Governor's Salmon Workgroup

Columbia River System Operations Draft EIS

March 5, 2020

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Agenda

- Introduction to NEPA
- CRSO EIS
    - Purpose and Need/ Scoping
    - Alternatives Development
    - Alternatives
- Modeling/Results Overview
- H&H/River Mechanics
- Water Quality
- Fish
- Costs
- Next Steps

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System Overview

Background

- Congress authorized the Corps and Reclamation to construct, operate and maintain Columbia River System projects to meet multiple specified purposes, including:
    - Flood risk management
    - Navigation – 456 river miles from Bonneville Dam to Lewiston
    - Hydropower – 196 units, 22,458 MW capacity – high regional output
    - Irrigation – 6% of flow is diverted
    - Fish and wildlife conservation- multiple programs across Basin
    - Recreation
- Congress authorized BPA to market and transmit the power generated from these projects

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System Overview

Geography

- Drains 219,000 mi^2 in seven western states & 39,500 mi^2 in British Columbia
- 1,243 miles long
- Flows into the Pacific Ocean near Astoria, OR

Hydrology

- 198 maf average annual runoff (2nd after Mississippi)
- 25% of flow comes from Canada
- 60% of runoff occurs during May-July

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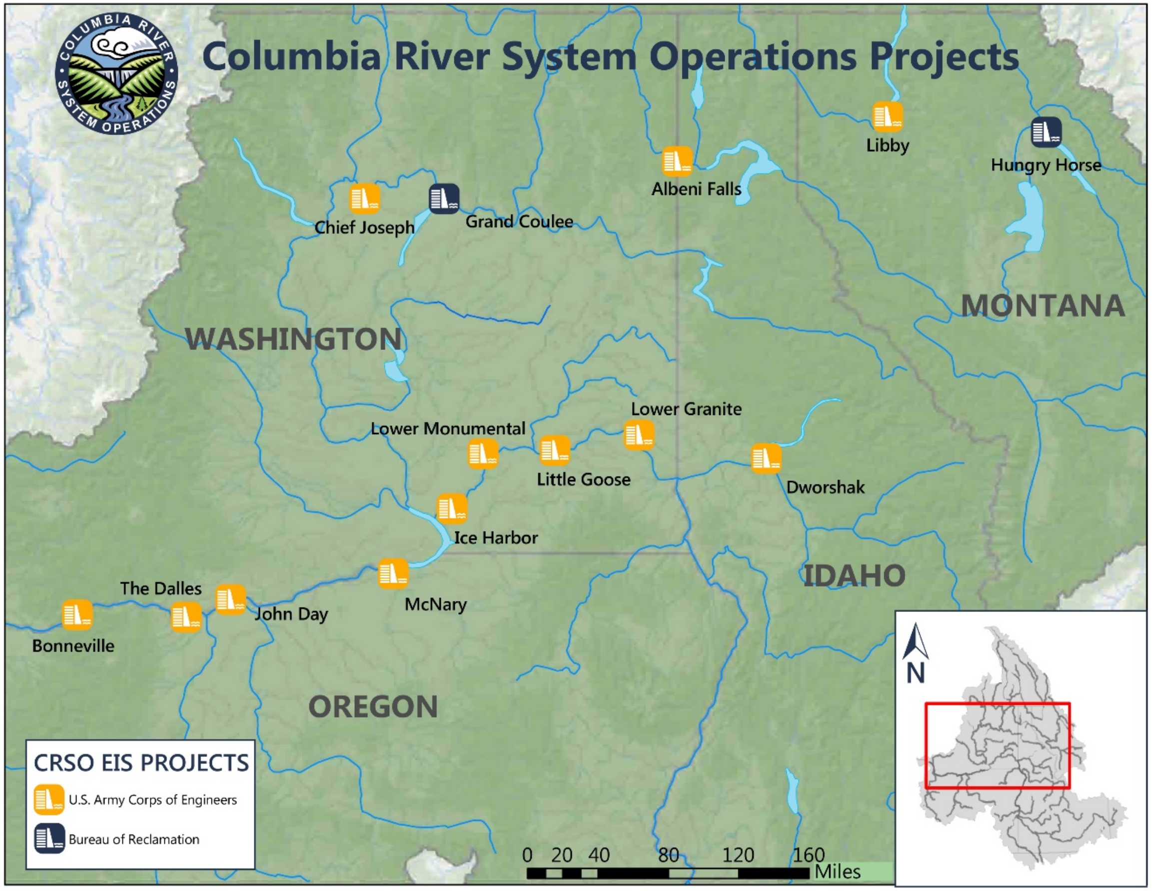
Scope

- 14 federal dam and reservoir projects that comprise the federal Columbia River System
- Columbia River within the U.S, lower Snake River and select tributaries
- Multiple Cooperating Agencies



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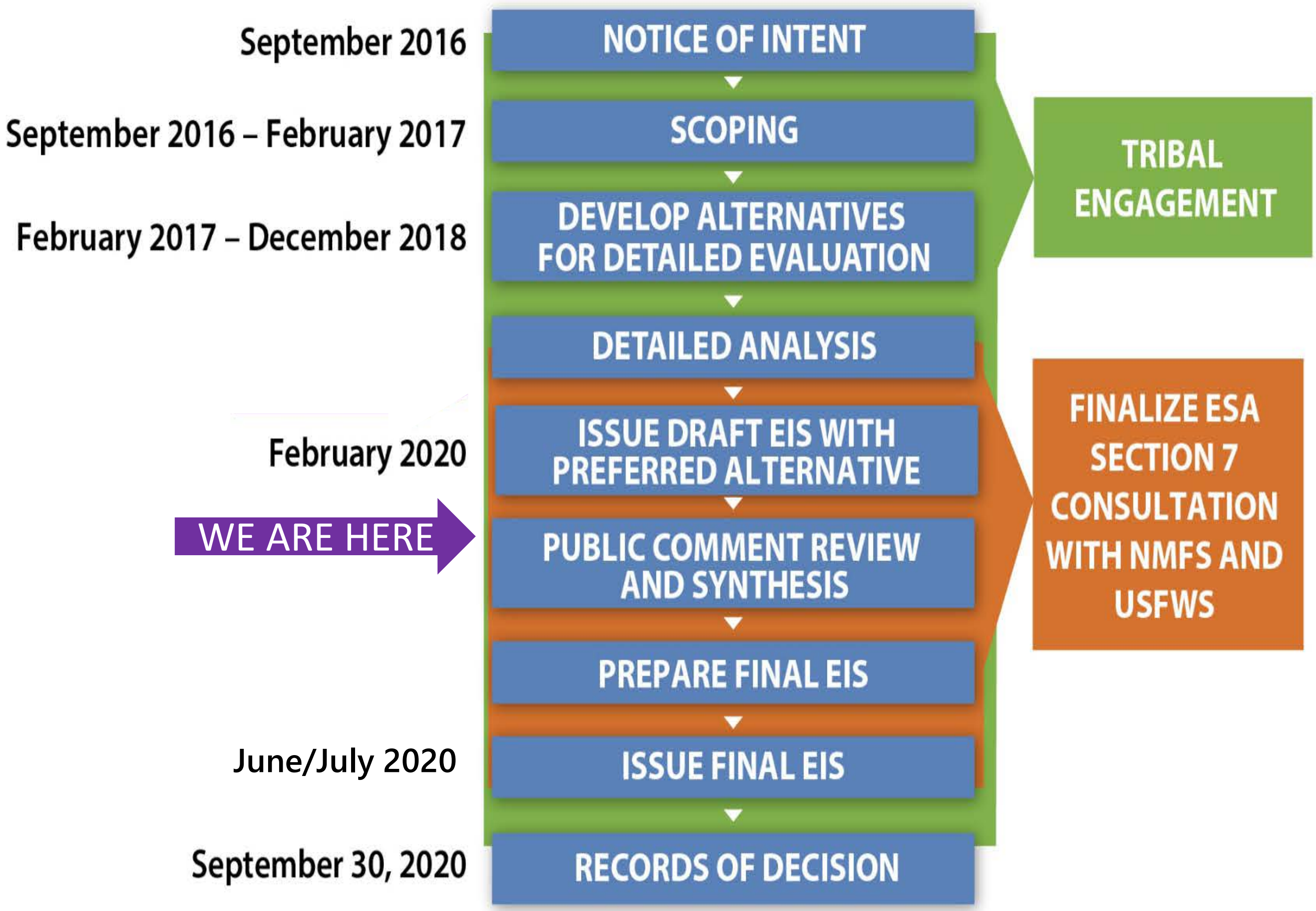
EIS Schedule



Purpose

- Develop a plan for long-term system operations, configuration, and maintenance of the 14 federal dam and reservoir projects in Idaho, Montana, Oregon and Washington
- Meet all federal statutory and regulatory requirements and respond to 2016 U.S. District Court for the District of Oregon court order
- Evaluate measures to avoid, offset or minimize impacts to environmental resources, including threatened and endangered species

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Scoping Overview

Provided opportunity for the public to inform the scope of the study and nature of the analysis

- Initiated September 2016
- Held 16 meetings, 2 (web-based) to talk about what we were looking at and solicit public interest
- Received over 400,000 comment letters
- Input categorized as:
  - proposed actions to take
  - resources to consider
  - methods to use in the evaluation
  - issues to address in the scope of the analysis

Scoping summary Report October 2017

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Scoping Comment Topic Areas

- NEPA Process
- Public Scoping Process
- Alternatives (e.g., dam breach, various levels of spill)
- Scope of Analysis for EIS
- Impact Analysis Methodologies
- Hydrology and Hydraulics
- Climate Change
- Water Quality
- Water Supply
- Air Quality
- Anadromous and Resident Fish
- Threatened and Endangered Fish Species
- Dam Configuration & Operation
- Wildlife
- Wetlands and Vegetation
- Invasive and Nuisance Species
- Cultural and Historic Resources
- Tribal Interests/Resources
- Flood Risk Management
- Power Generation/Energy
- Power Transmission
- River Navigation
- Transportation of Goods and Fish
- Recreation
- Socioeconomics and Environmental Justice
- General Opposition to EIS Development
- General Support to EIS Development

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Cooperating Agencies

Federal Government

- US EPA Region 10
- US Coast Guard, 13th Coast Guard District
- Bureau of Indian Affairs

Tribes/Tribal Organizations

- Upper Snake River Tribes Foundation
  - Burns Paiute Tribe
  - Fort McDermitt Paiute-Shoshone Tribe
  - Shoshone-Paiute Tribes of Duck Valley Reservation Spokane
- Kootenai Tribe of Idaho
- Confederated Tribes of the Colville Reservation
- Shoshone-Bannock Tribes
- Confederated Tribes of the Grand Ronde Community of Oregon
- Nez Perce
- Spokane
- Confederated Salish-Kootenai
- Cowlitz
- Yakama Nation
- Confederated Tribes of the Umatilla Indian Reservation

State Government

- Washington
  - Washington Department of Fish and Wildlife
  - Washington Department of Ecology
  - Washington Department of Agriculture
- Oregon
  - Oregon Dept of Fish and Wildlife
  - Oregon Department of Energy
  - Oregon Department of Water Resources
  - Oregon Department of Agriculture
  - Oregon Department of Environmental Quality
- Idaho
  - Governor's Office of Species Conservation
  - Governor's Office of Energy and Mineral Resources
  - Idaho Fish and Game
  - Idaho Department of Agriculture
  - Idaho Department of Lands
  - Idaho Department of Transportation
  - Idaho Department of Environmental Quality
  - Historic Preservation Office
  - Department of Parks and Recreation
  - Department of Water Resources
- Montana
  - Montana Department of Fish, Wildlife, and Parks
  - Lake County, Montana

Key Definitions

- **Objectives** describe the results you want to achieve (the "why")
- A **Measure** is an action at a specific location to achieve a desired effect (the "how")
  - One measure may be used to achieve multiple objectives
  - May be sited at multiple locations
- An **Alternative** is driven by one or more objectives
- The actions of an **Alternative** come from the **Measures** that are implemented together to achieve one or more of the objectives

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Alternatives Development

Refined Objectives and status of Measures

- Reviewed 100+ objectives and 500+ measures
  - Public, Tribes, Co-lead Agencies, Cooperating Agencies, Scoping
  - Meet the study purposes?
  - Identify primary objectives
- Screening: Review objectives and 230 measures
  - Measures - Meet an objective?
  - Meet technical criteria?
- Summer 2017: Began application of objectives and measures to develop single objective alternatives

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Objectives

1) Improve ESA-listed anadromous salmonid juvenile fish rearing, passage, and survival within the CRSO project area, through actions of project configuration, flow management, and water quality management;
2) Improve ESA-listed anadromous salmonid adult fish migration, through actions of project configuration, flow management, and water quality management ;
3) Improve ESA-listed resident fish survival and spawning success, through actions of project configuration, flow management, and water quality management ;
4) Improve conditions for lamprey, through actions of project configuration, flow management, and water quality management;

Objectives (cont.)

5) Provide an adequate, efficient, economical, and reliable power supply that supports the integrated CR Power System;

6) Minimize greenhouse gas emissions from power production in the Northwest by generating carbon-free power through a combination of hydropower and integrations of other renewable energy sources;

7) Maximize operating flexibility by implementing updated, adaptable water management strategies to be responsive to changing conditions, including hydrology, climate, and environment;

8) Meet existing contractual water supply obligations and provide for authorized additional regional water supply.

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Array of Alternatives

Twelve Preliminary Alternatives

- 8 Single-Objective Alternatives (SO)
  - Single resource-focused: Juvenile Fish, Adult Fish, Resident Fish, Hydropower flex, Water supply, Water management, 125% TDG juvenile fish spill, Lower Snake River dam breaching
  - All measures from scoping, workshops, technical teams, cooperators, tribes
- 4 Multiple Objective Alternatives (MO)
  - Multiple objective resource-focused
  - Used measures already developed and included in SO alternatives

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Overview of Alternatives

No Action Alternative NEPA requirement; used to compare other alternatives (2016 baseline year)			
Multiple Objective Alternatives – Key Themes *Some measures are included in most or all*			
MO1 (fish improvements, anadro & resident)	**MO2 (power gen, fish transport)**	**MO3 (dam breach, increase anadro fish spill)**	**MO4 (Lower river fish benefits, high anadro fish spill)**
• Water & Power Management • Water Supply • Spill (120/115%) • Fish/lamprey passage and survival	• Water & Power Management • Spill (110%) • Fish/lamprey passage and survival	• Dam Breach (4 Corps dams) • Water Management • Water Supply • Spill (120%) • Fish/lamprey passage and survival	• Water & Power Management • Water Supply • Spill (125%) • Fish/lamprey passage and survival

The Preferred Alternative includes a combination of measures from these alternatives based on the evaluation of resources benefits and environmental consequences.

No Action Alternative

Ongoing operation at the time the EIS was initiated (2016)

- Includes planned structural updates to dam facilities (turbine replacements, etc.)
- Includes actions described in existing Water Management Plan, Fish Passage Plan, Fish Operations Plan, and existing Biological Opinions
- System operations continues to meet agency mission requirements and benefit ESA-listed species
- Spill for anadromous fish is at “performance standard” from 2014 BiOp

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Multiple Objective Alternative 1

Integration of water management flexibility with measures to benefit fish species

- Alternating Spill (120%/115% TDG and Performance Std)
- Change in timing of cooling water release from Dworshak
- Additional Surface Fish Passage Structures at McNary and Ice Harbor
- Adjustment for water management flexibility (including GC maint.)
- Water Supply (Irrigation)
- Disruption of avian nesting to reduce predation on fish

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Multiple Objective Alternative 2

Increase in hydropower production and reduction in regional greenhouse gas emissions while minimizing effects to resources.

- Spring fish passage spill managed near 110% TDG
- Partially lift flow and pool elevation restrictions in lower Columbia River (LCR) and lower Snake River (LSR) for hydropower flexibility and integrate renewables. John Day operates within full reservoir operating range year-round
- Deeper drafts from storage projects for hydropower
- Construct powerhouse surface passage routes and remove screens
- Upgrade to adjustable spillway weirs
- Adjustment for water management flexibility (including GC maint.)

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Multiple Objective Alternative 3

Integration of water management flexibility with measures to breach the four Corps lower Snake River dams

- Remove earthen embankments and adjacent structures to facilitate drawdown LSR projects
- Spring juvenile fish passage spill to 120% TDG and end summer juvenile fish passage spill at LCR projects
- Construct surface passage route
- John Day operating range full pool year-round
- Upgrade to adjustable spillway weirs
- Partially lift flow and pool elevation restrictions in LCR
- Adjustment for water management flexibility (including GC maint.)
- Additional water supply

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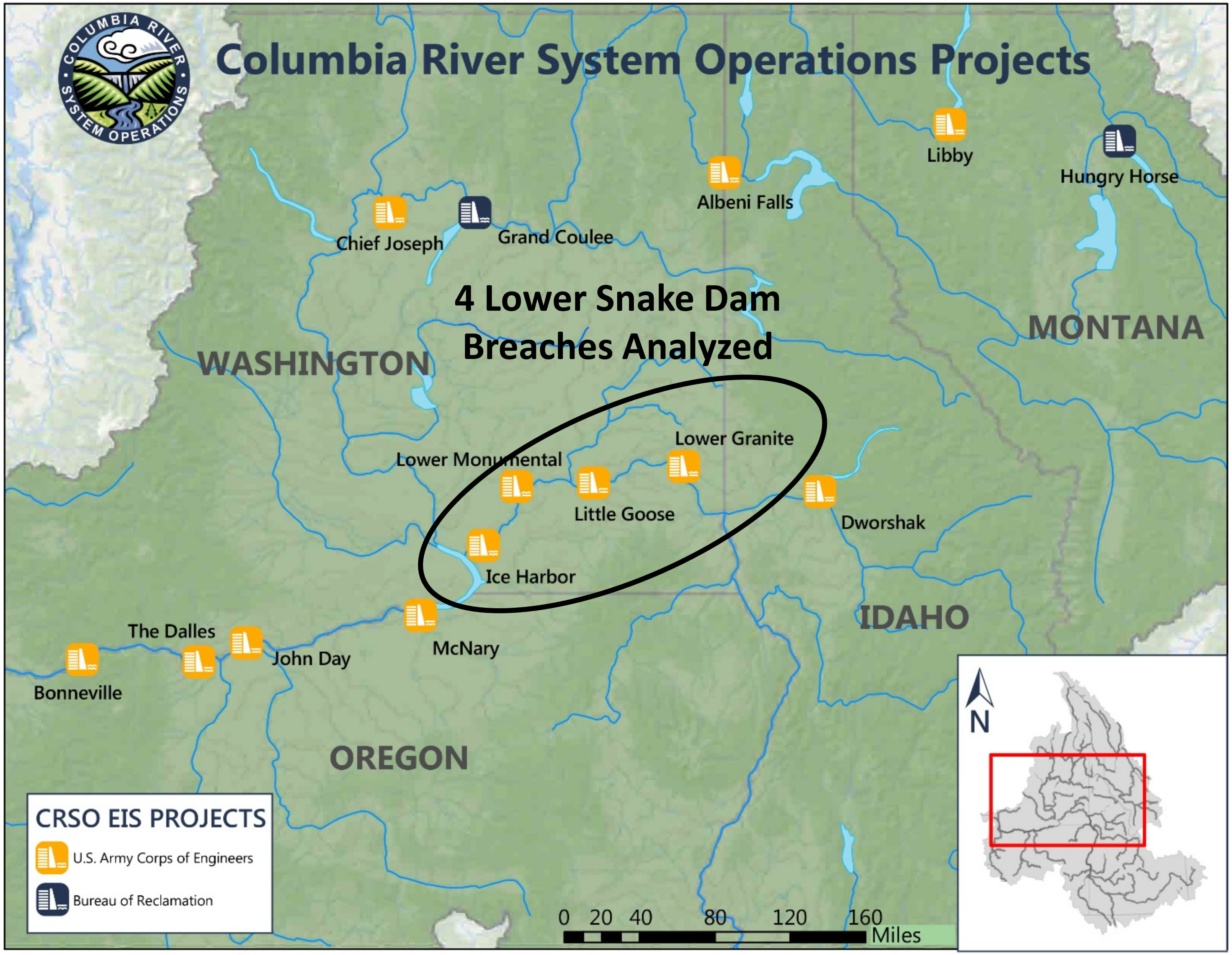
Dam Breaches in Alternative 3



Multiple Objective Alternative 4

Combination of measures to benefit anadromous ESA-listed fish in the lower basin

- Spring juvenile fish passage spill to 125% TDG
- 2 MAF of flow augmentation from storage projects (Hungry Horse, Libby, Albeni Falls and Grand Coulee)
- Powerhouse surface passage for fish
- Reservoir drawdown at LCR and LSR projects in spring and summer to reduce travel time for fish in reservoirs
- Fish transport from April 25 though November 25, except June 15 through August 15

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Good, Bad, Ugly and Better

- ➢ Alternative analysis demonstrated a range of benefits and adverse effects as a result of operational and structural measures.
- ➢ Teams moved forward optimizing the best measures, and avoiding where possible, measures that cause adverse effects.
- ➢ Examples of consideration:

- Moderate gains with moderate juvenile spill; monitoring for adult delays
- Power reliability not met in most scenarios, how to balance best
- Extensive interim adverse effects to environment with breaching measure, mitigation to help reach long term benefits for four listed fish and wetlands; other resource impacts not mitigated
- Refinement of lamprey passage/designs
- Bolder John Day pool drawdown needed for effectiveness
- Use of upper storage basins for lower river demands has significant environmental impacts, balance for upper river needs

Flex Spill Operations

- The operational concept of "flex spill" as described in recent Spill Agreement is reflected in the EIS.
- While the EIS analyzed different spill scenarios in the four MOs, it incorporated new analyses and lessons learned from the flexible spill operations that began in 2019. The spill operations may by further refined in the future using an adaptive management decision framework.
- This new information collected from flex spill operations will be used to assess the fish and power impacts of the operations and used to inform the preferred alternative analyzed in the EIS.
- It is important to note the current regional flex spill operations fall within the bookends of 110% to 125% in the NEPA analysis and would be covered for environmental effects.

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Preferred Alternative Structural Measures

Developed using elements of No Action Alternative and MO Alternatives:

1) Upgrade Spillway Weirs to Adjustable Weirs when they are due for replacement
2) Modify Lower Granite Trap
3) Modify Bonneville Ladder Serpentine Weir
4) Install Lamprey Passage Structures
5) Install Turbine Strainer Lamprey Exclusion
6) Bypass Screen Modifications for Lamprey
7) Lamprey Passage Ladder Modifications
8) Improved Fish Passage Turbines at John Day
9) No annual installation of fish screens at non-collector projects

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Preferred Alternative Operational Measures (1 of 2)

1) Flex Spill to 125% in spring, per the Flex Spill Agreement
2) Summer, reduce spill mid-August to surface spill, per the Flex Spill Agreement
3) Early transport for fish
4) Larger MOP and MIP range (matches 2019 and 2020 operations), end MOP/MIP when summer spill is reduced or ends; John Day larger winter operating range; John Day April/May higher range to disrupt avian predator nesting
5) Allow contingency reserves to be carried within juvenile fish passage spill
6) Modified draft and refill at Libby (FRM measure)
7) Update system FRM calculations at Grand Coulee
8) Decrease Grand Coulee draft rate used in planning drawdown (0.8 ft/day)
9) Operational constraint for ongoing Grand Coulee maintenance

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Preferred Alternative Operational Measures (2 of 2)

10) Lake Roosevelt additional water supply (45 kaf/yr)

11) Implement Sliding Scale summer draft at Libby and Hungry Horse

12) Cease installation of fish screens at non-collector projects—Ice Harbor, McNary, and John Day

13) Dworshak uses FCRC or VDL logic to draft slightly deeper for drawdown

14) Grand Coulee refills to 1283 by end of October (instead of end of September)

15) Zero Generation operations at night Oct 15-Feb 28, daytime mid-Dec to Feb 28

16) Operate turbines (LCOL and LSN) within and above 1% efficiency during fish passage season

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Summary of Effects (pre-mitigation)

Resource	MO1	MO2	MO3	MO4	Preferred
Power Generation	Moderate adverse effects to costs/rates	Moderate beneficial effects to costs/rates	Major adverse effects to costs/rates	Major adverse effects to costs/rates	Moderate adverse effects to costs/rates
Water Supply	No Change	No Change	Localized major adverse effects	Localized minor adverse effects	No Change
Add'l Water Supply	Major increase	No change	Major beneficial effects	Major beneficial effects	Minor beneficial effects
Navigation	Moderate effect to Lake Roosevelt Ferry	Moderate effect to Lake Roosevelt Ferry	Major long-term adverse effects in LSR; Minor effect to Lake Roosevelt Ferry	Minor increase in annual costs in LSR/LCR; Moderate effect to Lake Roosevelt Ferry	Minor effect to Lake Roosevelt Ferry
Anadromous Fish	Mixed; minor long term beneficial effects	Mixed; Major adverse effects	Mixed short/long-term; Major beneficial effects and adverse effects	Mixed; Moderate long term beneficial and adverse effects	Mixed; Minor - Moderate long term beneficial, Short tem Major adverse effects
Resident Fish	Upper Basin minor- moderate adverse effects	Upper Basin minor -major adverse effects	LSR major long-term beneficial effects; Upper Basin minor-moderate adverse effects	Upper Basin minor - major adverse effects	Upper Basin- Moderate beneficial and adverse effects
Cultural Resources	Major adverse effects	Major adverse effects	Major adverse effects	Major adverse effects	Minor beneficial effects
Recreation	Minor- localized Moderate adverse effects	Minor adverse effects	Mixed beneficial effects; Minor- major long-term adverse effects	Minor- major adverse effects	Localized Minor- moderate adverse effects

H&H Overview

- Background: CRS Projects and Regions
- Methods
- Alternatives comprised of measures
  - Structural Measures
  - Operational Measures
- Six Alternatives evaluated – H&H Reservoir Ops modeling & data analysis
  - No Action Alternative
  - MO1
  - MO2
  - MO3
  - MO4
  - Preferred Alternative
- River Mechanics
- Spill Allocation

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Seasonal Operations at Major CRS Storage Dams

<table>
<tr><th>Project</th><th colspan="2">Jan</th><th colspan="2">Feb</th><th colspan="2">Mar</th><th colspan="2">Apr</th><th colspan="2">May</th><th colspan="2">Jun</th><th colspan="2">Jul</th><th colspan="2">Aug</th><th colspan="2">Sep</th><th colspan="2">Oct</th><th colspan="2">Nov</th><th colspan="2">Dec</th></tr>
<tr><td rowspan="3">Libby</td><td colspan="6">Variable Discharge (VARQ) Flood Risk Management (FRM) Draft</td><td colspan="6">VARQ FRM Refill</td><td colspan="8"></td><td colspan="4">FRM Draft</td></tr>
<tr><td colspan="8"></td><td colspan="4">Operate To Sturgeon Flow Objectives</td><td colspan="6">Flow Augmentation Draft</td><td colspan="6"></td></tr>
<tr><td colspan="24">Operate To Bull Trout Ramping Rates and Minimum Outflows</td></tr>
<tr><td rowspan="3">Hungry Horse</td><td colspan="6">Minimum Flow or VARQ FRM</td><td colspan="6">VARQ FRM Refill</td><td colspan="12"></td></tr>
<tr><td colspan="6">Variable Draft Limit (VDL)</td><td colspan="6"></td><td colspan="6">Flow Augmentation Draft</td><td colspan="6"></td></tr>
<tr><td colspan="24">Operate To Follow Bull Trout Ramping Rates and Maintain Minimum Flows At Columbia Falls and Downstream Of Dam</td></tr>
<tr><td rowspan="3">Albeni Falls</td><td colspan="7">Operate No Lower Than MCE</td><td colspan="5">Refill</td><td colspan="5">Full For Summer</td><td colspan="4">Draft To Winter Pool (MCE)</td><td colspan="3">No Lower Than MCE</td></tr>
<tr><td colspan="7">Operate No Lower Than Kokanee Spawning Elevation</td><td colspan="14"></td><td colspan="3">1/2 Foot Operating Band For Kokanee</td></tr>
<tr><td colspan="24">Operate To Ramping Rates and Minimum Outflows</td></tr>
<tr><td rowspan="3">Grand Coulee</td><td colspan="12">FRM Draft and Refill</td><td colspan="4"></td><td colspan="5">Resident Fish Operation</td><td colspan="3"></td></tr>
<tr><td colspan="7">Operate For Chum and Vernita Bar</td><td colspan="5">Operate To Support Hanford Reach Egress and Spring Migrants</td><td colspan="4">Summer Flow Augmentation</td><td colspan="2"></td><td colspan="6">Operate For Chum and Vernita Bar</td></tr>
<tr><td colspan="7">VDL Operation To Provide 85% Probability Of Refill To April 10 Elevation Objective</td><td colspan="17"></td></tr>
<tr><td rowspan="3">Dworshak</td><td colspan="6"></td><td colspan="2">Spring Flow Augmentation</td><td colspan="3"></td><td colspan="7">Summer Flow Augmentation and Temperature Moderation</td><td colspan="6"></td></tr>
<tr><td colspan="12">Minimum Flow or FRM</td><td colspan="5"></td><td colspan="7">Minimum Flow or FRM Draft</td></tr>
<tr><td colspan="10"></td><td colspan="2">Refill To 1600'</td><td colspan="2"></td><td colspan="2">Draft To 1535'</td><td colspan="2">Draft To 1520'</td><td colspan="6"></td></tr>
</table>

Legend				
Legend	FISH OPERATION	FRM OR POWER OPERATION	FISH AND POWER OPERATION	OTHER PURPOSES

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H&H: Reservoir Operations Modeling

- Models
  - HEC-ResSim
  - HYDSIM

- The ResSim model provided FRM constraints as inputs to the HYDSIM model. Conversely, the HYDSIM model provided the CRT operation for the Canadian projects to ResSim. In addition, HYDSIM modeling provided the lack-of-market information that was layered on the ResSim output to provide daily spill flow.

- The CRS ResSim Model is the last modeling step from which daily flow and reservoir elevations are taken for analysis
  - Summary hydrographs
  - Water year type plots
  - Elevation-duration and flow-duration curves
  - Custom data sets for further technical analysis

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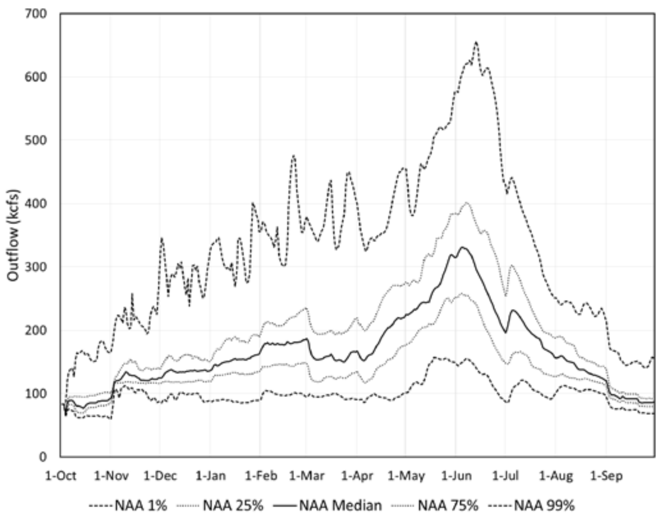
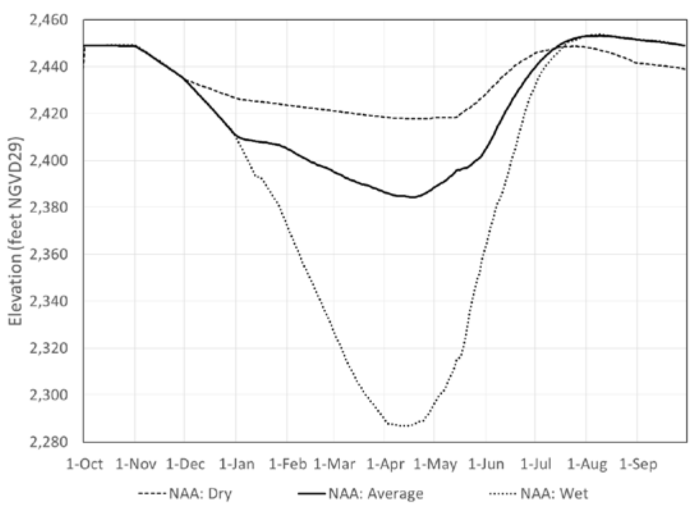
H&H: Data Analysis

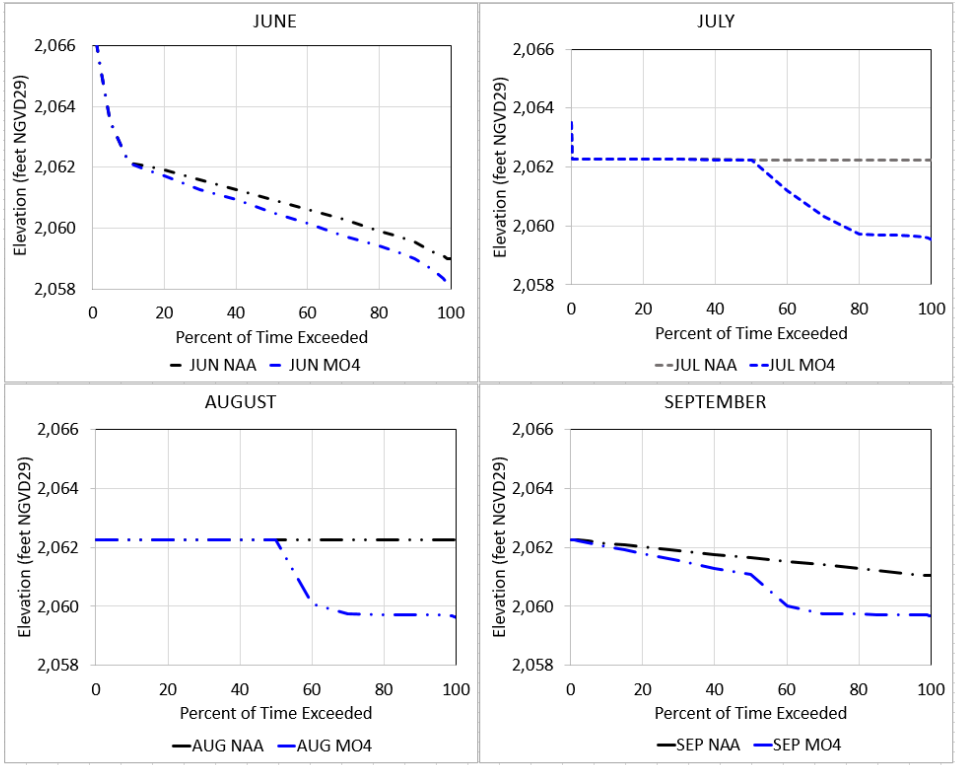


Summary hydrograph

Water year type plot



Elevation-duration curves



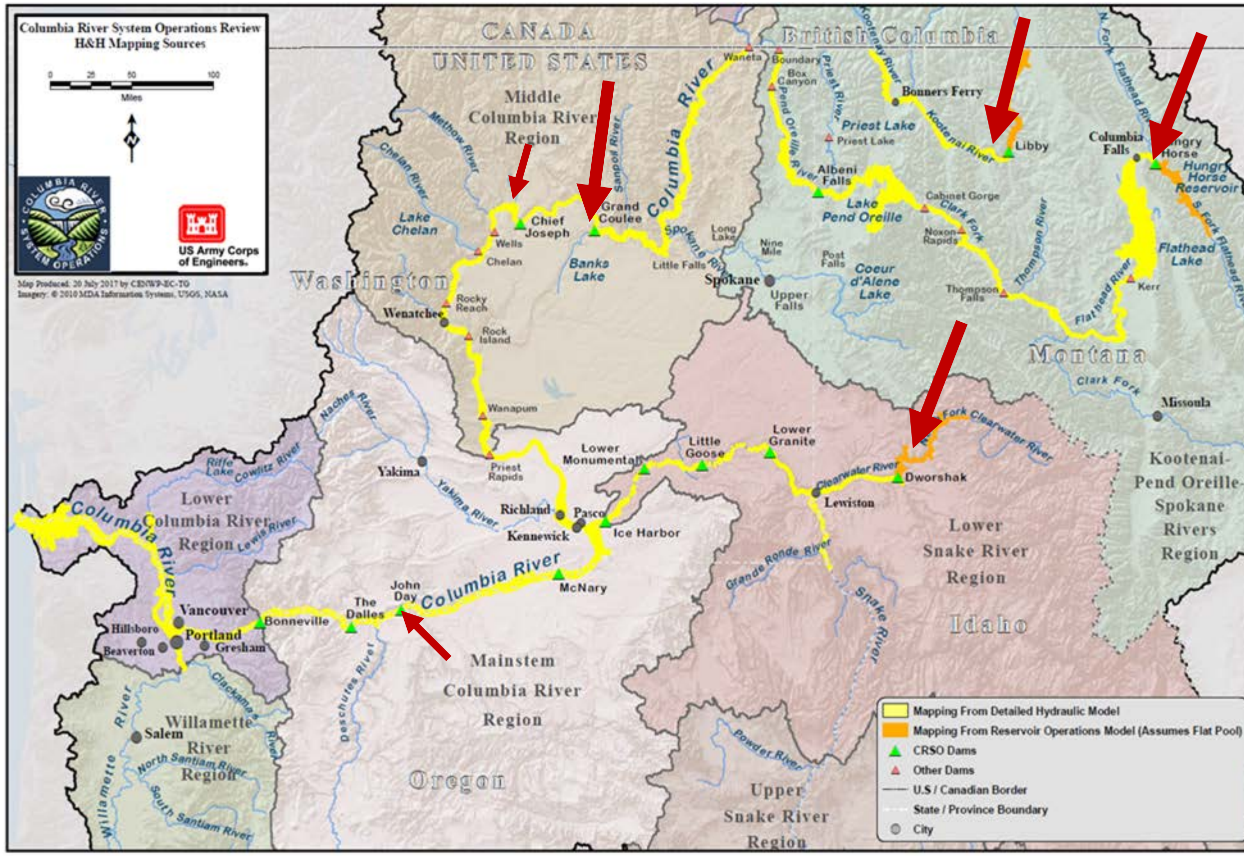
H&H Overview – MO1

Operational Changes

- Draft and refill operation at Libby
- Draft and refill operation at Grand Coulee
- Water supply measures at Lake Roosevelt, Flathead River, and below Chief Joseph Dam
- Libby and Hungry Horse summer draft (sliding scale)
- Modified Dworkshak Summer Draft
- Increase in spring pool at John Day for forebay range flexibility; Predator Disruption Operations

Spill changes

- Alternate fish passage spill between 120/115% and performance standard plus (two periods in spring, reverse order alternate years)



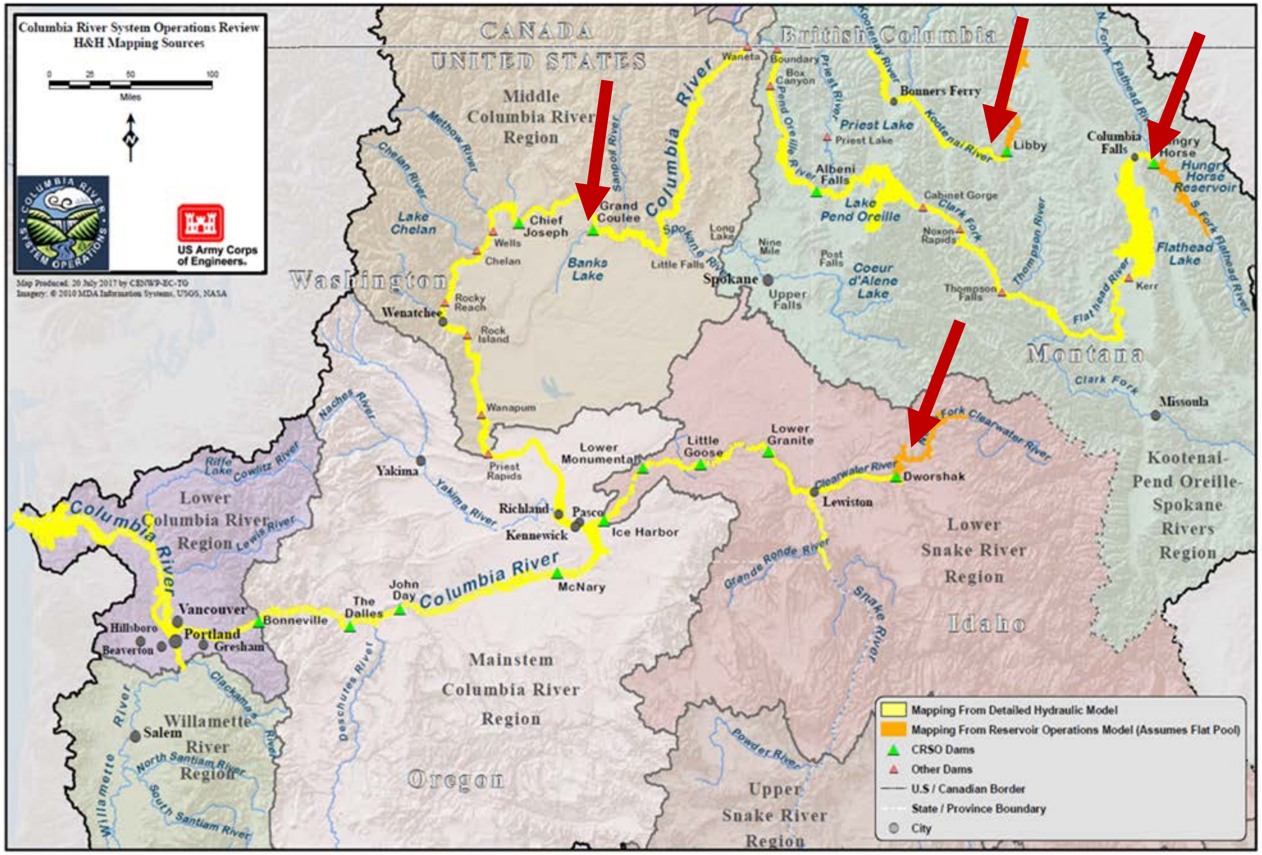
H&H Overview – MO2

Operational Changes

- Draft and refill operation at Libby
- Draft and refill operation at Grand Coulee
- Libby drafted deeper in November and December
- Dworshak, Hungry Horse, and Grand Coulee drafted deeper for hydropower generation
- New, less restrictive Libby and Hungry Horse ramping rates
- Libby and Hungry Horse summer draft (sliding scale)
- Changes to Grand Coulee October and September targets and minimums – 1283 ft min at the end of Oct instead of Sept

Spill changes

- Spill to 110% TDG



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H&H Overview – MO3

Major Structural Change

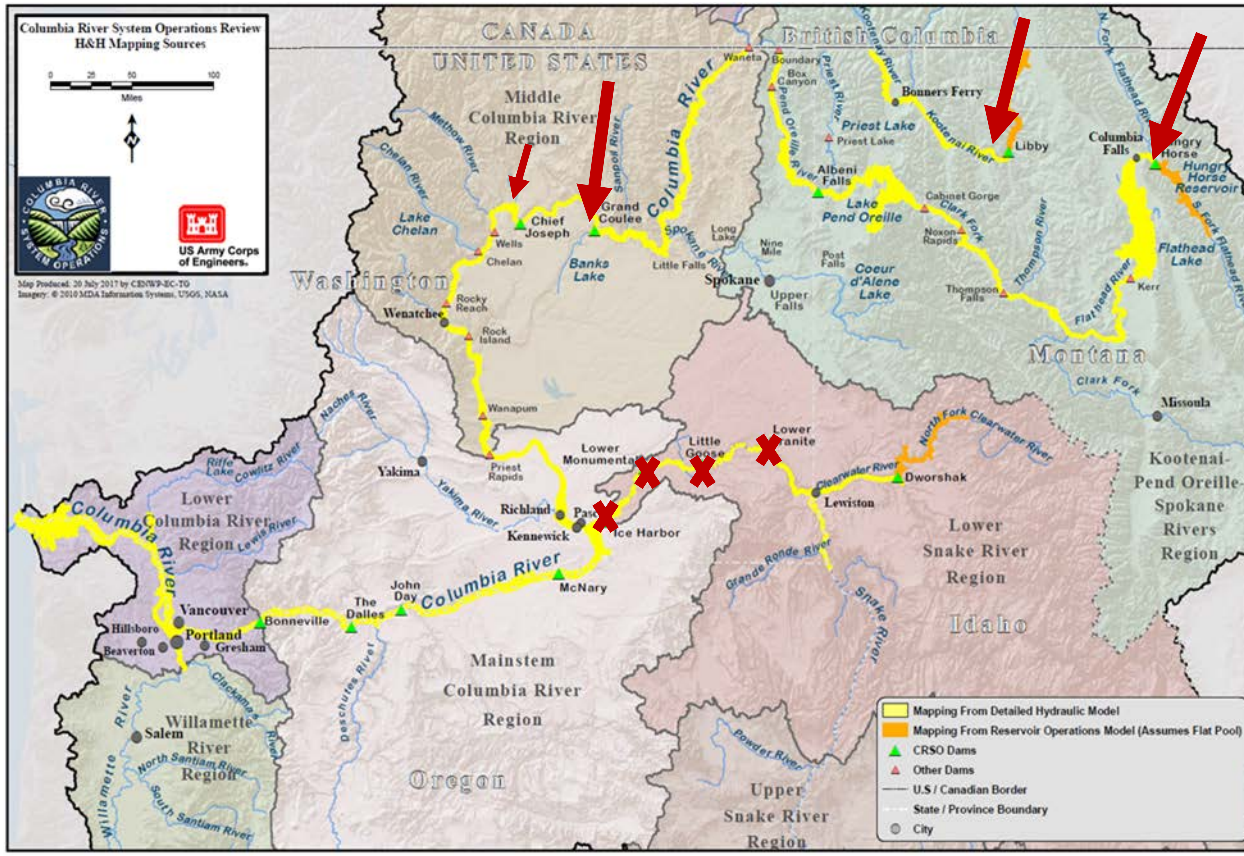
- Lower Snake Dam breach/removal

Operational Changes

- Draft and refill operation at Libby
- Draft and refill operation at Grand Coulee
- Libby drafted deeper in November and December
- Water supply measures at Lake Roosevelt, Flathead River, and below Chief Joseph Dam
- New, less restrictive Libby and Hungry Horse ramping rates
- Libby and Hungry Horse summer draft (sliding scale)

Spill changes

- Spring Spill to 120% TDG
- Reduced Summer Spill



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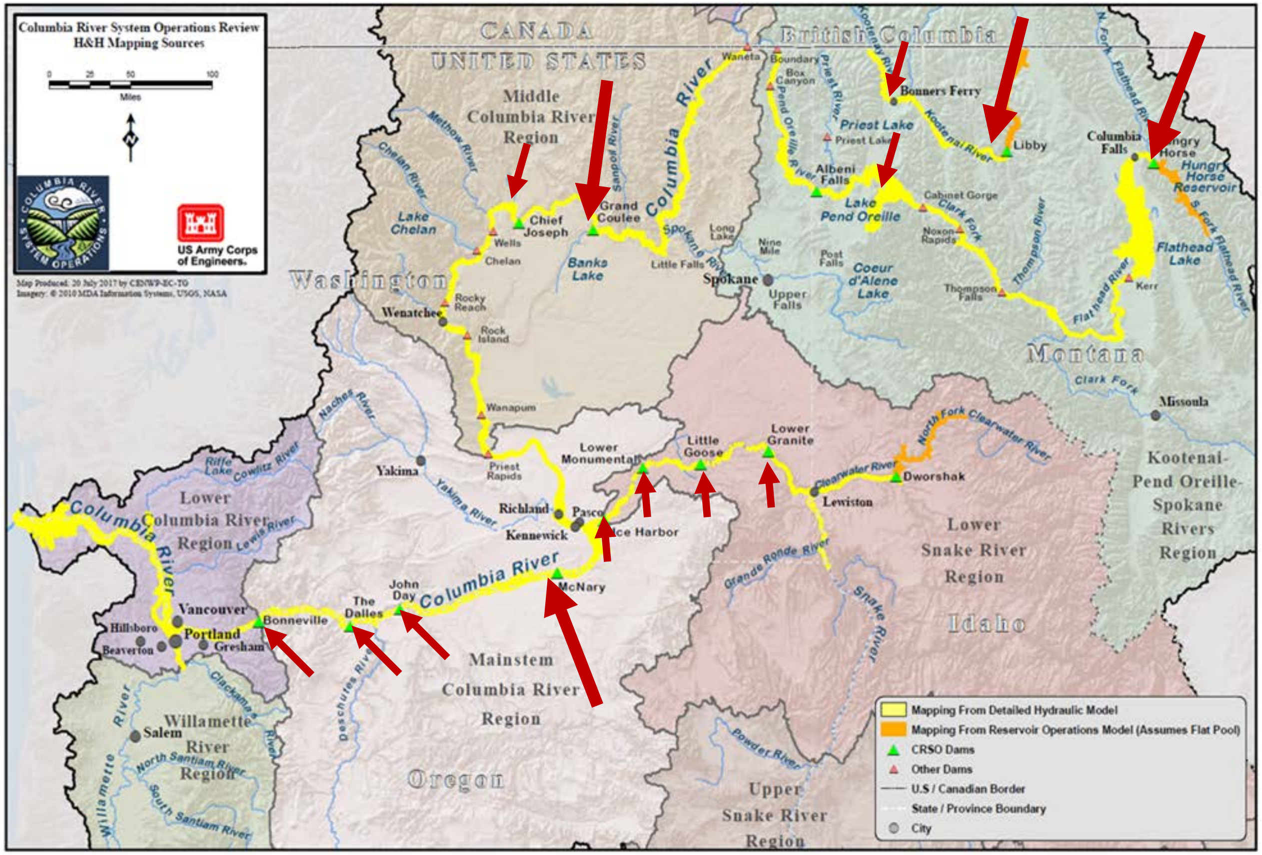
H&H Overview – MO4

Operational Changes

- Draft and refill operation at Libby
- Draft and refill operation at Grand Coulee
- Additional water supply diversions at Banks Lake, Flathead Lake, and below Chief Joseph Dam;
- Libby and Hungry Horse summer draft (sliding scale)
- Provide up to 2.0 Maf of flow augmentation at McNary using Libby, Hungry Horse, Albeni Falls, Grand Coulee Dams
    - 220 kcfs (May 1 – June 15)
    - 200 kcfs (June 16 – July 31)
- Winter Stage for Riparian: Limit winter river stage at Bonners Ferry when Libby's WSF is <6.9 Maf
- MOP operations on Lower 4 Columbia and Lower 4 Snake Dams

Spill Changes

- Spill to 125% TDG



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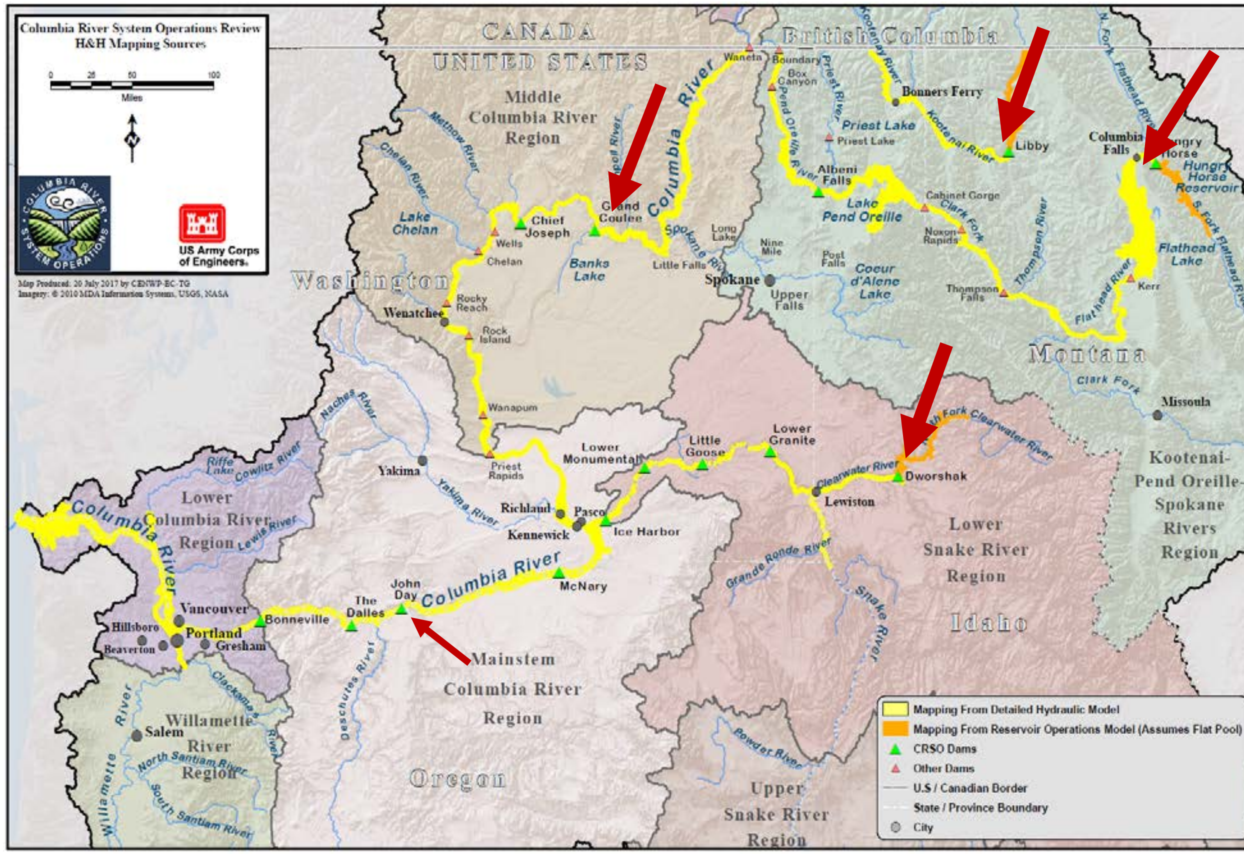
H&H Overview – Preferred Alt

Operational Changes

- Modified operations at Libby and Grand Coulee to maximize operating flexibility and improve overall systems operations
- Modified operations to meet existing and authorized smaller additional water supply at Banks Lake
- Libby and Hungry Horse summer draft (sliding scale)
- John Day Full Pool, Increased Forebay Range Flexibility and Predator Disruption Operations
- Slightly Deeper Draft for Hydropower at Dworshak deeper draft in winter

Spill Changes

- Flex spill up to 125% This is reflected in the HydSim output, water quality data, and fish modeling



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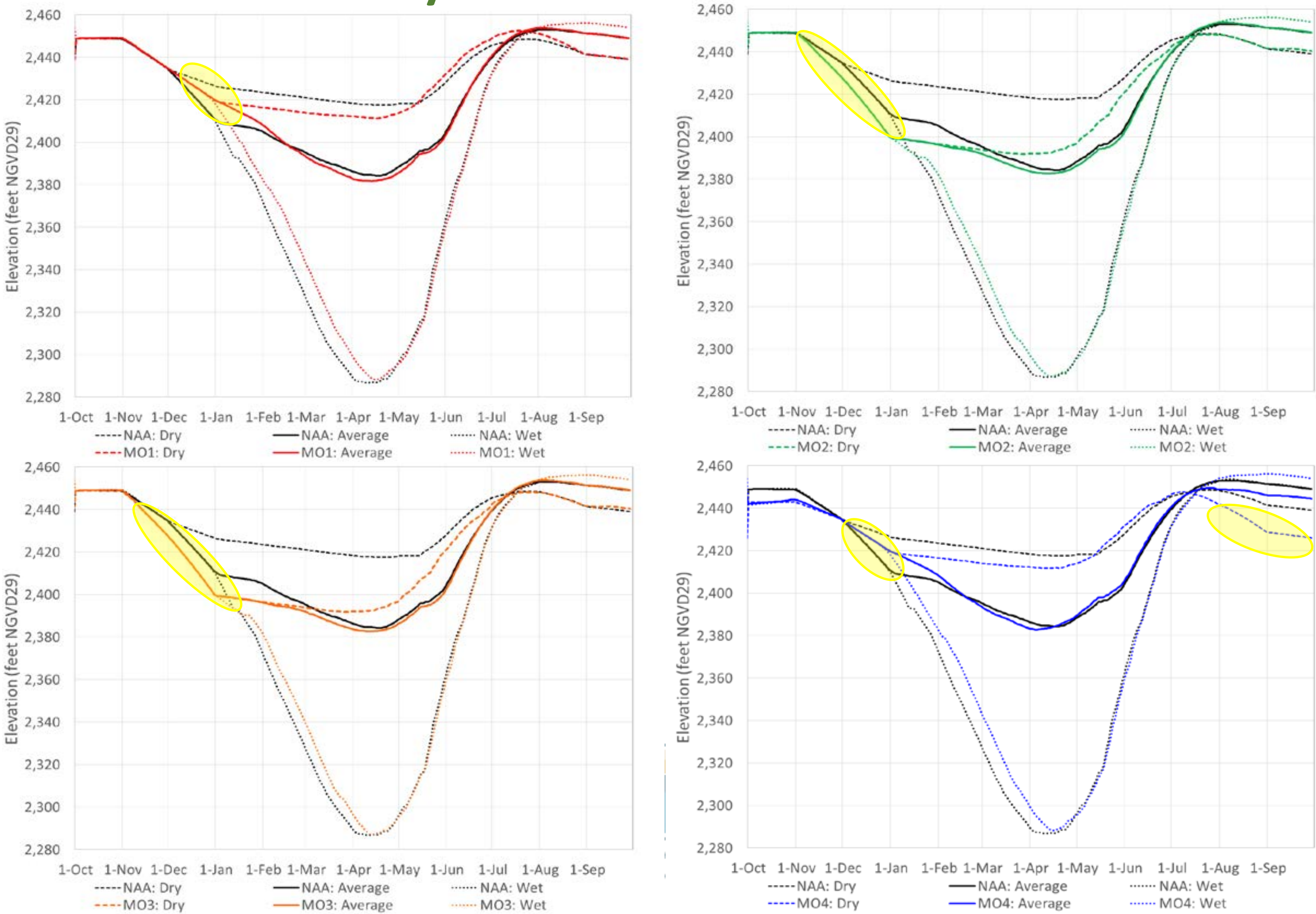
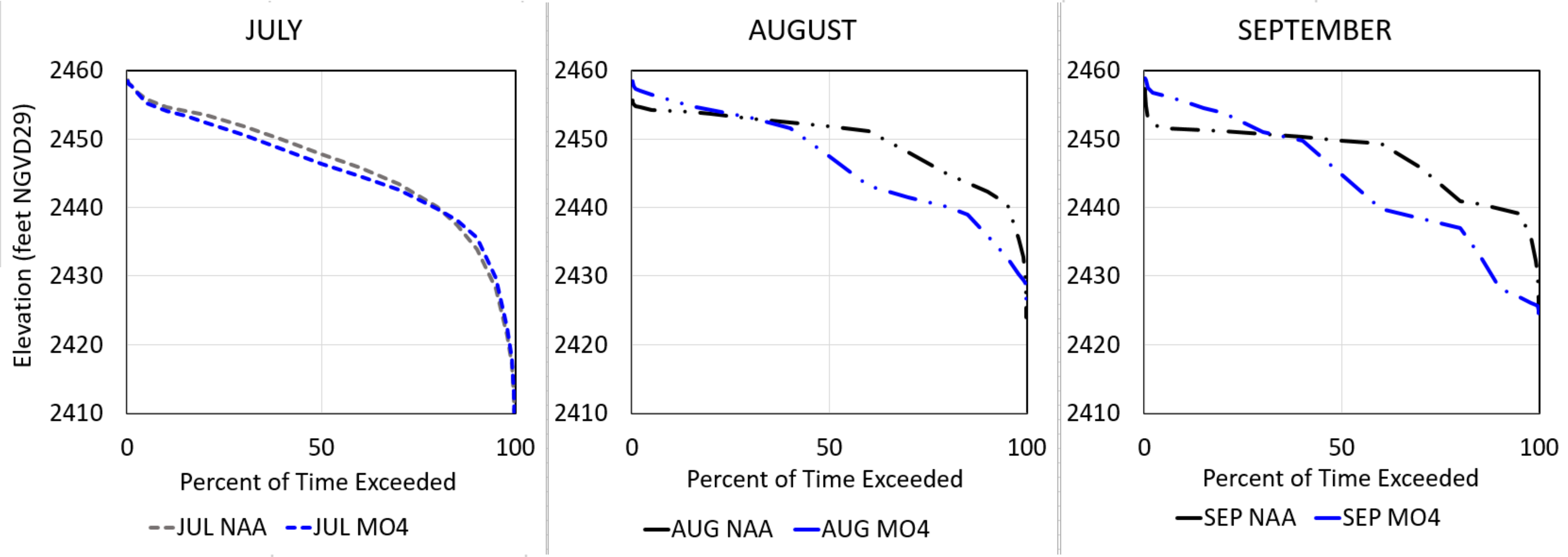
H&H: Libby Dam & Lake Koocanusa



H&H: Libby Dam & Lake Koocanusa



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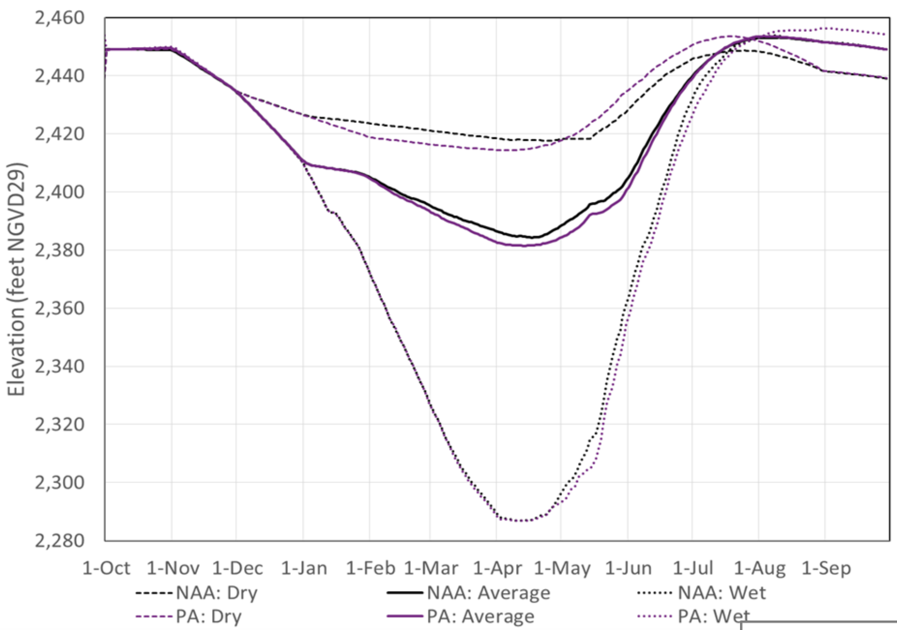
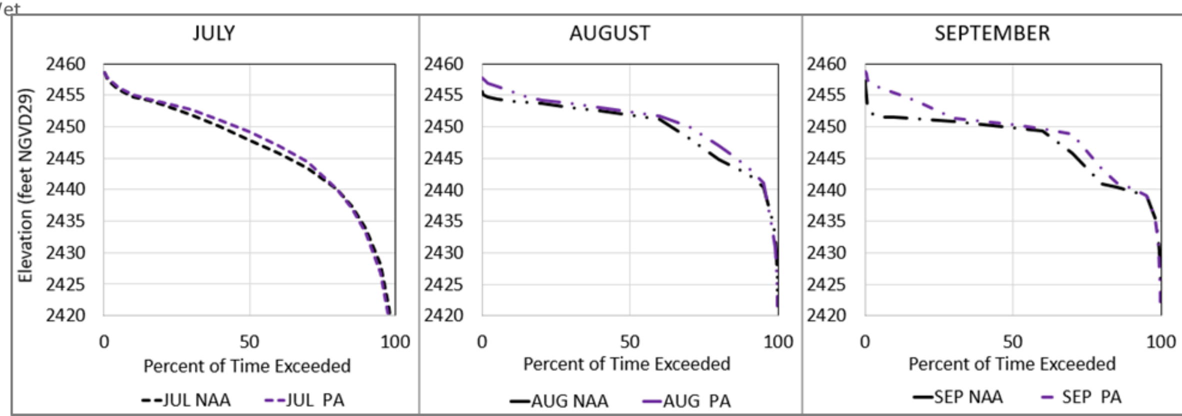
Bonneville
POWER ADMINISTRATION

H&H: Libby Dam & Lake Koocanusa





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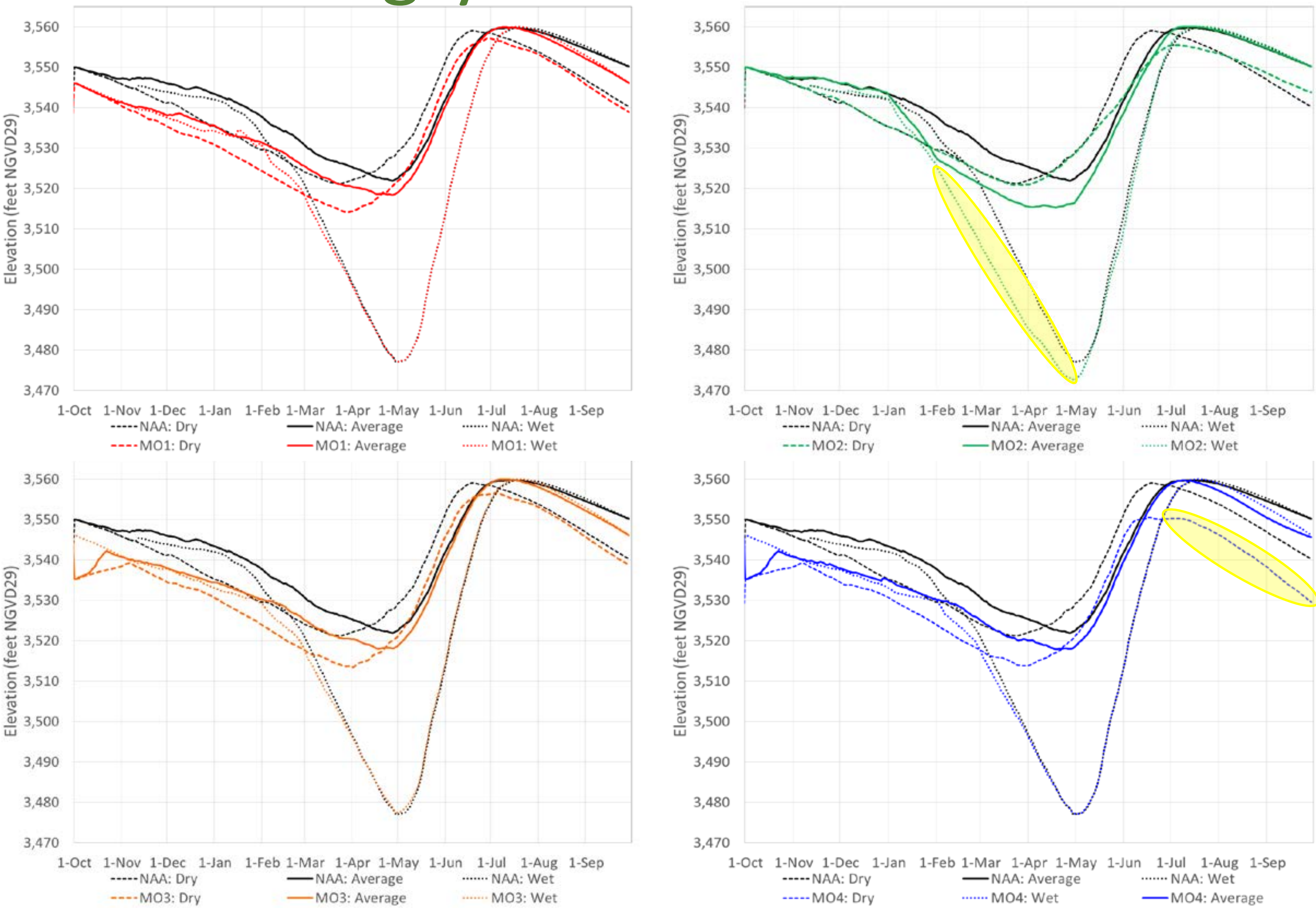
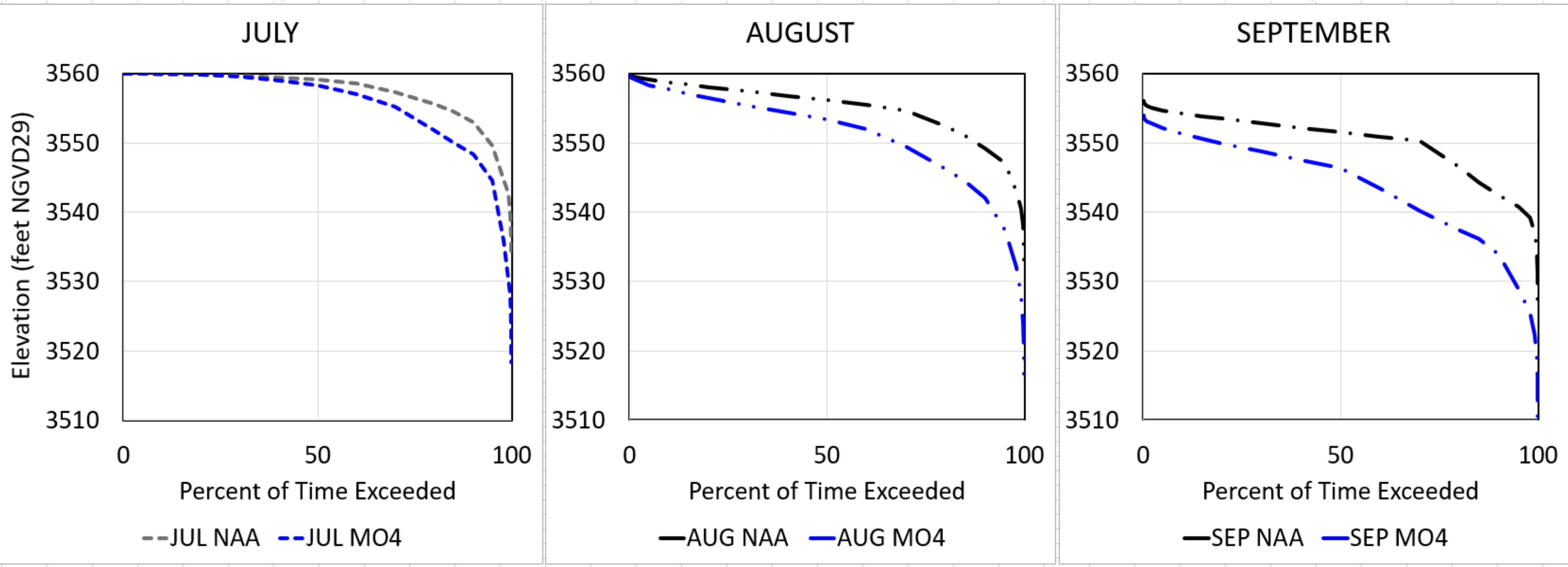
H&H: Hungry Horse Dam & Reservoir



H&H: Hungry Horse Dam & Reservoir



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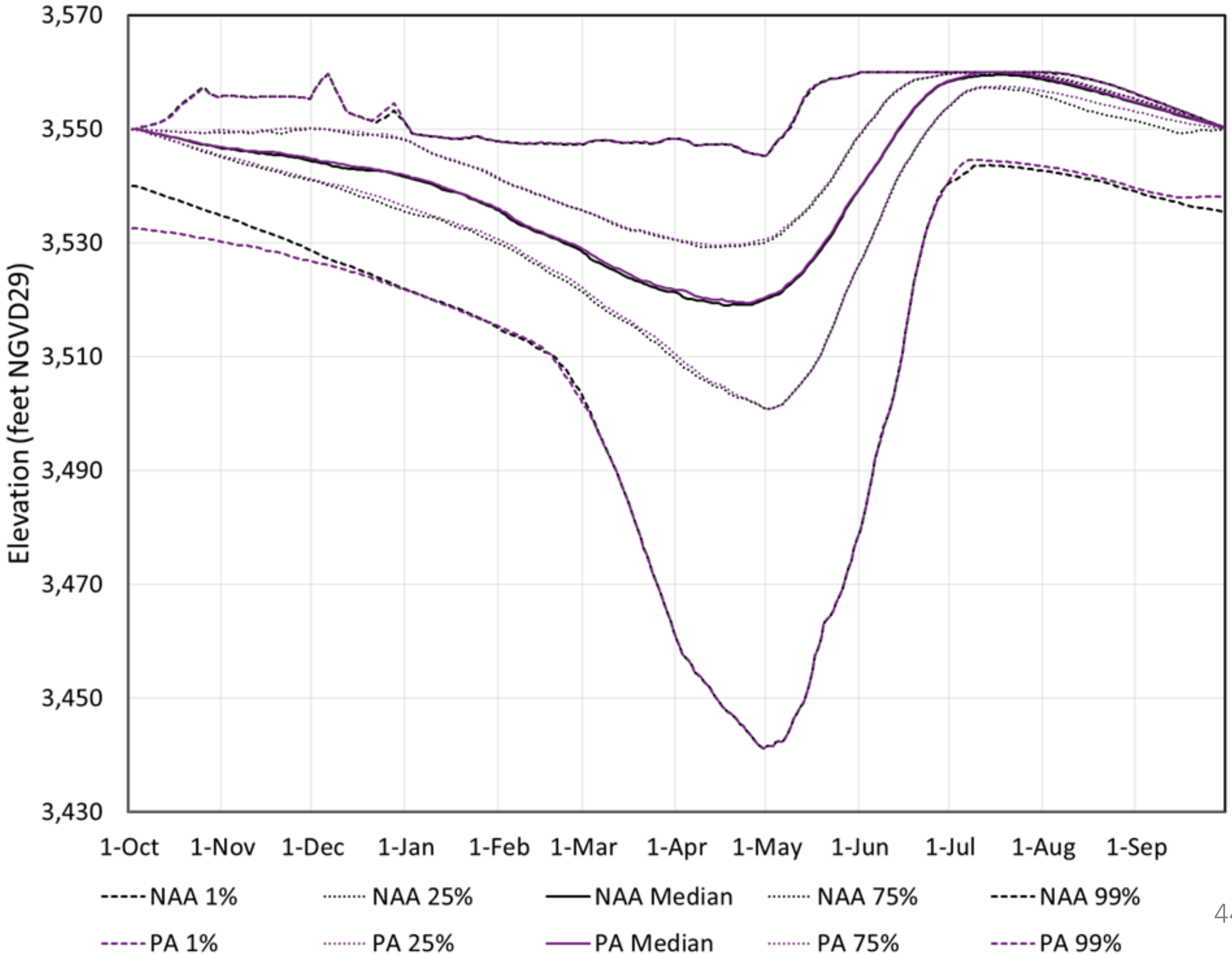
H&H: Hungry Horse Dam & Reservoir

PA has only one measure affecting Hungry Horse (sliding scale for end of Sept. draft)



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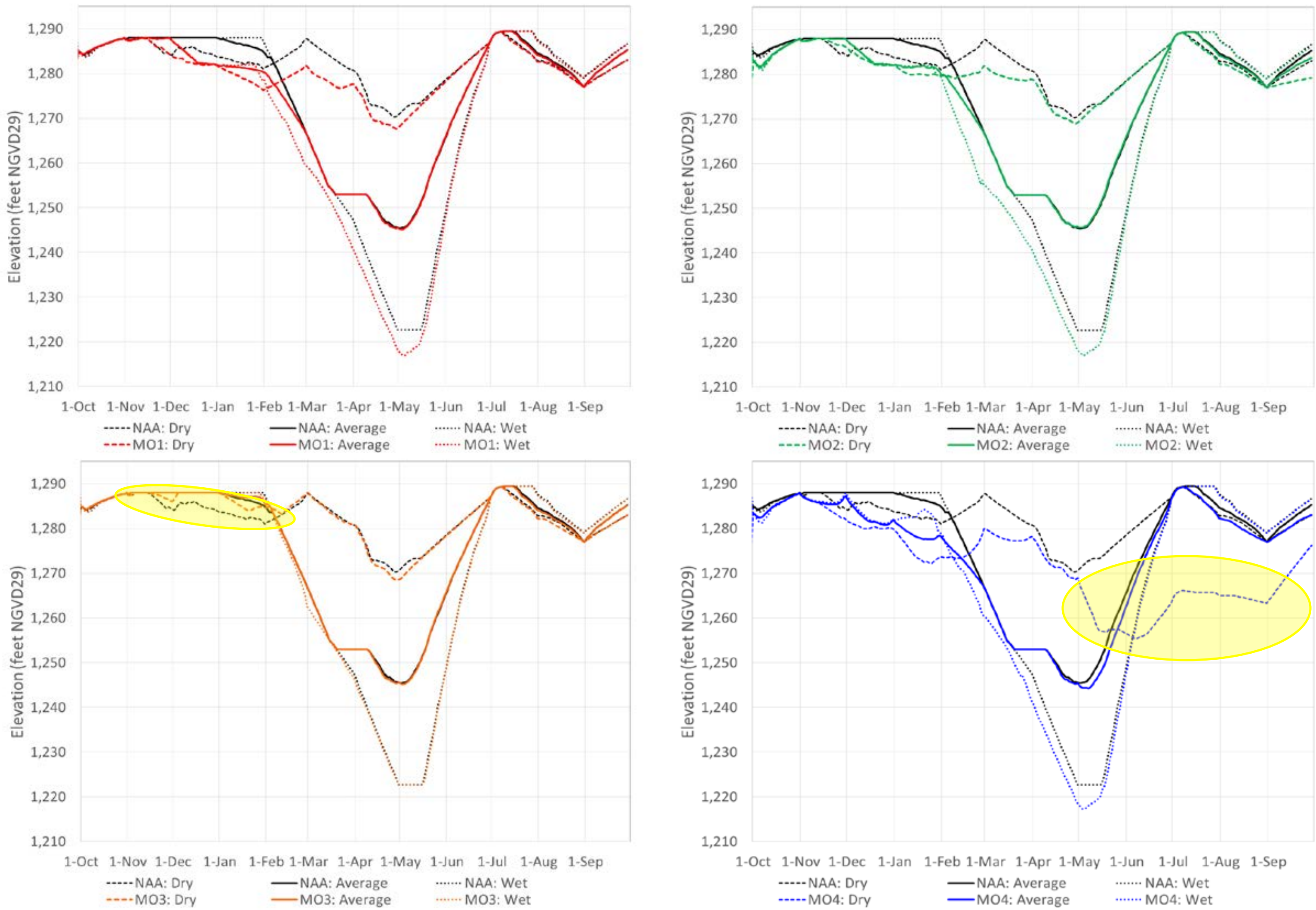
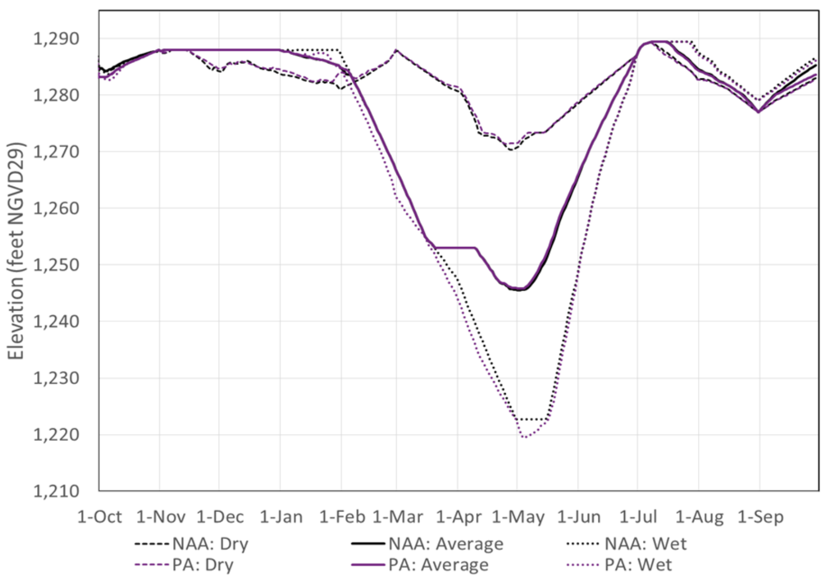
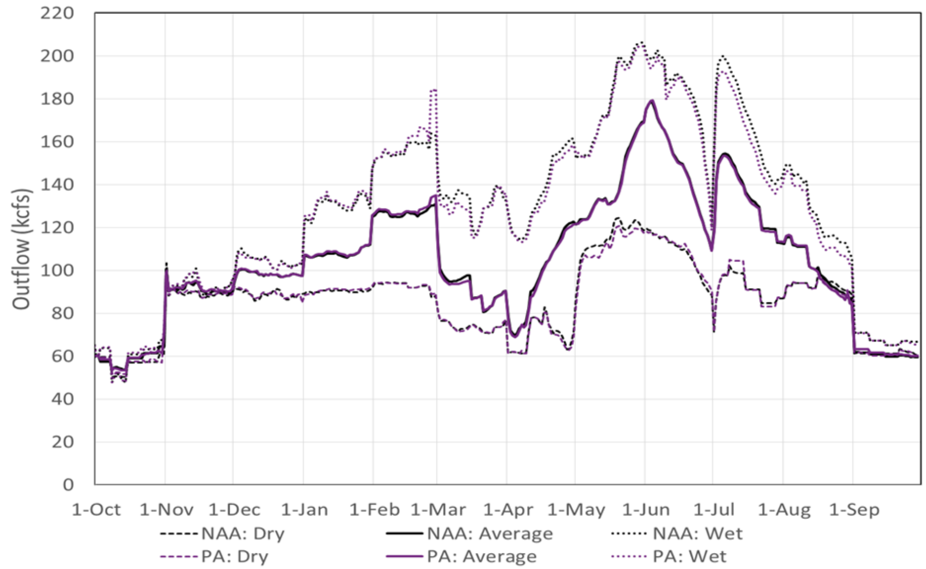
H&H: Grand Coulee Dam & Lake Roosevelt



H&H: Grand Coulee Dam & Lake Roosevelt





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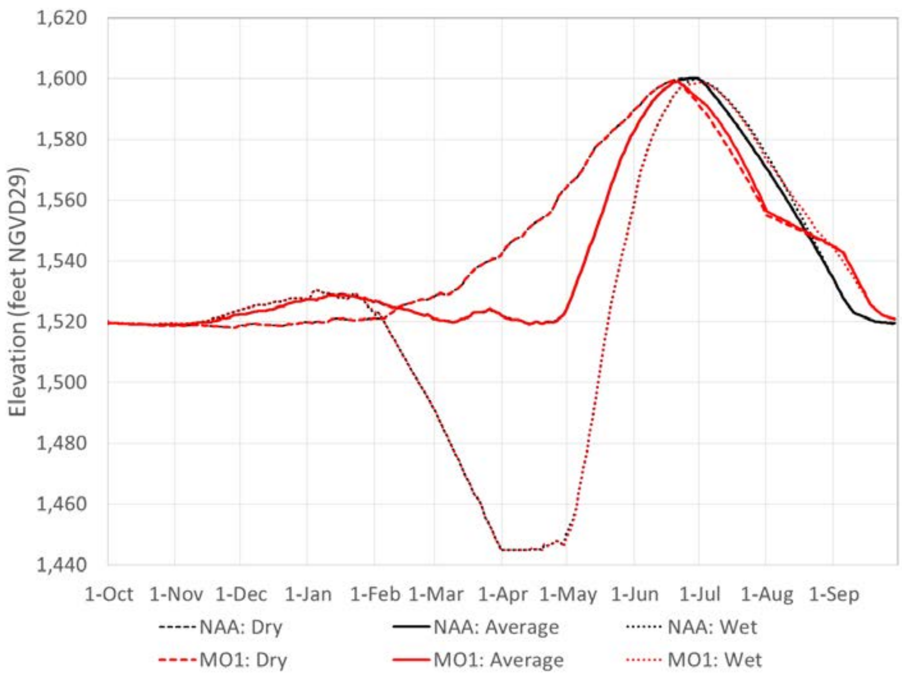
H&H: Dworshak Dam & Reservoir



		Exceedance Probability	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	15.6	13.2	13.6	6.4
		25%	7.5	11.9	11.0	5.2
		50%	4.8	10.7	10.2	5.0
		75%	2.4	9.6	9.8	4.8
		99%	1.6	7.4	9.3	4.5
MO1	Change (kcfs)	1%	0.1	0.1	-1.1	1.9
		25%	1.7	1.3	-3.5	1.9
		50%	1.6	1.6	-4.9	1.8
		75%	0.0	1.3	-5.6	1.8
		99%	0.0	2.8	-5.5	1.5
	Percent change	1%	0%	1%	-8%	29%
		25%	23%	11%	-32%	37%
		50%	33%	15%	-48%	37%
		75%	0%	13%	-57%	37%
		99%	0%	38%	-59%	33%

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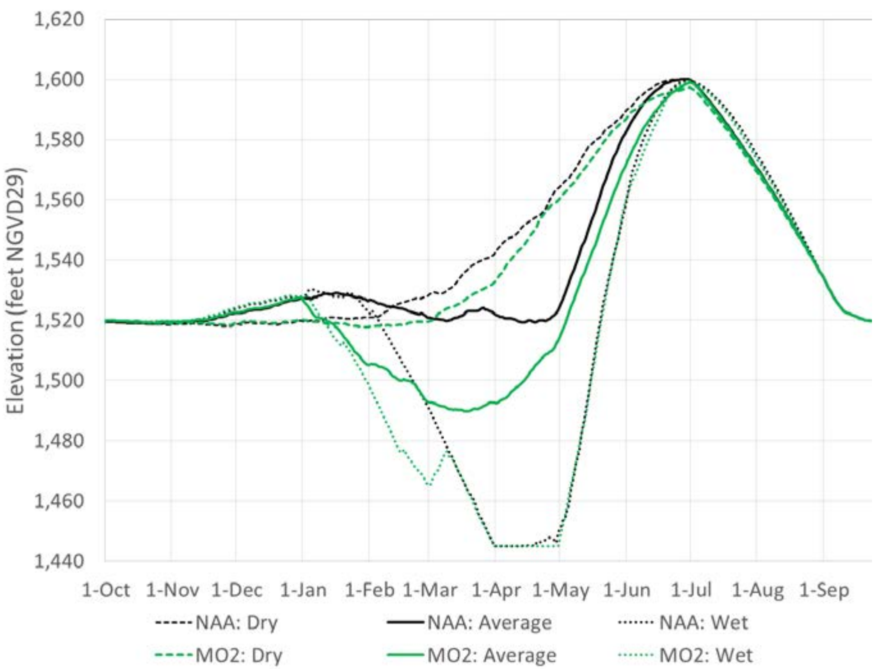
H&H: Dworshak Dam & Reservoir



		Exceedance Probability	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	Ave. mo. outflow (kcfs)	1%	13.5	23.3	25.0	25.0	17.3	15.6	13.2	13.6	6.4
		25%	4.2	9.3	11.8	13.2	6.2	7.5	11.9	11.0	5.2
		50%	2.1	5.1	6.2	9.6	3.5	4.8	10.7	10.2	5.0
		75%	1.6	1.6	2.3	4.6	2.4	2.4	9.6	9.8	4.8
		99%	1.6	1.6	1.6	1.6	1.6	1.6	7.4	9.3	4.5
MO2	Change (kcfs)	1%	7.4	-4.2	0.0	-0.6	-5.5	1.2	0.0	0.0	-0.1
		25%	5.5	0.7	-2.6	-0.3	0.5	-2.6	-0.2	-0.4	0.0
		50%	6.6	2.0	-1.5	-1.9	1.0	-2.2	-0.2	-0.4	0.0
		75%	2.3	0.3	-0.7	-2.5	0.6	-0.1	-0.3	-0.7	0.0
		99%	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-3.2	-0.1
	Percent change	1%	55%	-18%	0%	-2%	-31%	8%	0%	0%	-1%
		25%	129%	7%	-22%	-2%	8%	-35%	-1%	-4%	-1%
		50%	311%	39%	-24%	-20%	27%	-45%	-2%	-4%	0%
		75%	141%	19%	-30%	-54%	25%	-3%	-4%	-7%	-1%
		99%	0%	0%	0%	0%	0%	0%	-3%	-34%	-1%

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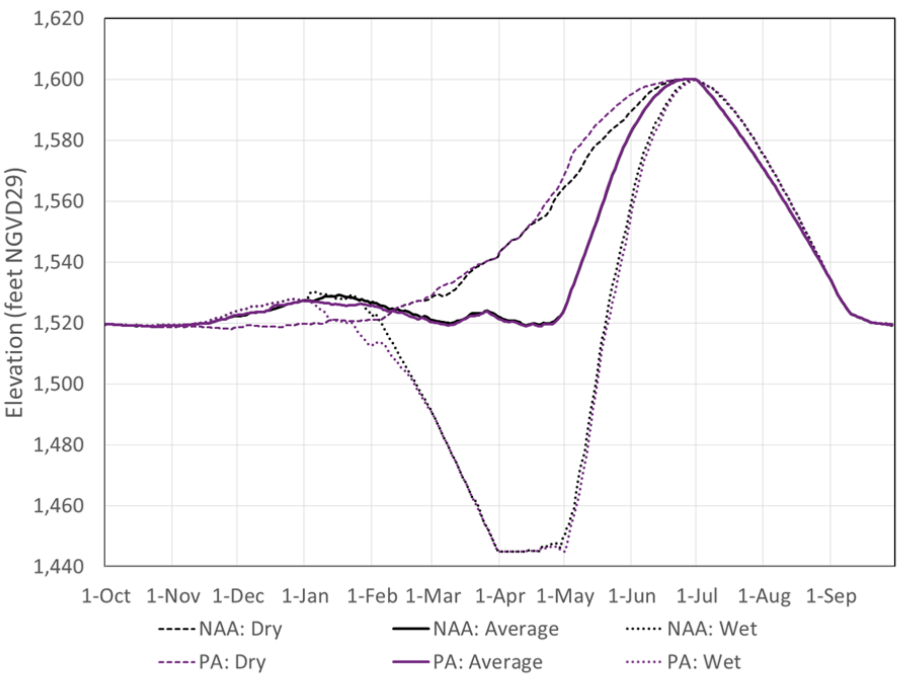
H&H: Dworshak Dam & Reservoir



		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR
No Action Alternative	Ave. mo. outflow (kcfs)	1%	1.7	1.6	8.7	13.5	23.3	25.0	25.0
		25%	1.6	1.6	1.9	4.2	9.3	11.8	13.2
		50%	1.6	1.6	1.6	2.1	5.1	6.2	9.6
		75%	1.6	1.6	1.6	1.6	1.6	2.3	4.6
		99%	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Preferred Alternative	Change (kcfs)	1%	0.0	0.0	0.0	0.0	-1.0	0.0	-1.0
		25%	0.0	0.0	0.0	3.3	-0.7	-0.8	0.0
		50%	0.0	0.0	0.0	0.3	-0.8	-0.3	0.0
		75%	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
		99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Percent change	1%	0%	0%	0%	0%	-4%	0%	-4%
		25%	0%	0%	0%	77%	-7%	-6%	0%
		50%	0%	0%	0%	12%	-15%	-5%	0%
		75%	0%	0%	0%	0%	0%	0%	-1%
		99%	0%	0%	0%	0%	0%	0%	0%

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H&H: Lower Snake River

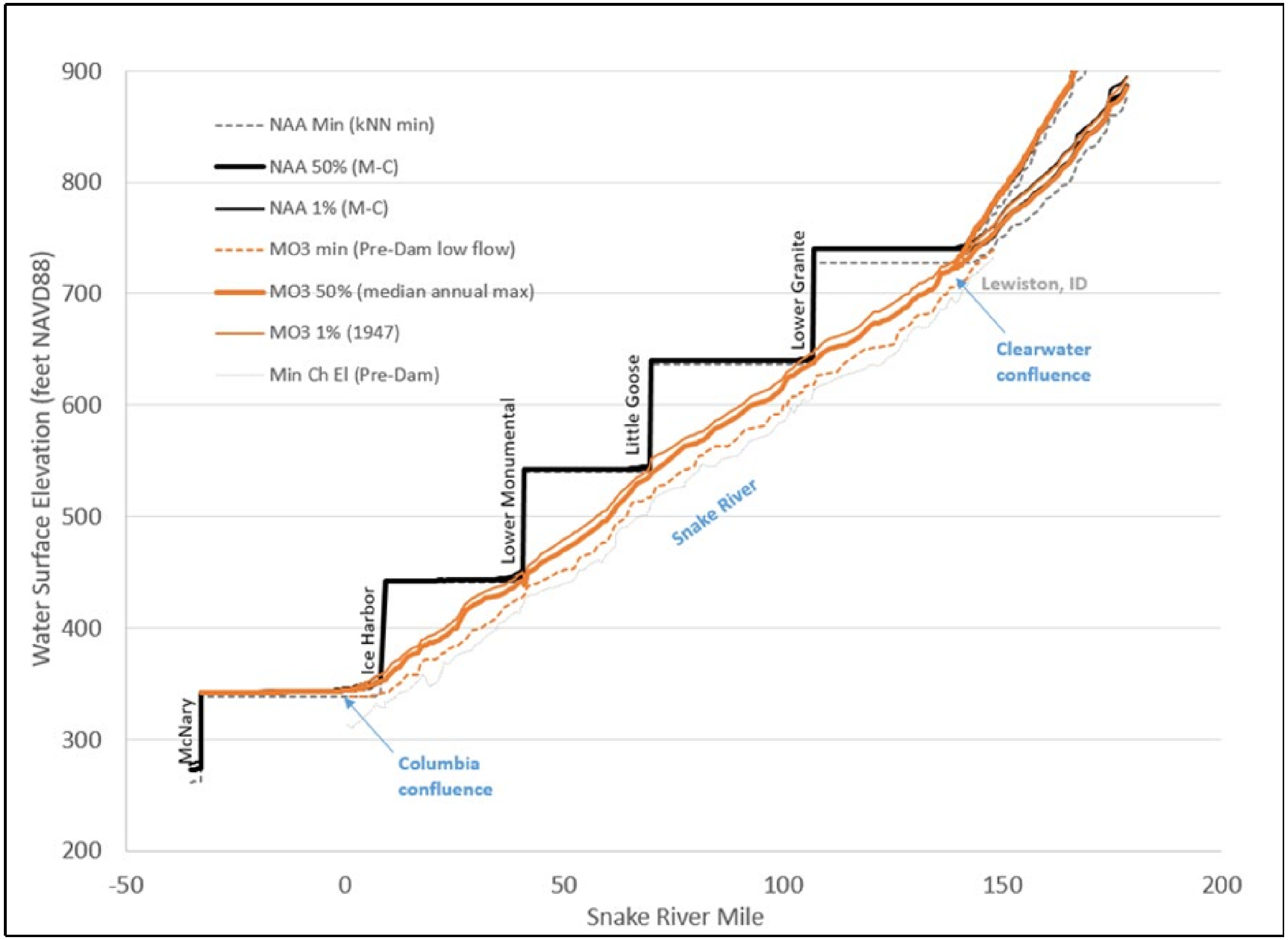

Figure 3-75. Lower Snake River Water Surface Profiles for Multiple Objective Alternative 3

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H&H: Lower Snake River flows

Clearwater and Snake Rivers below Dworshak Dam

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

H&H: Lower Snake River reservoirs

- Lower Granite Dam: the Preferred Alternative would have a MOP range of 733.0 to 734.5 feet NGVD29, compared to 733.0 to 734.0 feet NGVD29 under the No Action Alternative.
- Little Goose Dam: the Preferred Alternative would have MOP range of 633.0 to 634.5 feet NGVD29, compared to 633.0 to 634.0 feet NGVD29 under the No Action Alternative.
- Lower Monumental Dam: the Preferred Alternative would have a MOP range of 537.0 to 538.5 feet NGVD29, compared to 537.0 to 538.0 feet NGVD29 under the No Action Alternative).
- Ice Harbor Dam: the Preferred Alternative would have MOP range of 437.0 to 438.5 feet NGVD29, compared to 437.0 to 438.0 feet NGVD29 under the No Action Alternative).

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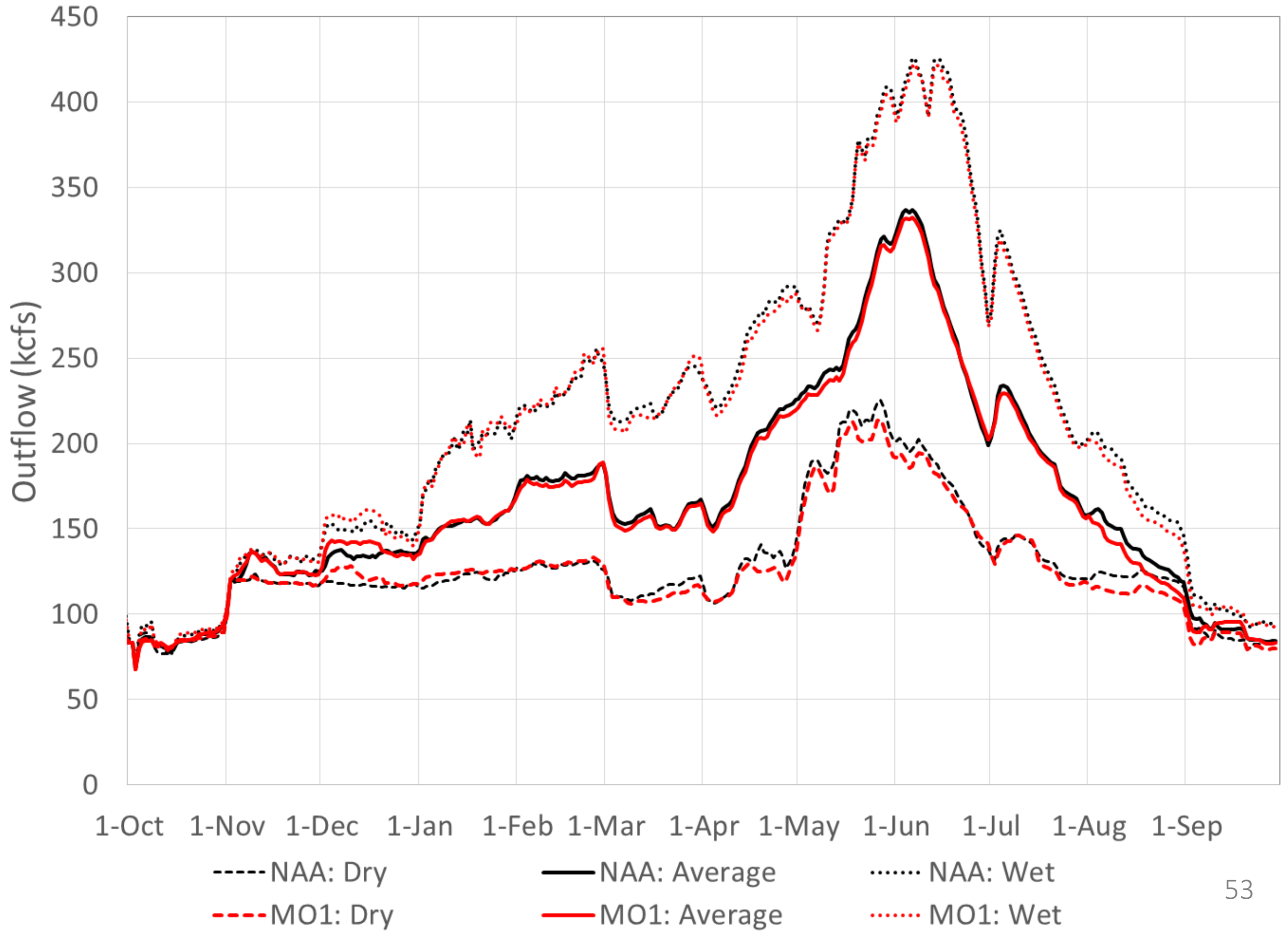
H&H: Lower Columbia River dams

McNary flows for dry, typical, and wet year categories.



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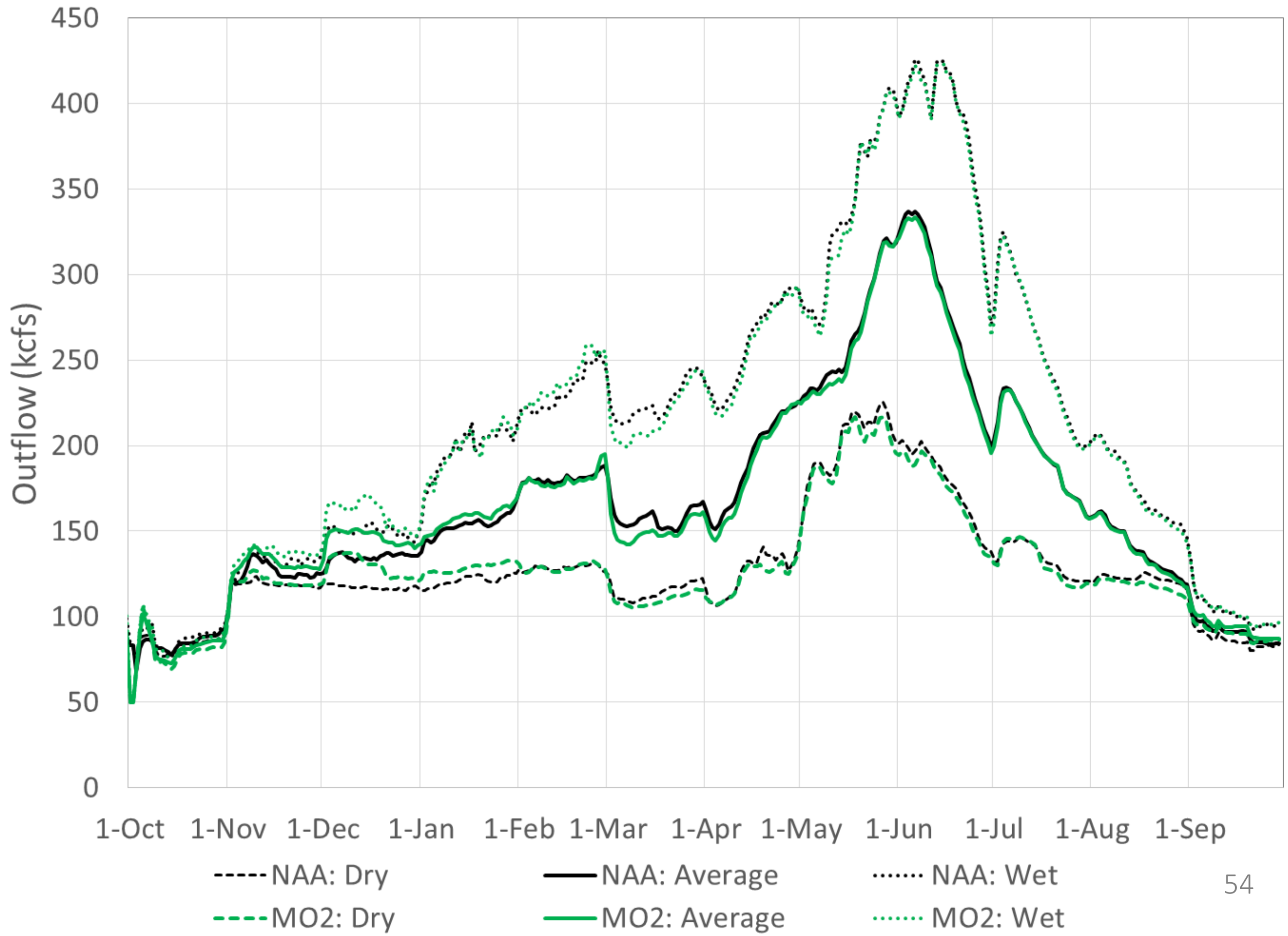
H&H: Lower Columbia River dams

McNary flows for dry, typical, and wet year categories.



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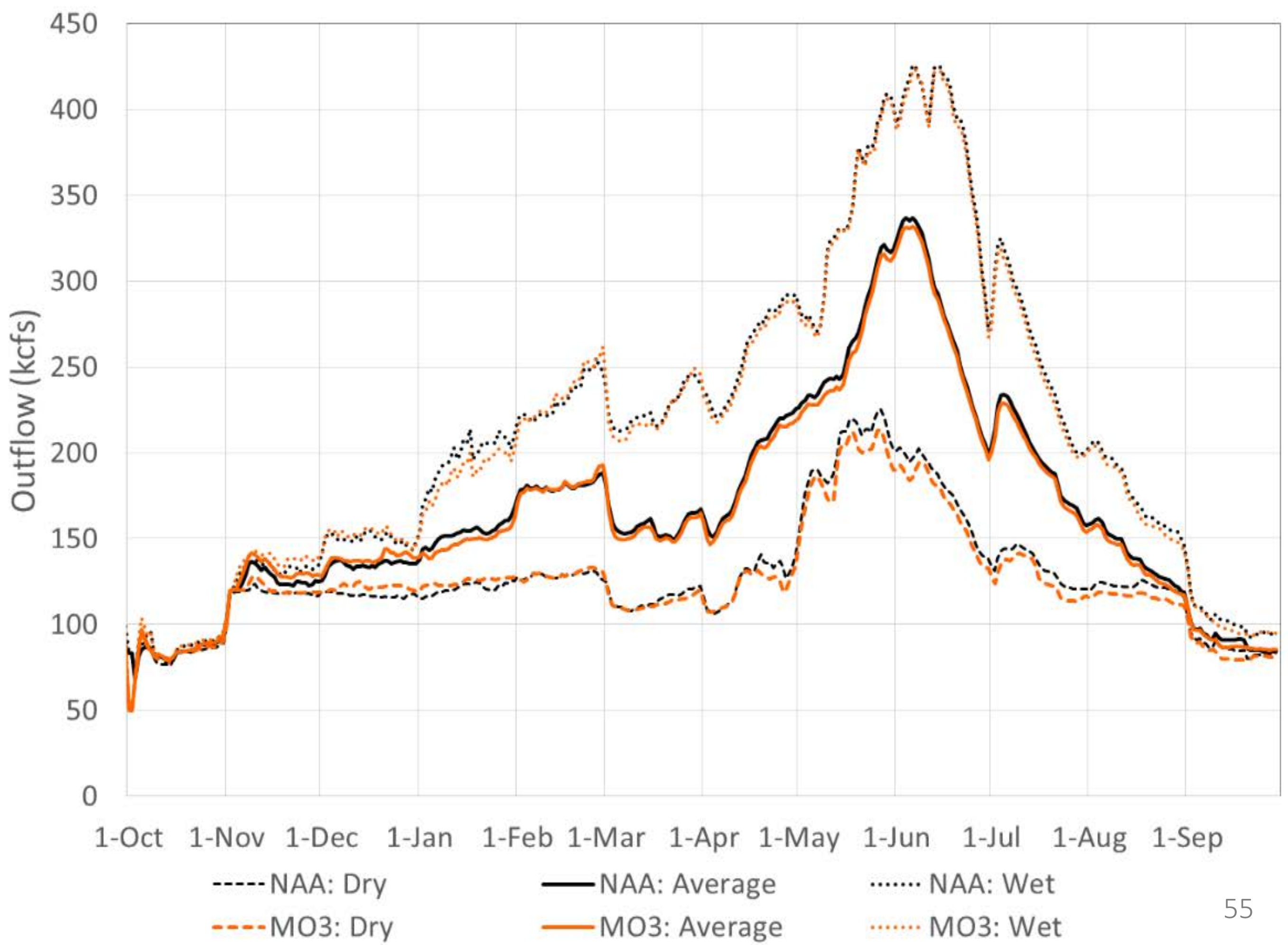
H&H: Lower Columbia River dams

McNary flows for dry, typical, and wet year categories.



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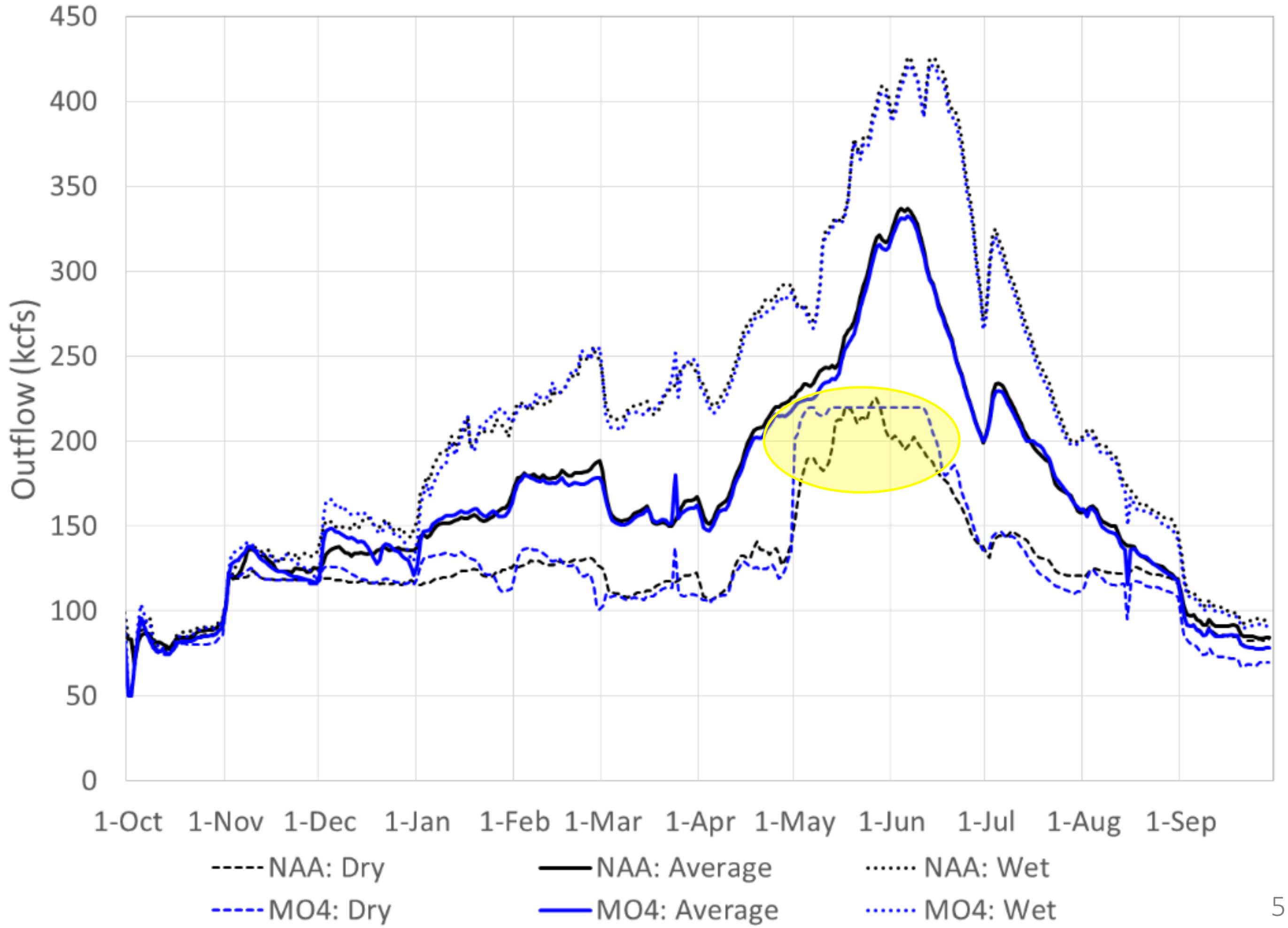
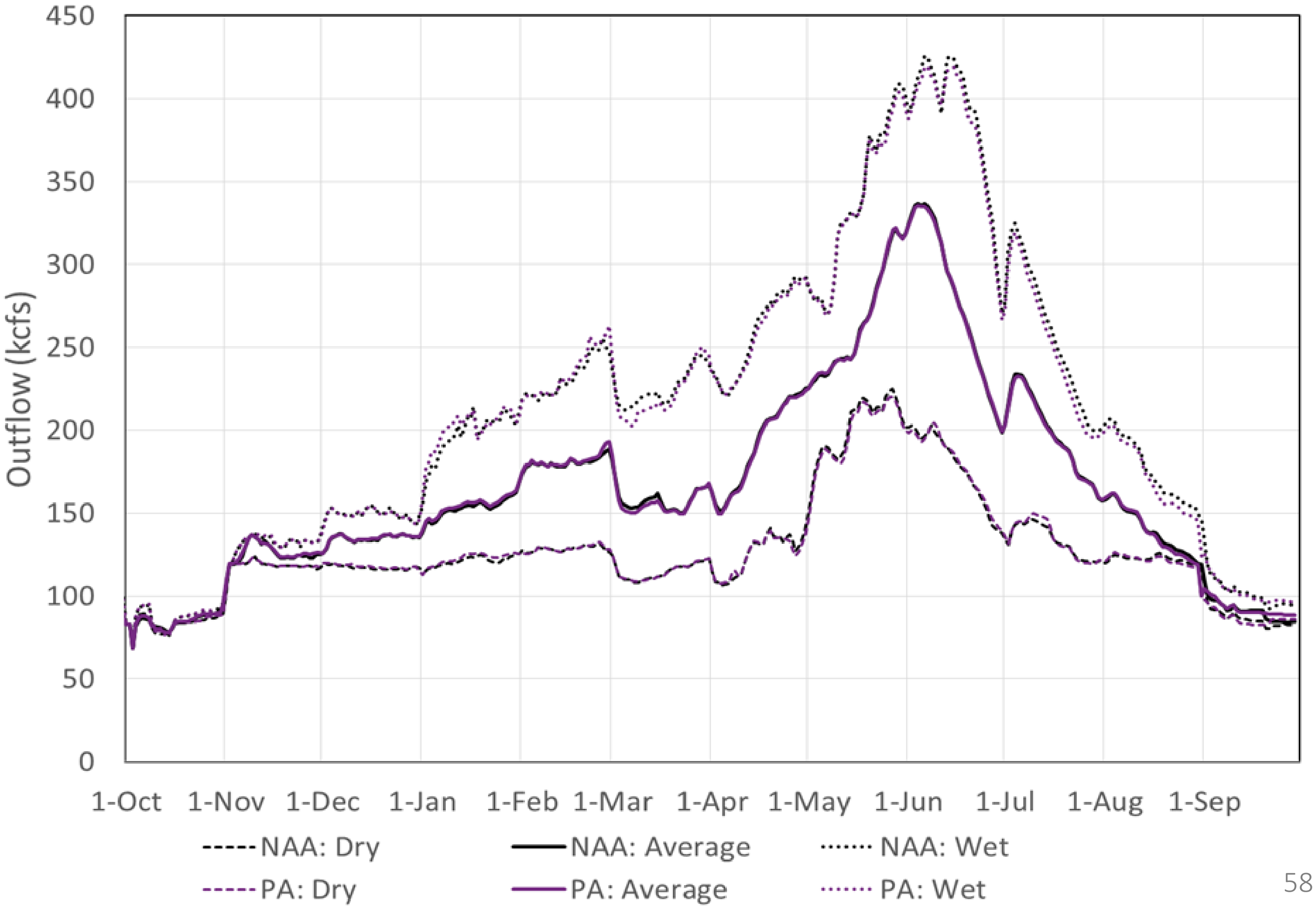
H&H: Lower Columbia River dams

McNary flows for dry, typical, and wet year categories.



H&H: Lower Columbia River dams

McNary flows for dry, typical, and wet year categories.



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CRSO EIS
Misc River Mechanics Supporting Slides

River Mechanics Metrics

- Storage project metrics
  - Head-of-Reservoir Sediment Mobilization
  - Sediment Trap Efficiency
  - Shoreline Exposure
- Run-of-river reservoirs and free-flowing reach metrics
  - Potential for Sediment Passing Reservoirs and Reaches
  - Potential for Bed Material Change
  - Potential Change to Width to Depth Ratio
  - Potential Changes to Navigation Channel Dredging Volumes

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River Mechanics Metrics

- Operational measures were estimated to cause Negligible to Minor relative effects to River Mechanics metrics in most sub-reaches.
- Increased flow does not necessarily influence River Mechanics metrics in backwater controlled reaches due to flattening of water surface slope.
- The duration of operational stage has a much stronger influence than flow magnitude on River Mechanics metrics in backwater controlled reaches.
- The only Major relative effects would result from the embankment breaching structural measure under MO3.

River Mechanics Storage Project Metrics: Reaches were estimated relative impacts are > Negligible.

Metric	MO1	MO2	MO3	MO4	PA
Head of Reservoir Mobilization	**Minor:** Grand Coulee	**Minor:** Dworshak	*Lower Snake***	**Minor:** Grand Coulee & John Day	**Minor:** Libby & John Day
Trap Efficiency	None	None		None	None
Shoreline Exposure	None	**Minor:** Dworshak		**Minor:** Hungry Horse	None

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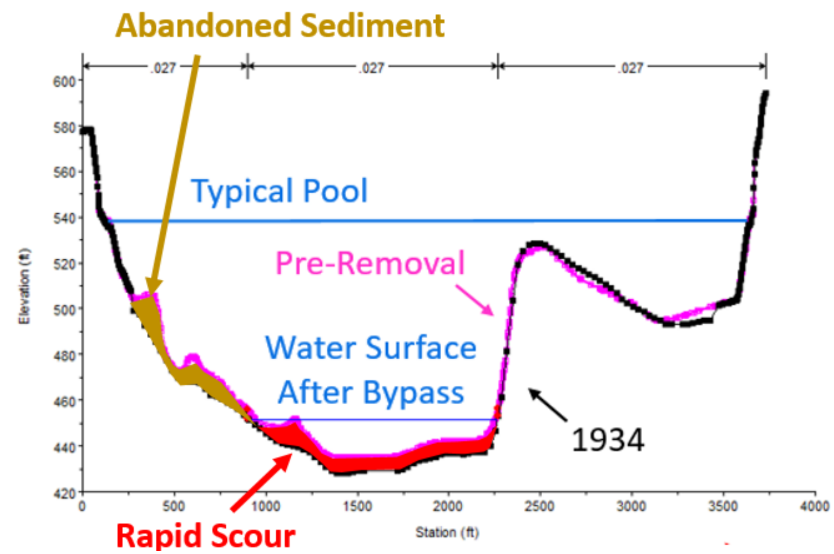
River Mechanics Run-of-River & Free-Flowing Reach Metrics: Reaches were estimated relative impacts are > Negligible.

Metric	MO1	MO2	MO3	MO4	PA
Sediment Passing Potential	**Minor:** Lower Clearwater[10.11]	None	**Major:** Snake – Lower Snake & Lower Clearwater[6, 7, 8, 9, 10.11, 11.11]	**Minor:** Northport Reach[21.14], Upper Lake Roosevelt[21.13]	None
Bed Material Change Potential	**Minor:** Upper Lake Roosevelt Pool[21.13]	**Minor:** Lower Flathead below Stillwater[28.13], Upper Lake Roosevelt[21.13]	**Minor:** Flathead - Polson to SKQ[28.11] **Major:** Snake – Lower Snake & Lower Clearwater[6, 7, 8, 9, 10.11, 11.11]	**Minor:** Lake Roosevelt Pool[21.], Ice Harbor Tailrace[6.11], Lower Columbia Snake Confluence to Wallula[5.12], Upper John Day Pool[4.12], Dalles Pool[3.], The Dalles to Bonneville Dam[2.]	**Minor:** Upper John Day Pool[4.12]
Geomorphic Change Potential	None	None	**Major:** Snake – Lower Snake & Lower Clearwater[6, 7, 8, 9, 10.11, 11.11]	None	None
Navigation Dredging Volumes	None	None	*None***	None	None

MO3 – Snake River Sediment - Draw Down & Embankment Removal

- Removal plan assumed consistent with 2002 EIS.
  - Year 1:LWG & LGS. Year 2: LMN & IHR
- Reservoir draw-down @ 2ft/day followed by embankment breaching.
- Rapid scour of fine grained sediment.
- Abandoned sediment deposits would remain on high banks and terraces.
- Suspended Sediment Concentrations would increase during both reservoir drawdown and embankment removal.
- Removal Sequence Re-Deposition between Years 1 & 2.



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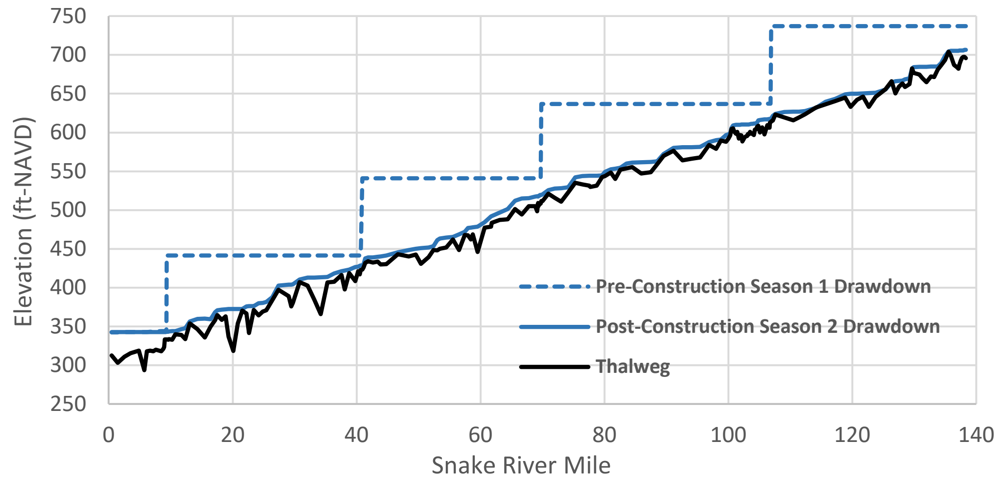
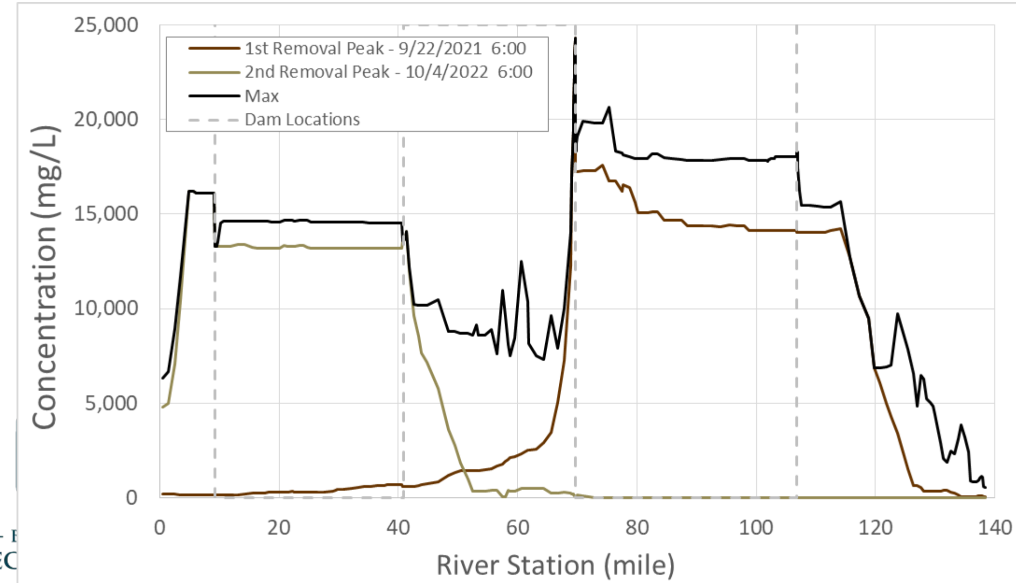
MO3 - Snake River Sediment – 2 Year Period: Draw Down & Embankment Removal

	First Year Dam Removals	Second Year Dam Removals
Peak Concentration	24,300 mg/L	16,100 mg/L
Location of Peak Concentration	River Mile 69.6	River Mile 7.59
Duration >5,000 mg/L	26 days	18 days
Duration >1,000 mg/L	76 days	49 days
Average Conc. Before Removal	1.9 mg/L	2.3 mg/L
Average Conc. After Removal*	30.4 mg/L	32.3 mg/L





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MO3 – Snake River Sediment
Long Term Annual Sediment Loads Following Embankment Removal

- Sediment Composition:
  - Washload: 83% Silt/Clay
  - Bed Material Load: 17% Sand & 0% Gravel.

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MO3 – Snake River Sediment – McNary Reservoir Impacts

	Snake River Sediment Depositing in McNary Reservoir					
	Affected Environment		MO3: Near Term Jul 2021 to Oct 2024		MO3: Long Term Oct 2024 to Oct 2040	
	% of Total	Average Annual Volume (Mcy)	% of Total	Average Annual Volume (Mcy)	% of Total	Average Annual Volume (Mcy)
Clay	28%	0.1	16%	1.9	1%	0.0
Silt	72%	0.3	66%	7.6	70%	1.5
Sand	0%	0.0	18%	2.1	29%	0.6
Gravel	0%	0.0	0%	0.0	0%	0.0
Total	**100%**	**0.4**	**100%**	**11.6**	**100%**	**2.1**

Snake River Sediment Impact to McNary Reservoir Volume		
	MO3: Near Term Jul 2021 to Oct 2024	MO3: Long Term Jul 2021 to Oct 2040
Depositional Volume (Mcy)	25.6	64.1
% of Normal Operation Pool Volume downstream of Snake River Confluence	1.6%	4.0%

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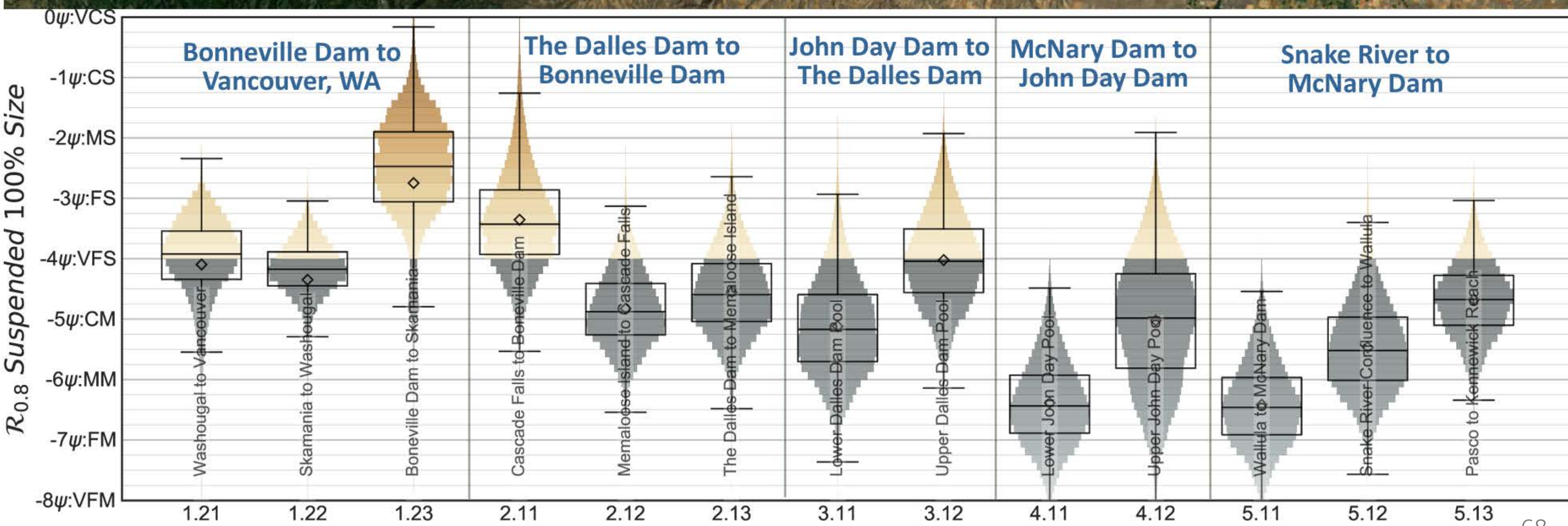
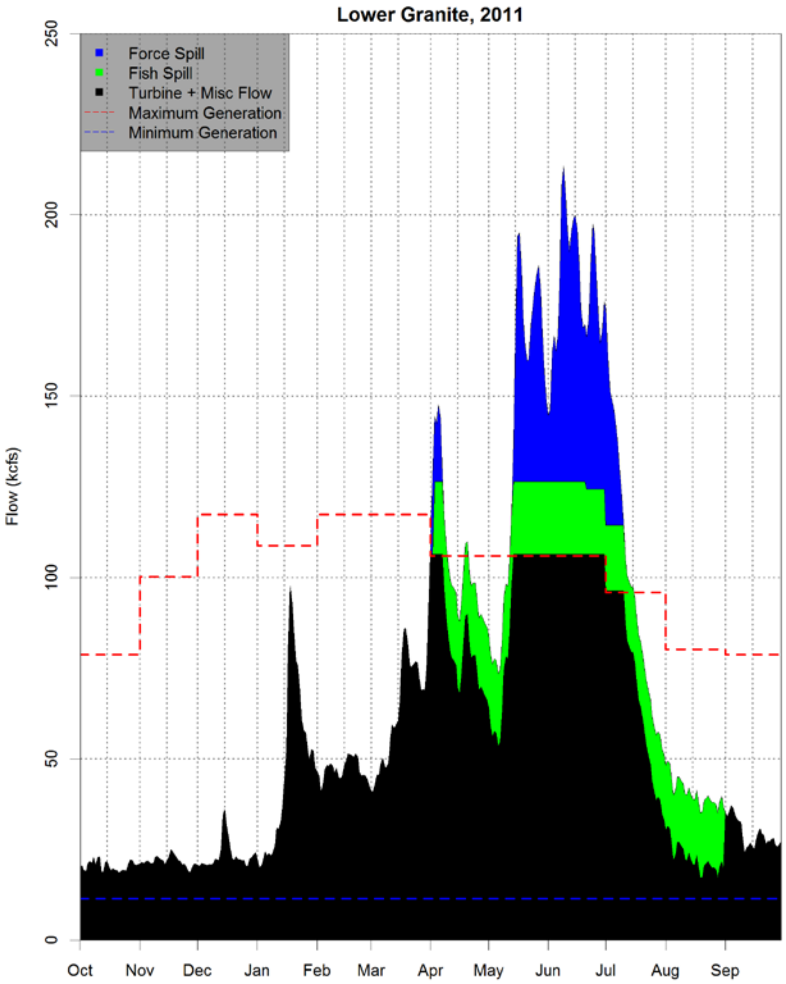
Columbia River Sediment – 100% Suspended Threshold Grain Size by Subreach



H&H Modeling: spill allocation



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CRSO EIS
Water Quality Results

Water Quality Results: Outline

- Overview and Approach
- MO and PA Temperature and TDG results
- Dam Breaching (MO3): Temperature impact
- Dam Breaching (MO3): Dissolved Oxygen
- MO1: Temperature impact of Dworshak operation

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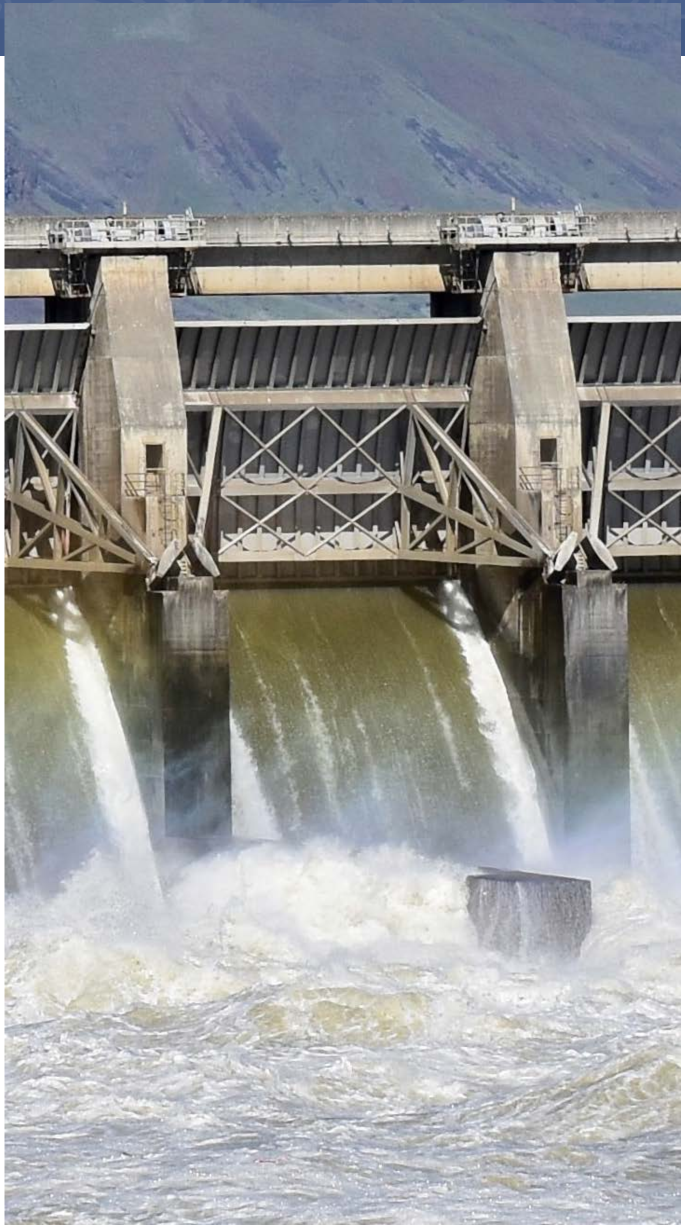
Overview

TOTAL DISSOLVED GAS (TDG)

- Amount of gas present in water.
- Supersaturation of gasses can cause gas bubble trauma to fish.
- Similar risks occur for SCUBA divers, often referred to as “the bends.”
- Primary source is flow through the dams’ spillways.

WATER TEMPERATURE

- Mostly natural sources of heat (e.g. solar and long wave radiation).
- Too warm in many locations.
- Long-term warming trends 0.5 °F (0.3 °C) per decade.
- Dams change the temperature by forming reservoirs resulting in warmer and cooler temperatures, depending on time of day, depth, season and location.



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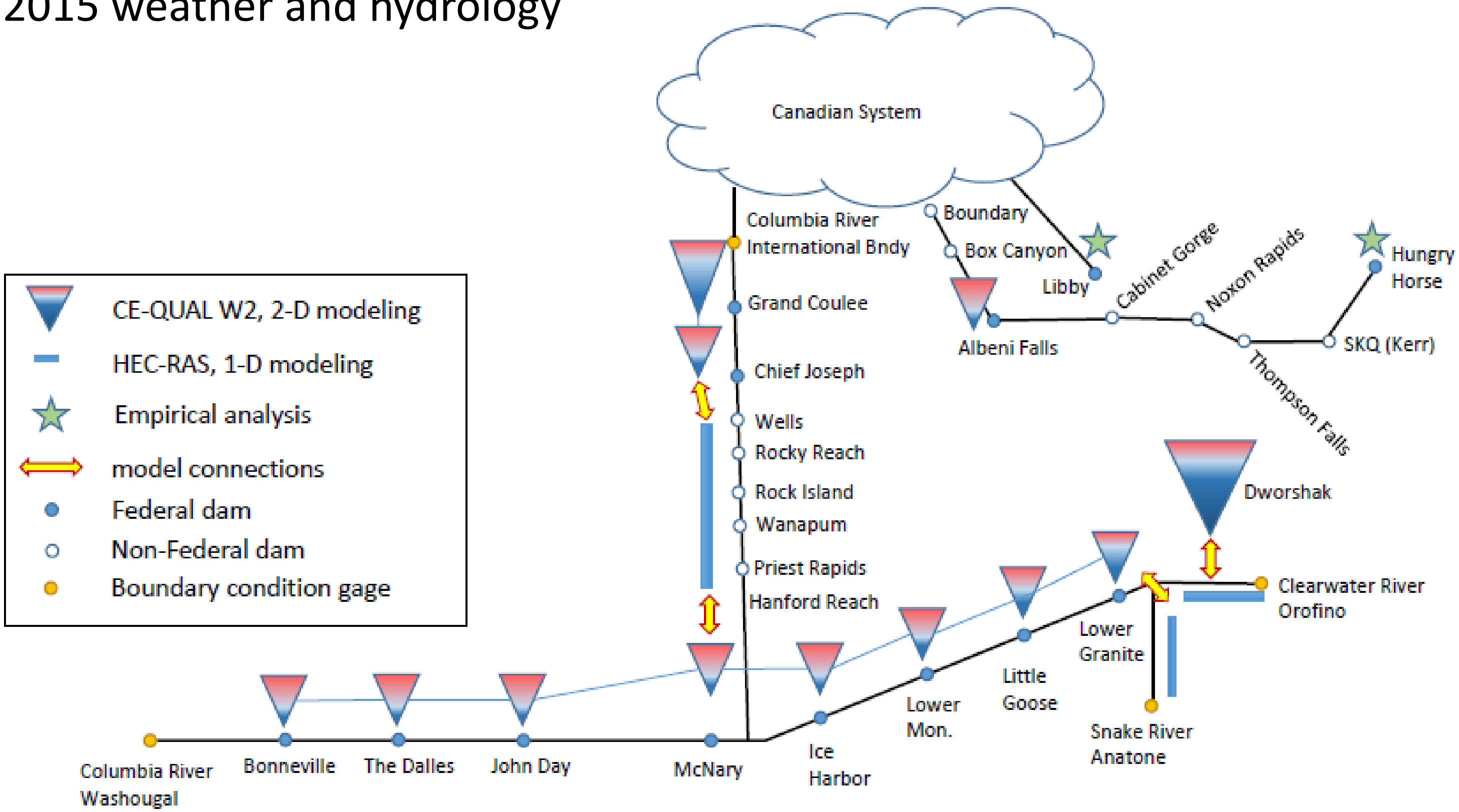
CRSO Water Quality Model Framework for NAA, MO1, MO2, MO4 & PA

2011 – 2015 weather and hydrology



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System Water Quality Calibration Model

Calibration years of 2011, 2014, 2015.

Hourly observations:

- Meteorology
- Flow, spill, powerhouse
- Water surface elevation
- Water temperature data - strings and gauges
- TDG data: fixed monitoring stations
- Spill patterns
- Bathymetry

Same TDG generation equations as SYSTDG

Year	Water Temperature (1-Dmax °C)		TDG (WA method, % saturation		Water supply, Apr-Sep (% of normal)*		Air Temperature (% of average)**	Water temperature	TDG
	Average of sites, # > 20	*Average of sites, maximum*	*Average of sites, # exceed 120%*	*Average of sites, maximum*	*LWG*	*TDA*	*Maximum of the mean monthly air temperature*	*# TW sites*	*# TW sites*
1995	52	22.2	8	127	109	100	98%	6	3
1996	41	21.9	66	135	140	126	103%	6	3
1997	42	21.7	78	140	171	152	100%	6	3
1998	67	23.4	36	137	119	104	105%	8	3
1999	30	21.5	23	131	129	127	100%	7	3
2000	41	21.9	11	125	89	98	99%	7	3
2001	50	22.2	1	118	56	62	103%	9	3
2002	35	21.2	7	121	93	108	104%	10	5
2003	47	22.1	10	133	86	85	106%	10	6
2004	44	22	3	121	81	87	102%	10	10
2005	36	21.3	4	138	70	78	101%	11	11
2006	44	21.8	30	134	123	110	105%	11	11
2007	41	21.2	4	120	65	90	107%	11	11
2008	24	20.7	26	129	116	106	100%	11	11
2009	40	21.5	10	126	116	94	102%	11	11
2010	28	21.1	10	129	93	90	99%	11	11
2011	26	20.7	47	136	164	143	100%	11	11
2012	28	20.8	30	130	111	134	102%	11	11
2013	49	21.5	6	123	70	100	105%	11	11
2014	43	21.3	8	124	98	108	106%	11	11
2015	54	22.1	0	119	56	69	102%	11	11
2016	40	21.3	4	126	83	89	100%	11	11

*(NWRFC 2017)
** (NCDC 2017)

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CRSO System Water Quality Model

Temperature and TDG "System" Model for NAA, MOs and PA

Weather and hydrology from 2011 – 2015

Daily reservoir operations

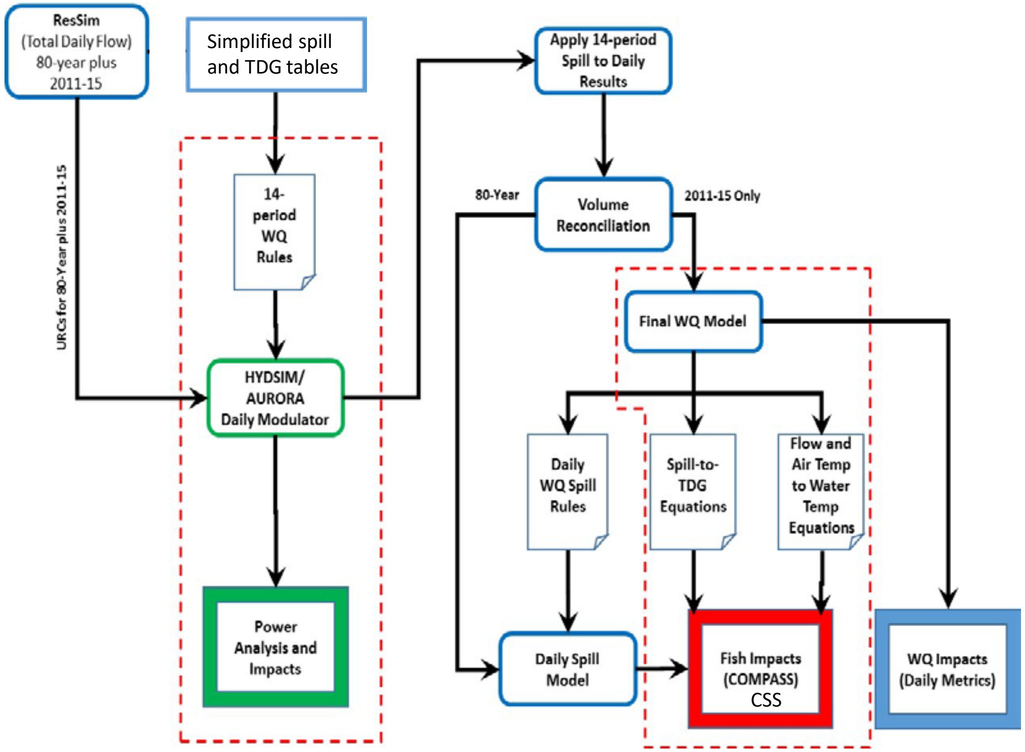
Connects directly:

Reservoir Operations

Power Model

Water Quality

Fish Modeling



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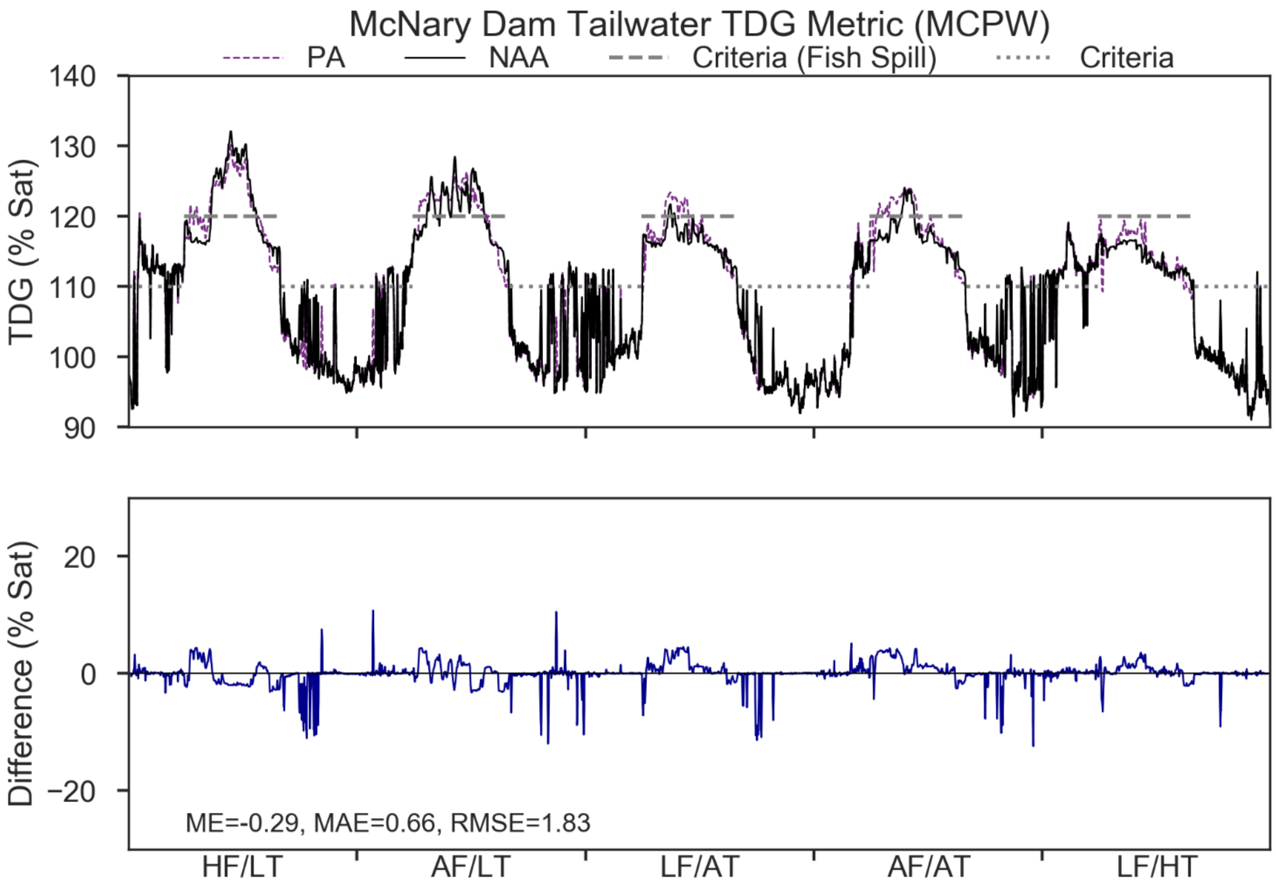
Total Dissolved Gas Results



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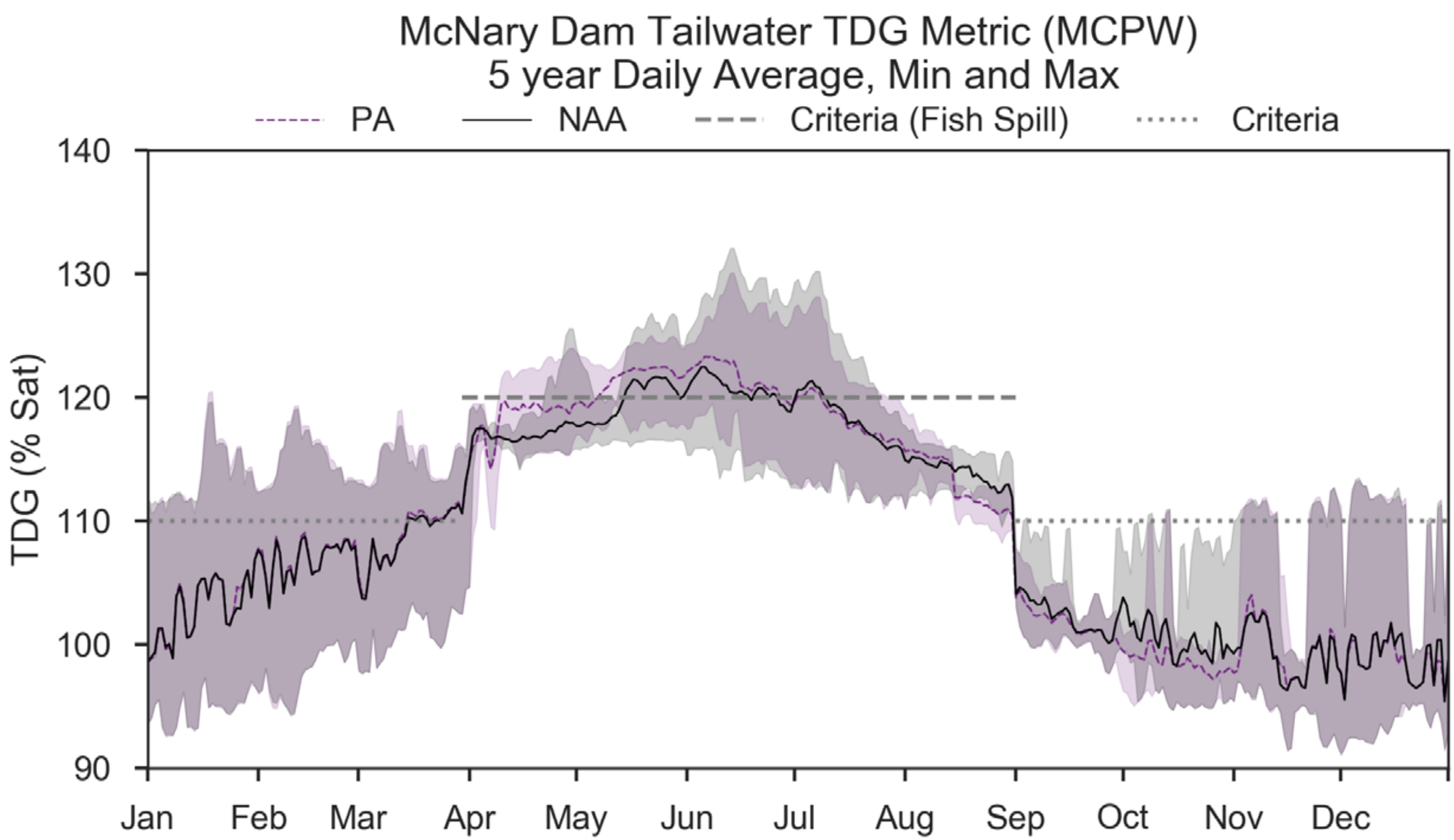
Total Dissolved Gas Results



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Total Dissolved Gas Results

	MO1	MO2	MO3	MO4	PA
Libby	negligible	negligible	negligible	negligible	minor
Hungry Horse	negligible	moderate	negligible	minor	negligible
Albeni Falls	negligible	negligible	negligible	negligible	negligible
Grand Coulee	major	major	major	major	negligible
Chief Joseph	negligible	negligible	negligible	negligible	negligible
Dworshak	negligible	negligible	negligible	negligible	negligible
Lower Granite	negligible	minor	major	major	minor
Little Goose	negligible	negligible	major	major	major
Lower Monumenta	negligible	minor	major	major	moderate
Ice Harbor	negligible	minor	major	moderate	minor
McNary	negligible	minor	minor	negligible	negligible
John Day	negligible	minor	minor	major	minor
The Dalles	negligible	moderate	negligible	moderate	negligible
Bonneville	negligible	negligible	negligible	negligible	negligible

Ranking Considerations:

- Change in annual maximum TDG as compared to No Action
  - < 1% change: negligible
  - > = 1% change: minor
  - > = 2% & < 3% change: moderate
  - > = 3% change: major

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Water Temperature Results

	MO1	MO2	MO3	MO4	PA
Libby	negligible	negligible	negligible	minor	negligible
Hungry Horse	negligible	negligible	negligible	negligible	negligible
Albeni Falls	negligible	negligible	negligible	minor	negligible
Grand Coulee	negligible	negligible	negligible	minor	negligible
Chief Joseph	negligible	negligible	negligible	minor	negligible
Dworshak	negligible	negligible	negligible	negligible	negligible
Lower Granite	major	negligible	major	negligible	negligible
Little Goose	moderate	negligible	major	negligible	negligible
Lower Monumenta	moderate	negligible	major	negligible	negligible
Ice Harbor	negligible	negligible	major	negligible	negligible
McNary	negligible	negligible	minor	minor	negligible
John Day	negligible	negligible	minor	negligible	negligible
The Dalles	negligible	negligible	minor	negligible	negligible
Bonneville	negligible	negligible	negligible	negligible	negligible

Ranking Considerations:

- Absolute change in seasonally averaged maximum and minimum water temperatures
  - <= 0.3°F
  - > 0.3°, but < 1°F
  - > 1°F, but < 2°F
  - > 2°F
- Season or seasons in which changes occur
  - Summer vs. non-summer
- Number of days that water temperatures exceed State water temperature standards (above No Action condition)
  - < 5 days
  - 5 - 10 days
  - > 10 days

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Preferred Alternative: Temperature and Spring TDG

- Results suggest that water temperatures are not notably influenced.

Project	NAA op	NAA Daily average TDG (%)	PA op, Gas Cap (16 hrs) / Performance Standard (8 hours)	PA Daily average TDG (%)	Change in TDG (%)
Lower Granite	20 kcfs	116.2	Spill to 125% TDG / 20 kcfs	120.5	4.3
Little Goose	30%	113.7	Spill to 125% TDG / 30 %	120.3	6.6
Lower Monumental	Spill to 120% / 115% TDG	116.7	Spill to 125% TDG / 30 kcfs	121.5	4.8
Ice Harbor	45 kcfs / 30%	115.0	Spill to 125% TDG / 30 %	120.4	5.5
McNary	40%	119.3	Spill to 125% TDG / 48 %	121.3	2.1
John Day	30% / 40%	117.2	Spill to 120% TDG / 32 %	118.8	1.6
The Dalles	40%	118.8	40%	120.3	1.5
Bonneville	100 kcfs	118.8	150 kcfs / 100 kcfs	120.3	1.5

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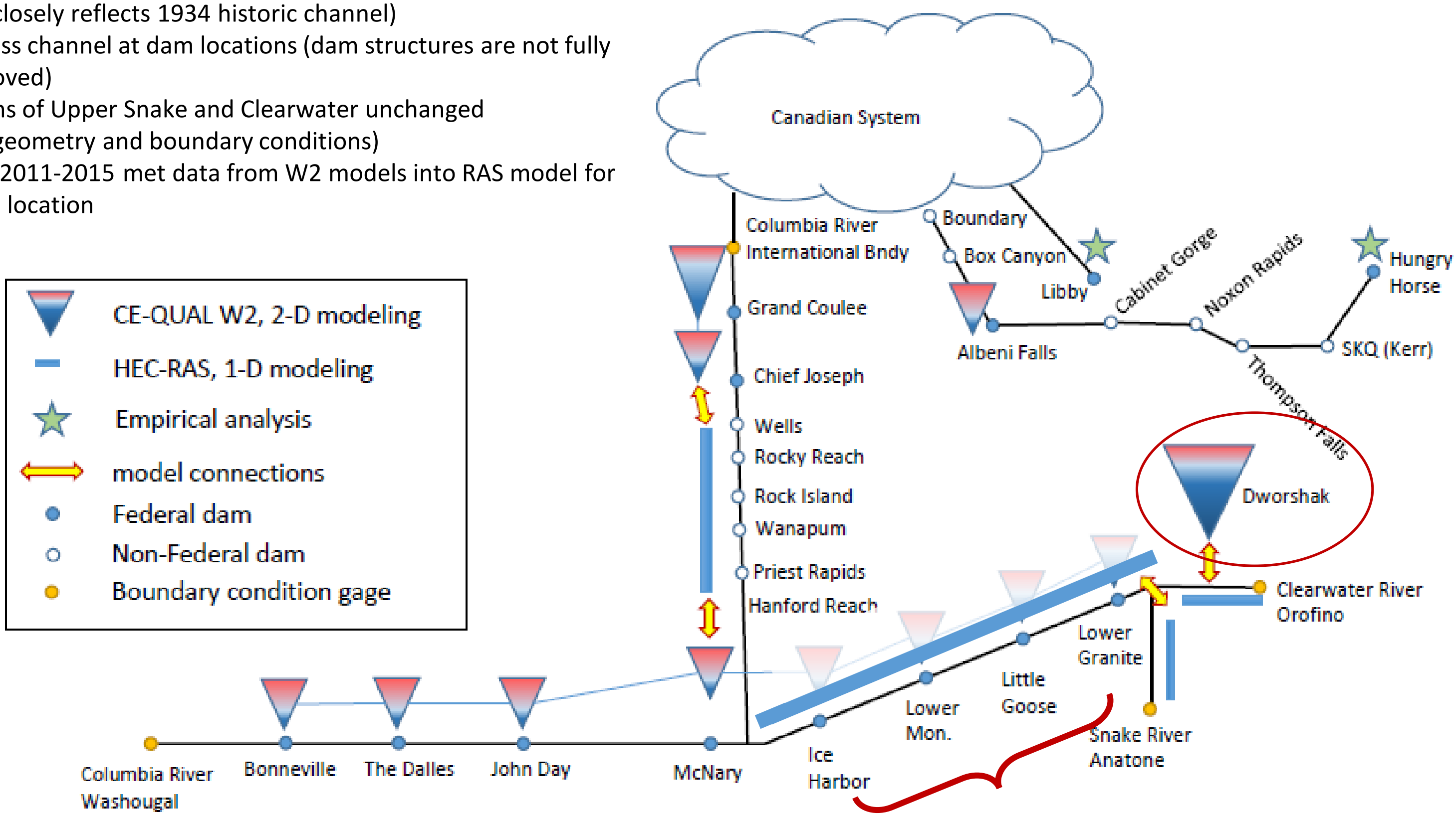
CRSO Water Quality Model Framework for MO3

- Bed geometry from River Mechanics includes:
  - channel shape/length at equilibrium of sediment movement (closely reflects 1934 historic channel)
  - bypass channel at dam locations (dam structures are not fully removed)
- Upper portions of Upper Snake and Clearwater unchanged (geometry and boundary conditions)
- Incorporated 2011-2015 met data from W2 models into RAS model for each LSR dam location



4 LSR 2-D W2 models replaced with 1-D HEC-RAS model

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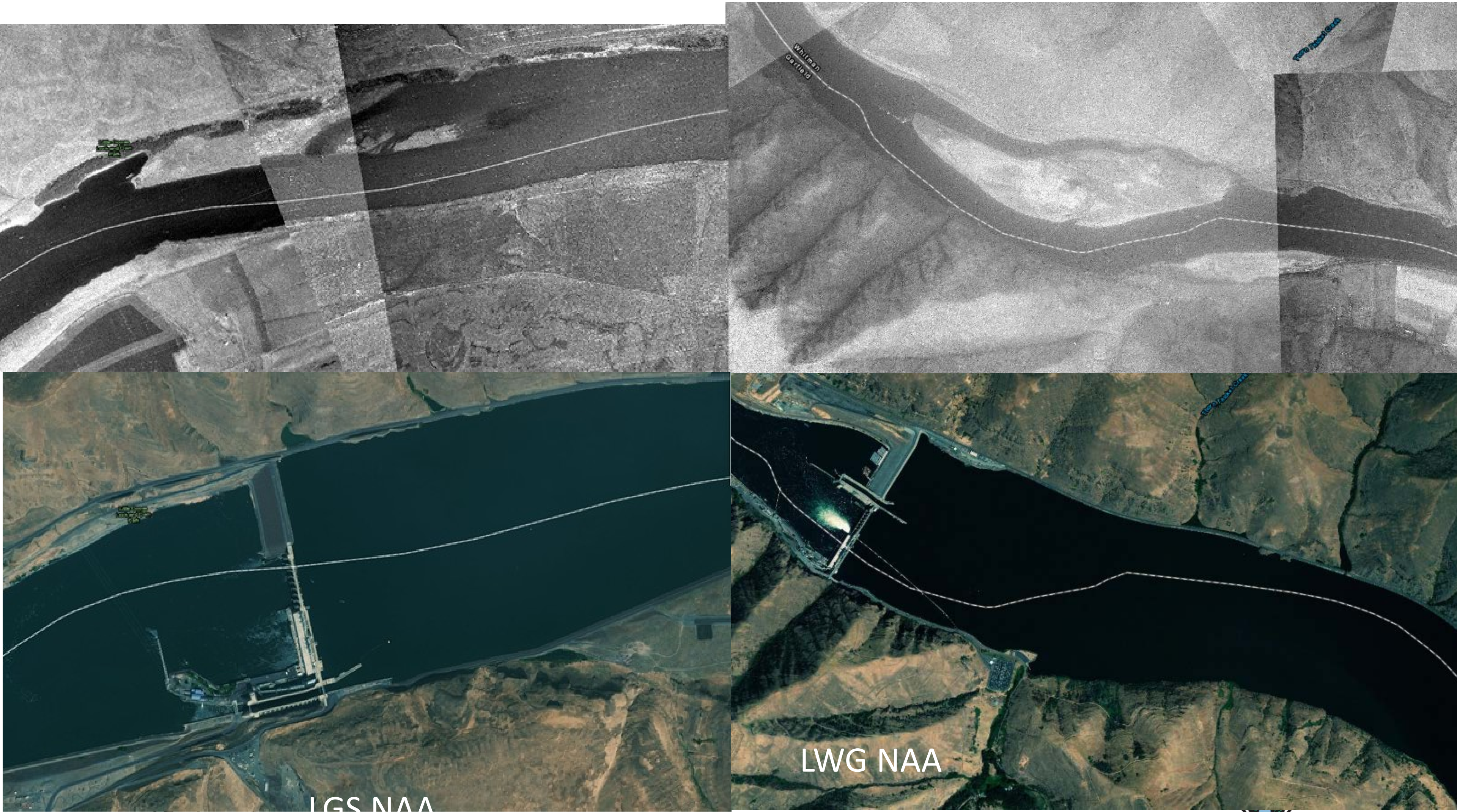
MO3 Dam Breach HEC-RAS temperature model

LGS Pre-dam

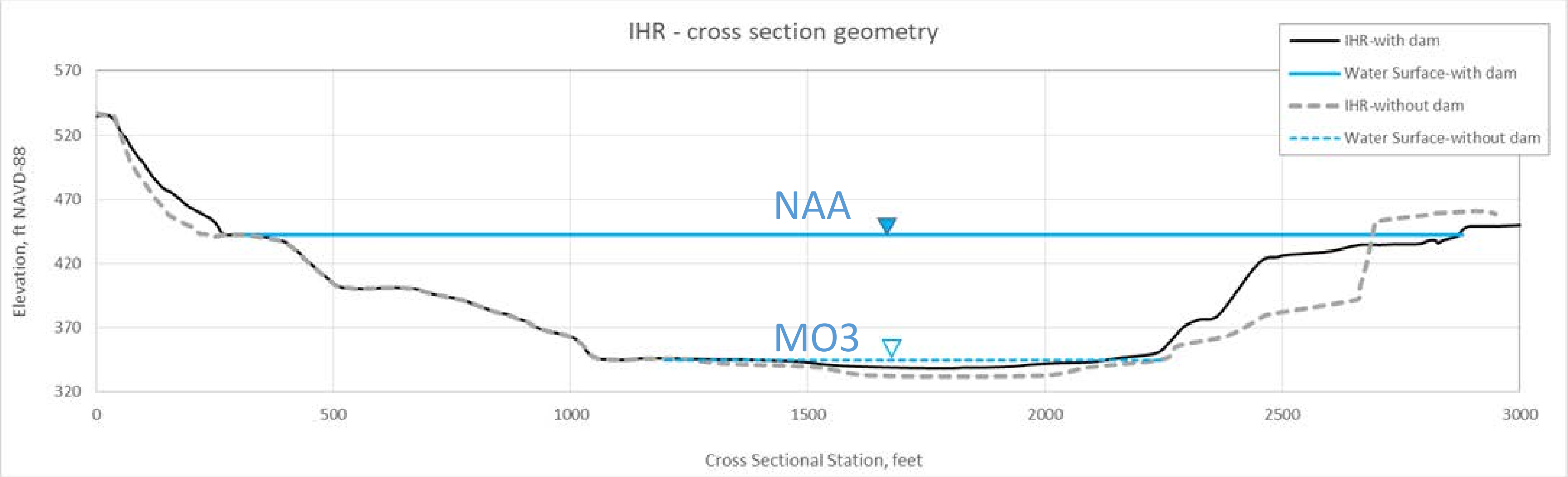
LWG Pre-dam



MO3 Dam Breach HEC-RAS temperature model Grid Comparison

Alternative Comparison on Aug 1, 2015	Streamflow (cfs)	Average Width (ft)	Average Depth (ft)	Water Particle Travel Time (days)
NAA	20,433	2,052	52	25 days
MO3	26,300	894	9	2 days

NAA and MO3 average cross-sections from just upstream of IHR on August 1



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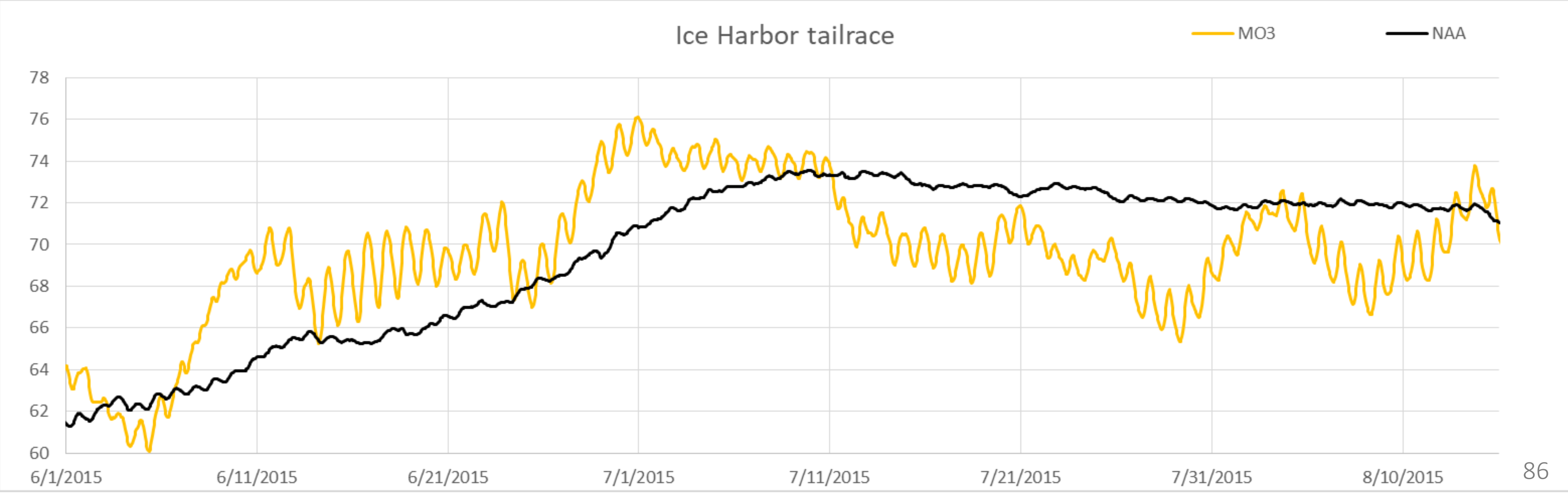
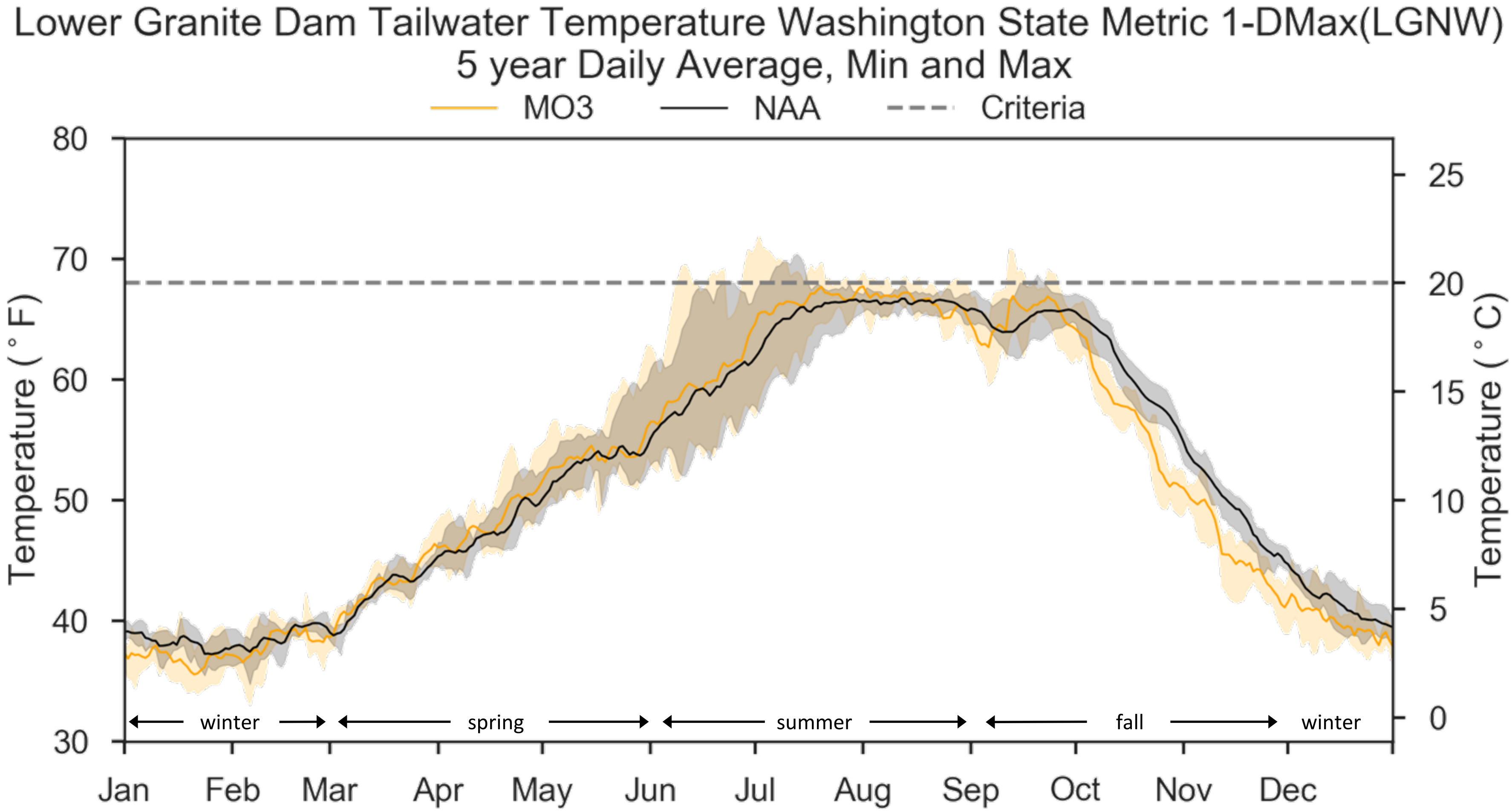
Lower Snake River Water Temperature Results for NAA v. MO3

MO3 as compared to NAA

- More diel variation (within day)
- More day to day variability.
- Greatest impact at Ice Harbor tailwater:
    - Higher highs and lower lows.
    - Annual average temperature 1.7 deg F cooler than NAA.

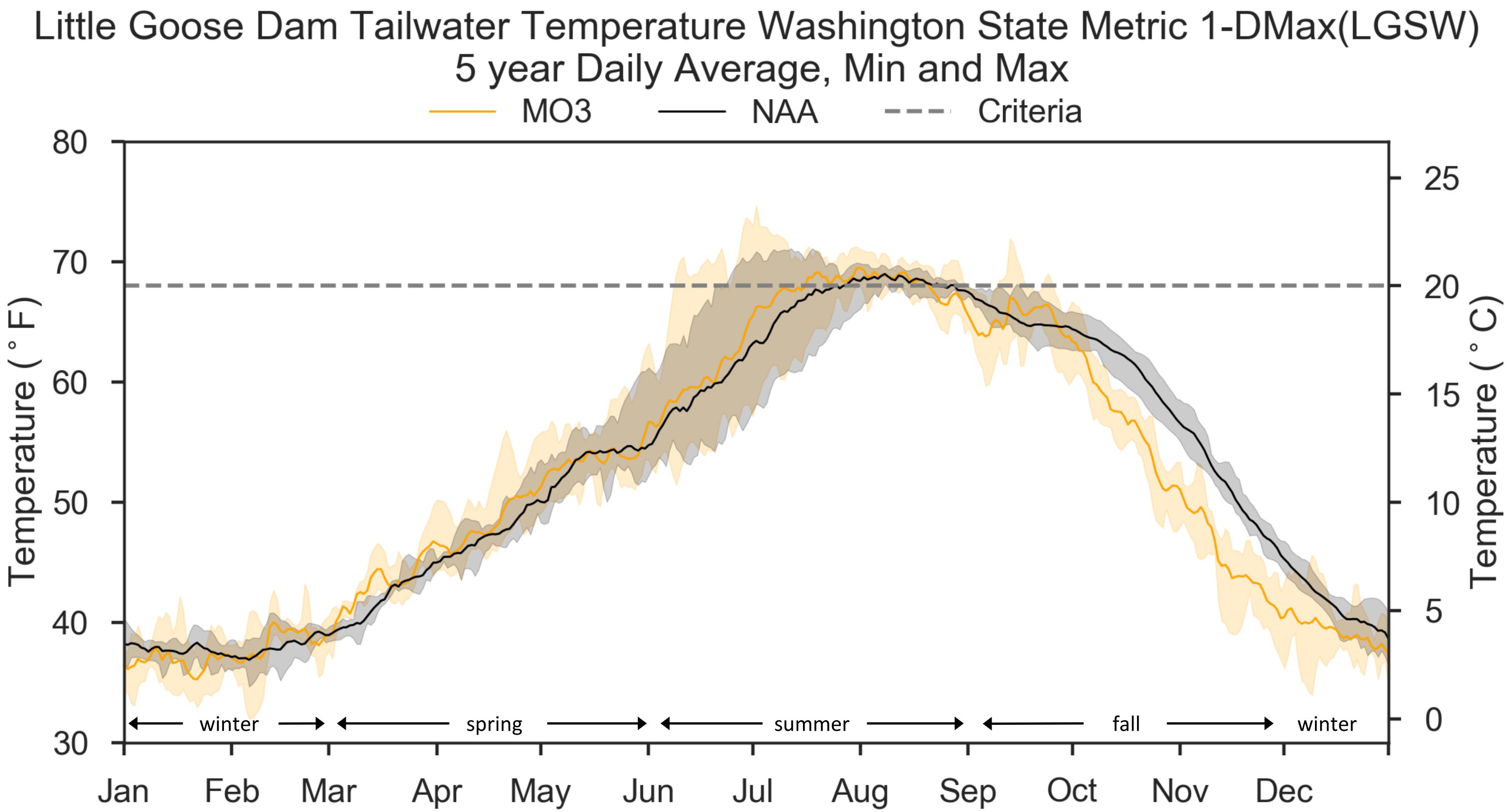




Difference in Lower Granite Tailwater Average Min/Max Seasonal Water Temperatures as Compared to No Action (MO-NAA) and Number of WQS Exceedances Above No Action (MO-NAA)

Lower Granite	MO1		MO2		MO3		MO4		PA	
	min	max	min	max	min	max	min	max	min	max
Winter	0.01	0.00	0.20	0.01	-1.05	0.00	0.00	0.00	0.03	0.00
Spring	0.00	-0.02	0.01	0.37	-0.86	1.25	0.00	0.00	0.00	0.00
Summer	0.04	0.87	-0.07	0.77	-0.93	0.60	-0.02	0.02	-0.03	-0.02
Fall	-0.11	-0.09	-0.01	-0.01	-3.65	-2.45	0.00	0.00	0.00	0.00
# of Days of WQS Exceedance (over NAA)	18		8		12		0		0	

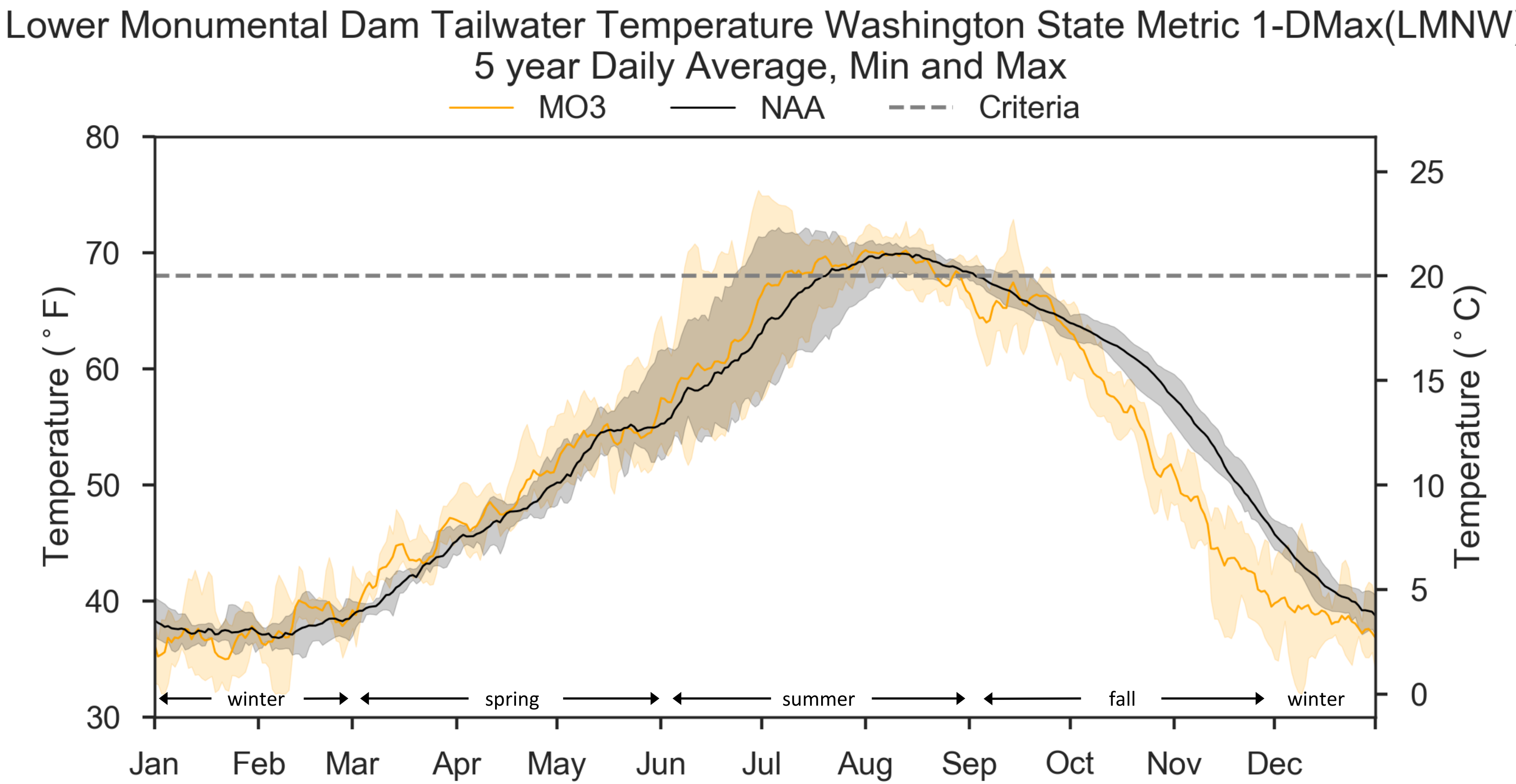
* Negative number indicates that MO is cooler than NAA; positive number indicates that MO is warmer than NAA.



Difference in Little Goose Tailwater Average Min/Max Seasonal Water Temperatures as Compared to No Action (MO-NAA) and Number of WQS Exceedances Above No Action (MO-NAA)

Little Goose	MO1		MO2		MO3		MO4		PA	
	min	max	min	max	min	max	min	max	min	max
Winter	0.01	-0.01	0.13	0.03	-1.10	0.90	0.01	0.01	0.04	0.01
Spring	0.00	0.00	0.01	0.20	-0.78	1.97	0.00	-0.01	0.00	-0.18
Summer	0.25	0.77	-0.06	0.72	-1.83	0.83	-0.01	0.00	0.02	-0.32
Fall	-0.24	-0.22	-0.01	0.00	-6.19	-3.28	0.00	0.00	0.01	-0.01
# of Days of WQS Exceedance (over NAA)	9		2		8		-1		7	

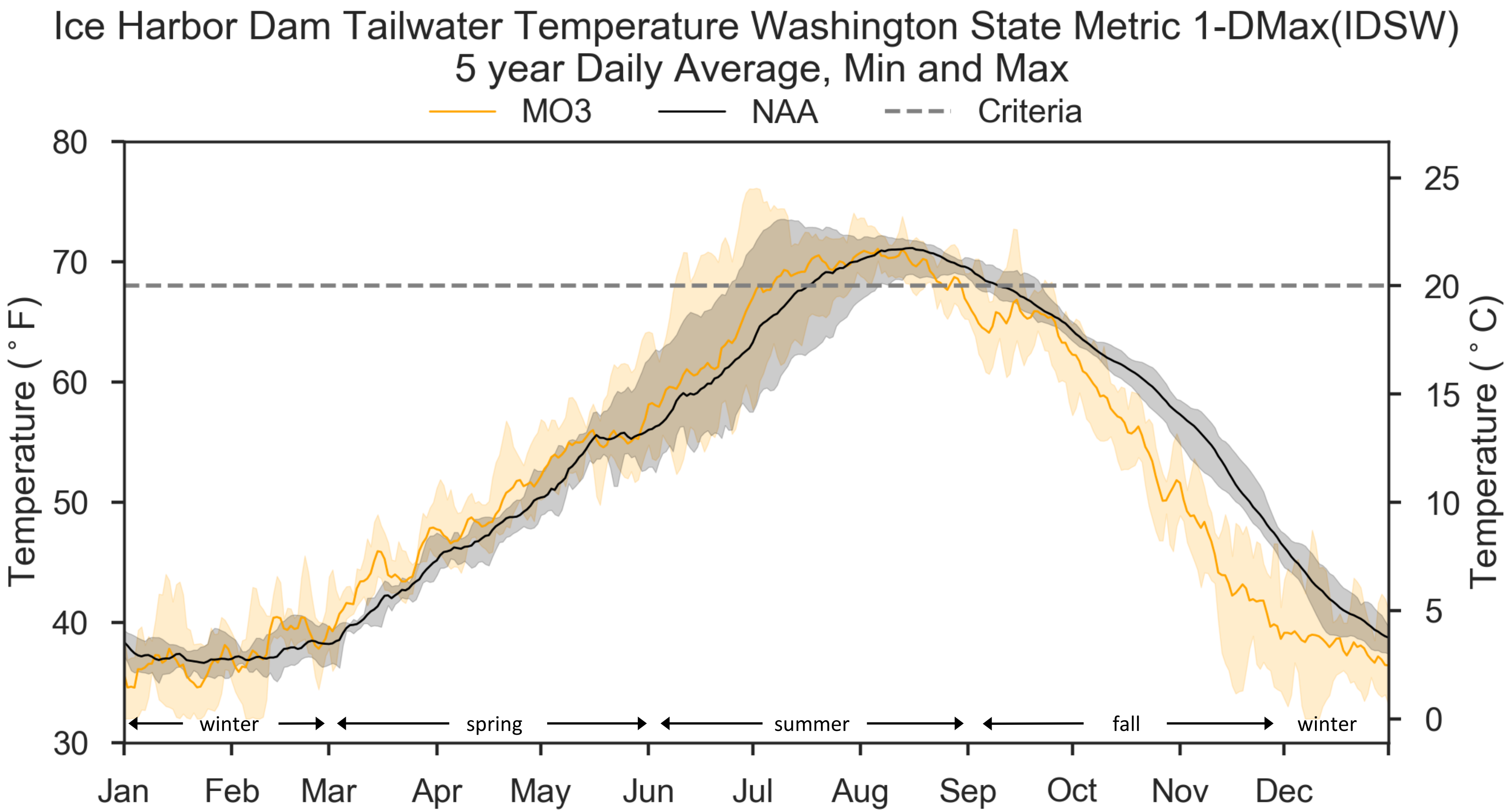
* Negative number indicates that MO is cooler than NAA; positive number indicates that MO is warmer than NAA.



Difference in Lower Monumental Tailwater Average Min/Max Seasonal Water Temperatures as Compared to No Action (MO-NAA) and Number of WQS Exceedances Above No Action (MO-NAA)

Lower Monumental	MO1		MO2		MO3		MO4		PA	
	min	max	min	max	min	max	min	max	min	max
Winter	0.01	0.00	0.07	0.04	-1.23	1.47	0.01	0.00	0.05	0.01
Spring	0.00	0.00	0.01	0.12	-0.67	2.48	0.00	0.00	0.00	-0.08
Summer	0.33	0.65	-0.05	0.60	-2.36	0.70	-0.01	0.00	0.01	-0.18
Fall	-0.28	-0.18	-0.01	0.01	-7.79	-3.38	0.00	0.01	0.00	0.00
Avg # of Days per year WQS Exceedance (as compared to NAA)	7		2		5		0		1	

* Negative number indicates that MO is cooler than NAA; positive number indicates that MO is warmer than NAA.



Difference in Ice Harbor Tailwater Average Min/Max Seasonal Water Temperatures as Compared to No Action (MO-NAA) and Number of WQS Exceedances Above No Action (MO-NAA)

Ice Harbor	MO1		MO2		MO3		MO4		PA	
	min	max	min	Max	min	max	min	max	min	max
Winter	0.00	-0.01	0.10	0.05	-1.24	2.12	0.00	0.00	0.05	0.03
Spring	0.00	-0.08	0.00	0.02	-0.97	2.93	0.00	-0.01	-0.01	-0.05
Summer	0.35	0.34	-0.02	0.41	-2.72	0.11	-0.01	0.00	0.02	-0.09
Fall	-0.22	-0.12	-0.01	0.03	-8.80	-3.26	0.00	0.00	0.01	-0.03
Avg # of Days per year WQS Exceedance (as compared to NAA)	5		2		0		0		0	

* Negative number indicates that MO is cooler than NAA; positive number indicates that MO is warmer than NAA.

MO3 Dam Breach HEC-RAS temperature model Uncertainty

Methods used to reduce and evaluate uncertainty:

- Model calibration, extensively reported elsewhere.
- Sensitivity analysis.
- Comparison to EPA's RBM10.

	Preliminary TMDL Analysis	CRSO EIS Analysis, MO3 specifically
Tools Utilized	RBM10 (1D)	CE-QUAL W2 (2D) & HEC-RAS (1D)
Temperature Metric	Daily average	Daily maximum for WQ impacts; Daily average results for Fish impacts
Period	Calibration: 2007 - 2016 Analysis: 2011 – 2016	2011-2015
Time step	Daily	Hourly
Hydrology/Hydro-Regulation	Observed	Calibration: Observed Analysis: Rule based reservoir regulation
Meteorological Stations	7 total stations	14 total stations
Geographic Extent	No DWR, extends to Col Riv. mouth	See figure.
Focus of Analysis	Analysis is focused on an assessment of the sources of thermal load based on historic operations.	Part of a broader analysis focused on the impacts of operations to biology, hydropower, flood risk, etc.
Baseline Conditions	Existing Conditions: Observed flow and dam operations for 2011-2016.	No Action: 2016 dam operational rules applied for 2011-2015.
No Dams Conditions	The free-flowing scenario has no dams in its study area. DWR is in. 2010 channel bathymetry is utilized throughout system.	Breaching the four lower Snake River dams. 1934 (pre-dam) channel bathymetry is utilized throughout lower Snake River;

MO3 Dam Breach HEC-RAS temperature model Uncertainty: Comparison to RBM10

Direct comparison:

- Worked collaboratively with EPA.
- Apples to apples: daily average, 2011-2015, observed flow, same units.
- Biggest difference in July (averaged)
  - RMB10, 19.2 deg C v HEC-RAS, 20.0 C at IHR

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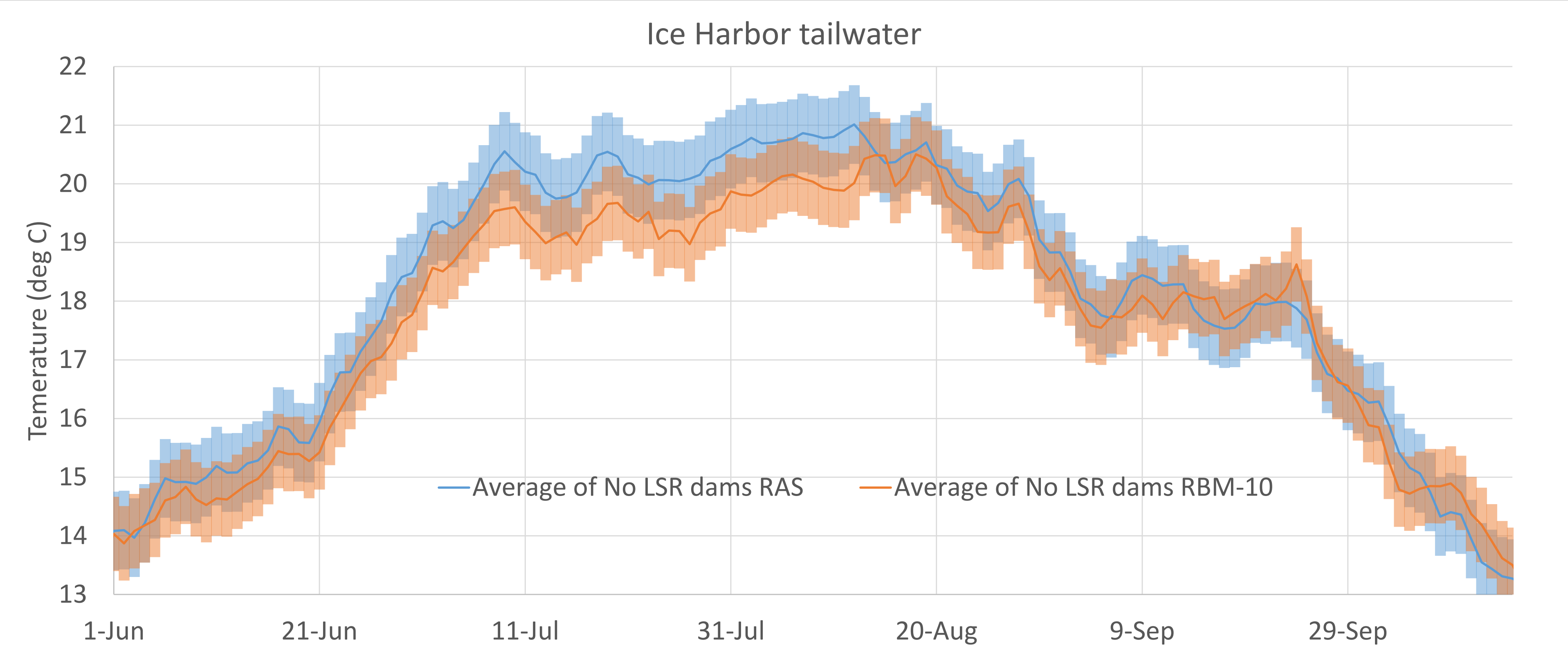
MO3 Dam Breach HEC-RAS temperature model Uncertainty: Comparison to RBM10

No Lower Snake River dam scenario (similar but not MO3)
Average of the daily average predicted temperature, 2011-2015 weather and hydrology



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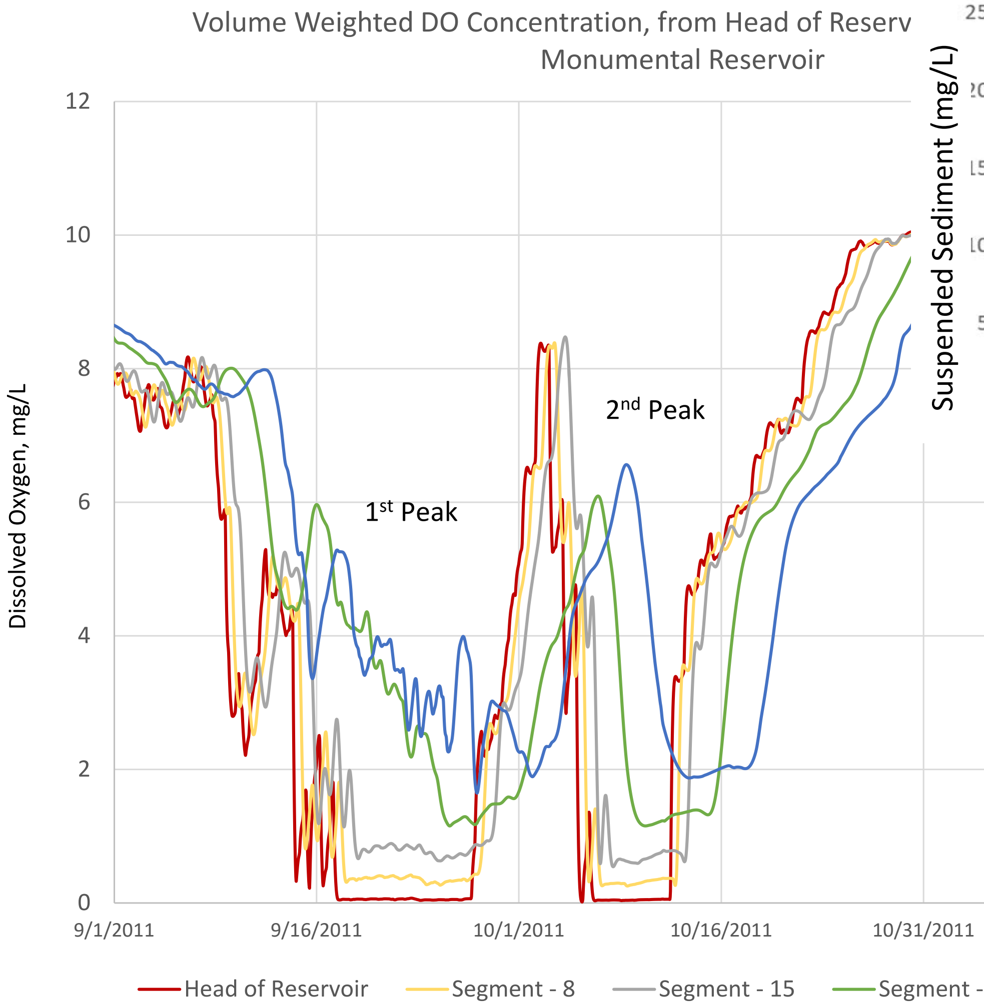
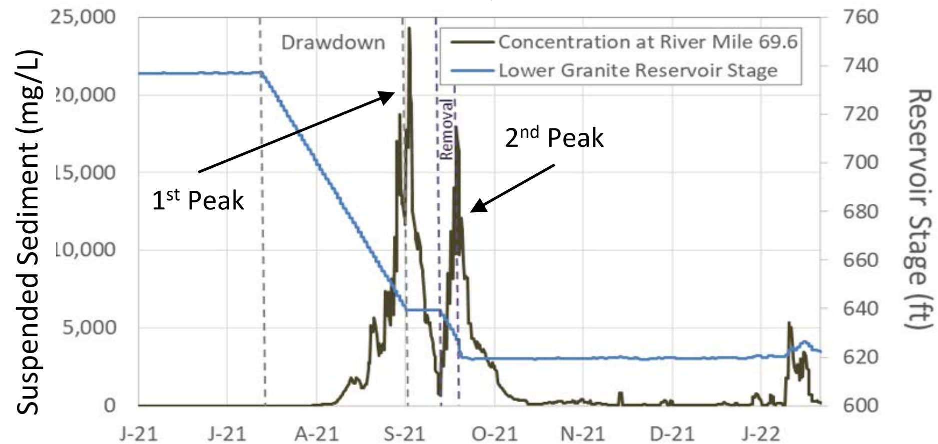
MO3 Dam Breach HEC-RAS temperature model Uncertainty: Comparison to RBM10

Many aspects of the models were evaluated and we reached the following conclusions:

- There are some differences in the equations used in each model to estimate the thermal heat budget.
- Each model was developed to answer different questions and has its advantages and drawbacks.
- Both approaches are transparent and have been documented.
- No errors were found during this model evaluation.
- Some of the perceived differences in the models are likely due to the presentation of results with RBM10 documentation using daily average temperatures and the CRSO WQ model documentation using daily maximum temperatures.
- The difference in model predictions is due to multiple factors and we could not find a simple explanation.
- The temperature predictions by both models are within a reasonable estimate of the uncertainty bounds.

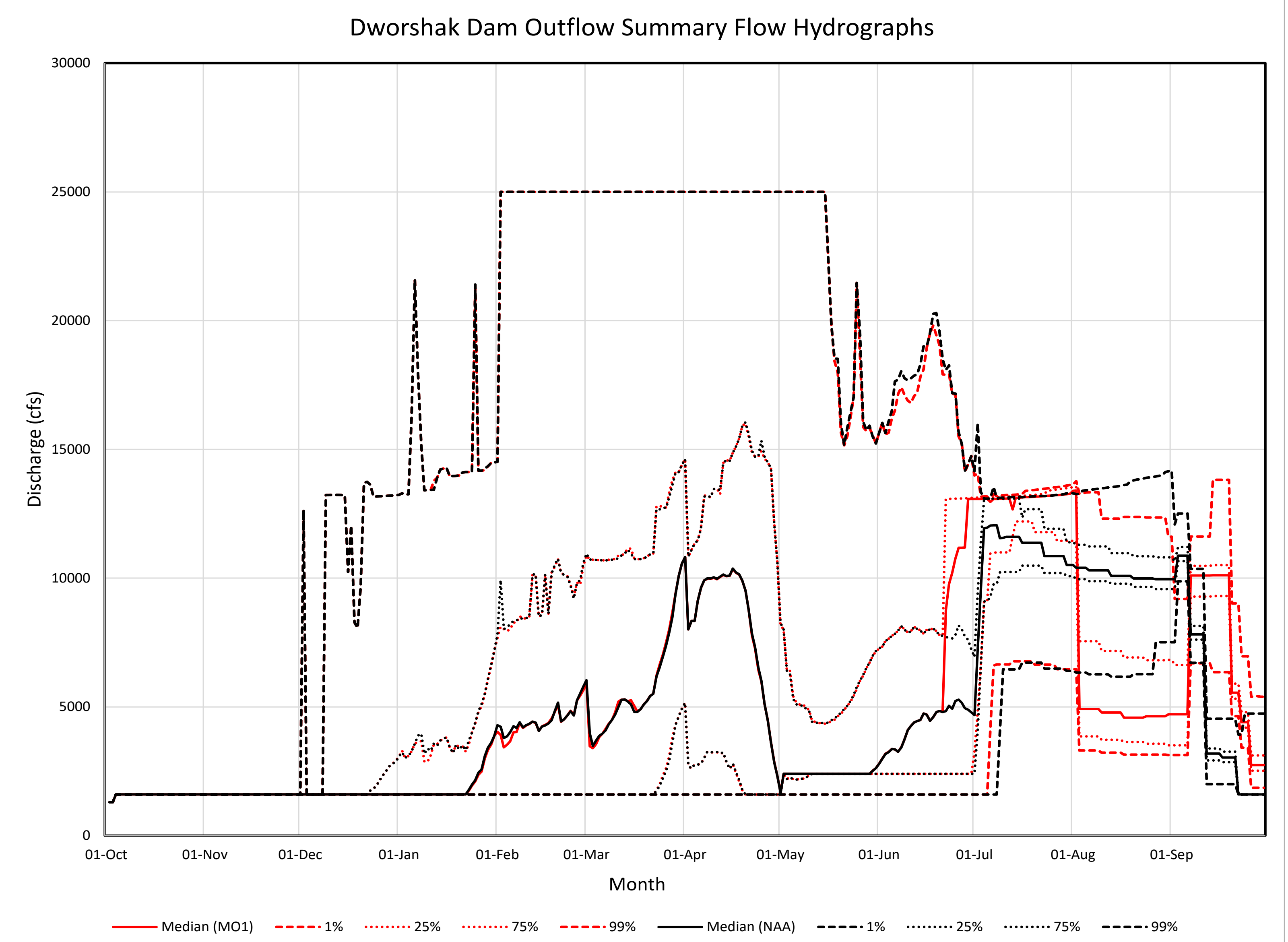
MO3 Dam Breach Estimated DO, Lower Monumental Reservoir Under First Breach



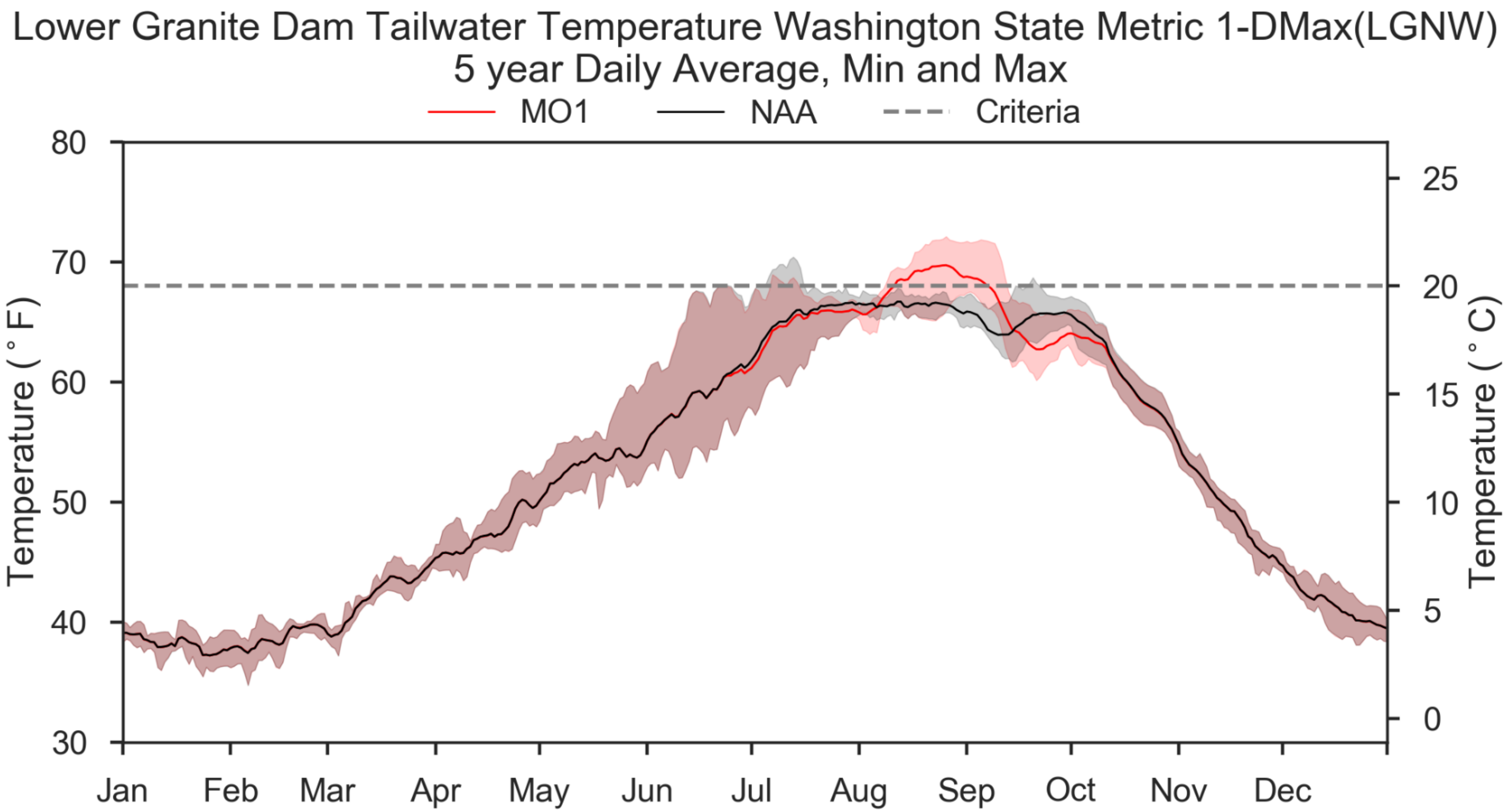


Number of Days DO Below Thresholds in Lower Monumental Reservoir, MO3		
1st Peak	5 mg/L	18-28 days
	2.5 mg/L	9-20 days
2nd Peak	5 mg/L	8-17 days
	2.5 mg/L	6-8 days

MO1 Dworshak operation



MO1 Dworshak operation



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Discussion & Questions

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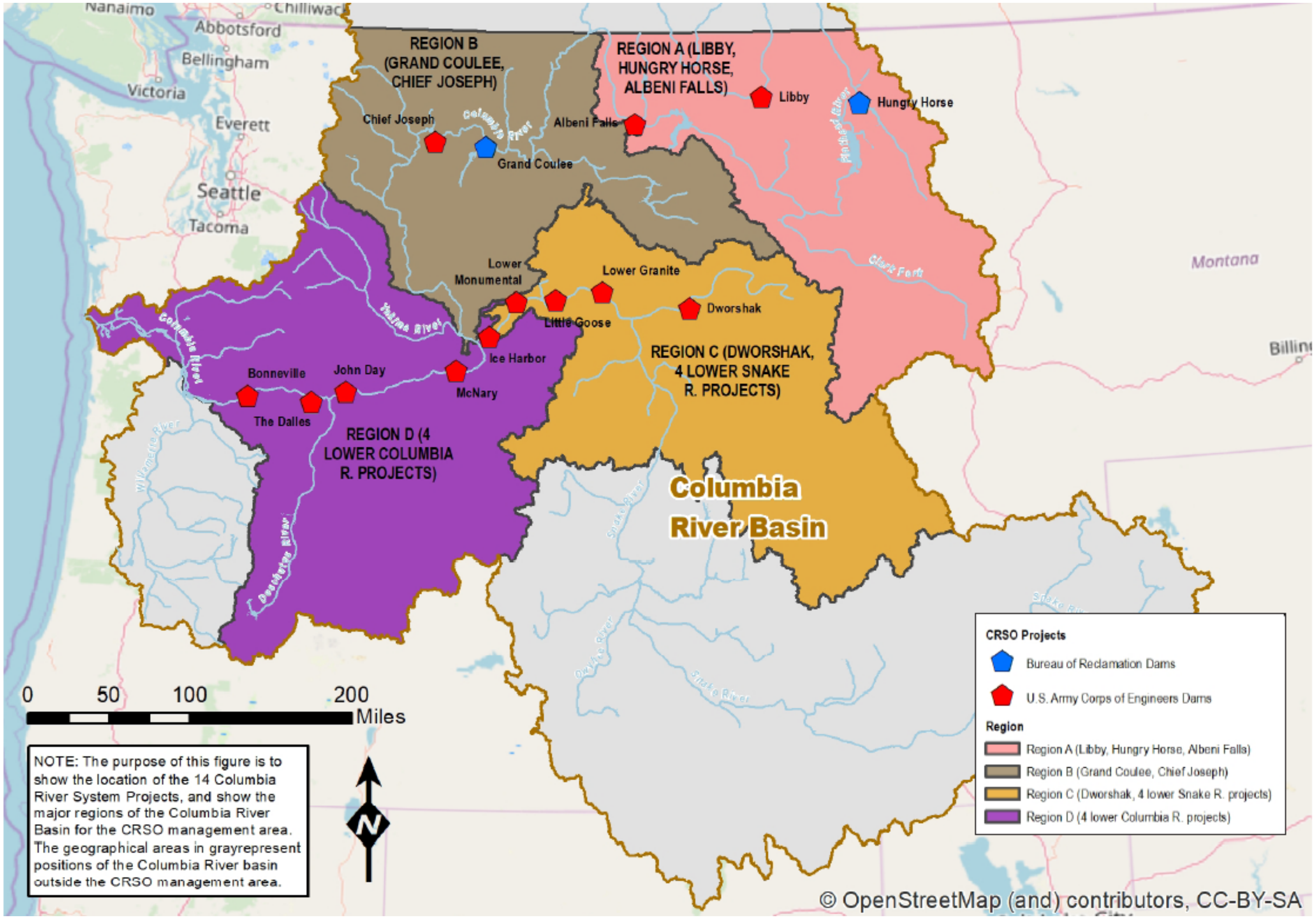
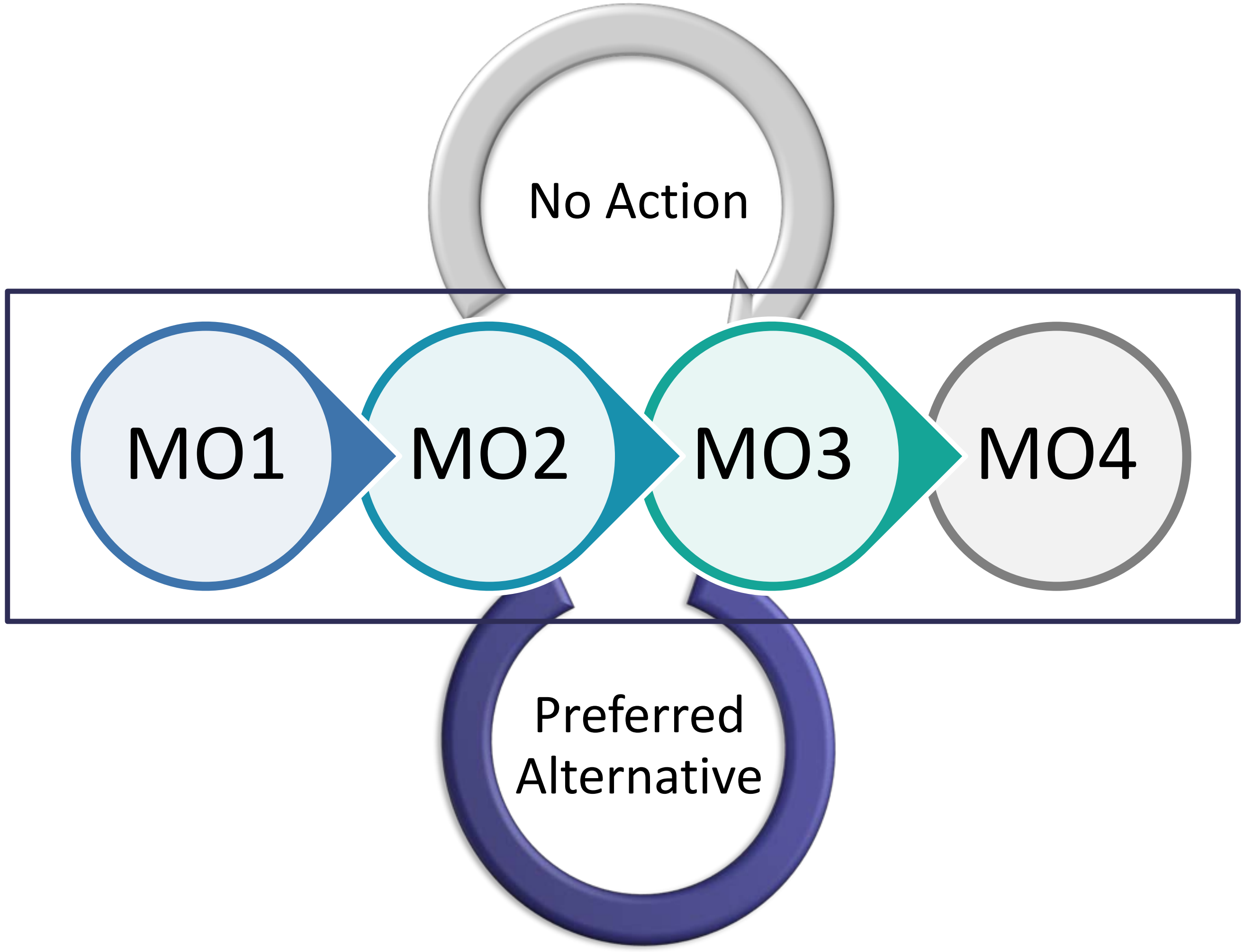
Fish Results

14 CRS Multiple Purpose Dams (projects)



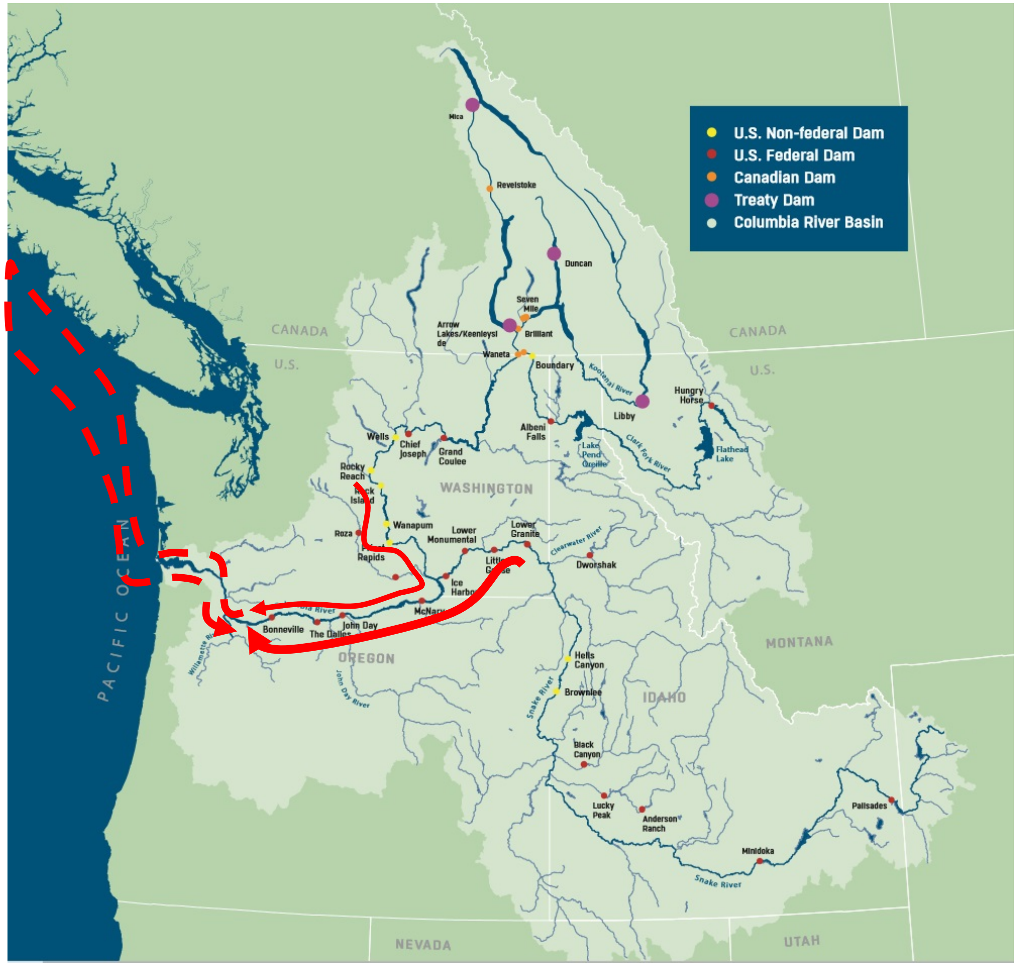
Range of Alternatives



CRSO Analysis of Fish Impacts – Methods and Models Used for Analysis

Species/ESU/DPS	Analysis Methods
Upper Columbia River Spring-Run Chinook Salmon	**COMPASS, NWFSC Life Cycle Model (Wenatchee Population),** TDG Tool, CEM, Qualitative
Upper Columbia River Steelhead	**COMPASS**, TDG Tool, CEM, Qualitative
Upper Columbia River Coho Salmon	UC Spring Chinook surrogate, CEM, Qualitative
Columbia River Sockeye Salmon	UC Spring Chinook surrogate, CEM, Qualitative
Upper Columbia Summer/Fall Chinook Salmon	CEM, Qualitative
Middle Columbia Spring-Run Chinook salmon	UC Spring Chinook surrogate, CEM, Qualitative
Middle Columbia Steelhead	UC Spring Chinook surrogate, CEM, Qualitative
Snake River Spring/Summer Chinook Salmon	**COMPASS, CSS cohort model, NWFSC Life Cycle Model (Upper Salmon, South Fork Salmon, and Middle Fork Salmon MPGs), CSS Life Cycle Model (Grande Ronde/Imnaha MPG)** TDG Tool, CEM, Qualitative
Snake River Steelhead	**COMPASS, CSS cohort model, CSS Life Cycle Model (Grand Ronde/Imnaha MPG),** TDG Tool, CEM, Qualitative
Snake River Coho Salmon	Snake River Spring Chinook Salmon Surrogate, CEM, Qualitative
Snake River Sockeye Salmon	Snake River Spring Chinook Surrogate, CEM, Qualitative
Snake River Fall Chinook Salmon	CEM, Qualitative
Lower Columbia Spring Chinook Salmon	Snake River Spring/Summer-Run Chinook Salmon Surrogate, CEM, Qualitative
Lower Columbia Steelhead	Snake River Steelhead Surrogate, CEM, Qualitative
Lower Columbia River Coho Salmon	Snake River Spring Run Chinook Salmon Surrogate, CEM, Qualitative
Chum Salmon	Snake River Spring Run Chinook Salmon Surrogate, CEM, Qualitative
Pacific Eulachon	CEM, Qualitative
Green Sturgeon	CEM, Qualitative
Pacific Lamprey	CEM, Qualitative
American Shad	Qualitative

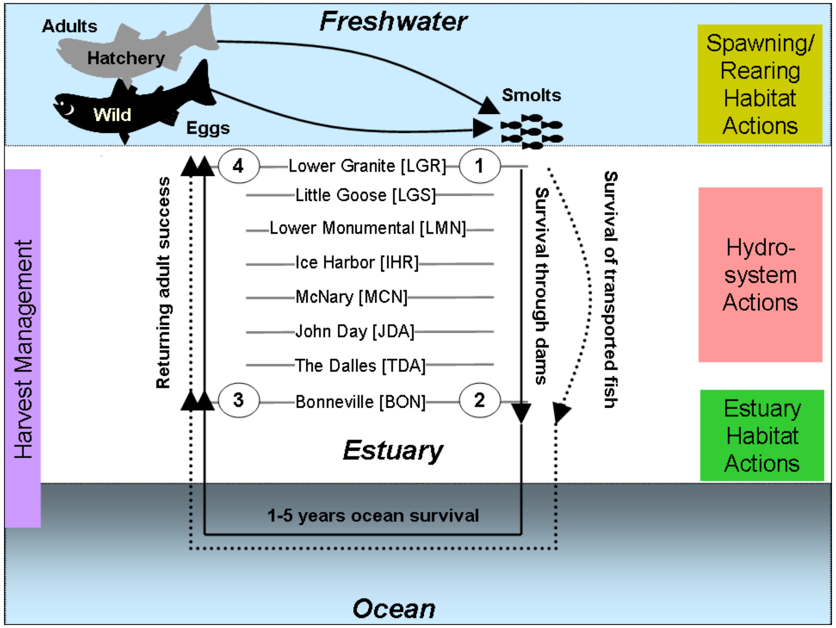
Columbia River System – Areas of quantitative model coverage



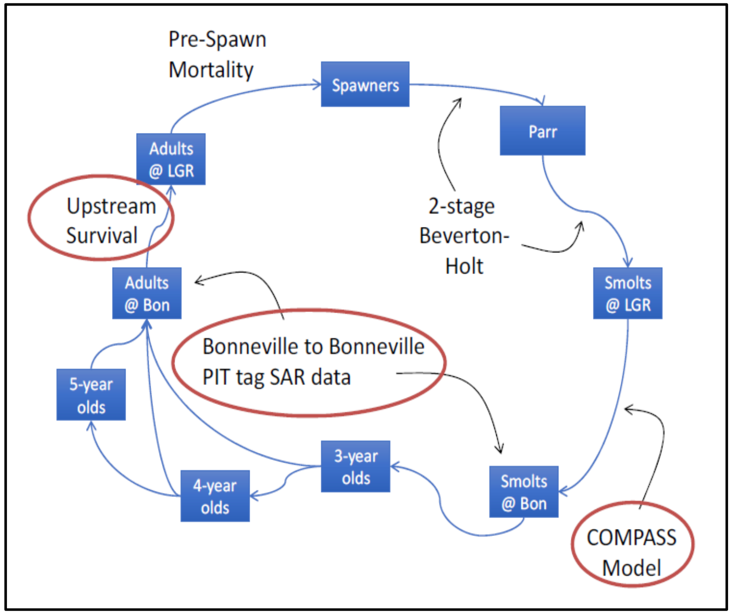
CSS and NOAA use various combinations of hatchery and natural origin fish

Both models use fish tagged specifically for study purpose as well as other studies

Life Cycle Model Analysis



Comparative Survival Study



NMFS - Life Cycle Model

Primary Metrics Used in CRSO Analysis

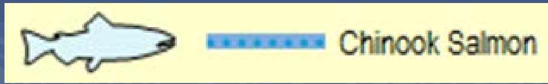
- In-River Survival
- Powerhouse Encounter Rates
- Travel Time (fish and water)
- Transportation Rates
- Smolt to Adult Return Rates

Latent Mortality

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

UCR Spring Chinook Salmon

Anadromous Fish



Absolute & Relative to NAA Values

	NAA	MO1	MO2	MO3	MO4
In-river Survival	LCM 69.5%	70.0% 0%	68.2% -2%	70.1% +1%	71.0% +2%
PITPH	LCM 3.29	3.08 -6%	3.66 +11%	2.89 -12%	2.53 -23%
SARS	LCM 0.94%	0.95% +1%	0.93% -1%	0.95% +1%	0.96% +2%

Chinook Salmon

UCR Spring Chinook Salmon

Anadromous Fish

Absolute & Relative to NAA Values

	NAA	PA	MO1	MO2	MO3	MO4
In-river Survival	LCM 69.5%	70.4% +1%	70.0% -0%	68.2% -2%	70.1% +1%	71.0% +2%
PITPH	LCM 3.29	2.96 -8%	3.08 -6%	3.66 +11%	2.89 -12%	2.53 -23%
SARS	LCM 0.94%	0.97% +3%	0.95% +1%	0.93% -1%	0.95% +1%	0.96% +2%

UCR Steelhead

Anadromous Fish

Steelhead

Absolute & Relative to NAA Values

	NAA	MO1	MO2	MO3	MO4
In-river Survival	LCM 65.8%	65.6% -0%	63.4% -3.5%	65.6% -0%	66.1% +0.4%
PITPH	LCM 2.72	2.59 -5%	2.89 +6%	2.52 -7%	2.31 -15%
SARS	LCM 2.26	N/A	N/A	N/A	N/A

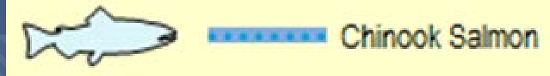
UCR Steelhead

Anadromous Fish

Steelhead

Absolute & Relative to NAA Values

	NAA	PA	MO1	MO2	MO3	MO4
In-River Survival	65.8%	65.7% -0.2%	65.6% -0%	63.4% -3.5%	65.6% -0%	66.1% +0.4%
PITPH	2.72	2.58 -5%	2.59 -5%	2.89 +6%	2.52 -7%	2.31 -15%
SARS	2.26	N/A	N/A	N/A	N/A	N/A



Snake River Spring Chinook Salmon

Anadromous Fish

Absolute & Relative to NAA Values

	NAA	MO1	MO2	MO3	MO4
In-river Survival	CSS 57.6% LCM 50.4%	58.3%/+0.7% 51.0%/+1.1%	53.7%/-6.7% 50.1%/-0.6%	68.2%/+18.4% 60%/+19.0%	63.5%/+10.2% 50.7%/+0.7%
PITPH	CSS 2.15 LCM 2.25	1.74/-19.0% 1.88/-16.0%	3.48/+62.0% 3.02/+34.0%	0.56/-74.0% 0.66/-71.0%	0.34/-84.0% 0.49/-78.0%
SARS	CSS 2.0% LCM 0.88%	2.2%/+10.0% 0.88%/0.0%	1.4%/-30.0% 0.9%/+2.3%	4.3%/+115.0% 1.0%/+13.6%	3.5%/+75.0% 0.8%/-12.5%

Snake River Spring Chinook Salmon

Anadromous Fish

Absolute & Relative to NAA Values

Metric	NAA	PA	MO1	MO2	MO3	MO4
In-river Survival	CSS 57.6% LCM 50.4%	60.5%/+5% 51%/+1%	58.3%/+0.7% 51.0%/+1.1%	53.7%/-6.7% 50.1%/-0.6%	68.2%/+18.4% 60%/+19.0%	63.5%/+10.2% 50.7%/+0.7%
PITPH	CSS 2.15 LCM 2.25	.98/-54% 1.2/-48%	1.74/-19.0% 1.88/-16.0%	3.48/+62.0% 3.02/+34.0%	0.56/-74.0% 0.66/-71.0%	0.34/-84.0% 0.49/-78.0%
SARS	CSS 2.0% LCM 0.88%	2.7%/+35% 0.81%/-7.5%	2.2%/+10.0% 0.88%/0.0%	1.4%/-30.0% 0.9%/+2.3%	4.3%/+115.0% 1.0%/+13.6%	3.5%/+75.0% 0.8%/-12.5%

Snake River Steelhead

Anadromous Fish

Steelhead

Absolute & Relative to NAA Values

	NAA	MO1	MO2	MO3	MO4
In-river Survival	CSS 57.1% LCM 42.7%	58.8%/+2.9% 42.2%/-1.1%	44.4%/-22.2% 40.2%/-6.0%	83.1%/+45.5% 52.7%/+23.3%	73.7%/+29.1% 43.1%/+0.1%
PITPH	CSS 1.96 LCM 1.73	1.64/-16.3% 1.47/-14.7%	3.26/+66.3% 2.26/+30.8%	0.46/-76.5% 0.42/-75.6%	0.28/-85.7% 0.35/-79.9%
SARS	CSS 1.8% LCM N/A	1.9%/+5.6% N/A	1.3%/-27.8% N/A	5.0%/+177.8% N/A	3.1%/+72.2% N/A

Steelhead

Snake River Steelhead

Anadromous Fish

Absolute & Relative to NAA Values

Metric	NAA	PA	MO1	MO2	MO3	MO4
In-river Survival	CSS 57.1% LCM 42.7%	64.5%/+7.4% 42.8%/+0.0%	58.8%/+2.9% 42.2%/-1.1%	44.4%/-22.2% 40.2%/-6.0%	83.1%/+45.5% 52.7%/+23.3%	73.7%/+29.1% 43.1%/+0.1%
PITPH	CSS 1.96 LCM 1.73	0.88/ -35% 0.93/ -46%	1.64/-16.3% 1.47/-14.7%	3.26/+66.3% 2.26/+30.8%	0.46/-76.5% 0.42/-75.6%	0.28/-85.7% 0.35/-79.9%
SARS	CSS 1.8% LCM N/A	2.3% +28% LCM N/A	1.9%/+5.6% N/A	1.3%/-27.8% N/A	5.0%/+177.8% N/A	3.1%/+72.2% N/A

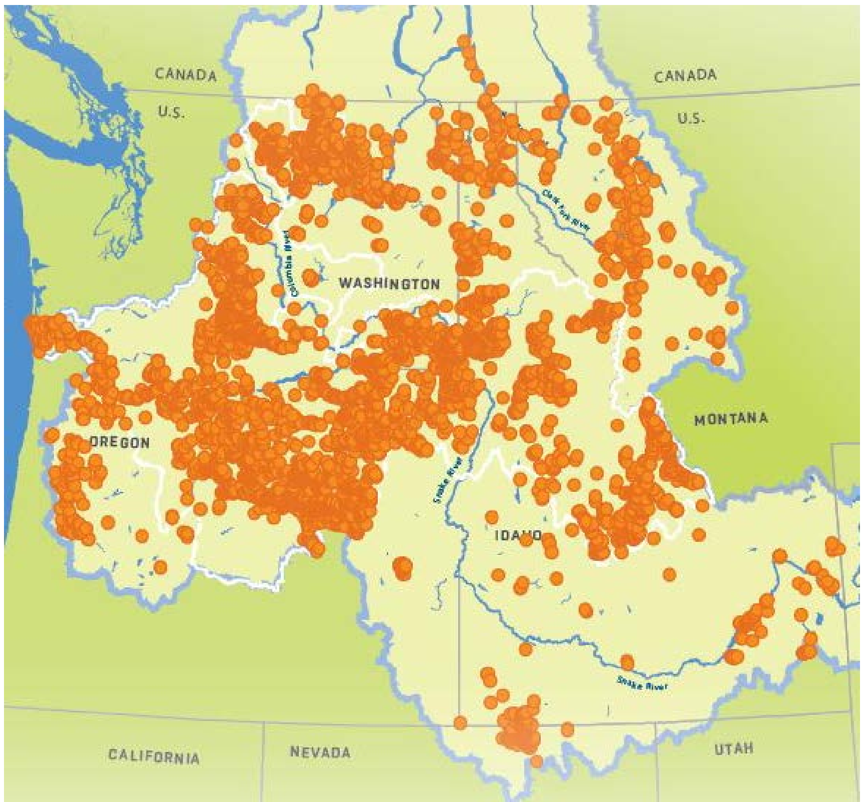
Resident Fish

White Sturgeon
Bull Trout

Effects for multi-species for regions A-D

Qualitative Results	PA	MO1	MO2	MO3	MO4
Region A Upper Basin	Mixed Results Minor +/-	Mixed Results Minor +/-	Moderate -	Mixed Results Minor +/-	Major -
Region B Grand Coulee & Mid-C	**Minor -**	Minor -	Minor -	Mixed Results Minor or moderate +/-	Moderate -
Region C Lower Snake & Salmon	Mixed Results Minor +/-	Minor -	Minor -	Major - then Major +	Minor / Moderate -
Region D Lower Columbia	Mixed Results Minor +/-	Minor -	Moderate -	Minor -	Minor / Moderate -

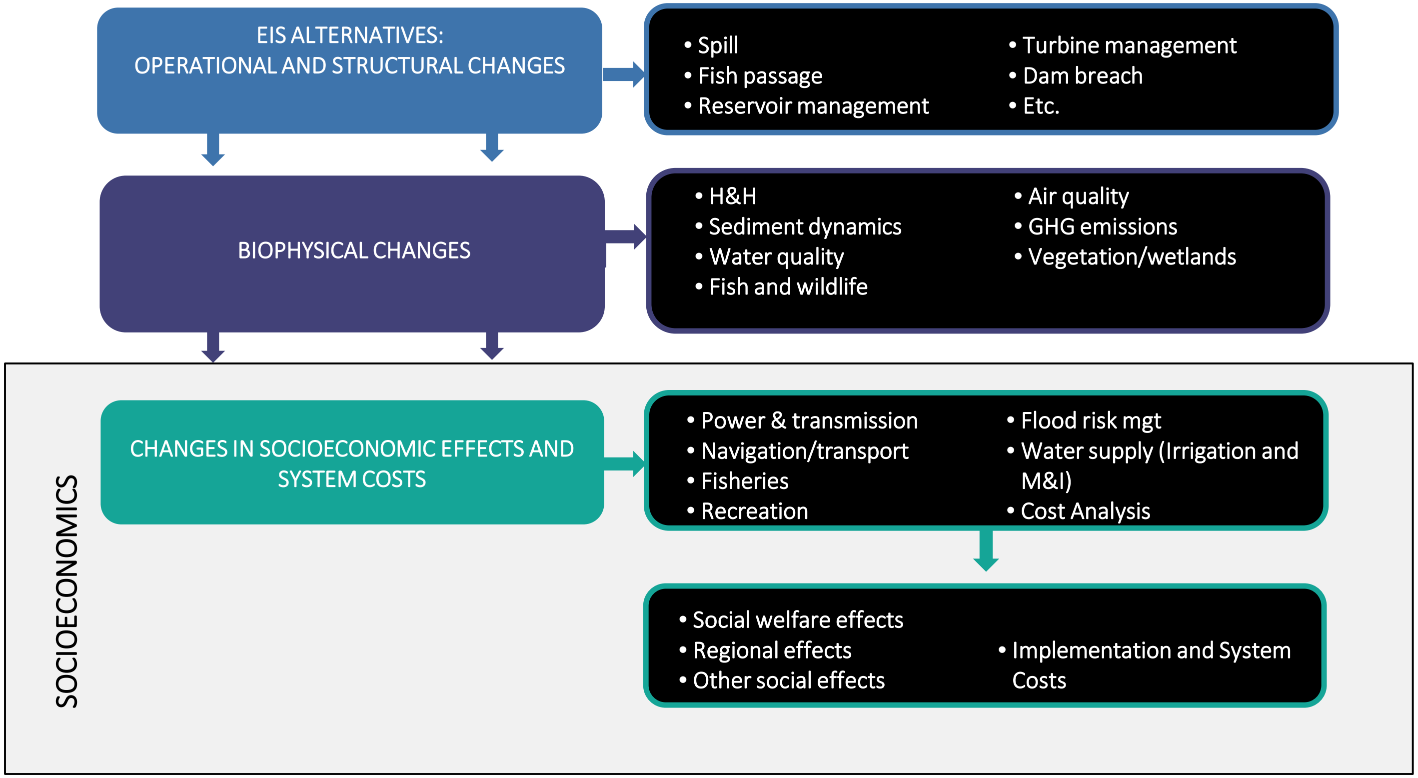
Bonneville's habitat program will continue under the preferred alternative



TRIBUTARY CONSERVATION (2008 TO 2018)

PROTECTED	99,520	ACRE-FEET OF WATER
IMPROVED	6,885	RIPARIAN ACRES
PROTECTED	36,399	RIPARIAN ACRES
OPENED ACCESS TO	1,975	MILES OF FISH HABITAT
RESTORED	588	STREAM MILES

Conceptual Model of Socioeconomic Effects and System Cost Analysis



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Socioeconomic Effects and Cost Analysis

COST ANALYSIS

Implementation and System Operations

- Baseline costs including system &OM, capital, fish & wildlife, mitigation
- Change in costs due to structural and operational measures, and changes to O&M, capital, fish & wildlife programs, and mitigation

SOCIOECONOMIC EFFECTS

Power and Transmission

- Change in hydropower generation
- Change in power reliability
- Costs of replacement power
- Impacts on power rates

Water Supply (irrigation and M&I)

- Change in agriculture production value (based on land value)
- Change in cost of accessing water supply

Fisheries

- Qualitative evaluation based on fish analysis
- Change in availability of fish for commercial, recreational, ceremonial use

Recreation

- Change in recreational visitation
- Change In quality of recreational activities and regional spending

Navigation & Transportation

- Change in costs of shipping goods
- Change in visitor days for commercial cruise lines
- Changes in days of ferry access

Flood Risk Management

- Change in flood risk (measured as potential change to flood hazard)

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Categories of Socioeconomic Effects

- **Social welfare effects:** Evaluates changes in the value of the national output of goods and services. Focus is on economic efficiency at societal level (i.e., these effects do not consider gains by one group at the expense of another, which are referred to as "transfers" of benefits).

- **Regional economic effects:** Regional or local perspective on changes in regional economic productivity (sales, jobs, income) due to changes in spending patterns (e.g., recreation) or in output or production of a given industry (e.g., agriculture).

- **Other social effects:** Additional information on how people's well-being is affected not otherwise quantified in the analysis, (e.g., community identity and cohesion, human health and safety).

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Implementation and System Costs

Categories of Costs *(some examples)*

Construction of Structural Measures

Construction costs (and contingency) of the structural measures for the action alternatives

Supervision, planning, management, design and engineering costs of the structural measures

Real estate administration costs (MO3)

Capital Costs

BPA-funded large and small capital costs (power) and "joint" features that serve multiple purposes

USACE and BOR share of joint capital costs

Operations & Maintenance Costs

Bonneville Non-routine Extraordinary Maintenance (NREX) Costs

USACE and BOR NREX Costs

Routine O&M Costs

USACE Non-routine Navigation Expenses

Mitigation Costs

Bonneville Fish and Wildlife Program

Lower Snake River Compensation Plan (LSRCP))

Columbia River Endangered Species Act (ESA) Mitigation (BOR)

Columbia River Fish Mitigation (USACE)

Additional Mitigation Measures for the Action Alternatives

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Summary of Social Welfare Effects (annual $000/yr)

Resource	Social Welfare Evaluation	No Action	Preferred Alternative	MO3
Hydropower (power and transmission)	Replacement energy cost	13,000 aMW generation	$25 million annual cost	$270 million to $540 million annual cost
Recreation	Recreation consumer surplus	No change from recent historic conditions, 2.7 million visitors to lower Snake River	$2,000 annual cost (lost benefit)	**Short term** $8.9 million to $26 million annual cost, **Long term** river recreation to 50 percent lower to 30 percent higher visitation
Irrigation	Agriculture production (lost value)	No change from recent historic conditions, 48,000 irrigated acres from lower Snake River	No change	$12.3 million to $17.0 million annual cost
M&I Water Supply	Modification costs	No change from recent historic conditions,2.4 million tons of downbound grain on lower Snake River	No change	$4.9 million to $7.6 million annual cost
Navigation & Transportation	Change in shipping cost	No change from recent historic conditions	$93,000 decrease annual cost	$14 million to $48 million annual cost
Fisheries	Qualitative assessment	Consistent with historic conditions	Minor decreases or increases to social welfare benefits could occur	Social welfare benefits to fisheries may occur
Flood Risk Mgt.	Hazard analysis	Consistent with historic conditions	No change	No change

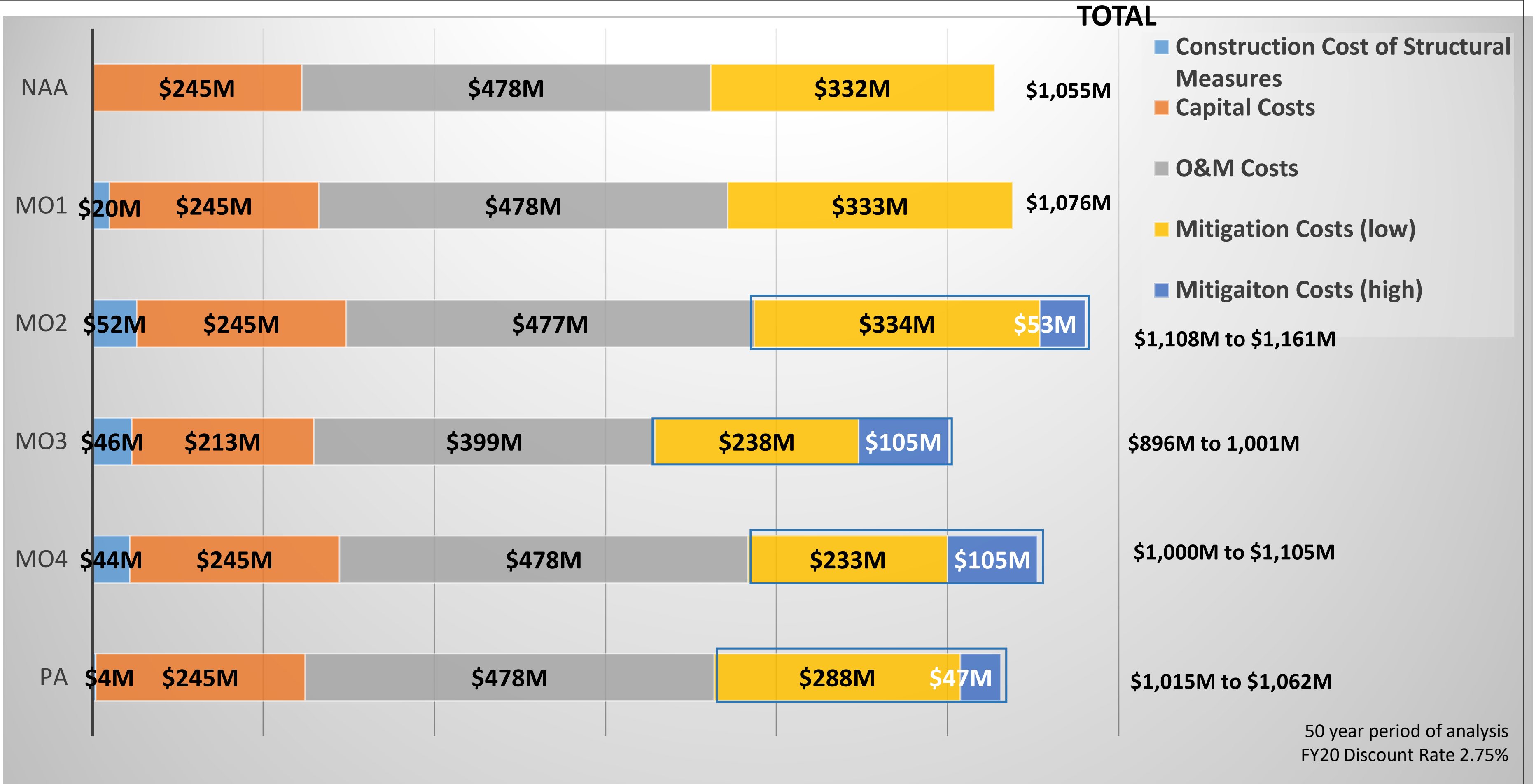
Summary of Regional and Other Social Effects

Resource	No Action	Preferred Alternative	MO3
Hydropower (power and transmission)	• Overtime 'real' residential rates could decrease	Increased electricity rates: • $68 million annual decrease regional output • Decrease of 440 jobs	Increased electricity rates: • $740 annual decrease regional output • Decrease 4,900 jobs Potential decrease in reliability, energy insecurity
Recreation	• Non-local visitor expenditures support 6,480 jobs, $265 million in income, and $843 million in regional sales annually • Continue to provide considerable recreation opportunities, including reservoir based on lower Snake River	• Negligible change to regional economic effects • Continued community cohesion/identity adjacent to reservoirs	Regional impact due to decreased non-local visitors: • Short term impact of $53 million to $189 million decreased sales and 450 to 1,420 decreased jobs, • Long term depending on river recreation conditions, regional effects could be offset Potential positive and adverse well-being effects depending upon recreation preferences
Irrigation	• No change from recent historic conditions, 48,000 irrigated acres from lower Snake River	• No change	Regional impact associated with loss of 48,000 irrigated acres: • $461 million total output (sales) • Decrease of 4,800 jobs
M&I Water Supply	• No change from recent historic conditions	• No change	Regional impact of M&I water effects: • $7.6 million decrease in output (sales) • Decrease of 55 jobs
Navigation & Transportation	• No change from recent historic conditions • 18,000 cruise ship passenger annually through lower Snake River supporting $17.8 million in output and 230 jobs	• $93,000 decrease annual cost	Regional impact of decreased agriculture revenue (from increased shipping cost): • $17.8 million decrease in output (sales) • Decrease of 230 jobs Potential need for road or rail investments: • Up to $10 million annually for road O&M • Additional shuttle rail facility ($25 to $50 million) and lines upgrades (~$30 million) Loss of cruise ship passengers/revenues Health and safety concerns
Fisheries	• Consistent with historic conditions	• Based on qualitative assessment - some regional decreases and benefits to fisheries may occur	Based on qualitative assessment - some regional benefits to fisheries may occur
Flood Risk Mgt.	• Consistent with historic conditions	• No change	• No change

Implementation and System Costs

Annualized Costs *($/year)*

(High and Low BPA F&W Program Scenario)



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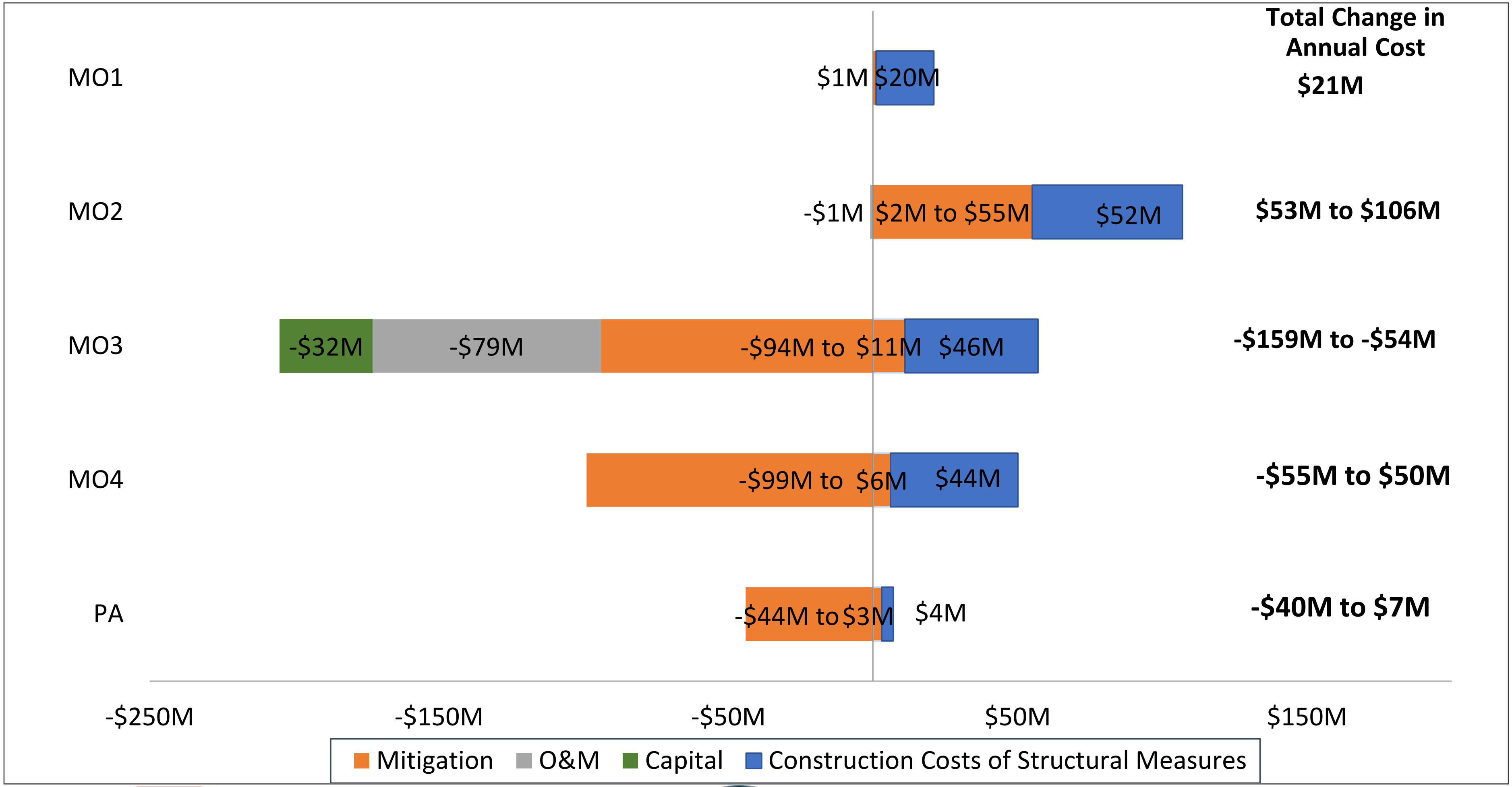
Implementation and System Costs

Change from the No Action Alternative, Annualized Costs *(millions)*



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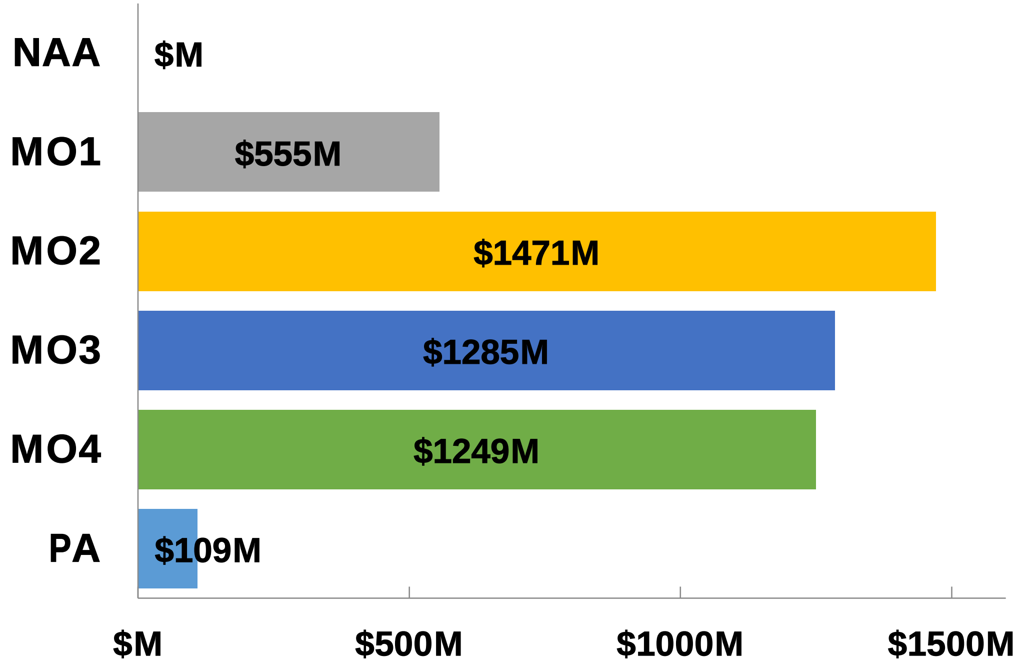
Implementation Costs

Construction Costs of the Structural Measures

TOTAL CONSTRUCTION COST *(millions)*



ANNUALIZED COST *($millions/year)*

$20 M per year

$52 M per year

$46 M per year

$44 M per year

$4 M per year

Annual costs estimated for 50 year period

FY20 discount rate 2.75%

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Summary Social Welfare Effects and System Costs (avg annual)

Social Welfare Effects (Beneficial and Adverse)	No Action	Preferred Alternative (change from No Action)	MO3 (change from No Action)
Hydropower	NA	Net loss of $6.7 million to $25 million annually	Net loss of $150 million to $540 million annually
Navigation and Transportation Systems	NA	Net gain of $93,000 in efficiency annually	Net loss of $14 million to $48 million in efficiency annually
Water Supply (M&I and Irrigation)	NA	No net change	Net loss of $17.18 million to $24.55 million annually
Recreation	NA	Net loss of $2,000 annually	Mixed – short term loss, long term loss and/or gain
Sum Total of Net Social Welfare Effects	**NA**	**Total net loss of $6.6 million to $24.9 million annually**	**Total net loss of $181.2 million to $612.6 million annually**

Summary System Cost Categories	No Action	Preferred Alternative (change from No Action)	MO3 (change from No Action)
Construction	NA	Net cost increase of $4.9 million annually	Net cost increase of $45.7 million annually
Capital and O&M	NA	Net cost savings of $700,000 annually	Net cost savings of $110.6 million annually
Mitigation	NA	Net cost savings of up to $47 million or net cost increase of up to $2.6 million annually	Net cost savings of up to $94.3 million or net cost increase up to $10.7 million annually
Total Net Effect on Implementation, O&M, and Mitigation Costs	**NA**	**Total net cost savings of up to $42.8 million or net cost increase of up to $6.8 million annually**	**Total net cost savings of $54.2 million to $159.2 million annually**

Next Steps

Public Review of DEIS

- Public comment open! All comments by April 13.

Public Meetings Schedule

- March 17, Lewiston, ID
- March 18, Kennewick, WA
- March 19, Seattle, WA
- March 25, Spokane, WA
- March 26, Kalispell, MT
- March 31, Portland, OR

Document Completion

- Publish FEIS June/July 2020
- Sign Record of Decision September 2020

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How to Access the documents and comment on the DEIS

- **Visit CRSO EIS website to download document**
  - **https://www.nwd.usace.army.mil/CRSO/#top**
- **Attend public meetings and provide comments in person**
- **Written comments must be post marked by April 13**

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- Home
- DEIS Executive Summary (17mb pdf)
- Complete DEIS
- View DEIS at a Public Library
- Submit Your Comment
- Cooperating Agencies
- Dam & Project Locations
- View Previous Website Content

Latest News

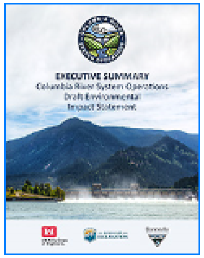
Federal agencies release Columbia River System Operations draft environmental impact statement and preferred alternative
Feb. 28, 2020

Introducing the affected environment
Nov. 22, 2019

Operating dams to support fish passage
Nov. 22, 2019

Defining the Environment under NEPA
Nov. 22, 2019

Comment Period Open
February 28 - April 13, 2020



DEIS Executive Summary (17mb pdf)

You are invited to review and provide comments on the Draft Environmental Impact Statement and the Preferred Alternative for the operations, maintenance and configuration of the Columbia River System, comprised of 14 federal dam and reservoir projects in Idaho, Montana, Oregon and Washington. In accordance with the National Environmental Policy Act (NEPA), the draft EIS documents the review of potential actions and discloses the environmental effects of taking those actions.

The review and comment period opened on February 28, 2020 with the publication of the NEPA Notice of Availability in the Federal Register.

U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration developed the draft EIS in response to the need to review and update management of the System, including evaluating impacts to resources in the context of new information and changed conditions in the Columbia River basin and in response to a court order by the U.S. District Court for the District of Oregon.

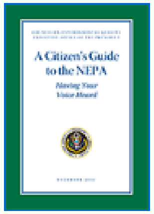
The Preferred Alternative detailed in the draft EIS is a suite of operational, maintenance and structural measures to allow the agencies to meet their congressionally authorized purposes, the Purpose and Need statement and EIS objectives, including those to benefit species listed as threatened and endangered under the Endangered Species Act. The agencies will respond to substantive comments on the draft EIS in the final EIS to be released this summer.

View the Draft EIS

View the Complete Draft EIS on this website
View at EPA.gov
View electronically at a public library

Request a CD-ROM or flash-drive of the complete DEIS or a hardcopy of the Executive Summary
by email to info@crso.info* or leave a message with your phone number at 800-290-5033

** Messages sent to info@crso.info or to the co-lead agencies by email, phone or social media are not recorded as comments for the public record. Use one of the methods posted on this website to submit your comment.*



Citizen's Guide to NEPA (1mb pdf)

Recommended reading to submit an effective comment

A Citizen's Guide to the NEPA: Having your Voice Heard (1MB pdf) helps citizens effectively participate in environmental reviews under the National Environmental Policy Act (NEPA)

Submit your comment

Online

Submit your comment at comments.crso.info

At a public comment meeting

We will have the following methods available:

Written Comments

- Computers for online submittal
- Comment forms
- Collection box

Verbal Comments

- Publicly or Privately recorded (2-minute limit)

Written comment via postal mail

US Army Corps of Engineers, Attn: CRSO EIS
P.O. Box 2870
Portland, OR 97208-2870
(Must be postmarked by April 13, 2020)

Written comment via delivery

US Army Corps of Engineers, Attn: CRSO EIS
1201 NE Lloyd Blvd.
Portland, OR 97232
(Must be delivered by 5 pm on April 13, 2020)

Messages sent to the co-lead agencies by email, phone or social media are not recorded as comments for the public record. Use one of the methods posted on this website to submit your comment.

Public comment meetings

Lewiston, ID • March 17 • 4 - 8 pm
Red Lion Hotel
621 21st St.
Lewiston ID, 83501

Kennewick, WA • March 18 • 4 - 8 pm
Red Lion Hotel
1101 N. Columbia Center Blvd.
Kennewick WA, 99336

Seattle, WA • March 19 • 4 - 8 pm
Hilton Seattle Airport
17620 International Blvd.
Seattle WA, 98188

Spokane, WA • March 25 • 4 - 8 pm
DoubleTree City Center
322 N Spokane Falls Ct.
Spokane WA, 99201

Kalispell, MT • March 26 • 4 - 8 pm
Red Lion Hotel
20 N Main St.
Kalispell MT, 59901

Portland, OR • March 31 • 4 - 8 pm
Oregon Convention Center
777 NE Martin Luther King Jr Blvd.
Portland OR, 97232

Discussion