effects and identify mechanisms of impacts

Recommendation 1: ☒ Adopt ☐ Not Adopt

Explanation: Due to uncertainty in TDG effects, latent mortality, etcetera, the co-lead agencies included in the Proposed Actions an Adaptive Management Frame to develop in conjunction with the Flexible Spill Working Group/RIOG a plan for rigorous evaluations to resolve the critical uncertainties around high spill. The methods have not yet been determined, but the process is described in Appendix R to the final EIS.

Panel Final BackCheck Response (FPC #12)

X Concur ☐ Non-Concur

Explanation: The Co-lead Agencies appear to recognize the value of the Review Panel recommendation and adopt the appropriate action.

Final Panel Comment 13

The model documentation does not provide the appropriate high-level descriptions of model assumptions, formulations, calibration, results, discussion, and conclusions or the materials to allow an independent modeler to use the models.

Relevant Model Assessment Criteria

Model Documentation Quality
Review of Operating Requirements of the Model

Basis for Comment

Many of the models have a long history that includes numerous modifications, some internally motivated and some suggested by external review such as the ISAB process. These improvements are ongoing, such that there have been many versions of a model. The documents provided to the Panel consisted of a mix of 1) documenting the equations, justifying the structure, and describing the parameterization (“fitting”) of a model, not necessarily for the most recent version (e.g., COMPASS Model – Main Documentation), 2) presenting analyses focused on modifying or extending the scope of a model (e.g., incorporating a new fish stock [McCann et al. 2017 CSS Annual Report, Chapter 6]), 3) presenting analyses potentially relevant to future model modifications (e.g., Zabel and Jordan 2019 LCM Report, Chapter 2), and 4) using models to predict the effects of a CRSO structural/operational scenario akin to, but not exactly corresponding to, a DEIS alternative (CSSOC 2017 Documentation of Experimental Spill Management Report, Chapter 3).

Although the Panel was given code and user manuals for some of the models, panel members experienced some difficulties in installation owing to a lack of adequate documentation. Panel members agreed not to use their limited time on attempting to run the software themselves. Thus, the Panel’s comments on these aspects of the charge are fairly limited. If, in the future, these models are to be made available for use by a more general audience beyond the modelers themselves, the Panel recommends more detailed instructions for installation and application, accompanied by a vignette that illustrates the basic uses.

The Panel’s charge was to establish that models, analyses, results, and conclusions are theoretically sound, computationally accurate, based on reasonable assumptions, well-documented, and in compliance with the requirements of the OMB Peer Review Bulletin (OMB, 2004). Due to the large number of models and variety of model usages contained in the documents for review, the panel members prioritized their reviews, focusing on models relevant to the DEIS. This focus required some searching through the documents provided, reviewing some material that was not originally provided, and obtaining some clarification and guidance from the modelers themselves. In particular, it was difficult to understand which models were used and which were not; which versions were used; and the interface between submodels, such as between the USACE HydSim model and the COMPASS juvenile migration and survival model, or between the COMPASS model and the LCM ocean survival or SAR models.

The documentation of many of the models was incomplete. The standard for such documentation is that a competent modeler should be able to recreate the model. The Panel found a range of clarity, from the quite good documentation of the COMPASS model (although not necessarily as good for the

Final Panel Comment 13

inputs), to the short and confusing documentation of the LCM adult upstream survival model, to the CSS documentation in which the only information about critical methods and variables was a reference to an outside document that was not provided.

Terminology was sometimes confusing. The definition of PITPH seemed inconsistent in different documents or document sections, and SAR could mean survival from an upstream dam to return to Bonneville, upstream dam to the same upstream dam, or Bonneville to an upstream dam. Sometimes the exact usage was not clear.

Significance – Medium/Low

A lack of adequate model documentation inhibits understanding; other modelers would not be able to replicate the models. A lack of accurate installation procedures means that interested parties would not be able to run or use the models.

Recommendations for Resolution

1. Document every component model thoroughly, including assumptions, limitations, validation, sensitivities, uncertainties, and areas of potential improvement.
2. Include alternative methodologies that could have been used and list pros and cons.
3. Create an overview of the documentation that addresses the technical aspects of the specific models used in the DEIS—in particular, the aspects not documented elsewhere (such as how submodels were integrated), with the goal of enabling a competent outside modeler to replicate the analyses.
4. Create an accurate installation guide, including minimum software needs, necessary to run the models.

PDT Final Evaluator Response (FPC #13)

X	Concur	Non-Concur

Explanation: Adequate documentation including describing assumptions, limitations, validations, sensitivities, and uncertainties is critical to developing a robust and replicable model framework. The co-lead agencies do not agree that an overview of potential modeling tools is necessary but recognize the value in other related applications. The co-lead agencies agree that some descriptions of the technical aspects could be better described, and that an end-user guide is warranted. The co-lead agencies will work with the modeling teams to incorporate these recommendations while encouraging them to provide a more complete documentation of technical methods, integration of sub-models, and assumption checking.

Recommendation 1:	X	Adopt		Not Adopt
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PDT Final Evaluator Response (FPC #13)

Explanation: The recommendation is valid and part of good modeling practice. Documentation should provide a basis for replication of methodology. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The co-lead agencies agree that the model documentation should be scrutinized and justified prior to implementation, but this does not warrant a comprehensive model comparison within the model documentation. Documentation should include descriptions of assumptions, uncertainty, and validation criteria. The documentation should also be sufficiently detailed such that an outside modeler could replicate. A comprehensive model comparison is outside the purpose of model documentation.

Recommendation 3: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The co-lead agencies agree, the descriptions of methodology should be detailed enough to enable replicable results. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Recommendation 4: ☒ **Adopt** ☐ **Not Adopt**

Explanation: This is a basic requirement of peer review. Source code should be replicable with adequate documentation to support end user implementation. These comments will be forwarded to the modelers to encourage further documentation, and the co-lead agencies will work with each model team to encourage implementation of this recommendation.

Panel Final BackCheck Response (FPC #13)

☒ **Concur** ☐ **Non-Concur**

Explanation: Recommendation #2 was “Include alternative methodologies that could have been used and list pros and cons. “ This recommendation was based on this comment in the “Basis for Comment” section: In particular, it was difficult to understand which models were used and which were not; which versions were used; and the interface between submodels, such as between the USACE HydSim model and the COMPASS juvenile migration and survival model, or between the COMPASS model and the LCM ocean survival or SAR models.

Our specific recommendation is that the FEIS includes more clarity around which version of the longstanding, constantly updated CSS and COMPASS models were applied to make decisions pertinent to the EIS. It would be helpful if this section were to list the available alternative configurations within (e.g.) COMPASS that were not used, and why the particular configuration was selected. Based on the PDT response “Documentation should include descriptions of assumptions, uncertainty, and validation criteria. The documentation should also be sufficiently detailed such that an outside modeler could replicate”, the PDT appears to agree with our intent.

Final Report for the Independent External Peer Review of the Economic Models Used for the Columbia River System Operations (CRSO)

Prepared by
Battelle Memorial Institute

Prepared for
Department of the Army
U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Mississippi Valley Division

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June 3, 2020

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Final Report for the Independent External Peer Review of the Economic Models Used for the Columbia River System Operations (CRSO)

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June 3, 2020

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Final Report for the Independent External Peer Review of the Economic Models Used for the Columbia River System Operations (CRSO)

Executive Summary

Project Background and Purpose

The U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and Bureau of Reclamation (Co-lead Agencies) are jointly developing a comprehensive Environmental Impact Statement (EIS), referred to as the Columbia River System Operations (CRSO) EIS, to evaluate long-term system operations and configurations of 14 multiple-purpose projects that are operated as a coordinated system within the interior Columbia River Basin in Idaho, Montana, Oregon, and Washington. USACE was authorized by Congress to construct, operate, and maintain 12 of these projects for flood risk management, navigation, power generation, fish and wildlife conservation, recreation, and municipal and industrial (M&I) water supply purposes. USACE projects that are included in the EIS are Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. The Bureau of Reclamation was authorized to construct, operate, and maintain the other two projects—Hungry Horse and Grand Coulee—for the purposes of irrigation, flood risk management, navigation, power generation, recreation, and other beneficial uses. The BPA is responsible for marketing and transmitting the power generated by these dams. Together, these Co-lead Agencies are responsible for managing the system for these various purposes, while meeting their other statutory and regulatory obligations.

The Co-lead Agencies will use this EIS to assess and update their approach for long-term system operations and configurations through the analysis of alternatives and evaluation of potential effects to the human and natural environments. The scope and scale of this project; its potential to impact human life safety; interest on the part of the Governors of Montana, Idaho, Washington, and Oregon, and 19 Federally recognized tribes; its connection to ongoing litigation on the Federal Columbia River Power System; and the likelihood for the project to result in public dispute drive a requirement for a heightened level of review and meet the criteria of a highly influential scientific assessment in Office of Management and Budget (OMB) and Bureau of Reclamation peer review policies.

The primary goal of economic model review and approval is to establish that models, analyses, results, and conclusions are theoretically sound, computationally accurate, based on reasonable assumptions, well-documented, and in compliance with the requirements of OMB Peer Review Bulletin (OMB, 2004). The primary criterion identified for model approval is technical soundness. Technical soundness reflects the ability of the model to represent or simulate the processes and/or functions it is intended to represent. The performance metrics for this criterion are related to theory and computational correctness. In terms of theory, a quality economic model should (1) be based on validated and accepted “state of the art” theory; (2) properly incorporate the conceptual theory into the software code; and, (3) clearly define the assumptions inherent in the model. In terms of computational correctness, a quality economic model

should (1) employ proper functions and mathematics to estimate functions and processes represented; and (2) properly estimate and forecast the actual parameters it is intended to estimate and forecast. Other criteria for quality economic models are efficiency, effectiveness, usability, and clarity in presentation of results. A well-documented quality economic model will stand the tests of technical soundness based on theory and computational correctness, efficiency, effectiveness, usability, and clarity in presentation of results. Three economic models are reviewed as part of the CRSO Economic Models Independent External Peer Review (IEPR): the CRSO Recreation Analysis Model, Snake Columbia Economic Navigation Tool (SCENT), and the Transportation Optimization Model (TOM).

Model Independent External Peer Review Process

Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analysis. USACE is conducting an IEPR of the CRSO Economic Models. As a 501(c)(3) non-profit science and technology organization, Battelle is independent, is free from conflicts of interest (COIs), and meets the requirements for an Outside Eligible Organization (OEO) per guidance described in USACE (2018a). Battelle has experience in establishing and administering peer review panels for USACE and was engaged to coordinate this IEPR. The IEPR was external to the agency and conducted following USACE and OMB guidance described in USACE (2018a) and OMB (2004). This final report presents the Final Panel Comments of the IEPR Panel (the Panel). Details regarding the IEPR (including the process for selecting panel members, the panel members' biographical information and expertise, and the charge submitted to the Panel to guide its review) are presented in appendices.

Based on the technical content of the documentation for the models and the objective of the models, Battelle identified potential candidates for the Panel in the following key technical areas: economics (two panel members) and a transportation modeling specialist. Battelle screened the candidates to identify those most closely meeting the selection criteria and evaluated them for COIs and availability. USACE was given the list of all the final candidates to independently confirm that they had no COIs, and Battelle made the final selection of the three-person Panel from this list.

The Panel received electronic versions of the model review documents and software along with a charge that solicited comments on specific sections of the documents to be reviewed. Following guidance provided in USACE (2018a) and OMB (2004), USACE prepared the charge questions, which were included in the draft and final Work Plans.

The USACE Project Delivery Team (PDT) briefed the Panel and Battelle on the development of each model and its intended application during a teleconference at the start of the review. The purpose of this teleconference was to familiarize the panel members with the models being reviewed. Other than Battelle-facilitated teleconferences, there was no direct communication between the Panel and USACE during the model peer review process.

IEPR panel members reviewed the model documents individually and produced individual comments in response to the charge questions. The panel members then met via teleconference with Battelle to review key technical comments and reach agreement on the Final Panel Comments to be provided to USACE. Each Final Panel Comment was documented using a five-part format consisting of (1) a comment statement; (2) relevant model assessment criteria; (3) the basis for the comment; (4) the significance of the comment (high, medium/high, medium, medium/low, or low); and (5) recommendations on how to resolve the comment.

Results, Recommendations, and Conclusions of the Model Independent External Peer Review

The panel members agreed on their assessment of the technical quality, system quality, and usability of CRSO Economic Models reviewed. The models are very comprehensive and provide a detailed comparison of alternatives under very flexible input specifications. However, the Panel has a number of concerns about the technical quality, system quality, and usability of the models and has provided specific recommendations to improve the models in the Final Panel Comments. Overall, 13 Final Panel Comments were identified and documented. Of these, one has been identified as having high significance, five have medium significance, five have medium/low significance, and two have low significance. Table ES-1 lists the Final Panel Comment statements by level of significance. The full text of the Final Panel Comments is presented in Section 5 of this report.

The Panel found the economic models reviewed in this IEPR to be successful in describing the project area conditions and complex interactions while taking into account policy, procedures, and regulations of the Co-lead Agencies. Given these parameters, based on the documentation provided, it appears that the models were generally developed in accordance with USACE's principles and guidelines, although the Panel noted the lack of adequate assessment of risk and uncertainty within the models and documentation. In general, the model documentation sufficiently describes the framework, inputs, operation, and outputs of the models. The CRSO Recreation Analysis Model documentation includes a step-by-step description of the general overall conceptual framework for a complex set of spreadsheets, which was accomplished within the EIS time and resource constraints. The SCENT Model documentation also walks the user through the model development process and model requirements; however, the Panel was unable to run the SCENT model using the files and documentation provided. The TOM documentation presents the structure of the model and includes the cost optimization equation and constraints that the model is based upon. The Panel finds that a considerable amount of high-quality, highly detailed flow, transportation mode, and cost data have been collected and compiled.

Based on the documents the Panel was asked to review, the Panel has a number of concerns about the technical quality, system quality, and usability of the models and has provided specific recommendations to improve the models in the Final Panel Comments. Concerns include the following:

- **CRSO Recreational Analysis Model** - The definitions of local versus non-local visitors for the CRSO Recreational Analysis Model should be closely reviewed because those definitions are dependent on the specification of the region. Using site-level definitions for impact analyses of Regions A through D and the CRSO area overestimates impacts. Additionally, the Panel could not replicate the estimates of the annual visitor expenditures under the No Action Alternative, or the allocation of the total visitor expenditures to IMPLAN sectors for the purpose of estimating regional economic effects.
- **SCENT** - The Panel noted that SCENT does not incorporate factors associated with congestion during a disruption/delay event, and the manner in which high-water conditions are incorporated into the SCENT disruption/delay matrix is unclear and possibly inaccurate. The Panel also found the SCENT User's Manual and files supplied to run the model to be unreliable, and the SCENT Model documentation incomplete. Although two different sets of files were supplied, the Panel was never able to run the model following the instructions provided in the User's Manual and documentation.

- **TOM** - The TOM documentation does not provide information on the relative cost of rerouting goods moving out of the Lower Snake River to support the assumption that modeling only wheat accurately represents the full impacts of Multiple Objective 3 (MO3).

These issues are important for the effective application of the models by experienced users and USACE staff. The Panel recommends that USACE and the modeling teams address these issues prior to finalizing the decisions made for the models' use.

Table ES-1. Overview of 13 Final Panel Comments Identified by the CRSO Economic Models IEPR Panel

No.	Final Panel Comment
Significance – High	
1	The CRSO Recreation Analysis Model inaccurately defines local versus non-local visitors when aggregating the impacts within economic Regions A through D and within the CRSO area as a whole.
Significance – Medium	
2	The TOM documentation does not provide information on the relative cost of rerouting goods moving out of the Lower Snake River to support the assumption that modeling only wheat accurately represents the full impacts of MO3, particularly during a disruption/delay event.
3	The SCENT User's Manual and files supplied to run the model were unreliable, and the SCENT Model documentation was incomplete.
4	The estimates of the annual visitor expenditures under the No Action Alternative could not be replicated.
5	The SCENT Model does not incorporate factors associated with congestion during a disruption/delay event.
6	The manner in which high-water conditions are incorporated into the SCENT disruption/delay matrix is unclear and possibly inaccurate.
Significance – Medium/Low	
7	The economic effects of a high-water year or a low-water year are not provided or accounted for in the analysis of alternatives within the CRSO Recreation Analysis Model.
8	The TOM documentation does not report results of an assessment of model assumptions, fit, or validation.

Table ES-1. Overview of 13 Final Panel Comments Identified by the CRSO Economic Models IEPR Panel (continued)

No.	Final Panel Comment
9	The CRSO Recreation Analysis Model and SCENT Model documents do not assess the impacts of uncertainty on the models' respective results.
10	The TOM documentation does not assess the impacts of uncertainty on the model's results.
11	Discussions of the interpretation and limitations of shipper survey data and waterway carrier survey data used to develop the disruption response matrix are incomplete.
Significance – Low	
12	Descriptions of the models that would allow an independent modeler to understand each model's functions and operational capabilities are not provided in a single, comprehensive document for each model.
13	The transportation cost minimization equations, as presented in the TOM documentation, do not accurately depict the underlying framework of the model.

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LIST OF ACRONYMS

ACF	Apalachicola-Chattahoochee-Flint
BLM	Bureau of Land Management
BPA	Bonneville Power Administration
CBM	Coalbed Methane
COI	Conflict of Interest
CRS	Columbia River System
CRSO	Columbia River System Operation
DrChecks	Design Review and Checking System
EC	Engineer Circular
EGM	Economic Guidance Memorandum
EIS	Environmental Impact Statement
ERDC	Engineer Research and Development Center
GAMS	General Algebraic Modeling System
H&H	Hydrologic and Hydraulic
IEPR	Independent External Peer Review
IWR	Institute for Water Resources
M&I	Municipal and Industrial
MO	Multiple Objective
NED	National Economic Development
NPS	National Park Service
OEO	Outside Eligible Organization
OMB	Office of Management and Budget
OPSEC	Operations Security
PCX	Planning Center of Expertise
PDT	Project Delivery Team
PSA	Project Site Area
SCENT	Snake Columbia Economic Navigation Tool
TMA	Travel Management Area
TOM	Transportation Optimization Model
USACE	United States Army Corps of Engineers

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1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and Bureau of Reclamation (Co-lead Agencies) are jointly developing a comprehensive Environmental Impact Statement (EIS), referred to as the Columbia River System Operations (CRSO) EIS, to evaluate long-term system operations and configurations of 14 multiple-purpose projects that are operated as a coordinated system within the interior Columbia River Basin in Idaho, Montana, Oregon, and Washington. USACE was authorized by Congress to construct, operate, and maintain 12 of these projects for flood risk management, navigation, power generation, fish and wildlife conservation, recreation, and municipal and industrial (M&I) water supply purposes. USACE projects that are included in the EIS are Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. The Bureau of Reclamation was authorized to construct, operate, and maintain the other two projects—Hungry Horse and Grand Coulee—for the purposes of irrigation, flood risk management, navigation, power generation, recreation, and other beneficial uses. The BPA is responsible for marketing and transmitting the power generated by these dams. Together, these Co-lead Agencies are responsible for managing the system for these various purposes, while meeting their other statutory and regulatory obligations.

The Co-lead Agencies will use this EIS to assess and update their approach for long-term system operations and configurations through the analysis of alternatives and evaluation of potential effects to the human and natural environments. The scope and scale of this project; its potential to impact human life safety; interest on the part of the Governors of Montana, Idaho, Washington, and Oregon, and 19 Federally recognized tribes; its connection to ongoing litigation on the Federal Columbia River Power System; and the likelihood for the project to result in public dispute drive a requirement for a heightened level of review and meet the criteria of a highly influential scientific assessment in Office of Management and Budget (OMB) and Bureau of Reclamation peer review policies.

The primary goal of economic model review and approval is to establish that models, analyses, results, and conclusions are theoretically sound, computationally accurate, based on reasonable assumptions, well-documented, and in compliance with the requirements of OMB Peer Review Bulletin (OMB, 2004). The primary criterion identified for model approval is technical soundness. Technical soundness reflects the ability of the model to represent or simulate the processes and/or functions it is intended to represent. The performance metrics for this criterion are related to theory and computational correctness. In terms of theory, a quality economic model should (1) be based on validated and accepted “state of the art” theory; (2) properly incorporate the conceptual theory into the software code; and, (3) clearly define the assumptions inherent in the model. In terms of computational correctness, a quality economic model should (1) employ proper functions and mathematics to estimate functions and processes represented; and (2) properly estimate and forecast the actual parameters it is intended to estimate and forecast. Other criteria for quality economic models are efficiency, effectiveness, usability, and clarity in presentation of results. A well-documented quality economic model will stand the tests of technical soundness based on theory and computational correctness, efficiency, effectiveness, usability, and clarity in presentation of results. Three economic models are reviewed as part of the CRSO Economic Models Independent External Peer Review (IEPR): the CRSO Recreation Analysis Model, Snake Columbia Economic Navigation Tool (SCENT), and the Transportation Optimization Model (TOM).

Report Organization

This report presents the approach and the results of the review of the CRSO Economic Models. It is organized into the following sections:

- Section 1 - Model Purpose, IEPR Evaluation Assessment Criteria and Approach, and Summary of Panel Findings – Describes the overall purpose of each model; explains the IEPR approach, including the review process and the criteria used to assess technical quality, system quality, and usability; and provides a high-level summary of the Panel's findings.
- Section 2 - Technical Quality Assessment – Summarizes the key issues identified from the model technical quality assessment.
- Section 3 - System Quality Assessment – Summarizes the key issues identified from the model system quality assessment.
- Section 4 - Usability Assessment – Summarizes the key issues identified from the usability assessment.
- Section 5 - Model Assessment Summary – Presents the full five-part Final Panel Comments prepared by the Panel.
- Section 6 - Conclusions – Summarizes the Panel's conclusions and overarching recommendations to resolve the key issues identified during the model review.
- Section 7 - References – Lists the references used for this model assessment and referenced from the model documentation.
- Appendix A - Information on the dates and steps followed to conduct the Model IEPR.
- Appendix B - Biographical information on the expert Panel selected to perform the review.
- Appendix C - The final charge guidance and questions to the Panel to guide its review of the CRSO Economic Models.
- Appendix D - The Conflict of Interest (COI) form that was provided with Battelle's original proposal.

1.1 Model Purpose and Summary

The purpose of each economic model reviewed as part of the CRSO Economic Models IEPR and a summary of what it does is provided here.

- **CRSO Recreation Analysis Model.** This model was developed through consultation with USACE staff, other cooperating agencies, and CRSO reservoir recreation managers. The method is based on an approach used for the Missouri River Recovery Management Plan Environmental Impact Statement. In general, the model evaluates how changes in reservoir, river, and wildlife habitat conditions under CRSO EIS alternatives could affect visitation, recreational opportunities, and the value of the recreation experience.
- **Snake Columbia Economic Navigation Tool (SCENT).** The SCENT is a model that calculates the additional transportation costs attributable to changes in flows and available draft on the commercially

navigable portions of the Columbia and Snake Rivers due to possible changes being studied in the CRSO study.

- **Transportation Optimization Model (TOM).** TOM was developed to specifically measure the impact of movements of shipments under proposed Multiple Objective Alternative 3 (MO3), which consisted of the intentional breaching of the four dams on the lower Snake River. The model is a constrained optimization model designed to capture the choices currently facing grain shippers that utilize the Columbia-Snake Navigation System, particularly the navigable portions of the Snake River system.

These models must be technically sound, represent the system being modeled, and have been reviewed for theoretical soundness and compliance with USACE planning policy and procedures.

1.2 Model Evaluation Assessment Criteria and Approach

Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analysis. The objective of the work described here was to conduct an IEPR of the CRSO Economic Models in accordance with procedures described in the Department of the Army, USACE, Engineer Circular (EC) *Review Policy for Civil Works* (EC 1165-2-217) (USACE, 2018a) and the OMB, *Final Information Quality Bulletin for Peer Review* (OMB, 2004). Supplemental guidance on evaluation for conflicts of interest (COIs) was obtained from the *Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports* (The National Academies, 2003).

USACE requires that all planning models be reviewed to ensure that they are technically sound. In this case, the IEPR of the CRSO Economic Models was conducted and managed using contract support from Battelle, which is an Outside Eligible Organization (OEO) (as defined by EC 1165-2-217). Battelle, a 501(c)(3) organization under the U.S. Internal Revenue Code, has experience conducting IEPRs for USACE.

This final report presents the findings of the IEPR Panel (the Panel) on the technical soundness and computational accuracy of the models and establishes whether the models' assumptions, analyses, results, and conclusions are well documented. Appendix A describes in detail how the IEPR was planned and conducted, including the schedule followed in executing the IEPR. Appendix B provides biographical information on the IEPR panel members and describes the method Battelle followed to select them. Appendix C presents the final charge to the IEPR panel members for their use during the review; the final charge was submitted to USACE in the final Work Plan according to the schedule listed in Table A-1. Appendix D presents the organizational COI form that Battelle completed and submitted to the Institute for Water Resources (IWR) prior to the award of the CRSO Economic Models IEPR.

The methods used to conduct the IEPR are briefly described in this section. The IEPR was completed in accordance with established due dates for milestones and deliverables as part of the final Work Plan; the due dates are based on the award/effective date and the receipt of review documents.

The Panel received electronic versions of the model review documents and software along with a charge that solicited comments on the quality of the model documentation, scientific theories, and usability. Following guidance provided in USACE (2018a) and OMB (2004), USACE prepared the charge questions, which were included in the draft and final Work Plans.

The Panel reviewed the CRSO Economic Models documents and produced 13 Final Panel Comments in response to 22 charge questions provided by USACE for the review. This charge also included two overview questions added by Battelle, for a total of 24 questions. Battelle instructed the Panel to develop the Final Panel Comments using a five-part structure:

1. Comment Statement (succinct summary statement of concern)
2. Relevant Model Assessment Criteria
3. Basis for Comment (details regarding the concern)
4. Significance (high, medium/high, medium, medium/low, or low; in accordance with specific criteria for determining level of significance)
5. Recommendation(s) for Resolution (at least one implementable action that could be taken to address the Final Panel Comment).

Battelle reviewed all Final Panel Comments for accuracy, adherence to USACE guidance (EC 1165-2-217), and completeness prior to determining that they were final and suitable for inclusion in the Final Model Report. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The Panel's overall findings are summarized in Section 1.3. The Panel's findings as they relate specifically to technical quality, system quality, and usability are discussed in greater detail in Sections 2, 3, and 4. Table 1 lists the Final Panel Comment statements by level of significance; the full Final Panel Comments are presented in Section 5.0.

Table 1. Overview of 13 Final Panel Comments Identified by the CRSO Economic Models IEPR Panel

No.	Final Panel Comment
Significance – High	
1	The CRSO Recreation Analysis Model inaccurately defines local versus non-local visitors when aggregating the impacts within economic Regions A through D and within the CRSO area as a whole.
Significance – Medium	
2	The TOM documentation does not provide information on the relative cost of rerouting goods moving out of the Lower Snake River to support the assumption that modeling only wheat accurately represents the full impacts of Multiple Objective 3 (MO3), particularly during a disruption/delay event.
3	The SCENT User's Manual and files supplied to run the model were unreliable, and the SCENT Model documentation was incomplete.
4	The estimates of the annual visitor expenditures under the No Action Alternative could not be replicated.

Table 1. Overview of 13 Final Panel Comments Identified by the CRSO Economic Models IEPR Panel (continued)

No.	Final Panel Comment
5	The SCENT Model does not incorporate factors associated with congestion during a disruption/delay event.
6	The manner in which high-water conditions are incorporated into the SCENT disruption/delay matrix is unclear and possibly inaccurate.
Significance – Medium/Low	
7	The economic effects of a high-water year or a low-water year are not provided or accounted for in the analysis of alternatives within the CRSO Recreation Analysis Model.
8	The TOM documentation does not report results of an assessment of model assumptions, fit, or validation.
9	The CRSO Recreation Analysis Model and SCENT Model documents do not assess the impacts of uncertainty on the models' respective results.
10	The TOM documentation does not assess the impacts of uncertainty on the model's results.
11	Discussions of the interpretation and limitations of shipper survey data and waterway carrier survey data used to develop the disruption response matrix are incomplete.
Significance – Low	
12	Descriptions of the models that would allow an independent modeler to understand each model's functions and operational capabilities are not provided in a single, comprehensive document for each model.
13	The transportation cost minimization equations, as presented in the TOM documentation, do not accurately depict the underlying framework of the model.

1.3 Summary of Findings

The panel members agreed on their assessment of the technical quality, system quality, and usability of the CRSO Economic Models reviewed. The models are very comprehensive and provide a detailed comparison of alternatives under very flexible input specifications, although the Panel noted the lack of adequate assessment of risk and uncertainty within the models and documentation. However, based on the documents the Panel was asked to review, the Panel has identified a number of concerns and has provided specific recommendations to improve the models in the Final Panel Comments. Concerns include the following:

- **CRSO Recreational Analysis Model** - The definitions of local versus non-local visitors for the CRSO Recreational Analysis Model should be closely reviewed because those definitions are dependent on the specification of the region. Using site-level definitions for impact analyses of Regions A through D and the CRSO area overestimates impacts. Additionally, the Panel could not replicate the estimates of the annual visitor expenditures under the No Action Alternative, or the allocation of the total visitor expenditures to IMPLAN sectors for the purpose of estimating regional economic effects.
- **SCENT** - The Panel noted that SCENT does not incorporate factors associated with congestion during a disruption/delay event, and the manner in which high-water conditions are incorporated into the SCENT disruption/delay matrix is unclear and possibly inaccurate. The Panel also found the SCENT User's Manual and files supplied to run the model to be unreliable, and the SCENT Model documentation incomplete. Although two different sets of files were supplied, the Panel was never able to run the model following the instructions provided in the User's Manual and documentation.
- **TOM** - The TOM documentation does not provide information on the relative cost of rerouting goods moving out of the Lower Snake River to support the assumption that modeling only wheat accurately represents the full impacts of Multiple Objective 3 (MO3).

These issues are important to the effective application of the models by experienced users and USACE staff. The Panel recommends that USACE and the modeling teams address these issues prior to finalizing the decisions made for the models' use.

2.0 TECHNICAL QUALITY ASSESSMENT

Analytical tools, including models, used for planning purposes need to be technically sound and based on widely accepted contemporary scientific theory. The economic impacts of CRSO, recreation at CRSO-related areas, and navigation and transportation of goods throughout CRSO must be reasonably represented by the model variables selected and must be supported by sound scientific studies. The model calculations must reflect how the system is expected to change with changes in project actions based on the application of scientific theory. Formulas and calculations that form the mechanics of the model must be accurate and correctly applied, with sound relationships among variables. The model should be able to reflect natural changes as well as the influence of laws, policies, and practices. All model assumptions must be reasonable and should be well-documented. The analytical requirements of the model must be identified, and the model must address these requirements. The model should also

produce robust, reproducible results that stand up to rigorous scrutiny in later stages of the plan formulation process. The results of the Panel's assessment of these criteria are summarized in the following sections.

2.1 Model Documentation Quality

The model documentation provided to the Panel for review of the three economic models consisted of a collection of documents developed for a variety of reasons at different times in the life of each model, rather than a cohesive document that reported on the specific model used to conduct the CRSO modeling of the alternatives. Throughout the remainder of this report, the Panel will outline how the lack of coherent and accurate documentation of the specific model and parameters used impacted the Panel's ability to establish that the models, analyses, results, and conclusions are theoretically sound, computationally accurate, based on reasonable assumptions, well-documented, and in compliance with the requirements of the OMB Peer Review Bulletin (OMB, 2004).

Final Panel Comment 12 specifically addresses the importance of compiling a single, comprehensive document for each model. Although listed as a medium/low significance comment because of the definitions of each significance level (medium/low is a documentation issue), Final Panel Comment 12 outlines how the lack of accurate high-level descriptions and thorough documentation affected the Panel's review. First, it hindered the Panel's ability to understand the assumptions, formulations, calibration, results, discussion, and conclusions of the models used for the CRSO analysis. Second, it prevented the Panel from using the models. Over half of the Final Panel Comments (2 through 4, 8 through 10, and 13) further outline specific issues related to the lack of information on model formulation, data inputs, assumptions, and sensitivity and uncertainty analyses conducted on the model.

2.2 Theory and External Model Components

The Panel agreed that the theory and external model components of the three economic models are sufficiently developed. No issues were identified during the review of these parts of the model.

2.3 Representation of the System

The Panel believes that the current economic models have value in the current EIS process, but that there are changes that could improve the models in their present form. From a conceptual standpoint, the Panel agrees that, in general, most of the model components used in the three economic models do a reasonable job of characterizing and projecting the various impacts being modeled. However, the Panel had several concerns that focus on potential discrepancies in representing the CRSO system, which could impact the overall economic impact assessment.

The Panel's greatest concern is that the CRSO Recreation Analysis Model inaccurately defines local versus non-local visitors when aggregating the impacts within economic Regions A through D and within the CRSO area as a whole (Final Panel Comment 1). Currently, the local and non-local visitor information is based on a site-level analysis. The Panel believes the site-level data is correct, however, when aggregated at the region and CRSO-area levels, adding all of the site-level data together overestimates the non-local impacts. A city or town that may not be local at a site level may be local at a regional or CRSO-area level. Other concerns related to the CRSO Recreation Analysis Model include the fact that the model does not calculate or account for the economic effects for a high-water year or a low-water year (Final Panel Comment 7), and the documentation does not assess the impacts of uncertainty on the

model results (Final Panel Comment 9); therefore, the Panel cannot assess the overall accuracy of the model.

When reviewing the SCENT Model, the Panel noted that (1) it does not incorporate factors associated with congestion during a disruption/delay event (Final Panel Comment 5), (2) the manner in which high-water conditions are incorporated into the SCENT disruption/delay matrix is unclear and possibly inaccurate (Final Panel Comment 6), and (3) discussions of the interpretation and limitations of shipper survey data and waterway carrier survey data used to develop the disruption response matrix are incomplete (Final Panel Comment 11). Without taking into account impacts from congestion and high-water / low-water conditions, the SCENT model does not reflect the real-world situations that could occur. Since the SCENT model documentation does not assess the impacts of uncertainty on the model results (Final Panel Comment 9), the Panel cannot assess the overall accuracy of the model.

In relation to the TOM, the Panel noted that the TOM documentation does not provide information on the relative cost of rerouting goods moving out of the Lower Snake River to support the assumption that modeling only wheat accurately represents the full impacts of MO3 (Final Panel Comment 2). The concern is that if wheat is the costliest commodity to reroute, the likelihood of it being delayed is less when compared to other commodities. Therefore, the impacts may be greater than estimated. Since the TOM documentation also does not assess the impacts of uncertainty on the model results (Final Panel Comment 10), the Panel cannot assess the overall accuracy of the TOM results.

2.4 Analytical Requirements

The Panel agreed that the analytical requirements of the three economic models are well-developed. However, the Panel was unable to replicate the estimates of the annual visitor expenditures under the No Action Alternative, or the allocation of the total visitor expenditures to IMPLAN sectors for the purpose of estimating regional economic effects using the approach described in the CRSO Recreational Analysis Model documentation (Final Panel Comment 4).

2.5 Model Assumptions and Limitations

As noted under Sections 2.1 and 2.3, the Panel believes that the documentation of and reasoning behind the various model assumptions and limitations is not always clear. At a minimum, the model documentation should contain a standard section listing assumptions and limitations relevant to the version of each model being used for the CRSO assessment. Of the nine Final Panel Comments the Panel stated as being relevant to the model assumptions and limitations, six of the Final Panel Comments (Final Panel Comments 1, 2, 5, 6, 10, and 11) have previously been discussed under Section 2.3, Representation of the System. The three Final Panel Comments that have not been previously discussed are discussed below.

The Panel could not replicate the estimates of the annual visitor expenditures under the No Action Alternative or the allocation of the total visitor expenditures to IMPLAN sectors for the purpose of estimating regional economic effects (Final Panel Comment 4). Using the approach described in the CRSO Recreational Analysis Model documentation, and the data provided for several locations in different regions as examples, the Panel attempted to reproduce the detailed visitor expenditure estimates for the No Action Alternative as provided in the documentation. However, in each instance the values could not be replicated.

An important aspect of understanding any model is understanding the model assumptions, fit, limitations, and method of validation. The Panel noted that the TOM documentation does not report on the assessment of the model assumptions, fit, or validation (Final Panel Comment 8), while the CRSO Recreational Analysis and SCENT Models do not assess model uncertainty (Final Panel Comment 9). Including this information is important in assessing the accuracy of the model results; therefore, the Panel believes it should be clearly documented.

3.0 SYSTEM QUALITY ASSESSMENT

System quality refers to the quality of the entire system used to develop, use, and support the model. In general, the Panel's evaluation of system quality included assessing whether the model's calculations and formulas were correct and whether the models had been tested and validated. The results of the Panel's assessment of system quality are summarized in the following sections.

3.1 Model Calculations/Formulas

As noted throughout Section 2, the Panel noted several concerns with the model calculations and formulas that they believe will impact the model outputs, including (1) the definition and use of local versus non-local visitors in the CRSO Recreation Analysis Model calculations for regions and for the CRSO area (Final Panel Comment 1), (2) the calculation of annual visitor expenditures under the No Action Alternative, since the Panel could not replicate several of the estimates provided (Final Panel Comment 4), and (3) the manner in which high-water conditions are incorporated into the SCENT disruption/delay matrix (Final Panel Comment 6).

The Panel also noted that the transportation cost minimization equations, as presented in the TOM documentation, do not accurately depict the underlying framework of the model (Final Panel Comment 13). The Panel asked about this calculation during the Mid-Review Teleconference call with USACE and was told that the equations in the documentation were incorrect; therefore, the Final Panel Comment has been provided as a low significance since the calculation was done correctly in the model, and only the documentation needs to be fixed.

3.2 Testing/Evaluation Process

As already suggested, to ensure that the TOM represents the system, the TOM documentation should report the results of an assessment of model assumptions, fit, and validation (Final Panel Comment 8), and all three models should provide information on the levels of uncertainty on the models' respective results (Final Panel Comments 9 and 10).

4.0 USABILITY ASSESSMENT

Usability refers to how easily model users can access and run the models, interpret model output, and use the model output to support planning decisions. An assessment of model usability includes evaluating the availability of data required to run the models and the ability of the user to learn how to use the model properly and effectively. Model outputs should be easy to interpret, useful for supporting the purpose of the model, easy to export to project reports, and sufficiently transparent to allow for easy verification of

calculations and outputs. The results of the Panel's usability assessment are summarized in the following sections.

4.1 Operating Requirements of the Model

The CRSO Recreational Analysis and TOM models were run by the Panel based on the information supplied. For TOM, the run used data that differed from the actual TOM findings as presented and assessed in the CRSO DEIS. Therefore, the Panel could not replicate the original findings. However, the Panel could not get SCENT to run. As noted in Final Panel Comment 3, the Panel tried following the SCENT User's Manual using two sets of files supplied to run the model; however, panel members were not able to get the model to actually run. The Panel believes that additional documentation and revisions to the model provided to the Panel are necessary to ensure that an independent operator can run the model.

4.2 Input Availability and Output Understandability

The Panel agreed that the input availability and output understandability of the three economic models is satisfactory. No specific issues were identified during the review of these parts of the models.

4.3 Condition Characterization Usefulness

The Panel agreed that the condition characterization usefulness of the three economic models is sufficiently developed. No issues were identified during the review of these parts of the models.

4.4 Model Usefulness in Selecting Alternatives

The Panel raised five concerns it believes will impact the use of the models for selecting the alternatives. All five have been previously mentioned: (1) the CRSO Recreation Analysis Model inaccurately defines local versus non-local visitors when aggregating the impacts within economic Regions A through D and within the CRSO area as a whole (Final Panel Comment 1), (2) estimates of the annual visitor expenditures under the No Action Alternative could not be replicated (Final Panel Comment 4), (3) the SCENT Model does not incorporate factors associated with congestion during a disruption/delay event (Final Panel Comment 5), (4) the manner in which high-water conditions are incorporated into the SCENT disruption/delay matrix is unclear and possibly inaccurate (Final Panel Comment 6), and (5) no calculations of the economic effects for a high-water year or a low-water year are provided or accounted for in the analysis of alternatives within the CRSO Recreation Analysis Model (Final Panel Comment 7). The Panel's main concern is that without these changes being taken into account, the overall economic impact of each alternative may not be accurately assessed.

5.0 MODEL ASSESSMENT SUMMARY

This section presents the full text of the Final Panel Comments prepared by the IEPR panel members.

Final Panel Comment 1

The CRSO Recreation Analysis Model inaccurately defines local versus non-local visitors when aggregating the impacts within economic Regions A through D and within the CRSO area as a whole.

Relevant Model Assessment Criteria

Representation of the System

Model Assumptions and Limitations

Model Calculations/Formulas

Model Usefulness in Selecting Alternatives

Basis for Comment

The CRSO Recreation Analysis Model's methodology for estimating regional economic effects using IMPLAN is based on the distinction between local and non-local visitors. Only changes in non-local visitor expenditures are used to determine regional economic effects; therefore, the definition of local versus non-local influences the magnitude of the estimated effects. Non-local visitors are considered to be those traveling more than 60 miles *to the site* for National Park Service (NPS) locations and more than 30 miles *to the site* for USACE locations. The regions in the recreation analysis are very large, extending more than 60 miles from most sites to major centers of population or from one side of the region to the other. So, it seems a visitor could be counted as a non-local relative to a particular site location, thereby including the loss of their trip expenditures in the regional IMPLAN analysis, when those expenditures should be counted as local *to the region*, in which case the loss of their expenditures should be excluded from the IMPLAN analysis. This methodology leads to an overestimation of the economic effects under each alternative for Regions A through D and for the CRSO area as a whole.

Site-level Analysis - As an example, all visitors from Seattle would be considered non-local visitors to Regions A, B, C, and D. Seattle is more than 60 miles outside of any of the CRSO sites, and King County, Washington, where Seattle is located, is not included within any of the CRSO regions (see Table 2-5 of CRSO DEIS Appendix M). Therefore, all lost visits to every site in Region A from people who live in Seattle should be counted as lost economic activity to Region A. Similarly, all lost visits to every site in Region B from people who live in Seattle should be counted as lost economic activity to Region B, and so on for Regions C and D.

To aggregate the economic impact to Region A from these lost Seattle-resident visits, simply add up the economic impact at each site in Region A, and so on for Regions B, C, and D. To aggregate the economic impact across the entire CRSO area, simply add up the economic impact across all regions.

Region-level Analysis - Portland, Oregon, however, is located in Multnomah County, which is considered part of Region D in the recreation analysis (see Table 2-5 of CRSO DEIS Appendix M). Portland is far enough from John Day Dam that Portland visitors would be considered non-local to the site, even though they reside within the same economic region (Region D). So, lost visits from Portland residents to John Day Dam should be included in an IMPLAN analysis of the economic

Final Panel Comment 1

impacts *at the John Day Dam site*. But lost visits from Portland to John Day Dam are *local to Region D*. Therefore, it is inappropriate to include those lost visits in an IMPLAN analysis of the economic impacts *to the region*, because the money the Portland visitors would have spent at John Day Dam is still being spent within Region D. To correctly assess the economic impact to each region, one must define local versus non-local visits *to the region*. It is inappropriate to simply add up each of the site-level impacts across the region.

CRSO Area-level Analysis - The same issue arises when estimating the impacts to the entire CRSO area. A new definition of local versus non-local to the CRSO must be employed. It is inappropriate to simply add up each of the region-level impacts. For example, lost visits in Region B from visitors who reside in Region A should be included in an IMPLAN analysis of Region B; those lost visits should not be included in an IMPLAN analysis of the entire CRSO because the Region A visitors are local to the CRSO area.

Significance – High

As currently reported, the methodology for estimating regional economic effects misrepresents aggregate impacts to the CRSO (i.e., treating visits by those who reside in a region as non-local to the region if they travel more than 30/60 miles to a site) and applies a faulty assumption (i.e., non-local visits to a site are also non-local visits to the CRSO).

Recommendations for Resolution

1. Define local versus non-local visitors to each economic region (A through D), as opposed to each site.
2. Define local versus non-local visitors to the entire CRSO area, as opposed to each site and economic region.
3. Run IMPLAN models for each economic region using the appropriate definition of local versus non-local visits to the region in order to aggregate the economic impacts from changes in recreation within Regions A, B, C, and D properly.
4. Run an IMPLAN model for the entire CRSO area using the appropriate definition of local versus non-local visits to the CRSO area to aggregate the economic impacts from changes in recreation across Regions A, B, C, and D properly.

Final Panel Comment 2

The TOM documentation does not provide information on the relative cost of rerouting goods moving out of the Lower Snake River to support the assumption that modeling only wheat accurately represents the full impacts of MO3, particularly during a disruption/delay event.

Relevant Model Assessment Criteria

Model Documentation Quality

Representation of the System

Model Assumptions and Limitations

Basis for Comment

The SCENT and TOM models use different years for commodities volumes. SCENT uses 2016 shipment volumes; however, it is unclear what year of shipments are modeled in TOM. Page L-3-4 states that TOM models 202 million bushels of grain based on a 2014 to 2018 average, but page L-3-8 states that TOM models 204 million bushels of grain based on 2018 production.

The decision to model only wheat in the TOM is based on the fact that wheat represents a large majority of the total volume of commodities moving out of the Lower Snake River (about 87%). However, modeling only wheat may not reflect the full impacts of MO3 on transportation costs.

To estimate the extra shipping costs for MO3, TOM calculates the MO3 shipping costs for wheat and subtracts the No Action Alternative shipping costs for wheat. If, in reality, wheat is the highest-cost commodity to reroute, it would be the last to be rerouted by cost-minimizing shippers or a cost-minimizing algorithm like TOM in cases of binding capacity constraint(s); all other commodities would be rerouted before any wheat. If the No Action Alternative has binding capacity constraints when modeling only wheat, then TOM would have rerouted all other commodities under both the No Action Alternative and MO3. In that case, the TOM calculation of the extra shipping costs under MO3 (MO3 wheat shipping costs minus the No Action Alternative wheat shipping costs) would effectively be the same as the calculations made using SCENT, because the shipping costs of other commodities in TOM would be moot, having canceled out through the subtraction.

If, however, wheat is not the highest-cost commodity to reroute, the shipping costs of the other commodities would not cancel out in a cost-minimizing algorithm like TOM through the subtraction. Here, if there are binding capacity constraints under MO3, then excluding those other commodities from the TOM would underestimate the amount of wheat that would be rerouted, thereby underestimating the extra shipping costs of MO3.

Significance – Medium

An accurate assessment of the impacts of a dam breach under MO3 on navigation is needed to accurately compare the MO3 impacts with impacts under the other alternatives.

Final Panel Comment 2

Recommendations for Resolution

1. Provide information on the relative cost of rerouting wheat compared to the other commodities being transported on the Lower Snake River.
2. Discuss how the decision to model only wheat in the TOM affects shipping costs under MO3 compared to the other MO alternatives.
3. If wheat is not the highest-cost commodity to reroute, incorporate the other commodities into TOM.

Final Panel Comment 3

The SCENT User's Manual and files supplied to run the model were unreliable, and the SCENT Model documentation was incomplete.

Relevant Model Assessment Criteria

Model Documentation Quality

Operating Requirements of the Model

Basis for Comment

The model developers supplied the Panel with a set of files and a User's Manual that had instructions on how to run the SCENT Model. None of the panel members were able to run the model by following the instructions in the User's Manual to execute the files provided to the Panel. After being notified of this problem during the Mid-Review Teleconference, the model developers provided the Panel with a new set of files, but the Panel still was not able to operate the SCENT Model using those new files.

Also, the SCENT Model documentation does not indicate whether the user is able to import new data into SCENT. For example, the SCENT Model was used to evaluate changes in shipping costs under MO1, MO2, MO4, and the Preferred Alternative for the CRSO DEIS. To perform that evaluation, the shipping list of goods transported through the CRSO in 2016 was used. The Panel cannot determine, from the SCENT Model documentation provided, whether an alternate shipping list could be imported into SCENT for evaluation and, if so, how the user could do so. This is an important omission in the SCENT Model documentation. It should be clear what data/parameters are fixed in the model, what data/parameters can be modified or imported into the model, and what steps to take to modify or import data/parameters. (Note: the SCENT User's Manual does mention some data sets that users can import on their own, but the SCENT Model documentation does not.)

Significance – Medium

The inability to operate the model, or to manipulate the input data, prevented the Panel from determining the effectiveness of the model to accurately assess the impacts on navigation, which is needed to validate the costs associated with each alternative.

Recommendations for Resolution

1. Revise the SCENT Model and model documentation to allow a user to operate the model.
2. Detail in the SCENT documentation which data/parameters in the SCENT Model can be modified directly within SCENT, and explain how to do so.
3. Detail in the SCENT documentation which data/parameters in the SCENT Model can be modified by importing a new file into SCENT, and explain how to do so.

Final Panel Comment 4

The estimates of the annual visitor expenditures under the No Action Alternative could not be replicated.

Relevant Model Assessment Criteria

Model Documentation Quality
 Analytical Requirements
 Model Assumptions and Limitations
 Model Calculations/Formulas
 Model Usefulness in Selecting Alternatives

Basis for Comment

The CRSO Recreation Analysis Model documentation (CRSO DEIS Appendix M – Recreation (Section M.2.2) and Attachment A: User Guide to the Recreational Analysis (Section 3)) describes the methodology for calculating the regional economic effects associated with changes in recreational access. Those effects (changes in jobs, income, sales) are developed in two parts: (1) calculation of visitor expenditures by reservoir/river reach and by region, and (2) conversion of total expenditures (by visitor segment and spending category) into expenditure estimates by IMPLAN sector for use in region-specific IMPLAN models.

Between Appendix M and Attachment A, the CRSO Recreation Analysis Model documentation provides visitor spending profiles and detailed trip characteristic data for USACE and NPS locations within the Columbia River System (CRS). Along with visitation data, the expenditure data and trip characteristics are direct inputs into the calculation of annual visitor expenditures. Calculations of annual visitor expenditures by region under the No Action Alternative are provided in Table 16 of Appendix M.

However, using the approach described in the model documentation and the data provided, the Panel could not reproduce the detailed visitor expenditure estimates provided in Table 16. The Panel chose several locations in different regions as examples to attempt to reproduce the results in Table 16.

- For two example locations with no camping activity, the Panel could reproduce the total expenditures, but could not reproduce the breakdown between local and non-local visitor expenditures.
- For two example locations with camping activity, the Panel could not reproduce any of the visitor expenditure data.

The percentage breakdown between local and non-local visitor expenditures listed in Table 16 appears to be the same as the percentage breakdown in visitation for those locations (Tables 4 and 6 of Attachment A). However, given that per-party expenditures for each trip for non-locals (boaters or non-boaters) are higher than for locals (as shown in Table 3 of Appendix M and Table 2 of Attachment A), the Panel would expect to find that (1) the percentage of non-local visitor expenditures

Final Panel Comment 4

would be greater than the percentage of non-local visitation and (2) the percentage of local visitor expenditures would be less than the percentage of local visitation.

The methods and assumptions for calculating visitor expenditures described in the documentation are not detailed enough to reproduce the data presented for the No Action Alternative or the changes in visitor expenditures under any of the alternatives.

In addition, the model spreadsheets provided to the Panel did not include the process or calculations for allocating the total visitor expenditures (by visitor segment and spending category) to expenditure estimates by IMPLAN sector. As a result, the regional economic impacts produced by IMPLAN also cannot be reproduced.

Significance – Medium

The inability to reproduce visitor expenditure data and convert visitor expenditures to IMPLAN sectors (and therefore reproduce the regional economic effects) provides uncertainty about the model's technical soundness and quality.

Recommendations for Resolution

1. Provide a step-by-step example of the calculation of visitor expenditures (total, local, and non-local) for locations with different visitor activities in Appendix M and in the User Guide.
2. Explain the assumption that the breakdown of visitor expenditures (local vs non-local) would reflect the breakdown of visitation (local vs. non-local) at each recreational location.
3. Revise the model documentation package to include an Excel-based spreadsheet that calculates visitor expenditures (by visitor segment and spending category) using the data, inputs, and assumptions provided in the model documentation.
4. Revise the model documentation package to include an Excel-based spreadsheet that converts total visitor expenditures, by visitor segment and spending category, to expenditure estimates by IMPLAN sector.

Final Panel Comment 5

The SCENT Model does not incorporate factors associated with congestion during a disruption/delay event.

Relevant Model Assessment Criteria

Representation of the System

Model Assumptions and Limitations

Model Usefulness in Selecting Alternatives

Basis for Comment

The SCENT Model documentation states that “Shipping can be disrupted by a number of factors, including high flows, shallow depths, wind, fog, congestion, and combinations thereof.” (page 1). Those disruptions result in additional costs to various parties on the river system, whether due to delays, changes in the number of barges per tow, or other shipper responses. However, the SCENT Model evaluates only those changes in costs associated with changes in flows or changes in channel depth (draft); it does not incorporate the effects of other factors, most notably congestion. Congestion could occur in combination with changes in flows or draft, potentially exacerbating the effects of those changes and perhaps resulting in additional navigation costs. For example, if changes in flows or draft resulted in four-barge tows being cut down to three-barge tows plus additional single barges on the river (since the same amount of tonnage is required to be moved), the additional vessels on the river would cause congestion, reducing vessel speed and increasing trip time. The change from a four-barge tow to a three-barge tow plus a single barge would result in some amount of increased cost, but the increased trip time would result in additional navigation costs. Delays may also result in additional vessels on the river at one time.

Congestion may also occur due to binding capacity constraints at locks/dams/loading sites along the CRS independent of changes in flows or drafts. Changes in shipping commodities and shipping volumes could result in congestion even under normal flow and draft conditions.

Although the documentation acknowledges that the effects of congestion are not evaluated in the model, the document does not provide any discussion of the potential effects of congestion, implications for changes in navigation costs under each alternative, or the potential for different degrees of impact under different alternatives.

Significance – Medium

Changes in navigation costs under different flow and draft scenarios may be underestimated because congestion is not accounted for in the model. Alternatives may have varying potential to be affected by waterway congestion. Incorporating an evaluation of the costs of waterway congestion into the model would provide a more accurate estimate of expected transportation costs.

Recommendations for Resolution

1. Revise the model to account for congestion effects.

Final Panel Comment 5

2. If congestion cannot be incorporated into the SCENT Model, explain why it cannot be modeled within SCENT.
3. If congestion cannot be incorporated into the SCENT Model, provide a qualitative discussion of the potential effects of congestion to deep-draft and shallow-draft operations, and describe potential impacts on navigation costs under each alternative.

Final Panel Comment 6

The manner in which high-water conditions are incorporated into the SCENT disruption/delay matrix is unclear and possibly inaccurate.

Relevant Model Assessment Criteria

Representation of the System

Model Assumptions and Limitations

Model Calculations/Formulas

Model Usefulness in Selecting Alternatives

Basis for Comment

Because four-barge tows may be unable to safely navigate certain high-water conditions, shippers will have to either delay the movement of their four-barge tows until after high-water conditions pass or break the four-barge tow into multiple smaller tows. This is referred to as the risk of disruption/delay and represents very real risks to shippers in the CRS.

Table 20 of the SCENT Model documentation presents a partial list of the full disruption/delay matrix, but the data shown are counter-intuitive. Per Table 20, all shallow-draft vessels (100%) that arrive at a node with a 1-day disruption should simply wait it out. On the other hand, for a 3-day disruption, 10% of shallow-draft vessels arriving on Day 1 should wait and 90% should change to a three-barge maximum tow, while 100% of those arriving on Day 2 or Day 3 should simply wait it out. For a 5-day disruption, 100% of shallow-draft vessels arriving on Day 1 and Day 2 should change to a three-barge maximum tow, 25% of those arriving on Day 3 should wait, and 75% should change to a three-barge maximum tow, and so on for Days 4 and 5. However, the Panel interprets the flow of goods to mean that all traffic should be cleared on Days 1 and 2 (albeit with three-barge tows instead of four-barge tows). This interpretation would mean that Day 3 of a 5-day disruption should operate in the same manner as Day 1 of a 3-day disruption, but that is not the case, which makes sense is if there is congestion at the node with respect to tugs during the 5-day disruption. The SCENT Model documentation states that the decision to wait or hire an extra tug is based on cost (Section 5.4.1); it does not mention a binding tug constraint.

Significance – Medium

The technical soundness of the SCENT model depends on the soundness of the disruption/delay matrix.

Recommendations for Resolution

1. Provide information on how high-water conditions are incorporated into the SCENT disruption/delay matrix.
2. Explain why the counter-intuitive information in Table 20 is appropriate.

Final Panel Comment 7

The economic effects of a high-water year or a low-water year are not provided or accounted for in the analysis of alternatives within the CRSO Recreation Analysis Model.

Relevant Model Assessment Criteria

Representation of the System

Model Usefulness in Selecting Alternatives

Basis for Comment

CRSO DEIS Appendix M (page M-3) states: “The analysis focuses on modeled daily water surface elevations associated with the 50th percentile (typical water year), but considers water surface elevations at the 25th and 75th percentiles to understand the possible extent of effects under various water conditions.”

However, only visitation changes are considered under the 25th (high-water year) and 75th (low-water year) percentiles; no data on the extent of economic effects (social welfare, visitor expenditures, regional economic impacts) are provided for either of those situations under any alternative. Therefore, no comparison of the economic effects in a high- or low-water year as compared to a typical water year is provided in the documentation.

Table 1 of Appendix M illustrates that there are instances (under MO4 and under the Preferred Alternative) where impacts to specific reservoirs would occur only in low-water years; no impacts would occur at those locations in a typical water year. Impacts that occur in low-water years are not quantified or included in the summary of effects for relevant alternatives and are not included in the overall comparison of alternatives. For example, in Appendix M, Recreation, the “Potential for major adverse effects to visitor expenditures and regional economic effects at Lake Pend Oreille in low water years” (page M-98) is not quantified or considered in the alternatives evaluation, other than an included qualitative sentence.

The absence of data and lack of consideration of economic effects under high- and low-water years has the potential to affect the selection of the chosen alternative. For example, the patterns of impacts among regions may be different in low- or high-water years, as compared to typical water years.

The CRSO Recreation Analysis Model documentation states that the period of analysis is 50 years and provides average annual changes or effects (visitation, social welfare, economic effects) in a typical water year for each alternative. However, no calculations of the total effects over the 50-year period are provided. That calculation would include the effects of about 25 typical years, 12 high-water years, and 12 low-water years, and would account for those locations that experience effects only in low-water years or for differences in patterns of effects in low- or high-water years. A calculation of average annual effects over the 50-year period that captures the frequency and extent of effects in typical, low-water, and high-water years would provide information on actual effects over the study period.

Final Panel Comment 7**Significance – Medium/Low**

Calculation of the economic effects expected to occur in low-water years and in high-water years would provide more complete information about potential project impacts. Inclusion of low- and high-water-year impacts in the alternatives analysis may affect the comparison of alternatives.

Recommendations for Resolution

1. Provide estimates of average annual changes in social welfare, visitor expenditures, and regional economic effects in low-water years and in high-water years under each alternative.
2. Calculate and report total effects and average annual changes in social welfare, visitor expenditures, and regional economic effects over the 50-year study period, accounting for high-water, typical, and low-water years.

Final Panel Comment 8

The TOM documentation does not report results of an assessment of model assumptions, fit, or validation.

Relevant Model Assessment Criteria

Model Documentation Quality

Model Assumptions and Limitations

Testing/Evaluation Process

Basis for Comment

The TOM documentation does not provide any information on the assessment of model assumptions, fit, or validation. The stability of the model solution with respect to price parameters and constraints is automatically generated by the General Algebraic Modeling System (GAMS), but that capability is not mentioned in the model documentation. The sensitivity of the TOM to changes in rail shipping rates is the only sensitivity analysis discussed in the documentation.

Significance – Medium/Low

A clear understanding of model assumptions, fit, and validation is important for conveying the robustness of the model results under different circumstances and the appropriateness of the model structure.

Recommendation for Resolution

1. Provide information on how the TOM was assessed with respect to its assumptions, fit, and validation.

Final Panel Comment 9

The CRSO Recreation Analysis Model and SCENT Model documents do not assess the impacts of uncertainty on the models' respective results.

Relevant Model Assessment Criteria

Model Documentation Quality
Representation of the System
Model Assumptions and Limitations
Testing/Evaluation Process

Basis for Comment

The Panel's review of the CRSO Recreation Analysis Model and SCENT Model documentation indicated that risk assessment within the models was limited to addressing uncertainty associated with the hydrologic and hydraulic (H&H) analysis. Several sources of uncertainty, due to assumptions or data quality, were acknowledged in the models' documentation or identified by the Panel, which were not quantitatively or qualitatively addressed. The ability of the models to predict future conditions within the project area would be greatly enhanced by addressing these uncertainties.

The following uncertainties associated with CRSO Recreation Analysis Model parameters were identified.

- The behavior of recreationists, when faced with varying river and reservoir conditions in the basin, was assumed to be known with certainty; the model did not take into account the potential for spatial or temporal substitution, or potential mitigation actions by resource providers.
- The model used boat ramp accessibility as a representation of all water-based recreation activity on the reservoirs. Some water-based activities which are not reliant on boat access to the reservoirs might not vary in the same manner as activities that rely directly on boat ramps.
- Modeled visitation data were based on annual historical data that were allocated to monthly visitation based on the average distribution from monthly data available for other sites at the reservoirs.
- The model used limited data, from multiple sources, to describe input variables used to calculate the social welfare effects and regional economic development benefits, including:
 - The use of incomplete visitation data for near-river sites from several sources, which may result in an underestimation of river-based recreation and visitation at some state and local sites;
 - The conversion of average recreational visits to recreation days using ratios from a limited number of recreation areas;
 - The lack of consistent visitation data prior to 2017 to describe water-based visitation for each reservoir for high and low-water years; and
 - The use of District-level data to describe trip characteristics (party size and trip length) for specific sites.

Final Panel Comment 9

- Unit Day Values (UDVs) were not assessed, in accordance with Economic Guidance Memorandum (EGM) 19-03 (USACE, 2018b), for all project site areas (PSAs). For those PSAs that were not assessed, UDV estimates were adapted from locations that were assessed in accordance with EGM 19-03.

The following uncertainties associated with SCENT Model parameters were identified.

- The model used a constant shipment list and assumed that commodity movements remain constant for all simulations over the period of analysis, limiting the ability of the model to accurately predict future conditions in the project area and increasing uncertainty in the model results.
- The model does not appear to address the uncertainty associated with the duration of shipment disruption/delay events as a result of water conditions; shippers are assumed to have perfect foresight into these future events.
- The CRSO DEIS states that standard deviations of the model results were calculated to determine the range of anticipated costs under the No Action Alternative. The model documentation did not cite the calculation of standard deviations of results, or any sensitivity, or risk analysis, being incorporated into the model.
- Extensive statistical analysis was conducted on the shippers' survey responses; however, it does not appear that these statistical data were used to describe or mitigate uncertainty in the model parameters that were based on survey responses.

Significance – Medium/Low

The ability of the models to more accurately predict future conditions within the project area would be greatly enhanced by incorporating risk analysis into the models, and model documentation, to address parameter uncertainties, and allow for a more comprehensive understanding of the National Economic Development (NED) benefits and project justification.

Recommendations for Resolution

For the CRSO Recreation Analysis Model:

1. Assess the impact of not accounting for spatial or temporal substitution, or potential mitigation actions by resource providers, to be reflected in the behavior of recreationists, when faced with varying river and reservoir conditions in the basin.
2. Assess the impact of using boat ramp accessibility to represent all water-based recreation activity on the reservoirs.
3. Assess the impact of modeling monthly visitation data using annual historic visitation data and monthly data for other reservoir sites.
4. Assess the impact of using limited data, from multiple sources, to describe input variables used to calculate the social welfare effects and regional economic development benefits.
5. Estimate UDVs, in accordance with EGM 19-03, for all PSAs.

For the SCENT Model:

6. Assess the impact of using a constant shipment list and constant commodity movements for all simulations over the period of analysis.

Final Panel Comment 9

7. Incorporate risk analysis into the model to address the uncertainty associated with the duration of shipment disruption/delay events as a result of water conditions.
8. Describe the standard deviations of the model results that were calculated to determine the range of anticipated costs under the No Action Alternative, as presented in the CRSO DEIS, in the model documentation.
9. Incorporate the extensive statistical analysis conducted on the shippers' survey responses to describe or mitigate uncertainty in the model parameters that were based on survey responses.

Literature Cited

USACE (2018b). Unit Day Values for Recreation for Fiscal Year 2019. Economic Guidance Memorandum (EGM) 19-03. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. October 18.

Final Panel Comment 10

The TOM documentation does not assess the impacts of uncertainty on the model's results.

Relevant Model Assessment Criteria

Model Documentation Quality

Representation of the System

Model Assumptions and Limitations

Basis for Comment

The Panel's review of the TOM documentation indicated that risk assessment within the model was limited to addressing uncertainty associated with the H&H analysis. Several sources of uncertainty related to assumptions or data quality were identified by the Panel, but these uncertainties were not quantitatively or qualitatively addressed. The ability of the model to predict future conditions within the project area would be greatly enhanced by addressing these uncertainties and would allow a more comprehensive understanding of the model results.

The following uncertainties associated with TOM parameters, many of which were acknowledged but not addressed in the documentation, were identified.

- The probability that rail rates may increase by more than 50 percent in response to the increased volumes of grain movements.
- The potential impact of silt/sediment on barge transportation on the Columbia River in the vicinity of Pasco, Washington.
- The ability of the grain terminals at Pasco, Washington, and on the Columbia River to accommodate the increased volumes of grain arriving by truck.
- The ability of the short-line railroads and the four shuttle rail facilities to adequately service the increased volumes of grain movements.
- The impact of the operation of the Lacrosse grain shuttle facility on wheat movements.
- The fact that the model does not account for grain shipments from non-shuttle rail facilities to river ports.
- The fact that the model does not account for any use of the existing Snake River grain terminals.
- The ability of the trucking industry to adequately service the increased volumes of grain movements, at current trucking rates, taking into account that truck ton-miles could increase by up to 84 percent, compared to the No Action Alternative.

Significance – Medium/Low

The ability of the model to more accurately predict future conditions within the project area would be greatly enhanced by incorporating risk analysis into the model, and model documentation, to address parameter uncertainties, and allow for a more comprehensive understanding of the NED benefits and project justification.

Final Panel Comment 10**Recommendations for Resolution**

1. Assess the impact of allowing rail rates to increase by more than 50 percent in response to increased volumes of grain movements.
2. Assess the potential impact of silt/sediment on barge transportation on the Columbia River in the vicinity of Pasco, Washington.
3. Assess the ability of the grain terminals at Pasco, Washington, and on the Columbia River, to accommodate increased grain movements arriving by truck.
4. Assess the ability of the short-line railroads and the four shuttle rail facilities to adequately service increased volumes of grain movements.
5. Incorporate the impact of the operation of the Lacrosse grain facility on wheat movements.
6. Assess the impact of allowing non-shuttle rail facilities to move shipments to river ports.
7. Assess the impact of allowing the use of the existing Snake River grain terminals.
8. Assess the ability of the trucking industry to transport increased volumes of grain movements.
9. Assess the impact of allowing trucking rates to fluctuate in response to increased volumes of grain movements.

Final Panel Comment 11

Discussions of the interpretation and limitations of shipper survey data and waterway carrier survey data used to develop the disruption response matrix are incomplete.

Relevant Model Assessment Criteria

Representation of the System

Model Assumptions and Limitations

Basis for Comment

As described in the SCENT Model documentation, shipper responses to changes in flows and draft were determined by data obtained through surveys of shippers, towing companies, vessel pilots, and others involved in the movement of commercial vessels. Therefore, the survey data are an important foundational component of the SCENT Model. Addendum 1 to the SCENT Model documentation provided by USACE (USACE report titled *Columbia River Treaty: Navigation, Results of Surveys of Shippers and Waterway Carriers*) describes the surveys conducted.

In the 2015 USACE survey report, the discussion of deep-draft terminal surveys notes the omission of containers and automobiles from the survey responses and the fact that no responses were supplied from two major inbound terminals handling liquid bulk and manufactured products, respectively. The report states that “respondents only move dry bulk cargo, so these responses are not necessarily relevant to auto carriers, container ships or bulk liquid carriers” (page 4). The documents provided to the Panel do not describe the implications of that statement to the development of the disruption response matrix or to SCENT Model outcomes.

In the 2015 USACE survey report, the discussion of the shallow-draft survey efforts notes that three commodities are represented in the survey responses (aggregates, agricultural products, and wood products). Those commodities account for the majority of tonnage moved (pages 10-11); however, no survey information was provided by petroleum shippers, who also move a sizable amount of product, or by other commodity movers (page 11). The documents provided to the Panel do not describe the implications of the lack of survey data from petroleum shippers or from other commodity movers on the development of the disruption response matrix or the SCENT Model outcomes.

For both the deep-draft and the shallow-draft survey efforts, in the documents provided to the Panel for review, there is no discussion regarding the interpretation of the data or the conversion of the raw survey data into the disruption response matrix. For example:

- The documents do not address how different responses to the same question by different respondents were reconciled or how the final responses/behaviors were developed for use in the disruption response matrix for the SCENT Model.
- The documents do not discuss any “check” on those behavior/response model inputs with operators, if such checks occurred.

Final Panel Comment 11**Significance – Medium/Low**

Additional information about the shipper and waterway carrier survey data would provide a more complete explanation of the development of the disruption response matrix and the matrix data.

Recommendations for Resolution

1. Discuss the implications related to the lack of automobile carriers, container ships, or bulk liquid carriers in the deep-draft survey responses to the data included in the disruption response matrix and used in the SCENT Model.
2. Discuss the implications related to the lack of data from petroleum shippers or other commodities not covered in the shallow-draft surveys to the data included in the disruption response matrix and used in the SCENT Model.
3. Discuss how raw survey data were evaluated and manipulated to develop the disruption response matrix for the SCENT Model.
4. Describe the range of behavior response data provided by deep-draft and shallow-draft survey respondents.
5. Describe any work completed to evaluate the sensitivity of the data developed for use in the disruption response matrix.

Final Panel Comment 12

Descriptions of the models that would allow an independent modeler to understand each model's functions and operational capabilities are not provided in a single, comprehensive document for each model.

Relevant Model Assessment Criteria

Model Documentation Quality

Basis for Comment

The documentation for the CRSO Recreation Analysis, SCENT, and TOM models would be enhanced by addressing the following issues.

Several documents, including the Draft DEIS, had to be reviewed to gain a full understanding of how each of the reviewed models functions. Use of the models would be enhanced if all information needed to understand and operate the models were compiled into one concise document for each model.

The CRSO Recreation Analysis Model documentation indicates the need to convert recreational visits to recreational days in order to calculate social welfare effects. The ratios needed to convert recreational visits to recreational days are provided in the Social Welfare Analysis spreadsheet; however, a discussion or tabular presentation of the ratios is not included in CRSO DEIS Appendix M or in the CRSO Recreational Analysis User Guide.

A list of which reservoirs and recreation areas are included in each USACE District (Walla Walla, Portland, or Seattle) is required to complete calculations of direct visitor expenditures; these data are not provided in the current documentation.

The Table of Contents of the document titled "3a_SCENT_Model Documentation Final," as provided to the Panel, does not align with the section headings and contents of the document.

The SCENT Model and the TOM documentation (exclusive of the CRSO DEIS) lacks adequate descriptions of the purpose and relationship between these two navigation models, and the rationale for developing two navigation models.

In the TOM documentation, quantities of grain movements are not presented in a consistent unit of measure, with weights being presented in bushels and/or tons. Figures 7 through 10, which depict grain movements under various scenarios, present quantities of movements by rail and barge in bushels, while movements by trucks are presented in tons. A consistent unit of measure of grain movements would aid in the understanding of the model and model results.

Significance – Low

Consolidated, precise documentation is needed to afford potential model users a better understanding of the functions and operation of the models.

Final Panel Comment 12**Recommendations for Resolution**

1. Provide all information needed to understand and operate the models in one concise document for each model.
2. Provide a table of the ratios needed to convert recreational visits to recreational days in the CRSO Recreation Analysis Model documentation.
3. Revise the CRSO Recreation Analysis Model documentation to include a list of which reservoirs and recreation districts are included in each USACE district in order to complete calculations of direct visitor expenditures.
4. Revise the 3a_SCENT_Model Documentation Final document to ensure that the Table of Contents is aligned with the section headings and contents of the document.
5. Revise the SCENT and TOM models' documentation to include a description of the purpose and relationship between these two navigation models, and the rationale for developing two navigation models.
6. Revise the TOM documentation to ensure that quantities of grain movements, by different modes, are presented in a consistent unit of measure.

Final Panel Comment 13

The transportation cost minimization equations, as presented in the TOM documentation, do not accurately depict the underlying framework of the model.

Relevant Model Assessment Criteria

Model Documentation Quality

Model Calculations/Formulas

Basis for Comment

Certain constraints to the TOM transportation cost minimization equation, as presented in the model documentation, are inaccurate.

The Node Balance Constraint states that the volume of grain moving from the i^{th} supply origin into the j^{th} intermediate destination on mode k (X_{ijk}) **IS EQUAL TO** the volume of grain moving from the j^{th} intermediate destination to the final demand location on mode k (Y_{ijk}).

The Destination Balance Constraint states that the volume of grain moving from the i^{th} supply origin into the j^{th} intermediate destination on mode k (X_{ijk}) **PLUS** the volume of grain moving from the j^{th} intermediate destination to the final demand location on mode k (Y_{ijk}) **IS EQUAL TO** the volume demanded at Portland, Oregon, k (D_i).

The cost minimization equation should be subject to the volume of grain moving from the i^{th} supply origin into the j^{th} intermediate destination on mode k (X_{ijk}) **BEING EQUAL TO** the volume of grain moving from the j^{th} intermediate destination to the final demand location on mode k (Y_{ijk}) which **SHOULD ALSO BE EQUAL TO** the volume demanded at Portland, Oregon, (D_i).

Significance – Low

Accurate documentation of model equations is needed to allow a complete understanding of the underlying quantitative framework of the model.

Recommendations for Resolution

1. Revise cost minimization equation constraints, as presented in the documentation, to accurately reflect a balanced supply from origin, through intermediate destination, to the demand at Portland, Oregon.
2. Verify that the cost minimization equation, as incorporated into the TOM, reflects the correct constraints.

6.0 CONCLUSIONS

The Panel found the economic models reviewed in this IEPR to be successful in describing the project area conditions and complex interactions while taking into account policy, procedures, and regulations of the Co-lead Agencies. Given these parameters, based on the documentation provided, it appears that the models were generally developed in accordance with USACE's principles and guidelines, although the Panel noted the lack of adequate assessment of risk and uncertainty within the models and documentation. In general, the model documentation sufficiently describes the framework, inputs, operation, and outputs of the models. The CRSO Recreation Analysis Model documentation includes a step-by-step description of the general overall conceptual framework for a complex set of spreadsheets, which was accomplished within the EIS time and resource constraints. The SCENT Model documentation also walks the user through the model development process and model requirements; however, the Panel was unable to run the SCENT model using the files and documentation provided. The TOM documentation presents the structure of the model and includes the cost optimization equation and constraints that the model is based upon. The Panel finds that a great deal of high-quality, highly detailed flow, transportation mode, and cost data have been collected and compiled. The Panel believes that the current models have value in the current EIS process, but that the models can be improved by incorporating some of the suggestions provided herein, in the near term and in the future, as more data become available and as understanding of the CRSO improves.

7.0 REFERENCES

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USACE (2018a). Water Resources Policies and Authorities: Review Policy for Civil Works. Engineer Circular (EC) 1165-2-217. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. February 20.

USACE (2018b). Unit Day Values for Recreation for Fiscal Year 2019. Economic Guidance Memorandum (EGM) 19-03. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. October 18.

APPENDIX A

IEPR Process for the CRSO Economic Models Project

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A.1 Planning and Conduct of the Independent External Peer Review (IEPR)

Table A-1 presents the major milestones and deliverables of the Independent External Peer Review (IEPR) of the Economic Models Used for the Columbia River System Operations (CRSO) (hereinafter: CRSO Economic Models IEPR). Due dates for milestones and deliverables are based on the award/effective date listed in Table A-1. The review documents were provided by U.S. Army Corps of Engineers (USACE) on March 1, 2020. Note that the actions listed under Task 6 occur after the submission of this report. Battelle anticipates submitting the pdf printout of the USACE's Design Review and Checking System (DrChecks) project file (the final deliverable) on August 3, 2020. The actual date for contract end will depend on the date that all activities for this IEPR are conducted and subsequently completed.

Table A-1. Major Milestones and Deliverables of the CRSO Economic Models IEPR

Task	Action	Due Date
1	Award/Effective Date	2/28/2020
	Review documents available	3/1/2020
	Battelle submits draft Work Plan ^a	3/5/2020
	USACE provides comments on draft Work Plan	3/12/2020
	Battelle submits final Work Plan ^a	3/17/2020
2	Battelle submits list of selected panel members ^a	3/9/2020
	Battelle submits revised list of selected panel members ^a	3/12/2020
	USACE confirms the panel members have no COI	3/11/2020
3	Battelle convenes kick-off meeting with USACE	3/6/2020
	Battelle convenes kick-off meeting with panel members	3/24/2020
	Battelle convenes kick-off meeting with USACE and panel members	3/24/2020
4	Panel members complete their individual reviews	5/1/2020
	Panel members provide draft Final Panel Comments to Battelle	5/13/2020
	Panel finalizes Final Panel Comments	5/18/2020
5	Battelle submits Final Model Report to USACE ^a	6/3/2020
6 ^b	Battelle convenes Comment Response Teleconference with panel members and USACE	7/17/2020
	Battelle submits pdf printout of DrChecks project file ^a	8/3/2020
	Contract End/Delivery Date	1/31/2021

^a Deliverable.

^b Task 6 occurs after the submission of this report.

At the beginning of the Period of Performance for the CRSO Economic Models IEPR, Battelle held a kick-off meeting with USACE to review the preliminary/suggested schedule, discuss the IEPR process, and address any questions regarding the scope (e.g., terminology to use, access to DrChecks, etc.). Any

revisions to the schedule were submitted as part of the final Work Plan. The final charge consisted of 22 charge questions provided by USACE, and two overview questions added by Battelle (all questions were included in the draft and final Work Plans), and general guidance for the Panel on the conduct of the peer review (provided in Appendix C of this final report).

Prior to beginning their review and after their subcontracts were finalized, all the members of the Panel attended a kick-off meeting via teleconference planned and facilitated by Battelle in order to review the IEPR process, the schedule, communication procedures, and other pertinent information for the Panel. Battelle planned and facilitated a second kick-off meeting via teleconference during which USACE presented project details to the Panel. Before the meetings, the IEPR Panel received an electronic version of the final charge, as well as the review documents and reference/supplemental materials listed in Table A-2.

Table A-2. Documents to Be Reviewed and Provided as Reference/Supplemental Information

Review Documents / Application Software	Number of Pages
CRSO Recreation Analysis Model - Model Overview and Summary	3
CRSO Recreation Analysis Model – Main Model Documentation	74
CRSO Recreation Analysis Model – Application Calculator (.xlsx)	N/A
SCENT – Model Documentation	64
TOM – Model Documentation	16
TOM – 2019 Columbia Snake River Navigation Survey	322
TOM – Application Software (.exe) and Spreadsheets (.xlsx)	N/A
Total Number of Review Pages	479
Supplemental Documents ^a	
SCENT – Application Software (.exe) ²	N/A
Total Number of Reference Pages	N/A

^a Supporting documentation only. These documents are not for Panel review and should be used as information sources only. They are not included in the total page count.

N/A – These files were spreadsheets and therefore did not have page counts.

In addition to the materials provided in Table A-2, the panel members were provided the following USACE guidance documents.

- Review Policy for Civil Works (EC 1165-2-217, February 20, 2018)
- Office of Management and Budget's Final Information Quality Bulletin for Peer Review (December 16, 2004)

About halfway through the review, a teleconference was held with USACE, Battelle, and the Panel so that USACE could answer any questions the Panel had concerning either the review documents or the project. Prior to this teleconference, Battelle submitted 47 panel member questions to USACE. USACE

was able to provide responses to all the questions during the teleconference, or was able to provide written responses to all the questions prior to the end of the review.

In addition, throughout the review period, USACE provided documents at the request of panel members. These documents were provided to Battelle and then sent to the Panel as additional information only and were not part of the official review. A list of these additional documents sent to the Panel is provided below.

- EGM18-03.pdf
- Social.Welfare.Analysis_3.31.20.xlsx
- Draft_Results of Survey Report_2015_09_16v3.pdf
- CRSO EIS Recreation Analysis Model Documentation.2020.04.16.docx
- RED Code.do
- Rec RED Inputs.xlsx
- TOM Model GAMS Description.pdf
- TOM-MAQUETTE.pptx
- TOM-MAQUETTE-DATA.xlsx
- TOM_M.gms.

A.2 Review of Individual Comments

The Panel was instructed to address the charge questions/discussion points within a charge question response form provided by Battelle. At the end of the review period, the Panel produced individual comments in response to the charge questions/discussion points. Battelle reviewed the comments to identify overall recurring themes, areas of potential conflict, and other overall impressions. At the end of the review, Battelle summarized the individual comments into a preliminary list of overall comments and discussion points. Each panel member's individual comments were shared with the full Panel.

A.3 IEPR Panel Teleconference

Battelle facilitated a teleconference with the Panel so that the panel members could exchange technical information. The main goal of the teleconference was to identify which issues should be carried forward as Final Panel Comments in the Final Model Report and decide which panel member should serve as the lead author for the development of each Final Panel Comment. This information exchange ensured that the Final Model Report would accurately represent the Panel's assessment of the project, including any conflicting opinions. The Panel engaged in a thorough discussion of the overall positive and negative comments, added any missing issues of significant importance to the findings, and merged any related individual comments. At the conclusion of the teleconference, Battelle reviewed each Final Panel Comment with the Panel, including the associated level of significance, and confirmed the lead author for each comment.

A.4 Preparation of Final Panel Comments

Following the teleconference, Battelle distributed a summary memorandum for the Panel documenting each Final Panel Comment (organized by level of significance). The memorandum provided the following detailed guidance on the approach and format to be used to develop the Final Panel Comments for the CRSO Economic Models IEPR:

- **Lead Responsibility:** For each Final Panel Comment, one panel member was identified as the lead author responsible for coordinating the development of the Final Panel Comment and submitting it to Battelle. Battelle modified lead assignments at the direction of the Panel. To assist each lead in the development of the Final Panel Comments, Battelle distributed a summary email detailing each draft final comment statement, an example Final Panel Comment following the four-part structure described below, and templates for the preparation of each Final Panel Comment.
- **Directive to the Lead:** Each lead was encouraged to communicate directly with the other panel members as needed and to contribute to a particular Final Panel Comment. If a significant comment was identified that was not covered by one of the original Final Panel Comments, the appropriate lead was instructed to draft a new Final Panel Comment.
- **Format for Final Panel Comments:** Each Final Panel Comment was presented as part of a four-part structure:
 1. Comment Statement (succinct summary statement of concern)
 2. Basis for Comment (details regarding the concern)
 3. Significance (high, medium/high, medium, medium/low, and low; see description below)
 4. Recommendation(s) for Resolution (see description below).
- **Criteria for Significance:** The following were used as criteria for assigning a significance level to each Final Panel Comment:
 1. **High:** There is a fundamental issue within study documents or data that will influence the economic model's technical soundness, system quality, or usability.
 2. **Medium/High:** There is a fundamental issue within study documents or data that has a strong probability of influencing the economic model's technical soundness, system quality, or usability.
 3. **Medium:** There is a fundamental issue within study documents or data that has a low probability of influencing the economic model's technical soundness, system quality, or usability.
 4. **Medium/Low:** There is missing, incomplete, or inconsistent technical or scientific information that affects clarity, understanding, or completeness of study documents, and there is uncertainty regarding whether the missing information will affect the economic model's technical soundness, system quality, or usability.

5. Low: There is a minor technical or scientific discrepancy or inconsistency that affects the clarity, understanding, or completeness of study documents, but does not influence the economic model's technical soundness, system quality, or usability.

- **Guidelines for Developing Recommendations:** The recommendation section was to include specific actions that USACE should consider to resolve the Final Panel Comment (e.g., suggestions on how and where to incorporate data into the analysis, how and where to address insufficiencies, areas where additional documentation is needed).

Battelle reviewed and edited the Final Panel Comments for clarity, consistency with the comment statement, and adherence to guidance on the Panel's overall charge, which included ensuring that there were no comments regarding either the appropriateness of the selected alternative or USACE policy. At the end of this process, 13 Final Panel Comments were prepared and assembled. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The full text of the Final Panel Comments is presented in Section 5.0 of the main report.

A.5 Final Model Report

After concluding the review and preparation of the Final Panel Comments, Battelle prepared a Final Model Report (this document) on the overall IEPR process and the IEPR panel members' findings. Each panel member and Battelle technical and editorial reviewers reviewed the IEPR report prior to submission to USACE for acceptance.

A.6 Comment Response Process

As part of Task 6, Battelle will enter the 13 Final Panel Comments developed by the Panel into USACE's DrChecks, a Web-based software system for documenting and sharing comments on reports and design documents, so that USACE can review and respond to them. USACE will provide responses (Evaluator Responses) to the Final Panel Comments, and the Panel will respond (BackCheck Responses) to the Evaluator Responses. All USACE and Panel responses will be documented by Battelle. Battelle will provide USACE and the Panel a pdf printout of all DrChecks entries, through comment closeout, as a final deliverable and record of the IEPR results.

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APPENDIX B

Identification and Selection of IEPR Panel Members for the
CRSO Economic Models Project

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B.1 Panel Identification

The candidates for the Independent External Peer Review (IEPR) of the Economic Models Used for the Columbia River System Operations (CRSO) (hereinafter: CRSO Economic Models IEPR) Panel were evaluated based on their technical expertise in the following key areas: economics (two panel members) and transportation modeling. These areas correspond to the technical content of the review documents and overall scope of the CRSO Economic Models project.

To identify candidate panel members, Battelle reviewed the credentials of the experts in Battelle's Peer Reviewer Database, sought recommendations from colleagues, contacted former panel members, and conducted targeted Internet searches. Battelle evaluated these candidate panel members in terms of their technical expertise and potential conflicts of interest (COIs). Of these candidates, Battelle chose the most qualified individuals, confirmed their interest and availability, and ultimately selected three experts for the final Panel. The remaining candidates were not proposed for a variety of reasons, including lack of availability, disclosed COIs, or lack of the precise technical expertise required.

Candidates were screened for the following potential exclusion criteria or COIs. These COI questions were intended to serve as a means of disclosure in order to better characterize a candidate's employment history and background. Battelle evaluated whether scientists in universities and consulting firms that are receiving USACE-funding have sufficient independence from USACE to be appropriate peer reviewers. Guidance in OMB (2004, p. 18) states,

"...when a scientist is awarded a government research grant through an investigator-initiated, peer-reviewed competition, there generally should be no question as to that scientist's ability to offer independent scientific advice to the agency on other projects. This contrasts, for example, to a situation in which a scientist has a consulting or contractual arrangement with the agency or office sponsoring a peer review. Likewise, when the agency and a researcher work together (e.g., through a cooperative agreement) to design or implement a study, there is less independence from the agency. Furthermore, if a scientist has repeatedly served as a reviewer for the same agency, some may question whether that scientist is sufficiently independent from the agency to be employed as a peer reviewer on agency-sponsored projects."

The term "firm" in a screening question referred to any joint venture in which a firm was involved. It applied to any firm that serves in a joint venture, either as a prime or as a subcontractor to a prime. Candidates were asked to clarify the relationship in the screening questions.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Economic Models used for the Columbia River System Operations (CRSO)

1. Previous and/or current involvement by you or your firm in the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS) (hereinafter: CRSO EIS), and related projects, including the CRSO Recreation Analysis Model, Snake Columbia Economic Navigation Tool (SCENT), and Transportation Optimization Model.
2. Previous and/or current involvement by you or your firm in economic or salmonid projects in the Columbia River Basin.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Economic Models used for the Columbia River System Operations (CRSO)

3. Previous and/or current involvement by you or your firm in the economic assessment of any projects in the Columbia River Basin.
4. Current employment by the U.S. Army Corps of Engineers (USACE), Bonneville Power Administration, or Bureau of Reclamation.
5. Previous and/or current involvement with paid or unpaid expert testimony related to Columbia River Basin projects.
6. Previous and/or current employment or affiliation with members of the following Federal, State, County, local and regional agencies, environmental organizations, and interested groups (*for pay or pro bono*):
 - Governor of Washington State
 - Governor of Oregon
 - Governor of Idaho
 - Governor of Montana
 - Burns Paiute Tribe
 - Confederated Salish and Kootenai Tribes
 - Confederated Tribes and Bands of the Yakama Nation
 - Confederated Tribes of the Colville Reservation
 - Confederated Tribes of Grand Ronde
 - Confederated Tribes of the Chehalis Reservation
 - Confederated Tribes of Siletz
 - Confederated Tribes of the Umatilla Indian Reservation
 - Confederated Tribes of the Warm Springs Reservation of Oregon
 - Coeur D'Alene Tribe
 - Cowlitz Indian Tribe
 - Fort McDermitt Paiute-Shoshone Tribe
 - Kalispel Tribe of Indians
 - Kootenai Tribe of Idaho
 - Nez Perce Tribe
 - Shoalwater Bay Tribe
 - Shoshone Bannock Tribes of the Fort Hall Reservation
 - Shoshone-Paiute Tribes of the Duck Valley Reservation
 - Spokane Tribe of Indians
 - Upper Columbia United Tribes
7. Past, current, or future interests or involvements (financial or otherwise) by you, your spouse, or your children related to Columbia River Basin.
8. Current personal involvement with other USACE projects, including whether involvement was to author any manuals or guidance documents for USACE. If yes, provide titles of documents or description of project, dates, and location (USACE district, division, Headquarters, Engineer

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Economic Models used for the Columbia River System Operations (CRSO)

Research and Development Center [ERDC], etc.), and position/role. Please highlight and discuss in greater detail any projects that are specifically with the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation.

9. Previous or current involvement with the development or testing of models that will be used for, or in support of, the CRSO EIS projects, including the Comprehensive Passage Model (COMPASS), Interior Columbus Basin Lifecycle Model (LCM), Comparative Survival Study (CSS) Model, and Total Dissolved Gas – University of Washington Model.
10. Current firm involvement with other projects, specifically those projects/contracts that are with the USACE Northwest Division, the Bonneville Power Administration, or the Bureau of Reclamation. If yes, provide title/description, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Please also clearly delineate the percentage of work you personally are currently conducting for the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation. Please explain.
11. Any previous employment by USACE as a direct employee, notably if employment was with the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
12. Any previous employment by USACE, Bonneville Power Administration, or Bureau of Reclamation as a contractor (either as an individual or through your firm) within the last 10 years, notably if those projects/contracts are with the USACE Northwest Division, the Bonneville Power Administration, or the Bureau of Reclamation, associated with the Columbia River Basin. If yes, provide title/description, dates employed, and the place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
13. Previous experience conducting technical peer reviews. If yes, please highlight and discuss any technical reviews concerning salmonids and include the client/agency and duration of review (approximate dates).
14. Pending, current, or future financial interests in contracts/awards from USACE, Bonneville Power Administration, or Bureau of Reclamation related to the CRSO EIS project.
15. Significant portion of your personal or office's revenues within the last three years came from USACE, Bonneville Power Administration, or Bureau of Reclamation contracts.
16. Significant portion of your personal or office's revenues within the last three years came from contracts with any of the organizations listed in Question 6.
17. Any publicly documented statement (including, for example, advocating for or discouraging against) related to the CRSO EIS project.
18. Participation in relevant prior and/or current Federal studies related to the CRSO project.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Economic Models used for the Columbia River System Operations (CRSO)

19. Previous and/or current participation in prior non-Federal studies related to the CRSO project.
20. Has your research or analysis been used or evaluated as part of the CRSO project, including development of the models noted in Question 1?
21. Is there any past, present, or future activity, relationship, or interest (financial or otherwise) that could make it appear that you would be unable to provide unbiased services on this project? If so, please describe.

Providing a positive response to a COI screening question did not automatically preclude a candidate from serving on the Panel. For example, participation in previous USACE technical peer review committees and other technical review panel experience was included as a COI screening question. A positive response to this question could be considered a benefit.

B.2 Panel Selection

In selecting the final members of the Panel, Battelle chose experts who best fit the expertise areas and had no COIs. Table B-1 provides information on each panel member's affiliation, location, education, and overall years of experience. Battelle established subcontracts with the panel members when they indicated their willingness to participate and confirmed the absence of COIs through a signed COI form. USACE was given the list of candidate panel members, but Battelle selected the final Panel.

Table B-1. CRSO Economic Models IEPR Panel: Summary of Panel Members

Name	Affiliation	Location	Education	P.E.	Exp. (yrs)
Economist 1					
Susan Walker	Harvey Economics	Denver, CO	M.S., Forest Economics	No	16
Transportation Modeling Specialist					
Jeff Mullen	Independent Consultant	Athens, GA	Ph.D., Applied Economics	No	24
Economist 2					
Daniel Maher	DSM Contracting, LLC	River Ridge, LA	M.S., Agricultural Economics	No	30+

Table B-2 presents an overview of the credentials of the final three members of the Panel and their qualifications in relation to the technical evaluation criteria. More detailed biographical information on the panel members and their areas of technical expertise is given in Section B.3.

Table B-2. CRSO Economic Models IEPR Panel: Technical Criteria and Areas of Expertise

Technical Criterion	Walker	Mullen	Maier
Economist 1			
At least ten years of experience in their area of expertise	X		
M.S. degree or higher	X		
Demonstrable understanding and experience in estimating demand for recreation	X		
Demonstrable understanding and experience in evaluating how changes in reservoir, river, and/or habitat conditions can affect visitation, recreational opportunities, and the value of the recreation experience	X		
Demonstrable understanding and experience in navigation, transportation, and recreation economic modeling is preferred	X		
Demonstrable understanding and experience in developing and testing of spreadsheets and user interface software for purposes of characterizing functionality and ease of use, identifying computational errors, characterizing susceptibility to deliver flawed results, and developing recommendations for best spreadsheet or software coding practices	X		
Experience in development and review of spreadsheets for computational accuracy	X		
Experience with economic modeling spreadsheets or software is preferred	X		
Transportation Modeling Specialist			
At least ten years of experience in their area of expertise		X	
M.S. degree or higher		X	
Demonstrable understanding and experience in applied transport economics (navigation and shipping)		X	
Demonstrable understanding and experience in allocation of resources within a transportation network		X	
Demonstrable understanding and experience in estimating demand for transportation		X	
Demonstrable understanding and experience in navigation, transportation, and recreation economic modeling is preferred		X	
Demonstrable understanding and experience in deep and shallow draft riverine navigation and transportation economic analysis and modeling		X	
Demonstrable understanding and experience in navigation shipping survey methods		X	
Knowledge of and familiarity using travel demand modeling and analysis, project-level alternatives analysis, and traffic operations analysis		X	
Demonstrable understanding and experience in examining large amounts of navigation data and constructing models that solve complex transportation problems		X	

Table B-2. CRSO Economic Models IEPR Panel: Technical Criteria and Areas of Expertise (continued)

Technical Criterion	Walker	Mullen	Maier
Expertise should include experience in Pacific Northwest transportation planning, operations analysis, and mathematics		X	
Expertise in general equilibrium modeling is preferred		X	
Demonstrable understanding and experience in Development and review of models applied using the General Algebraic Modeling System (GAMS) programming language/software package is required.		X	
Economist 2			
At least ten years of experience in their area of expertise			X
M.S. degree or higher			X
Demonstrable understanding and experience in applied transport economics (navigation and shipping)			X
Demonstrable understanding and experience in allocation of resources within a transportation network			X
Demonstrable understanding and experience in estimating demand for transportation			X
Demonstrable understanding and experience in estimating demand for recreation			X
Demonstrable understanding and experience in evaluating how changes in reservoir, river, and/or habitat conditions can affect visitation, recreational opportunities, and the value of the recreation experience			X
Demonstrable understanding and experience in navigation, transportation, and recreation economic modeling is preferred			X

B.3 Panel Member Qualifications

Detailed biographical information on each panel members' credentials, qualifications and areas of technical expertise is provided in the following paragraphs.

Name	Susan Walker
Role	Economist
Affiliation	Harvey Economics

Ms. Walker is the Director of Harvey Economics located in Denver, Colorado. She has a M.S. in forest economics and policy from Colorado State University (2004) and a B.S. in forest management from the University of Vermont. She has over 16 years of experience in applied economics and planning and 14 years of experience working with Federal agencies, including USACE, on environmental impact statement (EIS) projects and the Bureau of Reclamation on economic analyses. Recreational demand and economic modeling are her specialty. She has developed custom models to meet the specific needs

of individual clients and has utilized existing models to evaluate economic impacts (economic impact model IMPLAN, regional economic impact model RIMS II, and the USACE Economic Impact Forecast System).

For the White River Reservoir Feasibility Study, Ms. Walker evaluated the need for and economic benefits of a potential new reservoir in western Colorado. She estimated potential water-based recreational demand, projected near-term and long-term visitation levels, and quantified the associated regional economic benefits of visitor spending over a 30-year period. Ms. Walker also conducted an analysis of future water demands for municipal use, energy development, and recreation and environmental purposes and worked to quantify benefits to each sector from additional regional water storage. Using projected capital and operating costs, Ms. Walker completed a cost-benefit analysis for three alternatives. A financing plan identified potential project partners, associated benefits, and cost shares. This work began in 2014 and is ongoing.

Since 2005, Ms. Walker has been working to complete various components of the Halligan Water Supply Project EIS, Colorado. This project, led by USACE, focuses on the expansion of the Halligan Reservoir. Early on, she developed water demand projections for the City of Fort Collins to support the purpose and need analysis and has updated those projections in recent years. Her work included socioeconomic, recreation, and land use impact analyses. Impacts on water-based recreational activity and quality of experience stemmed largely from changes in streamflows and reservoir levels and accessibility to certain waterbodies. Ms. Walker quantified project impacts and determined the geographic extent, duration, and magnitude of resource effects.

Ms. Walker estimated the value of benefits to water providers, recreational users, and habitat and aquatic life from a reduction in nutrients in lakes and streams for the Nutrient Regulation Cost/Benefit Study, conducted for the Water Quality Control Division of Colorado. Water-based recreational benefits focused on changes in user days for fishing, boating, and swimming activities and associated recreational spending. For that 2012 effort, she developed detailed cost-benefit models incorporating the annual capital and operating costs to point source dischargers and estimated benefits of nutrient reduction over a 20-year period. Cost-benefit models were developed by region and at the statewide level for three levels of regulation.

For a New Mexico Interstate Stream Commission cost-benefit study, conducted in 2014 and 2015, Ms. Walker identified project beneficiaries, annual water yields, and detailed cost schedules that provided an economic basis for the prioritization and funding of 15 individual water development projects in New Mexico. She quantified the economic benefits of each project to municipal and industrial (M&I) uses, recreational activity, environmental uses, and the agricultural industry; she also addressed non-monetary project benefits. Her cost-benefit model for that project compared project-specific costs and benefits over a 50-year period.

Between 2005 and 2016, Ms. Walker also completed a socioeconomic impact analysis for the Denver Water Moffat Collection System EIS under the direction of USACE. This project focused on the potential expansion of Gross Reservoir and several alternatives. She reviewed the purpose and need for the project and evaluated the socioeconomic impacts, addressing construction benefits, tourism and business impacts, public facility and social service impacts, fiscal impacts, water rate effects, changes in property values, and environmental justice issues. Impacts to the tourism and recreation sectors in several mountain communities were addressed.

In 2016, Ms. Walker completed an economic analysis for Wyoming's New Fork Lake Dam Enlargement project, which was intended to increase storage volume in New Fork Lake located on U.S. Forest Service land. For three alternatives, she evaluated the potential benefits to recreation, fisheries, public safety, flood damage and control, fire suppression, and agricultural operations resulting from reservoir enlargement and rehabilitation. She developed long-term cost-benefit models, incorporating all project costs and benefits over a 50-year period.

Ms. Walker studied the economic benefits of water produced by coalbed methane (CBM) production in Las Animas County, Colorado, for the Purgatoire Water Benefits project. CBM wells within the Purgatoire watershed currently produce water which supports a variety of uses, including agriculture and recreational activity. Ms. Walker estimated the economic benefits of CBM water to each of those uses. She also gathered information about the regional economy and estimated the benefits of CBM industry activities to the region, in terms of employment, income, tax revenues, and total benefits to Las Animas County.

Working for the Wyoming Water Development Commission on the Glendo Reservoir Full Utilization Study – Benefits and Costs, Ms. Walker quantified the economic costs and benefits associated with re-operation of the reservoir, which is located in southeastern Wyoming. She evaluated costs and benefits to recreational amenities and state park finances, hydropower generation, agricultural productivity and access to irrigation water supplies, and environmental amenities. This 2018 project involved the Bureau of Reclamation, USACE, the States of Wyoming and Nebraska, and several State of Wyoming agencies.

Ms. Walker developed a set of specific economic methodologies to evaluate the socioeconomic effects of changes in recreational visitation, agricultural activity, and mining activity in the Bureau of Land Management (BLM) Gila San Simon Travel Management Area (TMA), Arizona. Management alternatives focused on changes to off-highway vehicles trails and other recreational amenities, as well as vehicle access to certain areas of the TMA. Her inputs addressed both the quantitative and qualitative economic impacts of those alternatives, including the effects of visitor spending in the region, changes to the recreational experience within the TMA, and potential changes in local industry activity.

Name	Jeff Mullen, Ph.D.
Role	Transportation Modeling Specialist
Affiliation	Independent Consultant

Dr. Mullen is an independent consultant and an associate professor in the Department of Agricultural and Applied Economics at the University of Georgia, specializing in water resource, natural resource, and environmental economics. He earned his Ph.D. in Agricultural and Applied Economics/Natural Resource Economics from Virginia Polytechnic Institute and State University in 1999. He has over 24 years of experience conducting numerous studies in the field of environmental and natural resource economics and has taught graduate courses in environmental and natural resource economics and econometrics.

Dr. Mullen recently was the Planning Formulator/Economist on an IEPR for USACE's Calumet Harbor, which was conducted for the Inland Navigation Planning Center of Expertise (PCX). He previously served on the Kissimmee River Restoration Project IEPR Panel for the Ecosystem Restoration PCX and is currently serving on the East San Pedro Bay, Long Beach, California, IEPR. He has considerable experience with transportation models, including the interconnection between inland navigation, rail, and trucking systems. In his graduate-level course Quantitative Methods for Agribusiness Decisions, about 25% of the course is dedicated to transportation optimization models focused primarily on the movement

of agricultural products. As a resource economist, Dr. Mullen has been teaching state-of-the-art methodologies for estimating recreational demand, including travel cost, contingent valuation, choice experiments, and hedonics for 20 years. In addition to covering recreational demand in his graduate courses, he has served as an expert witness regarding the impact of water levels and water quality on reservoir benefits in Georgia. He has also been involved with the evaluation of the blue crab fishery in Georgia and recreational sport fishing demand in the Gulf of Mexico. Dr. Mullen also teaches a course in Energy Economics, covering electric utility modeling as well as wholesale and retail electricity markets in all six North American Electric Reliability Corporation regions.

Dr. Mullen has programming experience with the General Algebraic Modeling System (GAMS). He has designed, coded, and solved linear and non-linear optimization models in GAMS, including models for his dissertation, parts of which have been published in peer-reviewed academic journals. Dr. Mullen has co-authored additional peer-reviewed articles concerning economic analyses and impacts related to municipal, wastewater, irrigation, and water impoundment projects and has been a contributing author to numerous publications concerning environmental economics and evaluation, economic modeling, transportation modeling, and price analysis. He has served as a consultant on a wide variety of projects related to environmental/natural resource issues. Additionally, he serves as a frequent reviewer for peer-review journals, including Land Economics, Ecological Economics, Journal of Agricultural and Resource Economics, Journal of Environmental Economics and Management, and Ecosystem Services. Dr. Mullen is a past president of the Southern Natural Resource Economics Committee and a member of the American Agricultural Economics Association.

Name	Daniel Maher, PMP
Role	Economist 2
Affiliation	DSM Contracting, LLC

Mr. Maher is a Project Manager and senior economist with DSM Contracting with over 30 years of experience. He received his M.S. in agricultural economics from Louisiana State University in 1988 and is a certified Project Management Professional. He has served as an economist and project manager on over 50 USACE planning studies and has been responsible for assisting in alternative development and screening and conducting economic analysis in accordance with USACE principles and guidelines. He has managed numerous economic feasibility, evaluation, and impact studies for navigation projects, ecosystem restorations, flood control and flood risk projects, water supply projects, and recreational studies. He has conducted incremental analyses, cost-effectiveness studies, and forecasting studies for clients across the country. Mr. Maher's computer skills include extensive experience with IMPLAN Economic Impact Software, IWR-Planning Suite, IWR-MAIN Water Use Forecast System, and the Microsoft Office Suite.

Mr. Maher is familiar with large, complex water resources planning efforts with high public and interagency interest. These efforts have frequently required his expertise in evaluating costs, benefits, and impacts related to M&I water supply, as well as forecasting future water use in both urban and rural areas. Mr. Maher was responsible for assessing the adequacy and acceptability of the economic methods, models, and analyses used to develop a water supply storage assessment of current and future water demands in the upper Apalachicola-Chattahoochee-Flint (ACF) basin as the economist for the ACF River Water Control Manual Update, Environmental Impact Statement and Water Supply Storage Assessment Report IEPR. He was also responsible for evaluating the impacts of operational changes in

reservoir systems to hydropower, flood risk management, and lake recreation as a panel member on the IEPR for the Allatoona-Coosa Reallocation Study. Mr. Maher has conducted reviews of other aspects of water use which are often intertwined in complex planning efforts, as demonstrated by the following examples: (1) Water Supply Demand Analysis, Pine Mountain Study Area, Arkansas, which developed an M&I water use forecast as part of the estimation and analysis of water supply benefits; (2) East Baton Rouge Parish Alternative Industrial Water Supply Study Market Demand Analysis, which not only prepared a market forecast but also examined cost, availability, and quality in assessing the ability of industrial users to convert to other water sources; (3) M&I Water Use Forecast, Southwest Florida Feasibility Study, which estimated existing water use and developed water demand projections; and (4) M&I Water Use Forecast, Comprehensive Everglades Restoration Plan Forecast Update. During the effort for the M&I Water Use Forecast, Lake Okeechobee Regulation Schedule Study for USACE, Mr. Maher was involved in the development of water supply forecasts for use in estimating the allocation (release) of water from Lake Okeechobee.

APPENDIX C

Final Charge for the CRSO Economic Models IEPR

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Charge Questions and Guidance to the Panel Members for the Independent External Peer Review (IEPR) of the Economic Models Used for the Columbia River System Operations (CRSO)

This is the final Charge to the Panel for the CRSO Economic Models IEPR. This final Charge was submitted to USACE as part of the final Work Plan, originally submitted on March 17, 2020. The dates and page counts in this document have not been updated to match actual changes made throughout the project.

BACKGROUND

The U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and Bureau of Reclamation (Co-lead Agencies) are jointly developing a comprehensive Environmental Impact Statement (EIS), referred to as the Columbia River System Operation (CRSO) EIS, to evaluate long-term system operations and configurations of 14 multiple-purpose projects that are operated as a coordinated system within the interior Columbia River Basin in Idaho, Montana, Oregon, and Washington State. USACE was authorized by Congress to construct, operate, and maintain 12 of these projects for flood risk management, navigation, power generation, fish and wildlife conservation, recreation, and municipal and industrial water supply purposes. USACE projects that will be included in the EIS are Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. The Bureau of Reclamation was authorized to construct, operate, and maintain the other two projects—Hungry Horse and Grand Coulee—for the purposes of irrigation, flood risk management, navigation, power generation, recreation, and other beneficial uses. The BPA is responsible for marketing and transmitting the power generated by these dams. Together, these Co-lead Agencies are responsible for managing the system for these various purposes, while meeting their other statutory and regulatory obligations.

The Co-lead Agencies will use the CRSO EIS to assess and update their approach for long-term system operations and configurations through the analysis of alternatives and evaluation of potential effects to the human and natural environments. The scope and scale of this project; its potential to impact human life safety; interest on the part of the Governors of Montana, Idaho, Washington, and Oregon, and on the part of 19 Federally recognized tribes; the project's connection to ongoing litigation on the Federal Columbia River Power System; and the likelihood for the project to result in public dispute drive a requirement for a heightened level of review and the need to meet the criteria of a highly influential scientific assessment in OMB and Bureau of Reclamation peer review policies.

OBJECTIVES

The objective of this work is to conduct an independent external peer review (IEPR) of the economic models used in the CRSO (hereinafter: CRSO Economic Models IEPR) in accordance with the Department of the Army, USACE, Water Resources Policies and Authorities' *Review Policy for Civil Works* (Engineer Circular [EC] 1165-2-217, dated February 20, 2018), and the Office of Management and Budget's (OMB's) *Final Information Quality Bulletin for Peer Review* (December 16, 2004). Peer review is one of the important procedures used to ensure that the quality of published information meets the standards of the scientific and technical community. Peer review typically evaluates the clarity of hypotheses, validity of the research design, quality of data collection procedures, robustness of the methods employed, appropriateness of the methods for the hypotheses being tested, extent to which the conclusions follow from the analysis, and strengths and limitations of the overall product.

The primary goal of the economic model review and approval is to establish that models, analyses, results, and conclusions are theoretically sound, computationally accurate, based on reasonable assumptions, well-documented, and in compliance with the requirements of the OMB Peer Review Bulletin. The use of a reviewed model does not constitute technical review of the planning product. Independent technical review of the selection and application of the model and the input data is still the responsibility of the users.

The primary criterion identified for model approval is technical soundness. Technical soundness reflects the ability of the model to represent or simulate the processes and/or functions it is intended to represent. The performance metrics for this criterion are related to theory and computational correctness. In terms of theory, a quality economic model should 1) be based on validated and accepted “state of the art” theory, 2) properly incorporate the conceptual theory into the software code, and 3) clearly define the assumptions inherent in the model. In terms of computational correctness, a quality economic model should 1) employ proper functions and mathematics to estimate functions and processes represented, and 2) properly estimate and forecast the actual parameters it is intended to estimate and forecast. Other criteria for quality economic models are efficiency, effectiveness, usability, and clarity in presentation of results. A well-documented, high-quality economic model will stand the tests of technical soundness based on theory and computational correctness, efficiency, effectiveness, usability, and clarity in presentation of results.

The IEPR will be limited to technical review and will not involve policy review. The IEPR will be conducted by subject matter experts (i.e., IEPR panel members) who meet the technical criteria and areas of expertise required for and relevant to the project and are free of conflicts of interest (COIs). The Panel will be “charged” with responding to specific technical questions as well as providing a broad technical evaluation of the overall models’ technical soundness, system quality, or usability.

DOCUMENTS PROVIDED

The following is a list of documents/application software, supporting information, and reference materials that will be provided for the review. The review assignments for the panel members will vary slightly according to discipline.

Review Documents / Application Software	No. of Review Pages ¹	Subject Matter Experts		
		Economist 1 (Recreational Model Focus)	Transportation Modeling Specialist	Economist 2 (USACE Expertise)
CRSO Recreation Analysis Model - Model Overview and Summary	3	3		3
CRSO Recreation Analysis Model – Main Model Documentation	74	74		74
CRSO Recreation Analysis Model – Application Calculator (.xlsx)	N/A	N/A		
SCENT – Model Documentation	64	64	64	64

Review Documents / Software Programs	No. of Review Pages ¹	Subject Matter Experts		
		Economist 1 (Recreational Model Focus)	Transportation Modeling Specialist	Economist 2 (USACE Expertise)
TOM – Model Documentation	16		16	16
TOM – 2019 Columbia Snake River Navigation Survey	322		322	322
TOM – Application Software (.exe) and Spreadsheets (.xlsx)	N/A		N/A	
Total Number of Review Pages	479	141	402	479
Supplemental Documents				
SCENT – Application Software (.exe) ²	N/A	N/A	N/A	N/A
Total Number of Reference Pages	N/A	N/A	N/A	N/A

¹ “N/A” indicates that a page count cannot be estimated from the Excel spreadsheet and executable files provided.

The Panel member is responsible for reviewing these files.

² The SCENT application software code and user interface have been previously reviewed. The application software and its documentation will be provided to allow the panel members to better understand the functionality of the model and assist during their review.

Policy Documents for Reference

- Review Policy for Civil Works (EC 1165-2-217, February 20, 2018)
- OMB’s Final Information Quality Bulletin for Peer Review (December 16, 2004)

SCHEDULE & DELIVERABLES

This schedule is based on the receipt date of the final review documents and may change due to circumstances out of Battelle’s control such as changes to USACE’s project schedule and unforeseen changes to panel member and USACE availability. As part of each task, the panel member will prepare deliverables by the dates indicated in the table (or as directed by Battelle). All deliverables will be submitted in an electronic format compatible with MS Word (Office 2003).

Task	Action	Due Date
Meetings	Subcontractors complete mandatory Operations Security (OPSEC) training	4/18/2020
	Battelle sends review documents to panel members	3/20/2020
	Battelle convenes kick-off meeting with panel members	3/24/2020
	Battelle convenes kick-off meeting with USACE and panel members	3/24/2020
	Battelle convenes mid-review teleconference for panel members to ask clarifying questions of USACE	4/6/2020
Review	Panel members complete their individual reviews	4/22/2020

Task	Action	Due Date
	Battelle provides talking points for Panel Review Teleconference to panel members	4/24/2020
	Battelle convenes Panel Review Teleconference	4/27/2020
	Battelle provides Final Panel Comment templates and instructions to panel members	4/28/2020
	Panel members provide draft Final Panel Comments to Battelle	5/4/2020
	Battelle provides feedback to panel members on draft Final Panel Comments; panel members revise Final Panel Comments	5/05/2020 - 5/11/2020
	Panel finalizes Final Panel Comments	5/12/2020
Final Report	Battelle provides Model Review Report to panel members for review	5/14/2020
	Panel members provide comments on Model Review Report	5/20/2020
	*Battelle submits Model Review Report to USACE	5/22/2020
	USACE Planning Center of Expertise (PCX) provides decision on Model Review Report acceptance	6/1/2020
Comment Response Process	Battelle inputs Final Panel Comments to Design Review and Checking System (DrChecks) and provides Final Panel Comment response template to USACE	6/3/2020
	Battelle convenes teleconference with Panel to review the Comment Response process	6/3/2020
	USACE Project Delivery Team (PDT) provides draft Evaluator Responses to USACE PCX for review	6/19/2020
	USACE PCX reviews draft Evaluator Responses and works with USACE PDT regarding clarifications to responses, if needed	6/25/2020
	USACE PCX provides draft PDT Evaluator Responses to Battelle	6/26/2020
	Battelle provides draft PDT Evaluator Responses to panel members	6/30/2020
	Panel members provide draft BackCheck Responses to Battelle	7/6/2020
	Battelle convenes teleconference with panel members to discuss draft BackCheck Responses	7/7/2020
	Battelle convenes Comment Response Teleconference with panel members and USACE	7/8/2020
	USACE inputs final PDT Evaluator Responses to DrChecks	7/15/2020
	Battelle provides final PDT Evaluator Responses to panel members	7/16/2020
	Panel members provide final BackCheck Responses to Battelle	7/21/2020

Task	Action	Due Date
	Battelle inputs panel members' final BackCheck Responses to DrChecks	7/22/2020
	*Battelle submits pdf printout of DrChecks project file	7/23/2020
	Contract End/Delivery Date	2/28/2021

* Deliverables

CHARGE FOR PEER REVIEW

Members of this IEPR Panel are asked to determine whether the CRSO economic models are technically sound relative to the design objectives. In addition to the underlying theory, conceptualization, and computational aspects of the methods, reviewers are asked to comment on aspects of the model that potentially affect its usability and reliability as a potential producer of information to be used to influence planning decisions. Specific questions for the Panel are included in the general charge guidance below. The intent of these questions is to focus your review on the assessment criteria that need to be evaluated.

General Charge Guidance

Please answer the scientific and technical questions listed below and conduct a broad overview of the materials provided for the CRSO economic models. Please focus your review on your discipline/area of expertise and technical knowledge. However, please feel free to answer any questions that you feel able to. In addition, please note the following guidance.

1. Your response to the charge questions should not be limited to a “yes” or “no.” Please provide complete answers to fully explain your response.
2. Answer the scientific and technical questions listed below and conduct a broad overview assessment of the planning tools. **Use the Charge Response Form provided when answering the questions.**
3. Evaluate the soundness of the models and comment on whether the models effectively represent the systems being modeled and how the models can be validated.
4. Focus the review on scientific information, including factual inputs, data, the use and soundness of model calculations, assumptions, and results that inform decision makers.
5. Offer opinions as to whether the model parameters and formulas are sufficient to quantify economic calculations.
6. Offer suggestions for future improvements that could be considered by USACE but are not necessary for model use at this time.
7. If desired, panel members can contact one another. However, panel members **should not** contact anyone who is or was involved in the project, prepared the subject documents, or was part of the model development team.
8. Please contact the Battelle Program Manager, Lynn McLeod; mcleod@battelle.org for requests or additional information.

9. In case of media contact, notify the Battelle Program Manager, Lynn McLeod (mcleod@battelle.org) immediately.
10. Your name will appear as one of the panel members in the peer review. Your comments will be included in the Model Review Report but will remain anonymous.

Please submit your comments in electronic form to the Program Manager, no later than 10 pm ET by the date listed in the schedule above.

Independent External Peer Review of the Economic Models used for the Columbia River System Operations (CRSO)

Charge Questions as Supplied by USACE

The following Review Charge to Reviewers outlines the objectives of the independent external peer review (IEPR) for the subject Economic Models and identifies specific items for consideration for the IEPR Panel.

The objective of the IEPR is to establish that models, analyses, results, and conclusions are theoretically sound, computationally accurate, based on reasonable assumptions, well-documented and in compliance with the requirements of Office of Management and Budget (OMB) Peer Review Bulletin. The IEPR Panel is requested to offer a broad evaluation of the overall model documentation in addition to addressing the specific technical and scientific questions included in the Review Charge. The Panel has the flexibility to bring important issues to the attention of decision makers, including positive feedback or issues outside those specific areas outlined in the Review Charge. The Panel can use all available information to determine what scientific and technical issues related to the model or its documentation may be important to raise to decision makers.

Panel review comments are to be structured to fully communicate the Panel's intent by including the comment, why it is important, any potential consequences of failure to address, and suggestions on how to address the comment.

The Panel is asked to consider the following items as part of its review of the model documentation and supporting materials.

Technical Quality

1. Does the model documentation clearly and precisely describe the focus of the model? Discussion may include, but is not limited to, geographic range, applicability limits, model domain, or boundary conditions.
2. Did the model development process clearly follow a general structure of conceptualization, quantification, and evaluation?
3. Are the intended uses of the model defined, clear, and appropriate?
4. Are the spatial and temporal resolutions of the model described appropriately?
5. Are interpretations and conclusions sound, justified by the data, and consistent with the objectives?
6. Are the assumptions and limitations of the model clearly communicated and supported?
7. Comment on the degree to which the model can be used to evaluate existing conditions of the evaluation area and to forecast conditions anticipated to occur during the period of analysis (50 years).

8. Does the model documentation sufficiently include a question or hypothesis and an appropriate underlying theoretical or quantitative framework?
9. Are the most sensitive parameters or factors of the model identified and supported with sensitivity analyses?
10. Are the model metrics, functions, and parameters clearly defined and dimensionalized, preferably in table format?
11. Is the organization of the model documentation satisfactory (e.g., no discussion in results)?
12. Is the model documentation sufficiently detailed such that it could be replicated, reproduced, or used independent of the model development team (i.e., black box vs open source)?
13. Comment on the degree to which the model facilitates sensitivity, uncertainty, and risk analyses.

System Quality

14. Are model computations presented in sufficient detail, accurate, and supported by current state of the practice methods?
15. Does the model documentation sufficiently describe testing steps utilized during model development (i.e., consistency check, sensitivity analyses, calibration, validation)?
16. Has the model programming system been tested for errors? If not, what is the potential for errors to occur?

Usability

17. What are the hardware, software, and operating system requirements of the model? To what degree can the hardware, software, and operating system requirements complicate use of the model?
18. Is user documentation user-friendly and complete? Comment on the model's ease of use.
19. Are the input requirements evident to the user? Is the data readily available?
20. Is the required level of precision and accuracy of inputs documented?
21. Comment on the understandability of model output(s).
22. Comment on the level of difficulty likely to be encountered when attempting to assess the model's sensitivities to alternative inputs.

Battelle Summary Charge Questions to the Panel Members¹

Summary Questions

23. Please identify the most critical concerns (up to five) you have with the project and/or review documents. These concerns can be (but do not need to be) new ideas or issues that have not been raised previously.
24. Please provide positive feedback on the project and/or review documents.

¹ Questions 23 and 24 are Battelle-supplied questions and should not be construed or considered part of the list of USACE-supplied questions. These questions were delineated in a separate appendix in the final Work Plan submitted to USACE.

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APPENDIX D

Conflict of Interest Form

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David Kaplan
USACE, Institute for Water Resources
February 3, 2020
C-2

Conflicts of Interest Questionnaire

Independent External Peer Review

Economic Models used for the Columbia River System Operations (CRSO)

The purpose of this document is to help the U.S. Army Corps of Engineers identify potential organizational conflicts of interest on a task order basis as early in the acquisition process as possible. Complete the questionnaire with background information and fully disclose relevant potential conflicts of interest. Substantial details are not necessary; USACE will examine additional information if appropriate. Affirmative answers will not disqualify your firm from this or future procurements.

NAME OF FIRM: **Battelle Memorial Institute Corporate Operations**

REPRESENTATIVE'S NAME: **Courtney Brooks**

TELEPHONE: **614-424-5623**

ADDRESS: **505 King Avenue, Columbus, Ohio 43201**

EMAIL ADDRESS: **brooksc1@battelle.org**

I. INDEPENDENCE FROM WORK PRODUCT. Has your firm been involved in any aspect of the preparation of the subject study report and associated analyses (field studies, report writing, supporting research etc.) No **Yes** (if yes, briefly describe): Battelle managed Pacific Northwest National Laboratories (PNNL) assisted with the scoping for the EIS. However, due to contractual requirements, Battelle Corporate staff do not work with PNNL staff and are firewalled from PNNL work, therefore the Battelle staff conducting the Economic Model Review have not had and will not have any involvement with the PNNL work and PNNL will not have any involvement with the Economic Model Review.


II. INTEREST IN STUDY AREA OR OUTCOME. Does your firm have any interests or holdings in the study area, or any stake in the outcome or recommendations of the study, or any affiliation with the local sponsor? No **Yes** (if yes, briefly describe):

III. REVIEWERS. Do you anticipate that all expert reviewers on this task order will be selected from outside your firm? No **Yes** (if no, briefly describe the difficulty in identifying outside reviewers):

IV. AFFILIATION WITH PARTIES THAT MAY BE INVOLVED WITH PROJECT IMPLEMENTATION. Do you anticipate that your firm will have any association with parties that may be involved with or benefit from future activities associated with this study, such as project construction? No **Yes** (if yes, briefly describe):

V. ADDITIONAL INFORMATION. Report relevant aspects of your firm's background or present circumstances not addressed above that might reasonably be construed by others as affecting your firm's judgment. Please include any information that may reasonably: impair your firm's objectivity; skew the competition in favor of your firm; or allow your firm unequal access to nonpublic information.

No additional information to report.


For Courtney Brooks

2/3/2020

Date

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal

BATTELLE

It can be done

Comment Response Record for the Independent External Peer Review of the Economic Models Used for the Columbia River System Operations (CRSO)

USACE Draft Evaluator Responses

Prepared by

Battelle
505 King Avenue
Columbus, Ohio 43201

for

Department of the Army
U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Mississippi Valley Division

Contract No. W912HQ-15-D-0001
Task Order: W912HQ20F0011

June 3, 2020

Final Panel Comment 1

The CRSO Recreation Analysis Model inaccurately defines local versus non-local visitors when aggregating the impacts within economic Regions A through D and within the CRSO area as a whole.

Relevant Model Assessment Criteria

Representation of the System

Model Assumptions and Limitations

Model Calculations/Formulas

Model Usefulness in Selecting Alternatives

Basis for Comment

The CRSO Recreation Analysis Model's methodology for estimating regional economic effects using IMPLAN is based on the distinction between local and non-local visitors. Only changes in non-local visitor expenditures are used to determine regional economic effects; therefore, the definition of local versus non-local influences the magnitude of the estimated effects. Non-local visitors are considered to be those traveling more than 60 miles *to the site* for National Park Service (NPS) locations and more than 30 miles *to the site* for USACE locations. The regions in the recreation analysis are very large, extending more than 60 miles from most sites to major centers of population or from one side of the region to the other. So, it seems a visitor could be counted as a non-local relative to a particular site location, thereby including the loss of their trip expenditures in the regional IMPLAN analysis, when those expenditures should be counted as local *to the region*, in which case the loss of their expenditures should be excluded from the IMPLAN analysis. This methodology leads to an overestimation of the economic effects under each alternative for Regions A through D and for the CRSO area as a whole.

Site-level Analysis - As an example, all visitors from Seattle would be considered non-local visitors to Regions A, B, C, and D. Seattle is more than 60 miles outside of any of the CRSO sites, and King County, Washington, where Seattle is located, is not included within any of the CRSO regions (see Table 2-5 of CRSO DEIS Appendix M). Therefore, all lost visits to every site in Region A from people who live in Seattle should be counted as lost economic activity to Region A. Similarly, all lost visits to every site in Region B from people who live in Seattle should be counted as lost economic activity to Region B, and so on for Regions C and D.

To aggregate the economic impact to Region A from these lost Seattle-resident visits, simply add up the economic impact at each site in Region A, and so on for Regions B, C, and D. To aggregate the economic impact across the entire CRSO area, simply add up the economic impact across all regions.

Region-level Analysis - Portland, Oregon, however, is located in Multnomah County, which is considered part of Region D in the recreation analysis (see Table 2-5 of CRSO DEIS Appendix M). Portland is far enough from John Day Dam that Portland visitors would be considered non-local to the site, even though they reside within the same economic region (Region D). So, lost visits from Portland residents to John Day Dam should be included in an IMPLAN analysis of the economic

Final Panel Comment 1

impacts *at the John Day Dam site*. But lost visits from Portland to John Day Dam are *local to Region D*. Therefore, it is inappropriate to include those lost visits in an IMPLAN analysis of the economic impacts *to the region*, because the money the Portland visitors would have spent at John Day Dam is still being spent within Region D. To correctly assess the economic impact to each region, one must define local versus non-local visits *to the region*. It is inappropriate to simply add up each of the site-level impacts across the region.

CRSO Area-level Analysis - The same issue arises when estimating the impacts to the entire CRSO area. A new definition of local versus non-local to the CRSO must be employed. It is inappropriate to simply add up each of the region-level impacts. For example, lost visits in Region B from visitors who reside in Region A should be included in an IMPLAN analysis of Region B; those lost visits should not be included in an IMPLAN analysis of the entire CRSO because the Region A visitors are local to the CRSO area.

Significance – High

As currently reported, the methodology for estimating regional economic effects misrepresents aggregate impacts to the CRSO (i.e., treating visits by those who reside in a region as non-local to the region if they travel more than 30/60 miles to a site) and applies a faulty assumption (i.e., non-local visits to a site are also non-local visits to the CRSO).

Recommendations for Resolution

1. Define local versus non-local visitors to each economic region (A through D), as opposed to each site.
2. Define local versus non-local visitors to the entire CRSO area, as opposed to each site and economic region.
3. Run IMPLAN models for each economic region using the appropriate definition of local versus non-local visits to the region in order to aggregate the economic impacts from changes in recreation within Regions A, B, C, and D properly.
4. Run an IMPLAN model for the entire CRSO area using the appropriate definition of local versus non-local visits to the CRSO area to aggregate the economic impacts from changes in recreation across Regions A, B, C, and D properly.

PDT Draft/Final Evaluator Response (FPC #1)

Concur	X	Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a “concur,” unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The PDT does not concur that the definition of local versus non-local visitors is not appropriate for the aggregation of economic impacts from changes in recreation. The focus of the regional economic impact analysis is at the site- or project- level, which is designed to estimate the economic impacts in terms of jobs and income of changes in non-local visitor spending in gateway communities. Visitor spending profiles (from standard expenditure profiles) are estimated for spending at the site level, not the regional level. The changes in non-local visitor spending in gateway communities at each site compared to the No Action Alternative were aggregated for all projects in the region to show the total changes in jobs and income supported by non-local visitor spending across all gateway communities in the region. Region-based IMPLAN models (and not site-specific models) were used for consistency with the regional economic evaluation across resources and to simplify the modeling approach. The regional economic effects (jobs and income) would largely be experienced by communities surrounding the recreation sites and parks (i.e., in gateway communities) where the changes in visitation would occur. However, because a broader IMPLAN regional model was used, relatively larger multipliers at the regional level (versus the site-level) capture economic activity linkages across the broader region, rather than only impacts experienced at or near the gateway communities.

The reviewer suggested that the proposed methodology for estimating regional economic effects likely overstates the lost “regional” visitation and expenditures. The commenter is concerned that some non-local visits that are considered to be lost from a particular site may actually still occur elsewhere in a region. The PDT agrees that visitors could be local to some sites, while they could be considered non-local at other sites within a region. However, the available data on visitation defines visits as being either local or non-local at the site-level; it does not capture the origins and destinations of every visitor. Without the specific information on origin of visitors, the PDT has assumed that non-local visitors would forego their travel to the gateway community if a site is unavailable, which indeed is likely to overstate the actual number of visits that would be “lost”. The PDT also concurs that there may be some substitution by visitors within sites or within other projects within a region, for example, if a particular boat ramp or area is unavailable for a period of time due to high or low water conditions. Therefore, the evaluation is likely to overestimate changes in visitation (and non-local visitation). However, it should be noted that other aspects of the recreation evaluation, such as under counting of non-reservoir based recreation (river reaches), would likely underestimate the visitation and associated economic impacts. The limitation on visitor origin and destination data could not be practically resolved for the purposes of this study.

Some of these limitations are described in Section 3.11.3.1, Recreation Methodology. The PDT has added additional caveats to describe the assumptions around the non-local visitor spending in the Final EIS.

The following additions have been made to Section 3.11.3.1 (change shown in bold italics):

Recreational Visitation

As described previously, visitation estimates are not available for all sites, and visitation data likely under-estimates river recreational visitation. The methodology presented above includes a number of assumptions due to data limitations. In particular, specific data about the behavior of recreationists when faced with varying river and reservoir conditions in the Basin is not known with certainty. The assumptions used in this analysis are conservative (i.e., they are more likely to overstate than understate effects of changes to water-based visitation), ***but the methodology is the best approach available given existing information.*** In particular, quantified effects do not take into account the potential for spatial substitution or temporal substitution.¹

1(foot note) That is, if a particular boat ramp is made temporarily inaccessible by changes in reservoir elevations, a recreationist might use a different ramp, pursue a shore-based activity on a given trip occasion ***to the same site, or make a trip to a different site in the region.*** The current methodology assumes that recreationists (local and non-local visitors) would forego that particular visit and not visit other adjacent reservoirs. Second, quantified effects do not take into account the potential for temporal substitution. That is, a recreationist may take a trip earlier or later in time to make up for a lost trip on another occasion due to an inaccessible boat ramp.

The following additions and changes have been made to section 3.11.3.1, Methodology (change shown in the italicized and bolded text):

Regional Economic Effects

Regional economic effects are measures of changes in economic activity as a result of changes in expenditures (also known as visitor spending) associated with recreational visitation. The approach to assess the regional economic effects is briefly described in this section. First, quantified changes in visitation resulting from changes in water surface elevations and boat ramp accessibility (results from the social welfare effects evaluation) are multiplied by per-day visitor spending estimates for recreation ***at each river reach or reservoir.***

The change in non-local visitation was estimated based on data on visitation patterns at affected sites. The focus of the regional economic effects evaluation was on non-local visitors ***to the site or project*** because, while local visitors are likely to continue to spend money in the affected area even if they forgo particular recreation trips, non-local visitors may divert spending to other areas if particular trips are not taken due to access issues. A majority of visitors in the study area are considered to be non-local (agencies define local by the distance travelled to sites, which is generally 30 or 60 miles, depending on agency). The percentage of visitors who are non-local for each reservoir/river reach are presented in Appendix M.

Second, estimates of non-local visitor spending in ***each reservoir/river reach*** are ***aggregated for each region*** to estimate the ***changes in*** regional economic activity in terms of jobs, income, and sales using the input-output model, IMPLAN. IMPLAN is a widely used industry-standard input-output data and software system that is used by many Federal and state agencies to estimate regional economic effects. The underlying data for IMPLAN is derived from multiple sources, including the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the U.S. Census Bureau. Any potential effects to regional economies associated with changes in recreation quality are discussed qualitatively.

Again, the current methodology associated with changes in water-based visitation assumes that recreationists (local and non-local visitors) when faced with reduced access would forego that particular visit and not visit other reservoirs. The specific origin of the visitor is

not known for non-local visitors, precluding a regional assessment of whether the visitor spending would be local or non-local to the region.

Regional economic effects are presented by CRS region and in total for the Basin. The study area for each region includes multi-county areas, as shown in Table 3-259. Region-based IMPLAN models (and not site-specific models) were used for consistency with the regional economic evaluation across resources and to simplify the modeling approach. The regional economic effects (jobs and income) would largely be experienced by communities surrounding the recreation sites and parks (i.e., in gateway communities) where the changes in visitation would occur. However, because a broader IMPLAN regional model was used, relatively larger multipliers at the regional level (versus the site-level) capture economic activity linkages across the broader region, rather than only impacts experienced at or near the gateway communities. A county was assigned to a CRS region if the majority of the county's area lies within the region.

Appropriate changes were also made to Appendix M.

Recommendation 1: ☐ **Adopt** ☒ **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The focus of the regional economic impact analysis is at the site- or project- level, which is designed to estimate the economic impact in terms of jobs and income of changes in non-local visitor spending in gateway communities at each site or project (i.e., reservoir) location. These economic impacts are presented for each region. Data is not available on the origin of visitors in terms of within or outside the "region."

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The focus of the regional economic impact analysis is at the site- or project- level, which is designed to estimate the economic impact in terms of jobs and income of changes in non-local visitor spending in gateway communities at each site or project (i.e., reservoir) location. These economic impacts are presented for each region. Data is not available on the origin of visitors in terms of within or outside the "CRSO area."

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The focus of the regional economic impact analysis is at the site- or project- level, which is designed to estimate the economic impact in terms of jobs and income of changes in non-local visitor spending in gateway communities at each site or project (i.e., reservoir) location. These economic impacts are presented for each region. Data is not available on the origin of visitors in terms of within or outside the "region."

Recommendation 4: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The focus of the regional economic impact analysis is at the site- or project- level, which is designed to estimate the economic impact in terms of jobs and income of changes in non-local visitor

spending in gateway communities at each site or project (i.e., reservoir) location. These economic impacts are presented for each region. Data is not available on the origin of visitors in terms of within or outside the “CRSO area.”

Panel Draft/Final BackCheck Response (FPC #1)

Concur

Non-Concur

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 2

The TOM documentation does not provide information on the relative cost of rerouting goods moving out of the Lower Snake River to support the assumption that modeling only wheat accurately represents the full impacts of MO3, particularly during a disruption/delay event.

Relevant Model Assessment Criteria

Model Documentation Quality

Representation of the System

Model Assumptions and Limitations

Basis for Comment

The SCENT and TOM models use different years for commodities volumes. SCENT uses 2016 shipment volumes; however, it is unclear what year of shipments are modeled in TOM. Page L-3-4 states that TOM models 202 million bushels of grain based on a 2014 to 2018 average, but page L-3-8 states that TOM models 204 million bushels of grain based on 2018 production.

The decision to model only wheat in the TOM is based on the fact that wheat represents a large majority of the total volume of commodities moving out of the Lower Snake River (about 87%). However, modeling only wheat may not reflect the full impacts of MO3 on transportation costs.

To estimate the extra shipping costs for MO3, TOM calculates the MO3 shipping costs for wheat and subtracts the No Action Alternative shipping costs for wheat. If, in reality, wheat is the highest-cost commodity to reroute, it would be the last to be rerouted by cost-minimizing shippers or a cost-minimizing algorithm like TOM in cases of binding capacity constraint(s); all other commodities would be rerouted before any wheat. If the No Action Alternative has binding capacity constraints when modeling only wheat, then TOM would have rerouted all other commodities under both the No Action Alternative and MO3. In that case, the TOM calculation of the extra shipping costs under MO3 (MO3 wheat shipping costs minus the No Action Alternative wheat shipping costs) would effectively be the same as the calculations made using SCENT, because the shipping costs of other commodities in TOM would be moot, having canceled out through the subtraction.

If, however, wheat is not the highest-cost commodity to reroute, the shipping costs of the other commodities would not cancel out in a cost-minimizing algorithm like TOM through the subtraction. Here, if there are binding capacity constraints under MO3, then excluding those other commodities from the TOM would underestimate the amount of wheat that would be rerouted, thereby underestimating the extra shipping costs of MO3.

Significance – Medium

An accurate assessment of the impacts of a dam breach under MO3 on navigation is needed to accurately compare the MO3 impacts with impacts under the other alternatives.

Final Panel Comment 2

Recommendations for Resolution

1. Provide information on the relative cost of rerouting wheat compared to the other commodities being transported on the Lower Snake River.
2. Discuss how the decision to model only wheat in the TOM affects shipping costs under MO3 compared to the other MO alternatives.
3. If wheat is not the highest-cost commodity to reroute, incorporate the other commodities into TOM.

PDT Draft/Final Evaluator Response (FPC #2)

Concur **X** **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The PDT concurs that an accurate assessment of the impacts of MO3 relative to the other alternatives is desirable and is important to the EIS. However, the reviewer implies that a correction is needed to the analysis to compare alternatives in the document because the TOM model estimates are not accurate due to its focus on wheat. The PDT disagrees with this point.

Recommendation 1: **X** **Adopt** **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: While the PDT disagrees that analytical changes are needed, some additional clarification has been added to section 3.10 and Appendix L with regard to discussion of the relationship of the volume of wheat to other commodities as well as potential effects to these movements under MO3. In 2018, 62 percent of overall freight volume on the Lower Snake system was wheat. In addition, 25 percent of overall freight on the Lower Snake River was petroleum products that terminated below Ice Harbor Dam. As such, shipments of petroleum products do not utilize the Snake River locks and would not be directly affected by dam removal under MO3. This movement and expected impacts on it was inconsistently presented in some instances in the DEIS, and has been corrected and clarified in Section 3.10 and Appendix L. Remaining commodities that utilized the Snake River system included pulp and paper products (4 percent of overall volume) as well as chemicals and iron/steel commodities (8.5 percent of overall volume), some of which also terminate below Ice Harbor Dam. To the extent that these shipments utilize the Snake River locks and dams, they would be affected under MO3 by increased transportation costs. Potential increases in costs for these other commodities that would occur under MO3 are discussed qualitatively in section 3.10.3.5. It is correct that by not including all

commodities in the quantitative modeling of MO3 effects that here is some underestimation of costs. However, this underestimation has no bearing on the relative ranking of alternatives in terms of their effects on navigation.

Recommendation 2: ☒ **Adopt** ☐ **Not Adopt**

Explanation: Similar to Recommendation 1, the PDT does not find that analytic changes are required in response to this recommendation, but the FEIS now more clearly describes that (1) some commodities would not be affected by dam removal at all (particularly petroleum which terminates below Ice Harbor dam), and (2) other non-wheat commodities (including pulp and paper products, chemicals, and iron/steel) that are not modeled but which could also be affected by increased transportation costs, comprise a minor component of the overall volume of commodities shipped (12.5 percent). It is correct that by not including all commodities in the quantitative modeling of MO3 effects there is some underestimation of costs. However, this underestimation has no bearing on the relative ranking of alternatives in terms of their effects on navigation.

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: Commodities on the lower Snake River are not in competition with each other on this system. The PDT does not find that other commodities need to be included as recommended, due to the fact that they have not historically competed for capacity on the lower Snake, and on and there is no known reason they would in the future. As discussed above, the movements of other commodities on the lower Snake River has been clarified in the FEIS.

Panel Draft/Final BackCheck Response (FPC #2)

☐ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 3

The SCENT User's Manual and files supplied to run the model were unreliable, and the SCENT Model documentation was incomplete.

Relevant Model Assessment Criteria

Model Documentation Quality

Operating Requirements of the Model

Basis for Comment

The model developers supplied the Panel with a set of files and a User's Manual that had instructions on how to run the SCENT Model. None of the panel members were able to run the model by following the instructions in the User's Manual to execute the files provided to the Panel. After being notified of

Final Panel Comment 3

this problem during the Mid-Review Teleconference, the model developers provided the Panel with a new set of files, but the Panel still was not able to operate the SCENT Model using those new files.

Also, the SCENT Model documentation does not indicate whether the user is able to import new data into SCENT. For example, the SCENT Model was used to evaluate changes in shipping costs under MO1, MO2, MO4, and the Preferred Alternative for the CRSO DEIS. To perform that evaluation, the shipping list of goods transported through the CRSO in 2016 was used. The Panel cannot determine, from the SCENT Model documentation provided, whether an alternate shipping list could be imported into SCENT for evaluation and, if so, how the user could do so. This is an important omission in the SCENT Model documentation. It should be clear what data/parameters are fixed in the model, what data/parameters can be modified or imported into the model, and what steps to take to modify or import data/parameters. (Note: the SCENT User's Manual does mention some data sets that users can import on their own, but the SCENT Model documentation does not.)

Significance – Medium

The inability to operate the model, or to manipulate the input data, prevented the Panel from determining the effectiveness of the model to accurately assess the impacts on navigation, which is needed to validate the costs associated with each alternative.

Recommendations for Resolution

1. Revise the SCENT Model and model documentation to allow a user to operate the model.
2. Detail in the SCENT documentation which data/parameters in the SCENT Model can be modified directly within SCENT, and explain how to do so.
3. Detail in the SCENT documentation which data/parameters in the SCENT Model can be modified by importing a new file into SCENT, and explain how to do so.

PDT Draft/Final Evaluator Response (FPC #3)

<input checked="" type="checkbox"/> Concur	<input type="checkbox"/> Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The PDT will revise the SCENT User's Manual to ensure the manual is more user friendly and easier to follow. Details will be added to point out which input files can be modified and how they can be modified.

Recommendation 1:	<input checked="" type="checkbox"/> Adopt	<input type="checkbox"/> Not Adopt
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Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The PDT will revise the SCENT User's Manual to ensure that a user will be able to follow the manual and use the provided files to run the model from start to finish. This will be accomplished by walking a novice user through the process on a computer that has not previously had SCENT installed on it, and adjusting the manual as necessary.

Recommendation 2:	<input type="checkbox"/> Adopt	<input checked="" type="checkbox"/> Not Adopt
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Explanation: There are no parameters or data that can be modified within the structure of the model itself without the knowledge of C# programming language. The original model was converted from Fortran programming language into C# to add a user interface in order to avoid users needing to know programming language to run the model.

Recommendation 3:	<input checked="" type="checkbox"/> Adopt	<input type="checkbox"/> Not Adopt
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Explanation: Details will be added to the manual clarifying which input files can be modified and how they can be modified.

Panel Draft/Final BackCheck Response (FPC #3)

<input type="checkbox"/> Concur	<input type="checkbox"/> Non-Concur
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Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 4

The estimates of the annual visitor expenditures under the No Action Alternative could not be replicated.

Relevant Model Assessment Criteria

Model Documentation Quality
 Analytical Requirements
 Model Assumptions and Limitations
 Model Calculations/Formulas
 Model Usefulness in Selecting Alternatives

Basis for Comment

The CRSO Recreation Analysis Model documentation (CRSO DEIS Appendix M – Recreation (Section M.2.2) and Attachment A: User Guide to the Recreational Analysis (Section 3)) describes the methodology for calculating the regional economic effects associated with changes in recreational access. Those effects (changes in jobs, income, sales) are developed in two parts: (1) calculation of visitor expenditures by reservoir/river reach and by region, and (2) conversion of total expenditures (by visitor segment and spending category) into expenditure estimates by IMPLAN sector for use in region-specific IMPLAN models.

Between Appendix M and Attachment A, the CRSO Recreation Analysis Model documentation provides visitor spending profiles and detailed trip characteristic data for USACE and NPS locations within the Columbia River System (CRS). Along with visitation data, the expenditure data and trip characteristics are direct inputs into the calculation of annual visitor expenditures. Calculations of annual visitor expenditures by region under the No Action Alternative are provided in Table 16 of Appendix M.

However, using the approach described in the model documentation and the data provided, the Panel could not reproduce the detailed visitor expenditure estimates provided in Table 16. The Panel chose several locations in different regions as examples to attempt to reproduce the results in Table 16.

- For two example locations with no camping activity, the Panel could reproduce the total expenditures, but could not reproduce the breakdown between local and non-local visitor expenditures.
- For two example locations with camping activity, the Panel could not reproduce any of the visitor expenditure data.

The percentage breakdown between local and non-local visitor expenditures listed in Table 16 appears to be the same as the percentage breakdown in visitation for those locations (Tables 4 and 6 of Attachment A). However, given that per-party expenditures for each trip for non-locals (boaters or non-boaters) are higher than for locals (as shown in Table 3 of Appendix M and Table 2 of Attachment A), the Panel would expect to find that (1) the percentage of non-local visitor expenditures

Final Panel Comment 4

would be greater than the percentage of non-local visitation and (2) the percentage of local visitor expenditures would be less than the percentage of local visitation.

The methods and assumptions for calculating visitor expenditures described in the documentation are not detailed enough to reproduce the data presented for the No Action Alternative or the changes in visitor expenditures under any of the alternatives.

In addition, the model spreadsheets provided to the Panel did not include the process or calculations for allocating the total visitor expenditures (by visitor segment and spending category) to expenditure estimates by IMPLAN sector. As a result, the regional economic impacts produced by IMPLAN also cannot be reproduced.

Significance – Medium

The inability to reproduce visitor expenditure data and convert visitor expenditures to IMPLAN sectors (and therefore reproduce the regional economic effects) provides uncertainty about the model's technical soundness and quality.

Recommendations for Resolution

1. Provide a step-by-step example of the calculation of visitor expenditures (total, local, and non-local) for locations with different visitor activities in Appendix M and in the User Guide.
2. Explain the assumption that the breakdown of visitor expenditures (local vs non-local) would reflect the breakdown of visitation (local vs. non-local) at each recreational location.
3. Revise the model documentation package to include an Excel-based spreadsheet that calculates visitor expenditures (by visitor segment and spending category) using the data, inputs, and assumptions provided in the model documentation.
4. Revise the model documentation package to include an Excel-based spreadsheet that converts total visitor expenditures, by visitor segment and spending category, to expenditure estimates by IMPLAN sector.

PDT Draft/Final Evaluator Response (FPC #4)

Concur	X	Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a “concur,” unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The PDT does not concur that the model documentation package was insufficient to replicate the detailed visitor expenditure estimates provided in Table 16 of Appendix M (Table 3-11 in DEIS version). The reviewers relied on the CRSO DEIS Appendix M – Recreation (Section M.2.2) and Attachment A: User Guide to the Recreational Analysis (Section 3). On April 20th, supplemental model documentation package files were provided to the reviewers: Stata code (“RED Code.do”) and an accompanying Excel spreadsheet (“Rec RED Inputs.xlsx”), which produce the expenditures in Table 3-11 of Appendix M. These were referenced in a revised version of Attachment A: User Guide to the Recreational Analysis.

Recommendation 1: ☐ **Adopt** ☒ **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will ‘adopt’ or ‘not adopt’ each recommendation and provide an explanation. If ‘adopt’, please provide information on how this recommendation will be adopted. If ‘not adopt’, please explain why.

Explanation: The supplemental model package files (“RED Code.do” and “Rec RED Inputs.xlsx”) produce the expenditures in Table 3-11 of Appendix M.

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The assumption is explained in an appendix footnote: “For Corps sites, *expenditures* associated with local and non-local visitation are approximated using the fraction of local and non-local *visitation* at each site. This is done because the Corps expenditure profile is generic to all sites (nationwide), whereas information about the distribution of visitor segments at Corps sites is site-specific. Visitor segments were defined as local or non-local for the purposes of this analysis as described in the note to Table 2-4. For Lake Roosevelt, expenditures associated with local and non-local visitation are estimated using the site-specific distribution of visitor segments and expenditure profile. Visitor segments were defined as local or non-local for the purposes of this analysis as described in the note to Table 2-5. For all sites, because some segments designated as non-local include local visitors, the estimates of non-local expenditures (and associated regional economic effects) may be overstated. However, any bias that may arise due to data limitations is expected to be small.”

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The supplemental model package files (“RED Code.do” and “Rec RED Inputs.xlsx”) produce the expenditures in Table 3-11 of Appendix M.

Recommendation 4: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The supplemental model package files (“RED Code.do” and “Rec RED Inputs.xlsx”) produce the expenditures in Table 3-11 of Appendix M.

Panel Draft/Final BackCheck Response (FPC #4)	
Concur	Non-Concur
<p>Please enter an X in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:</p>	

Final Panel Comment 5

The SCENT Model does not incorporate factors associated with congestion during a disruption/delay event.

Relevant Model Assessment Criteria

Representation of the System

Model Assumptions and Limitations

Model Usefulness in Selecting Alternatives

Basis for Comment

The SCENT Model documentation states that “Shipping can be disrupted by a number of factors, including high flows, shallow depths, wind, fog, congestion, and combinations thereof.” (page 1). Those disruptions result in additional costs to various parties on the river system, whether due to delays, changes in the number of barges per tow, or other shipper responses. However, the SCENT Model evaluates only those changes in costs associated with changes in flows or changes in channel depth (draft); it does not incorporate the effects of other factors, most notably congestion. Congestion could occur in combination with changes in flows or draft, potentially exacerbating the effects of those changes and perhaps resulting in additional navigation costs. For example, if changes in flows or draft resulted in four-barge tows being cut down to three-barge tows plus additional single barges on the river (since the same amount of tonnage is required to be moved), the additional vessels on the river would cause congestion, reducing vessel speed and increasing trip time. The change from a four-barge tow to a three-barge tow plus a single barge would result in some amount of increased cost, but the increased trip time would result in additional navigation costs. Delays may also result in additional vessels on the river at one time.

Congestion may also occur due to binding capacity constraints at locks/dams/loading sites along the CRS independent of changes in flows or drafts. Changes in shipping commodities and shipping volumes could result in congestion even under normal flow and draft conditions.

Although the documentation acknowledges that the effects of congestion are not evaluated in the model, the document does not provide any discussion of the potential effects of congestion, implications for changes in navigation costs under each alternative, or the potential for different degrees of impact under different alternatives.

Significance – Medium

Changes in navigation costs under different flow and draft scenarios may be underestimated because congestion is not accounted for in the model. Alternatives may have varying potential to be affected by waterway congestion. Incorporating an evaluation of the costs of waterway congestion into the model would provide a more accurate estimate of expected transportation costs.

Recommendations for Resolution

1. Revise the model to account for congestion effects.

Final Panel Comment 5

2. If congestion cannot be incorporated into the SCENT Model, explain why it cannot be modeled within SCENT.
3. If congestion cannot be incorporated into the SCENT Model, provide a qualitative discussion of the potential effects of congestion to deep-draft and shallow-draft operations, and describe potential impacts on navigation costs under each alternative.

PDT Draft/Final Evaluator Response (FPC #5)

Concur ☒ **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: In contrast to navigation systems in other parts of the United States, waterway congestion is generally not an issue on the Columbia-Snake River Navigation System. The PDT acknowledges that the SCENT model does not account for congestion, as mentioned in the documentation. The CRSO EIS is not evaluating opportunities for navigation improvements, but rather is focused on evaluating differences to navigation operations due to changing hydrologic conditions (system flow and depth).

Recommendation 1: ☐ **Adopt** ☒ **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: Congestion is generally not an issues on the Columbia-Snake River Navigation System, and would not ultimately change the SCENT model results and/or alternative selection for the CRSO EIS. Therefore congestion will not be incorporated in the SCENT model. Therefore, given the study constraints (schedule and budget), adding an analysis of congestion to the SCENT model was not adopted.

Recommendation 2: ☒ **Adopt** ☐ **Not Adopt**

Explanation: A description as to why the SCENT model cannot incorporate congestion will be added to the model documentation.

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: For the purposes of the CRSO EIS, a qualitative discussion of congestion impacts would not add significant value to the analysis. As stated above, congestion is generally not an issue on the Columbia-Snake Navigation System.

Panel Draft/Final BackCheck Response (FPC #5)

Concur

Non-Concur

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 6

The manner in which high-water conditions are incorporated into the SCENT disruption/delay matrix is unclear and possibly inaccurate.

Relevant Model Assessment Criteria

Representation of the System

Model Assumptions and Limitations

Model Calculations/Formulas

Model Usefulness in Selecting Alternatives

Basis for Comment

Because four-barge tows may be unable to safely navigate certain high-water conditions, shippers will have to either delay the movement of their four-barge tows until after high-water conditions pass or break the four-barge tow into multiple smaller tows. This is referred to as the risk of disruption/delay and represents very real risks to shippers in the CRS.

Table 20 of the SCENT Model documentation presents a partial list of the full disruption/delay matrix, but the data shown are counter-intuitive. Per Table 20, all shallow-draft vessels (100%) that arrive at a node with a 1-day disruption should simply wait it out. On the other hand, for a 3-day disruption, 10% of shallow-draft vessels arriving on Day 1 should wait and 90% should change to a three-barge maximum tow, while 100% of those arriving on Day 2 or Day 3 should simply wait it out. For a 5-day disruption, 100% of shallow-draft vessels arriving on Day 1 and Day 2 should change to a three-barge maximum tow, 25% of those arriving on Day 3 should wait, and 75% should change to a three-barge maximum tow, and so on for Days 4 and 5. However, the Panel interprets the flow of goods to mean that all traffic should be cleared on Days 1 and 2 (albeit with three-barge tows instead of four-barge tows). This interpretation would mean that Day 3 of a 5-day disruption should operate in the same manner as Day 1 of a 3-day disruption, but that is not the case, which makes sense is if there is congestion at the node with respect to tugs during the 5-day disruption. The SCENT Model documentation states that the decision to wait or hire an extra tug is based on cost (Section 5.4.1); it does not mention a binding tug constraint.

Significance – Medium

The technical soundness of the SCENT model depends on the soundness of the disruption/delay matrix.

Recommendations for Resolution

1. Provide information on how high-water conditions are incorporated into the SCENT disruption/delay matrix.
2. Explain why the counter-intuitive information in Table 20 is appropriate.

PDT Draft/Final Evaluator Response (FPC #6)

X	Concur		Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a “concur,” unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: Thank you for your thorough review. The information presented in Table 20 contained an error in the columns labeled “Vessel Dispatch Date (relative to disruption start)”. The SCENT model utilizes a “key” that translates a numeric code into a “dispatch date bucket”. The key was incorrectly shown in Table 20, rather than the dispatch dates. The counter-intuitive response in the table are not in the SCENT model, and the actual responses in the model follow a more intuitive pattern. Generally, the shippers will respond per the survey’s harmonized response table (Table 19), except for the latter days in the disruption period (with 4 to 5 days remaining in the period, shippers tend to wait rather than drop barges).

Recommendation 1:	X	Adopt		Not Adopt
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Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will ‘adopt’ or ‘not adopt’ each recommendation and provide an explanation. If ‘adopt’, please provide information on how this recommendation will be adopted. If ‘not adopt’, please explain why.

Explanation: Table 20 will be updated with the correct ‘Vessel Dispatch Date’ information.

Recommendation 2:	X	Adopt		Not Adopt
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Explanation: The information shown in table 20 was incorrect and not reflective of the SCENT model. Correct information will be provided in Table 20.

Panel Draft/Final BackCheck Response (FPC #6)

	Concur		Non-Concur
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Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 7

The economic effects of a high-water year or a low-water year are not provided or accounted for in the analysis of alternatives within the CRSO Recreation Analysis Model.

Relevant Model Assessment Criteria

Representation of the System

Model Usefulness in Selecting Alternatives

Basis for Comment

CRSO DEIS Appendix M (page M-3) states: “The analysis focuses on modeled daily water surface elevations associated with the 50th percentile (typical water year), but considers water surface elevations at the 25th and 75th percentiles to understand the possible extent of effects under various water conditions.”

However, only visitation changes are considered under the 25th (high-water year) and 75th (low-water year) percentiles; no data on the extent of economic effects (social welfare, visitor expenditures, regional economic impacts) are provided for either of those situations under any alternative. Therefore, no comparison of the economic effects in a high- or low-water year as compared to a typical water year is provided in the documentation.

Table 1 of Appendix M illustrates that there are instances (under MO4 and under the Preferred Alternative) where impacts to specific reservoirs would occur only in low-water years; no impacts would occur at those locations in a typical water year. Impacts that occur in low-water years are not quantified or included in the summary of effects for relevant alternatives and are not included in the overall comparison of alternatives. For example, in Appendix M, Recreation, the “Potential for major adverse effects to visitor expenditures and regional economic effects at Lake Pend Oreille in low water years” (page M-98) is not quantified or considered in the alternatives evaluation, other than an included qualitative sentence.

The absence of data and lack of consideration of economic effects under high- and low-water years has the potential to affect the selection of the chosen alternative. For example, the patterns of impacts among regions may be different in low- or high-water years, as compared to typical water years.

The CRSO Recreation Analysis Model documentation states that the period of analysis is 50 years and provides average annual changes or effects (visitation, social welfare, economic effects) in a typical water year for each alternative. However, no calculations of the total effects over the 50-year period are provided. That calculation would include the effects of about 25 typical years, 12 high-water years, and 12 low-water years, and would account for those locations that experience effects only in low-water years or for differences in patterns of effects in low- or high-water years. A calculation of average annual effects over the 50-year period that captures the frequency and extent of effects in typical, low-water, and high-water years would provide information on actual effects over the study period.

Final Panel Comment 7

Significance – Medium/Low

Calculation of the economic effects expected to occur in low-water years and in high-water years would provide more complete information about potential project impacts. Inclusion of low- and high-water-year impacts in the alternatives analysis may affect the comparison of alternatives.

Recommendations for Resolution

1. Provide estimates of average annual changes in social welfare, visitor expenditures, and regional economic effects in low-water years and in high-water years under each alternative.
2. Calculate and report total effects and average annual changes in social welfare, visitor expenditures, and regional economic effects over the 50-year study period, accounting for high-water, typical, and low-water years.

PDT Draft/Final Evaluator Response (FPC #7)

Concur **X** **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The PDT does not concur that information was not provided on the economic effects (social welfare, visitor expenditures, regional economic impacts) in low-water years and high-water years. The limited data and/or evaluation of economic effects for high- and low- water years is because there were no difference or negligible difference between effects presented for low water years and high water years for the MOs and the difference that would occur under the median water year. When a difference occurred, this information was provided. For example, under MO4, economic effects are presented for low-water years at Lake Pend Oreille in Region A and Lake Roosevelt in Region B (e.g., see Table 3-265). The Lake Pend Oreille effects are described qualitatively because "...the analysis [did] not detect changes in boat ramp accessibility at Federal and state-managed boat ramps at Lake Pend Oreille" (Section 3.11.3.6, line 2368 in the DEIS). The Lake Roosevelt effects are quantified (e.g., see Table 3-265 in the DEIS) because the change in visitation is notably different from a typical water year. Under the Preferred Alternative, economic effects are presented for low-water years at Dworshak Reservoir because no changes in visitation (or economic effects) were detected for a typical year (Table 8-7 in Appendix M). In all other cases, changes in visitation under high- and low- water years are similar to changes in visitation in typical-water years (median water year), so while changes in visitation are reported, the associated economic effects are not (see detailed tables in Appendix M that report all monthly and annual changes in visitation under high- and low-water years for each alternative).

The following sentence has been added to Section 2.1.3 in Appendix M:

Social welfare effects are presented for a typical-water year and for high- or low-water years where changes in visitation under low- and high-water years differ by more than 2.5 percent compared with visitation under typical-water years.

The following sentence has been

Section 2.2 on Regional Economic Effects in Appendix M:

Regional economic effects are presented for a typical water year and for high- or low-water years where changes in visitation under low- and high-water years differ by more than 2.5 percent compared with visitation under typical-water years.

Recommendation 1: ☐ **Adopt** ☒ **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: Economic effects are provided under high- and low-water years for cases where changes in visitation differ by more than 2.5 percent when compared to differences under typical-water years or if there is no change in a typical-water year, but there is under high- or low-water years. These include MO4 low-water years at Lake Pend Oreille in Region A and Lake Roosevelt in Region B, and Preferred Alternative low-water years at Dworshak Reservoir. In all other cases, changes in visitation under high- and low- water years are similar to changes under typical water years, so while changes in visitation under are reported, changes in economic effects are not reported for low- and high-water years (see detailed tables in Appendix that report all monthly and annual changes in visitation under high- and low-water years for each alternative).

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: Section 3.11.3 (and Section 2.1 in Appendix M) states that the analysis considered short-term and long-term impacts and that results are presented as annual or annual equivalent effects over the 50-year period. Further, the H&H hydrographs used for the analysis cannot be used to predict water levels in any future year. Therefore, it would be infeasible to calculate the total effects over the 50-year period because the timing of typical, low-water, and high-water years in the future is unknown. In addition, this approach is consistent with the approaches in other socioeconomic evaluations.

Panel Draft/Final BackCheck Response (FPC #7)

☐ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 8

The TOM documentation does not report results of an assessment of model assumptions, fit, or validation.

Relevant Model Assessment Criteria

Model Documentation Quality

Model Assumptions and Limitations

Testing/Evaluation Process

Basis for Comment

The TOM documentation does not provide any information on the assessment of model assumptions, fit, or validation. The stability of the model solution with respect to price parameters and constraints is automatically generated by the General Algebraic Modeling System (GAMS), but that capability is not mentioned in the model documentation. The sensitivity of the TOM to changes in rail shipping rates is the only sensitivity analysis discussed in the documentation.

Significance – Medium/Low

A clear understanding of model assumptions, fit, and validation is important for conveying the robustness of the model results under different circumstances and the appropriateness of the model structure.

Recommendation for Resolution

1. Provide information on how the TOM was assessed with respect to its assumptions, fit, and validation.

PDT Draft/Final Evaluator Response (FPC #8)

X Concur **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The TOM model, like any model, is built from inputs. How accurately it fits reality is limited only by those inputs. The EIS discusses how those inputs were derived and the sources of that information. The PDT met with the shippers in Lewiston who agreed with the assumption that wheat moves in a least cost fashion, and thus lending support for the basic assumption of the TOM, which minimizes total transportation costs. However, the PDT concurs that some additional discussion of the

sensitivity of alternatives is warranted. These have been added to Appendix L as discussed below under Recommendation 1.

Recommendation 1: **X** **Adopt** **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The FEIS includes additional discussion of some key assumption in the analysis, including the forecast of future wheat volumes that will travel on the lower Snake River and the assumption regarding availability of shortline rail. Additional contextual information regarding the historical variation in shipping volumes and regional wheat production has also been included. Additional vetting of the model logic and results has been conducted through discussions with shippers, rail line operators, and port operators throughout the region.

Panel Draft/Final BackCheck Response (FPC #8)

Concur **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 9

The CRSO Recreation Analysis Model and SCENT Model documents do not assess the impacts of uncertainty on the models' respective results.

Relevant Model Assessment Criteria

Model Documentation Quality
Representation of the System
Model Assumptions and Limitations
Testing/Evaluation Process

Basis for Comment

The Panel's review of the CRSO Recreation Analysis Model and SCENT Model documentation indicated that risk assessment within the models was limited to addressing uncertainty associated with the hydrologic and hydraulic (H&H) analysis. Several sources of uncertainty, due to assumptions or data quality, were acknowledged in the models' documentation or identified by the Panel, which were not quantitatively or qualitatively addressed. The ability of the models to predict future conditions within the project area would be greatly enhanced by addressing these uncertainties.

The following uncertainties associated with CRSO Recreation Analysis Model parameters were identified.

- The behavior of recreationists, when faced with varying river and reservoir conditions in the basin, was assumed to be known with certainty; the model did not take into account the potential for spatial or temporal substitution, or potential mitigation actions by resource providers.
- The model used boat ramp accessibility as a representation of all water-based recreation activity on the reservoirs. Some water-based activities which are not reliant on boat access to the reservoirs might not vary in the same manner as activities that rely directly on boat ramps.
- Modeled visitation data were based on annual historical data that were allocated to monthly visitation based on the average distribution from monthly data available for other sites at the reservoirs.
- The model used limited data, from multiple sources, to describe input variables used to calculate the social welfare effects and regional economic development benefits, including:
 - The use of incomplete visitation data for near-river sites from several sources, which may result in an underestimation of river-based recreation and visitation at some state and local sites;
 - The conversion of average recreational visits to recreation days using ratios from a limited number of recreation areas;
 - The lack of consistent visitation data prior to 2017 to describe water-based visitation for each reservoir for high and low-water years; and
 - The use of District-level data to describe trip characteristics (party size and trip length) for specific sites.

Final Panel Comment 9

- Unit Day Values (UDVs) were not assessed, in accordance with Economic Guidance Memorandum (EGM) 19-03 (USACE, 2018b), for all project site areas (PSAs). For those PSAs that were not assessed, UDV estimates were adapted from locations that were assessed in accordance with EGM 19-03.

The following uncertainties associated with SCENT Model parameters were identified.

- The model used a constant shipment list and assumed that commodity movements remain constant for all simulations over the period of analysis, limiting the ability of the model to accurately predict future conditions in the project area and increasing uncertainty in the model results.
- The model does not appear to address the uncertainty associated with the duration of shipment disruption/delay events as a result of water conditions; shippers are assumed to have perfect foresight into these future events.
- The CRSO DEIS states that standard deviations of the model results were calculated to determine the range of anticipated costs under the No Action Alternative. The model documentation did not cite the calculation of standard deviations of results, or any sensitivity, or risk analysis, being incorporated into the model.
- Extensive statistical analysis was conducted on the shippers' survey responses; however, it does not appear that these statistical data were used to describe or mitigate uncertainty in the model parameters that were based on survey responses.

Significance – Medium/Low

The ability of the models to more accurately predict future conditions within the project area would be greatly enhanced by incorporating risk analysis into the models, and model documentation, to address parameter uncertainties, and allow for a more comprehensive understanding of the National Economic Development (NED) benefits and project justification.

Recommendations for Resolution

For the CRSO Recreation Analysis Model:

1. Assess the impact of not accounting for spatial or temporal substitution, or potential mitigation actions by resource providers, to be reflected in the behavior of recreationists, when faced with varying river and reservoir conditions in the basin.
2. Assess the impact of using boat ramp accessibility to represent all water-based recreation activity on the reservoirs.
3. Assess the impact of modeling monthly visitation data using annual historic visitation data and monthly data for other reservoir sites.
4. Assess the impact of using limited data, from multiple sources, to describe input variables used to calculate the social welfare effects and regional economic development benefits.
5. Estimate UDVs, in accordance with EGM 19-03, for all PSAs.

For the SCENT Model:

6. Assess the impact of using a constant shipment list and constant commodity movements for all simulations over the period of analysis.

Final Panel Comment 9

7. Incorporate risk analysis into the model to address the uncertainty associated with the duration of shipment disruption/delay events as a result of water conditions.
8. Describe the standard deviations of the model results that were calculated to determine the range of anticipated costs under the No Action Alternative, as presented in the CRSO DEIS, in the model documentation.
9. Incorporate the extensive statistical analysis conducted on the shippers' survey responses to describe or mitigate uncertainty in the model parameters that were based on survey responses.

Literature Cited

USACE (2018b). Unit Day Values for Recreation for Fiscal Year 2019. Economic Guidance Memorandum (EGM) 19-03. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. October 18.

PDT Draft/Final Evaluator Response (FPC #9)

Concur	X	Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The PDT does not concur that uncertainties associated with the CRSO Recreation Analysis Model parameters were not identified or characterized. In cases where modeling assumptions or data limitations could lead to an over- or underestimate of impacts, the direction of potential uncertainty was identified. In cases where the direction of uncertainty was not clear, the PDT described the uncertainty, but did not try to speculate on the direction of potential uncertainty. The uncertainties associated with the CRSO Recreation Analysis Model are discussed in detail under the responses to each recommendation below. A summary of the uncertainty factors affecting the recreation parameters has been added to Section 2.3 in Appendix M.

The SCENT model is not used to predict future use within the system. Rather, it is used to assess impacts on use of the navigation system based on hydraulic inputs. These hydraulic inputs already undergo an uncertainty analysis. For the purposes of this analysis, the action alternatives were not notably different from the no action in regards to flow, river stage and sedimentation. The SCENT model runs were conducted to confirm that there would likely not be a significant change for navigation users outside of the localized impacts of dam removal.

Recommendation 1:	Adopt	X	Not Adopt
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Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The impact of not accounting for spatial or temporal substitution, or potential mitigation actions by resource providers, is described in various spots in Chapter 3.11 and Appendix M. For example, Section 3.11.3.1 and Section 2.1.1 in Appendix M state: "The assumptions utilized in this analysis are conservative (i.e., they are more likely to overstate than understate effects of changes to water-based visitation), but the methodology is a reasonable approach given existing information." The text then goes on to describe how spatial substitution, temporal substitution, and potential mitigation actions were not accounted for in the analysis, which would lead to overstating impacts. The extent to which impacts are overstated is unknown, so the direction of potential bias is stated, but not the magnitude. To account for spatial and temporal substitution in the analysis, the PDT would require data on recreational behavior with and without changes in boat ramp accessibility. Site-specific surveys could not be conducted in the timeframe for the EIS, so reasonable assumptions were made and documented for the analysis. Similarly, the certainty of potential future mitigation actions beyond those identified as within the co-lead agencies' authorities are unknown, so it was not possible to incorporate them into the analysis. As described in PDT Response above, a summary of the uncertainty factors affecting the recreation parameters has been added to Section 2.3 in Appendix M.

Recommendation 2:	<input type="checkbox"/>	Adopt	<input checked="" type="checkbox"/>	Not Adopt
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Explanation: Using changes in boat ramp accessibility to estimate changes in all water-based visitation is a key assumption of the modeling approach, so it is documented clearly in the EIS. Section 3.11.3.1 and Section 2.1.1 in Appendix M state: "The approach also uses boat ramp accessibility as a representation of water-based recreation activity on the reservoirs. That is, all water-based recreation is assumed to decrease when a boat ramp is inaccessible. While some water-based activities, like shore fishing and swimming, might not vary in the same manner as activities that rely directly on boat ramps (e.g., motorized boating), the assumption was supported by conversations with reservoir recreation managers." While some water-based activities might not vary in the same manner as activities that rely directly on boat ramps, it is possible some land-based activities could be affected by reduced water levels. For example, decreased aesthetics due to lower water levels could affect camping, picnicking, and other shoreline activities. Taken altogether, the PDT believes the approach is conservative (i.e., it is more likely to overstate than understate effects of changes to water-based visitation), as stated in Section 3.11.3.1 and Section 2.1.1 in Appendix M. Had the EIS timeline allowed for survey data to be collected on recreational behavior under a range of water levels, a different analysis approach may have been pursued. However, this was not feasible, but the methodology is a reasonable approach given existing information. As described in PDT Response above, a summary of the uncertainty factors affecting the recreation parameters has been added to Section 2.3 in Appendix M.

Recommendation 3:	<input type="checkbox"/>	Adopt	<input checked="" type="checkbox"/>	Not Adopt
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Explanation: Most visitation data used in the analysis were at the monthly level. As stated in Table 3-6 in Appendix M: "At some recreation sites on these reservoirs, visitation data are only available at the annual level (rather than monthly). These annual data are allocated to months using the average distribution from monthly data available for other sites at the reservoirs." This approach is reasonable given the information available for the analysis and should not result in an expected overestimate or

underestimate of monthly visitation. As described in PDT Response above, a summary of the uncertainty factors affecting the recreation parameters has been added to Section 2.3 in Appendix M.

Recommendation 4: ☐ **Adopt** ☒ **Not Adopt**

Explanation:

Appendix M states in numerous places that visitation may be underestimated at some state and local sites, as well as river sites, due to incomplete visitation data. Therefore, this limitation of the analysis is clearly documented and its impact is assessed. The following sentence will be added to Section 3.11.3.1 in the final EIS: “As described previously, visitation estimates are not available for all sites, and visitation data likely under-estimates river recreational visitation.” Had the EIS timeline allowed for survey data to be collected on recreational use in the region, these data gaps may have been filled. However, this was not feasible; the application of available existing data was reasonable for this analysis.

The conversion of recreational visits to recreational days relied on ratios developed from information covering a subset of sites in the analysis. This information was shared as part of the modeling documentation package. Since information was unavailable for four reservoirs and one river reach included in the analysis, ratios were adapted from other locations, as described in Appendix M. This approach is reasonable given the information available for the analysis and should not result in an expected overestimation or underestimation of recreation days.

While consistent visitation data for years prior to 2017 were not available from all Federal and state agencies for this analysis, 2017 and 2018 visitation data were sufficient to carry out the analysis approach. As stated in Section 3.11.2 and Section 3.1.1 in Appendix M “2017 and 2018 represent relatively typical years in terms of water levels and recreational visitation”. Section 3.1.2 in Appendix M describes the approach used to estimate water-based visitation under the No Action Alternative in high and low-water years. If data prior to 2017 had been available, covering high- and low-water years, an alternative approach may have been taken. However, the approach that was used is reasonable given the information available for the analysis and should not result in an expected overestimation or underestimation of visitation during high- and low-water years.

The application of Corps district-level data to describe trip characteristics (i.e., party size and trip length) for specific sites is consistent with the information available. If more specific data were available or if schedule would have allowed for collection of survey data, they would have been applied. As described in PDT Response above, a summary of the uncertainty factors affecting the recreation parameters has been added to Section 2.3 in Appendix M.

Recommendation 5: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The PDT does not concur that Unit Day Values (UDVs) were not assessed, in accordance with Economic Guidance Memorandum (EGM) 19-03 (USACE, 2018b), for all project site areas (PSAs). As stated in Section 2.1.3 in Appendix M. “The UDV estimates were obtained from the USACE Recreation Budget Evaluation System (RecBest) (Chang 2019a).” These UDV estimates were shared as part of the modeling documentation package. Since the Corps does not have UDV estimates for three reservoirs and one river reach included in the analysis, UDV estimates were adapted from other locations, as described in Appendix M. This approach is reasonable given the information available for the analysis and should not result in an expected overestimation or underestimation of social welfare

impacts. As described in PDT Response above, a summary of the uncertainty factors affecting the recreation parameters has been added to Section 2.3 in Appendix M.

Recommendation 6: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The model was not designed to conduct forecasts. In theory, however, the model could incorporate shipment lists for future years based on forecasts completed outside of the model. In practice, this could be done using a base year with shipment data, and one or multiple future years with forecasted shipment lists. The use of forecast years was not found to be necessary, given the needs of the CRSO EIS. Such steps could be taken for other studies without need for modifications to the SCENT model.

Given that the SCENT model is a hydraulic sensitivity model that assesses whether or not a hydraulic change would have an impact on current river use, the uncertainties modeled within the hydraulic models are sufficient for the purposes of the SCENT model.

Recommendation 7: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The SCENT model was computed for each alternative simulation, which consisted of 5,000 distinct hydrologic conditions per alternative. Each hydrologic condition contained different levels, durations, and timing of traffic disruption. The SCENT model computed navigation costs for each of the 5,000 events in each simulation, and the mean costs were provided along with standard deviations. Therefore, the estimates have already accounted for the uncertainty associated with the duration of shipment disruption/delay events as a result of water conditions

Recommendation 8: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The SCENT model was computed for each alternative simulation, which consisted of 5,000 distinct hydrologic conditions per alternative. Each hydrologic condition contained different levels, durations, and timing of traffic disruption. The SCENT model computed navigation costs for each of the 5,000 events in each simulation. The standard deviation calculations were computed from the 5,000 events in each simulation. This was done within spreadsheets outside of the model, not part of the model runs themselves, which is why it is not mentioned in the documentation. The calculation itself is not needed to run the model and is at the discretion of the user in their post processing. Information will be added to the User's Manual section on post processing about methods that can be used quantify uncertainty within the results.

Recommendation 9: ☐ **Adopt** ☒ **Not Adopt**

Explanation: Harmonized shipper responses were developed based on the uncertainties provided in the shipper response surveys, which represents the most likely responses to varying flow conditions on the river. Quantification of the shipper response variability would require extensive programming efforts that are outside of the purpose of the model.

Panel Draft/Final BackCheck Response (FPC #9)

☐ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 10

The TOM documentation does not assess the impacts of uncertainty on the model's results.

Relevant Model Assessment Criteria

Model Documentation Quality

Representation of the System

Model Assumptions and Limitations

Basis for Comment

The Panel's review of the TOM documentation indicated that risk assessment within the model was limited to addressing uncertainty associated with the H&H analysis. Several sources of uncertainty related to assumptions or data quality were identified by the Panel, but these uncertainties were not quantitatively or qualitatively addressed. The ability of the model to predict future conditions within the project area would be greatly enhanced by addressing these uncertainties and would allow a more comprehensive understanding of the model results.

The following uncertainties associated with TOM parameters, many of which were acknowledged but not addressed in the documentation, were identified.

- The probability that rail rates may increase by more than 50 percent in response to the increased volumes of grain movements.
- The potential impact of silt/sediment on barge transportation on the Columbia River in the vicinity of Pasco, Washington.
- The ability of the grain terminals at Pasco, Washington, and on the Columbia River to accommodate the increased volumes of grain arriving by truck.
- The ability of the short-line railroads and the four shuttle rail facilities to adequately service the increased volumes of grain movements.
- The impact of the operation of the Lacrosse grain shuttle facility on wheat movements.
- The fact that the model does not account for grain shipments from non-shuttle rail facilities to river ports.
- The fact that the model does not account for any use of the existing Snake River grain terminals.
- The ability of the trucking industry to adequately service the increased volumes of grain movements, at current trucking rates, taking into account that truck ton-miles could increase by up to 84 percent, compared to the No Action Alternative.

Significance – Medium/Low

The ability of the model to more accurately predict future conditions within the project area would be greatly enhanced by incorporating risk analysis into the model, and model documentation, to address parameter uncertainties, and allow for a more comprehensive understanding of the NED benefits and project justification.

Final Panel Comment 10

Recommendations for Resolution

1. Assess the impact of allowing rail rates to increase by more than 50 percent in response to increased volumes of grain movements.
2. Assess the potential impact of silt/sediment on barge transportation on the Columbia River in the vicinity of Pasco, Washington.
3. Assess the ability of the grain terminals at Pasco, Washington, and on the Columbia River, to accommodate increased grain movements arriving by truck.
4. Assess the ability of the short-line railroads and the four shuttle rail facilities to adequately service increased volumes of grain movements.
5. Incorporate the impact of the operation of the Lacrosse grain facility on wheat movements.
6. Assess the impact of allowing non-shuttle rail facilities to move shipments to river ports.
7. Assess the impact of allowing the use of the existing Snake River grain terminals.
8. Assess the ability of the trucking industry to transport increased volumes of grain movements.
9. Assess the impact of allowing trucking rates to fluctuate in response to increased volumes of grain movements.

PDT Draft/Final Evaluator Response (FPC #10)

X Concur **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The PDT concurs that some additional discussion of uncertainties is warranted. As described in PDT Response below, a summary of the uncertainty factors affecting the navigation parameters has been added to Appendix L.

Recommendation 1: **X Adopt** **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The PDT agrees that the specific changes in rail rates that would occur are not known with certainty. The EIS evaluates the impacts of various potential rate increases in Section 3.10.3.5 that range from 0 to 50 percent. The modeling effort shows that if rail rates are not increased, freight volume would likely exceed current capacity, which would put upward pressure on rail rates. The TOM modeling effort found that if rail rates increase by 50 percent, truck transport to the Columbia River ports would then be relatively attractive to shippers, which would put competitive pressure on rail companies not to increase rail rates much higher. This suggests that increases in rates that are higher than 50 percent would drive shipments away, dropping them lower than current shipments. This result would be likely to occur. Some additional discussion of this aspect of model results has been added to the text in Appendix L in the new Uncertainties section.

Recommendation 2: **X** **Adopt** **Not Adopt**

Explanation: The effect of MO3 on siltation/sedimentation in the area below Ice Harbor Dam and above McNary Dam is discussed in Section 3.10.3.5. The section assumes that increased sedimentation would increase dredging costs in this area, but would not affect shipping volumes. Some of the text in the DEIS was not clear about the location of the dredging activities, which has been clarified in the FEIS and Appendix L.

Recommendation 3: **Adopt** **X** **Not Adopt**

Explanation: The increased truck transport volumes at Pasco are assessed as part of modeling efforts that are described under MO3 in Section 3.10.3.5. It is stated that increased investments would be required in order to accommodate increased truck deliveries to river terminals on the Columbia.

Recommendation 4: **Adopt** **X** **Not Adopt**

Explanation: The ability of the short-line railroads and the four shuttle rail facilities to adequately service increased volumes of grain movements are assessed as part of modeling efforts that are described under MO3 in Section 3.10.3.5.

Recommendation 5: **Adopt** **X** **Not Adopt**

Explanation: The Endicott (LaCrosse) grain facility is assessed as part of modeling efforts that are described under MO3 in Section 3.10.3.5. The facility is not included as part of the historical assessment since it was not operating until 2019.

Recommendation 6: **X** **Adopt** **Not Adopt**

Explanation: The choice to limit allowing non-shuttle rail facilities to move shipments to river ports in TOM modelling assumptions was determined after consultation with grain shippers and WATCO. The Great Northwest Railroad, operated by WATCO, is a short-line railroad that runs along the Snake River from Lewiston, ID to Ayer Junction, WA. Research conducted as part of the EIS suggested that elevator to river port movements via short line rail are not currently occurring because in order for them to ship grain to river terminals on the Columbia, they must operate on part of Union Pacific's rail line and WATCO's operating agreement with Union Pacific does not allow for these shipments. The effect

of including this assumption and allowing movements on these short lines during a breach scenario would be to somewhat reduce the anticipated increases in shipping costs to shippers. However, information has been added to Appendix L that describes the impacts of modifying this assumption on quantified costs to shippers, which was allowed in an earlier model run. The impacts of allowing that option are that increases in transportation costs would be reduced relative to results when that option is not allowed.

Recommendation 7: ☐ **Adopt** ☒ **Not Adopt**

Explanation: As discussed under Recommendation 6, the revised Appendix L now includes assessment of the impacts of allowing rail to river port movements. The document acknowledges in Section 3.10.3.5 that “it is likely that the facilities with rail access would continue to be used to some extent for storage and transport via rail or truck; however, these facilities are assumed to be closed for purposes of this analysis,” and that, “to the extent that some terminals on the lower Snake River could continue to be used, the effects to shippers would be lower than model results suggest.”

Recommendation 8: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The TOM model finds that truck volumes would increase most when rail prices increases are high. An estimate of truck traffic volume is included under MO3 in Section 3.10.3.5, and in Appendix L. Depending upon how rail rates change with a LSR dam breach, truck ton-miles may experience an increase of 19 percent (under Scenario 1, when rail rates are not assumed to increase) to 84 percent (when rail rates increase by 50 percent) under MO3 when compared to the No Action Alternative. The EIS finds that under a scenario where rail rates increase by 50 percent, increasing demands on roads would require up to \$10 million in additional annual road wear and tear costs. However, the ability and availability of the truck industry to transport increased volumes of grain movements is not anticipated to be a limiting factor. This is because of the specialized type of truck transport (hopper-bottom grain trailers) and the fact that wheat truck transport in the Pacific Northwest is conducted by owner-operated trucking operations that already transport all wheat that is produced in region, albeit for shorter distances. This is different than would occur in an area where commercial trucking of wheat occurred. This has been clarified in Appendix L in the FEIS.

Recommendation 9: ☐ **Adopt** ☒ **Not Adopt**

Explanation: As discussed in the response to Recommendation 8, trucking rates in this region are based on operating costs primarily, including labor and fuel costs to owner-operator wheat operations. As such, commercial trucking has a limited impact on grain truck rates. This is further addressed under Recommendation 8.

Panel Draft/Final BackCheck Response (FPC #10)

Concur ☐ **Non-Concur** ☐

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 11

Discussions of the interpretation and limitations of shipper survey data and waterway carrier survey data used to develop the disruption response matrix are incomplete.

Relevant Model Assessment Criteria

Representation of the System

Model Assumptions and Limitations

Basis for Comment

As described in the SCENT Model documentation, shipper responses to changes in flows and draft were determined by data obtained through surveys of shippers, towing companies, vessel pilots, and others involved in the movement of commercial vessels. Therefore, the survey data are an important foundational component of the SCENT Model. Addendum 1 to the SCENT Model documentation provided by USACE (USACE report titled *Columbia River Treaty: Navigation, Results of Surveys of Shippers and Waterway Carriers*) describes the surveys conducted.

In the 2015 USACE survey report, the discussion of deep-draft terminal surveys notes the omission of containers and automobiles from the survey responses and the fact that no responses were supplied from two major inbound terminals handling liquid bulk and manufactured products, respectively. The report states that “respondents only move dry bulk cargo, so these responses are not necessarily relevant to auto carriers, container ships or bulk liquid carriers” (page 4). The documents provided to the Panel do not describe the implications of that statement to the development of the disruption response matrix or to SCENT Model outcomes.

In the 2015 USACE survey report, the discussion of the shallow-draft survey efforts notes that three commodities are represented in the survey responses (aggregates, agricultural products, and wood products). Those commodities account for the majority of tonnage moved (pages 10-11); however, no survey information was provided by petroleum shippers, who also move a sizable amount of product, or by other commodity movers (page 11). The documents provided to the Panel do not describe the implications of the lack of survey data from petroleum shippers or from other commodity movers on the development of the disruption response matrix or the SCENT Model outcomes.

For both the deep-draft and the shallow-draft survey efforts, in the documents provided to the Panel for review, there is no discussion regarding the interpretation of the data or the conversion of the raw survey data into the disruption response matrix. For example:

- The documents do not address how different responses to the same question by different respondents were reconciled or how the final responses/behaviors were developed for use in the disruption response matrix for the SCENT Model.
- The documents do not discuss any “check” on those behavior/response model inputs with operators, if such checks occurred.

Final Panel Comment 11**Significance – Medium/Low**

Additional information about the shipper and waterway carrier survey data would provide a more complete explanation of the development of the disruption response matrix and the matrix data.

Recommendations for Resolution

1. Discuss the implications related to the lack of automobile carriers, container ships, or bulk liquid carriers in the deep-draft survey responses to the data included in the disruption response matrix and used in the SCENT Model.
2. Discuss the implications related to the lack of data from petroleum shippers or other commodities not covered in the shallow-draft surveys to the data included in the disruption response matrix and used in the SCENT Model.
3. Discuss how raw survey data were evaluated and manipulated to develop the disruption response matrix for the SCENT Model.
4. Describe the range of behavior response data provided by deep-draft and shallow-draft survey respondents.
5. Describe any work completed to evaluate the sensitivity of the data developed for use in the disruption response matrix.

PDT Draft/Final Evaluator Response (FPC #11)

X Concur	Non-Concur		
<p>Please enter an X in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.</p> <p>Explanation: The survey for the SCENT model was comprehensive, in that it interviewed as many waterway users as were willing to respond. The model applies the harmonized responses to inland and deep draft traffic based on surveys that were conducted, regardless of whether specific types of traffic responded to the survey or not.</p> <p>Further description of the interpretation of the raw survey responses will be added to the model documentation.</p>			
Recommendation 1:	<table border="1"> <thead> <tr> <th>Adopt</th> <th>X Not Adopt</th> </tr> </thead> </table>	Adopt	X Not Adopt
Adopt	X Not Adopt		

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The aggregated survey results from the inland and deep draft traffic were utilized, regardless of whether specific types of shippers responded to the survey or not. Tonnage was not ignored.

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The aggregated survey results from the inland and deep draft traffic were utilized, regardless of whether specific types of shippers responded to the survey or not. Tonnage was not ignored.

Recommendation 3: ☒ **Adopt** ☐ **Not Adopt**

Explanation: Further description of the interpretation of the raw survey responses will be added to the SCENT model documentation.

Recommendation 4: ☒ **Adopt** ☐ **Not Adopt**

Explanation: Further description of the interpretation of the raw survey responses will be added to the SCENT model documentation.

Recommendation 5: ☒ **Adopt** ☐ **Not Adopt**

Explanation: Further description of the interpretation of the raw survey responses will be added to the SCENT model documentation.

Panel Draft/Final BackCheck Response (FPC #11)

☐ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 12

Descriptions of the models that would allow an independent modeler to understand each model's functions and operational capabilities are not provided in a single, comprehensive document for each model.

Relevant Model Assessment Criteria

Model Documentation Quality

Basis for Comment

The documentation for the CRSO Recreation Analysis, SCENT, and TOM models would be enhanced by addressing the following issues.

Several documents, including the Draft DEIS, had to be reviewed to gain a full understanding of how each of the reviewed models functions. Use of the models would be enhanced if all information needed to understand and operate the models were compiled into one concise document for each model.

The CRSO Recreation Analysis Model documentation indicates the need to convert recreational visits to recreational days in order to calculate social welfare effects. The ratios needed to convert recreational visits to recreational days are provided in the Social Welfare Analysis spreadsheet; however, a discussion or tabular presentation of the ratios is not included in CRSO DEIS Appendix M or in the CRSO Recreational Analysis User Guide.

A list of which reservoirs and recreation areas are included in each USACE District (Walla Walla, Portland, or Seattle) is required to complete calculations of direct visitor expenditures; these data are not provided in the current documentation.

The Table of Contents of the document titled "3a_SCENT_Model Documentation Final," as provided to the Panel, does not align with the section headings and contents of the document.

The SCENT Model and the TOM documentation (exclusive of the CRSO DEIS) lacks adequate descriptions of the purpose and relationship between these two navigation models, and the rationale for developing two navigation models.

In the TOM documentation, quantities of grain movements are not presented in a consistent unit of measure, with weights being presented in bushels and/or tons. Figures 7 through 10, which depict grain movements under various scenarios, present quantities of movements by rail and barge in bushels, while movements by trucks are presented in tons. A consistent unit of measure of grain movements would aid in the understanding of the model and model results.

Significance – Low

Consolidated, precise documentation is needed to afford potential model users a better understanding of the functions and operation of the models.

Final Panel Comment 12

Recommendations for Resolution

1. Provide all information needed to understand and operate the models in one concise document for each model.
2. Provide a table of the ratios needed to convert recreational visits to recreational days in the CRSO Recreation Analysis Model documentation.
3. Revise the CRSO Recreation Analysis Model documentation to include a list of which reservoirs and recreation districts are included in each USACE district in order to complete calculations of direct visitor expenditures.
4. Revise the 3a_SCENT_Model Documentation Final document to ensure that the Table of Contents is aligned with the section headings and contents of the document.
5. Revise the SCENT and TOM models' documentation to include a description of the purpose and relationship between these two navigation models, and the rationale for developing two navigation models.
6. Revise the TOM documentation to ensure that quantities of grain movements, by different modes, are presented in a consistent unit of measure.

PDT Draft/Final Evaluator Response (FPC #12)

Concur ☒ **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The recreation model documentation, SCENT model documentation, and TOM model documentation, along with the attached spreadsheets and models provided, contain the model assumptions, characteristics, and results needed to understand how the results were calculated in the EIS. The PDT recognizes that it would be more convenient to have all of these materials in a single, concise, document, but it is not practically feasible to reorganize the materials as the reviewer asks in the time remaining for this work.

Recommendation 1: ☐ **Adopt** ☒ **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The recreation model documentation, SCENT model documentation, and TOM model documentation, along with the attached spreadsheets and models provided, contain the model assumptions, characteristics, and results needed to understand how the results were calculated in the EIS. The PDT recognizes that it would be more convenient to have all of these materials in a single, concise, document, but it is not practically feasible to reorganize the materials as the reviewer asks in the time remaining for this work.

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: This information can be found in the supplemental model documentation package files—Stata code ("RED Code.do") and an accompanying Excel spreadsheet ("Rec RED Inputs.xlsx")—which were provided on April 20th.

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: This information can be found in the supplemental model documentation package files—Stata code ("RED Code.do") and an accompanying Excel spreadsheet ("Rec RED Inputs.xlsx")—which were provided on April 20th.

Recommendation 4: ☒ **Adopt** ☐ **Not Adopt**

Explanation: Table of contents within the SCENT model documentation will be edited to reflect the section headings and contents of the document body.

Recommendation 5: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The application of each model is described in Section 3.10.3.1 of the EIS. Specifically, the EIS states that the analysis uses two models to evaluate the effects of changes to social welfare: the SCENT model calculates changes in barge operational costs attributable to changes in flows and/or navigation channel depths on the commercially navigable portions of the Columbia and Snake Rivers. For MO3, where navigation is expected to be eliminated for a portion of the CSNS, the TOM model is used in addition to the SCENT model. The TOM model is used to assess the shipper cost impacts resulting from changing grain shipments under a dam breach scenario where navigation on the lower Snake River is eliminated. The operational changes to river flow are so minor as to be unlikely to be detectable for shipping rate changes in the TOM model. In contrast, the SCENT model is not able to assess impacts of fully removing a river segment from operations.

Recommendation 6: ☒ **Adopt** ☐ **Not Adopt**

Explanation: Although the results are reported in standard industry terms, bushels, and ton-miles, the conversion factors for these had not been provided. The conversion of 1 bushel of wheat = 60 lbs = 0.3 tons. Costs/ ton-mile is the costs to transport one ton for one mile and is dependent on the length of the movement. These conversions have been added to Appendix L.

Panel Draft/Final BackCheck Response (FPC #12)

Concur	Non-Concur
<p>Please enter an X in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:</p>	

Final Panel Comment 13

The transportation cost minimization equations, as presented in the TOM documentation, do not accurately depict the underlying framework of the model.

Relevant Model Assessment Criteria

Model Documentation Quality

Model Calculations/Formulas

Basis for Comment

Certain constraints to the TOM transportation cost minimization equation, as presented in the model documentation, are inaccurate.

The Node Balance Constraint states that the volume of grain moving from the i^{th} supply origin into the j^{th} intermediate destination on mode k (X_{ijk}) **IS EQUAL TO** the volume of grain moving from the j^{th} intermediate destination to the final demand location on mode k (Y_{ijk}).

The Destination Balance Constraint states that the volume of grain moving from the i^{th} supply origin into the j^{th} intermediate destination on mode k (X_{ijk}) **PLUS** the volume of grain moving from the j^{th} intermediate destination to the final demand location on mode k (Y_{ijk}) **IS EQUAL TO** the volume demanded at Portland, Oregon, k (D_i).

The cost minimization equation should be subject to the volume of grain moving from the i^{th} supply origin into the j^{th} intermediate destination on mode k (X_{ijk}) **BEING EQUAL TO** the volume of grain moving from the j^{th} intermediate destination to the final demand location on mode k (Y_{ijk}) which **SHOULD ALSO BE EQUAL TO** the volume demanded at Portland, Oregon, (D_i).

Significance – Low

Accurate documentation of model equations is needed to allow a complete understanding of the underlying quantitative framework of the model.

Recommendations for Resolution

1. Revise cost minimization equation constraints, as presented in the documentation, to accurately reflect a balanced supply from origin, through intermediate destination, to the demand at Portland, Oregon.
2. Verify that the cost minimization equation, as incorporated into the TOM, reflects the correct constraints.

PDT Draft/Final Evaluator Response (FPC #13)

X	Concur	Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The reviewer correctly identified an error in the model documentation. This error was not reflected in the modeling efforts and does not have implications for reported results.

Recommendation 1: ☒ **Adopt** **Recommendation 1:**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The model documentation has been corrected.

Recommendation 2: ☒ **Adopt** **Recommendation 2:**

Explanation: This has been verified and adopted.

Panel Draft/Final BackCheck Response (FPC #13)

Concur **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Report for the Independent External Peer Review of the Columbia River System Operations (CRSO) Power Analysis Models

Prepared by
Battelle Memorial Institute

Prepared for
Department of the Army
U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Mississippi Valley Division

Contract No. W912HQ-15-D-0001
Task Order: W912HQ20F0034

June 11, 2020

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CONTRACT NO. W912HQ-15-D-0001
Task Order: W912HQ20F0034

Final Report for the Independent External Peer Review of the Columbia River System Operations (CRSO) Power Analysis Models

Prepared by

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for

Department of the Army
U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Mississippi Valley Division

June 11, 2020

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Final Report for the Independent External Peer Review of the Columbia River System Operations (CRSO) Power Analysis Models

Executive Summary

Project Background and Purpose

The U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and Bureau of Reclamation (Co-lead Agencies) are jointly developing a comprehensive Environmental Impact Statement (EIS), referred to as the Columbia River System Operations (CRSO) EIS, to evaluate long-term system operations and configurations of 14 multiple-purpose projects that are operated as a coordinated system within the interior Columbia River Basin in Idaho, Montana, Oregon, and Washington. USACE was authorized by Congress to construct, operate, and maintain 12 of these projects for flood control management, navigation, power generation, fish and wildlife conservation, recreation, and municipal and industrial water supply purposes. USACE projects that are included in the EIS are Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. The Bureau of Reclamation was authorized to construct, operate, and maintain the other two projects—Hungry Horse and Grand Coulee—for the purposes of irrigation, flood control management, navigation, power generation, recreation, and other beneficial uses. The BPA is responsible for marketing and transmitting the power generated by these dams. Together, these Co-lead Agencies are responsible for managing the system for these various purposes, while meeting their other statutory and regulatory obligations.

The Co-lead Agencies will use this EIS to assess and update their approach for long-term system operations and configurations through the analysis of alternatives and evaluation of potential effects to the human and natural environments. The scope and scale of this project; its potential to impact human life safety; interest on the part of the Governors of Montana, Idaho, Washington, and Oregon, and 19 Federally recognized tribes; its connection to ongoing litigation on the Federal Columbia River Power System; and the likelihood for the project to result in public dispute, drive a requirement for a heightened level of review and meet the criteria of a highly influential scientific assessment in Office of Management and Budget (OMB) and Bureau of Reclamation peer review policies.

The primary goal of power analysis model review and approval is to establish that models, analyses, results, and conclusions are theoretically sound, computationally accurate, based on reasonable assumptions, well-documented, and in compliance with the requirements of OMB Peer Review Bulletin (OMB, 2004). The primary criterion identified for model approval is technical soundness. Technical soundness reflects the ability of the model to represent or simulate the processes and/or functions it is intended to represent. The performance metrics for this criterion are related to theory and computational correctness. In terms of theory, a quality power analysis model should 1) be based on validated and

accepted “state of the art” theory and engineering practice; 2) properly incorporate the conceptual theory into the software code; and 3) clearly define the assumptions inherent in the model. In terms of computational correctness, a quality power analysis model should 1) employ proper functions and mathematics to estimate functions and processes represented; and 2) properly estimate and forecast the actual parameters it is intended to estimate and forecast. Other criteria for quality power analysis models are efficiency, effectiveness, usability, and clarity in the presentation of results. A well-documented, high-quality power analysis model will stand the tests of technical soundness based on theory and computational correctness, efficiency, effectiveness, usability, and clarity in the presentation of results.

Five power analysis models are reviewed as part of the CRSO Power Analysis Models Independent External Peer Review (IEPR): the Hydro System Simulator (HYDSIM), Hourly Operations System Simulator (HOSS), Resource Adequacy Model (GENESYS), Power Rate Model (RAM2020), and the Long-Term Transmission Rates Model.

Model Independent External Peer Review Process

Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analysis. USACE is conducting an IEPR of the CRSO Power Analysis Models. As a 501(c)(3) non-profit science and technology organization, Battelle is independent, is free from conflicts of interest (COIs), and meets the requirements for an Outside Eligible Organization (OEO) per guidance described in USACE (2018). Battelle has experience in establishing and administering peer review panels for USACE and was engaged to coordinate this IEPR. The IEPR was external to the agency and conducted following USACE and OMB guidance described in USACE (2018) and OMB (2004). This final report presents the Final Panel Comments of the IEPR Panel (the Panel). Details regarding the IEPR (including the process for selecting panel members, the panel members’ biographical information and expertise, and the charge submitted to the Panel to guide its review) are presented in appendices.

Based on the technical content of the documentation for the models and the objective of the models, Battelle identified potential candidates for the Panel in the following key technical areas: hydroelectric power utilities engineering, economics, hydroelectric operations research, and hydroregulation / hydrology and hydraulic engineering. Battelle screened the candidates to identify those most closely meeting the selection criteria and evaluated them for COIs and availability. USACE was given the list of all the final candidates to independently confirm that they had no COIs, and Battelle made the final selection of the four-person Panel from this list.

The Panel received electronic versions of the model review documents and software along with a charge that solicited comments on specific sections of the documents to be reviewed. Following guidance provided in USACE (2018) and OMB (2004), USACE prepared the charge questions, which were included in the draft and final Work Plans.

The USACE Project Delivery Team (PDT) briefed the Panel and Battelle on the development of the model and its intended application during a teleconference at the start of the review. The purpose of this teleconference was to familiarize the panel members with the models being reviewed. Other than Battelle-facilitated teleconferences, there was no direct communication between the Panel and USACE during the model peer review process.

IEPR panel members reviewed the model documents individually and produced individual comments in response to the charge questions. The panel members then met via teleconference with Battelle to review

key technical comments and reach agreement on the Final Panel Comments to be provided to USACE. Each Final Panel Comment was documented using a five-part format consisting of (1) a comment statement; (2) relevant model assessment criteria; (3) the basis for the comment; (4) the significance of the comment (high, medium/high, medium, medium/low, or low); and (5) recommendations on how to resolve the comment.

Results, Recommendations, and Conclusions of the Model Independent External Peer Review

The panel members agreed on their assessment of the technical quality, system quality, and usability of the CRSO Power Analysis Models reviewed. The models are very comprehensive and provide data required to support comparisons of alternatives. However, the Panel has a number of concerns about the technical quality, system quality, and usability of the models and have provided specific recommendations to improve the models in the Final Panel Comments. Overall, 15 Final Panel Comments were identified and documented. Of these, two have been identified as having medium/high significance, nine have medium significance, three have medium/low significance, and one has low significance. Table ES-1 lists the Final Panel Comment statements by level of significance. The full text of the Final Panel Comments is presented in Section 5.0 of this report.

The Panel noted that the BPA staff running these models are quite dedicated and proficient at maintaining and running these aging models and providing information and results that can be used in a constructive manner by BPA, USACE, and the Bureau of Reclamation on a number of fronts, from managing the Columbia River Treaty, to ensuring safe reliable planning for the hydro system and setting the rates for this valuable cost-based asset pool in the Pacific Northwest. Clearly, the process of running and forecasting the operation of the Columbia River System is a highly involved and complex undertaking. To BPA's credit, the approach it has created satisfies the needs within the region for the BPA. The model results in the CRSO Draft EIS are well documented, providing the results clearly by alternative, compared to the No Action Alternative (NAA) results, and the analysts have identified the key differences between the NAA and each individual alternative that result in different system behavior.

Based on the documents the Panel was asked to review and the presentations/discussions on each model, the Panel has identified a number of specific concerns about the technical quality, system quality, and usability of the models and has provided specific recommendations to improve the models in the Final Panel Comments. Recommendations include the following:

- Develop documentation specific to each model used to evaluate alternatives for operating/altering the CRSO project, detailing the exact state of the model at the time it was run; the assumptions applied; limitations that remain; outcomes of calibrations conducted; evidence of the model's suitability and validation to the Columbia River System; and uncertainties and risks that remain within the outputs and conclusions. In addition, clear documentation of how each model interacted and exchanged information is needed for each alternative assessed.
- Verify the accuracy of the models by using test data sets to ensure that model changes have not resulted in changes to data outputs.
- Update the older models to use current or future operating systems and building them so they can run more autonomously (thereby reducing operator-induced discrepancies) are also suggested.

- Conduct sensitivity analysis and document the findings to demonstrate that the selected resource additions for both the least-cost and least-carbon alternatives represent the most cost-effective resource additions.

These issues are important for the effective application of the models by experienced users and USACE staff. The Panel recommends that USACE and the modeling teams address these issues prior to finalizing the decisions made for the models' use.

Table ES-1. Overview of 15 Final Panel Comments Identified by the CRSO Power Analysis Models IEPR Panel

No.	Final Panel Comment
Significance – Medium/High	
1	The HYDSIM model output cannot be understood without contextual explanation from an experienced model operator.
2	There is no rigorous analytical process to ensure that least-cost and least-carbon resource additions in the alternative resource portfolios are cost-effective.
Significance – Medium	
3	The models are being used to extrapolate beyond the range of conditions for which they were originally designed.
4	Calculation of the Loss of Load Probability (LOLP), including the filtering that was applied, and related output metrics was not included in the GENESYS model documentation.
5	It is unclear why trapezoidal approximations for estimating peaking are used when hourly models that should provide more reliable results are available.
6	The model documentation does not provide the appropriate high-level descriptions of model assumptions, formulations, calibration, results, discussion, and conclusions or the materials to allow an independent modeler to use the models.
7	The HYDSIM and HOSS models cannot be operated properly (i.e., with minimal potential for operator-initiated deviations) unless the models are run by highly experienced users, which limits the number of qualified operators.
8	BPA's current package of software tools, consisting of the HYDSIM, HOSS, and GENESYS computer programs, will not run on modern computer systems and will need to be upgraded in the near future.
9	The overall iterative process of how the models interact is unclear.

Table ES-1. Overview of 15 Final Panel Comments Identified by the CRSO Power Analysis Models IEPR Panel (Continued)

No.	Final Panel Comment
10	The BPA renewable generation integration costs in the Long-Term Transmission Rates model were not updated to reflect the impact of changing BPA portfolios and regional renewable integration demands under each scenario.
11	It is not clear that the RAM2020 model includes an unbiased estimate for the impact of market transactions made to address surplus or deficit power positions.
Significance – Medium/Low	
12	No documentation was provided indicating that sensitivity, uncertainty, and risk analyses have been conducted on the models.
13	It does not appear that the HOSS model runs were assessed for accuracy, and it is unclear what impact inaccuracies in the HOSS output would have on the model runs for the CRSO.
14	There does not appear to be an agreed-upon way to verify that past or future changes to the Fortran code have not introduced (or will not introduce) errors in the HYDSIM, HOSS, and GENESYS programs.
Significance – Low	
15	It is unclear how HOSS calculates the flexibility of the system to shift generation from Light Load Hours (LLH) to Heavy Load Hours (HLH) and how this flexibility was used in the assessment of the Draft EIS alternatives.

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LIST OF ACRONYMS

ACME	Accelerated California Market Estimator
BPA	Bonneville Power Administration
BRP	Brookfield Renewable Power
COI	Conflict of Interest
CRSO	Columbia River System Operation
CVaR95	Conditional Value at Risk 95th Percentile
DrChecks	Design Review and Checking System
EC	Engineer Circular
EIS	Environmental Impact Statement
ELAM	Eularian-Lagrangian-Agent Method
ERDC	Engineer Research and Development Center
FCRPS	Federal Columbia River Power System
GENESYS	GENERation Evaluation SYstem
HCP	Habitat Conservation Plan
HEC	Hydrologic Engineering Center
HEC-HMS	Hydrologic Engineering Center-Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center-River Analysis System
HEC-ResSim	Hydrologic Engineering Center-Reservoir System Simulation
HLH	Heavy Load Hours
HOSS	Hourly Operations System Simulator
HYDSIM	Hydro System Simulator
IEPR	Independent External Peer Review
IWR	Institute for Water Resources
LLH	Light Load Hours
LOLP	Loss of Load Probability
MO	Multiple Objective
MW	Megawatt
NAA	No Action Alternative
OEO	Outside Eligible Organization
OMB	Office of Management and Budget

PA	Preferred Alternative
PCX	Planning Center of Expertise
PDT	Project Delivery Team
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PUD	Public Utility District
RAM2020	Power Rate Model
TDG	Total Dissolved Gas
TEA	The Energy Authority
VBA	Visual Basic for Application
USACE	United States Army Corps of Engineers

1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and Bureau of Reclamation (Co-lead Agencies) are jointly developing a comprehensive Environmental Impact Statement (EIS), referred to as the Columbia River System Operations (CRSO) EIS, to evaluate long-term system operations and configurations of 14 multiple-purpose projects that are operated as a coordinated system within the interior Columbia River Basin in Idaho, Montana, Oregon, and Washington. USACE was authorized by Congress to construct, operate, and maintain 12 of these projects for flood control management, navigation, power generation, fish and wildlife conservation, recreation, and municipal and industrial water supply purposes. USACE projects that are included in the EIS are Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. The Bureau of Reclamation was authorized to construct, operate, and maintain the other two projects—Hungry Horse and Grand Coulee—for the purposes of irrigation, flood control management, navigation, power generation, recreation, and other beneficial uses. The BPA is responsible for marketing and transmitting the power generated by these dams. Together, these Co-lead Agencies are responsible for managing the system for these various purposes, while meeting their other statutory and regulatory obligations.

The Co-lead Agencies will use this EIS to assess and update their approach for long-term system operations and configurations through the analysis of alternatives and evaluation of potential effects to the human and natural environments. The scope and scale of this project; its potential to impact human life safety; interest on the part of the Governors of Montana, Idaho, Washington, and Oregon, and 19 Federally recognized tribes; its connection to ongoing litigation on the Federal Columbia River Power System; and the likelihood for the project to result in public dispute, drive a requirement for a heightened level of review and meet the criteria of a highly influential scientific assessment in Office of Management and Budget (OMB) and Bureau of Reclamation peer review policies.

The primary goal of power analysis model review and approval is to establish that models, analyses, results, and conclusions are theoretically sound, computationally accurate, based on reasonable assumptions, well-documented, and in compliance with the requirements of OMB Peer Review Bulletin (OMB, 2004). The primary criterion identified for model approval is technical soundness. Technical soundness reflects the ability of the model to represent or simulate the processes and/or functions it is intended to represent. The performance metrics for this criterion are related to theory and computational correctness. In terms of theory, a quality power analysis model should 1) be based on validated and accepted “state of the art” theory; 2) properly incorporate the conceptual theory into the software code; and 3) clearly define the assumptions inherent in the model. In terms of computational correctness, a quality power analysis model should 1) employ proper functions and mathematics to estimate functions and processes represented; and 2) properly estimate and forecast the actual parameters it is intended to estimate and forecast. Other criteria for quality power analysis models are efficiency, effectiveness, usability, and clarity in the presentation of results. A well-documented, high-quality power analysis model will stand the tests of technical soundness based on theory and computational correctness, efficiency, effectiveness, usability, and clarity in the presentation of results.

Five power analysis models are reviewed as part of the CRSO Power Analysis Models Independent External Peer Review (IEPR): Hydro System Simulator (HYDSIM), Hourly Operations System Simulator (HOSS), Resource Adequacy Model (GENESYS), Power Rate Model (RAM2020), and the Long-Term Transmission Rates Model.

Report Organization

This report presents the approach and the results of the review of the CRSO Power Analysis Models. It is organized into the following sections:

Section 1.0 - Model Purpose, IEPR Evaluation Assessment Criteria and Approach, and Summary of Panel Findings – Describes the overall purpose of each model; explains the IEPR approach, including the review process and the criteria used to assess technical quality, system quality, and usability; and provides a high-level summary of the Panel's findings.

Section 2.0 - Technical Quality Assessment – Summarizes the key issues identified from the model technical quality assessment.

Section 3.0 - System Quality Assessment – Summarizes the key issues identified from the model system quality assessment.

Section 4.0 - Usability Assessment – Summarizes the key issues identified from the usability assessment.

Section 5.0 - Model Assessment Summary – Presents the full five-part Final Panel Comments prepared by the Panel.

Section 6.0 - Conclusions – Summarizes the Panel's conclusions and overarching recommendations to resolve the key issues identified during the model review.

Section 7.0 - References – Lists the references used for this model assessment and referenced from the model documentation.

Appendix A - Information on the dates and steps followed to conduct the Model IEPR.

Appendix B - Biographical information on the expert Panel selected to perform the review.

Appendix C - The final charge guidance and questions to the Panel to guide its review of the CRSO Power Analysis Models.

Appendix D - The Conflict of Interest (COI) form that was provided with Battelle's original proposal.

1.1 Model Purpose and Summary

The purpose of each power analysis model reviewed as part of the CRSO Power Analysis Models IEPR is provided here, along with a brief summary of how each model operates.

- *Hydro System Simulator (HYDSIM)*. HYDSIM is a seasonal planning model developed by the BPA's Power Services. It is a computer model for simulating seasonal operation of the Pacific Northwest Hydroelectric System. HYDSIM uses initial reservoir content, historical natural streamflows, operating requirements, fixed operation targets, and non-power operating requirements to compute average generation, average regulated streamflow, and ending reservoir content at each project for each month (April and August split into half-month periods) for a defined study period.

- **Hourly Operations System Simulator (HOSS).** HOSS is a VAX-based model that simulates the hourly operation of Federal hydro resources to maximize heavy load hour generation within project constraints and daily forebay targets.

HYDSIM can be used as a seasonal planning tool for HOSS for multiple water conditions. As such, it provides the status (for example, forebays and inflows) of each project at the beginning of each month. The next month's status is used as a target to be met, if possible. An hourly loads program (HRLYLOADS) provides hourly load forecasts for the Federal and Northwest Generating Utilities systems.

- **Resource Adequacy Model (GENESYS).** GENESYS (GENeration Evaluation SYStem) was developed by the Northwest Power and Conservation Council in cooperation with BPA. It is used to perform studies for adequacy assessments. GENESYS simulates the operation of the hydro system and other regional generating resources, using Monte Carlo sampling to model uncertainty in loads, streamflows, wind and solar generation, and forced outages of thermal resources.
- **Power Rate Model (RAM2020).** For the CRSO EIS, BPA's power rates model from the BP-20 rate case (RAM2020) computes BPA's expected power rates under the No Action Alternative (NAA) and the various Multiple Objective (MO) alternatives for FY2022.
- **Long-Term Transmission Rates Model.** For the CRSO EIS, BPA's long-term transmission rates model was utilized to conduct a transmission rate pressure sensitivity analysis on the various multi-objective alternatives. Specifically, the model was used to calculate long-term cumulative rate pressure for each of the multi-objective alternatives in order to compare the effects of the alternatives on transmission rates to the rates under the NAA.

These models must be technically sound, represent the system being modeled, and have been reviewed for theoretical soundness and compliance with USACE planning policy and procedures.

1.2 Model Evaluation Assessment Criteria and Approach

Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analysis. The objective of the work described here was to conduct an IEPR of the CRSO Power Analysis Models in accordance with procedures described in the Department of the Army, USACE, Engineer Circular (EC) *Review Policy for Civil Works* (EC 1165-2-217) (USACE, 2018) and the OMB, *Final Information Quality Bulletin for Peer Review* (OMB, 2004). Supplemental guidance on evaluation for COIs was obtained from the *Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports* (The National Academies, 2003).

USACE requires that all planning models be reviewed to ensure that they are technically sound. In this case, the IEPR of the CRSO Power Analysis Models was conducted and managed using contract support from Battelle, which is an Outside Eligible Organization (OEO) (as defined by EC 1165-2-217). Battelle, a 501(c)(3) organization under the U.S. Internal Revenue Code, has experience conducting IEPRs for USACE.

This final report presents the findings of the IEPR Panel (the Panel) on the technical soundness and computational accuracy of the models and establishes whether the models' assumptions, analyses, results, and conclusions are well documented. Appendix A describes in detail how the IEPR was planned and conducted, including the schedule followed in executing the IEPR. Appendix B provides biographical

information on the IEPR panel members and describes the method Battelle followed to select them. Appendix C presents the final charge to the IEPR panel members for their use during the review; the final charge was submitted to USACE in the final Work Plan according to the schedule listed in Table A-1. Appendix D presents the organizational COI form that Battelle completed and submitted to the Institute for Water Resources (IWR) prior to the award of the CRSO Power Analysis Models IEPR.

The methods used to conduct the IEPR are briefly described in this section. The IEPR was completed in accordance with established due dates for milestones and deliverables as part of the final Work Plan; the due dates are based on the award/effective date and the receipt of review documents.

The Panel received electronic versions of the model review documents and software along with a charge that solicited comments on the quality of the model documentation, scientific theories, and usability. Following guidance provided in USACE (2018) and OMB (2004), USACE prepared the charge questions, which were included in the draft and final Work Plans.

The Panel reviewed the CRSO Power Analysis Models documents and produced 15 Final Panel Comments in response to 23 charge questions provided by USACE for the review. This charge also included two overview questions added by Battelle, for a total of 25 questions. Battelle instructed the Panel to develop the Final Panel Comments using a five-part structure:

1. Comment Statement (succinct summary statement of concern)
2. Relevant Model Assessment Criteria (list of model review criteria applicable to the Final Panel Comment)
3. Basis for Comment (details regarding the concern)
4. Significance (high, medium/high, medium, medium/low, or low; in accordance with specific criteria for determining level of significance)
5. Recommendation(s) for Resolution (at least one implementable action that could be taken to address the Final Panel Comment).

Battelle reviewed all Final Panel Comments for accuracy, adherence to USACE guidance (EC 1165-2-217), and completeness prior to determining that they were final and suitable for inclusion in the Final Model Report. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The Panel's overall findings are summarized in Section 1.3. The Panel's findings as they relate specifically to technical quality, system quality, and usability are discussed in greater detail in Sections 2.0, 3.0, and 4.0. Table 1 lists the Final Panel Comment statements by level of significance; the full Final Panel Comments are presented in Section 5.0.

Table 1. Overview of 15 Final Panel Comments Identified by the CRSO Power Analysis Models IEPR Panel

No.	Final Panel Comment
Significance – Medium/High	
1	The HYDSIM model output cannot be understood without contextual explanation from an experienced model operator.
2	There is no rigorous analytical process to ensure that least-cost and least-carbon resource additions in the alternative resource portfolios are cost-effective.
Significance – Medium	
3	The models are being used to extrapolate beyond the range of conditions for which they were originally designed.
4	Calculation of the Loss of Load Probability (LOLP), including the filtering that was applied, and related output metrics was not included in the GENESYS model documentation.
5	It is unclear why trapezoidal approximations for estimating peaking are used when hourly models that should provide more reliable results are available.
6	The model documentation does not provide the appropriate high-level descriptions of model assumptions, formulations, calibration, results, discussion, and conclusions or the materials to allow an independent modeler to use the models.
7	The HYDSIM and HOSS models cannot be operated properly (i.e., with minimal potential for operator-initiated deviations) unless the models are run by highly experienced users, which limits the number of qualified operators.
8	BPA's current package of software tools, consisting of the HYDSIM, HOSS, and GENESYS computer programs, will not run on modern computer systems and will need to be upgraded in the near future.
9	The overall iterative process of how the models interact is unclear.
10	The BPA renewable generation integration costs in the Long-Term Transmission Rates model were not updated to reflect the impact of changing BPA portfolios and regional renewable integration demands under each scenario.
11	It is not clear that the RAM2020 model includes an unbiased estimate for the impact of market transactions made to address surplus or deficit power positions.

Table 1. Overview of 15 Final Panel Comments Identified by the CRSO Power Analysis Models IEPR Panel (Continued)

No.	Final Panel Comment
Significance – Medium/Low	
12	No documentation was provided indicating that sensitivity, uncertainty, and risk analyses have been conducted on the models.
13	It does not appear that the HOSS model runs were assessed for accuracy, and it is unclear what impact inaccuracies in the HOSS output would have on the model runs for the CRSO.
14	There does not appear to be an agreed-upon way to verify that past or future changes to the Fortran code have not introduced (or will not introduce) errors in the HYDSIM, HOSS, and GENESYS programs.
Significance – Low	
15	It is unclear how HOSS calculates the flexibility of the system to shift generation from Light Load Hours (LLH) to Heavy Load Hours (HLH) and how this flexibility was used in the assessment of the Draft EIS alternatives.

1.3 Summary of Findings

The panel members agreed on their assessment of the technical quality, system quality, and usability of the CRSO Power Analysis Models reviewed. The models are very comprehensive and provide data required to support comparisons of alternatives. However, based on the documents the Panel was asked to review and the presentations/discussions on each model, the Panel has identified a number of concerns and has provided specific recommendations to improve the models in the Final Panel Comments. Recommendations include the following:

- Develop documentation specific to each model used to evaluate alternatives for operating/altering the CRSO project, detailing the exact state of the model at the time it was run; the assumptions applied; limitations that remain; outcomes of calibrations conducted; evidence of the model's suitability and validation to the Columbia River System; and uncertainties and risks that remain within the outputs and conclusions. In addition, clear documentation of how each model interacted and exchanged information is needed for each alternative assessed.
- Verify the accuracy of the models by using test data sets to ensure that model changes have not resulted in changes to data outputs.
- Update the older models to use current or future operating systems and building them so they can run more autonomously (thereby reducing operator-induced discrepancies) are also suggested.

- Conduct sensitivity analysis and document the findings to demonstrate that the selected resource additions for both the least-cost and least-carbon alternatives represent the most cost-effective resource additions.

These issues are important to the effective application of the models by experienced users and USACE staff. The Panel recommends that USACE and the modeling teams address these issues prior to finalizing the decisions made for the models' use.

2.0 TECHNICAL QUALITY ASSESSMENT

Analytical tools, including models, used for planning purposes need to be technically sound and based on widely accepted contemporary scientific theory and engineering practice. The model calculations must reflect how the power analysis system is expected to change with changes in project actions based on the application of scientific theory. Formulas and calculations that form the mechanics of the model must be accurate and correctly applied, with sound relationships among variables. The model should be able to reflect resource changes as well as the influence of laws, policies, and practices. All model assumptions must be reasonable and should be well-documented. The analytical requirements of the model must be identified, and the model must address these requirements. The model should also produce robust, reproducible results that stand up to rigorous scrutiny in later stages of the plan formulation process. The results of the Panel's assessment of these criteria are summarized in the following sections.

2.1 Model Documentation Quality

The model documentation provided to the Panel for review of the five power analysis models consisted of a collection of documents developed for a variety of reasons at different times in the life of each model, rather than a cohesive document that reported on the specific model used to conduct the CRSO modeling of the alternatives. Most of the information supplied focused on identifying the steps that modelers follow to run the software and presentations or descriptions of how the models work in general, but even that information was not always complete. The Panel noted a lack of coherent and accurate documentation of the specific model and parameters used in order to establish that the models, analyses, results, and conclusions are theoretically sound, computationally accurate, based on reasonable assumptions, well-documented, and in compliance with the requirements of the OMB Peer Review Bulletin (OMB, 2004).

Final Panel Comment 6 specifically addresses the importance of compiling a single, comprehensive document for each model such that an independent modeler could operate each model without oversight. Final Panel Comment 1 focuses on how discussions with BPA's model operators clearly revealed that the HYDSIM model cannot currently be understood without contextual explanation from an experienced model operator, therefore prompting the Panel to consider whether consistent results can be achieved when two different modelers operate the model independently.

2.2 Theory and External Model Components

The Panel agreed that the theory and external model components of the five power analysis models are appropriate. No issues were identified during the review of these parts of the model.

2.3 Representation of the System

The Panel recognizes that the current power analysis models have value in the current EIS process; however, changes could be made to improve the models in their present form, and to enable the models to continue to improve over time. From a conceptual standpoint, the Panel agrees that, in general, most of the model components used in the five power analysis models do a reasonable job of characterizing and projecting the various systems, processes, and changes that are being modeled. However, the Panel is concerned that the models are being used to extrapolate beyond the range of conditions for which they were originally designed (Final Panel Comment 3). The models reviewed (HYDSIM, HOSS, GENESYS, RAM2020, and the Transmission Rates Model) were designed for different purposes and timeframes. Ideally, long-range modeling would incorporate regional load growth, projected changes in power systems, evolution of new technologies allowing improved grid management, declining costs for emerging generation technologies, or climatological changes in river flows. However, only two test years (2023 and 2028) were analyzed, and it is unclear how those results were used to extrapolate a long-term forecast window. Similarly, without documentation on the sensitivity, uncertainty, and risk analyses of the model results (Final Panel Comment 12) as they relate to the findings for CRSO alternatives, it is unclear how much variability is expected over the 50-year timeframe of the CRSO project.

Another Panel concern as it relates to representation of the system focuses on the BPA renewable generation integration costs in the Long-Term Transmission Rates model (Final Panel Comment 10). From the documentation provided, it appears these costs were not updated to reflect the impact of changing BPA portfolios and regional renewable integration demands under each scenario. Changes to the BPA generation impact their flexibility and ability to provide grid integration services, especially the removal of the lower four Snake River projects. Increased regional renewable generation capacity would increase the demand for grid integration services, especially under the early coal retirements with zero-carbon replacements. The combination of changes to both the capacity to provide and the demand for renewable integration services should drive price differences that would impact the rate pressures calculated for each scenario and reported in the Draft EIS.

2.4 Analytical Requirements

The Panel's main concerns regarding the analytical requirements of these models focus on the fact that the accuracy of the models relies heavily on experienced users to operate the models and identify problems. The HYDSIM and HOSS models cannot be operated properly (i.e., with minimal potential for operator-initiated deviations) unless the models are run by highly experienced users, which limits the number of qualified operators (Final Panel Comment 7). The overall iterative process of running the HYDSIM, Hydrologic Engineering Center (HEC) - Reservoir System Simulation (ResSim), HOSS, and GENESYS programs adds difficulty in assessing the results of a study and determining whether such results are accurate and reliable.

As noted under Section 2.3, no documentation was provided indicating that sensitivity, uncertainty, and risk analyses have been conducted on the models (Final Panel Comment 12). Therefore, there is nothing to state how accurate one run of these models really is compared to real-life situations, and since no documentation exists on how runs are prepared, there is no indication of the accuracy of one experienced user over another.

The HOSS documentation in the Draft EIS indicates that in addition to the Heavy Load Hours (HLH)/Light Load Hours (LLH) generation split, HOSS provides output on the "...flexibility of the system [ability to shift

generation from LLH to HLH]...” (Draft EIS, page I-5-5). It is unclear how HOSS calculates the flexibility of the system to shift generation from LLH to HLH and how this flexibility was used in the assessment of the Draft EIS alternatives (Final Panel Comment 15).

2.5 Model Assumptions and Limitations

As noted under Sections 2.1 and 2.3, the Panel believes that the documentation of and reasoning behind the various model assumptions and limitations are not always clear. At a minimum, the model documentation should contain a standard section listing assumptions and limitations relevant to the version of each model being used for the CRSO assessment. Of the 15 Final Panel Comments the Panel stated as being relevant to the model assumptions and limitations, two of the Final Panel Comments (Final Panel Comments 3 and 10) have previously been discussed under Section 2.3, Representation of the System. The three Final Panel Comments that have not been previously discussed are discussed below.

The GENESYS model is used to determine the amount of resource additions to each alternative through the Loss of Load Probability (LOLP) calculation. The GENESYS user documentation describes the use of a trapezoid approximation, which defines, on a pre-processor basis, the sustained peaking capability and hydro minimums of the system as functions of monthly energy. The pre-processor itself determines these relationships by estimating the twin peak load shape to be a trapezoid. (See page 5, GENESYS (version 9) Documentation dated August 31, 2013). However, it is unclear why trapezoidal approximations for estimating peaking are used when hourly models that should provide more reliable results are available (Final Panel Comment 5).

It is not clear that the RAM2020 model includes an unbiased estimate for the impact of market transactions made to address surplus or deficit power positions (Final Panel Comment 11). There is a potential for a biased deviation from the net volume and average pricing assumed in the model if the timing and volume of the individual transactions given the hourly price shape are not considered. Strategic or forced transactions could lead to increased or decreased net revenues, which, if consistently present, should be accounted for in the transaction estimates.

The HOSS model appears to be a powerful tool used by BPA to shape its forward wholesale marketing strategy. The Panel assumes that this model must be well-trusted by BPA staff to be used for such an important function. However, it does not appear that the HOSS model runs were assessed for accuracy, and it is unclear what impact inaccuracies in the HOSS output would have on the model runs for the CRSO (Final Panel Comment 13). At a minimum, the impact to the Draft EIS analysis resulting from minor variations in HOSS results through sensitivity analysis could have been quantified. Alternatively, the HOSS results could have been cross-checked against historic generation patterns to assess reasonableness.

3.0 SYSTEM QUALITY ASSESSMENT

System quality refers to the quality of the entire system used to develop, use, and support the model. In general, the Panel’s evaluation of system quality included assessing whether the model’s calculations and formulas were correct and whether the models had been tested and validated. The results of the Panel’s assessment of system quality are summarized in the following sections.

3.1 Model Calculations/Formulas

As noted in Section 2.5, Final Panel Comment 11 relates to the estimate for the impact of market transactions made to address surplus or deficit power positions as calculated in the RAM2020 model. This is the only Final Panel Comment specifically focused on the calculations and formulas associated with the five power analysis models. However, one caveat of this review is that the Panel was not able to actually see and use or test any of the five power analysis models during this review. Therefore, the actual accuracy of model calculations and formulas could not be assessed.

3.2 Testing/Evaluation Process

As previously suggested in Section 2.0, to ensure that the models accurately represent the system, the results of sensitivity, uncertainty, and risk analyses should be documented for each of the models (Final Panel Comment 12), and the HOSS model runs should be assessed for accuracy (Final Panel Comment 13). In addition, the Panel believes that these models should be checked for accuracy using an agreed-upon way to verify that past or future changes to the Fortran code have not introduced (or will not introduce) errors in the HYDSIM, HOSS, and GENESYS programs (Final Panel Comment 14). The review of the program outputs is subjective, where one analyst might find no issues and another might determine that some minor discrepancies occurred, resulting in some input adjustments and a reanalysis before going forward. The Panel suggests that for these BPA programs, test datasets, a quick start guide, and release notes should be developed. Test datasets could be created using subsets of one or more of the MO alternatives (MO1, MO2, MO3 and MO4) or the NAA.

4.0 USABILITY ASSESSMENT

Usability refers to how easily model users can access and run the models, interpret model output, and use the model output to support planning decisions. An assessment of model usability includes evaluating the availability of data required to run the models and the ability of the user to learn how to use the model properly and effectively. Model outputs should be easy to interpret, useful for supporting the purpose of the model, easy to export to project reports, and sufficiently transparent to allow for easy verification of calculations and outputs. The results of the Panel's usability assessment are summarized in the following sections.

4.1 Operating Requirements of the Model

For this review, the Panel could not actually run any of the power analysis models. All of these models only exist on BPA's main servers and therefore it was not possible for the Panel to directly assess each model. However, the Panel still had three concerns regarding the operating requirements. The first two have already been discussed – Final Panel Comment 6, regarding a lack of model documentation, and Final Panel Comment 7, on the need for highly experienced users to accurately operate these models. However, the Panel is also concerned that BPA's current package of software tools, consisting of the HYDSIM, HOSS, and GENESYS computer programs, will need to be upgraded in the near future (Final Panel Comment 8). The current versions of BPA's HYDSIM, HOSS, and GENESYS computer programs (Software Tools Package) lack a modern, enterprise-level, computational architecture. Over the years, in an effort to avoid disturbing or renegotiating treaty rules, these programs' computer codes have been adapted repeatedly to introduce unconventional computations, resulting in a very complicated, iterative, and manual approach to addressing regulation operation alternatives that can be modeled using newer

and widely adopted software. The aging software relies too heavily on user input of system-constrained operations, which introduces the likelihood of errors, and the overall process carries heavy operational inefficiencies.

4.2 Input Availability and Output Understandability

The set of five power analysis models reviewed by the Panel include a large amount of information from a variety of sources and output complex spreadsheets and printouts that in many cases require contextual explanations from an experienced model operator (Final Panel Comment 1). The Panel noted that the overall iterative process of how the models interact is unclear (Final Panel Comment 9). During the review, the Panel attempted to understand and flowchart the processes, but from the responses received during the Mid-Review Teleconference that Battelle facilitated between the Panel and BPA, it is clear that the flowchart did not reflect the interactions. The Panel suggests that a complete documentation of what information comes from which location in what format and how it is entered be captured, including information from models outside of this review.

For the GENESYS Model, the Panel also suggests that the calculation of the LOLP, including the filtering that was applied, and related output metrics be included in the GENESYS model documentation (Final Panel Comment 4), as it was not included in the information provided.

4.3 Condition Characterization Usefulness

When assessing the models' usefulness in characterizing the conditions of the CRSO project, the Panel noted that there is no rigorous analytical process to ensure that least-cost and least-carbon resource additions in the alternative resource portfolios are cost-effective (Final Panel Comment 2). The Draft EIS states that the determination of least-cost additions were made "Based on co-lead agency analysis..." (see page 25, Draft EIS Executive Summary). Least-cost planning analysis, such as the studies employed in utility Integrated Resource Plans, is now typically performed by running a variety of different portfolio options to test which ones produce least-cost results compared to other resource options. Given the model capabilities, the Co-lead Agencies could have tested different resource options in this manner to confirm that the additions are truly least-cost options given the parameters for each of the alternatives.

4.4 Model Usefulness in Selecting Alternatives

The Panel raised four concerns it believes will impact the use of the models for selecting the alternatives. All four have been previously mentioned: (1) there is no rigorous analytical process to ensure that least-cost and least-carbon resource additions in the alternative resource portfolios are cost-effective (Final Panel Comment 2), (2) the overall iterative process of how the models interact is unclear (Final Panel Comment 9), (3) no documentation was provided indicating that sensitivity, uncertainty, and risk analyses have been conducted on the models (Final Panel Comment 12), and (4) it is unclear how HOSS calculates the flexibility of the system to shift generation from LLH to HLH and how this flexibility was used in the assessment of the Draft EIS alternatives (Final Panel Comment 15). The Panel's main concern is that without these changes being taken into account, the overall impact of each alternative may not be accurately assessed.

5.0 MODEL ASSESSMENT SUMMARY

This section presents the full text of the Final Panel Comments prepared by the IEPR panel members.

Final Panel Comment 1

The HYDSIM model output cannot be understood without contextual explanation from an experienced model operator.

Relevant Model Assessment Criteria

Model Documentation Quality
Input Availability and Output Understandability

Basis for Comment

It is the Panel's understanding that the HYDSIM is a hydro-regulation model and does not include optimization capability. Any optimization, or improvement of the regulation produced by HYDSIM, is achieved by operator adjustments made using independent spreadsheet tools to adjust the constraints and rules provided as inputs to HYDSIM. Final HYDSIM results are the product of many iterative HYDSIM model runs with output evaluation and input adjustments between each run.

The Panel was not able to review a final set of operating instructions for producing HYDSIM NAA results or any documentation for operating HYDSIM to produce MO or Preferred Alternative (PA) results. The base HYDSIM overview, NAA order of operations document, and one spreadsheet model provided to the Panel were not sufficient to communicate the intended purpose, the required inputs, the method of HYDSIM output evaluation, the nature of changes applied by each spreadsheet model, or the spreadsheet model modifications and additions required to evaluate MO and PA hydro-regulation.

The Panel was also not able to review any data evaluation tools used to determine if HYDSIM output was acceptable for progressing to the next iteration in the HYDSIM order of operations. The Panel was provided with a set of initial and final HYDSIM vs. USACE's HEC-ResSim flow and elevation plots; the evaluation of this output required an experienced HYDSIM operator to highlight the conditions requiring adjustment in the initial plots.

It is not clear to the Panel whether there is a standard tool or a set of criteria used to evaluate HYDSIM model output that would indicate that the use of a spreadsheet tool is required to modify inputs. Without any indicators to clearly flag the need for input modifications, operators are required to rely on their experience and judgment in the optimization or adjustment of HYDSIM outputs. The HYDSIM modeling process is therefore accessible only to experienced BPA analysts and is not reviewable by external parties.

It is the Panel's understanding that even experienced users regularly make errors in the application of the HYDSIM modeling process and need to backtrack to previously archived model results to correct their errors. Archiving interim model runs is a useful mitigation approach but it does not address the underlying issue: reliance on operator experience to interpret HYDSIM output and properly apply the required adjustments.

Final Panel Comment 1

Significance – Medium/High

It is not clear to the Panel that two HYDSIM model operators would create the same results given the need to evaluate interim model outputs based on experience or judgment to identify undesirable system behavior and make corrections through modifications to HYDSIM inputs using spreadsheet tools.

Recommendations for Resolution

1. Develop a “universal” data visualization tool that can plot HYDSIM outputs and constraints together for each project, identify what the driving constraint is for each month, and overlay the intended objective of each spreadsheet tool.
2. Alternatively, transition hydro-regulation planning into a more modern tool and customize it such that it can provide constraint outputs for use as inputs to HYDSIM for verification and any lingering HYDSIM specific needs (e.g., treaty communications or evaluations).

Final Panel Comment 2

There is no rigorous analytical process to ensure that least-cost and least-carbon resource additions in the alternative resource portfolios are cost-effective.

Relevant Model Assessment Criteria

Condition Characterization Usefulness
Model Usefulness in Selecting Alternatives

Basis for Comment

The Draft EIS alternatives have different resource additions creating least-cost and least-carbon alternatives. The least-cost resource additions tend to be single-cycle or combined-cycle gas units, while the least-carbon additions are typically a combination of solar, battery storage, and demand response.

The resource additions are determined by adding the specified resource types to the GENESYS model until the LOLP is brought back in line with the NAA. The Draft EIS states that the determination of least-cost additions were made “Based on co-lead agency analysis...” (see page 25, Draft EIS Executive Summary). Analysis demonstrating the least-cost approach was not provided in the review, although GENESYS modelers indicated that resource types identified in regional portfolio analyses performed by the Northwest Power and Conservation Council were applied to the alternative portfolio, with specific resource decisions based on professional judgment regarding how much annual energy and dependable capacity was required.

Least-cost planning analysis, such as the studies employed in utility Integrated Resource Plans, is now typically performed by running a variety of different portfolio options to test which ones produce least-cost results compared to other resource options. Given the model capabilities, the Co-lead Agencies could have tested different resource options in this manner to confirm that the additions are truly least-cost options given the parameters for each of the alternatives.

Certain factors related to new resource costs have high degrees of uncertainty. These factors include the price of natural gas for portfolios with gas supplies, incentives for renewable resource construction, price-efficiency projections relative to the timing of new resource construction, potential costs for carbon emissions, and the costs to expand use of solar, energy storage batteries, and demand response in the least-carbon portfolio additions. The uncertainties related to these costs are not considered.

Significance – Medium/High

Because the amount of additional resources added is a primary cost driver for the different alternatives, these resources could have a significant impact on the comparative results, limiting the usability.

Final Panel Comment 2

Recommendations for Resolution

1. Near-term: Test the least-cost and least-carbon alternatives using sensitivity analysis, employing different resource types to develop alternative portfolio options and determine the relative costs of the different options. Also, vary the costs associated with higher degrees of uncertainty (natural gas, solar projects, energy storage batteries, and demand response).
2. Long-term: Modernize the model sets so that alternative portfolios can more easily be developed and analyzed to produce least-cost alternative analysis consistent with current utility practice.

Final Panel Comment 3

The models are being used to extrapolate beyond the range of conditions for which they were originally designed.

Relevant Model Assessment Criteria

Representation of the System
Model Assumptions and Limitations

Basis for Comment

The models reviewed (HYDSIM, HOSS, GENESYS, RAM2020, and the Transmission Rates Model) were designed for different purposes. HYDSIM (and HEC-ResSim) appear to have been designed to support Columbia River Treaty studies in cooperation with Canada. HOSS appears to have been designed to do near-term HLH and LLH analysis supporting BPA's marketing activities. RAM2020 and the Transmission Rates Model are used to support the BPA rate-setting process, which forecasts two years into the future and is generally used in the context of a rate process that runs about a year or so before the start of the rate period in question.

The Draft EIS cites a 50-year period of analysis. That time period was applied in the socioeconomic analysis, which relied on output from the models referenced above. Ideally, long-range modeling would incorporate regional load growth, projected changes in power systems, evolution of new technologies allowing improved grid management, declining costs for emerging generation technologies, or climatological changes in river flows. However, only two test years (2023 and 2028) were analyzed, and it is unclear how those results were used to extrapolate a long-term forecast window.

Throughout the analytical process, there was a focus on utilizing the historic record of river flows with adjustments for current levels of irrigation withdrawals. HYDSIM, HOSS, and GENESYS all use this approach to capture potential flow variability. This approach is appropriate when forecasting nearer-term uncertainty, in the manner for which the models have been developed, but this approach does not provide a clear picture of how hydrology and markets might change over the next 50 years.

Since the models were not really designed to handle year-on-year trending, it appears they were adapted to the test years as a surrogate approach to provide some information about longer-term trends. Year-on-year escalation in financial information could be applied in the financial models, but this approach is not the same as a detailed analytical approach for determining how the system operation could change over time or how the regional portfolio might evolve.

Significance – Medium

Utilizing models that can be run over a long-range planning window could provide better and more detailed information regarding the alternatives but is unlikely to change the relative results.

Recommendation for Resolution

1. Expand the modeling capabilities by developing or procuring models capable of performing long-range planning studies and which can be used to better understand how uncertainty

Final Panel Comment 3

related to certain planning factors might influence the relative value of the different alternatives. This resolution is a long-term fix. The approach of using two test years is likely the reasonable short-term resolution given the limitations of the current model set.

Final Panel Comment 4

Calculation of the LOLP, including the filtering that was applied, and related output metrics was not included in the GENESYS model documentation.

Relevant Model Assessment Criteria

Input Availability and Output Understandability

Basis for Comment

The amounts of added resources for the different alternatives were determined using the GENESYS model. The amounts were determined by iterative GENESYS runs until a portfolio was found that produced the same LOLP as the NAA. The LOLP is a metric that represents the probability that a set of resources will fail to meet load over a specified period.

GENESYS was run for CRSO purposes using a filtering process that excluded short-term failures to meet load up to a certain threshold of daily duration and total annual energy. Both the length of outages that defined short-term failures and the limit on total annual energy resulting from these short-term failures to meet load requirements were parameters which were applied to the output of GENESYS runs and could be adjusted based on the judgment of the analysis staff.

Given the limitations of GENESYS, it is logical to apply a filter to eliminate short-term failures to meet load because the short-term failures may be more indicative of model limitations than the limitations of the portfolio being analyzed.

However, the filters and the process used to apply them to the different portfolios were not provided as part of the review. Without data on how the filters were applied or the filtered vs. unfiltered results, it is unclear if the filtering might have introduced differences between the runs that could produce an errant determination of the LOLP and the resulting resource additions required for the alternatives.

Significance – Medium

Applying a more methodological approach to the portfolio filters would improve the GENESYS model results but would not likely alter the relative differences between the alternatives.

Recommendations for Resolution

1. Near-term: Review the filters applied to the GENESYS LOLP determinations for model runs defining the final resulting portfolios for each alternative, and determine whether they were consistent or they introduced biases between the options. Report the total hours filtered and the percent of total annual filter utilized for each alternative and scenario.
2. Long-term: Develop a methodological approach for calculating LOLP using GENESYS that ensures that the resulting LOLP values between runs are consistent and free of any biasing effects.

Final Panel Comment 5

It is unclear why trapezoidal approximations for estimating peaking are used when hourly models that should provide more reliable results are available.

Relevant Model Assessment Criteria

Model Assumptions and Limitations

Basis for Comment

The GENESYS model is used to determine the amount of resource additions to each alternative through the LOLP calculation. The GENESYS user documentation describes the use of a trapezoid approximation, which defines, on a pre-processor basis, the sustained peaking capability and hydro minimums of the system as functions of monthly energy. The pre-processor itself determines these relationships by estimating the twin peak load shape to be a trapezoid. (See page 5, GENESYS (version 9) Documentation dated August 31, 2013).

It is unclear why the trapezoid approximation is needed when both GENESYS and HOSS can be run in hourly timesteps and should be able to determine the sustained peaking capability of the hydro system. Given that the HOSS model is used to determine the peaking and sustained peaking of the hydro system in support of BPA's forward-marketing activities, it seems that model should provide better estimates of the system's peaking capability.

The other concern is the underlying assumption that a trapezoid representing the twin daily peak load shape makes sense in a long-term forecast of system need. California has identified and discussed the impact of solar generation for a number of years, resulting in what the state has called the "duck curve." This impact on residual load (load after reduction by non-dispatchable resources) creates a deeper afternoon trough which has begun pushing afternoon hourly wholesale prices below night-time prices on a fairly regular basis. The Draft EIS alternatives with large amounts of solar additions will exacerbate this phenomenon.

The long-term impacts of climate change on the daily load shape also does not appear to have been taken into account, nor has the potential depth of demand response technologies to help reshape load beneficially.

Significance – Medium

Given the importance of peaking and sustained peaking analysis within GENESYS, it seems that the results of this analysis would have a bearing on the financial results, but possibly not to a degree to change the final decision.

Recommendation for Resolution

1. Leverage the hourly capability inherent in GENESYS and/or HOSS to provide a better model of the sustained peaking capability of the Federal hydro system for use in determining the LOLP and ultimately new resource additions.

Final Panel Comment 6

The model documentation does not provide the appropriate high-level descriptions of model assumptions, formulations, calibration, results, discussion, and conclusions or the materials to allow an independent modeler to use the models.

Relevant Model Assessment Criteria

Model Documentation Quality
Operating Requirements of the Model

Basis for Comment

The documentation of the current system of models focuses heavily on a user-manual style, with insufficient descriptive information on the model assumptions, formulations, calibration, results, discussion, uncertainties, and need for future development.

The documentation identifies steps that need to be followed to run the software, rather than discussing the overall tools developed, logical processes, operating parameters (specifically, how they are reflected in the models), general model capabilities, and model limitations. Much of the software development and knowledge of how the tools are operated seem to be in the hands of a few BPA employees. Also, the limited program documentation is sporadically scattered over a number of file folders, with no logic that would enable the user to find a specific document or identify the model's system of version control. Locating all the current documentation for all the applications into one folder, with sub-folders for the various applications, would expedite the learning curve.

Significance – Medium

Insufficient model documentation impacts the ability of new operators to become proficient at using the models, has the potential to lead to misunderstanding of the model capabilities, and may lead to errors or misleading results. Additionally, a more comprehensive discussion of model limitations would help to guide future model development.

Recommendations for Resolution

1. Develop more descriptive, overview materials to describe model assumptions, formulations, calibration, uncertainties, results and discussion.
2. Develop a plan for ongoing model development.
3. Consolidate model documents into a single location and implement configuration control at all documentation levels (e.g., summary descriptions and technical user manuals).

Final Panel Comment 7

The HYDSIM and HOSS models cannot be operated properly (i.e., with minimal potential for operator-initiated deviations) unless the models are run by highly experienced users, which limits the number of qualified operators.

Relevant Model Assessment Criteria

Analytical Requirements
Operating Requirements of the Model

Basis for Comment

The main complicating factor for use of the models is the heavy user input required to run the models. Model training and competency likely takes considerable time and effort to bring model operators up to a sufficient skill level to reliably run the models. Although the model documentation may allow for an independent user to run the models, the Panel believes that the level of competency required to run the models would be reached only through longer-term training and immersion into the modeling teams.

The overall iterative process of running the HYDSIM, HEC-ResSim, HOSS, and GENESYS programs adds difficulty in assessing the results of a study and determining whether such results are accurate and reliable. The HYDSIM program requires initial input from HEC-ResSim to establish flood control constraints through the determination of reservoir upper rule curves. This effort requires continued coordination with USACE and introduces another potential source of error.

Once HYDSIM uses this input (along with other operating constraint input for a specific alternative), the operator needs to be seasoned enough (or must have another properly trained person interpret the HYDSIM output) to establish that the results are adequate before proceeding to the next step in the analysis.

Additionally, a review of some of the program outputs can be subjective, where one operator might find no issues and another might deem some minor discrepancies occurred, resulting in some input adjustments and a reanalysis before going forward.

As for the outputs needed for the subsequent CRSO processes (GENESYS, HOSS, RAM), the outputs of period elevations, flows, and generation by project are easy to understand. As far as examining the HYDSIM output to evaluate run quality and accuracy, the outputs are a bit more challenging to understand and require post-processing, which is also challenging to understand. One description offered in the presentations was that after many years and many thousands of runs, a user gets to the point where run quality issues jump out at them. Without being steeped in this level of user expertise, it seems that run quality is a challenging effort and appears potentially subjective, particularly when alternatives, representing a major departure from the current system, are analyzed.

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Significance – Medium

HYDSIM and HOSS are only accessible to highly skilled and specialized operators at BPA, which makes the models opaque to outside users and reviewers.

The high likelihood for errors, and associated inefficiencies, is related to the heavy user input needed to run the models and the associated errors that might occur in that user-led process.

Recommendations for Resolution

1. Conduct a test of two seasoned operators to perform separate and independent analyses for a proposed study to see if any differences in the system regulation occur. If any deviations surface, a review of the subjective aspects of the process could be identified for further documentation refinement.
2. Develop both short- and long-term plans to upgrade the modeling systems to be less reliant on interactive user inputs.
3. Develop model training and succession planning to ensure that (1) modeling capabilities are not lost when individual employees leave BPA in the short term, and (2) model knowledge and experience are distributed throughout BPA in the long term.

Final Panel Comment 8

BPA's current package of software tools, consisting of the HYDSIM, HOSS, and GENESYS computer programs, will not run on modern computer systems and will need to be upgraded in the near future.

Relevant Model Assessment Criteria

Operating Requirements of the Model

Basis for Comment

The current versions of BPA's HYDSIM, HOSS, and GENESYS computer programs (Software Tools Package) lack a modern, enterprise-level, computational architecture. Over the years, in an effort to avoid disturbing or renegotiating treaty rules, these programs' computer codes have been adapted repeatedly to introduce unconventional computations, resulting in a very complicated, iterative, and manual approach to addressing regulation operation alternatives that can be modeled using newer and widely adopted software. The aging software relies too heavily on user input of system-constrained operations, which introduces the likelihood of errors, and the overall process carries heavy operational inefficiencies.

BPA's dependence on 32-bit architecture computer programs to investigate system operations alternatives in the Columbia River Basin is in dire need of upgrading to a 64-bit architecture. These programs were originally developed in the 1970s using FORTRAN with a 32-bit architecture. All new computer hardware is 64-bit architecture, requiring older FORTRAN software to be recompiled as a 64-bit executable.

In recent years, USACE's HEC-ResSim program has been introduced into BPA's system operations process, particularly with regard to establishing flood control operating limits. HEC-ResSim was selected by BPA because a large majority of the dams in the Columbia River Basin were already using it for flood control operation. The current version of HEC-ResSim on BPA's system uses a 32-bit architecture. Much effort has been expended attempting to get the vintage HYDSIM and modern HEC-ResSim programs to produce similar results. However, differences still occur.

USACE's HEC software is currently dealing with the transition from 32-bit to 64-bit applications. Today, the HEC-ResSim program can be installed as either a 32-bit or 64-bit program. Since older 32-bit hardware is beginning to be phased out due to hardware failures and replaced with 64-bit hardware, the HEC will start to only provide 32-bit applications in legacy form, similar to the transition from older FORTRAN applications like HEC-1, HEC-2, and HEC-5 with replacement applications HEC-Hydrologic Modeling System (HEC-HMS), HEC-River Analysis System (HEC-RAS), and HEC-ResSim. Consequently, new enhancements to HEC-ResSim will occur only within the 64-bit version.

Therefore, BPA is facing the reality that a transition to a 64-bit architecture will be needed soon. Going forward, BPA needs to develop both short-term and long-term plans to update its software's computer architecture.

Final Panel Comment 8

A suggested short-term fix might be to create a 64-bit executable of the HYDSIM, HOSS, and GENESYS programs that interface with a 64-bit version of HEC-ResSim.

A long-term fix would require a much more aggressive approach. One suggestion is to replace the HYDSIM and HOSS programs with the HEC-ResSim program and Python code, along with conversion of the GENESYS program with Excel and Visual Basic for Application (VBA) code. A significant benefit of this approach is that the 32-bit to 64-bit conversion dilemma is solved, and any future computer operating system architecture transitions would be easy. Although transition from 32-bit to 64-bit is the current problem, conversion from 64-bit to 128-bit is the logical progression in the future.

Multiple modern modeling platforms are available that could perform the same functions as HEC-ResSim, HYDSIM, HOSS, and GENESYS. These tools include Excel-based re-creations of the same models, customized off-the-shelf products (e.g., RT Vista), expanded applications of HEC-ResSim, or fully custom third-party developed models. Updated systems would be able to run with fewer iterations and reduced reliance on user input and subjective evaluation of outputs.

Any long-term fix will require BPA to start discussions with the Columbia River Treaty participants and to maintain the current regulation process such that comparison of results can be conducted until a time of transition is agreed to by all treaty participants.

Significance – Medium

As existing 32-bit hardware fails, only a new 64-bit version of software programs will be able to continue simulating the system operations on the Columbia River Basin.

Recommendations for Resolution

1. Develop a short-term plan to transition the software tool package to a 64-bit computer architecture.
2. Develop a long-term plan to update the software tool package to a modern platform using 64-bit computer architecture, with easy transition to future hardware requirements such as a 128-bit architecture.

Final Panel Comment 9

The overall iterative process of how the models interact is unclear.

Relevant Model Assessment Criteria

Input Availability and Output Understandability
Model Usefulness in Selecting Alternatives

Basis for Comment

It is the Panel's understanding that the modeling process for the CRSO Draft EIS is iterative within individual models and between models. For each Draft EIS alternative (i.e., NAA, MO, and PA):

- HYDSIM is run multiple times independently and with HEC-ResSim, using Aurora in some runs, to generate regulated stream flows and total monthly generation;
- HOSS is run once based on the regulated stream flows from HYDSIM and simulated hourly loads to generate monthly HLH/LLH generation ratios;
- GENESYS is run once to establish baseline alternative LOLP using total generation amounts from HYDSIM and simulated hourly loads;
- GENESYS is then run iteratively to determine the size of portfolio additions required to bring LOLP back in line with the NAA LOLP for each of the various Draft EIS scenarios (e.g., coal plant retirement schedules and resource addition type categories of conventional least-cost and zero-carbon) and to generate LOLP and Conditional Value at Risk 95th Percentile (CVaR95);
- RAM2020 is run for each alternative and scenario using HYDSIM generation (1937 as the critical water year for firm generation and a Power Loads and Resources Study forecast water year to determine plan total generation), monthly HLH/LLH generation ratios from HOSS (same 1937 critical and forecast water year), Aurora wholesale price forecast, and new capital investments from GENESYS to calculate rate pressures for BPA rates and wholesale power rates relative to the base NAA scenario; and
- Long-Term Transmission Rates Model is run for each alternative and scenario using new capital investments, Aurora wholesale price forecast, and short-term sales to calculate rate pressures relative to the base NAA scenario.

Developing the above understanding relied heavily on interviews with model operators and would not have been possible using only the Draft EIS and model documentation. Further, the above understanding only addresses the models reviewed in this IEPR; for a reader to get a complete picture of all models used in the CRSO Draft EIS effort, they would need access to materials on at least Aurora, HEC-ResSim, HRLYLOADS, ToolKit, and all BPA analyses and studies performed to generate appropriate inputs (e.g., Transmission Capacity Studies and associated Capital Cost Estimates and Bonneville Screening Studies).

Further clarification of this complex and iterative modeling approach would allow Draft EIS readers to better understand what data and assumptions were used in the modeling efforts, how these models are used together, and the basis for alternative evaluations and projections (e.g., rate pressures). From the Panel's standpoint, the complexity and iterative nature of the modeling approach does not

Final Panel Comment 9

provide assurance that readers would be able to understand the modeling approach, track the use of similar inputs in multiple models, or correctly interpret the overall results.

Significance – Medium

Additional clarification of the modeling approach, data sources, and model interactions will provide the basis for understanding alternative evaluations and projections.

Recommendations for Resolution

1. Create flow diagrams for each model identifying interactions with other models and all relevant inputs and outputs. Depict iterative modeling processes, including the reasons for iterative runs, and show where model results are used in the overall modeling process and in the Draft EIS. Specifically highlight where models are run in different modes (e.g., HYDSIM based on historic water years for most uses vs. HYDSIM on forecast conditions as part of the Power Loads and Resources Study for RAM2020 generation forecast).
2. Revise the overall modeling flow diagram(s) to include and reference all individual model diagrams. Show the summary flow of information through the models and note how the results are used in the Draft EIS.
3. Create a video description of each individual model and an overall model interaction discussion documenting the same information captured in the flow diagrams. Include a time-phased animation of data flows from inputs to outputs and highlight how they were used in the Draft EIS alternative evaluations. Post these online in a format that allows viewers to ask questions and maintain a set of curated frequently asked question responses.

Final Panel Comment 10

The BPA renewable generation integration costs in the Long-Term Transmission Rates model were not updated to reflect the impact of changing BPA portfolios and regional renewable integration demands under each scenario.

Relevant Model Assessment Criteria

Representation of the System
Model Assumptions and Limitations

Basis for Comment

The scenarios considered in the Draft EIS included significant changes to the BPA generation portfolio and regional renewable generation capacity. The BPA grid integration services budget was not adjusted for each scenario based on these inputs. Changes to the BPA generation impact their flexibility and ability to provide grid integration services, especially the removal of the lower four Snake River projects. Increased regional renewable generation capacity would increase the demand for grid integration services, especially under the early coal retirements with zero-carbon replacements. The combination of changes to both the capacity to provide and the demand for renewable integration services should drive price differences that would impact the rate pressures calculated for each scenario and reported in the Draft EIS.

Significance – Medium

The use of a static renewable integration services budget is not representative of the likely BPA costs under the range of scenarios evaluated. A representative budget would impact the long-term transmission rate pressures for each scenario.

Recommendations for Resolution

1. Develop quantitative forecasts of reasonable renewable integration service levels and budgets. Incorporate these forecasts into the Long-Term Transmission Rate pressures. If quantitative output is not possible, include a qualitative discussion of the possible outcomes and include the likely renewable integration service impacts for each scenario in the Draft EIS.
 - a. Evaluate the system flexibility and capacity to provide renewable grid integration services for the renewable generation capacity by type (e.g., solar vs. wind) under each scenario.
 - b. Evaluate integration costs, system flexibility and renewable generation capacity of the system in past years.
 - c. Identify reasonable alternative integration prices based on other ancillary services' market data.

Final Panel Comment 11

It is not clear that the RAM2020 model includes an unbiased estimate for the impact of market transactions made to address surplus or deficit power positions.

Relevant Model Assessment Criteria

Model Assumptions and Limitations
Model Calculations/Formulas

Basis for Comment

It is not clear that the two aggregated monthly transactions (a single net transaction volume in megawatt hours at the average monthly price for LLH and HLH each) in the RAM2020 model provides a sufficiently accurate estimate for the actual impacts of the transactions made in a month. There is a potential for a biased deviation from the net volume and average pricing assumed in the model if the timing and volume of the individual transactions given the hourly price shape are not considered. Strategic or forced transactions could lead to increased or decreased net revenues, which, if consistently present, should be accounted for in the transaction estimates. The difference in operational constraints and portfolio of generation resources under each scenario could impact BPA's ability to strategically shape transactions and the likelihood of it being forced to make transactions. The overall portfolio size relative to the loads served will also drive the direction and volume of net transactions. It is the Panel's understanding that larger portfolios with more flexibility could likely implement more strategic transactions; smaller portfolios with less flexibility may be forced to make more purchases; and larger portfolios with less flexibility may be forced to make more sales. The Secondary Revenue and Balancing Purchases Input Data do not appear to be included in the publicly available RAM2020 model.

Significance – Medium

Without evaluation, the level and effect of bias are unknown. The potential bias causes uncertainty in the impact of secondary market transactions on the relative rate pressures calculated for each scenario.

Recommendations for Resolution

1. Compare past actual monthly transaction results to aggregated net transaction volumes at average HLH and LLH prices by month. Use these results to determine if RAM2020 estimates should be adjusted to reflect consistent biases or time-of-year trends.
2. Evaluate the potential impacts of each scenario (i.e., overall portfolio size and flexibility) on the ability of BPA to strategically shape market transactions. Include these results as quantitative adjustments to the model or as qualitative discussions for each scenario.

Final Panel Comment 12

No documentation was provided indicating that sensitivity, uncertainty, and risk analyses have been conducted on the models.

Relevant Model Assessment Criteria

Representation of the System
 Analytical Requirements
 Testing/Evaluation Process
 Model Usefulness in Selecting Alternatives

Basis for Comment

Some uncertainties are identified in the Draft EIS, but none appear to be formally evaluated in a risk analysis that would allow the preparation of inputs for sensitivity analysis on any of the relevant models.

It is the Panel's understanding that the HYDSIM and HOSS models are not geared for sensitivity analysis but do incorporate 80 water years in their inputs and therefore run analyses over a range of water year inputs. The sensitivity of HYDSIM and HOSS model outputs to changes in other inputs (e.g., unit/project availability, changes to Mid-Columbia project operations, or irrigation withdrawal changes) were not evaluated for the Draft EIS.

Further, the Panel understands that the GENESYS model includes 80 water years (i.e., combination of HYDSIM generation and HOSS HLH/LLH generation split) and 77 temperature/load years that are run in combinations exhaustively without replacement. The model also has 20 wind variations and 12 solar years that are run based on a random draw to reduce load. The GENESYS model evaluates different levels of regional portfolios as defined by the Draft EIS alternatives and scenarios. The sensitivity of GENESYS LOLP and CVaR95 outputs to changes in other inputs (e.g., firm contracts, thermal resource assumptions, sustained peaking limits, filter levels, or transmission/market purchase limits) were not evaluated for the Draft EIS.

The Panel also understands that the RAM2020 and Long-Term Transmission Rates models took different inputs as required for each scenario evaluated in the Draft EIS (e.g., capital generation asset and transmission investments). The sensitivity of the RAM2020 and Long-Term Transmission Rates rate pressure outputs to changes in other inputs (e.g., regional market power prices, water year, project/line availability) were not evaluated for the Draft EIS.

The inclusion of coal retirement and replacement resource constraints (i.e., least cost conventional vs. zero-carbon) provide scenario-based ranges around the rate pressures reported for each MO and the PA. It would be useful to understand how sensitive rate pressures are to changes in a wider range of inputs for each scenario considered in the Draft EIS.

Final Panel Comment 12**Significance – Medium/Low**

Although uncertainties are discussed, they are not evaluated to the point where a sensitivity analysis could be conducted to determine the relative impact the uncertainties may have on the alternatives evaluated in the Draft EIS.

Recommendations for Resolution

1. Conduct a high-level risk analysis of the uncertainties identified in the Draft EIS (e.g., long-term regional loads, generation capacity, and wholesale power rates) such that likely worst-case and likely best-case combinations of inputs can be identified for the most sensitive model inputs. Run keyhole analyses on the most likely worst- and best-case input combinations to further populate the range of power and transmission rate pressures for each Draft EIS alternative and portfolio scenario.
2. Expand uncertainties already partially analyzed (e.g., climate change impacts) using a similar approach.

Final Panel Comment 13

It does not appear that the HOSS model runs were assessed for accuracy, and it is unclear what impact inaccuracies in the HOSS output would have on the model runs for the CRSO.

Relevant Model Assessment Criteria

Model Assumptions and Limitations
Testing/Evaluation Process

Basis for Comment

The HOSS model appears to be a powerful tool used by BPA to shape its forward wholesale marketing strategy. The Panel assumes that this model must be well-trusted by BPA staff to be used for such an important function. As part of the review, however, the actual processes coded into HOSS to determine hourly and multi-hour sustained capability were not explained in any great detail, other than a broad explanation that HOSS observes LLH minimum generation, maximizes HLH generation, and has all the project constraints. This general logic is instructive for short-term forecasts under the current system conditions, but it may not be effective in addressing potential longer-term trends in the power industry, such as increases in solar generation and improvements in demand response.

Despite the presumed reliability of HOSS, the accuracy of HOSS does not appear to have been validated as part of the CRSO analysis. At a minimum, the impact to the Draft EIS analysis resulting from minor variations in HOSS results through sensitivity analysis could have been quantified. Alternatively, the HOSS results could have been cross-checked against historic generation patterns to assess reasonableness.

The CRSO model process deploys HOSS for a single, somewhat rudimentary exercise, which may be why the model was not explained or seemingly validated to a greater extent. The single purpose of HOSS is to determine the HLH and LLH generation patterns for all the various HYDSIM runs. This HLH and LLH generation pattern is then used by the RAM2020 Microsoft Excel model to help determine the cost implications to the BPA system.

The HOSS documentation that was provided was more akin to a user's how-to manual and did not document the logic, goals, or overall high-level functions and limitations of the model.

Significance – Medium/Low

Although the accuracy of the HOSS model's output does not seem to have been fully validated, even significant changes in the HLH/LLH energy allocations are unlikely to materially change the CRSO financial analysis.

Recommendations for Resolution

1. Validate HOSS output by comparing it against historic HLH and LLH generation patterns related to monthly flow and constraints.

Final Panel Comment 13

2. Perform a sensitivity analysis to determine whether changes in the HLH/LLH generation patterns have a material impact on the financial results.
3. Provide or develop documentation that describes the approach HOSS utilizes to determine the HLH/LLH generation patterns of the Federal system for different periods and water conditions.

Final Panel Comment 14

There does not appear to be an agreed-upon way to verify that past or future changes to the Fortran code have not introduced (or will not introduce) errors in the HYDSIM, HOSS, and GENESYS programs.

Relevant Model Assessment Criteria

Testing/Evaluation Process

Basis for Comment

The BPA has used the HYDSIM, HOSS, and GENESYS software programs in Columbia River Basin studies for many decades. Much of the knowledge of how the programs interface and operate is in the hands of a few BPA employees.

A HYDSIM User's Manual was provided on April 30, 2020, however even with this document it would be difficult (if not impossible) for an independent operator to reproduce a specific CRSO model alternative result without direct help from experienced BPA operators because of the need for these BPA operators to identify errors in the runs. The current approach for novice users to gain expertise is to watch an experienced analyst edit input files and run the software programs, then slowly integrate into the overall process.

The iterative process of running the HYDSIM, HEC-ResSim, HOSS, and GENESYS programs adds difficulty in assessing the results of a study. The HYDSIM program requires initial input from HEC-ResSim to establish flooding constraints using upper rule curves. Once HYDSIM uses these HEC-ResSim outputs along with other operating constraint input for a specific alternative, the BPA operator needs to be seasoned enough (or must have another properly trained person interpret the HYDSIM output) to establish that the results are adequate before proceeding to the next step in the analysis.

The review of the program outputs is subjective, where one analyst might find no issues and another might determine that some minor discrepancies occurred, resulting in some input adjustments and a reanalysis before going forward.

Test datasets for HYDSIM, HOSS, and GENESYS do not seem to have been developed. Test datasets verify that any future program coding changes have no effects on prior results. An example to be followed is how USACE's HEC software is managed. For example, the HEC-ResSim program has four test datasets provided with the software. The documentation includes a User's Manual, a Quick Start Guide, and Release Notes.

USACE's HEC-ResSim User's Manual details how to use the program to model and simulate any new reservoir system operational studies. A Quick Start Guide concentrates on the test datasets provided with the software. This document initially guides the user through fundamental actions required for any use of a program, in small, easily achievable steps that help the user develop confidence. Once complete, each test data example is discussed in more detail.

This effort would require the BPA to create a downloadable version of the programs, along with non-proprietary test data files and their associated input files, output files, and databases. Non-BPA users could then download the applications onto their own computers, similar to how the HEC webpage allows for non-USACE entities to use programs.

Final Panel Comment 14

Release notes concentrate on the current version release of the software. They discuss any enhancements made to the code to correct errors in the previous version of the program and detail how some requested program enhancements have been addressed. For unresolved issues, release notes explain why they still exist and when they will potentially be addressed in the future.

For these BPA programs, test datasets, a quick start guide, and release notes are currently only conceptual. As a suggestion, test datasets could be created using subsets of one or more of the MO alternatives (MO1, MO2, MO3 and MO4) or the NAA.

Significance – Medium/Low

Currently, only a subjective check is used to test whether changes to computer code have introduced inadvertent regulation errors. Given that no universal approach has been developed, the chances that subtle unwanted results have been or will be introduced into the code are significant.

Recommendations for Resolution

1. Update existing program user manuals.
2. Add a quick user's guide and release notes component to the software tools.
3. Develop a set of test datasets for the overall process of simulating reservoir operations on the CRSO.

Final Panel Comment 15

It is unclear how HOSS calculates the flexibility of the system to shift generation from LLH to HLH and how this flexibility was used in the assessment of the Draft EIS alternatives.

Relevant Model Assessment Criteria

Analytical Requirements
Model Usefulness in Selecting Alternatives

Basis for Comment

The HOSS documentation in the Draft EIS indicates that in addition to the HLH/LLH generation split, HOSS provides output on the "...flexibility of the system [ability to shift generation from LLH to HLH]..." (Draft EIS, page I-5-5).

The Panel did not see this capability discussed in the provided documentation or the model presentations. The Panel was informed, in response to its initial round of questions, that "HOSS doesn't provide a quantitative measure of flexibility. It provides an hourly regulation of the Federal Columbia River Power System (FCRPS). It would be left to a different process to define a flexibility metric and use HOSS outputs if necessary and appropriate".

These appear to be conflicting statements.

Significance – Low

A discussion of how the flexibility metrics are calculated and used to compare Draft EIS alternatives would be helpful in both the model documentation and the Draft EIS.

Recommendations for Resolution

1. Describe how the system flexibility is calculated, what metrics are used, and how they are compared across Draft EIS alternatives and scenarios.
2. Alternatively, remove the Draft EIS reference to HOSS providing a measure of flexibility.

6.0 CONCLUSIONS

The Panel noted that the BPA staff running these models are quite dedicated and proficient at maintaining and running these aging models and providing information and results that can be used in a constructive manner by BPA, USACE, and the Bureau of Reclamation on a number of fronts, from managing the Columbia River Treaty, to ensuring safe reliable planning for the hydro system and setting the rates for this valuable cost-based asset pool in the Pacific Northwest. Clearly, the process of running and forecasting the operation of the Columbia River System is a highly involved and complex undertaking. To BPA's credit, the approach satisfies the needs within the region for the BPA.

The Panel noted concerns regarding the lack of complete and clear documentation for the models reviewed, including lack of accurate documentation regarding the interaction between the various models. In its review, the Panel relied upon interviews with the model operators and evidence that the models are regularly used for decision processes by BPA in both internal and public forums as assurance that the models provide reasonable results for the CRSO.

The model results in the CRSO Draft EIS are well-documented, providing the results clearly by alternative, compared to the NAA results, and the analysts have identified the key differences between the NAA and each individual alternative that result in different system behavior. The Panel recognizes that the current models have value in the current EIS process; however, changes will be required to improve the models from their present form, and to enable the models to continue to support this type of analysis.

7.0 REFERENCES

OMB (2004). Final Information Quality Bulletin for Peer Review. Executive Office of the President, Office of Management and Budget, Washington, D.C. Memorandum M-05-03. December 16.

The National Academies (2003). Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports. The National Academies (National Academy of Science, National Academy of Engineering, Institute of Medicine, National Research Council). May 12.

USACE (2018). Water Resources Policies and Authorities: Review Policy for Civil Works. Engineer Circular (EC) 1165-2-217. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. February 20.

APPENDIX A

IEPR Process for the CRSO Power Analysis Models Project

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A.1 Planning and Conduct of the Independent External Peer Review (IEPR)

Table A-1 presents the major milestones and deliverables of the Independent External Peer Review (IEPR) of the Columbia River System Operations (CRSO) Power Analysis Models (hereinafter: CRSO Power Analysis Models IEPR). Due dates for milestones and deliverables are based on the award/effective date listed in Table A-1. The review documents were provided by U.S. Army Corps of Engineers (USACE) on March 2, 2020. Note that the actions listed under Task 6 occur after the submission of this report. Battelle anticipates submitting the pdf printout of the USACE's Design Review and Checking System (DrChecks) project file (the final deliverable) on August 11, 2020. The actual date for contract end will depend on the date that all activities for this IEPR are conducted and subsequently completed.

Table A-1. Major Milestones and Deliverables of the CRSO Power Analysis Models IEPR

Task	Action	Due Date
1	Award/Effective Date	3/2/2020
	Review documents available	3/2/2020
	Battelle submits draft Work Plan ^a	3/9/2020
	USACE provides comments on draft Work Plan	3/16/2020
	Battelle submits final Work Plan ^a	3/19/2020
2	Battelle submits list of selected panel members ^a	3/10/2020
	USACE confirms the panel members have no COI	3/17/2020
3	Battelle convenes kick-off meeting with USACE	3/9/2020
	Battelle convenes kick-off meeting with panel members	3/30/2020
	Battelle convenes kick-off meeting with USACE and panel members	3/30/2020
4	Panel members complete their individual reviews	5/5/2020
	Panel members provide draft Final Panel Comments to Battelle	5/21/2020
	Panel finalizes Final Panel Comments	5/28/2020
5	Battelle submits Final Model Report to USACE ^a	6/11/2020
6 ^b	Battelle convenes Comment Response Teleconference with panel members and USACE	7/27/2020
	Battelle submits pdf printout of DrChecks project file ^a	8/11/2020
	Contract End/Delivery Date	1/31/2021

^a Deliverable.

^b Task 6 occurs after the submission of this report.

At the beginning of the Period of Performance for the CRSO Power Analysis Models IEPR, Battelle held a kick-off meeting with USACE to review the preliminary/suggested schedule, discuss the IEPR process, and address any questions regarding the scope (e.g., terminology to use, access to DrChecks, etc.). Any revisions to the schedule were submitted as part of the final Work Plan. The final charge consisted of 23 charge questions provided by USACE, two overview questions added by Battelle (all questions were

included in the draft and final Work Plans), and general guidance for the Panel on the conduct of the peer review (provided in Appendix C of this final report).

Prior to beginning their review and after their subcontracts were finalized, all the members of the Panel attended a kick-off meeting via teleconference planned and facilitated by Battelle in order to review the IEPR process, the schedule, communication procedures, and other pertinent information for the Panel. Battelle planned and facilitated a second kick-off meeting via teleconference during which USACE presented project details to the Panel. Before the meetings, the IEPR Panel received an electronic version of the final charge, as well as the review documents and reference/supplemental materials listed in Table A-2.

Table A-2. Documents to Be Reviewed and Provided as Reference/Supplemental Information

Review Documents	Number of Pages
Hydro System Simulator (HYDSIM) Model Documentation	
General Guidelines for Running the Updated OPER Study Process for CRSO	39
Quick User Guide for Plant Editor Version 1.0	46
File Utilities Quick User Guide	31
Hourly Operations System Simulator (HOSS) Model Documentation	
HOSS User Guide	43
HOSS Training Guide	13
Loss-of-Load Probability Model Documentation (GENESYS)	
GENESYS Version 9 Documentation	15
2013 GENESYS Changes	5
Power Rate Model (RAM2020)	
RAM2020: Power Rates Model Documentation	31
Long-Term Transmission Rates Analysis Model	
Long-Term Transmission Rates Model Documentation	8
Total Number of Review Pages	231
Supplemental Documents	
GENESYS Final Code	8 MB of software code
HOSS Code Documentation	65 MB of software code
HOSS Flow Charts	58
Total Number of Reference Pages	58

^a Supporting documentation only. These documents are not for Panel review and should be used as information sources only. They are not included in the total page count.

In addition to the materials provided in Table A-2, the panel members were provided the following USACE guidance documents.

- Review Policy for Civil Works (EC 1165-2-217, February 20, 2018)
- Office of Management and Budget's Final Information Quality Bulletin for Peer Review (December 16, 2004)

About halfway through the review, a teleconference was held with USACE, Battelle, and the Panel so that USACE could answer any questions the Panel had concerning either the review documents or the project. Prior to this teleconference, Battelle submitted 20 panel member questions to USACE. USACE

was able to provide responses to all the questions during the teleconference, and additional information prior to the end of the review.

In addition, throughout the review period, USACE provided documents at the request of panel members. These documents were provided to Battelle and then sent to the Panel as additional information only and were not part of the official review. A list of these additional documents sent to the Panel is provided below.

- Appendix Rate Summary_v1_est.xlsx
- GENESYS_techdocumentation_20161011.pdf
- Hydsim_manual062513
- MCN_FlowAug2.xlsx
- SummaryRateTables_V14ext.xlsx
- AURORA.png
- LIB_MO4_final.html
- LIB_MO4_Init.html
- Q5_table.png
- Q5_text.png

A.2 Review of Individual Comments

The Panel was instructed to address the charge questions/discussion points within a charge question response form provided by Battelle. At the end of the review period, the Panel produced individual comments in response to the charge questions/discussion points. Battelle reviewed the comments to identify overall recurring themes, areas of potential conflict, and other overall impressions. At the end of the review, Battelle summarized the individual comments into a preliminary list of overall comments and discussion points. Each panel member's individual comments were shared with the full Panel.

A.3 IEPR Panel Teleconference

Battelle facilitated a teleconference with the Panel so that the panel members could exchange technical information. The main goal of the teleconference was to identify which issues should be carried forward as Final Panel Comments in the Final Model Report and decide which panel member should serve as the lead author for the development of each Final Panel Comment. This information exchange ensured that the Final Model Report would accurately represent the Panel's assessment of the project, including any conflicting opinions. The Panel engaged in a thorough discussion of the overall positive and negative comments, added any missing issues of significant importance to the findings, and merged any related individual comments. At the conclusion of the teleconference, Battelle reviewed each Final Panel Comment with the Panel, including the associated level of significance, and confirmed the lead author for each comment.

A.4 Preparation of Final Panel Comments

Following the teleconference, Battelle distributed a summary memorandum for the Panel documenting each Final Panel Comment (organized by level of significance). The memorandum provided the following detailed guidance on the approach and format to be used to develop the Final Panel Comments for the CRSO Power Analysis Models IEPR:

- **Lead Responsibility:** For each Final Panel Comment, one panel member was identified as the lead author responsible for coordinating the development of the Final Panel Comment and submitting it to Battelle. Battelle modified lead assignments at the direction of the Panel. To assist each lead in the development of the Final Panel Comments, Battelle distributed a summary email detailing each draft final comment statement, an example Final Panel Comment following the five-part structure described below, and templates for the preparation of each Final Panel Comment.
- **Directive to the Lead:** Each lead was encouraged to communicate directly with the other panel members as needed and to contribute to a particular Final Panel Comment. If a significant comment was identified that was not covered by one of the original Final Panel Comments, the appropriate lead was instructed to draft a new Final Panel Comment.
- **Format for Final Panel Comments:** Each Final Panel Comment was presented as part of a five-part structure:
 1. Comment Statement (succinct summary statement of concern)
 2. Relevant Model Assessment Criteria (list of model review criteria applicable to the Final Panel Comment)
 3. Basis for Comment (details regarding the concern)
 4. Significance (high, medium/high, medium, medium/low, and low; see descriptions below)
 5. Recommendation(s) for Resolution (see description below).
- **Criteria for Significance:** The following were used as criteria for assigning a significance level to each Final Panel Comment:
 1. **High:** There is a fundamental issue within study documents or data that will influence the power analysis model's technical soundness, system quality, or usability.
 2. **Medium/High:** There is a fundamental issue within study documents or data that has a strong probability of influencing the power analysis model's technical soundness, system quality, or usability.
 3. **Medium:** There is a fundamental issue within study documents or data that has a low probability of influencing the power analysis model's technical soundness, system quality, or usability.
 4. **Medium/Low:** There is missing, incomplete, or inconsistent technical or scientific information that affects clarity, understanding, or completeness of study documents, and there is uncertainty regarding whether the missing information will affect the power analysis model's technical soundness, system quality, or usability.
 5. **Low:** There is a minor technical or scientific discrepancy or inconsistency that affects the clarity, understanding, or completeness of study documents, but does not influence the power analysis model's technical soundness, system quality, or usability.

- **Guidelines for Developing Recommendations:** The recommendation section was to include specific actions that USACE should consider to resolve the Final Panel Comment (e.g., suggestions on how and where to incorporate data into the analysis, how and where to address insufficiencies, areas where additional documentation is needed).

Battelle reviewed and edited the Final Panel Comments for clarity, consistency with the comment statement, and adherence to guidance on the Panel's overall charge, which included ensuring that there were no comments regarding either the appropriateness of the selected alternative or USACE policy. At the end of this process, 15 Final Panel Comments were prepared and assembled. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The full text of the Final Panel Comments is presented in Section 5.0 of the main report.

A.5 Final Model Report

After concluding the review and preparation of the Final Panel Comments, Battelle prepared a Final Model Report (this document) on the overall IEPR process and the IEPR panel members' findings. Each panel member and Battelle technical and editorial reviewers reviewed the IEPR report prior to submission to USACE for acceptance.

A.6 Comment Response Process

As part of Task 6, Battelle will enter the 15 Final Panel Comments developed by the Panel into USACE's DrChecks, a Web-based software system for documenting and sharing comments on reports and design documents, so that USACE can review and respond to them. USACE will provide responses (Evaluator Responses) to the Final Panel Comments, and the Panel will respond (BackCheck Responses) to the Evaluator Responses. All USACE and Panel responses will be documented by Battelle. Battelle will provide USACE and the Panel a pdf printout of all DrChecks entries, through comment closeout, as a final deliverable and record of the IEPR results.

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APPENDIX B

Identification and Selection of IEPR Panel Members for the
CRSO Power Analysis Models Project

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B.1 Panel Identification

The candidates for the Independent External Peer Review (IEPR) of the Columbia River System Operations (CRSO) Power Analysis Models (hereinafter: CRSO Power Analysis Models IEPR) Panel were evaluated based on their technical expertise in the following key areas: hydroelectric power utilities engineering, economics, hydroelectric operations research, and hydropower / hydrology and hydraulic engineering. These areas correspond to the technical content of the review documents and overall scope of the CRSO Power Analysis Models project.

To identify candidate panel members, Battelle reviewed the credentials of the experts in Battelle's Peer Reviewer Database, sought recommendations from colleagues, contacted former panel members, and conducted targeted Internet searches. Battelle evaluated these candidate panel members in terms of their technical expertise and potential conflicts of interest (COIs). Of these candidates, Battelle chose the most qualified individuals, confirmed their interest and availability, and ultimately selected four experts for the final Panel. The remaining candidates were not proposed for a variety of reasons, including lack of availability, disclosed COIs, or lack of the precise technical expertise required.

Candidates were screened for the following potential exclusion criteria or COIs. These COI questions were intended to serve as a means of disclosure in order to better characterize a candidate's employment history and background. Battelle evaluated whether scientists in universities and consulting firms that are receiving USACE-funding have sufficient independence from USACE to be appropriate peer reviewers. Guidance in OMB (2004, p. 18) states,

“...when a scientist is awarded a government research grant through an investigator-initiated, peer-reviewed competition, there generally should be no question as to that scientist's ability to offer independent scientific advice to the agency on other projects. This contrasts, for example, to a situation in which a scientist has a consulting or contractual arrangement with the agency or office sponsoring a peer review. Likewise, when the agency and a researcher work together (e.g., through a cooperative agreement) to design or implement a study, there is less independence from the agency. Furthermore, if a scientist has repeatedly served as a reviewer for the same agency, some may question whether that scientist is sufficiently independent from the agency to be employed as a peer reviewer on agency-sponsored projects.”

The term “firm” in a screening question referred to any joint venture in which a firm was involved. It applied to any firm that serves in a joint venture, either as a prime or as a subcontractor to a prime. Candidates were asked to clarify the relationship in the screening questions.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Columbia River System Operations (CRSO) Power Analysis Models

1. Previous and/or current involvement by you or your firm in the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS) (hereinafter: CRSO EIS), and related projects including the following models: Hydro System Simulator (HYDSIM), Hourly Operations System Simulator (HOSS), LOLP Model (GENESYS), Power Rate Analysis Model (RAM2020), Transmission Long-Term Rates Analysis Model, and Aurora.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Columbia River System Operations (CRSO) Power Analysis Models

2. Previous and/or current involvement by you or your firm in salmonid projects in the Columbia River Basin.
3. Previous and/or current involvement by you or your firm in the conceptual or actual design, construction, or operation and maintenance of any projects in the Columbia River Basin.
4. Current employment by the USACE, Bonneville Power Administration, or Bureau of Reclamation.
5. Previous and/or current involvement with paid or unpaid expert testimony related to Columbia River Basin projects.
6. Previous and/or current employment or affiliation with members of the following Federal, State, County, local and regional agencies, environmental organizations, and interested groups (*for pay or pro bono*):
 - State of Washington State
 - State of Oregon
 - State of Idaho
 - State of Montana
 - Burns Paiute Tribe
 - Confederated Salish and Kootenai Tribes
 - Confederated Tribes and Bands of the Yakama Nation
 - Confederated Tribes of the Colville Reservation
 - Confederated Tribes of Grand Ronde
 - Confederated Tribes of the Chehalis Reservation
 - Confederated Tribes of Siletz
 - Confederated Tribes of the Umatilla Indian Reservation
 - Confederated Tribes of the Warm Springs Reservation of Oregon
 - Coeur D'Alene Tribe
 - Cowlitz Indian Tribe
 - Fort McDermitt Paiute-Shoshone Tribe
 - Kalispel Tribe of Indians
 - Kootenai Tribe of Idaho
 - Nez Perce Tribe
 - Shoalwater Bay Tribe
 - Shoshone Bannock Tribes of the Fort Hall Reservation
 - Shoshone-Paiute Tribes of the Duck Valley Reservation
 - Spokane Tribe of Indians
 - Upper Columbia United Tribes
 - Center for Whale Research
 - Save Our Wild Salmon
 - National Resources Defense Council
 - Sierra Club

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Columbia River System Operations (CRSO) Power Analysis Models

- Earth Justice
 - Dam Sense
 - Defenders of Wildlife
 - Trout Unlimited
 - Wild Orca Center
 - Earth Economics
 - Bluefish.org
 - Columbia Riverkeepers
 - Northwest River Partners
 - Audubon Society
 - American Rivers
 - Oceana
7. Past, current, or future interests or involvements (financial or otherwise) by you, your spouse, or your children related to Columbia River Basin.
 8. Current personal involvement with other USACE projects, including whether involvement was to author any manuals or guidance documents for USACE. If yes, provide titles of documents or description of project, dates, and location (USACE district, division, Headquarters, Engineer Research and Development Center [ERDC], etc.), and position/role. Please highlight and discuss in greater detail any projects that are specifically with the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation.
 9. Previous or current involvement with the development or testing of models that will be used for, or in support of the CRSO EIS project projects including the Hydro System Simulator (HYDSIM), Hourly Operations System Simulator (HOSS), Loss of Load Probability Model (GENESYS), Power Rate Analysis Model (RAM2020), Transmission Long-Term Rates Analysis Model, and Aurora.
 10. Current firm involvement with other projects, specifically those projects/contracts that are with the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation. If yes, provide title/description, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Please also clearly delineate the percentage of work you personally are currently conducting for the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation. Please explain.
 11. Any previous employment by USACE as a direct employee, notably if employment was with the USACE Northwest Division, Bonneville Power Administration, or Bureau of Reclamation. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
 12. Any previous employment by USACE, Bonneville Power Administration, or Bureau of Reclamation as a contractor (either as an individual or through your firm) within the last 10 years, notably if those projects/contracts are with the USACE Northwest Division, and Bonneville Power

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Columbia River System Operations (CRSO) Power Analysis Models

Administration, or Bureau of Reclamation associated with the Columbia River Basin. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.

13. Previous experience conducting technical peer reviews. If yes, please highlight and discuss any technical reviews concerning salmonids and include the client/agency and duration of review (approximate dates).
14. Pending, current, or future financial interests in contracts/awards from USACE, Bonneville Power Administration, or Bureau of Reclamation related to the CRSO EIS project.
15. Significant portion of your personal or office's revenues within the last three years came from USACE Bonneville Power Administration, or Bureau of Reclamation contracts.
16. Significant portion of your personal or office's revenues within the last three years came from contracts with any of the organizations listed in Question 6.
17. Any publicly documented statement (including, for example, advocating for or discouraging against) related to the CRSO EIS project.
18. Participation in relevant prior and/or current Federal studies related to the CRSO EIS project.
19. Previous and/or current participation in prior non-Federal studies related to the CRSO EIS project.
20. Has your research or analysis been used or evaluated as part of the CRSO EIS project including development of the models noted in Question 1?
21. Is there any past, present, or future activity, relationship, or interest (financial or otherwise) that could make it appear that you would be unable to provide unbiased services on this project? If so, please describe.

Providing a positive response to a COI screening question did not automatically preclude a candidate from serving on the Panel. For example, participation in previous USACE technical peer review committees and other technical review panel experience was included as a COI screening question. A positive response to this question could be considered a benefit.

B.2 Panel Selection

In selecting the final members of the Panel, Battelle chose experts who best fit the expertise areas and had no COIs. Table B-1 provides information on each panel member's affiliation, location, education, and overall years of experience. Battelle established subcontracts with the panel members when they indicated their willingness to participate and confirmed the absence of COIs through a signed COI form. USACE was given the list of candidate panel members, but Battelle selected the final Panel.

Table B-1. CRSO Power Analysis Models IEPR Panel: Summary of Panel Members

Name	Affiliation	Location	Education	P.E.	Exp. (yrs)
Hydroelectric Power Utilities Engineer					
Steven Lewis	Sapere Consulting, Inc.	Tukwila, WA	B.S., Physics with a Mathematics Minor	No	30
Economist					
Erich Wolf	Sapere Consulting, Inc.	Tukwila, WA	B.A., Economics M.B.A., expected in 2021	No	17
Hydroelectric Operations Research Analyst					
Gary Franc	Franc Logic	Liverpool, NY	B.S., Civil Engineering	No	40+
Hydroregulation Analyst/Hydrology and Hydraulics Specialist					
Larry Weber	Independent consultant	Iowa City, IA	Ph.D., Civil Engineering	Yes	30+

Table B-2 presents an overview of the credentials of the final four members of the Panel and their qualifications in relation to the technical evaluation criteria. More detailed biographical information on the panel members and their areas of technical expertise is given in Section B.3.

Table B-2. CRSO Power Analysis Models IEPR Panel: Technical Criteria and Areas of Expertise

(A bolded X indicates primary role; an unbolded X indicates experience in this area also)

Technical Criterion	Lewis	Wolf	Franc	Weber
Hydroelectric Power Utilities Engineer				
At least ten years of experience in their area of expertise	X			
M.S. degree or higher	W¹			
Extensive experience and knowledge in engineering theory and practices relating to power generation, transmission, distribution, and marketing	X		X	
Extensive experience and knowledge in electric utility operation and management	X	X	X	
Extensive experience and knowledge in engineering studies to determine markets for electric power, methods for supplying power, and power load growth and power rates	X			
Extensive experience and knowledge in designs and cost estimates of power transmission systems for hydroelectric generating plants	X	X		
Extensive experience and knowledge in revenue forecasting, revenue risk analysis, and commercial business analysis for Transmission Revenue Forecasting	X	X	X	
Economist				
At least ten years of experience in their area of expertise		X		
M.S. degree or higher		W¹		
Extensive experience and knowledge in industry power marketing and economics, including the market for and value of electric power, methods of marketing power and rates, agreements	X	X	X	
Extensive experience and knowledge in power market rates and cost assessments	X	X	X	
Extensive experience and knowledge in the management, maintenance, and development of a suite of risk models for Monte Carlo simulation of electricity market prices	X	X		
Familiarity with AURORAxmp inputs/outputs	X	X		
Extensive experience and knowledge in developing, implementing, or preparing power, transmission and ancillary service rates, rate adjustments, rate designs, and related forecasts, allocations, strategies, and industry evaluations for hydropower operations	X	X	X	
Extensive experience and knowledge in methodologies for determining costs associated with the investment or operation and maintenance facilities for Federal and non-Federal entities	X	X	X	

Table B-2. CRSO Power Analysis Models IEPR Panel: Technical Criteria and Areas of Expertise (continued)

(A bolded X indicates primary role; an unbolded X indicates experience in this area also)

Technical Criterion	Lewis	Wolf	Franc	Weber
Hydroelectric Operations Research Analyst				
At least ten years of experience in their area of expertise			X	
M.S. degree or higher			W¹	
Experience with hydroregulation studies for the CRSO process and other customers. Extensive hydroregulation study experience in other similar large river basins may be substituted for direct CRSO experience	X		X	
Experience developing, implementing, and reviewing hydroregulation optimization models that consolidate external factors such as weather data, water levels, and market prices with system infrastructure and generate optimized plans for operational facilities, such as the opening and closing of gates, reservoir water level regulation, and hydro turbine operation	X		X	
Hydroregulation Analyst/Hydrology and Hydraulics Specialist				
At least ten years of experience in their area of expertise				X
M.S. degree or higher				X
Extensive experience and knowledge in all aspects of hydrology and hydraulic engineering, including a thorough understanding of regulated systems as well as regional water management operations	X		X	X
Extensive experience and knowledge in the development and application of complex hydroregulation and hydraulic models used to rapidly calculate a river system's response to a variety of streamflow and operating conditions	X		X	X
Extensive experience and knowledge in the time-dependent nature of hourly hydroregulation capability	X	X	X	X
Extensive experience and knowledge in model cascading through multiple dams as part of connected riverine and reservoir systems	X	X	X	X
Extensive experience and knowledge in the interaction between assignment of reserves and system capacity	X			X

¹ – USACE accepted a waiver of this criteria for this panel member.

B.3 Panel Member Qualifications

Detailed biographical information on each panel member's credentials, qualifications, and areas of technical expertise is provided in the following paragraphs.

Name	Steven Lewis
Role	Hydroelectric Power Utilities Engineer
Affiliation	Sapere Consulting, Inc.

Mr. Lewis is a senior consultant and owner of Sapere Consulting, Inc, in charge of leading their Energy Solutions Practice since 2016. He has 30 years of near-continuous experience working on Pacific Northwest hydroregulations models in one form or another. He has written code for and administered numerous models and is highly familiar with HYDSIM, Aurora, HOSS, GENESYS and RAM, as well as a number of other models. In addition, he has direct experience working with utilities and generation owners to optimize the dispatch and use of hydro assets to multiple optimization parameters, including non-power constraints, non-power objectives, electric load service, transmission availability, and financial optimization against wholesale markets.

Mr. Lewis earned his bachelor's degree in physics, with a minor in mathematics, from Gonzaga University in 1989. He has expertise in all areas of power trading, power management, and utility operations, including asset optimization, risk management, power resource planning and acquisition, power plant development and acquisition, transmission contracting and issues, hydro operations, and balancing authority area operations. He has supported numerous northwest electricity transactions, including structured solicitations for resources or specified energy products. Mr. Lewis led the review, analysis, and preparation of a proposal by Seattle City Light to provide another northwest public utility with wholesale management of its generation portfolio and load service. The analysis established the potential value to Seattle of the management services and identified wholesale market risk factors, including transmission and market price exposure. He evaluated the operation and determined the financial value of small hydroelectric generating projects for Tollhouse Energy Company. This included evaluating and developing marketing and sales strategies for the Smith Creek hydro project in northern Idaho and two small hydro projects in northern California.

Mr. Lewis conducts ongoing oversight of the monthly cash flows resulting from the Warm Springs Tribes operation of the Pelton Round Butte hydro facilities. The independent review, supporting the Trustee (Bank of New York), ensures that the revenues are being properly allocated to projects costs and debt service in accordance with the terms of an Indenture of Trust specifying how revenues are to be used. For the bond refinancing last year, he provided an independent financial assessment of the expected future financial value of the Pelton Round Butte facility and how that compared to the expected bond repayment schedule. As independent engineer, financial projections, including revenue from electricity production, are made to ensure that sufficient funds are available to meet bond payment schedules.

As owner and president of Lands Energy Consulting (2001 to 2016), Mr. Lewis oversaw a variety of projects, including working with The Energy Authority (TEA) to improve its optimization of client-generating assets in northwest U.S. markets. The improvement effort included working with TEA's technology staff to improve the optimization software to ensure that solutions recognize Bonneville Power Administration (BPA) Slice operating limits and produce actionable results. It also required working directly with real-time trading staff on the proper deployment and use of the TEA Optimizer and the

creation of performance metrics that quantified the value added from successful optimization and related market trading activities. The combination of tool improvement melded with business process improvements resulted in a demonstrable benefit to TEA's clients. He also guided the development of risk management strategies and trading/scheduling practices for northwest hydroelectric-based utilities, including Snohomish Public Utility District (PUD) and Seattle City Light.

Mr. Lewis was a power marketer with Seattle City Light from 1999 to 2001, where he led within-month generation asset optimization and related power marketing in conformance with the overall utility resource hedging strategy. Included in Seattle's portfolio was over 2,000 megawatts (MW) of hydroelectric generating assets, multiple long-term contracts for power purchases/sales, 1,312 MW of long-term firm transmission rights on the BPA main grid, and 160 MW of capacity ownership on the Northwest/Southwest AC Intertie. The hydroelectric assets included a number of large storage and run-of-river projects (Boundary, Ross, Diablo, and Gorge) as well as two smaller storage projects with first-purpose water supply uses (Cedar River and Tolt River). Mr. Lewis built an operations model for the larger hydroelectric projects allowing Seattle's energy traders to accurately plan the operation of those projects and buy or sell energy for future hours or days as needed to properly balance Seattle's system.

From 1990 through 1999, Mr. Lewis worked for Puget Sound Energy. While there, he participated in regional planning called for under the U.S.-Canadian Columbia River Treaty, including 1) review and understanding of the Annual Operating Plan and Detailed Operating Plan, and 2) the development of the determination of the downstream power benefits and the resulting Canadian Entitlement to one-half of the energy and capacity determination. He also reviewed BPA's loads and resources planning process (the "White Book") and related model results. He participated on behalf of Puget in the BPA System Operations Review conducted in the late 1990s to evaluate the Pacific Northwest system operations; the review resulted in various Records of Decision by the operating agencies in 1997.

While at Puget, Mr. Lewis was also responsible for developing and maintaining operational models for the optimization of Puget's hydroelectric generating projects. This included both spreadsheet tools and computer program coding to meet refill, flood control, and reliability uses of the projects while maximizing the financial value. Projects included the Upper and Lower Baker projects, the White River project, the Snoqualmie Falls project, and over 1,000 MW of participant rights in the five non-Federal Mid-Columbia projects (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids). He also maintained and ran a stand-alone copy of the Northwest Power Pool's hydroelectric regulation model. The primary purpose of this model was to support coordination of the northwest hydroelectric system as called for under the Pacific Northwest Coordination Agreement. Puget's independent model runs were made to support short-term operational strategies as well as to provide input to the long-term production costing models uses for ratemaking purposes.

Mr. Lewis negotiated the operating provisions of the first BPA Slice Agreement. This effort included the development of the modeling process that would be used to determine Seattle's rights to capacity and energy in near-term planning and operations down to real-time determination of schedules of power from BPA to Seattle. The modeling process represented the BPA Slice system flexibility which Seattle purchased under a 10-year contract.

As a BPA engineering intern during the summer of 1988, Mr. Lewis designed and programmed various aspects of the Accelerated California Market Estimator (ACME) computer model, which simulated economic dispatch of the southwest electric generating resources to forecast the southwest electric market through identification of the highest-cost marginal resources. ACME was a subroutine of the SAM

model, which was run for various purposes, including value justification of investment in and construction of various BPA transmission assets.

Name	Erich Wolf, PMP, PMI-RMP
Role	Economist
Affiliation	Sapere Consulting, Inc.

Mr. Wolf is a senior consultant with Sapere Consulting, Inc. He has 17 work years as a management consultant in the energy industry and has extensive work experience conducting economic analyses and developing hydropower operations models for public and private clients. He has used power generation data, market rates, forecasts, and transmission and ancillary service rates in analyses in support of facility investment and operational decisions. He has also led many risk management projects related to construction and operations of large facilities, including hydropower facilities. Mr. Wolf earned his bachelor's degree in economics from Whitman College in 2002 and holds certifications in Project Management and Risk Management Professional from the Project Management Institute.

Mr. Wolf is familiar with the application of the Aurora model in economic dispatching and price forecasting analyses. He understands the Aurora inputs, model functions, and outputs; he has developed projections like those used as Aurora inputs and has used Aurora outputs in analyses for multiple clients.

Mr. Wolf supported the preparation and review of a proposal by Seattle City Light to provide another northwest public utility with wholesale management of its generation portfolio and load service. The other utility's portfolio includes a hydroelectric project, contractual rights in another hydroelectric project, and a BPA Shaped Block power purchase agreement. He conducted analyses to establish the potential value to Seattle of the management services and identified wholesale market risk factors, including transmission and market price exposure.

Mr. Wolf currently serves as the lead scheduler and risk manager providing Chelan PUD the ability to operate its two Columbia River hydroelectric projects independently of Mid-Columbia Central coordination. He also served as the senior project reviewer and developer of a risk analysis methodology for a \$75 million to \$100 million annual Tacoma Power Capital Portfolio. The risk analysis results were used to prioritize projects and set portfolio budget targets.

Mr. Wolf developed and implemented a risk analysis approach used in developing a Guaranteed Maximum Price contract for a 10-month, \$16 million hydroelectric project spillway modification project. Project risks were identified and analyzed with the project stakeholders, owner, and contractor; these risks were modeled and used as the basis for negotiating the contract and setting contractor contingency.

Mr. Wolf supports the independent engineering analysis of the Pelton Round-Butte hydroelectric project that Sapere conducts for the Bank of New York. Efforts include a recent bond refinancing effort and development of a financial model of the hydroelectric plant water flows, generation, revenues, and costs to verify the accuracy of stated cash flows in support of the new bond offering package and evaluated risk scenarios.

Mr. Wolf supported an effort to plan and implement a first-of-its-kind Habitat Conservation Plan (HCP) for anadromous fish impacted by hydroelectric dams on the Columbia River in Washington State, with Phase I (survival studies and systems installation) costs estimated at \$200 million. He built a system

dynamics model to model flows across multiple hydroelectric projects and evaluate fish passage survival for operational configuration choices. Mr. Wolf also built a cost estimating model using Monte Carlo simulation that produced ranges and probabilities of costs covering the first 11 years of an HCP implementation. The ranges and probabilities were based on a database of uncertainties associated with the implementation of the HCP which he helped develop. These tools are being used to evaluate risks in current budgets and projected expenditures.

Mr. Wolf is a member of the Sapere team representing the Harvest Wind (99 MW; owners) and Off-takers for the White Creek Wind I (204 MW) project located near Goldendale, Washington, in the Columbia River Gorge. The owners and off-takers are a group of PUDs and energy purchasers with partial ownership and rights to the generation of these two wind farms. He performs routine tracking and reporting on asset generation and status, as well as advising the clients on topics such as currency hedging, power purchase contract strategies, repurchase options, decommissioning and repowering decisions, power scheduling services, industry and market trends, and contractual obligations and rights. Mr. Wolf also developed and continues to support a financial model capable of optimizing and evaluating energy asset investments (i.e., wind farms, solar arrays, fossil fuel generation facilities). The model accepts input assumptions ranging from high-level feasibility assumptions to detailed construction quotes and allows the user to modify all inputs to create and analyze investment scenarios. This model is used to analyze potential investments from various perspectives, including investment partner, equity swap partner, power purchaser, site developer, construction or operations contractor, lender, regulatory agency, transmission supplier, and major equipment supplier.

Name	Gary Franc
Role	Hydroelectric Operations Research Analyst
Affiliation	Franc Logic

Mr. Franc is a civil engineer with over 40 years of extensive experience interfacing with Federal Energy Regulatory Commission and other Federal and state agencies on hydroelectric licensing, relicensing, and compliance issues. He currently is a sole proprietor of Franc Logic, but has prior experience working for USACE, the New York Power Authority, Niagara Mohawk Power Corporation, an independent power producer, and engineer consultant firms. He earned his bachelor's degree in civil engineering from the University of New York at Buffalo in 1973, taking numerous classes in hydropower planning, programming courses, and additional engineering graduate level courses. He has established a solid background in water resources modeling, hydrology, hydraulics, finance, database management, stochastic processes, computer systems, statistics, and application software development.

As a former USACE HEC employee, Mr. Franc wrote computer software code for HEC-1 (rainfall/runoff), HEC-2 (backwater), and HEC-5 (reservoir simulation). He conducted numerous flooding studies for various USACE districts throughout the United States requiring the development of flood insurance rate maps and effects of potential dam failures. These packages have since been replaced with newer version: HEC-Hydrologic Modeling System, HEC-River Analysis System, and HEC-Reservoir System Simulation (ResSim).

Mr. Franc's current work focus is on compliance and computer modeling of water resources and hydroelectric systems. A part of this work involves the use of proprietary software packages (HELP-FL, HMR52-FL, COMPLYTRACK-FL and CORRESTRACK-FL) that afford detailed study and development of

energy potential and financial estimates for existing and proposed turbine upgrades, replacements, or additions. Another area of study is the development of Probable Maximum Precipitation (PMP) and/or Probable Maximum Floods (PMFs) as they relate to the inflow design floods, spillway adequacy, and emergency action plans. Since 2014, Mr. Franc has been contracted with Applied Weather Associates to conduct a PMP study on the Lake Marburg, Bellwood, and Mill Run Dams in Pennsylvania using Franc Logic's HMR52-FL software package. He also conducted HEC-ResSim modeling for First Light Energy projects on the Connecticut River.

In the past, Mr. Franc has managed projects dealing with the identification of new potential conventional hydropower, water supply, and pumped storage sites and the acquisition of existing hydro assets. This work required an understanding of unregulated inflow, flood-flow frequency analysis, drought contingency plans, river-channel and reservoir routing, and open-channel and rainfall runoff modeling and analysis.

Mr. Franc has developed reservoir operations models and evaluated the energy output and financial viability of hydroelectric projects as part of feasibility studies. While working for Tetra Tech's Energy Division, he modeled energy production and/or losses for various flow scenarios and impoundment fluctuation limits on the Oswegatchie River Developments of Brown's Falls, Flat Rock, and South Edwards. While working at Brookfield Renewable Power (BRP), he developed software applications for all BRP hydro plants throughout New York State to satisfy reporting requirements mandated by the New York Independent System Operator and instructed water resources managers in the use of hydro optimization software. As part of a five-year settlement negotiation process, Mr. Franc developed a new reservoir operating policy for the regulation of the 40-square mile Great Sacandaga Lake near Albany, New York.

Name	Larry Weber, Ph.D., PE
Role	Hydroregulation Analyst/Hydrology and Hydraulics Specialist
Affiliation	Independent Consultant

Dr. Weber earned a Ph.D. from the University of Iowa in civil and environmental engineering in 1993. He is an independent consultant but also currently is the Edwin B. Green Chair in Hydraulics and a full professor in the Department of Civil and Environmental Engineering at the University of Iowa. His current area of focus includes coupling computational fluid dynamics models to community-based and individual-based behavioral models to further understand fish behavioral decisions in the immediate vicinity of passage facilities. These models have been applied to natural river reaches and hydraulic structures both for fundamental advancement of scientific understanding of fish swim path selection and for practical application to the design of successful fish passage facilities.

From 2004 to 2017, Dr. Weber served as the Director of IIHR – Hydrosience & Engineering, the nation's oldest academic research program focused on hydraulics, hydrology, and fluid mechanics. He has extensive knowledge in community resilience and planning; flooding; flood mapping; flood mitigation; river hydraulics; fate and transport of nutrients; hydropower; coupling of individual-based ecological and fluid mechanics models; fish passage facilities; environmental hydraulics; hydraulic structures; and river restoration and sustainability. Through these research programs, Dr. Weber's impact has ranged from theoretical numerical model development and scientific discovery (as demonstrated in over 60 peer-reviewed scholarly publications) to the broad application of numerical models and systems-level design approaches to solve complex large-river ecological challenges (as demonstrated in over 200 conference papers and engineering research reports for contracted projects).

In particular, Dr. Weber led the computational fluid dynamics model development for the first fully coupled Eulerian-Lagrangian-Agent Method (ELAM) model to fully predict the swim path of downstream migrating juvenile salmonids on the Columbia-Snake River system. This ELAM model, developed in partnership with scientists at the USACE Engineer Research and Development Center, was successfully applied to develop downstream fish passage structures at several USACE projects (Walla Walla District, Seattle District), public power utilities (Grant PUD, Chelan PUD) and private power utilities (Idaho Power). From 2000 to the present, Dr. Weber and his team have developed the most physically accurate, computational fluid dynamics model coupled with air entrainment and gas transfer modules to predict the fully three-dimensional total dissolved gas (TDG) distribution downstream of hydropower dams. This TDG model has been used extensively throughout the Pacific Northwest, Asia, and South America and has led to spillway deflector designs in the Mid-Columbia, Lower Snake, and Hells Canyon reaches in the Columbia River system.

Through these integrated model development and application projects, Dr. Weber has gained a deep understanding of numerical methods and algorithms, a visionary approach to systems-level integrated design and development, and a genuine understanding of the complexities of both engineering physics and ecological behavior/ecosystem response.

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APPENDIX C

Final Charge for the CRSO Power Analysis Models IEPR

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Charge Questions and Guidance to the Panel Members for the Independent External Peer Review (IEPR) of the Columbia River System Operations (CRSO) Power Analysis Models

This is the final Charge to the Panel for the CRSO Power Analysis Models IEPR. This final Charge was submitted to USACE as part of the final Work Plan, originally submitted on March 19, 2020.

The dates and page counts in this document have not been updated to match actual changes made throughout the project.

BACKGROUND

The U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and Bureau of Reclamation (Co-lead Agencies) are jointly developing a comprehensive Environmental Impact Statement (EIS), referred to as the Columbia River System Operation (CRSO) EIS, to evaluate long-term system operations and configurations of 14 multiple-purpose projects that are operated as a coordinated system within the interior Columbia River Basin in Idaho, Montana, Oregon, and Washington. USACE was authorized by Congress to construct, operate, and maintain 12 of these projects for flood risk management, navigation, power generation, fish and wildlife conservation, recreation, and municipal and industrial water supply purposes. USACE projects that will be included in the EIS are Libby, Albeni Falls, Dworshak, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. The Bureau of Reclamation was authorized to construct, operate, and maintain the other two projects—Hungry Horse and Grand Coulee—for the purposes of irrigation, flood risk management, navigation, power generation, recreation, and other beneficial uses. The BPA is responsible for marketing and transmitting the power generated by these dams. Together, these Co-lead Agencies are responsible for managing the system for these various purposes, while meeting their other statutory and regulatory obligations.

The Co-lead Agencies will use this EIS to assess and update their approach for long-term system operations and configurations through the analysis of alternatives and evaluation of potential effects to the human and natural environments. The scope and scale of this project, its potential to impact human life safety, interest on the part of the Governors of Montana, Idaho, Washington, and Oregon, 19 Federally recognized tribes, connection to ongoing litigation on the Federal Columbia River Power System, as well as the likelihood for the project to result in public dispute, drive a requirement for a heightened level of review and meet the criteria of a highly influential scientific assessment in OMB and Bureau of Reclamation peer review policies.

OBJECTIVES

The objective of this work is to conduct an independent external peer review (IEPR) of the CRSO Power Analysis Models (hereinafter: CRSO Power Analysis Models IEPR) in accordance with the Department of the Army, USACE, Water Resources Policies and Authorities' *Review Policy for Civil Works* (Engineer Circular [EC] 1165-2-217, dated February 20, 2018), and the Office of Management and Budget's (OMB's) *Final Information Quality Bulletin for Peer Review* (December 16, 2004). Peer review is one of the important procedures used to ensure that the quality of published information meets the standards of the scientific and technical community. Peer review typically evaluates the clarity of hypotheses, validity of the research design, quality of data collection procedures, robustness of the methods employed, appropriateness of the methods for the hypotheses being tested, extent to which the conclusions follow from the analysis, and strengths and limitations of the overall product.

The primary goal of the power analysis model review and approval is to establish that models, analyses, results, and conclusions are theoretically sound, computationally accurate, based on reasonable assumptions, well-documented, and in compliance with the requirements of OMB Peer Review Bulletin. The use of a reviewed model does not constitute technical review of the planning product. Independent technical review of the selection and application of the model and the input data is still the responsibility of the users.

The primary criterion identified for model approval is technical soundness. Technical soundness reflects the ability of the model to represent or simulate the processes and/or functions it is intended to represent. The performance metrics for this criterion are related to theory and computational correctness. In terms of theory, a quality power analysis model should 1) be based on validated and accepted “state of the art” theory, 2) properly incorporate the conceptual theory into the software code, and 3) clearly define the assumptions inherent in the model. In terms of computational correctness, a quality power analysis model should 1) employ proper functions and mathematics to estimate functions and processes represented, and 2) properly estimate and forecast the actual parameters it is intended to estimate and forecast. Other criteria for quality Power Analysis Models are efficiency, effectiveness, usability, and clarity in presentation of results. A well-documented quality power analysis model will stand the tests of technical soundness based on theory and computational correctness, efficiency, effectiveness, usability and clarity in presentation of results. The IEPR will be limited to technical review and will not involve policy review. The IEPR will be conducted by subject matter experts (i.e., IEPR panel members) who meet the technical criteria and areas of expertise required for and relevant to the project and are free of conflicts of interest (COIs).

The Panel will be “charged” with responding to specific technical questions as well as providing a broad technical evaluation of the overall models’ technical soundness, system quality, or usability.

DOCUMENTS PROVIDED

The following is a list of documents, supporting information, and reference materials that will be provided for the review. The review assignments for the panel members may vary slightly according to discipline.

Review Documents	No. of Review Pages
Hydro System Simulator (HYDSIM) Model Documentation	
General Guidelines for Running the Updated OPER Study Process for CRSO	39
Quick User Guide for Plant Editor Version 1.0	46
File Utilities Quick User Guide	31
Hourly Operations System Simulator (HOSS) Model Documentation	
HOSS User Guide	43
HOSS Training Guide	13
Loss-of-Load Probability Model Documentation (GENESYS)	
GENESYS Version 9 Documentation	15
2013 GENESYS Changes	5
Power Rate Model (RAM2020)	
RAM2020: Power Rates Model Documentation	31
Long-Term Transmission Rates Analysis Model	
Long-Term Transmission Rates Model Documentation	8
Total Number of Review Pages	231

Supplemental Documents	
GENESYS Final Code	8 MB of software code
HOSS Code Documentation	65 MB of software code
HOSS Flow Charts	58
Total Number of Reference Pages	58

Policy Documents for Reference

- Review Policy for Civil Works (EC 1165-2-217, February 20, 2018)
- OMB's Final Information Quality Bulletin for Peer Review (December 16, 2004)

SCHEDULE & DELIVERABLES

This schedule is based on the receipt date of the final review documents and may change due to circumstances out of Battelle's control such as changes to USACE's project schedule and unforeseen changes to panel member and USACE availability. As part of each task, the panel member will prepare deliverables by the dates indicated in the table (or as directed by Battelle). All deliverables will be submitted in an electronic format compatible with MS Word (Office 2003).

Task	Action	Due Date
Meetings	Subcontractors complete mandatory Operations Security (OPSEC) training	5/1/2020
	Battelle sends review documents to panel members	4/2/2020
	Battelle convenes kick-off meeting with panel members	4/3/2020
	Battelle convenes kick-off meeting with USACE and panel members	4/3/2020
	Battelle convenes mid-review teleconference for panel members to ask clarifying questions of USACE	4/30/2020
Review	Battelle and Panel participate in a virtual meeting to review the models	4/14/2020 – 4/16/2020
	Panel members complete their individual reviews	5/11/2020
	Battelle provides talking points for Panel Review Teleconference to panel members	5/13/2020
	Battelle convenes Panel Review Teleconference	5/14/2020
	Battelle provides Final Panel Comment templates and instructions to panel members	5/18/2020
	Panel members provide draft Final Panel Comments to Battelle	5/28/2020
	Battelle provides feedback to panel members on draft Final Panel Comments; panel members revise Final Panel Comments	5/29/2020 - 6/04/2020
	Panel finalizes Final Panel Comments	6/5/2020
Final Report	Battelle provides Model Review Report to panel members for review	6/9/2020
	Panel members provide comments on Model Review Report	6/15/2020

Task	Action	Due Date
	*Battelle submits Model Review Report to USACE	6/17/2020
	USACE Planning Center of Expertise (PCX) provides decision on Model Review Report acceptance	6/24/2020
Comment Response Process	Battelle inputs Final Panel Comments to Design Review and Checking System (DrChecks) and provides Final Panel Comment response template to USACE	6/26/2020
	Battelle convenes teleconference with Panel to review the Comment Response process	6/26/2020
	USACE Project Delivery Team (PDT) provides draft Evaluator Responses to USACE PCX for review	7/15/2020
	USACE PCX reviews draft Evaluator Responses and works with USACE PDT regarding clarifications to responses, if needed	7/21/2020
	USACE PCX provides draft PDT Evaluator Responses to Battelle	7/22/2020
	Battelle provides draft PDT Evaluator Responses to panel members	7/24/2020
	Panel members provide draft BackCheck Responses to Battelle	7/29/2020
	Battelle convenes teleconference with panel members to discuss draft BackCheck Responses	7/30/2020
	Battelle convenes Comment Response Teleconference with panel members and USACE	7/31/2020
	USACE inputs final PDT Evaluator Responses to DrChecks	8/7/2020
	Battelle provides final PDT Evaluator Responses to panel members	8/10/2020
	Panel members provide final BackCheck Responses to Battelle	8/13/2020
	Battelle inputs panel members' final BackCheck Responses to DrChecks	8/14/2020
	*Battelle submits pdf printout of DrChecks project file	8/17/2020
	Contract End/Delivery Date	1/31/2021

* Deliverables

CHARGE FOR PEER REVIEW

Members of this IEPR Panel are asked to determine whether the CRSO Power Analysis Models are technically sound relative to the design objectives. In addition to the underlying theory, conceptualization, and computational aspects of the methods, reviewers are asked to comment on aspects of the model that potentially affect its usability and reliability as a potential producer of information to be used to influence planning decisions. Specific questions for the Panel are included in the general charge guidance below. The intent of these questions is to focus your review on the assessment criteria that need to be evaluated.

General Charge Guidance

Please answer the scientific and technical questions listed below and conduct a broad overview of the materials provided for the CRSO Power Analysis Models. Please focus your review on your discipline/area of expertise and technical knowledge. However, please feel free to answer any questions that you feel able to. In addition, please note the following guidance.

1. Your response to the charge questions should not be limited to a “yes” or “no.” Please provide complete answers to fully explain your response.
2. Answer the scientific and technical questions listed below and conduct a broad overview assessment of the planning tools.
3. It is possible that the supplied questions by USACE are not applicable or relevant to the type of analysis being performed by the model in question. Where this is the case, please indicate as such.
4. Evaluate the soundness of the models and comment on whether the models effectively represent the systems being modeled and how the models can be validated.
5. Focus the review on scientific information, including factual inputs, data, the use and soundness of model calculations, assumptions, and results that inform decision makers.
6. Offer opinions as to whether the model parameters and formulas are sufficient to quantify ecosystem function.
7. Offer suggestions for future improvements that could be considered by USACE but are not necessary for model use at this time.
8. If desired, panel members can contact one another. However, panel members **should not** contact anyone who is or was involved in the project, prepared the subject documents, or was part of the model development team.
9. Please contact the Battelle Program Manager, Lynn McLeod; mcleod@battelle.org for requests or additional information.
10. In case of media contact, notify the Battelle Program Manager, Lynn McLeod (mcleod@battelle.org) immediately.
11. Your name will appear as one of the panel members in the peer review. Your comments will be included in the Model Review Report but will remain anonymous.

Please submit your comments in electronic form to the Program Manager, no later than 10 pm ET by the date listed in the schedule above.

Independent External Peer Review of the Columbia River System Operations (CRSO) Power Analysis Models

Charge Questions as Supplied by USACE

The following review charge to reviewers outlines the general process of review, expectations for reviewers, and questions the reviewers are encouraged to consider during review of the Power Analysis Models.

The overall objective of the model review is to perform a comprehensive evaluation of the model development methodology, quantification procedures, model evaluation (i.e., validation) techniques, and the degree to which final model outputs can be expected to be reasonable and computationally correct. Reviewers are not explicitly required to review software code, but rather will review the testing procedures and evaluation techniques model proponents employ to ensure computational correctness.

This review will occur in three phases: 1) pre-workshop review of available information to gain an understanding of the current state of the models, 2) in-person model review workshop with model developers and application specialists to investigate and ascertain the technical quality, software quality and computational correctness, and usability of the models, and 3) post-workshop review of any and all information gained/gathered during the workshop including, but not limited to, additional documentation, spreadsheets, or software; feedback and discussions held with model POCs; and/or model specific research completed to finalize the review.

The review panel may use the specific technical and scientific questions included below to guide the individual's review. The review panel has the flexibility to modify or add questions they believe will help in evaluating the quality of the models based on the reviewers' expertise and experience. The reviewers also have the flexibility to bring important issues to the attention of decision makers, including positive feedback or issues outside those areas outlined below. The reviewers can use all available information to determine what scientific and technical issues related to the models may be important to raise to users.

The reviewers are to focus on scientific and technical matters, leaving policy determinations for the lead Federal agencies. The reviewers should not make recommendations on whether a particular alternative should be implemented or present findings that become "directives" in that they call for modifications or additional studies or suggest new conclusions and recommendations.

Review comments are to be structured to fully communicate intent and context by including the comment, why the comment is important, potential consequences of failure to address the comment, and recommendations for addressing the comment. To the best of your ability, reviewers may consider and ask the following questions during review of the models, including asking model developers and application specialists each question to ascertain the degree to which the models appropriately capture the key model factors. Reviewers have the flexibility to modify and/or add specific questions they believe would contribute to a deeper understanding of the models.

Technical Quality

1. Is model documentation developed and available? If so, is it sufficiently detailed to allow the reader to understand the model development process: conceptualization, quantification, evaluation, and application?
2. Does the model documentation include clear and precise description for the focus of the model? Discussion may include, but is not limited to, applicability limits, assumptions, model domain, or boundary conditions.
3. Is the intended use of the model defined, clear, and appropriate?
4. Are the spatial and temporal resolutions of the model described appropriately?
5. Are there complicating factors which could impact the usefulness and soundness of interpretations and conclusions?
6. Are the assumptions and limitations of the model clearly communicated and supported?
7. Comment on the degree to which the model can be used to evaluate existing conditions of the evaluation area and to forecast conditions anticipated to occur during the period of analysis (50 years).
8. Does the model documentation sufficiently include a question or hypothesis and an appropriate underlying theoretical framework?
9. Are the most sensitive parameters or factors of the model identified and supported with sensitivity analyses?
10. Are the model variables, functions, and parameters clearly defined and dimensionalized, preferably in table format?
11. Is the organization of the model documentation satisfactory (e.g., no discussion in results)?
12. Is the model documentation sufficiently detailed such that it could be replicated, reproduced, or used independent of the model development team (i.e., black box vs open source)?
13. Comment on the degree to which the model facilitates sensitivity, uncertainty, and risk analyses.

System Quality

14. Are model computations and equations presented in sufficient detail, and are they relevant?
15. Does the model documentation sufficiently describe testing steps utilized during model development (i.e., consistency check, sensitivity analyses, calibration, validation) to ensure computational correctness?
16. Is a model system quality test plan available for each model? Has the model programming system been tested for errors? If not, what is the potential for errors to occur?

17. Does the model inform users of erroneous or inappropriate inputs or outputs? If not, what is the potential for errors to occur?

Usability

18. To what degree can the hardware, software, and operating system requirements complicate use of the model?
19. Is user documentation available? If so, is it user-friendly and complete? Comment on the model's ease of use.
20. Are the input requirements readily available?
21. Is the required level of precision and accuracy of inputs documented?
22. Comment on the understandability of model output(s).
23. Comment on the level of difficulty likely to be encountered when attempting to assess the model's sensitivities to alternative inputs.

Battelle Summary Charge Questions to the Panel Members¹

Summary Questions

24. Please identify the most critical concerns (up to five) you have with the project and/or review documents. These concerns can be (but do not need to be) new ideas or issues that have not been raised previously.
25. Please provide positive feedback on the project and/or review documents.

¹ Questions 24 and 25 are Battelle-supplied questions and should not be construed or considered part of the list of USACE-supplied questions. These questions were delineated in a separate appendix in the final Work Plan submitted to USACE.

APPENDIX D

Conflict of Interest Form

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David Kaplan
USACE, Institute for Water Resources
February 19, 2020
C-2

Conflicts of Interest Questionnaire
Independent External Peer Review
Columbia River System Operations (CRSO) Power Analysis Models

The purpose of this document is to help the U.S. Army Corps of Engineers identify potential organizational conflicts of interest on a task order basis as early in the acquisition process as possible. Complete the questionnaire with background information and fully disclose relevant potential conflicts of interest. Substantial details are not necessary; USACE will examine additional information if appropriate. Affirmative answers will not disqualify your firm from this or future procurements.

NAME OF FIRM: **Battelle Memorial Institute Corporate Operations**

REPRESENTATIVE'S NAME: **Courtney Brooks**

TELEPHONE: **614-424-5623**

ADDRESS: **505 King Avenue, Columbus, Ohio 43201**

EMAIL ADDRESS: **brooksc1@battelle.org**

I. INDEPENDENCE FROM WORK PRODUCT. Has your firm been involved in any aspect of the preparation of the subject study report and associated analyses (field studies, report writing, supporting research etc.) No **Yes** (if yes, briefly describe): Battelle manages Pacific Northwest National Laboratories (PNNL). PNNL assisted with the scoping for the CRSO EIS. However, due to contractual requirements, Battelle Corporate staff do not work with PNNL staff and are firewalled from PNNL work, therefore the Battelle staff conducting the Model Review have not had and will not have any involvement with the PNNL work and PNNL will not have any involvement with the Model Review.

II. INTEREST IN STUDY AREA OR OUTCOME. Does your firm have any interests or holdings in the study area, or any stake in the outcome or recommendations of the study, or any affiliation with the local sponsor? **No** **Yes** (if yes, briefly describe):

III. REVIEWERS. Do you anticipate that all expert reviewers on this task order will be selected from outside your firm? No **Yes** (if no, briefly describe the difficulty in identifying outside reviewers):

IV. AFFILIATION WITH PARTIES THAT MAY BE INVOLVED WITH PROJECT IMPLEMENTATION. Do you anticipate that your firm will have any association with parties that may be involved with or benefit from future activities associated with this study, such as project construction? **No** **Yes** (if yes, briefly describe):

V. ADDITIONAL INFORMATION. Report relevant aspects of your firm's background or present circumstances not addressed above that might reasonably be construed by others as affecting your firm's judgment. Please include any information that may reasonably: impair your firm's objectivity; skew the competition in favor of your firm; or allow your firm unequal access to nonpublic information.

No additional information to report.

Courtney M. Brooks
Courtney Brooks

February 19, 2020
Date

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal

BATTELLE

It can be done

Comment Response Record for the Independent External Peer Review of the Columbia River System Operations (CRSO) Power Analysis Models

Prepared by

Battelle
505 King Avenue
Columbus, Ohio 43201

for

Department of the Army
U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Mississippi Valley Division

Contract No. W912HQ-15-D-0001
Task Order: W912HQ20F0034

June 11, 2020

Final Panel Comment 1

The HYDSIM model output cannot be understood without contextual explanation from an experienced model operator.

Relevant Model Assessment Criteria

Model Documentation Quality
Input Availability and Output Understandability

Basis for Comment

It is the Panel's understanding that the HYDSIM is a hydro-regulation model and does not include optimization capability. Any optimization, or improvement of the regulation produced by HYDSIM, is achieved by operator adjustments made using independent spreadsheet tools to adjust the constraints and rules provided as inputs to HYDSIM. Final HYDSIM results are the product of many iterative HYDSIM model runs with output evaluation and input adjustments between each run.

The Panel was not able to review a final set of operating instructions for producing HYDSIM NAA results or any documentation for operating HYDSIM to produce MO or Preferred Alternative (PA) results. The base HYDSIM overview, NAA order of operations document, and one spreadsheet model provided to the Panel were not sufficient to communicate the intended purpose, the required inputs, the method of HYDSIM output evaluation, the nature of changes applied by each spreadsheet model, or the spreadsheet model modifications and additions required to evaluate MO and PA hydro-regulation.

The Panel was also not able to review any data evaluation tools used to determine if HYDSIM output was acceptable for progressing to the next iteration in the HYDSIM order of operations. The Panel was provided with a set of initial and final HYDSIM vs. USACE's HEC-ResSim flow and elevation plots; the evaluation of this output required an experienced HYDSIM operator to highlight the conditions requiring adjustment in the initial plots.

It is not clear to the Panel whether there is a standard tool or a set of criteria used to evaluate HYDSIM model output that would indicate that the use of a spreadsheet tool is required to modify inputs. Without any indicators to clearly flag the need for input modifications, operators are required to rely on their experience and judgment in the optimization or adjustment of HYDSIM outputs. The HYDSIM modeling process is therefore accessible only to experienced BPA analysts and is not reviewable by external parties.

It is the Panel's understanding that even experienced users regularly make errors in the application of the HYDSIM modeling process and need to backtrack to previously archived model results to correct their errors. Archiving interim model runs is a useful mitigation approach but it does not address the underlying issue: reliance on operator experience to interpret HYDSIM output and properly apply the required adjustments.

Significance – Medium/High

It is not clear to the Panel that two HYDSIM model operators would create the same results given the need to evaluate interim model outputs based on experience or judgment to identify undesirable

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system behavior and make corrections through modifications to HYDSIM inputs using spreadsheet tools.

Recommendations for Resolution

1. Develop a “universal” data visualization tool that can plot HYDSIM outputs and constraints together for each project, identify what the driving constraint is for each month, and overlay the intended objective of each spreadsheet tool.
2. Alternatively, transition hydro-regulation planning into a more modern tool and customize it such that it can provide constraint outputs for use as inputs to HYDSIM for verification and any lingering HYDSIM specific needs (e.g., treaty communications or evaluations).

PDT Draft/Final Evaluator Response (FPC #1)

X Concur **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a “concur,” unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: HYDSIM is a complex modeling tool. Trained analysts are qualified to understand and interpret HYDSIM results.

HYDSIM, and all hydraulic models, are complicated tools that require years of experience and training to reliably run. The interpretation of model results, similar to any complicated model regardless of the industry, requires years of experience. This is particularly the case in hydraulic models where real conditions are highly variable from year to year: a single year of experience constitutes only one observation.

The Panel was provided a set of instructions for producing the No Action Alternative run following the model presentation. The Panel was also provided with visual representation of the tools used to analyze (whether graphically or in tabular form) HYDSIM results. The evaluation of these plots takes experience with the model, and experience with system operations.

As with all models, users occasionally make errors. This is unavoidable. With all models, user judgment may be required to identify and rectify errors.

Recommendation 1: **Adopt** **X Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will ‘adopt’ or ‘not adopt’ each recommendation and provide an explanation. If ‘adopt’, please provide information on how this recommendation will be adopted. If ‘not adopt’, please explain why.

Explanation: Analysts currently use a preferred tool for review/visualization and inputs preparation.

Analysts have a number of visualization tools that they may use depending on the application of the model. Many analysts develop new tools on an as-needed basis for new visualization needs for specific purposes.

Recommendation 2: ☒ **Adopt** ☐ **Not Adopt**

Explanation: Bonneville is constantly updating HYDSIM to keep up with computing technology and exploring new tools. To date, however, no other model exists that can model the operation including some of the Treaty operations.

Panel Draft/Final BackCheck Response (FPC #1)

☒ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 2

There is no rigorous analytical process to ensure that least-cost and least-carbon resource additions in the alternative resource portfolios are cost-effective.

Relevant Model Assessment Criteria

Condition Characterization Usefulness
Model Usefulness in Selecting Alternatives

Basis for Comment

The Draft EIS alternatives have different resource additions creating least-cost and least-carbon alternatives. The least-cost resource additions tend to be single-cycle or combined-cycle gas units, while the least-carbon additions are typically a combination of solar, battery storage, and demand response.

The resource additions are determined by adding the specified resource types to the GENESYS model until the LOLP is brought back in line with the NAA. The Draft EIS states that the determination of least-cost additions were made “Based on co-lead agency analysis...” (see page 25, Draft EIS Executive Summary). Analysis demonstrating the least-cost approach was not provided in the review, although GENESYS modelers indicated that resource types identified in regional portfolio analyses performed by the Northwest Power and Conservation Council were applied to the alternative portfolio, with specific resource decisions based on professional judgment regarding how much annual energy and dependable capacity was required.

Least-cost planning analysis, such as the studies employed in utility Integrated Resource Plans, is now typically performed by running a variety of different portfolio options to test which ones produce least-cost results compared to other resource options. Given the model capabilities, the Co-lead Agencies could have tested different resource options in this manner to confirm that the additions are truly least-cost options given the parameters for each of the alternatives.

Certain factors related to new resource costs have high degrees of uncertainty. These factors include the price of natural gas for portfolios with gas supplies, incentives for renewable resource construction, price-efficiency projections relative to the timing of new resource construction, potential costs for carbon emissions, and the costs to expand use of solar, energy storage batteries, and demand response in the least-carbon portfolio additions. The uncertainties related to these costs are not considered.

Significance – Medium/High

Because the amount of additional resources added is a primary cost driver for the different alternatives, these resources could have a significant impact on the comparative results, limiting the usability.

Recommendations for Resolution

1. Near-term: Test the least-cost and least-carbon alternatives using sensitivity analysis, employing different resource types to develop alternative portfolio options and determine the

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relative costs of the different options. Also, vary the costs associated with higher degrees of uncertainty (natural gas, solar projects, energy storage batteries, and demand response).

2. Long-term: Modernize the model sets so that alternative portfolios can more easily be developed and analyzed to produce least-cost alternative analysis consistent with current utility practice.

PDT Draft/Final Evaluator Response (FPC #2)

Concur	X	Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: **Least Cost / Least Risk**

A high-level analysis of the least-cost/least-risk approach was included in the draft EIS. See Appendix J, Hydropower, Section 4.2.2. However, the final EIS contains a more full description of the processes and steps used in the power resource replacement analysis for determining the resource replacement portfolios in Appendix H, Power and Transmission, Section 2.2.2.

This analysis includes many of the features of least cost / least risk planning analysis that is employed in utility Integrated Resource Plans (IRPs). However, it should be noted that there are a number of differences between the scope and the framework of the EIS that make conducting an IRP or IRP-like analysis not comparable with the CRSO EIS analysis. IRPs are a utility resource acquisition planning tool, usually developed in response to state regulatory requirements, and are not a requirement for a NEPA analysis. Many utilities perform IRPs to fulfill regulatory requirements created by state law or state utility commissions. In this regard, the scope of an IRP in almost all cases is from a particular utility's perspective solving for that utility's energy need over a planning horizon (typically 20 years) using the utility's criteria or objectives.

The scope of the CRSO EIS is much broader in that CRS operations affect communities throughout the Northwest. The EIS analyzes the impacts of the various alternatives, including the No Action and five Multiple Objective Alternatives, on not just Bonneville, or Bonneville's customers, but on the region as a whole. For this reason, the power resource replacement analysis in the EIS does not identify the cost of resources for a particular utility, but presents the costs as either costs of Bonneville (through its wholesale power rates) or costs of other utilities in the region (through the regional retail rates analysis).

The EIS performs a form of optimization that focuses on ensuring that the portfolios used in the power replacement analysis (1) reflects reasonable estimates of the cost of available replacement resources; and (2) as applied to the MOs, are the least-cost resource categories available. The EIS used the

screened set of primary resources and cost data from the region's regional resource planning organization, the Council, as a primary source for these replacement resources. This approach allows the co-lead agencies to eliminate obvious non-viable resource portfolios, and provides a spectrum of primary resource portfolios to assess the impacts of the MOs. The EIS analysis tested these resources with GENESYS modeling for each alternative to identify the least-cost options. These results are included in Appendix H, Section 2.2.2. The EIS intentionally leaves open any further optimization for utilities or policy makers to make with their respective specific criteria or objectives when and if new resources are to be acquired.

Resource Cost Uncertainty

To address concerns about uncertainty in resource costs, the EIS shows a range of costs for potential replacement portfolios and includes a rate sensitivity analysis. This analysis accounts for changing costs of new resources using publicly released draft information, such as updated prices for solar and battery storage from development of the 8th Power Plan, which will be included as a rate sensitivity in the final EIS. The final EIS will also include the de-escalating cost curves prepared by the National Renewable Energy Laboratory that will likely be used by the Council in the 8th Power Plan.

In regards to demand response price uncertainty, a range of costs was developed. To define a low-end range, a survey study performed by the Cadmus Group found that demand response, consisting of both for Firm and non-firm demand response actions, could be achieved for as low as \$17.31/kW-year (2017\$) in the region in the near term. This report is available at <https://www.bpa.gov/EE/Technology/demand-response/Pages/dr-potential-and-barriers-studies.aspx>. See pages xi and 30. This value was used to define the low-end range of the sensitivity, while the upper end range was tied to the purchase of batteries of 300MW and only 300MW of demand response to estimate the impact of less potential in the region. See Section 3.7.3.1 – Rate Sensitivities and Assumptions, “Demand Response Analysis for CRSO.”

Natural Gas Cost Uncertainty

In the EIS, BPA considered gas price uncertainty using a distribution of 800 forecasts, representing a wide range of possible future conditions. The distribution was created by using an econometric model to estimate key characteristics from 10 years of historical gas hub price variation, and then generating 800 simulations of future gas price variation centered on the forecast prices. For more information on the gas risk model used, please see Section 2.3.1.4 of BPA's Power Market Price Study and Documentation, BP-20-FS-BPA-04 (July 2019).

Potential Costs for Carbon Emissions

The EIS does address the potential costs of carbon emissions. The power analysis in Section 3.7 includes an analysis on “other regional cost pressure” which encompasses an analysis of the cost of carbon compliance resulting from how changes in hydrogeneration between alternatives in the EIS impact generation in the Northwest, greenhouse gas emissions, and ultimately potential costs of those emissions. As explained in the EIS, it would be speculative for BPA to quantify what percentage of these costs would be borne by BPA's ratepayers versus other utilities in the region, therefore, it is considered an “other regional cost pressure.”

Recommendation 1:	Adopt	X	Not Adopt
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Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: A high-level analysis of the least-cost/least-risk approach was included in the draft EIS. See Appendix J, Hydropower, Section 4.2.2. The final EIS contains a more full description of the processes and steps used in the power resource replacement analysis for determining the resource replacement portfolios in Appendix H, Power and Transmission, Section 2.2.2. Individual resources were tested. However, rather than identifying a single preferred portfolio, the goal in the EIS was to identify a range of costs and resource options, with the understanding that costs, technology, other regional resources, and potentially selection criteria would be determined by the acquiring entity(ies) at the time actual replacement resources were selected.

Recommendation 2:	<input checked="" type="checkbox"/>	Adopt	<input type="checkbox"/>	Not Adopt
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Explanation: If an alternative is selected that requires replacement resources, a much more extensive approach would be used by the acquiring entities. The details of such a process are laid out in Appendix H, Section 2.2 of the final EIS.

Panel Draft/Final BackCheck Response (FPC #2)

<input checked="" type="checkbox"/>	Concur	<input type="checkbox"/>	Non-Concur
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Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 3

The models are being used to extrapolate beyond the range of conditions for which they were originally designed.

Relevant Model Assessment Criteria

Representation of the System
Model Assumptions and Limitations

Basis for Comment

The models reviewed (HYDSIM, HOSS, GENESYS, RAM2020, and the Transmission Rates Model) were designed for different purposes. HYDSIM (and HEC-ResSim) appear to have been designed to support Columbia River Treaty studies in cooperation with Canada. HOSS appears to have been designed to do near-term HLH and LLH analysis supporting BPA's marketing activities. RAM2020 and the Transmission Rates Model are used to support the BPA rate-setting process, which forecasts two years into the future and is generally used in the context of a rate process that runs about a year or so before the start of the rate period in question.

The Draft EIS cites a 50-year period of analysis. That time period was applied in the socioeconomic analysis, which relied on output from the models referenced above. Ideally, long-range modeling would incorporate regional load growth, projected changes in power systems, evolution of new technologies allowing improved grid management, declining costs for emerging generation technologies, or climatological changes in river flows. However, only two test years (2023 and 2028) were analyzed, and it is unclear how those results were used to extrapolate a long-term forecast window.

Throughout the analytical process, there was a focus on utilizing the historic record of river flows with adjustments for current levels of irrigation withdrawals. HYDSIM, HOSS, and GENESYS all use this approach to capture potential flow variability. This approach is appropriate when forecasting nearer-term uncertainty, in the manner for which the models have been developed, but this approach does not provide a clear picture of how hydrology and markets might change over the next 50 years.

Since the models were not really designed to handle year-on-year trending, it appears they were adapted to the test years as a surrogate approach to provide some information about longer-term trends. Year-on-year escalation in financial information could be applied in the financial models, but this approach is not the same as a detailed analytical approach for determining how the system operation could change over time or how the regional portfolio might evolve.

Significance – Medium

Utilizing models that can be run over a long-range planning window could provide better and more detailed information regarding the alternatives but is unlikely to change the relative results.

Recommendation for Resolution

1. Expand the modeling capabilities by developing or procuring models capable of performing long-range planning studies and which can be used to better understand how uncertainty related to certain planning factors might influence the relative value of the different

Final Panel Comment 3

alternatives. This resolution is a long-term fix. The approach of using two test years is likely the reasonable short-term resolution given the limitations of the current model set.

PDT Draft/Final Evaluator Response (FPC #3)

Concur **X** **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The models were designed to model a wide range of conditions for multiple purposes, and are suitable for long-term planning.

The models used were designed to model the Federal Columbia River Power System (FCRPS) under any plausible condition. Experience, and the CRSO EIS modeling, demonstrates that they are able to do so. Importantly, and as discussed directly during the live webinar with the IEPR panel, modeling within HYDSIM is independent of any factors listed as areas of concern, i.e. emergent technologies, grid management regimes and load growth.

Climate change scenarios were studied, which capture the most likely changes to hydrology in the Columbia River Basin. As indicated above, changes in market design have no bearing on HYDSIM modeling.

We agree that the modeling undertaken, and the power market forecast data available, do not support a reliable quantification of socioeconomic impacts over 50 years. As described in Section 3.7, the quantitative analysis for impacts of changes in power generation and transmission is based on a shorter timeframe, with qualitative discussion regarding how these effects may persist or change over the 50-years. The quantitative socioeconomic analysis instead reflects the time over which information is available to reasonably predict future impacts. Specifically, the presentation of social welfare effects focuses on average annual changes in the marginal cost of producing power, along with a qualitative description that these average annual estimates are subject to increasing uncertainty over the 50-year timeframe. Additionally, the quantitative analysis of changes in rate pressure for residential, commercial, and industrial ratepayers is based on a 20-year timeframe (2022 to 2041). The 20-year analysis relies on the Northwest Power and Conservation Council retail rate forecast, which incorporates data on regional economic trends including population, household characteristics and power system costs.

Bonneville is exploring other options for future modeling. Currently, Bonneville is not aware of any model that can handle the operation with only minor customization.

Recommendation 1: **X** **Adopt** **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: Forecasting long term is difficult and the model methodology incorporates limitations, which is why test years were chosen. Further, no other model that Bonneville is aware of, not even HEC-ResSim, is able to model the Canadian Treaty operation for proportional draft. Thus, the models used in the EIS are suitable for long-term planning. However, Bonneville is exploring other options for future modeling.

Panel Draft/Final BackCheck Response (FPC #3)

Concur

Non-Concur

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 4

Calculation of the LOLP, including the filtering that was applied, and related output metrics was not included in the GENESYS model documentation.

Relevant Model Assessment Criteria

Input Availability and Output Understandability

Basis for Comment

The amounts of added resources for the different alternatives were determined using the GENESYS model. The amounts were determined by iterative GENESYS runs until a portfolio was found that produced the same LOLP as the NAA. The LOLP is a metric that represents the probability that a set of resources will fail to meet load over a specified period.

GENESYS was run for CRSO purposes using a filtering process that excluded short-term failures to meet load up to a certain threshold of daily duration and total annual energy. Both the length of outages that defined short-term failures and the limit on total annual energy resulting from these short-term failures to meet load requirements were parameters which were applied to the output of GENESYS runs and could be adjusted based on the judgment of the analysis staff.

Given the limitations of GENESYS, it is logical to apply a filter to eliminate short-term failures to meet load because the short-term failures may be more indicative of model limitations than the limitations of the portfolio being analyzed.

However, the filters and the process used to apply them to the different portfolios were not provided as part of the review. Without data on how the filters were applied or the filtered vs. unfiltered results, it is unclear if the filtering might have introduced differences between the runs that could produce an errant determination of the LOLP and the resulting resource additions required for the alternatives.

Significance – Medium

Applying a more methodological approach to the portfolio filters would improve the GENESYS model results but would not likely alter the relative differences between the alternatives.

Recommendations for Resolution

1. Near-term: Review the filters applied to the GENESYS LOLP determinations for model runs defining the final resulting portfolios for each alternative, and determine whether they were consistent or they introduced biases between the options. Report the total hours filtered and the percent of total annual filter utilized for each alternative and scenario.
2. Long-term: Develop a methodological approach for calculating LOLP using GENESYS that ensures that the resulting LOLP values between runs are consistent and free of any biasing effects.

PDT Draft/Final Evaluator Response (FPC #4)

Concur	X	Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The calculation of LOLP, filtering and related metrics are a post process, separate from the GENESYS model run. The calculation, filtering and selected metrics were defined during the workshop and Q&A with the IEPR panel.

Recommendation 1:	X	Adopt	Not Adopt
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Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The same filter and post-process was used for all of the model runs. The same metrics were reported for each of the model runs. Specific metrics were selected for report inclusion, and were the same metrics for each of the model runs.

Recommendation 2:	X	Adopt	Not Adopt
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Explanation: The methodology for calculating the LOLP is the same as used by the Northwest Power and Conservation Council to avoid introducing any bias from Bonneville. Similarly, we use their standards for key assumptions, and their data for the region.

Panel Draft/Final BackCheck Response (FPC #4)

Concur	Non-Concur
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Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 5

It is unclear why trapezoidal approximations for estimating peaking are used when hourly models that should provide more reliable results are available.

Relevant Model Assessment Criteria

Model Assumptions and Limitations

Basis for Comment

The GENESYS model is used to determine the amount of resource additions to each alternative through the LOLP calculation. The GENESYS user documentation describes the use of a trapezoid approximation, which defines, on a pre-processor basis, the sustained peaking capability and hydro minimums of the system as functions of monthly energy. The pre-processor itself determines these relationships by estimating the twin peak load shape to be a trapezoid. (See page 5, GENESYS (version 9) Documentation dated August 31, 2013).

It is unclear why the trapezoid approximation is needed when both GENESYS and HOSS can be run in hourly timesteps and should be able to determine the sustained peaking capability of the hydro system. Given that the HOSS model is used to determine the peaking and sustained peaking of the hydro system in support of BPA's forward-marketing activities, it seems that model should provide better estimates of the system's peaking capability.

The other concern is the underlying assumption that a trapezoid representing the twin daily peak load shape makes sense in a long-term forecast of system need. California has identified and discussed the impact of solar generation for a number of years, resulting in what the state has called the "duck curve." This impact on residual load (load after reduction by non-dispatchable resources) creates a deeper afternoon trough which has begun pushing afternoon hourly wholesale prices below night-time prices on a fairly regular basis. The Draft EIS alternatives with large amounts of solar additions will exacerbate this phenomenon.

The long-term impacts of climate change on the daily load shape also does not appear to have been taken into account, nor has the potential depth of demand response technologies to help reshape load beneficially.

Significance – Medium

Given the importance of peaking and sustained peaking analysis within GENESYS, it seems that the results of this analysis would have a bearing on the financial results, but possibly not to a degree to change the final decision.

Recommendation for Resolution

1. Leverage the hourly capability inherent in GENESYS and/or HOSS to provide a better model of the sustained peaking capability of the Federal hydro system for use in determining the LOLP and ultimately new resource additions.

PDT Draft/Final Evaluator Response (FPC #5)

Concur	X	Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The Northwest Power and Conservation Council's (Council) TRAP model is used by both BPA and Council to create the peaking limitation inputs for regional GENESYS studies.

The "duck curve" phenomenon may create two daily peaks even in the summer. In the Northwest, there are already two daily peaks in the winter. Thus, the twin daily peak load is appropriate for the Northwest.

Recommendation 1:	Adopt	X	Not Adopt
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Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: GENESYS is not capable of creating its own peaking limitations, so this information must be provided as input. HOSS is not an appropriate model for creating regional peaking limitations because it models federal system peaking only.

Panel Draft/Final BackCheck Response (FPC #5)

Concur	Non-Concur
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Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 6

The model documentation does not provide the appropriate high-level descriptions of model assumptions, formulations, calibration, results, discussion, and conclusions or the materials to allow an independent modeler to use the models.

Relevant Model Assessment Criteria

Model Documentation Quality
Operating Requirements of the Model

Basis for Comment

The documentation of the current system of models focuses heavily on a user-manual style, with insufficient descriptive information on the model assumptions, formulations, calibration, results, discussion, uncertainties, and need for future development.

The documentation identifies steps that need to be followed to run the software, rather than discussing the overall tools developed, logical processes, operating parameters (specifically, how they are reflected in the models), general model capabilities, and model limitations. Much of the software development and knowledge of how the tools are operated seem to be in the hands of a few BPA employees. Also, the limited program documentation is sporadically scattered over a number of file folders, with no logic that would enable the user to find a specific document or identify the model's system of version control. Locating all the current documentation for all the applications into one folder, with sub-folders for the various applications, would expedite the learning curve.

Significance – Medium

Insufficient model documentation impacts the ability of new operators to become proficient at using the models, has the potential to lead to misunderstanding of the model capabilities, and may lead to errors or misleading results. Additionally, a more comprehensive discussion of model limitations would help to guide future model development.

Recommendations for Resolution

1. Develop more descriptive, overview materials to describe model assumptions, formulations, calibration, uncertainties, results and discussion.
2. Develop a plan for ongoing model development.
3. Consolidate model documents into a single location and implement configuration control at all documentation levels (e.g., summary descriptions and technical user manuals).

PDT Draft/Final Evaluator Response (FPC #6)

X	Concur	Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The models are complex tools and are not intended for independent users without training and familiarity with FCRPS operations.

The modeling environment required to complete a regulation of the FCRPS is complex. New analysts take many months to become proficient, and years to become experts. Documentation for HYDSIM exists and is used extensively to train new analysts. BPA continuously improves the documentation it uses to train new employees.

While the documentation is not all in one folder, the documents are available in the folders for the workgroups for their application of HYDSIM.

Recommendation 1: ☒ **Adopt** ☐ **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The recommended materials, plans, and controls already exist.

Recommendation 2: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The recommended materials, plans, and controls already exist.

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The recommended materials, plans, and controls already exist.

All BPA documentation exists on the BPA operations server, held internally at BPA. Of the various models used (including some spreadsheet models) it would be contrary to current practice to house their documentation within the same folder. Further, different models may be maintained by different organizations within BPA, so warehousing them together would not be consistent with internal agency organizational structure. The model documentation has version control associated with it.

Panel Draft/Final BackCheck Response (FPC #6)

☐ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 7

The HYDSIM and HOSS models cannot be operated properly (i.e., with minimal potential for operator-initiated deviations) unless the models are run by highly experienced users, which limits the number of qualified operators.

Relevant Model Assessment Criteria

Analytical Requirements
Operating Requirements of the Model

Basis for Comment

The main complicating factor for use of the models is the heavy user input required to run the models. Model training and competency likely takes considerable time and effort to bring model operators up to a sufficient skill level to reliably run the models. Although the model documentation may allow for an independent user to run the models, the Panel believes that the level of competency required to run the models would be reached only through longer-term training and immersion into the modeling teams.

The overall iterative process of running the HYDSIM, HEC-ResSim, HOSS, and GENESYS programs adds difficulty in assessing the results of a study and determining whether such results are accurate and reliable. The HYDSIM program requires initial input from HEC-ResSim to establish flood control constraints through the determination of reservoir upper rule curves. This effort requires continued coordination with USACE and introduces another potential source of error.

Once HYDSIM uses this input (along with other operating constraint input for a specific alternative), the operator needs to be seasoned enough (or must have another properly trained person interpret the HYDSIM output) to establish that the results are adequate before proceeding to the next step in the analysis.

Additionally, a review of some of the program outputs can be subjective, where one operator might find no issues and another might deem some minor discrepancies occurred, resulting in some input adjustments and a reanalysis before going forward.

As for the outputs needed for the subsequent CRSO processes (GENESYS, HOSS, RAM), the outputs of period elevations, flows, and generation by project are easy to understand. As far as examining the HYDSIM output to evaluate run quality and accuracy, the outputs are a bit more challenging to understand and require post-processing, which is also challenging to understand. One description offered in the presentations was that after many years and many thousands of runs, a user gets to the point where run quality issues jump out at them. Without being steeped in this level of user expertise, it seems that run quality is a challenging effort and appears potentially subjective, particularly when alternatives, representing a major departure from the current system, are analyzed.

Significance – Medium

HYDSIM and HOSS are only accessible to highly skilled and specialized operators at BPA, which makes the models opaque to outside users and reviewers.

Final Panel Comment 7

The high likelihood for errors, and associated inefficiencies, is related to the heavy user input needed to run the models and the associated errors that might occur in that user-led process.

Recommendations for Resolution

1. Conduct a test of two seasoned operators to perform separate and independent analyses for a proposed study to see if any differences in the system regulation occur. If any deviations surface, a review of the subjective aspects of the process could be identified for further documentation refinement.
2. Develop both short- and long-term plans to upgrade the modeling systems to be less reliant on interactive user inputs.
3. Develop model training and succession planning to ensure that (1) modeling capabilities are not lost when individual employees leave BPA in the short term, and (2) model knowledge and experience are distributed throughout BPA in the long term.

PDT Draft/Final Evaluator Response (FPC #7)

X Concur **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: HYDSIM and HOSS are complex modeling tools. Trained analysts are qualified to run studies. The models are not meant for independent users without training and familiarity with FCRPS operations.

Models responsible for simulating complicated systems are themselves complicated. Complicated models require a great deal of time and effort to operate in an expert fashion. Of the many complicated models run at BPA, each requires months, if not years, of experience to gain mastery. This process involves working with more experienced team members, performing model sensitivities and model enhancement when necessary.

The interdependence in modeling between Bonneville's HYDSIM model and the Corps' ResSim model occurs for several reasons. HYDSIM is the only current model capable of modeling the Treaty operation with proportional draft. Conversely, flood risk management is the Corps' purview, so Bonneville uses flood risk management constraints from the Corps rather than developing their own. In the end, both models produce hydroregulations of the river, which enables careful comparison to ensure that operations were implemented correctly, particularly as ResSim was being adopted for modeling the Columbia River System and required extensive fine-tuning.

For the EIS, both HYDSIM and ResSim were run in parallel, and all results were compared to catch any differences between the two outputs. Some of the differences that came to light were programming issues with ResSim as the model was being applied to this complex river system, updates to ongoing operations that needed to be adjusted in one or both programs, and fine tuning how best to translate the many new measures in the CRSO EIS into operating rules for modeling.

Recommendation 1: ☒ **Adopt** ☐ **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The recommended plans and controls already exist. Tests of this nature are performed almost constantly at BPA. Referred to as 'shadow studies,' we use them to validate our results, train new employees, and test new versions of the models themselves. Furthermore, as described above, the co-lead agencies applied a variation of this concept to the CRSO EIS. Corps and Bonneville staff, with Reclamation participation, compared ResSim and HYDSIM output for all model runs for the EIS.

Recommendation 2: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The recommended plans and controls already exist. NEPA requires agencies to use current, high-quality information and agencies are not required to procure new models or develop new tools if high-quality information exists.

Recommendation 3: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The recommended plans and controls already exist. BPA constantly trains new employees and hires new team members to ensure that modeling needs are covered.

Panel Draft/Final BackCheck Response (FPC #7)

☐ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 8

BPA's current package of software tools, consisting of the HYDSIM, HOSS, and GENESYS computer programs, will not run on modern computer systems and will need to be upgraded in the near future.

Relevant Model Assessment Criteria

Operating Requirements of the Model

Basis for Comment

The current versions of BPA's HYDSIM, HOSS, and GENESYS computer programs (Software Tools Package) lack a modern, enterprise-level, computational architecture. Over the years, in an effort to avoid disturbing or renegotiating treaty rules, these programs' computer codes have been adapted repeatedly to introduce unconventional computations, resulting in a very complicated, iterative, and manual approach to addressing regulation operation alternatives that can be modeled using newer and widely adopted software. The aging software relies too heavily on user input of system-constrained operations, which introduces the likelihood of errors, and the overall process carries heavy operational inefficiencies.

BPA's dependence on 32-bit architecture computer programs to investigate system operations alternatives in the Columbia River Basin is in dire need of upgrading to a 64-bit architecture. These programs were originally developed in the 1970s using FORTRAN with a 32-bit architecture. All new computer hardware is 64-bit architecture, requiring older FORTRAN software to be recompiled as a 64-bit executable.

In recent years, USACE's HEC-ResSim program has been introduced into BPA's system operations process, particularly with regard to establishing flood control operating limits. HEC-ResSim was selected by BPA because a large majority of the dams in the Columbia River Basin were already using it for flood control operation. The current version of HEC-ResSim on BPA's system uses a 32-bit architecture. Much effort has been expended attempting to get the vintage HYDSIM and modern HEC-ResSim programs to produce similar results. However, differences still occur.

USACE's HEC software is currently dealing with the transition from 32-bit to 64-bit applications. Today, the HEC-ResSim program can be installed as either a 32-bit or 64-bit program. Since older 32-bit hardware is beginning to be phased out due to hardware failures and replaced with 64-bit hardware, the HEC will start to only provide 32-bit applications in legacy form, similar to the transition from older FORTRAN applications like HEC-1, HEC-2, and HEC-5 with replacement applications HEC-Hydrologic Modeling System (HEC-HMS), HEC-River Analysis System (HEC-RAS), and HEC-ResSim. Consequently, new enhancements to HEC-ResSim will occur only within the 64-bit version.

Therefore, BPA is facing the reality that a transition to a 64-bit architecture will be needed soon. Going forward, BPA needs to develop both short-term and long-term plans to update its software's computer architecture.

A suggested short-term fix might be to create a 64-bit executable of the HYDSIM, HOSS, and GENESYS programs that interface with a 64-bit version of HEC-ResSim.

Final Panel Comment 8

A long-term fix would require a much more aggressive approach. One suggestion is to replace the HYDSIM and HOSS programs with the HEC-ResSim program and Python code, along with conversion of the GENESYS program with Excel and Visual Basic for Application (VBA) code. A significant benefit of this approach is that the 32-bit to 64-bit conversion dilemma is solved, and any future computer operating system architecture transitions would be easy. Although transition from 32-bit to 64-bit is the current problem, conversion from 64-bit to 128-bit is the logical progression in the future.

Multiple modern modeling platforms are available that could perform the same functions as HEC-ResSim, HYDSIM, HOSS, and GENESYS. These tools include Excel-based re-creations of the same models, customized off-the-shelf products (e.g., RT Vista), expanded applications of HEC-ResSim, or fully custom third-party developed models. Updated systems would be able to run with fewer iterations and reduced reliance on user input and subjective evaluation of outputs.

Any long-term fix will require BPA to start discussions with the Columbia River Treaty participants and to maintain the current regulation process such that comparison of results can be conducted until a time of transition is agreed to by all treaty participants.

Significance – Medium

As existing 32-bit hardware fails, only a new 64-bit version of software programs will be able to continue simulating the system operations on the Columbia River Basin.

Recommendations for Resolution

1. Develop a short-term plan to transition the software tool package to a 64-bit computer architecture.
2. Develop a long-term plan to update the software tool package to a modern platform using 64-bit computer architecture, with easy transition to future hardware requirements such as a 128-bit architecture.

PDT Draft/Final Evaluator Response (FPC #8)

Concur **X** **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation:

The applications were originally developed long ago, and have been subject to modifications over the years to maintain compatibility with current hardware. The applications do run on modern, 64-bit

systems, and 64-bit systems are not strictly limited to running 64-bit applications, they are generally compatible with 32-bit applications as well. All software applications used at BPA were subject to rigorous compatibility testing prior to IT services transitioning to new hardware/OS. HYDSIM, HOSS and GENESYS are capable of running on agency network shares, virtual machines, and stand-alone PCs.

NEPA requires agencies to use current, high-quality information and agencies are not required to procure new models or develop new tools if high-quality information exists.

While Bonneville may consider using ResSim in the future, the model is not currently capable of modeling key features that Bonneville needs, such as all Canadian Treaty operations, spill versus turbine flow, and adjusting flows to meet power operations when there is flexibility in the system to permit shaping for power.

Recommendation 1: ☒ **Adopt** ☐ **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The recommended plans already exist.

NEPA requires agencies to use current, high-quality information and agencies are not required to procure new models or develop new tools if high-quality information exists.

Recommendation 2: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The recommended plans already exist.

NEPA requires agencies to use current, high-quality information and agencies are not required to procure new models or develop new tools if high-quality information exists.

Panel Draft/Final BackCheck Response (FPC #8)

☒ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 9

The overall iterative process of how the models interact is unclear.

Relevant Model Assessment Criteria

Input Availability and Output Understandability
Model Usefulness in Selecting Alternatives

Basis for Comment

It is the Panel's understanding that the modeling process for the CRSO Draft EIS is iterative within individual models and between models. For each Draft EIS alternative (i.e., NAA, MO, and PA):

- HYDSIM is run multiple times independently and with HEC-ResSim, using Aurora in some runs, to generate regulated stream flows and total monthly generation;
- HOSS is run once based on the regulated stream flows from HYDSIM and simulated hourly loads to generate monthly HLH/LLH generation ratios;
- GENESYS is run once to establish baseline alternative LOLP using total generation amounts from HYDSIM and simulated hourly loads;
- GENESYS is then run iteratively to determine the size of portfolio additions required to bring LOLP back in line with the NAA LOLP for each of the various Draft EIS scenarios (e.g., coal plant retirement schedules and resource addition type categories of conventional least-cost and zero-carbon) and to generate LOLP and Conditional Value at Risk 95th Percentile (CVaR95);
- RAM2020 is run for each alternative and scenario using HYDSIM generation (1937 as the critical water year for firm generation and a Power Loads and Resources Study forecast water year to determine plan total generation), monthly HLH/LLH generation ratios from HOSS (same 1937 critical and forecast water year), Aurora wholesale price forecast, and new capital investments from GENESYS to calculate rate pressures for BPA rates and wholesale power rates relative to the base NAA scenario; and
- Long-Term Transmission Rates Model is run for each alternative and scenario using new capital investments, Aurora wholesale price forecast, and short-term sales to calculate rate pressures relative to the base NAA scenario.

Developing the above understanding relied heavily on interviews with model operators and would not have been possible using only the Draft EIS and model documentation. Further, the above understanding only addresses the models reviewed in this IEPR; for a reader to get a complete picture of all models used in the CRSO Draft EIS effort, they would need access to materials on at least Aurora, HEC-ResSim, HRLYLOADS, ToolKit, and all BPA analyses and studies performed to generate appropriate inputs (e.g., Transmission Capacity Studies and associated Capital Cost Estimates and Bonneville Screening Studies).

Further clarification of this complex and iterative modeling approach would allow Draft EIS readers to better understand what data and assumptions were used in the modeling efforts, how these models are used together, and the basis for alternative evaluations and projections (e.g., rate pressures). From the Panel's standpoint, the complexity and iterative nature of the modeling approach does not provide assurance that readers would be able to understand the modeling approach, track the use of similar inputs in multiple models, or correctly interpret the overall results.

Final Panel Comment 9

Significance – Medium

Additional clarification of the modeling approach, data sources, and model interactions will provide the basis for understanding alternative evaluations and projections.

Recommendations for Resolution

1. Create flow diagrams for each model identifying interactions with other models and all relevant inputs and outputs. Depict iterative modeling processes, including the reasons for iterative runs, and show where model results are used in the overall modeling process and in the Draft EIS. Specifically highlight where models are run in different modes (e.g., HYDSIM based on historic water years for most uses vs. HYDSIM on forecast conditions as part of the Power Loads and Resources Study for RAM2020 generation forecast).
2. Revise the overall modeling flow diagram(s) to include and reference all individual model diagrams. Show the summary flow of information through the models and note how the results are used in the Draft EIS.
3. Create a video description of each individual model and an overall model interaction discussion documenting the same information captured in the flow diagrams. Include a time-phased animation of data flows from inputs to outputs and highlight how they were used in the Draft EIS alternative evaluations. Post these online in a format that allows viewers to ask questions and maintain a set of curated frequently asked question responses.

PDT Draft/Final Evaluator Response (FPC #9)

Concur **X** **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The model flow is very complex, and it is adequately represented using simplified diagrams that were included in the CRSO EIS (Appendix I Figures 2-1, 5-1, and Appendix H Figure 1-1).

Recommendation 1: **X** **Adopt** **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: Thank you for the suggestion. Simplified model flow diagrams already exist and are included in the CRSO EIS (Appendix I Figures 2-1, 5-1, and Appendix H Figure 1-1). Bonneville created a more detailed diagram showing interactions with ResSim, power models, and modeling in

other resource teams. Because ResSim was the primary model for the EIS, the hydropower modeling documentation did not include this level of detail.

Recommendation 2: ☐ **Adopt** ☒ **Not Adopt**

Explanation: The simplified diagrams were included in the CRSO EIS (Appendix I Figures 2-1, 5-1, and Appendix H Figure 1-1). provide the key model flow components and dependencies. Bonneville will consider whether to create this information in the future.

Recommendation 3: ☐ **Adopt** ☒ **Not Adopt**

Explanation: Model flow is represented using the simplified diagrams that were included in the CRSO EIS (Appendix I Figures 2-1, 5-1, and Appendix H Figure 1-1).

Panel Draft/Final BackCheck Response (FPC #9)

☐ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 10

The BPA renewable generation integration costs in the Long-Term Transmission Rates model were not updated to reflect the impact of changing BPA portfolios and regional renewable integration demands under each scenario.

Relevant Model Assessment Criteria

Representation of the System
Model Assumptions and Limitations

Basis for Comment

The scenarios considered in the Draft EIS included significant changes to the BPA generation portfolio and regional renewable generation capacity. The BPA grid integration services budget was not adjusted for each scenario based on these inputs. Changes to the BPA generation impact their flexibility and ability to provide grid integration services, especially the removal of the lower four Snake River projects. Increased regional renewable generation capacity would increase the demand for grid integration services, especially under the early coal retirements with zero-carbon replacements. The combination of changes to both the capacity to provide and the demand for renewable integration services should drive price differences that would impact the rate pressures calculated for each scenario and reported in the Draft EIS.

Significance – Medium

The use of a static renewable integration services budget is not representative of the likely BPA costs under the range of scenarios evaluated. A representative budget would impact the long-term transmission rate pressures for each scenario.

Recommendations for Resolution

1. Develop quantitative forecasts of reasonable renewable integration service levels and budgets. Incorporate these forecasts into the Long-Term Transmission Rate pressures. If quantitative output is not possible, include a qualitative discussion of the possible outcomes and include the likely renewable integration service impacts for each scenario in the Draft EIS.
 - a. Evaluate the system flexibility and capacity to provide renewable grid integration services for the renewable generation capacity by type (e.g., solar vs. wind) under each scenario.
 - b. Evaluate integration costs, system flexibility and renewable generation capacity of the system in past years.
 - c. Identify reasonable alternative integration prices based on other ancillary services' market data.

PDT Draft/Final Evaluator Response (FPC #10)

X	Concur	Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation:

In the base case modeling and analysis for the power and transmission resources, the generation balancing reserves needed for each MO were held equal to balancing reserve needs under the No Action Alternative. This generation balancing reserves assumption in the base case reflects the uncertainty regarding whether additional generation balancing reserves might be needed to integrate renewable resources. This depends on a number of factors, including resource type, size, and location (e.g. depending on in which balancing authority any new resources would be located and the source of any additional reserves should they be needed, and potential advances in technology that reduce the need for additional balancing reserves).

However, integration services above those needed in the No Action Alternative would be required for zero-carbon portfolio replacements for in MO1, MO3 and MO4. The power and transmission analysis does provide additional information on the estimated value of needed reserves and integration services for both the zero-carbon and conventional least-cost resource replacement portfolios as a sensitivity analysis. The value of the reserves for the replacement resources would range from about \$1.6 million (MO1 least cost portfolio) and \$129.5 million (MO4 zero-carbon portfolio) annually (Table 3-113 in the DEIS; table was updated with additional information for the FEIS). In the FEIS, the retail rates analysis then estimates the average retail rate effect for the high and low wholesale rate sensitivities (a portion of which is comprised of the integration services sensitivity value). Because the value of these integration services were reflected in the sensitivity analysis, the inclusion in the transmission rate pressure modeling would represent a double counting of the integration services effects in the retail rates.

Recommendation 1a:	X	Adopt	Not Adopt
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Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: Appendix J, Section 4.3, Integration of Other Renewable Resources and Hydrosystem Flexibility Analysis evaluates the increases and decreases in system flexibility for each alternative with a focus on how that would impact the ability to integrate additional variable generation.

Recommendation 1b:	X	Adopt	Not Adopt
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Explanation: The power and transmission analysis provided additional information on the estimated value of needed reserves and integration services for both the zero-carbon and conventional least-cost resource replacement portfolios as a sensitivity analysis. In the FEIS, the retail rates analysis estimates the average retail rate effect for the high and low wholesale rate sensitivities (a portion of which is comprised of the integration services sensitivity value). The historical value of integration services was

used to estimate the value of integration services in the Lower Snake River dams in the FEIS in section 3.7.3.1, Integration Services.

Recommendation 1c: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The power and transmission analysis provided additional information on the estimated value of needed reserves and integration services for both the zero-carbon and conventional least-cost resource replacement portfolios as a sensitivity analysis. In the FEIS, the retail rates analysis estimates the average retail rate effect for the high and low wholesale rate sensitivities (a portion of which is comprised of the integration services sensitivity value). Given the rapid evolution of the energy market and technology, it would be speculative to estimate a specific quantity, and therefore the EIS includes a range.

Panel Draft/Final BackCheck Response (FPC #10)

☒ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 11

It is not clear that the RAM2020 model includes an unbiased estimate for the impact of market transactions made to address surplus or deficit power positions.

Relevant Model Assessment Criteria

Model Assumptions and Limitations
Model Calculations/Formulas

Basis for Comment

It is not clear that the two aggregated monthly transactions (a single net transaction volume in megawatt hours at the average monthly price for LLH and HLH each) in the RAM2020 model provides a sufficiently accurate estimate for the actual impacts of the transactions made in a month. There is a potential for a biased deviation from the net volume and average pricing assumed in the model if the timing and volume of the individual transactions given the hourly price shape are not considered. Strategic or forced transactions could lead to increased or decreased net revenues, which, if consistently present, should be accounted for in the transaction estimates. The difference in operational constraints and portfolio of generation resources under each scenario could impact BPA's ability to strategically shape transactions and the likelihood of it being forced to make transactions. The overall portfolio size relative to the loads served will also drive the direction and volume of net transactions. It is the Panel's understanding that larger portfolios with more flexibility could likely implement more strategic transactions; smaller portfolios with less flexibility may be forced to make more purchases; and larger portfolios with less flexibility may be forced to make more sales. The Secondary Revenue and Balancing Purchases Input Data do not appear to be included in the publicly available RAM2020 model.

Significance – Medium

Without evaluation, the level and effect of bias are unknown. The potential bias causes uncertainty in the impact of secondary market transactions on the relative rate pressures calculated for each scenario.

Recommendations for Resolution

1. Compare past actual monthly transaction results to aggregated net transaction volumes at average HLH and LLH prices by month. Use these results to determine if RAM2020 estimates should be adjusted to reflect consistent biases or time-of-year trends.
2. Evaluate the potential impacts of each scenario (i.e., overall portfolio size and flexibility) on the ability of BPA to strategically shape market transactions. Include these results as quantitative adjustments to the model or as qualitative discussions for each scenario.

PDT Draft/Final Evaluator Response (FPC #11)

Concur	X	Non-Concur
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Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a “concur,” unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The panel misconstrues the approach to forecasting net secondary revenues, and proposes a recommendation which would impose bias into the analysis by relying on historical market trends which may not be, and likely are not, representative of future expectations. Historical marketing activity is largely affected by idiosyncratic conditions related to weather, hydrology, and demand or supply shocks. RevSim – the model which computes net secondary revenues - was not included in the scope of this analysis, because it is largely an arithmetic engine which takes modeled output from the HYDSIM/HOSS and AURORA results to compute net secondary revenue expectations across 3200 iterations of future conditions. This approach uses historical hydrology across 80 water years applied to the forward-looking capability of the FCRPS to forecast Bonneville’s surplus/deficit position after load obligations are taken into account.

Moreover, HOSS provides for a shaped Federal system output which would occur in any strategy to maximize revenues, because it shapes as much energy as possible into higher-priced periods. In this way, the secondary forecast is inherently strategic and forward-looking. The time-step of the forecast is monthly-diurnal in nature: that is, inter-day shaping is mapped to the products most commonly bought and sold under WSPP agreements in the WECC. Historical volume data at Mid-C shows that the vast majority of balancing activity occurs in the day-ahead market, which trades defined products that are monthly-diurnal in nature. Real-time operations, which are hourly in nature, only account for a quarter of all transaction volumes. In this way, net secondary revenues are modeled to the time-step of the majority of actual anticipated transactions that would occur in the future, and is therefore a better representation of anticipated future net secondary sales revenues.

Further, it should be noted that this panel comment implies much more averaging of inventory position and pricing than is actually occurring the net secondary forecast. AURORA forecasts *hourly* prices, which are averaged into month-diurnal time-steps only for a single iteration among 3200 games. For each *game*, a 12 month, 2-period-per-month market price forecast is applied to a net position for that 24 bin period per year which is similarly aggregated from load and resource data using the same time-step, and mapped to the same hydrology and weather assumptions used to make the market price forecast for that same 24 bin period. In this way, aggregation is only occurring down to the monthly-diurnal level; net position and net revenues are disaggregated above this level before building the net secondary revenue distribution across 3200 potential future conditions (of which the central tendency is used in RAM2020). This methodology was detailed in documentation provided to the panel (see Power and Transmission Risk Study, BP-20-FS-BPA-05, and associated documentation, BP-20-FS-BPA-05A, and Power Market Price Study and Documentation, BP-20-FS-BPA-04 from the BP-20 rate case [website](#)).

The panel notes that the data for the 3200 iterations are not contained in RAM2020. While that is true, this omission does not cast doubt on the analysis, or in particular, induce potential bias. The approach used in RAM2020 to revenue forecasting has been vetted in formal administrative hearings (Bonneville’s section 7(i) rate proceedings) for over a decade. Modelling improvements have occurred over that time, with the model being updated when warranted. For example, modeling of extra-regional sales transactions has been added following an evaluation in a section 7(i) hearing. An Excel version

of the RevSim is uploaded to the publicly available external site in every Bonneville rate case, where it receives rigorous regional review by stakeholders in Bonneville's formal administrative hearings.

Recommendation 1: ☐ **Adopt** ☒ **X** ☐ **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: Use of historical data would impose backward looking bias into the evaluation of each alternative. The approach used in the analysis is inherently forward-looking and far more disaggregated than the panel comment implies.

Recommendation 2: ☐ **Adopt** ☒ **X** ☐ **Not Adopt**

Explanation: Use of the monthly-diurnal time-step matches the granularity of most market transactions in the WECC. Evaluation of inter-hour shaping may improve estimates of real-time sales and purchases, but the real-time market only accounts for a small proportion of transaction volume and is largely revenue-neutral. Value associated with flexibility of the Federal Columbia River Power System at smaller time-steps is incorporated into the sensitivity analysis, which includes ranges for integration services costs and ramping/flexibility value where a particular alternative clearly may have some differential value, which is not incorporated into the base rates analysis.

Panel Draft/Final BackCheck Response (FPC #11)

☒ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 12

No documentation was provided indicating that sensitivity, uncertainty, and risk analyses have been conducted on the models.

Relevant Model Assessment Criteria

Representation of the System
Analytical Requirements
Testing/Evaluation Process
Model Usefulness in Selecting Alternatives

Basis for Comment

Some uncertainties are identified in the Draft EIS, but none appear to be formally evaluated in a risk analysis that would allow the preparation of inputs for sensitivity analysis on any of the relevant models.

It is the Panel's understanding that the HYDSIM and HOSS models are not geared for sensitivity analysis but do incorporate 80 water years in their inputs and therefore run analyses over a range of water year inputs. The sensitivity of HYDSIM and HOSS model outputs to changes in other inputs (e.g., unit/project availability, changes to Mid-Columbia project operations, or irrigation withdrawal changes) were not evaluated for the Draft EIS.

Further, the Panel understands that the GENESYS model includes 80 water years (i.e., combination of HYDSIM generation and HOSS HLH/LLH generation split) and 77 temperature/load years that are run in combinations exhaustively without replacement. The model also has 20 wind variations and 12 solar years that are run based on a random draw to reduce load. The GENESYS model evaluates different levels of regional portfolios as defined by the Draft EIS alternatives and scenarios. The sensitivity of GENESYS LOLP and CVaR95 outputs to changes in other inputs (e.g., firm contracts, thermal resource assumptions, sustained peaking limits, filter levels, or transmission/market purchase limits) were not evaluated for the Draft EIS.

The Panel also understands that the RAM2020 and Long-Term Transmission Rates models took different inputs as required for each scenario evaluated in the Draft EIS (e.g., capital generation asset and transmission investments). The sensitivity of the RAM2020 and Long-Term Transmission Rates rate pressure outputs to changes in other inputs (e.g., regional market power prices, water year, project/line availability) were not evaluated for the Draft EIS.

The inclusion of coal retirement and replacement resource constraints (i.e., least cost conventional vs. zero-carbon) provide scenario-based ranges around the rate pressures reported for each MO and the PA. It would be useful to understand how sensitive rate pressures are to changes in a wider range of inputs for each scenario considered in the Draft EIS.

Significance – Medium/Low

Although uncertainties are discussed, they are not evaluated to the point where a sensitivity analysis could be conducted to determine the relative impact the uncertainties may have on the alternatives evaluated in the Draft EIS.

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Recommendations for Resolution

1. Conduct a high-level risk analysis of the uncertainties identified in the Draft EIS (e.g., long-term regional loads, generation capacity, and wholesale power rates) such that likely worst-case and likely best-case combinations of inputs can be identified for the most sensitive model inputs. Run keyhole analyses on the most likely worst- and best-case input combinations to further populate the range of power and transmission rate pressures for each Draft EIS alternative and portfolio scenario.
2. Expand uncertainties already partially analyzed (e.g., climate change impacts) using a similar approach.

PDT Draft/Final Evaluator Response (FPC #12)

X Concur **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The sensitivity, uncertainty and risk associated with the models is evaluated through detailed examination of results, such as focusing on critical water.

Sensitivity analyses are perhaps the most common exercise performed at BPA using these models. Every year, BPA evaluates a multitude of possibilities involving operational changes, spill, biological obligations, etc., and the impact of these possibilities. All models, where applicable, are run in Monte Carlo fashion, meaning that a distribution of inputs are run through the same model, thus producing a distribution of outputs. In doing this, Bonneville creates best- and worst-case scenarios. Indeed, each alternative within the CRSO EIS constitutes a sensitivity relative to the No Action Alternative.

Recommendation 1: **X Adopt** **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The recommended action is already part of current practice.

All inputs, when applicable, are modeled with uncertainty. We model load risk in every model where it is applicable, and hydrological risk in every model where it is applicable. Several other variables are input stochastically. With respect to generation capacity, the models are not situated to perform Monte Carlo analyses (recall that new models need not be developed where high-quality information exists) but Bonneville maintain outage 'buffers,' or hold reserves beyond our operational obligation to provide greater assurance that the agencies can operate as modeled. There is no value in identifying the worst possible combination of inputs with respect to Rates, as Rates are set based upon expected revenues

and expected costs. While that expectation is influenced by the 'worst possible' outcome, that outcome is sufficiently unlikely that there is no additional merit in singling it out for further analysis. Bonneville is fully aware that very low water supply and very high prices would be detrimental for the agency.

Recommendation 2: ☒ **Adopt** ☐ **Not Adopt**

Explanation: The recommended action is already part of current practice.

Climate change impacts have been extensively analyzed within the scope of the CRSO EIS, as detailed in Appendix J, Chapter 6. As discussed above, sensitivity studies are routinely performed for these models.

Panel Draft/Final BackCheck Response (FPC #12)

☒ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 13

It does not appear that the HOSS model runs were assessed for accuracy, and it is unclear what impact inaccuracies in the HOSS output would have on the model runs for the CRSO.

Relevant Model Assessment Criteria

Model Assumptions and Limitations
Testing/Evaluation Process

Basis for Comment

The HOSS model appears to be a powerful tool used by BPA to shape its forward wholesale marketing strategy. The Panel assumes that this model must be well-trusted by BPA staff to be used for such an important function. As part of the review, however, the actual processes coded into HOSS to determine hourly and multi-hour sustained capability were not explained in any great detail, other than a broad explanation that HOSS observes LLH minimum generation, maximizes HLH generation, and has all the project constraints. This general logic is instructive for short-term forecasts under the current system conditions, but it may not be effective in addressing potential longer-term trends in the power industry, such as increases in solar generation and improvements in demand response.

Despite the presumed reliability of HOSS, the accuracy of HOSS does not appear to have been validated as part of the CRSO analysis. At a minimum, the impact to the Draft EIS analysis resulting from minor variations in HOSS results through sensitivity analysis could have been quantified. Alternatively, the HOSS results could have been cross-checked against historic generation patterns to assess reasonableness.

The CRSO model process deploys HOSS for a single, somewhat rudimentary exercise, which may be why the model was not explained or seemingly validated to a greater extent. The single purpose of HOSS is to determine the HLH and LLH generation patterns for all the various HYDSIM runs. This HLH and LLH generation pattern is then used by the RAM2020 Microsoft Excel model to help determine the cost implications to the BPA system.

The HOSS documentation that was provided was more akin to a user's how-to manual and did not document the logic, goals, or overall high-level functions and limitations of the model.

Significance – Medium/Low

Although the accuracy of the HOSS model's output does not seem to have been fully validated, even significant changes in the HLH/LLH energy allocations are unlikely to materially change the CRSO financial analysis.

Recommendations for Resolution

1. Validate HOSS output by comparing it against historic HLH and LLH generation patterns related to monthly flow and constraints.
2. Perform a sensitivity analysis to determine whether changes in the HLH/LLH generation patterns have a material impact on the financial results.

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3. Provide or develop documentation that describes the approach HOSS utilizes to determine the HLH/LLH generation patterns of the Federal system for different periods and water conditions.

PDT Draft/Final Evaluator Response (FPC #13)

X Concur **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: The HOSS model was validated against agency actuals. Sensitivity to the range of HLH/LLH is already a key feature of routine inventory modeling that Bonneville employs for day-to-day operations.

HOSS has been used extensively by the agency to identify Bonneville's marketing position, perform sensitivity analyses and, in part, set Rates. HOSS output is evaluated by users on a near constant basis at BPA. Consistent with the panel's observations, the HOSS HLH/LLH ratios are not a significant determinant of the agency's costs or revenues.

Recommendation 1: **X Adopt** **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The recommended action is currently in practice or has already been completed (or both).

BPA analysts frequently perform this exercise. Retrospective analyses have been part of the agency's analysis for many years.

Recommendation 2: **X Adopt** **Not Adopt**

Explanation: The recommended action is currently in practice and/or has already been completed.

Changes in the HLH/LLH ratios are among the least impactful inputs to the rate-setting process. This sensitivity has been performed. The bulk of the rate setting process relies on average annual energy under certain conditions, and as such changes in HLH/LLH ratios are not likely to bear greatly on the result.

Recommendation 3: **X Adopt** **Not Adopt**

Explanation: The recommended action has already been completed and is available to HOSS analysts.

The native logic employed by HOSS does not change by condition or period. Importantly, it is the constraints imposed by the system, either through fuel (water) limits, outages or biological

requirements that result in different results by period (or season). As this is the variable input for the model, not a fixed feature, there is no documentation for the input assumption.

Panel Draft/Final BackCheck Response (FPC #13)

Concur

Non-Concur

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. Explanation:

Final Panel Comment 14

There does not appear to be an agreed-upon way to verify that past or future changes to the Fortran code have not introduced (or will not introduce) errors in the HYDSIM, HOSS, and GENESYS programs.

Relevant Model Assessment Criteria

Testing/Evaluation Process

Basis for Comment

The BPA has used the HYDSIM, HOSS, and GENESYS software programs in Columbia River Basin studies for many decades. Much of the knowledge of how the programs interface and operate is in the hands of a few BPA employees.

A HYDSIM User's Manual was provided on April 30, 2020, however even with this document it would be difficult (if not impossible) for an independent operator to reproduce a specific CRSO model alternative result without direct help from experienced BPA operators because of the need for these BPA operators to identify errors in the runs. The current approach for novice users to gain expertise is to watch an experienced analyst edit input files and run the software programs, then slowly integrate into the overall process.

The iterative process of running the HYDSIM, HEC-ResSim, HOSS, and GENESYS programs adds difficulty in assessing the results of a study. The HYDSIM program requires initial input from HEC-ResSim to establish flooding constraints using upper rule curves. Once HYDSIM uses these HEC-ResSim outputs along with other operating constraint input for a specific alternative, the BPA operator needs to be seasoned enough (or must have another properly trained person interpret the HYDSIM output) to establish that the results are adequate before proceeding to the next step in the analysis.

The review of the program outputs is subjective, where one analyst might find no issues and another might determine that some minor discrepancies occurred, resulting in some input adjustments and a reanalysis before going forward.

Test datasets for HYDSIM, HOSS, and GENESYS do not seem to have been developed. Test datasets verify that any future program coding changes have no effects on prior results. An example to be followed is how USACE's HEC software is managed. For example, the HEC-ResSim program has four test datasets provided with the software. The documentation includes a User's Manual, a Quick Start Guide, and Release Notes.

USACE's HEC-ResSim User's Manual details how to use the program to model and simulate any new reservoir system operational studies. A Quick Start Guide concentrates on the test datasets provided with the software. This document initially guides the user through fundamental actions required for any use of a program, in small, easily achievable steps that help the user develop confidence. Once complete, each test data example is discussed in more detail.

This effort would require the BPA to create a downloadable version of the programs, along with non-proprietary test data files and their associated input files, output files, and databases. Non-BPA users could then download the applications onto their own computers, similar to how the HEC webpage allows for non-USACE entities to use programs.

Release notes concentrate on the current version release of the software. They discuss any enhancements made to the code to correct errors in the previous version of the program and detail

Final Panel Comment 14

how some requested program enhancements have been addressed. For unresolved issues, release notes explain why they still exist and when they will potentially be addressed in the future.

For these BPA programs, test datasets, a quick start guide, and release notes are currently only conceptual. As a suggestion, test datasets could be created using subsets of one or more of the MO alternatives (MO1, MO2, MO3 and MO4) or the NAA.

Significance – Medium/Low

Currently, only a subjective check is used to test whether changes to computer code have introduced inadvertent regulation errors. Given that no universal approach has been developed, the chances that subtle unwanted results have been or will be introduced into the code are significant.

Recommendations for Resolution

1. Update existing program user manuals.
2. Add a quick user's guide and release notes component to the software tools.
3. Develop a set of test datasets for the overall process of simulating reservoir operations on the CRSO.

PDT Draft/Final Evaluator Response (FPC #14)

X Concur **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: Internal controls are practiced to ensure any changes are tested and verified, involving the developers and multiple analysts. The 80 water years serve as the standard test data set. When the model is updated, it undergoes extensive testing.

Recommendation 1: **X Adopt** **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will 'adopt' or 'not adopt' each recommendation and provide an explanation. If 'adopt', please provide information on how this recommendation will be adopted. If 'not adopt', please explain why.

Explanation: The recommended action is something that is currently in practice.

Recommendation 2: **Adopt** **X Not Adopt**

Explanation: The programs are complex modeling tools and quick user guides are not available because of this complexity.

Recommendation 3: ☒ **Adopt** ☐ **Not Adopt**

Explanation: Data sets for a wide range of study types are available to HYDSIM analysts.

Panel Draft/Final BackCheck Response (FPC #14)

☒ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**

Final Panel Comment 15

It is unclear how HOSS calculates the flexibility of the system to shift generation from LLH to HLH and how this flexibility was used in the assessment of the Draft EIS alternatives.

Relevant Model Assessment Criteria

Analytical Requirements
Model Usefulness in Selecting Alternatives

Basis for Comment

The HOSS documentation in the Draft EIS indicates that in addition to the HLH/LLH generation split, HOSS provides output on the "...flexibility of the system [ability to shift generation from LLH to HLH]..." (Draft EIS, page I-5-5).

The Panel did not see this capability discussed in the provided documentation or the model presentations. The Panel was informed, in response to its initial round of questions, that "HOSS doesn't provide a quantitative measure of flexibility. It provides an hourly regulation of the Federal Columbia River Power System (FCRPS). It would be left to a different process to define a flexibility metric and use HOSS outputs if necessary and appropriate".

These appear to be conflicting statements.

Significance – Low

A discussion of how the flexibility metrics are calculated and used to compare Draft EIS alternatives would be helpful in both the model documentation and the Draft EIS.

Recommendations for Resolution

1. Describe how the system flexibility is calculated, what metrics are used, and how they are compared across Draft EIS alternatives and scenarios.
2. Alternatively, remove the Draft EIS reference to HOSS providing a measure of flexibility.

PDT Draft/Final Evaluator Response (FPC #15)

X Concur **Non-Concur**

Please **enter an X** in front of your selection above. A concur should be provided if the PDT will revise the document or conduct activities to address the issue presented in the Final Panel Comment (statement and Basis for Comment). Please note that agreeing with the statement does not constitute a "concur," unless an action is provided. A non-concur should be provided if the PDT does not agree that the issue presented in the Final Panel Comment (statement and Basis for Comment) should be addressed and will not revise the document or conduct other activities in response to this issue.

Explanation: BPA believes this comment can be addressed with additional explanation. At one point in the process, HOSS output was intended for use in devising a flexibility metric. HOSS produces hourly

operational data. During the CRSO EIS process, we attempted to establish a quantitative flexibility analysis and metric using HOSS data. This effort, however, was later abandoned as a criterion after it was determined that the methodology demonstrated peaking versus minimum generation, but did not measure “flexibility”, e.g., how quickly generation could move in response to reserves and renewables balancing for hour-to-hour and within-hour flexibility. That is why we state that “HOSS doesn’t provide a quantitative measure of flexibility.” There is an important difference between ‘flexibility metric,’ which might have a concrete quantitative mathematical norm, and ‘flexibility’ used more generically to describe the system’s ability to load factor. In lieu of this quantitative metric, the EIS contains a qualitative assessment of hour-to-hour and within-hour system flexibility for the alternatives in Appendix J, Section 4.3, Integration of Other Renewable Resources and Hydrosystem Flexibility Analysis.

Recommendation 1: ☐ **Adopt** ☒ **Not Adopt**

Please **enter an X** in front of your selection above. For each recommendation, please indicate whether the PDT will ‘adopt’ or ‘not adopt’ each recommendation and provide an explanation. If ‘adopt’, please provide information on how this recommendation will be adopted. If ‘not adopt’, please explain why.

Explanation: System flexibility is not calculated, and there is no metric of ‘flexibility’ used in the CRSO EIS process.

Recommendation 2: ☒ **Adopt** ☐ **Not Adopt**

Explanation: BPA will correct the documentation to reflect this.

Panel Draft/Final BackCheck Response (FPC #15)

☐ **Concur** ☐ **Non-Concur**

Please **enter an X** in front of your selection above. Based on the PDT response, the Panel has provided the following response. **Explanation:**