US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.1 INTRODUCTION

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CHAPTER 3 - AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

THE INTRODUCTION SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **Formatting has been updated for improved readability and information organization. The DEIS methodology section has been deleted and pertinent information incorporated into Section 3.1, Introduction. Information on resources not analyzed has been moved to newly added Section 3.1.6, Resources Considered but not Analyzed in Detail.**
- **Information suggesting the Proposed Action is an alternative has been deleted; clarifications on the range of alternatives have been made.**
- **Modifications have been made to clarify that the environmental consequences analyses are not based on the degree of change from existing conditions but on the degree of impact that would occur under an alternative relative to the No-action Alternative (e.g., adverse or beneficial) per Council on Environmental Quality NEPA regulations (40 CFR 1502.16).**
- **References to "magnitude" of impact have been converted to "degree," consistent with 40 CFR 1508.27.**
- **Modifications have been made to clarify that the analyses do not present conclusions on degree of significant impact and that these conclusions are documented in the agency's Record of Decision.**
- **Information has been provided to clarify how evaluation criteria have been developed in the FEIS in Section 3.1.2.2., Evaluation Criteria for Potential Effects. DEIS Table 3.1-1, Duration of Measures, has been removed because it confused duration of a measure (or activity) with duration of an impact. Impact assessments applying all criteria are more appropriately and accurately described under each resource analysis.**
- **DEIS Section 3.1.2, Structure of the Effects Analysis by Resource, has been modified to clarify the revised approach presented in the FEIS (FEIS Section 3.1.3, Approach for the Effects Analyses). Only one analysis approach is presented in the FEIS; comprehensive analyses from implementation of each alternative are presented rather than analyses of each individual measure. Measure effects are now incorporated into the comprehensive alternatives analyses. This analysis revision from the DEIS provides a more consistent comparison of effects and anticipated trends among alternatives and among resources than the DEIS approach.**

Summary of changes from the DEIS, continued:

- **DEIS Table 3.1-2, Structure of the Effects Analysis by Resource, has been removed. Information on the scope of analysis is more appropriately and accurately described under each resource where some modifications have been made to reflect all public comments and internal revisions of the DEIS.**
- **Information on the NEPA tiering process has been removed from DEIS Section 3.1.2, Structure of the Effects Analysis by Resource, because this repeats information presented in Chapter 1, Introduction.**
- **Information identifying operational measures that will not require further NEPA analysis in DEIS Section 3.1.2, Structure of the Effects Analysis by Resource, has been deleted because decisions on further NEPA review are not appropriately determined in this EIS. Information is refocused on measures that have been analyzed in the EIS at the programmatic level (FEIS Section 3.1.3, Approach for the Effects Analyses).**
- **DEIS information that routine and non-routine maintenance activities were not assessed has been deleted. These activities have been assessed under applicable resources in the FEIS (newly added Section 3.1.3.2, Routine and Non-routine Maintenance).**
- **DEIS Table 3.1-5, Relevant Climate Factors Analyzed in Resource Topics, has been deleted. Some of the table information has been modified in the FEIS resource analyses. The scope of climate change analyses is more appropriately presented in each resource section.**
- **Information in Section 3.1.5, Climate Change, has been updated.**
- **DEIS Section 3.5, Near-term Operations Measures, has been deleted because this information is provided in Chapter 2, Alternatives.**
- **DEIS Table 3.1-6, Summary of Environmental Consequences, has been moved to newly added FEIS Section 3.25, Summary of Environmental Consequences. A summary provided at the end of Chapter 3, Affected Environment and Environmental Consequences, is the logical placement for a summary of effects presented throughout the chapter. Further, this comprehensive information is best placed in its own section for improved document readability (note that DEIS Section 3.25 through Section 3.28 have been renumbered).**
- **A map depicting subbasins, Willamette Valley System dams, hatcheries, and adult fish facilities has been added as Figure 3.1-1. This map can be used for reference when reviewing resource analyses in Chapter 3, Affected Environment and Environmental Consequences.**

3.1 Introduction

This chapter presents both the Affected Environment and Environmental Consequences for resources that could be affected by the alternatives. A summary of direct and indirect effects by alternative is presented at the end of the resource analyses in Section 3.25, Summary of Environmental Consequences.

3.1.1 Affected Environment Descriptions

Resources analyzed in this EIS are discussed in Section 3.2, Hydrologic Processes, through Section 3.24, Tribal Resources. Resource information is presented in the Affected Environment sections for each resource to be analyzed under the No-action Alternative and the action alternatives.

The scope of the Affected Environment descriptions is narrowed to those elements that may be potentially affected by any of the alternatives. Resource analyses address the current physical, biological, social, and economic conditions for a given resource as applicable.

The Affected Environment descriptions reference subbasins, Willamette Valley System (WVS) dams, hatcheries, and adult fish facilities within the Willamette River Basin. A map depicting these features has been added at the end of this Section 3.1 (Introduction) (Figure 3.1-1).

Figures of each of the six primary analysis area subbasins are provided in Chapter 11, Analysis Area Subbasins. Identification of bank protection structures are provided in Section 3.4, Geology and Soils.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

3.1.2 Environmental Consequences Analysis Overview

The Environmental Consequences analyzed under each resource demonstrate the degree of effect that would occur if no action were taken (i.e., none of the action alternatives were implemented). Subsequent analyses of resource effects under each of the action alternatives are then compared to effects anticipated for the same resource under the No-action Alternative.

Direct and indirect effects are demonstrated for each resource (cumulative effects are analyzed in Chapter 4) and are summarized for comparisons among alternatives. Direct and indirect effects are also described as either adverse or beneficial.

For most resources, adverse or beneficial effects have been described by evaluation criteria specific to each resource. These criteria establish the parameters for varying degrees of effect, such as none/negligible, minor, moderate, or major, and are defined in the methodology sections for each resource analysis. Degree of effect criteria are based on context and intensity significance criteria in the NEPA regulations (40 CFR 1508.27)[1]. Criteria address the degree (how much), duration (how long), and extent (how big or how far) of potential effects.

Not all resources were analyzed by assigning a degree of effect with evaluation criteria because this approach would not be most applicable for addressing effects (Section 3.1.2.3, Effect Factors and Scales).

END REVISED TEXT

The determination of significance is not made in the EIS but is documented in the agency's Record of Decision following completion of the Final EIS.

Per 1978 Council on Environmental Quality NEPA regulations[2], "effects" and "impacts" are used synonymously in this EIS (40 CFR 1508.8).

3.1.2.1 Types of Effects

Direct and indirect effects are defined as follows (40 CFR 1508.8):

Direct Effects

Effects that are caused by the action and occur at the same time and place. Examples include filling a wetland or excavating an archaeological site.

Indirect Effects

Effects that are caused by the action but occur later in time or are farther removed in distance but are still reasonably foreseeable. Indirect effects also include "induced changes" in the human and natural environments (40 CFR 1508.8(b)). Examples of indirect effects include environmental changes over time caused by direct economic change in a community (e.g., through development, increased taxes, etc.) or an action that directly causes turbidity in spawning grounds, which then increases sedimentation and adversely impacts future salmonid development.

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[1] Context – the significance of an action must be analyzed in several contexts such as society as a whole, the affected region, the affected interests, and the locality. Both short- and long-term effects are relevant.

Intensity – refers to the severity of the action. A significant effect may occur even if the effect may be beneficial on balance.

[2] When this EIS was initiated, the Council on Environmental Quality was in the process of revising NEPA regulations. Consequently, USACE provided notice to the public that the EIS complies with the 1978 CEQ NEPA implementing regulations as amended. Additionally, the EIS follows the most current CEQ guidance on use of programmatic NEPA reviews, December 18, 2014.

The Council on Environmental Quality does not define adverse or beneficial effects in the 1978 NEPA regulations, and it does not require a degree of effect or impact be assigned in the analyses (e.g., minor, moderate, major).

For purposes of the analyses in this FEIS, effects have been defined as the following:

Adverse Effects

Adverse effects are those that would have a negative and harmful effect on the analyzed resource. An adverse impact causes a change that moves the resource away from a desired condition or detracts from its appearance or condition.

Beneficial Effects

Beneficial effects are those that would have a positive effect on the analyzed resource. A beneficial impact is a positive change in the condition of the resource or a change that moves the resource toward a desired condition (i.e., an improved condition).

Per the NEPA regulations, actions can result in both adverse and beneficial effects. As such, a resource analysis may demonstrate overall adverse effects, but improvement trends toward beneficial outcomes from operations measures proposed under a given alternative.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

3.1.2.2 Evaluation Criteria for Potential Effects

For some resources, evaluation criteria were developed to provide a structured framework for assessing effects, supporting conclusions regarding the degree of effects, and comparing effects among alternatives. Some sections in the FEIS have been modified from the DEIS to update the criteria or approach used for a resource analysis. In some cases, the approach differs from the DEIS based on analysis revisions needed from the DEIS and on the optimal method for demonstrating a degree of effect under a resource or specific resource parameters to make an informed decision about impacts among alternatives.

3.1.2.3 Effect Factors and Scales

In general, effect factors address the degree (how much), extent (how big or how far), and duration (how long or how often) of an activity. Degree is unique to each individual resource and is described in more detail under the methodology section for each resource analysis. Further, the effect of an activity incorporates the degree of effect as defined under NEPA regulations (40 CFR 1508.27(1)).

For some resources, the degree of effect is defined as negligible, minor, moderate, and major with supporting criteria for each degree category. For other resources, the degree of effect is more appropriately descriptive because defined criteria would be subjective (e.g., criteria demonstrating what data or compliance with a standard constitutes a negligible or major adverse effect). Descriptions of degree of effect include slight, moderate, substantial, etc. where terminology reflects common language uses (e.g., dictionary definitions) as described in each resource if applicable.

The scales to address the extent of effects generally include small, medium, and large or local, regional, and state-wide. Some resource scales address subbasin or basin-wide effects. The scales to assess duration are short term, medium term, and long term. Definitions for scale and duration are provided in each resource analysis section.

3.1.3 Approach for the Effects Analyses

Each resource is analyzed as a comprehensive assessment of effects under each alternative. Measures that would be implemented under each alternative are incorporated into the analyses but are not analyzed separately from their contribution to overall alternative implementation[3]. Analyses of direct and indirect effects are narrowed to relevant analysis areas; the analysis area is uniquely defined in each resource analysis.

Programmatic analyses of the resources in this chapter are at a broad scale and scope. The broad effects analyses are a framework for future site-specific evaluations of direct, indirect, and cumulative effects (Chapter I, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act). However, where applicable, localized effects are also described.

The level of analysis in this EIS depended on the amount of information available when the alternatives were analyzed and whether detailed design and construction will be needed. Assessments of effects of most operational measures under a given alternative that do not require detailed design and construction to implement immediately are provided at the programmatic level (Table 3.1-1). Some operational measures would eventually require dam modifications to address operational and dam safety concerns and, therefore, may require further analysis (Table 3.1-2).

Table 3.1-1. Operational Measures Analyzed under Applicable Alternatives.

Measures	Locations[1]
Flow Measures	–
30b. Refined Integrated temperature and habitat flow regime	FRN, CTG, DOR, DEX, LOP, FCR, HCR, CGR, BLU, FOS, GPR, BCL, DET
304. Augment instream flows by using the power pool	LOP, HCR, CGR, GPR, DET
718. Augment instream flows by using the inactive pool	CTG, DOR, FCR, BLU
723. Reduce minimum flows to Congressionally authorized minimum flow requirements	FRN, CTG, DOR, DEX, LOP, FCR, HCR, CGR, BLU, FOS, GPR, BCL, DET

[3] Some exceptions were necessary where identification of measures for a comprehensive alternative analysis was required, such as effects to geology and soils.

Measures	Locations[1]
Water Quality Measures	–
166. Use regulating outlets for temperature management	LOP, GPR
721. Use spillway for surface spill in summer	LOP, GPR, DET
Downstream Passage Measures	–
40. Deeper fall reservoir drawdowns for downstream fish passage for the drawdown operation to the diversion tunnel	LOP, HCR, CGR, BLU, GPR, DET
714. Pass water over spillway in spring for downstream fish passage	DEX, LOP, FCR, GPR, BCL, DET
720. Deep spring reservoir drawdown for downstream fish passage for the drawdown operation to the diversion tunnel	LOP, CGR, DET
Measures Common to All Alternatives	–
719. Adapt Hatchery Mitigation Program	North Santiam, South Santiam, McKenzie, and Middle Fork Willamette River Subbasins
Fall Creek drawdown	FCR
Continued operation of existing adult fish facilities	North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette River Subbasins
Scheduled/routine maintenance of WVS facilities	Basin-wide

[1]Dam abbreviations:

BCL – Big Cliff	BLU – Blue River	CGR – Cougar	CTG – Cottage Grove
DET – Detroit	DEX – Dexter	DOR – Dorena	FCR – Fall Creek
FOS – Foster	FRN – Fern Ridge	GPR – Green Peter	HCR – Hills Creek
LOP – Lookout Point			

Table 3.1-2. Operational Measures that may Require Site- or Project-specific NEPA Review.

Measures	Locations[1]
Water Quality	–
721. Use spillway for surface spill in summer	HCR, BLU
Downstream Passage Measures	–
40. Deeper fall reservoir drawdowns for downstream fish passage for the drawdown operation to the diversion tunnel	CGR
714. Pass water over spillway in spring for downstream fish passage	HCR, BLU
720. Deep spring reservoir drawdown for downstream fish passage for the drawdown operation to the diversion tunnel	CGR

Measures	Locations[1]
Measures Common to All Alternatives	–
726. Maintenance of existing and new fish release sites above dams	North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette River Subbasins
Major maintenance and rehabilitation of WVS facilities	Basin-wide

[1]Dam abbreviations:

BLU – Blue River CGR – Cougar HCR – Hills Creek

3.1.3.1 Structural Measures

A range of potential effects from general construction activities are included in the effects analysis for each resource under applicable alternatives (Table 3.1-3). Site-specific alternatives development and evaluation may be required. Actual proposed features and activities would be assessed during subsequent NEPA reviews when site-specific design objectives and constraints will be developed (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act).

Subsequent analyses would include project features or activities, such as construction equipment, site preparation, access, staging, material storage, and transfer facilities. Typical descriptions of several activities that could occur during implementation of the measures are summarized in Appendix A, Alternatives Development.

Table 3.1-3. Structural Measures that may Require Site- or Project-specific NEPA Review.

Measures	Locations[1]
Water Quality Measures	–
105. Construct selective withdrawal structure	LOP, HCR, DET
479. Foster Fish Ladder temperature improvement	FOS
174. Structural improvements to reduce TDG	DEX, LOP, CGR, FOS, GPR, DET
Downstream Passage Measures	–
639. Restore upstream and downstream passage at drop structures	FRN
392. Construct structural downstream fish passage	LOP, HCR, CGR, FOS, DET
Upstream Passage Measures	**–**
52. Provide Pacific lamprey passage infrastructure	FRN, HCR, BLU, GPR
722. Construct adult fish facility	HCR, BLU, GPR

Measures	Locations[1]
Measures Common to All Alternatives	–
384. Gravel augmentation	North Santiam, South Santiam, and McKenzie River Subbasins below Big Cliff, Foster, Cougar, and Blue River Dams
9. Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration	Basin-wide

[1]Dam abbreviations:

BCL – Big Cliff	BLU – Blue River	CGR – Cougar	CTG – Cottage Grove
DET – Detroit	DEX – Dexter	DOR – Dorena	FCR – Fall Creek
FOS – Foster	FRN – Fern Ridge	GPR – Green Peter	HCR – Hills Creek
LOP – Lookout Point			

END REVISED TEXT

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

3.1.3.2 Routine and Non-routine Maintenance

Qualitative assessments of potential effects from routine and non-routine maintenance are provided under applicable resources. The operation, maintenance, repair, replacement, and rehabilitation phase begins after a WVS facility is constructed. Ongoing activities are conducted during this phase to support facility functions; some activities will require additional NEPA review prior to initiation (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act).

This phase includes a range of activities from regular maintenance activities, such as repainting a rusty guardrail or replacement of lightbulbs, to major maintenance and rehabilitation activities, such as the repair, replacement, or rehabilitation of entire facility components (e.g., the replacement of the slide gate seals or repair of hydraulics in a dam). These collective activities occur at all facilities in the WVS, including within and around the dams and powerhouses, adult fish facilities, and hatcheries. However, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities Distinctions between regular and major activities are described in Chapter 1, Introduction, Section 1.11.3, Operations, Maintenance, Repair, Replacement, and Rehabilitation.

END NEW TEXT

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

3.1.4 Resource Analyses Methodologies

The methodology used to characterize potential effects is explained in each resource, including methods used to collect data. Methodology sections also provide a description of the analysis area, types of impacts that could occur (direct, indirect, beneficial, adverse), and the evaluation criteria applied to the analyses under each alternative.

3.1.5 Climate Change

A Tier 1 (qualitative) assessment of climate change impacts was performed to analyze effects under each alternative in the Willamette River Basin following USACE protocol under Engineering and Construction Bulletin (ECB) 2014-18, *Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects* (USACE 2022a). Hydroclimate (i.e., ambient temperature, evapotranspiration, rainfall, etc.) and hydrologic (i.e., streamflow rates and volumes) effects and associated vulnerability for the analyses were also evaluated based on ECB-2020-6, *Implementation of Resilience Principles in the Engineering & Construction Community of Practice* (USACE 2022b). Details on the analysis methodology and a qualitative overview of climate change-related effects to resources analyzed in the EIS are provided in Appendix F1, Qualitative Assessment of Climate Change Impacts and Appendix F2, Supplemental Climate Change Information.

Climate change factors relevant to resource analyses are summarized below. These factors were identified as causing direct or indirect impacts to all operations and maintenance activities, including flood risk management, during the 30-year implementation timeframe (Appendix F2, Supplemental Climate Change Information).

- Ambient air temperature change
- Water temperature change
- Precipitation change
- Seasonal timing of flow peaks and volumes
- Low summer flow—shortage/volume/frequency
- Change in snowpack accumulation and spring freshet timing
- Reservoir evaporation/reach evapotranspiration effects
- Wildfire intensity/frequency change
- Wildfire impacts to water quality

There are critical linkages between rising temperatures and changing rainfall and snowmelt on the projected shifts in seasonal and annual, average, and extreme flow quantity and timing in the region[4]. Changes in average ambient temperatures and in reduced baseflows over the 30-year implementation timeframe will directly stress thermal regulation necessary for fish and other species in the Willamette River Basin. These climate change effects, along with other cumulative effects, are assessed under each resource analysis (see also Chapter 4, Cumulative Effects).

Resource analyses under each alternative considered potential amplification of resource limiting factors as a result of climate change. Change in the climate factors identified above during the 30-year implementation timeframe may have varying, and sometimes conflicting, impacts on resources depending on the alternative implemented.

The USACE Climate Preparedness and Response Community of Practice defines residual risk as the risk that remains after measures have been implemented (i.e., after an alternative incorporating measures has been implemented). The USACE response to climate change is adaptation-focused whereby alternatives, and incorporated measures, are developed to be as resilient as possible. A more resilient feature is one that is conceptually more resistant to likely future conditions and/or possesses inherent flexibility to adapt successfully to projected changes (Table 3.1-4) (Appendix N, Implementation and Adaptive Management Plan).

3.1.6 Operations and Activities Considered but Not Analyzed in Detail

The following were not analyzed and were dismissed from further analysis:

- Flood Risk Management

  Flood risk management was not analyzed because the level of flood risk under any alternative would not increase when compared to current operations and management levels of flood risk.

- Navigation and River Transportation

  Authorized flows for navigation serve the dual purpose of also meeting water quality standards; therefore, impacts to navigation due to the availability or lack of water to support these flows are analyzed in the water quality analysis. Further analysis of impacts to navigation would be redundant.

- Transportation

  Ground transportation was not analyzed because effects on traffic under any alternative would be negligible to minor. Further, specific information on transportation is out of scope for the programmatic review. Ground transportation impacts for actions requiring construction will be assessed under subsequent tiered NEPA analyses.

[4] In Appendix F1, Qualitative Assessment of Climate Change Impacts, the WVS project design and current water management is predicted on past years of record. WVS flood and conservation space were provided based on estimates of observed record winter and spring volumes as well as the time of year that the inflows would occur.

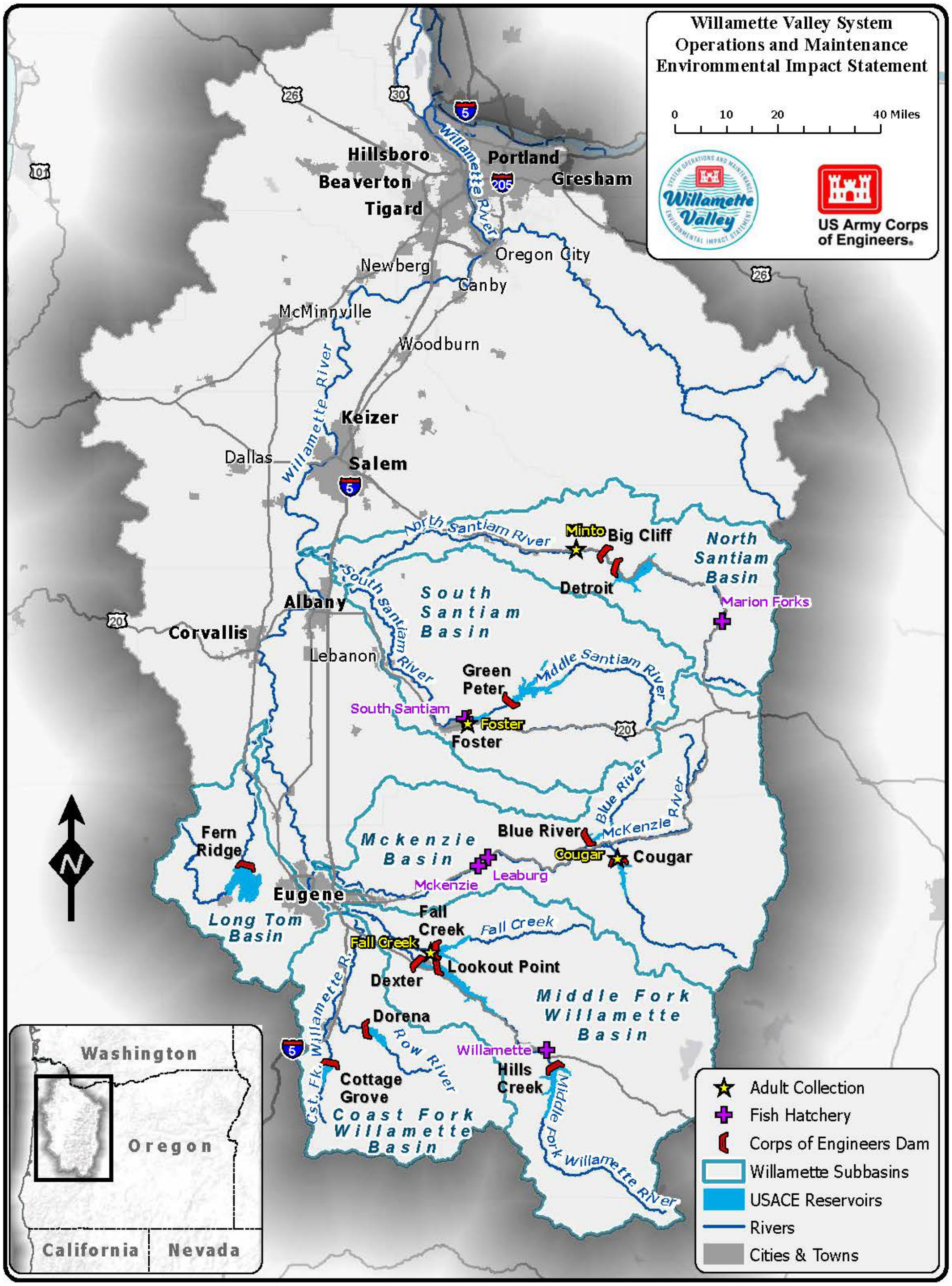

Figure 3.1-1. Willamette Valley System Dams, Fish Hatcheries, and Adult Fish Facilities.

Table 3.1-4. Residual Risks Incorporated into Resource Analyses.

<table>
<tr><th>Trigger</th><th>Hazard</th><th>Harm (or reduction in harm where specified)</th><th>Likelihood of Harm</th></tr>
<tr><td rowspan="6">Decreased Summer Precipitation in Combination with Warmer Summer Temperatures</td><td rowspan="3">Increased wildfire intensity and frequency</td><td>Wildfires resulting in increased erosion, which would further increase sediment loads and turbidity and could further reduce the quantity and quality of some fish species and habitat.</td><td rowspan="3">Likely</td></tr>
<tr><td>Wildfires would negatively affect all types of cultural resources.</td></tr>
<tr><td>Degradation of water quality in streams and rivers throughout the Willamette River Basin (e.g., higher pollutant loads, etc.).</td></tr>
<tr><td rowspan="3">Decreased summer flows/prolonged conservation season low flow conditions (worsened by increased evapotranspiration due to warmer temperatures)</td><td>Climate change is likely to increase the demand for municipal and industrial water supply and agricultural irrigation. A decrease in flow and water volumes in the summer may have an adverse effect on water supply as users are unable to withdraw water from the stream for consumptive uses.</td><td>Likely</td></tr>
<tr><td>USACE would release more reservoir water to meet downstream flow targets as local inflows will be less. Reservoir storage volume is the primary driver for providing augmentation flows in summer and fall. Immediately downstream of each dam, water temperature is dependent on temperature management (the ability to mix cooler, deeper reservoir water with warmer, surface lake water). Decreased water supply in the conservation season. WVS dams and reservoirs may reach minimum water surface elevations more frequently. Reduced water levels in the summer that expose archaeological sites.</td><td>Less Likely to Likely</td></tr>
<tr><td>If reservoir levels are lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color, clarity, and texture.</td><td>Less Likely to Likely</td></tr>
<tr><td>Increase in Frequency of Wintertime Extreme Precipitation Events</td><td>Future flood volumes may be larger than at present

Large flood volumes may occur more frequently

Flood hydrographs may be flashier</td><td>Increased flooding (more frequent bank-full flows); rule curves dictating reservoir operations might not suffice during extreme wet conditions; increased winter precipitation that erodes archaeological sites.</td><td>Unlikely</td></tr>
</table>

Trigger	Hazard	Harm (or reduction in harm where specified)	Likelihood of Harm
Increase in Frequency, Duration, and Intensity of Droughts	Future droughts may be more severe than at present. Future droughts might occur at increasing frequency	Lower summer streamflows imply that USACE will release more reservoir water to meet downstream flow targets. Downstream flow targets may not be met; rule curves dictating reservoir operations might not suffice during extreme dry conditions.	Likely
Warmer Wintertime Temperatures	Shift from a combined rainfall-snowmelt regime to a rainfall-only regime, resulting in lower late winter/spring flows	Reservoirs might not adequately fill. Reservoir storage volume is the primary driver for providing augmentation flows in summer and fall. Immediately downstream of each dam, water temperature is dependent on temperature management (the ability to mix cooler, deeper reservoir water with warmer, surface lake water). Decreased water supply in the conservation season. Higher winter flows occurring in December-January would not be stored, as the guide curves for the WVS generally begin February 1. Therefore, climate change will likely lead to a decreased release in volumes in spring and summer compared to the Affected Environment and could shorten the recreational season/reduce recreational opportunity.	Highly Likely
		Reduction in Harm: Flood risk contribution from the annual spring snow melt may be reduced, especially in higher elevation reservoirs that are presently influenced by snowpack.	Highly Likely
	Shift from a combined rainfall-snowmelt regime to a rainfall-only regime, resulting in higher wintertime flows	Higher winter flow may increase Total Dissolved Gas (TDG) levels if no TDG management is in place, as turbine capacity at power dams would likely be exceeded more often and result in “spill” releases through non-power outlets.	Likely
		Increased winter and early spring flows may complicate USACE ability to initiate refill earlier.	Likely
		Reduction in Harm: Because the WVS will likely experience increasing wintertime (December through March) flow volumes due to climate change generally, it is possible that dams and reservoirs may capture some additional flow, which could produce incremental increases in power generation during the winter.	Likely
		Because precipitation is not stored as snow upstream of the reservoirs, fall and winter inflows are likely to increase, which could result in more frequent flood risk management operations and demand on the flood risk management storage within the reservoirs.	Unlikely

Trigger	Hazard	Harm (or reduction in harm where specified)	Likelihood of Harm
Increasing Temperatures	Warmer water temperatures	Impairment/loss of Pacific lamprey, UWR steelhead, and UWR Chinook salmon habitat.	Highly Likely
		Degradation of water quality in streams and rivers throughout the Willamette River Basin (e.g., increased harmful algal blooms, etc.).	
Increasing Variability in Spring Precipitation	Decreased spring flows	Increased variability in spring precipitation may result in less reliable reservoir refill.	Likely

END REVISED TEXT

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CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.2 HYDROLOGIC PROCESSES

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3.2 Hydrologic Processes

THE HYDROLOGIC PROCESSES SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **Clarifications regarding summaries of effects as compared to the No-action Alternative have been made in the summary tables for environmental consequences by subbasin.**
- **A definition of "baseline targets" has been added to Section 3.2.1.4, Flow Management Goals.**
- **Summary hydrographs produced to describe the changes to the flow and water surface elevation under each alternative have been updated as warranted in Section 3.2.2.3, Alternatives Analyses.**
- **Figure 3.2-92a has been added as a depiction of minimum pool elevation at 1,300 feet under Alternative 5.**
- **Figures under the Interim Operations analyses have been updated to reflect current modeling. The term "Near-term Operations" has been changed to "Interim Operations throughout the EIS." However, some figures retain the term "Interim Operations."**
- **Additional comparisons to the No-action Alternative and to other alternatives as applicable have been added.**
- **Climate change analyses have been revised for clarity and consistency.**
- **Consistent terminology has been applied and defined as applicable.**

3.2.1 Affected Environment

With a basin of approximately 11,500 square miles, the Willamette River is located entirely within the State of Oregon, beginning south of Cottage Grove and extending approximately 187 miles to the north where it flows into the Columbia River. The Willamette River is the 13th largest river in the coterminous United States in terms of streamflow (annual discharge) and produces more runoff per unit area than any of the 12 larger rivers (EPA 2013b). The Willamette River Basin averages 75 miles in width and encompasses approximately 12 percent of the total area of the state. The Willamette Valley System (WVS) spans the Willamette River Basin from the reservoirs on the Willamette River and its tributaries to the Willamette Falls in Oregon City, Oregon.

3.2.1.1 Willamette River Basin

The Willamette River Basin is bounded by three mountain ranges: the Cascade Mountains to the east, the Coast Range to the west, and the Calapooya Mountains to the south. Maximum elevations exceed 10,000 feet in the Cascade Mountains, 4,000 feet in the Coast Range, and 6,000 feet in the Calapooya Mountains. In the upper reaches, Willamette River tributaries flow in narrow valleys with steep gradients.

Major Cascade Mountains tributaries include the Santiam, McKenzie, Middle Fork Willamette, Molalla, and Clackamas Rivers. The Willamette River is also fed by major tributaries from the Coast Range, including the Long Tom, Marys, Luckiamute, Yamhill, and Tualatin Rivers. At the south end of the basin, the Coast Fork Willamette River emerges from the Calapooya Mountains and joins the mainstem Willamette River near the City of Springfield, Oregon. The average annual flow at Salem, Oregon (River Mile [RM] 84, drainage area of 7,280 square miles) for the water years 1910–2020 was about 24,200 cubic feet per second (cfs) or about 17.5 million acre-feet annually per USGS gage data.

Most of the state's population, larger cities, and major industries are located within the Willamette River Basin. The basin also contains much of Oregon's most productive agricultural lands and supports nationally and regionally important fish and wildlife species and populations. Thirteen of Oregon's 36 counties (Benton, Clackamas, Columbia, Douglas, Klamath, Lane, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill) intersect or lie within the boundary of the Willamette River Basin, where nearly 70 percent of Oregon's population lives.

3.2.1.2 Willamette River Basin Climate

Topography, proximity to the Pacific Ocean, and exposure to middle latitude westerly winds are the principal climate controls for the Willamette River Basin. The Basin's climate ranges from warm dry summers and cool wet winters in the center of the Basin to extreme alpine conditions in the highest Cascade Mountain reaches. Rainfall ranges from 40 inches per year in most of the Basin to over 200 inches per year in the highest Cascade Mountain reaches. For the entire Basin, average annual precipitation totals approximately 63 inches, with 60 percent falling during November through March based on rain gage and snow depth data (USACE 2015b).

During the winter months, high-pressure centers are characteristically to the south so that winds consistently come from the relatively warm and humid ocean surface and bring precipitation into the Willamette River Basin. The most intense events are usually atmospheric rivers, which are occasionally preceded by low elevation freezing conditions. Atmospheric rivers combined with rain-on-snow events caused some of the largest floods in the Willamette River Basin. In contrast, summer conditions typically have high-pressure centers near the west coast, which often forces the flow of air over the Basin from a northerly direction. This pattern decreases relative humidity and reduces the amount of cloud cover and precipitation over the entire area during summer months. Thunderstorms can occur during the summer but are not a major source of precipitation in the Basin. During spring and autumn, intermediate conditions occur causing alternating wet and dry periods (USACE 2015b).

3.2.1.3 Willamette River System

There are approximately 465 RM along the Willamette River and its regulated subbasins below USACE's WVS. The approximate regulated river length in each subbasin is:

Mainstem Willamette River	187 RM From the confluence of the Middle and Coast Forks of the Willamette River to the Columbia River
Mainstem Santiam River	11 RM
North Santiam River	46 RM
South Santiam River	44 RM
Long Tom River	25 RM
McKenzie River (including South Fork)	60 RM
Blue River	2 RM
Coast Fork Willamette River	30 RM
Middle Fork Willamette River	45 RM
Fall Creek	7 RM

Most of the drainage area in the Willamette River Basin is located downstream of the WVS dams and reservoirs. For example, although more than 90 percent of the Middle Fork Willamette River drainage passes through USACE reservoirs upstream of Eugene, Oregon, only about 27 percent of the drainage area is above a reservoir at the Willamette River confluence with the Columbia River. The relative volume of water in the Willamette River from USACE reservoirs varies substantially throughout the year depending on the primary seasonal flow management goal.

3.2.1.4 Flow Management Goals

During each year there are three reservoir control periods: flood risk management (fall/winter), conservation storage (spring), and conservation holding and release (summer). The transition date between seasons varies slightly at each reservoir (USACE 2014a).

Operation of each dam and reservoir is guided by its water control diagram, including the rule curve[1], which establishes the elevation at which the pool is to be maintained at or below during various seasons and during seasonal transitions unless regulating a flood event (Figure 3.2-1).

From September to November (or December at some dams and reservoirs), the reservoirs are drawn down to minimum flood pool elevations to reserve space to detain and release winter flood flows as necessary. In February (depending on the dam/reservoir), reservoirs begin to accumulate water in conservation storage by releasing less water than flows in. By about the end of May or June, WVS reservoirs are as full as possible for the summer season (USACE 2015b).

As required by Congress, USACE manages the WVS to meet multiple responsibilities or purposes, including flood control or flood risk management, hydropower, water quality, fish and wildlife, recreation, irrigation, navigation, and municipal and industrial water supply (Chapter 1, Introduction, Section 1.10, Congressionally Authorized Purposes). In some years, inflow to WVS reservoirs is not sufficient to fully meet all the demands on the system.

The goal of spring and summer flow management planning is to develop a strategy for the release of stored water using the National Oceanic and Atmospheric Administration Regional Forecast Center's (NOAA RFC) anticipated precipitation and runoff patterns. Each year, the Willamette Action Team for Ecosystem Restoration (WATER) forum, made up of U.S. Fish and Wildlife Service, National Marine Fisheries Service (NMFS), USACE, Bureau of Reclamation, Bonneville Power Administration, Oregon Water Resources Department, and Oregon Department of Fish and Wildlife representatives, works cooperatively and adaptively before and during the conservation storage and release season to plan WVS operations to meet flow objectives for ESA-listed fish and management for other Congressionally authorized purposes (Section 1.10, Congressionally Authorized Purposes). Because each water year is different, this coordination is preferable to establishing fixed operating criteria. Adaptive management is necessary as it is not possible for USACE to forecast, describe, model, and implement a comprehensive release program that addresses potential management scenarios and contingencies without frequent coordination.

[1] A rule curve is seasonal reservoir elevation targets or restrictions, represented graphically as curves, that guide reservoir operations.

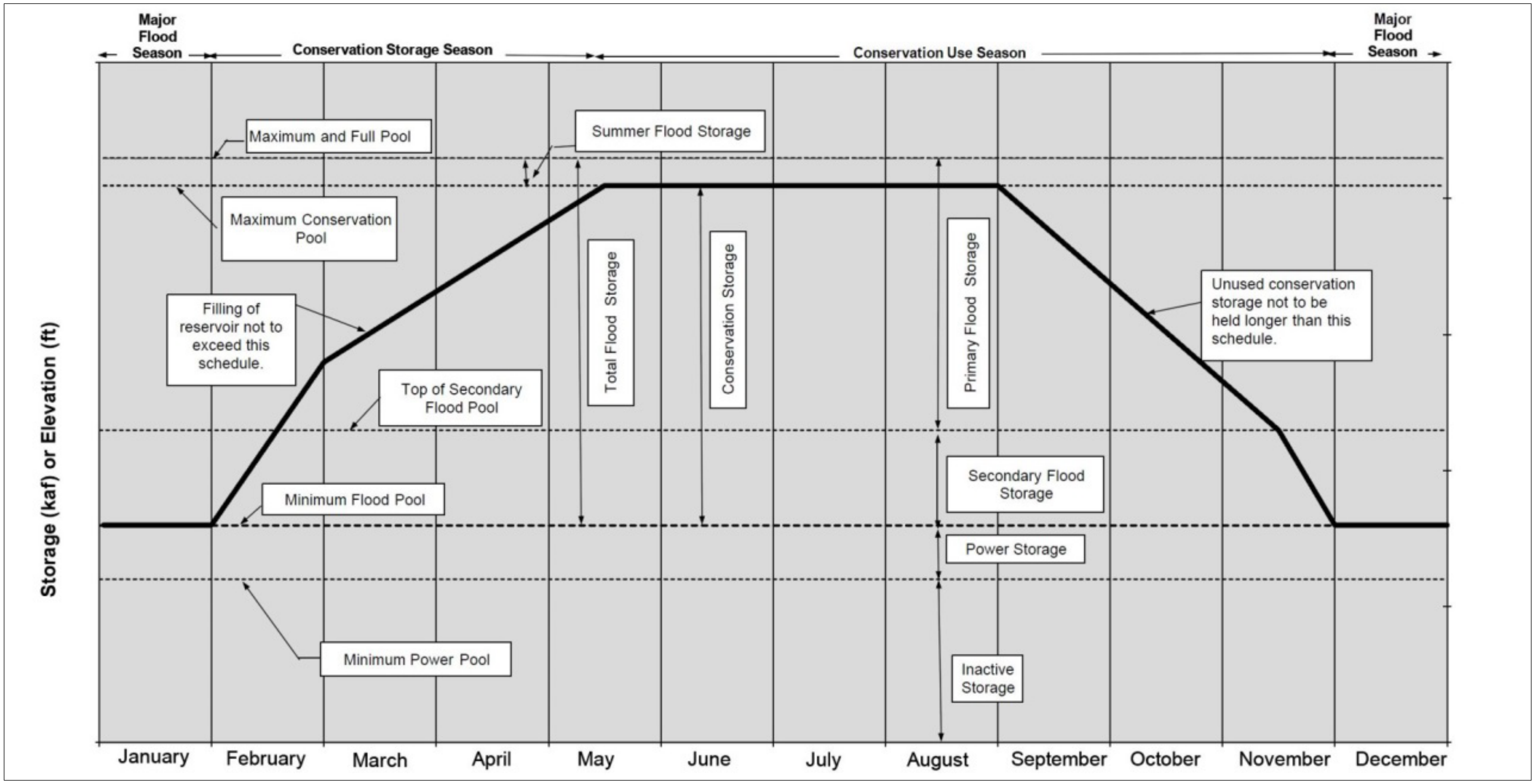

Figure 3.2-1. Typical Willamette River Basin Dam and Reservoir Water Control Diagram and Rule Curve*.

* The main features of the water control diagram are annotated.

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The Conservation Plan developed in cooperation with the WATER forum describes individual reservoir and system flow objectives, reservoir release priorities, minimum and maximum flows, and balances the multipurpose needs given the forecasted availability of water. The general operational goal—assuming sufficient inflow of water—is to maintain each reservoir above minimum conservation pool ("Minimum Flood Pool" level in Figure 3.2-1) through October 31 while attempting to meet the other Congressionally authorized purposes. Operational flow objectives at Salem, Oregon begin on April 1, before the reservoir refill period ends in May, so WVS releases may be adjusted through the conservation season[2]. The availability of water is reassessed as necessary (monthly, at a minimum) through October, and changes in the WVS management strategy are made in coordination with the representatives from the WATER forum throughout the conservation season (USACE 2015b). The typical targets (for example, 4,500/5,000 cfs at Albany, Oregon under the 2008 Biological Opinion) are referred to as the 'baseline' targets for the hydrologic processes analysis. Two objectives of the WATER forum are oversight of this target and changes to this target to account for conditions during individual water years.

During the winter months, WVS reservoirs are primarily operated for flood risk management. There is a notable history of flooding in the Willamette Valley, with large floods occurring in 1861, 1964, and 1996. The largest historical flow at Salem, Oregon was during 1861, peaking at an estimated 500,000 cfs. The 1964 and 1996 floods peaked at 308,000 cfs and 244,000 cfs, respectively. Both the 1964 and 1996 events were reduced by the WVS winter storage capacity. If the WVS had not existed during these events, the peak flows would have been substantially higher: approximately 472,000 cfs and 381,000 cfs, respectively (USACE 1997).

Each WVS reservoir is managed for targets at control points downstream (Figure 3.2-2). These targets can apply only to an individual USACE dam or to the entire system. For example, Detroit Dam flood season flow decisions are immediately evaluated at its nearest control point at Mehama, Oregon, on the North Santiam River, and no other WVS reservoir can influence water levels at this location. Continuing downstream, the control point at Salem on the mainstem Willamette River is influenced by all the WVS reservoirs. Section 3.2.1.5, Willamette Basin Description and Reservoir System, contains a more detailed explanation and maps of each subbasin.

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[2] The term "conservation season" encompasses spring, summer, and fall seasons and is composed of "conservation storage season" and "conservation use season" (when reservoir water is used most often). The conservation season is in contrast to the flood season.

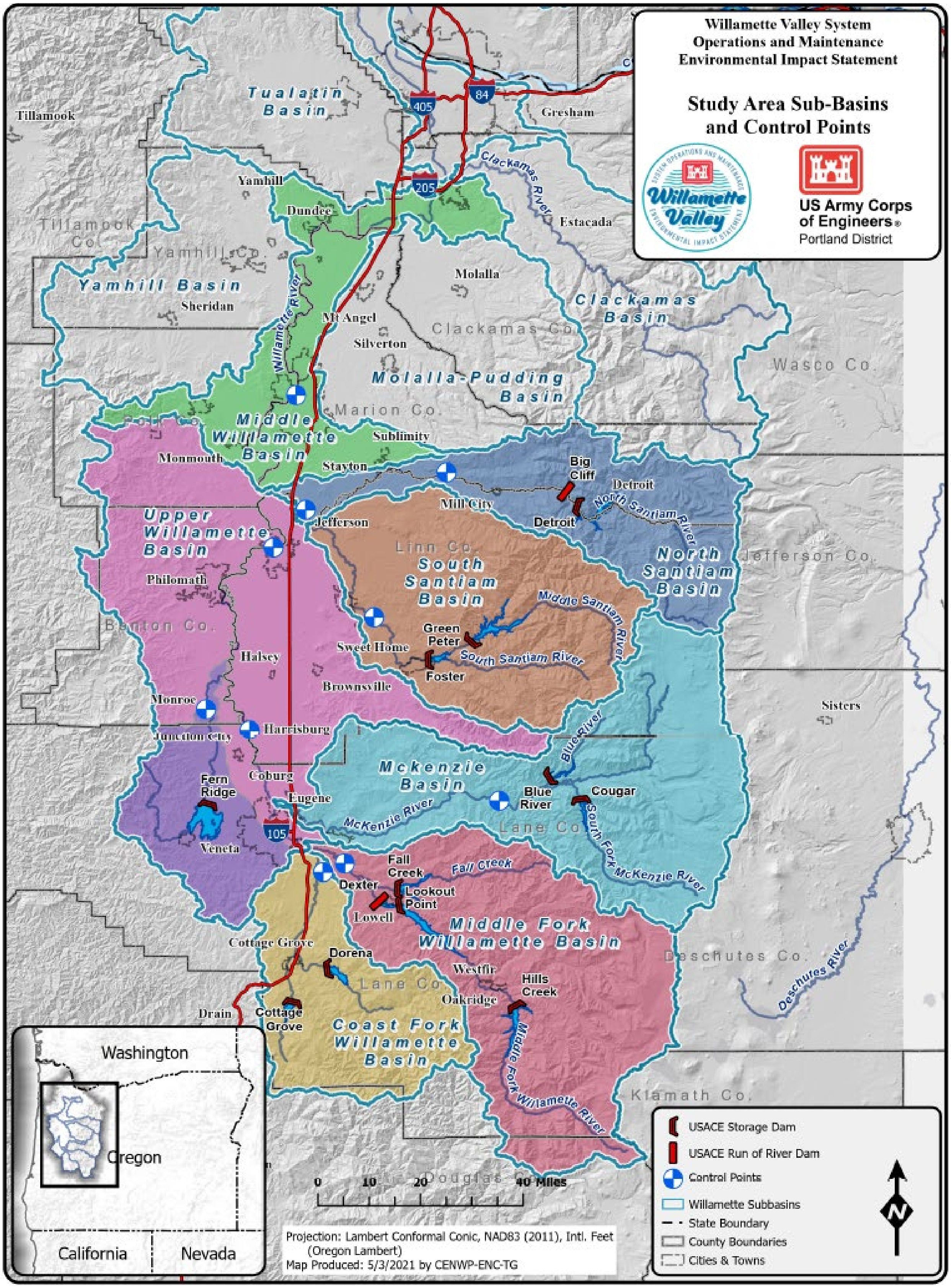

Figure 3.2-2. Willamette River Basin Subbasins and Willamette Valley System.

END REVISED TEXT

Major flood season runs from the middle of November through early February in the Willamette River Basin. Floods result principally from rainfall, augmented by snowmelt. House Document 531 (HD531) established the guidelines for flood season operation for the WVS and established two types of flood storage. Primary flood storage provides risk management for floods of record except for the 1861 flood, while secondary flood storage provides risk management for flows to the 1861 level.

Secondary flood storage can be used jointly for flood risk management and hydropower purposes. The document mandates that the maximum amount of flood storage space (i.e., the bottom of secondary flood storage) at the non-power dams and reservoirs must be available at the start of each flood season. Current practice is to lower the water level in all reservoirs, regardless of power-generating capability and excluding the smaller re-regulating dams (Big Cliff and Dexter Dams), to minimum flood storage prior to the beginning of the flood season.

As downstream flood waters allow, USACE lowers reservoir levels to the minimum flood pool elevation, which is the bottom of the secondary flood storage pool. Timelines are dictated by dam/reservoir limitations such as flow change limits and outlet capacities, which vary at each WVS dam, but the bottom of flood storage is typically achieved in 7 to 10 days.

3.2.1.5 Willamette River Basin Description and Reservoir System

The WVS was constructed over approximately 30 years starting with Fern Ridge Dam (completed 1942) on the Long Tom River, west of Eugene, Oregon. The complete WVS is authorized for flood control, hydropower, pollution abatement, fish and wildlife, navigation (removed in 1986), recreation, irrigation, municipal and industrial water supply, and water quality (Chapter 1, Introduction, Section 1.10, Congressionally Authorized Purposes). Based on the hydrologic dataset from 1935 to 2019, the total average annual basin flow volume is 17.2 million acre-feet at Salem, Oregon and 22.7 million acre-feet at Willamette Falls, or an annual average of 23,700 cfs and 31,300 cfs, respectively. Approximately 6.1 million acre-feet, or an average of 8,350 cfs (35 and 27 percent of the flow at Salem and Willamette Falls, respectively), flowed through the WVS, compared to a total conservation storage volume of 1.59 million acre-feet. Annual variability accounts for slightly different flow measurements when using different time periods for the analysis.

Construction of the 13 USACE dams and reservoirs in the Willamette River Basin fundamentally changed the character of the flow regime in the basin. The WVS moderates floods during the winter by storing and releasing water to manage flood risk. Outside of flood season, the WVS releases stored water to maintain downstream flows throughout the summer, supplementing downstream basin inflows. Using Hydrology Engineering Center Reservoir Simulation System (HEC-ResSim) and other models, USACE can calculate the effects of reducing and increasing flows at various points in the Willamette River Basin. An unregulated flow refers to a natural flow regime without the influence of the WVS and an observed flow refers to the Basin with the WVS in place, managing flow in the system.

Figure 3.2-3 shows a comparison between the observed and unregulated flow for the 1996 water year at Salem and the daily minimum, average, and maximum unregulated flow as calculated by the USGS for 1928 to 2008 (USGS 2018). Note the reduced peaks during the winter and increased flow during the summer and fall. Similar patterns are present across most years; 1996 was a wetter than average year and both the unregulated and regulated flows are above the median flow for most of the winter months.

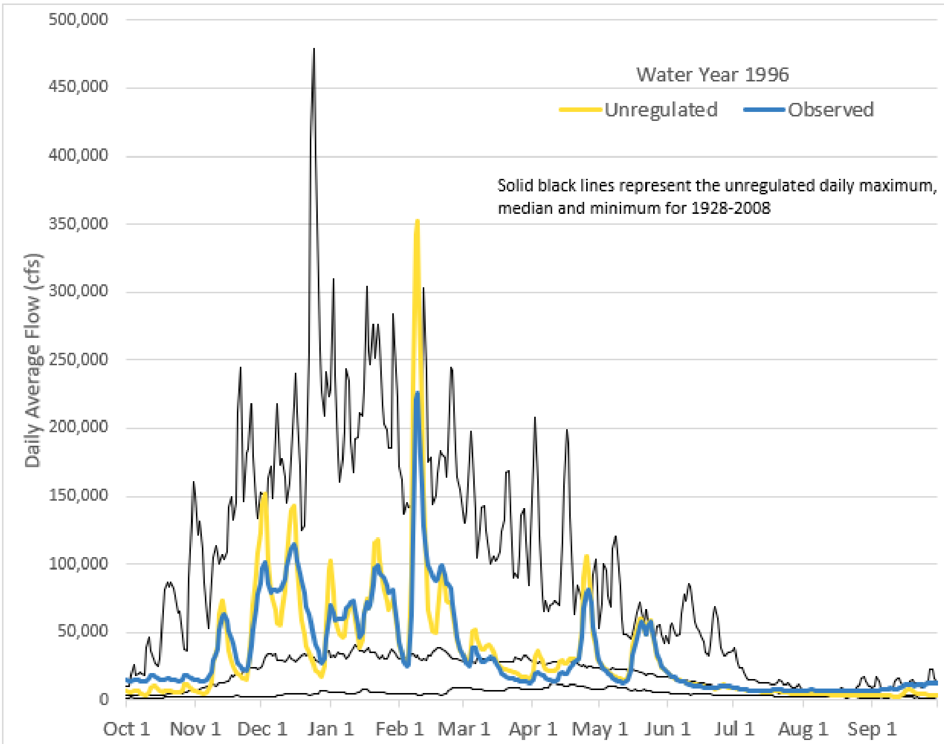

Figure 3.2-3. Willamette River Stream Flows at Salem, Oregon, for October 1995 to September 1996 (WY1996).

The WVS stores water in its reservoirs and some of this water evaporates. Except at Fern Ridge Dam, the evaporation is a relatively minor component of the total reservoir inflow—WVS reservoirs have a large volume compared to their surface area. Because inflow is calculated with the change in storage and the measured outflow, the evaporated water is already accounted for in the input dataset as a slightly lower inflow. At Fern Ridge Dam, because it is shallower than the other WVS reservoirs and has the largest surface area, evaporation is estimated and removed from the reservoir in the HEC-ResSim model. Appendix B, Hydrologic Processes Technical Information, has additional information on the hydrologic dataset development.

WVS has target flows at the mainstem control points during the summer. The goal is to augment the natural downstream flows with stored water for fish and irrigation withdrawals. This actual target flow varies with the conditions identified in the 2008 NMFS Biological Opinion (NMFS 2008), based on the projected amount of stored water each spring.

The hydrologic study area ends at the Willamette Falls in Oregon City, Oregon. The portion of the Willamette River flowing through Portland, Oregon, is downstream of Willamette Falls and is not included in the reservoir model, and neither is any flow coming into the river downstream of the Falls. The Willamette River below the Falls has a tidal influence that cannot be modeled in HEC-ResSim. Refer to the Columbia River System Operations EIS for information on the tidally influenced portion of the river (USACE et al. 2020).

Willamette River Basin Flow

Total basin-wide inflow is not evenly distributed throughout the Willamette River Basin. In general, larger size and higher elevation subbasins contribute more flow. Most of the flow from the Willamette River Basin originates from areas that are not upstream of a WVS dam. For example, 1.5 percent and 2.8 percent of the total Basin flow comes into Blue River and Cougar Reservoirs, respectively. Considerably more water (8.8 percent of the total) flows into the control point at Vida, Oregon below those two reservoirs without having passed through the reservoirs upstream. Moreover, about 24 percent of annual flow of the Willamette River at its confluence with the Columbia River enters the river from tributaries downstream of Salem, Oregon, the most downstream control point for current operational targets. Figure 3.2-4 shows the origin of Basin flows on an average annual basis. The values represent the additional accumulated inflow as compared to the next upstream point under natural conditions with no dams present.

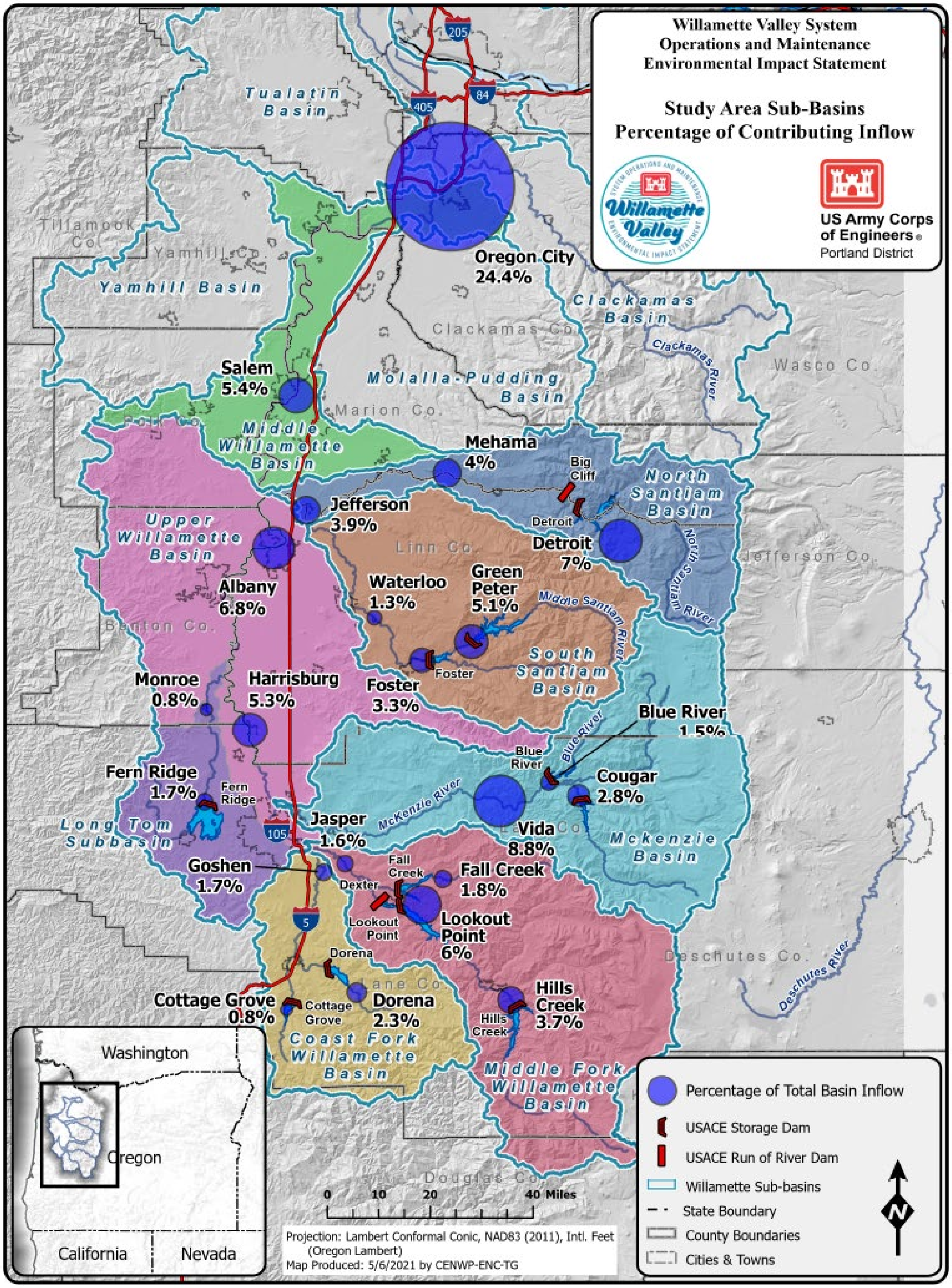

Figure 3.2-4. Basin Inflow Origin by Willamette Valley System and Control Point Location.

Willamette River Basin Unregulated and Observed Flow

As discussed in Section 3.2.1.4, Flow Management Goals, the primary objectives of the WVS change throughout the year based on the season. During the winter, the primary objective is flood risk management with a goal to reduce flows, and hence flood stages, downstream of the WVS. During the spring, USACE holds water in the WVS and releases the stored water through the summer and fall.

A comparison of the observed (USGS gage records after the construction of WVS) and unregulated (Lind and Stonewall 2018) flows show the effects of WVS operations. The example figures below show a reduction in peaks (the 5 percent non-exceedance line—5 percent of years are above that threshold on that calendar day) and increased median flows from December to February. The median regulated flow is higher in the winter because the water volume stored during large peak inflows is generally released over 7 to 14 days, increasing the flow of a larger number of days than peak reduction over 2 to 3 days. In the spring, the median observed flows go below the unregulated flow as the WVS reservoirs store water and high peaks are reduced. Later into the summer, flow augmentation from the reservoirs means that observed flow is higher than unregulated flow. In fall, the reservoirs release any remaining water to return to minimum elevation in preparation for major flood season.

Figure 3.2-5 and Figure 3.2-6 show the water year flows at Jasper (the control point for Lookout Point and Hills Creek) and Albany, respectively. The difference in observed and unregulated flows is greater at Jasper than Albany because a much higher percentage of the drainage basin flows through a WVS dam and reservoir upstream of Jasper. Similar figures for the remaining Willamette River Basin control points are available in Appendix B, Hydrologic Processes Technical Information.

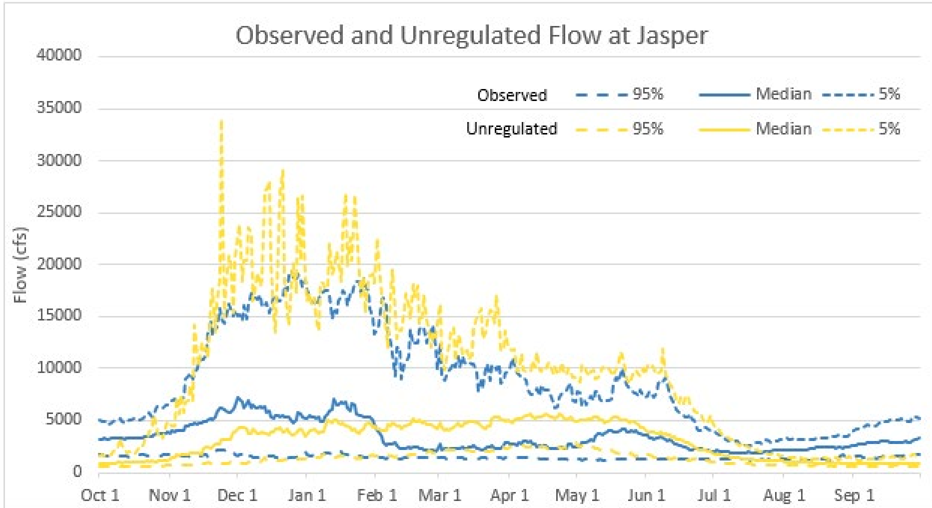

Figure 3.2-5. Middle Fork Willamette River at Jasper, Oregon, Flows across the Water Year.

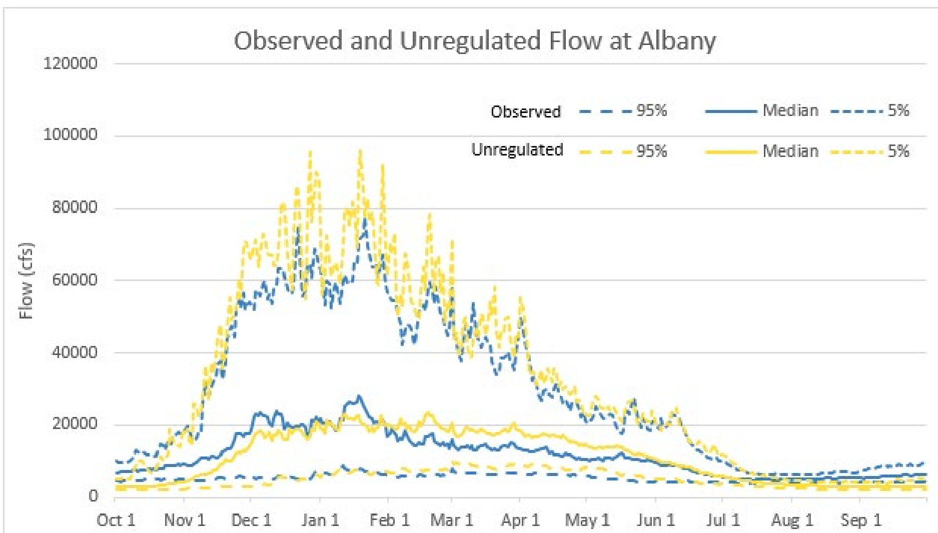

Figure 3.2-6. Willamette River at Albany, Oregon, Flows across the Water Year.

__Willamette Valley System Reservoir Pool Operations__

During April and May, the WATER forum assigns a rating of abundant, adequate, insufficient, or deficit for the upcoming conservation storage season based on the forecasted refill volume of the WVS reservoirs. The insufficient and deficit designations change the mainstem flow targets at Albany and Salem and allowable withdrawals from the Willamette River. Modeling and analyses of three recent prototypical years show the range of the designations: 2011, abundant; 2015, deficit; and 2016, insufficient are demonstrated in Section 3.5, Water Quality.

The figures below are of actual operations, not model results, for illustration purposes. WVS reservoirs were nearly full during the 2011 conservation season and stayed at or near rule curve until they were drafted (i.e., lowered) in preparation for a major flood season. Detroit Reservoir (Figure 3.2-7) is operated for downstream temperature control in insufficient years, so levels stayed relatively high in 2016; maintaining the pool above the spillway crest (elevation 1,541 feet) makes these operations more effective. In contrast, Green Peter (Figure 3.2-8) and Lookout Point Reservoirs (Figure 3.2-9) were drafted down as USACE used its stored water to meet the 2008 NMFS Biological Opinion mainstem flow requirements.

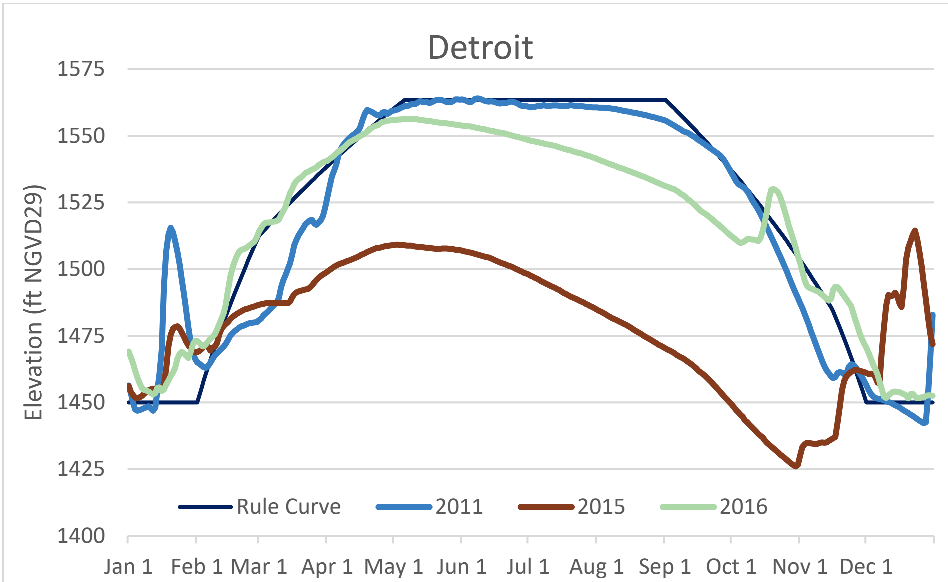

Figure 3.2-7. Detroit Reservoir Water Surface Elevation across 2011, 2015, and 2016.

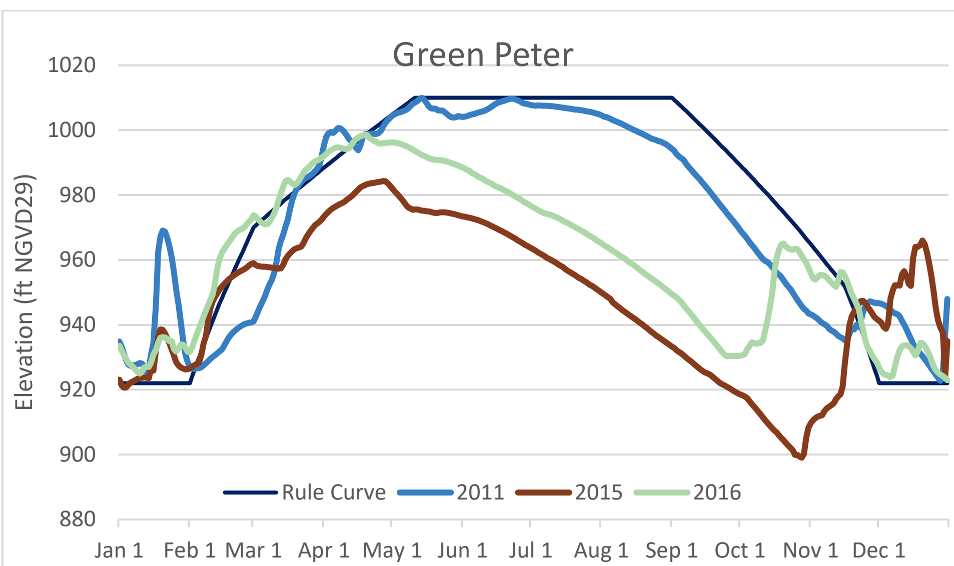

Figure 3.2-8. Green Peter Reservoir Water Surface Elevation across 2011, 2015, and 2016.

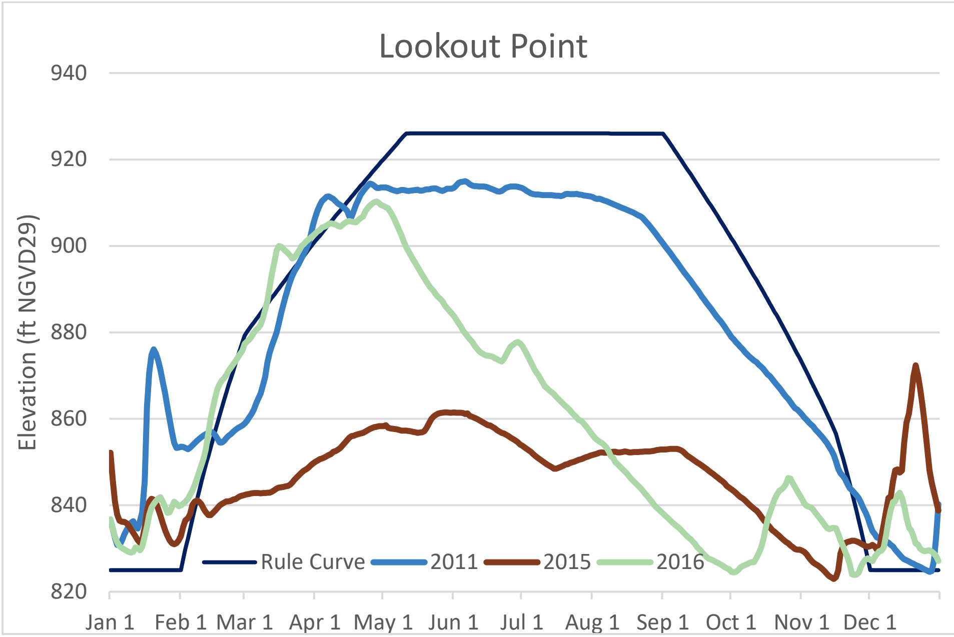

Figure 3.2-9. Lookout Point Reservoir Water Surface Elevation across 2011, 2015, and 2016.

2015 was a deficit year, so the reservoirs did not reach the rule curve during the spring and released the stored water, going below minimum conservation pool into the power pool. Similar figures of the remaining storage reservoirs are available in Appendix B, Hydrologic Processes Technical Information.

Mainstem Willamette River Subbasins

The mainstem Willamette River subbasins are divided into three main sections. The upper portion of the mainstem Willamette River starts at the confluence between the Middle and Coast Forks and continues up to the Santiam River. The extent of the Middle Willamette River stretches from the Santiam River to Willamette Falls at Oregon City. The Lower Willamette River below Willamette Falls is the tidal portion of the river to the Columbia River and is not part of this study area. Including the Clackamas River, which is the largest drainage basin downstream of the Falls, the Lower Willamette River is about 12 percent of the Willamette River Basin at its confluence with the Columbia River.

The Middle Willamette Subbasin is characterized by a meandering channel upstream of the mouth of the Yamhill River (Figure 3.2-10). From the Yamhill River to Willamette Falls, the river is characterized by a well-defined channel with comparatively narrow floodplain, most of which is located on its right bank. In the 5 miles above Oregon City, the river flows through a gorge upstream of the Tualatin River confluence to Willamette Falls. Above the falls, a fixed-crest hydropower dam (Thomas A. Sullivan Dam) was built and during low flows, the backwater effects of this dam extend upstream nearly 23 miles to Newberg, Oregon.

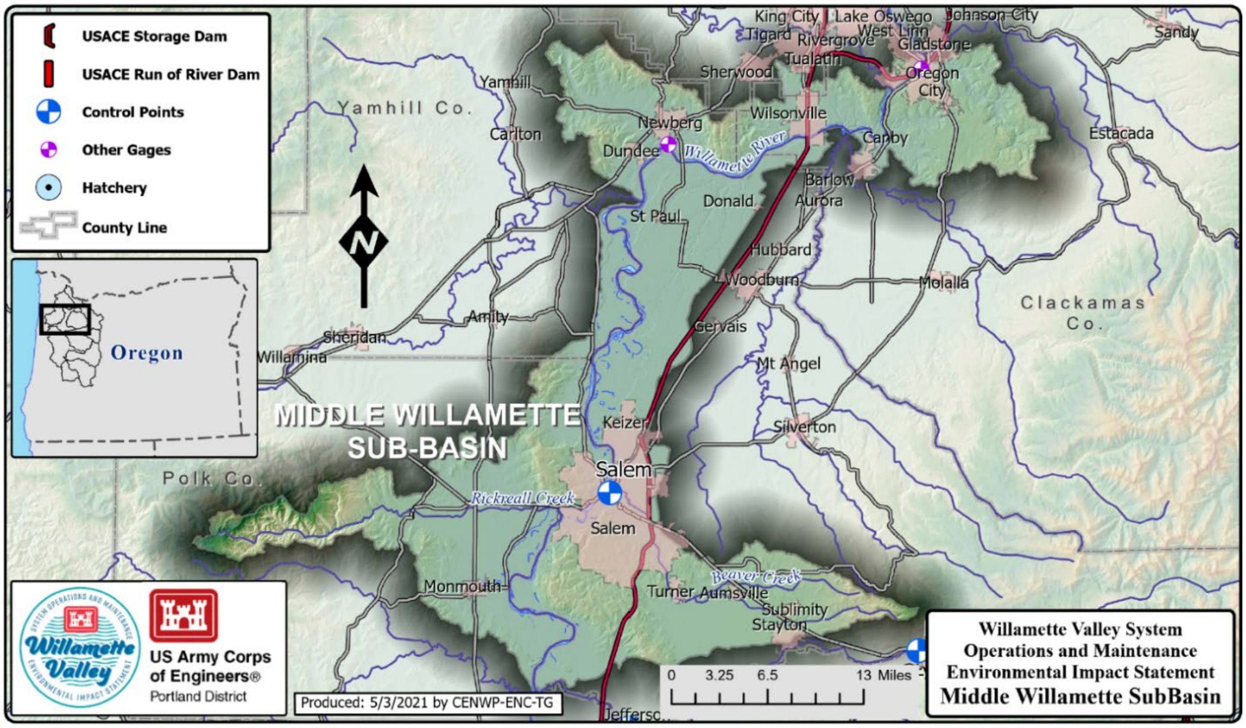

Figure 3.2-10. Middle Willamette Basin Subbasin.

Major population centers downstream of Salem include Newberg, Wilsonville, Canby, Oregon City, and Portland, Oregon. The percentage of developed area in this reach of the Willamette River Basin is greater than the other reaches. This downstream-most control point for WVS is at Salem (USGS gage 14191000) and all dams and reservoirs affect flows at this location. The total drainage area of the Middle Willamette (including inflows from Yamhill, Tualatin, and Molalla-Pudding Subbasins) makes up about 27 percent of the Willamette River Basin.

The upper Willamette River mainstem reach flows north from just south of Eugene, Oregon in a meandering channel to the Santiam River confluence, which is north of Albany, Oregon and west of Jefferson, Oregon (Figure 3.2-11). The floodplain in this approximately 130-mile reach is flat and wide. This reach was shaped through natural patterns of erosion and avulsion (abandonment of an existing channel and formation of a new one) as the Willamette River wandered laterally in a swath 2 to 3 miles wide. Many secondary channels, dead-end sloughs, and oxbow lakes remain as a result. Development activity near the river, mainly for agriculture and city growth, compelled the disconnection of the Willamette River from its floodplain by cutting it off from these secondary channels. The historical wandering of the Willamette River is now prevented with the application of revetments, embankments, or levees (Appendix S, USACE-managed Dams, Reservoirs, and Bank Protection Structures).

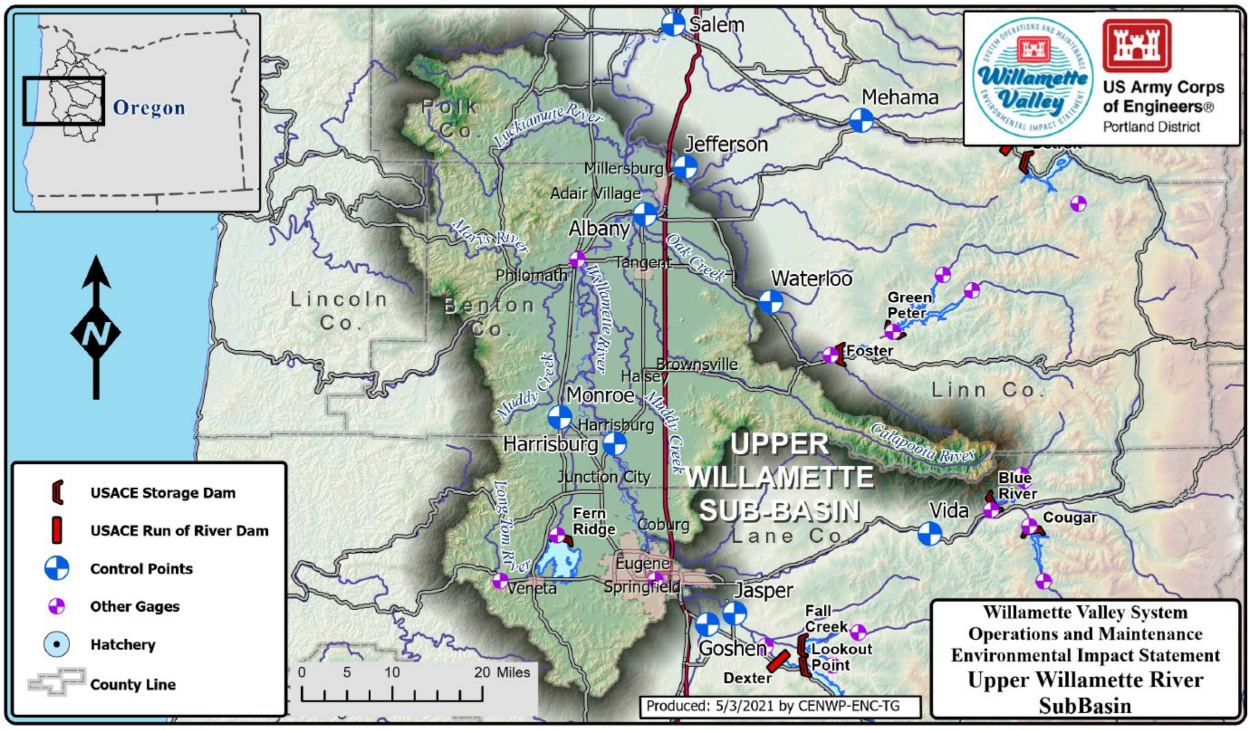

Figure 3.2-11. Upper Willamette River Basin Subbasin.

Major population centers along the mainstem Willamette River include Eugene-Springfield, Harrisburg, Corvallis, and Albany, Oregon. Areas within the urban growth boundaries of these cities are primarily developed. Outside the urban growth boundaries, the land is primarily used for agricultural purposes and state and national forests fringe the valley. The two control points in this reach are at Harrisburg (USGS gage 14166000) and Albany (USGS gage 14174000). Because they are upstream of the Santiam River confluence, dams and reservoirs in the Santiam River Subbasin are not able to affect flows at these locations. This reach, west-to-east from the Coast Range to the Cascade Mountains and south-to-north from Eugene to the Santiam River, encompasses approximately 16 percent of the Willamette River Basin, including the Long Tom River.

Santiam River Subbasin

The Santiam River Subbasin has a drainage area of approximately 1,827 square miles, or about 16 percent of the entire Willamette River Basin, divided between the North (Figure 3.2-12) and South (Figure 3.2-13) Santiam Rivers. Santiam River Subbasin elevations range between 200 and 10,495 feet and average 2,040 feet mean sea level (msl). The Middle and South Santiam Rivers meet in Foster Reservoir, and the South Santiam River flows north to near Jefferson, Oregon where it joins the North Santiam River. The North and South Santiam River form the mainstem Santiam River 11.7 miles upstream from the confluence of the Santiam and Willamette Rivers.

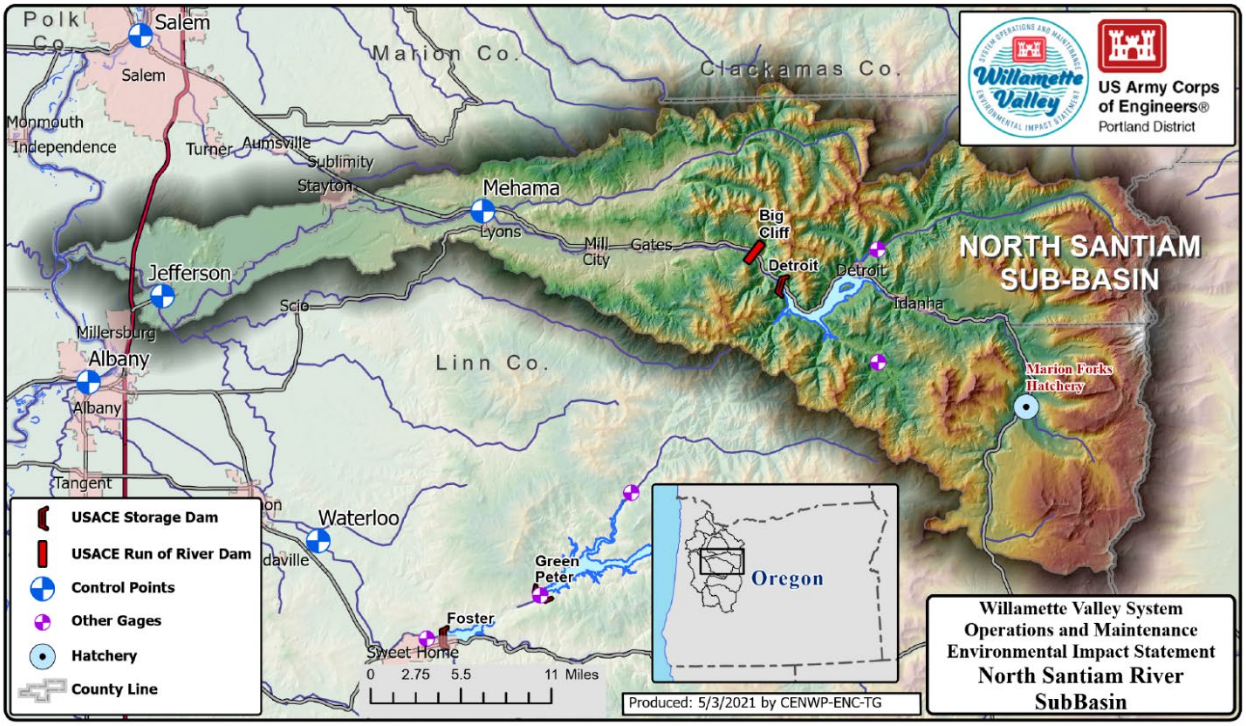

Figure 3.2-12. North Santiam River Subbasin.

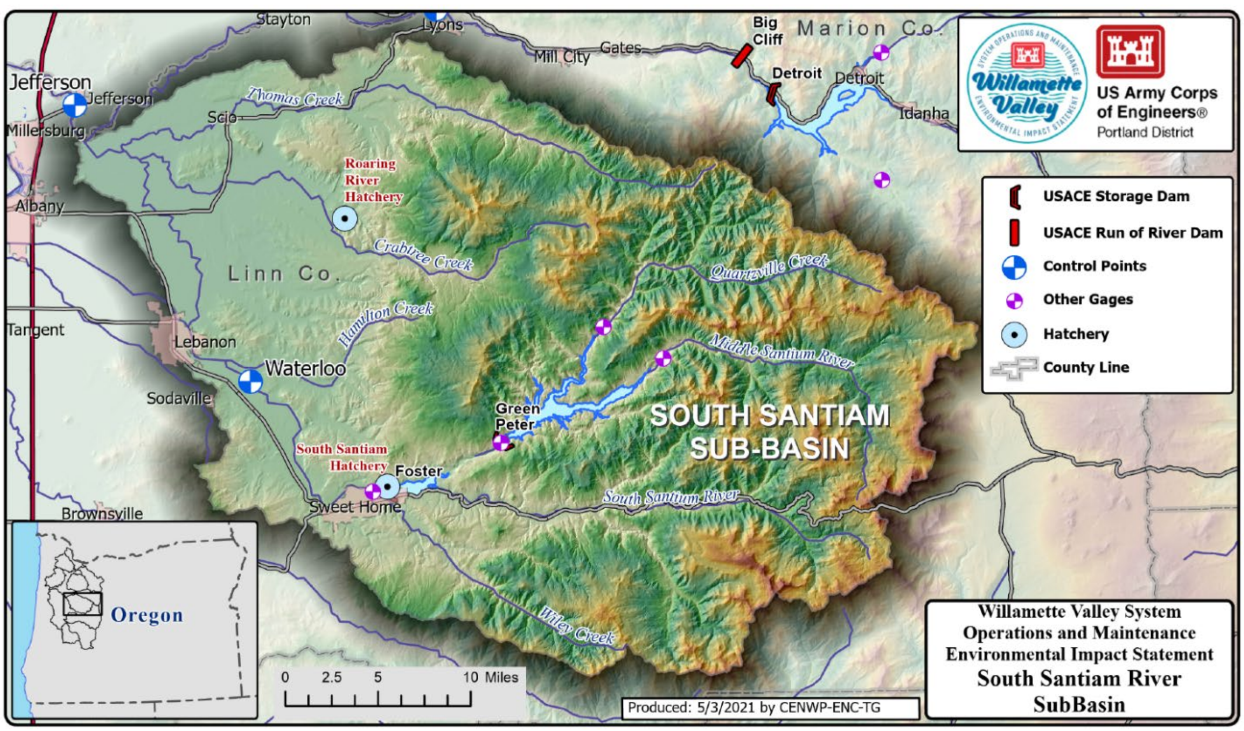

Figure 3.2-13. South Santiam River Subbasin.

The North Santiam River is about 92 miles long and drains an area of approximately 655 square miles. The subbasin features heavily forested basins and high plateaus containing scattered volcanic peaks and rugged slopes. The Middle Santiam River also flows through steep, heavily forested mountain terrain, draining an area of 287 square miles. Stream gradients upstream of Green Peter Dam are exceptionally steep, dropping several hundred feet per mile in places. The South Santiam River, roughly 66 miles long, drains an area of approximately 1,040 square miles in geologically older terrain. The South and Middle Santiam Rivers join within Foster Reservoir.

There are two USACE dams in the North Santiam Subbasin. Detroit Dam is a 450-foot-high concrete gravity dam and main storage reservoir with a usable volume of 321 thousand acre-feet and total storage of 455.1 thousand acre-feet. Big Cliff is the 172-foot-high re-regulating dam directly downstream of Detroit Dam. This enables Detroit Dam to supply power at peak times and not cut off flow to the North Santiam River downstream. In other words, the Big Cliff Reservoir pool elevation varies throughout the day as it supplies a constant daily flow as Detroit Dam switches on and off. Total storage at Big Cliff Dam is 6.5 thousand acre-feet. Both Detroit and Big Cliff Dams have powerhouses rated at 100 MW and 18 MW, respectively (USACE 2015a).

The control points downstream of Detroit and Big Cliff Dams are the North Santiam at Mehama (USGS gage 14183000) and the Santiam at Jefferson (UGSG gage 14189000) on the mainstem, which they share with the dams and reservoirs in the South Santiam Subbasin.

There are two USACE dams in the South Santiam Subbasin, Foster and Green Peter. Green Peter impounds the Middle Santiam River and receives a greater share of the total flow as compared to the South Santiam River above Foster Dam. Green Peter is a 327-foot-high concrete gravity dam and has usable storage of 312.5 thousand acre-feet and total volume of 430 thousand acre-feet. Foster Dam is a rock-fill dam, 126 feet high, with usable storage of 28.3 thousand acre-feet and total storage of 60.7 Kaf. Foster Dam re-regulates Green Peter Dam but also has some flood storage of its own. Green Peter and Foster Dams have powerhouses rated at 80 MW and 20 MW, respectively (USACE 2015a).

The control points downstream of Foster and Green Peter Dams are the South Santiam at Waterloo (USGS gage 14187500) and the Santiam at Jefferson (UGSG gage 14189000) on the mainstem, which they share with the dams and reservoirs in the North Santiam Subbasin.

Long Tom River Subbasin

The Long Tom River and Coyote Creek are the two principal rivers entering Fern Ridge Lake, with a combined drainage area of about 2 percent of the entire Willamette River Basin (Figure 3.2-14). A portion of Amazon Creek in Eugene is also diverted into the lake, thus adding an additional 23 square miles to the lake's drainage area.

The Long Tom River Basin is relatively low, with a maximum elevation of 2,125 feet. Mean elevation of the Fern Ridge's entire subbasin, including the Amazon Creek drainage, is 670 feet, and 99 percent of the entire subbasin is below 1,500 feet.

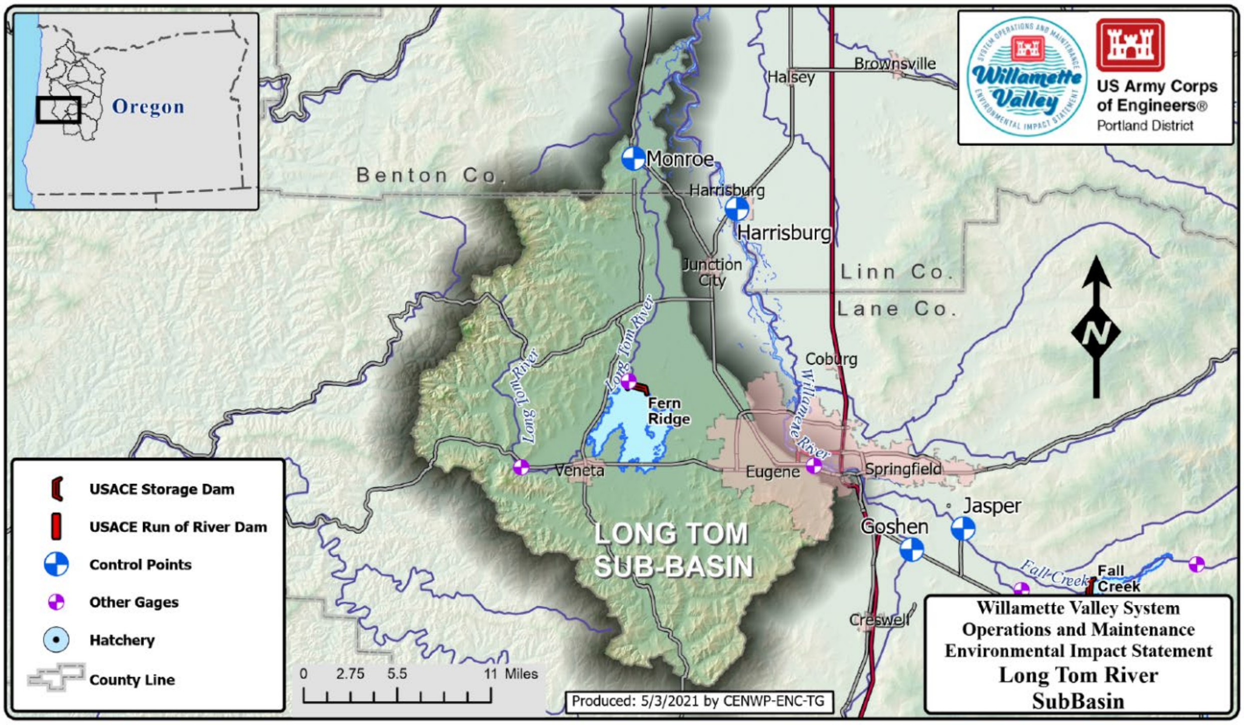

Figure 3.2-14. Long Tom River Subbasin.

Below Fern Ridge Dam, the Long Tom River meanders for 24 miles before joining the mainstem Willamette River north of Monroe, Fern Ridge's control point (USGS gage 14170000). Portions of the Long Tom River are channelized to increase the maximum allowable release from Fern Ridge. Three smaller streams, Amazon, Bear, and Ferguson join the Long Tom River between the dam and the Long Tom-mainstem Willamette River confluence.

Fern Ridge Dam is an earth-fill dam with a concrete outlet works. It is 49 feet high with usable storage of 101.1 thousand acre-feet and total capacity of 101.2 thousand acre-feet. The lake is much shallower than the other WVS reservoirs and evaporation is a substantial factor. Fern Ridge Dam does not have a powerhouse (USACE 2015a).

McKenzie River Subbasin

The McKenzie River Subbasin has a drainage area of approximately 1,300 square miles, or about 12 percent of the entire Willamette River Basin (Figure 3.2-15). The McKenzie River is roughly 90 miles long, joining the mainstem Willamette River a few miles north of Eugene, Oregon. Elevations range from 350 feet to 6,650 feet. The highest elevations in the headwaters are rugged and heavily forested. There are two non-Federal dams in the McKenzie River Subbasin: Carmen-Smith Hydroelectric Project in the upper McKenzie River and Leaburg-Walterville Hydroelectric Project in the lower McKenzie River.

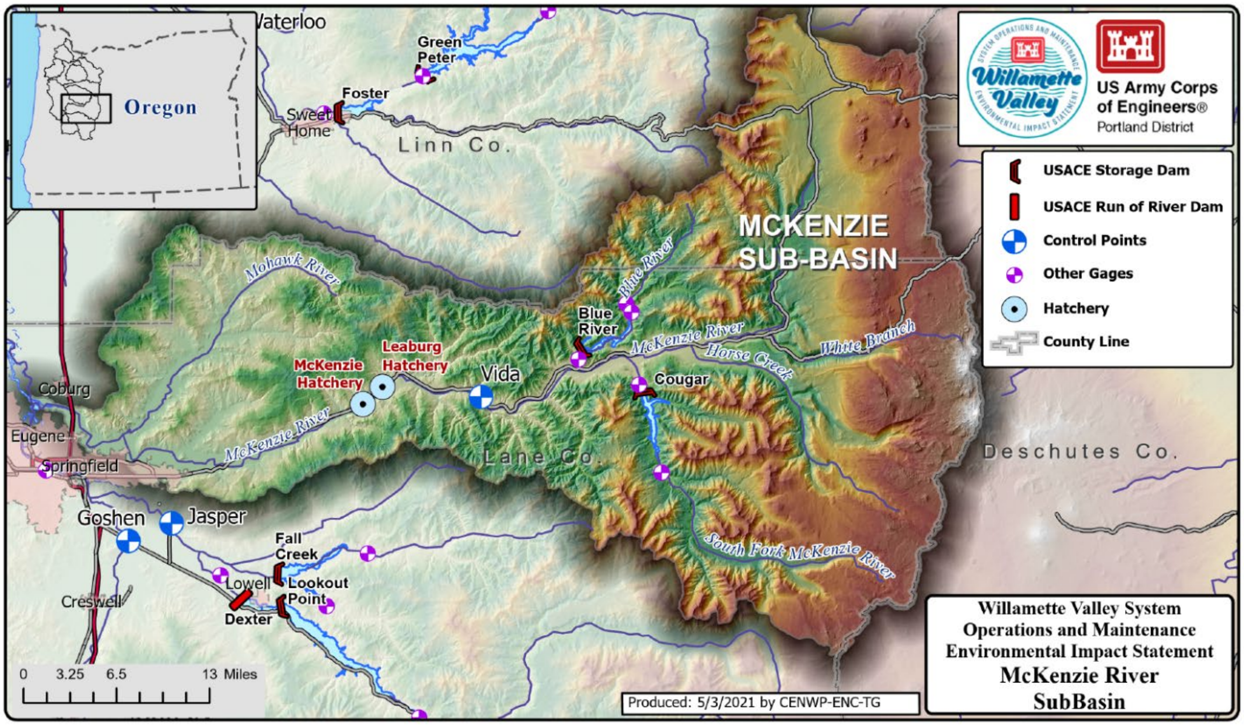

Figure 3.2-15. McKenzie River Subbasin.

Blue River Dam is on the Blue River about 2 miles upstream of its confluence with the McKenzie River, near Blue River, Oregon. It is a 270-foot-high earth-fill dam, with a usable storage of 82.8 thousand acre-feet and total storage of 89.5 thousand acre-feet. Blue River Dam does not have a powerhouse.

Cougar Dam impounds the South Fork of the McKenzie River, which joins the mainstem McKenzie River about 3 miles upstream of the Blue River confluence. The earth-fill dam is 452 feet high and has an installed power capacity of 25 MW. A water temperature control tower was constructed in 2005, enabling water to be withdrawn from a greater variety of depths in the reservoir. The usable storage capacity is 165.1 thousand acre-feet and total storage is 219.3 thousand acre-feet (USACE 2015a). Mean subbasin elevations above Blue River and Cougar Dams are higher than 3,500 feet, and both dams control more than 95 percent of their respective subbasins.

Blue River and Cougar Dams share a control point on the McKenzie River at Vida (USGS gage 14162500). Further downstream, the first common control point with the WVS outside the subbasin is on the mainstem Willamette River at Harrisburg (USGS gage 14166000).

Middle Fork Willamette River Subbasin

The Middle Fork Willamette River Subbasin has a drainage area of approximately 1,569 square miles, or about 14 percent of the entire Willamette River Basin, ranging from 450 feet at Eugene to 8,790 feet at Diamond Peak, located on the eastern boundary of the subbasin (Figure 3.2-16). Most of the subbasin is within the Willamette and Umpqua National Forests.

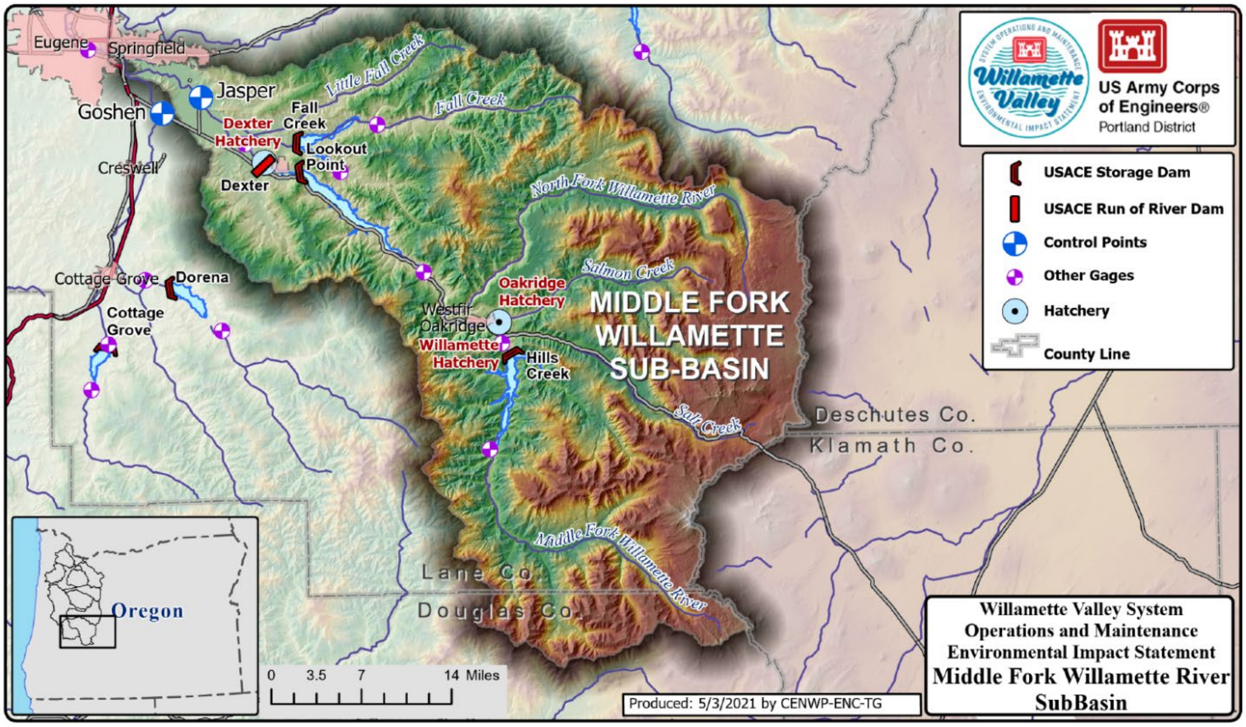

Figure 3.2-16. Middle Fork Willamette River Subbasin.

Water originating from the headwaters of the Middle Fork Willamette River pass through three reservoirs before Eugene, Oregon in Hills Creek, Lookout Point, and Dexter Dams. Salt Creek, Salmon Creek, and the North Fork of the Willamette River also join the Middle Fork between Hills Creek and Lookout Point Dams. Downstream of Lookout Point Dam, Dexter Dam re-regulates Lookout Point Dam to enable power peaking operations. Fall Creek Dam impounds Fall Creek and Winberry Creek. The confluence between Fall Creek and the Middle Fork Willamette River is about 2 miles east of Jasper and 6 miles west of Lowell, Oregon on the northern bank of Dexter Reservoir.

Hills Creek is a 304-foot-high earth and gravel-fill embankment dam. The usable storage of the reservoir is 234.3 thousand acre-feet and total storage is 356 thousand acre-feet. Lookout Point Dam is a 246-foot-high earth-fill dam with concrete outlet works flowing directly into Dexter Reservoir. The usable storage is 336.4 thousand acre-feet and total storage is 455.8 thousand acre-feet. The earth-fill Dexter Dam is considerably smaller, with a total storage capacity of 27.5 thousand acre-feet. Hills Creek, Lookout Point, and Dexter Dams have powerhouse capacities of 30 MW, 120 MW, and 15 MW, respectively. Fall Creek Dam does not have power generating capacity (USACE 2015a).

The shared control point for all four WVS dams and reservoirs in the Middle Fork Willamette River Basin is at Jasper (USGS gage 14152000). The Middle Fork Willamette River and Coast Fork River join to become the mainstem Willamette River south of Springfield. Further downstream, the first common control point with WVS outside the subbasin is on the mainstem Willamette River at Harrisburg (USGS gage 14166000).

Coast Fork Willamette River Subbasin

The Coast Fork Willamette River Subbasin has a drainage area of 669 square miles, or about 6 percent of the entire Willamette River Basin (Figure 3.2-17). Elevations in the Coast Fork Willamette River Subbasin range from about 450 feet at Eugene to 6,000 feet at the headwaters. The drainage headwaters consist largely of steep, rugged, mountainous terrain dissected by narrow river valleys. Much of the land is heavily forested. Downstream of Cottage Grove, the Coast Fork runs through a relatively wide and flat river valley before becoming confined by the hills south of Eugene just upstream of the confluence with the Middle Fork. The Coast Fork Willamette River Subbasin is lower in elevation than the other Willamette River headwater basins and so contributes less flow as compared to its drainage area.

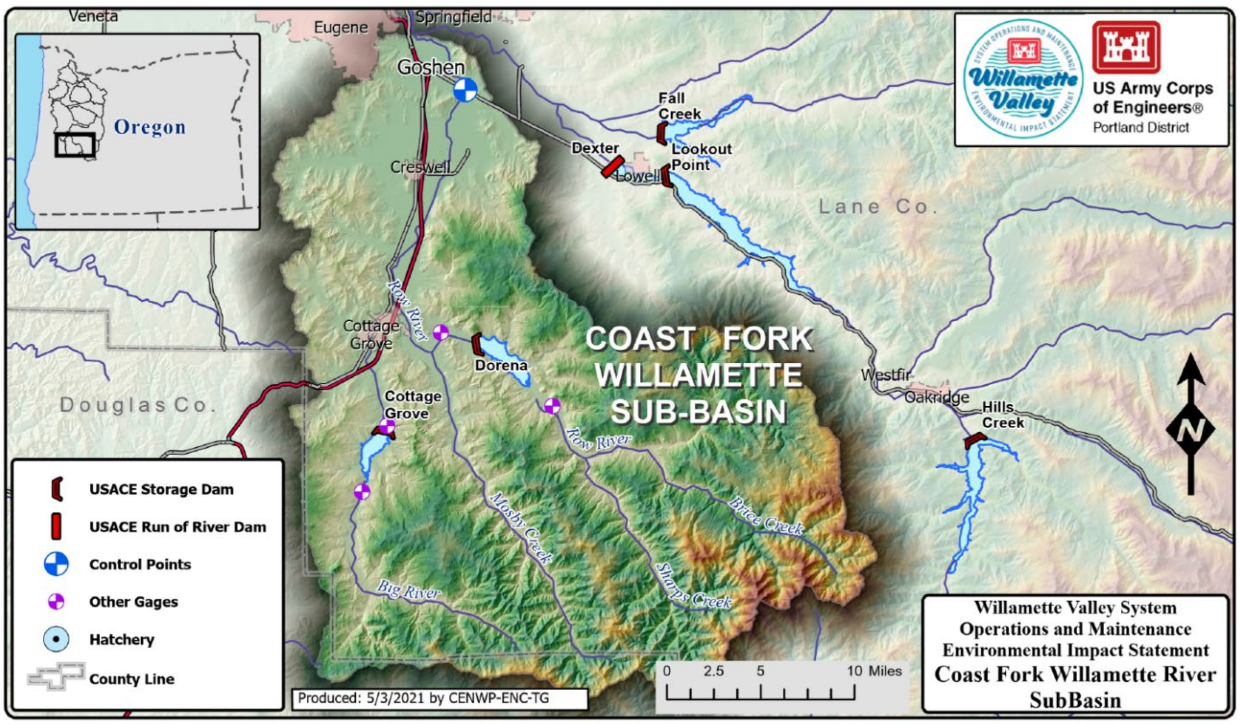

Figure 3.2-17. Coast Fork Willamette River Subbasin.

Cottage Grove and Dorena are the WVS dams on the Coast Fork and Row Rivers, respectively. Both dams are earth-fill with concrete outlet works. Dorena Dam is the larger of the two, with a height of 145 feet, usable storage capacity of 72.1 thousand acre-feet, and total capacity of 77.6 thousand acre-feet, compared with Cottage Grove Dam at 114 feet high and usable and total capacities at 31.8 thousand acre-feet and 33.5 thousand acre-feet, respectively. Dorena Dam hosts a non-Federal powerhouse with a capacity of 7.5 MW; Cottage Grove Dam does not have generating capacity (USACE 2015a).

Cottage Grove and Dorena Dams share a control point on the Coast Fork at Goshen (USGS gage 14157500). The Coast and Middle Forks join to become the mainstem Willamette River south of Springfield, Oregon. Further downstream, the first common control point with WVS outside the subbasin is on the mainstem Willamette River at Harrisburg (USGS gage 14166000).

3.2.2 Environmental Consequences

3.2.2.1 Methodology

USACE and others commonly use the term hydrology and hydraulics to discuss the quantity, movement, or behavior of water. For the WVS analyses, USACE modeled the No-action Alternative (NAA) and action alternatives over the observed period of record to show how water would move through the system, both within and downstream of the WVS dams and reservoirs, given a specific set of operational measures. Because hydrologic processes describes the flow of water through the system, only measures that would affect the volume or timing of flow are analyzed in this section. For example, structural measures that alter the water temperature would not affect hydrologic processes overall, and therefore, are not included in this analysis.

Reservoir Operations Model

The primary method to model basin flow and WVS reservoir operations for the analyses was the Hydrologic Engineering Center Reservoir Simulation System (HEC-ResSim). HEC-ResSim simulates reservoir operations for flood management, low flow augmentation, and water supply for planning studies, detailed reservoir regulation plan investigations, and real-time decision support. The input flow data, both for inflows to the reservoirs and flows from river systems downstream, are daily average flow for the period of record (1935 to 2019). This dataset is an extended version of the Willamette Flood Insurance Study (USACE 2011a; USACE 2013a) and 2010 Level Modified Streamflows (BPA 2011). Appendix B, Hydrologic Processes Technical Information, has additional information on the development of the hydrologic dataset.

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Outputs for each alternative are compared to the NAA to determine potential effects on the WVS under each alternative. Details of flows modeled by the HEC-ResSim model were also applied to other resource analyses. Furthermore, the HEC-ResSim model varies dam outlets as part of reservoir operations, but those differences rarely affect hydrologic processes. Appendix B, Hydrologic Processes Technical Information, contains detailed information on operational outlet selection. Other resource analyses (i.e., water temperature and hydropower) apply the outlet selection as part of those analyses.

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The period of record analysis provides a wide range of historical meteorological variability. The HEC-ResSim model can use the flow information to show how the system operates with a variety of goals across a long period. The longer period enables the model to compute probability based on the historical record. For example, the model can estimate the chance in any given year that a reservoir will fill to capacity during the spring or exhaust the available stored water prior the major flood season. The period of record analysis also allowed USACE to study how the system behaves under conditions that did not exist, like running inflows from before the WVS dams were constructed.

A computer reservoir regulation model, such as HEC-ResSim, requires fixed operational scenarios, or reservoir rule set, tested over many years of data. Each alternative alters the reservoir rule set to show differences in operation under the same inputs—the flow data—without human interference or preferences. Real-world reservoir operation is complex: different information is available to the water manager for decision-making, and decisions are shaped by an individual water manager's experience and risk tolerance. Water managers also adapt operations to the extent possible within constraints to meet goals responding to the unique conditions of a specific water year. Operational changes of this nature to match the observed record are not possible nor desirable to represent in a planning model such as this programmatic NEPA review. They would make comparing different alternatives substantially more challenging and would likely skew results toward the activities already undertaken in real-world reservoir operations.

Results

Summary hydrographs were produced to describe the changes to the flow and water surface elevation under each alternative. A hydrograph is a figure showing an indicator of water flow (such as stage or discharge) over time, typically over a water year. A summary hydrograph is an especially useful way to display information because it shows the expected range and likelihood of water levels (or flow) at a given location for each day of the water year.

The curves on a summary hydrograph do not represent a single water year. Rather, each curve represents the percentage chance of not exceeding the corresponding water level (or flow) on a given day. Five non-exceedance levels are shown: 5, 25, 50, 75, and 95 percent, representing the percentile (P##) of data below the line. In Figure 3.2-18, the color series for one alternative is compared against the base greyscale background to show differences between the presented alternative and the NAA. For example, the 25 percent curve on the summary hydrograph of reservoir elevation is about 1,500 feet on April 1, which means there is 75 percent chance the water surface elevation would be above 1,500 feet and a 25 percent chance it would be below 1,500 feet on April 1 across all water years.

Only selected figures are presented in analyses below. A complete set of figures across all WVS dams and reservoirs and control points is provided in Appendix B, Hydrologic Processes Technical Information.

Figure 3.2-19 illustrates the fall reservoir drawdown at Green Peter Dam with average reservoir elevation across all years and the year 1993 as an example year, where the reservoir moved parallel to the target for several months (Figure 3.2-19, P50 line). While there would be enough outlet capacity to quickly reach the target, the drafting limit of 3 feet/day prevents achieving the target elevation more quickly. More broadly, this shows an instance where operating a reservoir is a matter of competing goals; a specific target may not always be possible due to other constraints within the reservoir or larger WVS for operations and maintenance.

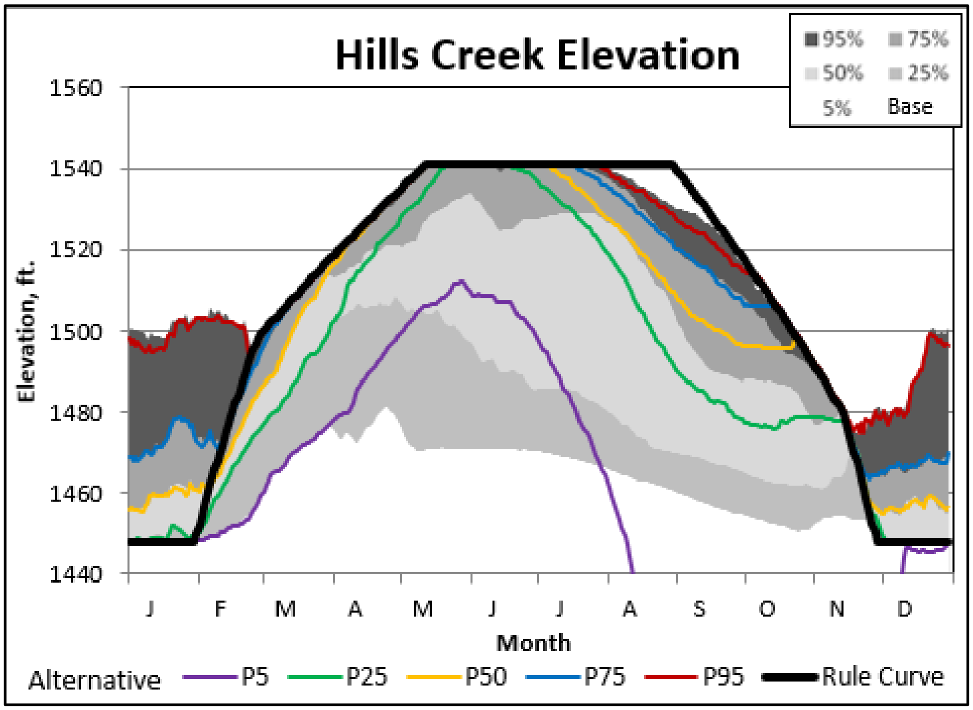

Figure 3.2-18. Example of Non-exceedance Figure at Hill Creek Reservoir.

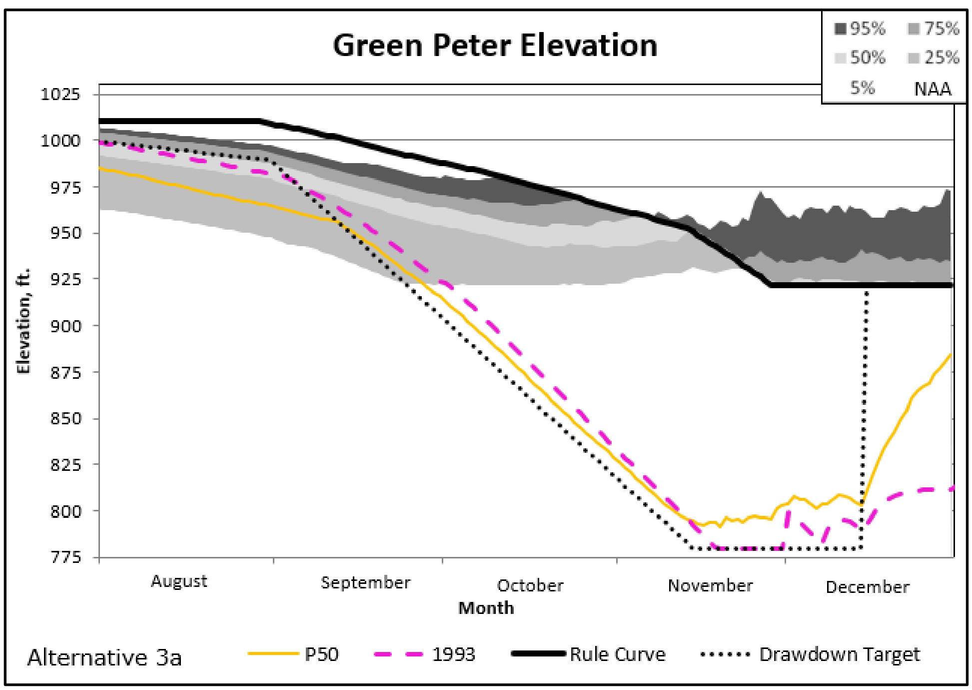

Figure 3.2-19. Alternative 3A Green Peter Reservoir Drawdown with the Year 1993 as an Example of Drafting Limits Preventing the Reservoir from Reaching the Target Elevation.

Certain other reservoir operational constraints can also limit the level of the drawdowns in each year. Apart from high inflow, the primary limitation on drawdowns for the WVS reservoirs is the general USACE drafting guideline of no more than 3 feet of water surface elevation per day. Implemented as a result of experience with the water temperature control tower construction at Cougar Dam (completed in 2005), this guideline is used during non-emergency situations to reduce the probability of landslides around the reservoir rim, upstream embankment settlement, and slope stability issues. In practice, this draft limit would cause the reservoir to be above the drawdown target elevation for extended periods as both the reservoir water surface elevation and the target descend at the same 3 feet/day.

Flood Risk Management Assessment Methodology

Across all alternatives, USACE used a screening criterion of "No Increase in Flood Risk" to exclude measures with the potential to increase flood risk during the development phase of the WVS EIS. Specifically, these are measures that increase the frequency, duration, or magnitude of flow at control points during flood season above threshold stages along tributaries and the mainstem of the Willamette River, increasing flood risk.

Operations that increase flood risk can include increased maximum releases from WVS dams or reduced flood storage, leading to higher pool elevations and higher releases to mitigate the risk of overtopping. For the range of alternatives development, operations that increase maximum releases or reduce seasonal flood storage were removed from consideration (Appendix B, Hydrologic Processes Technical Information).

Construction Effects on Hydrologic Processes Analysis Methodology

General qualitative effects from construction at the programmatic level are analyzed. Site-specific details for each construction measure would be determined during the implementation phase with subsequent environmental analyses as warranted. Most construction activities associated with the measures under each alternative would only locally affect the hydrology of the river reaches, with the exception of selective withdrawal structures. For example, water routed through a different outlet for construction activities at a fish facility would alter the reservoir regulation outlet choice but not the total flow out of the dam.

Depending on construction methods, construction of the selective withdrawal structures at Detroit, Lookout Point, Green Peter, and Hills Creek Dams may require reservoir drawdowns and pool restrictions over several years. A long drawdown may also be necessary at Cougar Dam to construct the outlet works for the routine use of the diversion tunnel. If there are drawdowns in the site-specific plans, water would be drafted out of the reservoir prior to construction, increasing the instream flow downstream of the reservoir until it reaches the necessary elevation. During construction activities, a lower pool at each of these reservoirs would mean notably reduced conservation season water storage. This could also impact other reservoirs, lowering their stored water volume as they release more water to meet shared downstream flow targets, potentially inducing system-wide effects for construction at selected locations. In the winter, each reservoir could be subject to pool restrictions over the construction period, which may impact flood risk management operations.

Routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation). Consequently, hydrologic effects from maintenance activities are unknown. The hydrologic effects for these activities, along with all other types of effects, would be the subject of additional analysis under the tiered NEPA process (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act).

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Climate Change Effects Analysis Methodology

Climate change effects and potential implications rely on the climate change projection and trend information provided in the climate change appendices (Appendix F1, Qualitative Assessment of Climate Change Impacts; Appendix F2, Supplemental Climate Change Information). Appendix F2 also identifies changing climate factors and hydrology that could have a consequential impact to the resources potentially impacted by the alternatives. The climate change factors most important to the hydrologic processes are projected future changes in precipitation (rainfall and snow), changing rates in peak and average streamflow, change in snowpack, and flow volumes.

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USACE expects climate change to impact the WVS in several ways. Temperatures in the Willamette River Basin are expected to warm relative to the historic period 1970–1999 by another 1.5°F to 3°F by about mid-century and 2°F to 5°F by end-of-century. Winter snowpack is likely to decline over time as more winter precipitation falls as rain instead of snow. Future precipitation is projected to trend upward for the rest of the century, particularly in the winter and early spring. Later spring months will become drier, effectively starting already dry summers earlier than under current conditions. Decreasing baseflow could become drier, further reducing summer flow. USACE applied these impact trends to qualitatively assess expected changes to reservoir storage and flow, mapped onto the operations implemented under each alternative.

Effects Criteria

Table 3.2-1 explains the environmental effects criteria to describe potential hydrologic effects within the Willamette River Basin under the alternatives. Duration and extent of potential activities are incorporated into these criteria as explained below.

Table 3.2-1. Hydrologic Process Effects Criteria.

Degree of Effect	Criteria
No Effect/Negligible	Willamette River Basin-regulated hydrology would not be changed, would be nondetectable, or changes to water level, discharge, volume, or timing would be slight and localized. The area extent of effects would be small (limited) and would not require additional consideration or adaptive management.
Minor	Changes to the Willamette River Basin-regulated hydrology would be measurable, although the change in water level, discharge, volume, or timing would be small and localized at the subbasin level. The need for adaptive management measures would be evaluated to reduce or minimize any potential changes.
Moderate	Changes to the Willamette River Basin-regulated hydrology would be measurable and would have either subbasin or basin-wide differences in water surface elevation, discharge, volume, or timing. The regulated hydrology would be within current regulatory standards[1], but potentially differ from historical condition. The need for adaptive management would be evaluated and would likely be able to reduce the degree of potential changes.
Major	Changes to the Willamette River Basin-regulated hydrology would be readily measurable and would have substantial differences in water level, discharge, volume, or timing on a regional level. The regulated hydrology may not meet existing regulatory standards[1]. The need for adaptive management would be evaluated to reduce changes in the system, although hydrologic changes would be expected regardless of the activities implemented.

[1] Applicable regulatory standards can include minimum target flows that the WVS intends to exceed, flow ramping rate limitations (how fast the flow can change in a given time period), and maximum flowrate at a given point (flood operations or physical limits).

Effects Criteria Context

Effects to the hydrologic processes would be inherently long term as they would last for the duration of the Proposed Action (2050) and potentially have lasting effects beyond 2050. The WVS dams and reservoirs alter the hydrology of the Willamette River Basin, and the imposed hydrology will continue to effect lasting change on other resources as analyzed in other sections. Because all WVS activities discussed across all alternatives would be long term for hydrologic processes, duration is not evaluated or discussed further in this section. These effects are determined by comparing to the NAA throughout these sections unless a specific exception is noted.

Hydrologic effects are evaluated with an integrated reservoir regulation model. The geographic extent of every alternative implementation would be basin-wide or regional. For example, under the NAA and any of the action alternatives, even a seemingly small change to water storage at one reservoir would alter the operation of any other, or several, reservoirs within the Willamette River Basin. While dams and reservoirs closer to each other are more likely to affect each other's operations, shared river control points and flow targets require that the WVS dams and reservoirs operate together. Because all WVS regulation activities discussed across all alternatives would be regional for hydrologic processes, extents are not evaluated or discussed further in this section.

The changes to hydrologic processes are not characterized as adverse or beneficial. Such a determination would be arbitrary without some other criteria to judge the changes in hydrologic processes, such as fish survival or recreation resources. Furthermore, some potential changes to hydrologic processes could reasonably be both adverse and beneficial depending on the criteria and perspective applied.

Because results of hydrologic processes are some of the inputs to various resource analyses, the determination of adverse or beneficial effects is more properly assigned to each of those effects analyses.

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3.2.2.2 Environmental Consequences Summary

The NAA would represent the current management direction of the WVS. Each of the action alternatives would change the seasonal flow and use of stored water in the system. In comparison to the NAA, operations under Alternative 1 and Alternative 4 would store more water in the spring and release it during the summer and fall; however, operations for how flow is stored and released would be different between Alternative 1 and Alternative 4. Operations under Alternative 2A and Alternative 2B would store more water during spring for release in the summer and fall as compared to the NAA, but less than operations under Alternative 1 or Alternative 4 while incorporating selected drawdowns.

Operations under Alternative 3A and Alternative 3B would include spring reservoir drawdowns at different, selected reservoirs and deeper fall drawdowns at WVS reservoirs in the Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins—excluding Foster Dam and the re-regulating dams. Operations under Alternative 5 would incorporate activities under Alternative 2B but USACE would prioritize higher spring flow during dry years under Alternative 5 as compared to Alternative 2B.

The degree of effect under the NAA would be none/negligible. Comparatively, the degree of effect under all action alternatives would be major (through Table 3.2-7).

Table 3.2-2. Santiam River Subbasin Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Detroit Reservoir[1]	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage more than 75% of years during the spring and would very rarely reach the bottom of conservation storage in the fall.	Would reach the top of conservation storage about 75% of years during the spring and would very rarely reach the bottom of conservation storage in the fall.	Same as Alternative 2A.	Would never reach the top of conservation storage during summer and would reach lower minimum elevation 75% of years. Increased winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage about 75% of years during the spring and would very rarely reach the bottom of conservation storage prior to deeper fall reservoir drawdown. Increased winter storage space from deeper fall reservoir drawdown.	Same as Alternative 2A.	Same as Alternative 2A.
Detroit Reservoir/ Big Cliff Reservoir Outflow	Would meet or exceed outflow targets between 1,000 cfs and 1,500 cfs except in fall of very dry years.	Would meet or exceed outflow target of 1,050 cfs in nearly all years.	Would meet or exceed outflow target of between 1,000 cfs and 1,600 cfs in nearly all years.	Same as Alternative 2A.	Would increase spring flow. Would meet outflow target between 1,000 and 1,600 cfs in only 25% of wettest years; minimum flow of about 400 cfs in dry years.	Would meet or exceed outflow target of between 1,000 cfs and 1,600 cfs except in fall of very dry years.	Same as Alternative 2A.	Same as Alternative 2A.
North Santiam River at Mehama	Flow would vary within Biological Opinion targets, falling to about 700 cfs in fall of very dry years.	Steadier flow with Congressionally authorized minimum flow targets, falling to about 950 cfs in fall of very dry years.	Lower varied spring flow across all years. About 1,000 cfs in fall of very dry years.	Same as Alternative 2A.	Higher spring flow. Only wettest years would approach NAA flows in summer with about 400 cfs in fall of very dry years.	Lower varied spring flow and higher summer flow across all years. About 1,000 cfs in fall of very dry years.	Same as Alternative 2A.	Same as Alternative 2A.
Green Peter Reservoir[2]	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage more than 90% of years during the spring and would very rarely reach bottom of conservation storage in the fall.	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior to the deeper fall reservoir drawdown. Would increase winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior to the deeper fall reservoir drawdown. Would increase winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior to the deeper fall reservoir drawdown. Would increase winter storage space from deeper fall reservoir drawdown.	Would never reach the top of conservation storage during summer and would reach lower minimum elevation about 70% of years. Would increase winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage less than 75% of years during the spring and the lower minimum elevation in about 5% of years in late fall.	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior to the deeper fall reservoir drawdown. Would increase winter storage space from deeper fall reservoir drawdown.
Foster Reservoir[3]	Would only vary from rule curve during flood operations.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same No-action Alternative.	Would reach the bottom of conservation storage in summer during average and drier years.	Same No-action Alternative.	Would only vary from rule curve during flood operations.
Green Peter Reservoir / Foster Reservoir Outflow	Would meet or exceed outflow targets between 800 cfs and 1,500 cfs except in summer and fall of very dry years.	Would meet or exceed outflow target of 750 cfs in nearly all years.	Would increase fall flow. Would meet or exceed outflow target of between 1,000 cfs and 1,550 cfs except in fall of very dry years.	Same as Alternative 2A.	Same as Alternative 2A.	Would increase spring flow. Would only meet flow targets in very wet years. Average summer flow about 600 cfs, and dry years minimum flow about 110 cfs.	Would meet or exceed outflow target of between 1,000 cfs and 1,550 cfs except in fall of very dry years.	Same as Alternative 2A.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
South Santiam River at Waterloo	Flow would vary within Biological Opinion targets, falling to about 550 cfs in fall of very dry years.	Steadier flow with Congressionally authorized minimum targets, falling to about 700 cfs in fall of very dry years.	Lower varied spring flow and higher summer flow across all years. About 900 cfs in very dry years. Higher fall flows due to drawdown.	Same as Alternative 2A.	Same as Alternative 2A.	Higher spring flow. Only wettest years would approach NAA flow in summer with minimum of about 100 cfs in dry years.	Lower varied spring flow and higher summer flow across all years. About 900 cfs in very dry years.	Same as Alternative 2A.
Santiam River at Jefferson	Flow would vary within Biological Opinion targets, falling to about 1,200 cfs in summer of very dry years.	Lower, steadier flow across all years in spring and summer and higher flow in fall as reservoirs prepare for flood season. About 1,200 cfs in very dry years.	Lower spring flow in dry years. Higher summer flow across all years and much higher fall flow during Green Peter Reservoir drawdown. About 1,400 cfs in very dry years.	Same as Alternative 2A.	More varied flow from spring to fall. More flow during wet years and less flow during dry years. About 800 cfs in very dry years.	Higher spring flow. More summer flow during wet years and less during dry years. About 700 cfs in very dry years.	Lower spring flow in dry years and higher summer and fall flow across all years. About 1,400 cfs in very dry years.	Lower spring flow in dry years. Higher summer flow across all years and much higher fall flow during Green Peter Reservoir drawdown. About 1,700 cfs in very dry years.

% = percent; cfs = cubic feet per second

[1] Detroit Reservoir top and bottom of conservation storage are elevations 1,563.5 feet and 1,450 feet, respectively.

[2] Green Peter Reservoir top and bottom of conservation storage are elevations 1,010 feet and 922 feet, respectively.

[3] Foster Reservoir top and bottom of conservation storage are elevations 637 feet and 613 feet, respectively.

Table 3.2-3. Long Tom River Subbasin Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Fern Ridge Reservoir[1]	Would reach the top of conservation storage about 50% of years during the spring. Fall drawdown to prepare for flood operations.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Long Tom River at Monroe	Would maintain 50 cfs summer target. Winter regulation maximum target of 6,000 cfs.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.

% = percent; cfs = cubic feet per second

[1] Fern Ridge Reservoir top and bottom of conservation storage are elevations 373.5 feet and 353 feet, respectively.

Table 3.2-4. McKenzie River Subbasin Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Blue River Reservoir[1]	Would reach the top of conservation storage more than 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage about 95% of years during the spring and would very rarely reach the bottom of conservation storage in the fall.	Would reach the top of conservation storage about 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage about 75% of years during the spring and the bottom of conservation storage more than 5% of years in late fall.	Would reach the top of conservation storage about 75% of years during the spring and would reach lower minimum elevation 5% of years. Increased winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage about 75% of years during the spring and would very rarely reach bottom of conservation prior to fall drawdown. Increased winter storage space from deeper fall reservoir drawdown.	Same as Alternative 2A.	Same as Alternative 2A.
Blue River Reservoir Outflow	Would meet downstream flow targets in nearly all years.	Steadier flow and slightly lower flow in spring of dry years as reservoir fills. Would meet downstream flow targets in nearly all years.	Slightly lower flow in spring of dry years as reservoir fills. Would meet downstream flow targets in nearly all years.	Same as Alternative 2A.	Higher flow in summer due to mainstem Willamette flow targets and would miss downstream flow targets in fall of the driest years.	Higher flow in summer due to mainstem Willamette flow targets. Would meet downstream flow targets in nearly all years.	Same as Alternative 2A.	Same as Alternative 2A.
Cougar Reservoir[2]	Would reach the top of conservation storage about 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage more than 75% of years during the spring and lower minimum elevation about 5% of years in late fall.	Would reach the top of conservation storage less than 75% of years during the spring and lower minimum elevation about 5% of years in late fall.	Would never reach the top of conservation storage during summer and reach very low minimum elevation about 25% of years. Increased winter storage space from deeper fall reservoir drawdown.	Would never reach the top of conservation storage during summer and reach lower minimum elevation about 60% of years. Increased winter storage space from deeper fall reservoir drawdown.	Same as Alternative 2B.	Same as Alternative 2A.	Same as Alternative 2B.
Cougar Reservoir Outflow	Would meet downstream flow targets in nearly all years.	Steadier flow and slightly lower flow in spring of dry years as reservoir fills. Would meet downstream flow targets in nearly all years.	Slightly lower flow in spring of dry years as reservoir fills. Higher summer flow in dry years.	Higher spring flow for spring reservoir drawdown. Would meet downstream targets in about 75% wettest years, with lower flows throughout summer.	Higher spring flow for spring reservoir drawdown. Would meet downstream targets in about 40% wettest years, with lower flows throughout summer.	Same as Alternative 2B.	Same as Alternative 2A.	Same as Alternative 2B.
McKenzie River at Vida	Elevated spring flow due to mainstem Willamette flow targets. Summer/fall flow about 1,500 cfs in very dry years.	Lower spring and higher summer flows. Summer/fall flow about 1,400 cfs in very dry years.	Lower spring flows. Summer/fall flow about 1,700 cfs in very dry years.	Lower spring flow in dry years and lower summer/fall flow in wet years. Summer/fall flow about 1,500 cfs in very dry years.	Lower spring flow in dry years and lower summer/fall flow across all years. Summer/fall flow about 1,400 cfs in very dry years.	Same as Alternative 2B.	Lower spring flows. Summer/fall flow about 1,700 cfs in very dry years.	Lower spring flow in dry years and lower summer/fall flow in wet years. Summer/fall flow about 1,400 cfs in very dry years.

% = percent; cfs = cubic feet per second

[1] Blue River Reservoir top and bottom of conservation storage are elevations 1,350 feet and 1,180 feet, respectively.

[2] Cougar Reservoir top and bottom of conservation storage are elevations 1,690 feet and 1,532 feet, respectively.

Table 3.2-5. Middle Fork Willamette River Subbasin Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Hills Creek Reservoir[1]	Would reach the top of conservation storage less than 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage more than 75% of years during the spring and lower minimum elevation about 5% of years in late fall.	Would reach the top of conservation storage less than 75% of years during the spring and lower minimum elevation about 10% of years in late fall.	Same as Alternative 2A.	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 75% of years in summer/fall, with an average of middle of September.	Would never reach the top of conservation storage during summer and would reach bottom of conservation storage 50% of years.	Same as Alternative 2A.	Would reach the top of conservation storage about 50% of years during the spring and lower minimum elevation about 20% of years in late fall.
Hills Creek Reservoir Outflow	Flow would meet downstream flow targets in nearly all years. Minimum flow about 350 cfs.	Flow higher in spring and summer of average and wetter years. Flow would miss downstream flow target in fall of driest years. Minimum flow about 250 cfs.	Same as Alternative 1.	Same as Alternative 1.	Higher flow in spring/early summer. Flow downstream would be below target for at least 2 months in dry years. Minimum flow about 250 cfs.	Higher spring flow. Flow downstream would be below target for at least 3 months in dry years. At target in all other years. Minimum flow about 220 cfs.	Same as Alternative 1.	Higher flow in spring and summer of average and wetter years. Flow would miss downstream flow target in summer and fall of driest years. Minimum flow about 230 cfs.
Lookout Point Reservoir[2]	Would reach the top of conservation storage about 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage about 75% of years during the spring and lower minimum elevation about 5% of years in late fall.	Same as Alternative 1.	Would reach the top of conservation storage about 75% of years during the spring and lower minimum elevation about 10% of years in late fall.	Would never reach the top of conservation storage and lower minimum elevation 5% of years. Increased winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage more than 75% of years during the spring and lower minimum elevation about 5% of years in summer. Increased winter storage space from deeper fall reservoir drawdown.	Same as Alternative 1.	Same as Alternative 2B.
Lookout Point Reservoir/ Dexter Reservoir Outflow	Would miss downstream flow target in fall of driest years	Lower flow in spring and higher flow in summer/fall. Would miss downstream flow target in fall of driest years.	Minor differences compared to NAA. Would miss downstream flow target in fall of driest years.	Would miss downstream flow target in fall of driest years for longer periods than NAA.	Higher flow in spring and minimum flow in summer across all years. Would miss downstream flow target in fall of driest years.	Higher spring flow. Would miss downstream flow target during late summer and fall.	Minor differences compared to NAA. Would miss downstream flow target in fall of driest years.	Would miss downstream flow target during late summer and fall of driest years.
Fall Creek Reservoir[3]	Would reach the top of conservation storage less than 75% of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown.	Would reach the top of conservation storage about 75% of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

Fall Creek Reservoir Outflow	Flow would meet downstream flow targets.	Lower spring flow. Flow would meet downstream flow targets.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Middle Fork Willamette River at Jasper	Elevated spring flow due to mainstem Willamette River flow targets. Fall flow about 1,200 cfs in very dry years.	Lower spring flow in dry years and higher summer/fall flow across all years. Flow about 1,100 cfs in very dry years.	Lower spring flow and higher summer/fall flow in dry years. Flow about 1,500 cfs in very dry years.	Lower spring flow in September of driest years. Higher flow in fall of most years. Flow about 1,300 cfs in very dry years.	Higher spring flows. Summer/fall flow at minimum for 3 months for all years. Flow about 1,100 cfs for 5 months in very dry years.	Lower spring flow in dry years. Flow at 1,100 cfs for 2 months in very dry years.	Same as Alternative 2A.	Lower spring flow, late August and September of driest years. Higher flow in fall of most years. Flow about 1,100 cfs in very dry years.

% = percent; cfs = cubic feet per second

[1] Hills Creek Reservoir top and bottom of conservation storage are elevations 1,541 feet and 1,448 feet, respectively.

[2] Lookout Point Reservoir top and bottom of conservation storage are elevations 926 feet and 825 feet, respectively.

[3] Fall Creek Reservoir top and bottom of conservation storage are elevations 830 feet and 728 feet, respectively.

Table 3.2-6. Coast Fork Willamette River Subbasin Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Dorena Reservoir[1]	Would reach the top of conservation storage about 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage less than 75% of years during the spring and would very rarely reach lower minimum elevation.	Would reach the top of conservation storage more than 50% of years and would very rarely reach the bottom of conservation storage.	Same as Alternative 2A.	Would reach the top of conservation storage more than 50% of years during the spring and lower minimum elevation about 5% of years in late fall.	Would reach the top of conservation storage more than 50% of years during the spring and lower minimum elevation about 25% of years in late fall.	Same as Alternative 3B.	Same as No-action Alternative.
Dorena Reservoir Outflow	Would maintain minimum flows except in fall of driest years.	Would maintain minimum flows in nearly all years.	Same as No-action Alternative.	Same as No-action Alternative.	Same as described under the NAA.	Would maintain minimum flows except in fall of dry years.	Same as Alternative 1.	Same as No-action Alternative.
Cottage Grove Reservoir[2]	Would reach the top of conservation storage less than 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage more than 50% of years during the spring and would very rarely reach lower minimum elevation.	Would reach the top of conservation storage about 50% of years during the spring and would very rarely reach the bottom of conservation storage.	Same as Alternative 2A.	Would reach the top of conservation storage more than 50% of years during the spring and lower minimum elevation in more than 5% of years during fall.	Would reach the top of conservation storage about 50% of years during the spring and lower minimum elevation in about 25% of years during fall.	Same as Alternative 3B.	Same as No-action Alternative.
Cottage Grove Reservoir Outflow	Would maintain minimum flows except in fall of driest years.	Would maintain minimum flows in nearly all years.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Coast Fork Willamette River at Goshen	Elevated spring flow due to mainstem Willamette River flow targets. Low flow in fall about 80 cfs in very dry years.	Lower spring and higher summer flow in dry years. Low flow in fall about 150 cfs in very dry years.	Lower spring flow in dry years. Low flow in fall about 80 cfs in very dry years.	Same as Alternative 2A.	Lower spring and higher summer flow in dry years. Low flow in fall about 90 cfs in very dry years.	Lower spring flow in dry years. Low flow in fall about 90 cfs in very dry years.	Lower spring flow in dry years. Low flow in fall about 100 cfs in very dry years.	Same as Alternative 2A.

% = percent; cfs = cubic feet per second

[1] Dorena Reservoir top and bottom of conservation storage are elevations 832 feet and 771 feet, respectively.

[2] Cottage Grove Reservoir top and bottom of conservation storage are elevations 790 feet and 750 feet, respectively.

Table 3.2-7. Mainstem Willamette River Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Willamette River at Harrisburg	Elevated spring flow due to downstream flow targets. Low flow about 3,000 cfs around October in very dry years.	Lower spring flow in dry years and higher summer flow. Low flow about 3,000 cfs around October in very dry years.	Lower spring flow in dry years. Less variation in summer flow. Low flow about 3,700 cfs around October in very dry years.	Lower spring flow in dry years. Less variation in summer flow. Low flow about 3,300 cfs around October in very dry years.	Increased spring flow variation. Lower summer flow across all years. Low flow about 2,800 cfs around August in very dry years.	Lower spring flow in dry years. Less variation in summer flow. Low flow about 2,900 cfs around September in very dry years.	Same as Alternative 2A.	Lower spring flow in dry years. Less variation in summer flow. Low flow about 2,900 cfs around October in very dry years.
Willamette River at Albany, Oregon	Elevated spring flow in dry years due to downstream flow target. Would miss baseline[1] flow target from middle of summer to fall in driest years. Low flow about 3,200 cfs around August in very dry years.	Lower spring flow in dry years. Would miss flow target in fall of driest years. Low flow about 3,000 cfs around October in very dry years.	Lower spring flow in dry years. Somewhat lower summer flow, while meeting flow target in nearly all years. Low flow about 4,000 cfs around October in very dry years.	Lower spring flow in dry years. Somewhat lower summer flow and would miss flow target in fall of driest years. Low flow about 4,000 cfs in very dry years.	Increased spring flow variation. Much lower summer flow. Would miss flow target in about 80% of years. Typical year would miss target for about 2 months. Low flow about 3,000 cfs around September in very dry years.	Increased spring flow variation. Would miss baseline[1] flow target from August to October in driest years. Low flow about 3,200 cfs around October in very dry years.	Lower spring flow in dry years. Somewhat lower summer flow and would meet flow target in nearly all years. Low flow about 3,800 cfs around October in very dry years.	Lower spring flow in dry years. Somewhat lower summer flow and would miss flow target in late August through October of driest years. Low flow about 3,300 cfs in fall in very dry years.
Willamette River at Salem, **Salem, Oregon**	Spring flow below baseline[1] target more than 25% of years. Summer flow below baseline[1] target in 5% of years for about 4 months. Low flow about 4,800 cfs around August in very dry years.	Lower spring flow in dry years. Higher summer flow across all years. Flow would miss lower target in October of driest years. Low flow about 5,500 cfs around October in very dry years.	Lower spring flow would meet lower seasonal target. Higher summer flow and elevated fall flow from Green Peter Reservoir deeper fall drawdown. Low flow about 6,200 cfs around August in very dry years.	Lower spring flow would meet lower seasonal target. Higher summer flow and elevated fall flow from Green Peter Reservoir deeper fall drawdown. Low flow about 6,000 cfs around August in very dry years.	Lower spring flow would meet lower seasonal target. Lower summer flow misses lower target in August of driest years. Low flow about 4,000 cfs around August in very dry years.	Lower spring flow would meet lower seasonal target. Lower summer flow misses lower target very rarely in August. Low flow about 4,500 cfs around August in very dry years.	Lower spring flow would meet lower seasonal target. Higher summer and fall flow in dry years. Low flow about 6,100 cfs around August in very dry years.	Lower spring flow would meet lower seasonal target. Higher summer flow and elevated fall flow from Green Peter Reservoir deeper fall drawdown. Low flow about 5,900 cfs around August in very dry years.

% = percent; cfs = cubic feet per second

[1] "Baseline" refers to the typical flow target for a location, which can be modified by the WATER forum during seasonal operations.

END REVISED TEXT

3.2.2.3 Alternatives Analyses

No-action Alternative

The NAA direct and indirect effects analyses reflect continuation of existing WVS operations and maintenance for the 30-year implementation timeframe. The following assumptions were made regarding the NAA analyses:

- Rule curves across the WVS would remain as they currently operate. Relatively recent changes, such as the Fall Creek Reservoir fall drawdown, are simulated across the complete period of record.
- Current, in-progress projects are included, even if they are not fully implemented at time of analysis. Regulation operations intended to be temporary, even if currently active, are not included.
- USACE would continue to operate the WVS to meet Willamette River mainstem and tributary flow objectives to the maximum extent possible as described in the 2008 NMFS Biological Opinion (NMFS 2008) and implemented per the Willamette Fish Operations Plan (USACE 2017a) (Chapter 1, Introduction, Section 1.3.3, Willamette Valley System Endangered Species Act and National Environmental Policy Act History since 2008).
- Additional releases and downstream withdrawals would be implemented to satisfy anticipated municipal and industrial (M&I) water storage agreements.
- Only those measures that affect the amount of flow through a dam and reservoir or that would change the flow of an outlet are modeled in the reservoir regulation model (HEC-ResSim). Activities that change other variables, such as construction of selective withdrawal structures, are not included in the HEC-ResSim; these changes are not reflected in the analyses below.

USACE would not attempt to reproduce observed past operations under the NAA (Section 3.2.2.1, Methodology). In this way, the set of measures under each alternative can be compared to the NAA without the influence of other factors, such as reservoir regulator preferences. Also, all figures below show the calculated value for that date and do not reflect a specific year or sequence of flows or reservoir elevations. As an example, the average, or P50, line is the median flow on that date across all years of the simulation; even a “typical” year is very unlikely to exactly follow that sequence.

Under the NAA, existing operations and maintenance management activities would continue throughout the WVS with the addition of increased releases for municipal and industrial water storage agreements.

Santiam River Subbasin

Detroit reservoir would reach the maximum conservation pool elevation more than 50 percent of years (P50 line) and would stay near the top of the conservation pool for more than half the summer provided it does reach maximum pool (Figure 3.2-20). Even in the driest years, the pool would remain above the minimum conservation pool until September under the NAA (P5 line).

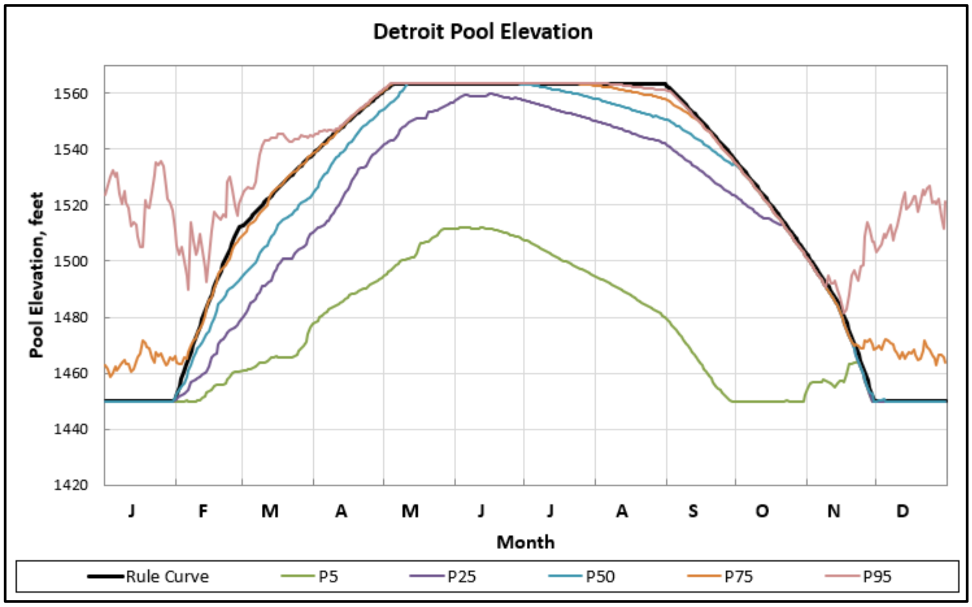

Figure 3.2-20. No-action Alternative Detroit Reservoir Water Surface Elevation Non-exceedance.

On the South Santiam River, USACE would also fill Green Peter Reservoir more than half the time (P50 line) but would draft below the rule curve earlier in the season under the NAA (Figure 3.2-21). Green Peter Reservoir releases would remain an important component to meet 2008 NMFS Biological Opinion flow targets in the mainstem Willamette River prior to drafting Detroit Reservoir. Because all the stored water in both reservoirs is needed to meet downstream flow demands during the driest years, the P5 line would reach minimum conservation pool at about the same time at Green Peter and Detroit Reservoirs under the NAA.

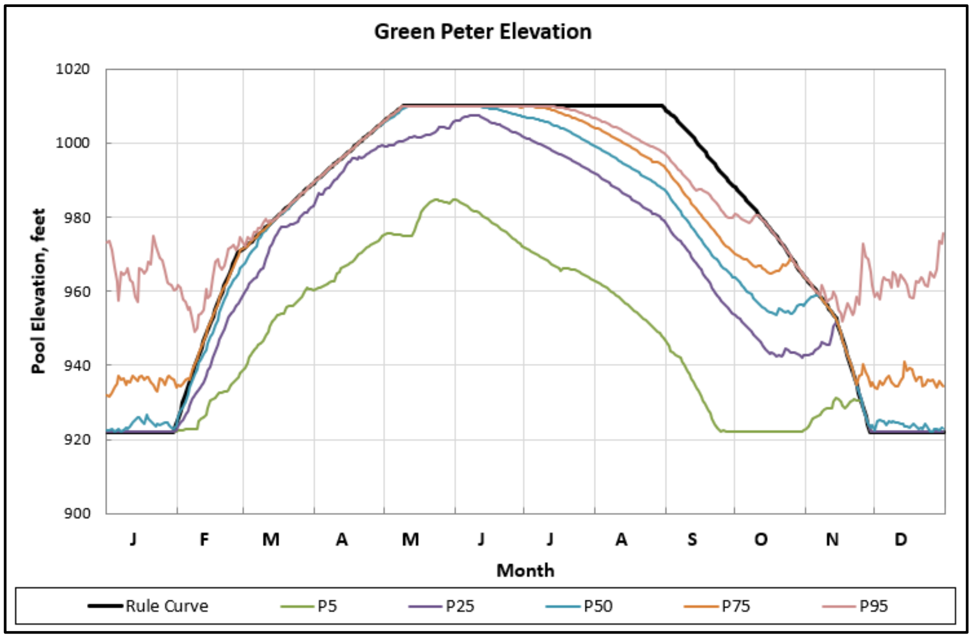

Figure 3.2-21. No-action Alternative Green Peter Reservoir Water Surface Elevation Non-exceedance.

Figures for Big Cliff and Foster Dams are not shown as they primarily re-regulate Detroit and Green Peter Dams during the conservation season, smoothing power peaking flow from the upstream dam. They would follow the rule curve very closely in all years under the NAA.

Figure 3.2-22 shows the results of the regulation model for the Santiam River at Jefferson, a couple miles downstream of the confluence of the North and South Santiam Rivers. The figure combines the flow from the dams and the 'local' flows into the Santiam River from tributaries downstream of the WVS dams. The maximum flow reflects the high flows from high water events and floods. Flows at or above bankfull (35,000 cfs) have occurred at Jefferson in every month except July, August, and September.

Mean and minimum flows would show substantially greater consistency throughout the year, reflecting typical flows in the river and the minimum flows reached during an abnormally dry period. The dry periods do not reflect a single year but show that dry periods which reduce flow can happen at any time during the year. These conditions and trends would be expected to continue under the NAA.

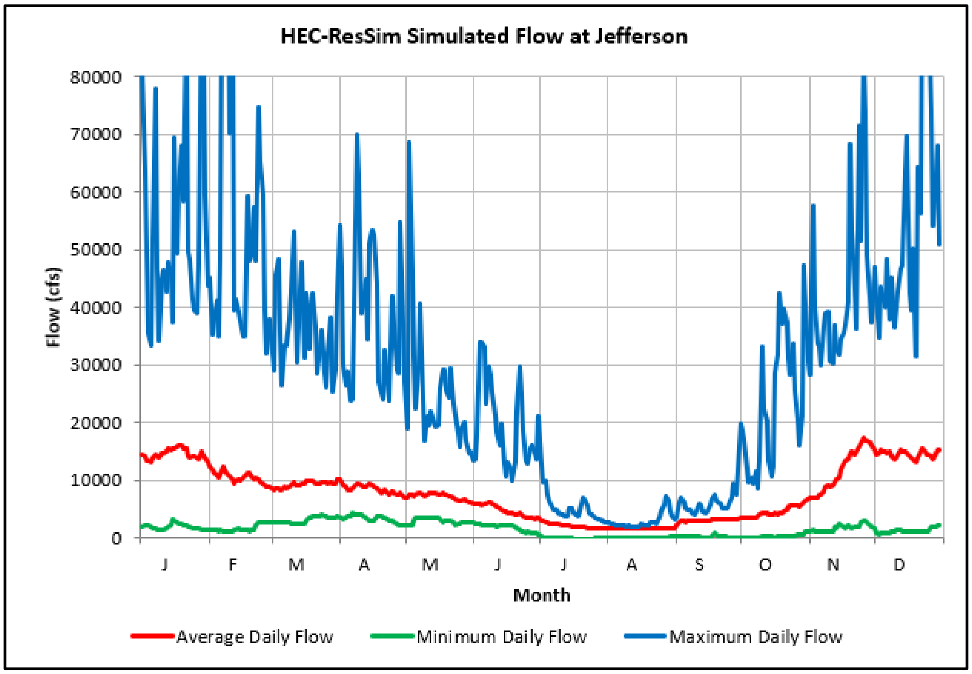

Figure 3.2-22. No-action Alternative Santiam River at Jefferson, Oregon Daily Minimum, Average, and Maximum Flows.

Long Tom River Subbasin

Fern Ridge Reservoir is relatively small in volume and shallow as compared to the other reservoirs in the WVS (Figure 3.2-23). Fern Ridge would reach within 6 feet of its maximum conservation pool in 95 percent of years (P5 line). USACE manages water levels to maintain the highest pool elevation possible until the rule curve falls, starting in September.

Recreation and fish and wildlife habitat would remain a high priority for management at Fern Ridge Dam under the NAA, and other WVS reservoirs would be drafted to meet downstream requirements prior to using the relatively limited water stored in Fern Ridge Reservoir. Therefore, it is rare for Fern Ridge Reservoir to empty during the summer months.

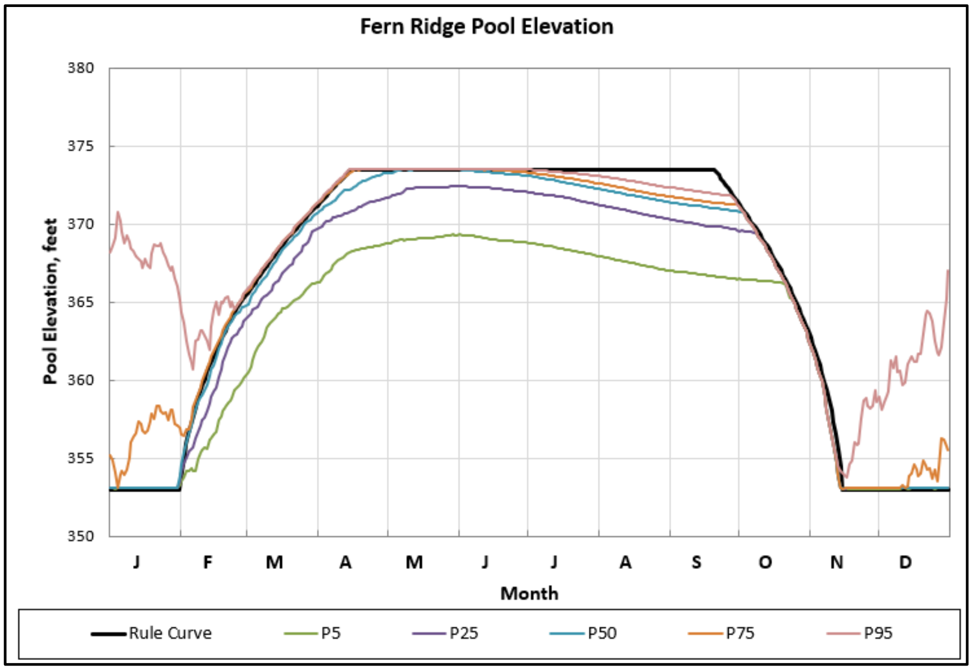

Figure 3.2-23. No-action Alternative Fern Ridge Reservoir Water Surface Elevation Non-exceedance.

Flow in the Long Tom River at Monroe downstream of Fern Ridge Dam shows typical seasonal variation in the Willamette River Basin (Figure 3.2-24). The high minimum flow in November is the flow out of the reservoir in preparation for winter flood season.

Because USACE prioritizes keeping this reservoir relatively high through the fall in support of recreation, fish, and wildlife, there would be no years in which the reservoir pool has already drafted to minimum conservation elevation prior to October[3]. Therefore, under the NAA, there would always be an elevated November flow to return the reservoir to minimum pool.

[3] For a counterexample, see Green Peter Dam in the Santiam River Subbasin description.

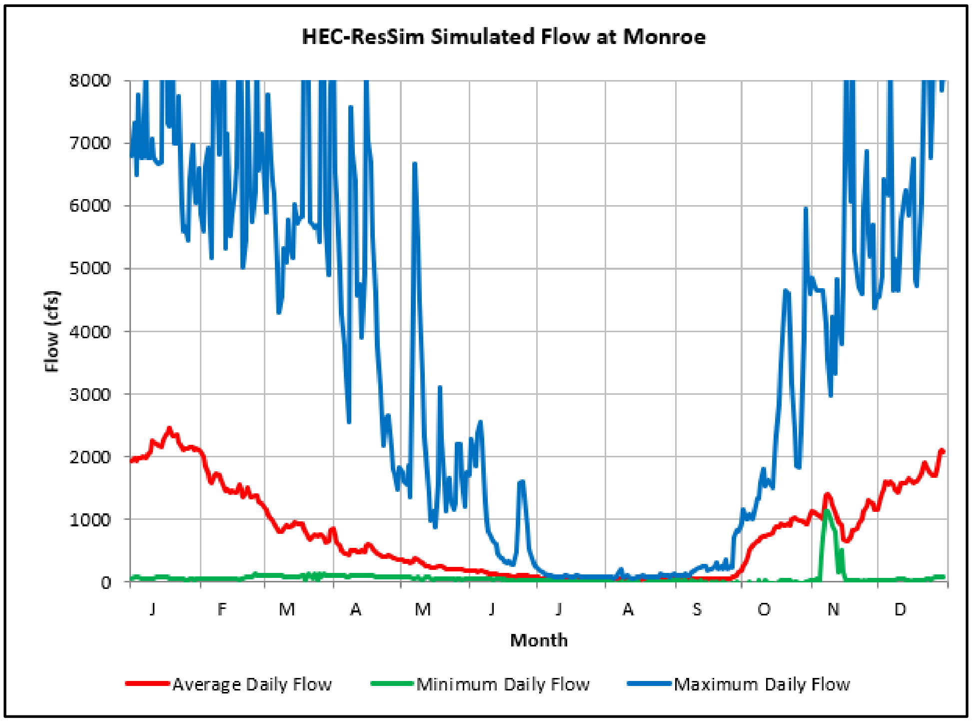

Figure 3.2-24. No-action Alternative Long Tom River at Monroe, Oregon Daily Minimum, Average, and Maximum Flows.

McKenzie River Subbasin

Cougar Reservoir and Blue River Reservoir would behave similarly with respect to their rule curves during average and wetter years (Figure 3.2-25 and Figure 3.2-26, respectively). Both Blue River Reservoir and Cougar Reservoir primarily release water to meet mainstem Willamette River flow targets, steadily drafting from their spring peak. Under the NAA, during drier years (the P5 and P25 lines), Cougar Reservoir would draft toward its minimum conservation elevation more frequently than Blue River Reservoir despite its larger capacity. This is because Cougar Dam has hydropower turbines, dictating a high minimum flow when running, and reservoir storage is more often used to meet minimum flows on the mainstem Willamette River at Albany and Salem.

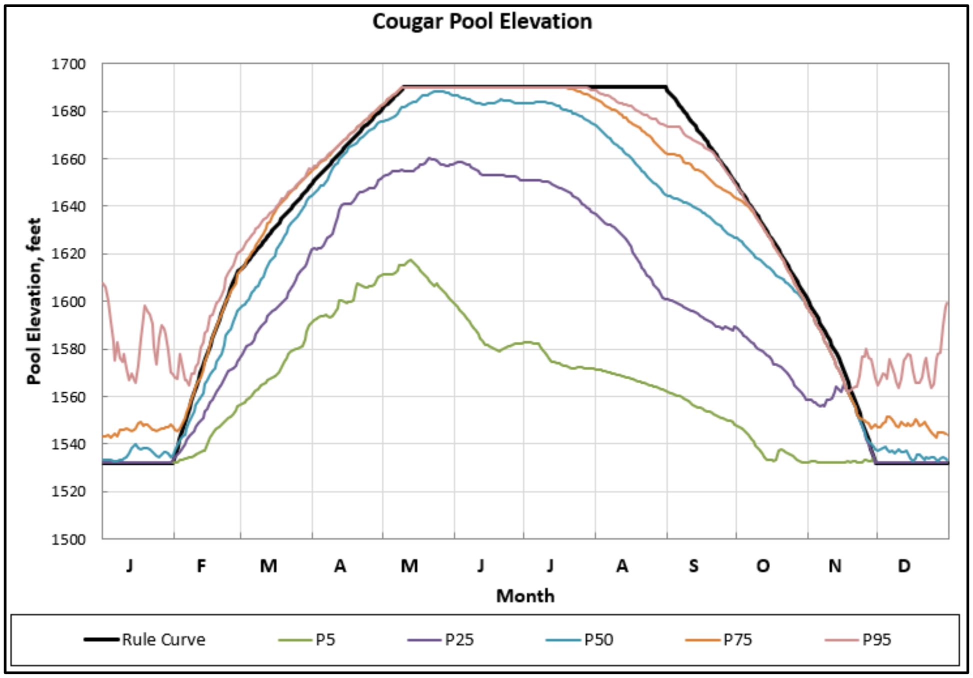

Figure 3.2-25. No-action Alternative Cougar Reservoir Water Surface Elevation Non-exceedance.

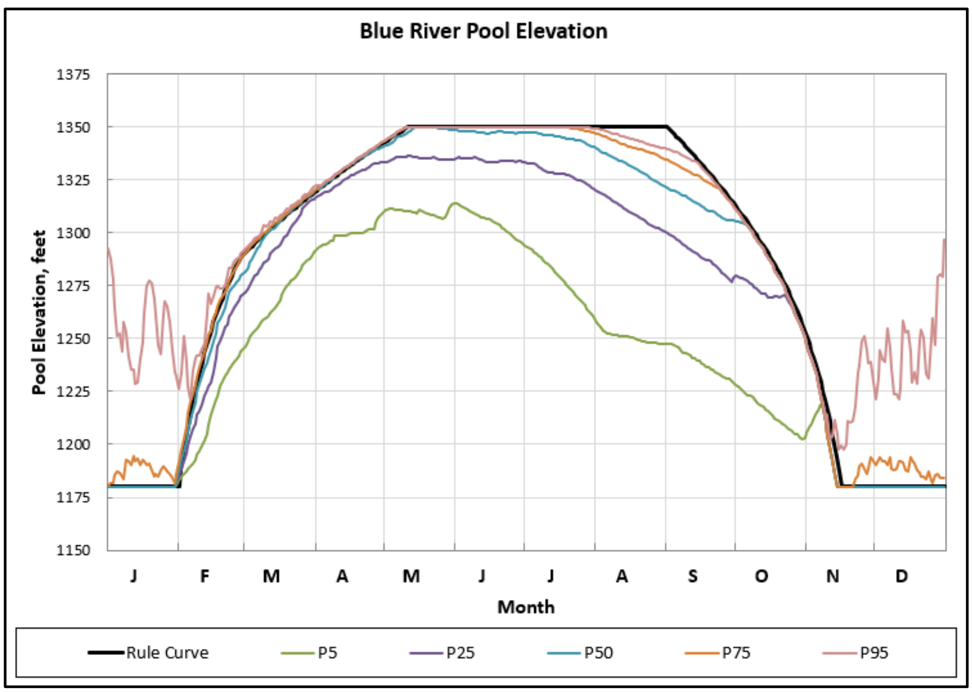

Figure 3.2-26. No-action Alternative Blue River Reservoir Water Surface Elevation Non-exceedance.

The minimum flow is higher relative to its average flow across the period of record at the McKenzie River at Vida as compared to other Willamette River Basin subbasins due to the geology in the upstream area (Figure 3.2-27). The control point for Blue River Dam and Cougar Dam is also downstream of the relatively large uncontrolled basin from the mainstem McKenzie River headwaters. There are no minimum flow targets for Blue River Reservoir and Cougar Reservoir to meet at this location.

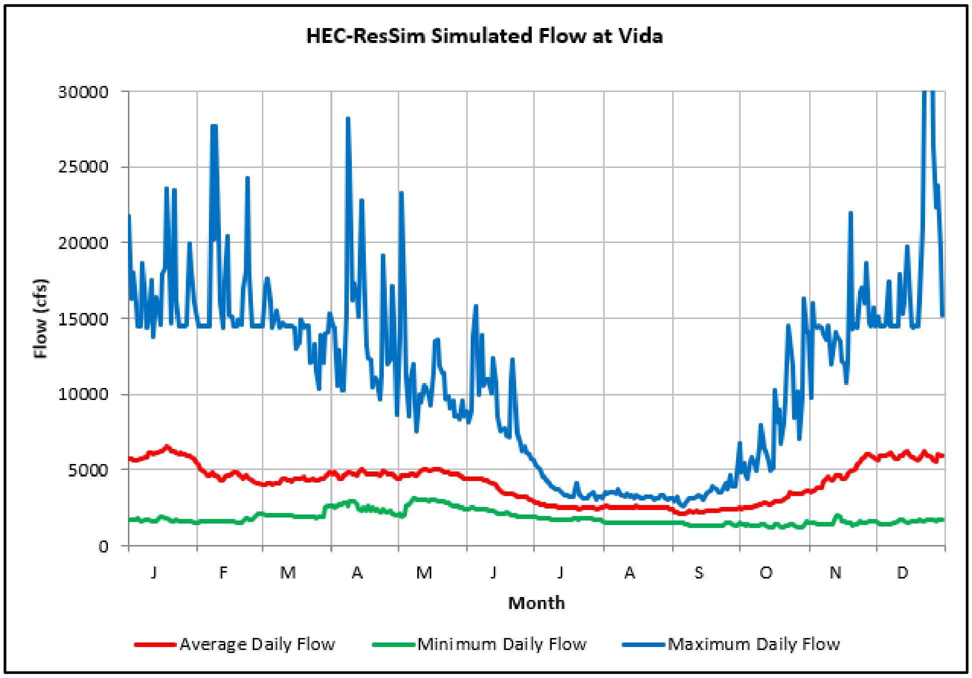

Figure 3.2-27. No-action Alternative McKenzie River at Vida, Oregon Daily Minimum, Average, and Maximum Flows.

Middle Fork Willamette River Subbasin

Fall Creek Reservoir is fully drained each year by late November and early December to facilitate downstream passage of juvenile UWR spring Chinook salmon (Figure 3.2-28). This deeper fall reservoir drawdown would be implemented under the NAA.

Although this deeper fall drawdown is a relatively recent operation (the first one was in 2011), this operation was applied to the analysis throughout the period of record to reflect the current USACE management of the WVS. During the deeper fall reservoir drawdown period, there are still periods of high water due to flood operations, which would be expected to continue under the NAA. Further, Fall Creek Reservoir has historically consistently returned to the minimum conservation pool elevation prior to the start of refill in February, which is also expected to continue under the NAA.

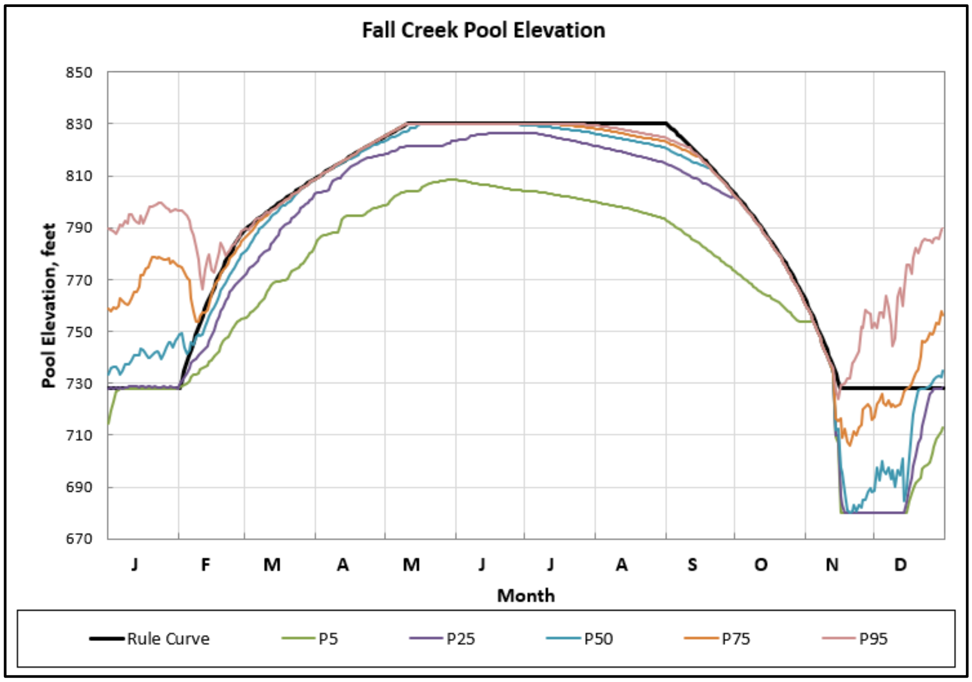

Figure 3.2-28. No-action Alternative Fall Creek Reservoir Water Surface Elevation Non-exceedance.

Hills Creek Dam is upstream of Lookout Point Dam. Under the NAA, these dams would continue to be operated to balance water storage between them. Therefore, they would tend to follow a similar path in average to wet years.

Under the NAA, flow leaving Hills Creek Reservoir during drier years (Figure 3.2-29; P25 and P5 lines) would be stored in Lookout Point Reservoir so Lookout Point Reservoir can remain higher for longer. The "twice stored" water would be required in the fall to meet downstream flow targets, so this effect would only last through about early September. For example, the Lookout Point Reservoir P25 line falls in September and October (Figure 3.2-30), whereas the Hills Creek Reservoir line is already nearing its minimum annual level during this period.

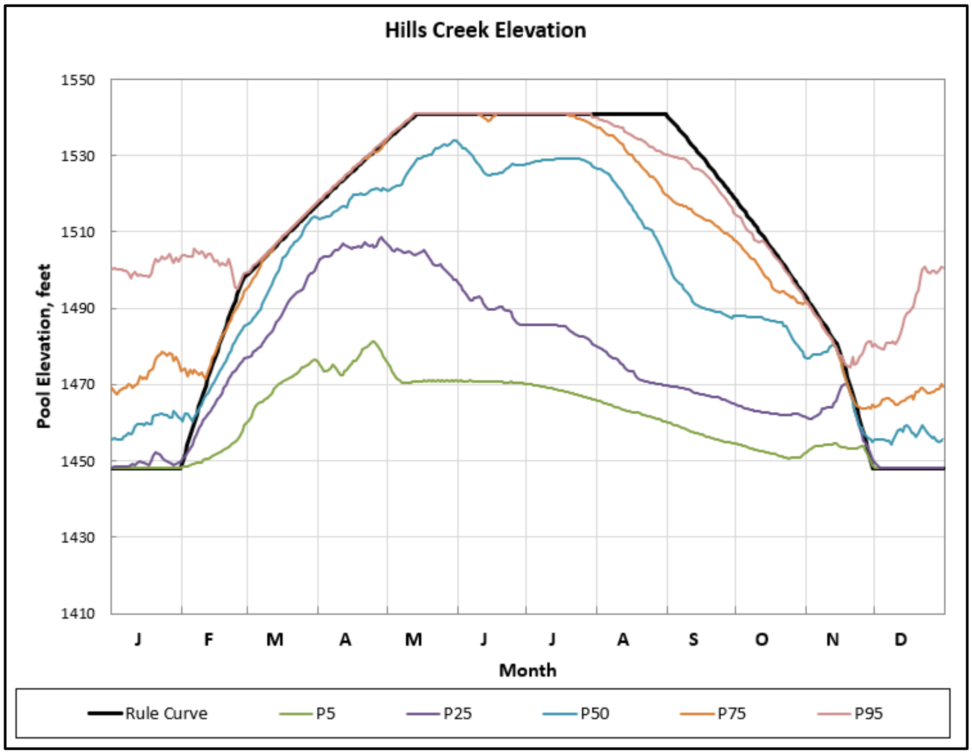

Figure 3.2-29. No-action Alternative Hills Creek Reservoir Water Surface Elevation Non-exceedance.

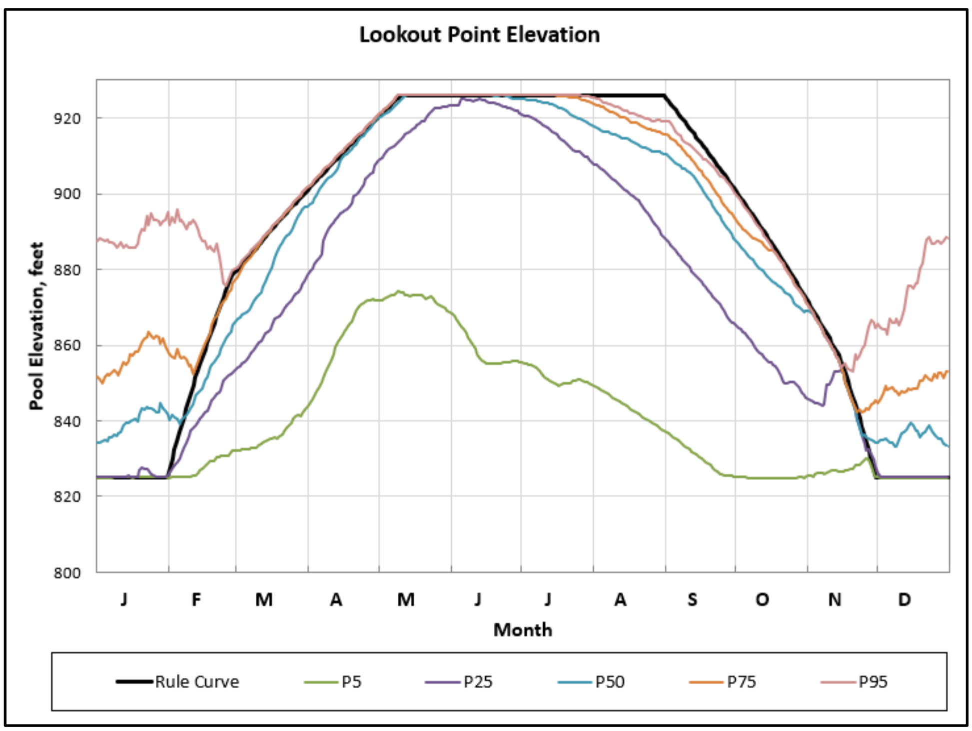

Figure 3.2-30. No-action Alternative Lookout Point Reservoir Water Surface Elevation Non-exceedance.

A figure for Dexter Dam is not shown as it re-regulates Lookout Point Dam, smoothing power peaking flow. It follows its flat rule curve very closely in all years and would continue this trend under the NAA.

The downstream control point for the Middle Fork Willamette River at Jasper shows a typical regulated shape for the Willamette River (Figure 3.2-31). Flood season from November to April experiences regular high flows with a possibility of low flow at any time during the winter. The most consistent low flow occurs during July through early September. These trends would be expected to continue under the NAA.

The bankfull regulation target at Jasper is 20,000 cfs, so the maximum flows congregate around this target during early winter as USACE drafts the upstream reservoirs in preparation for storing water during winter storm events. Because this is the maximum daily flow across all years, each individual year would reach bankfull for a much shorter time to draft the upstream reservoirs than the maximum daily line shows in Figure 3.2-31.

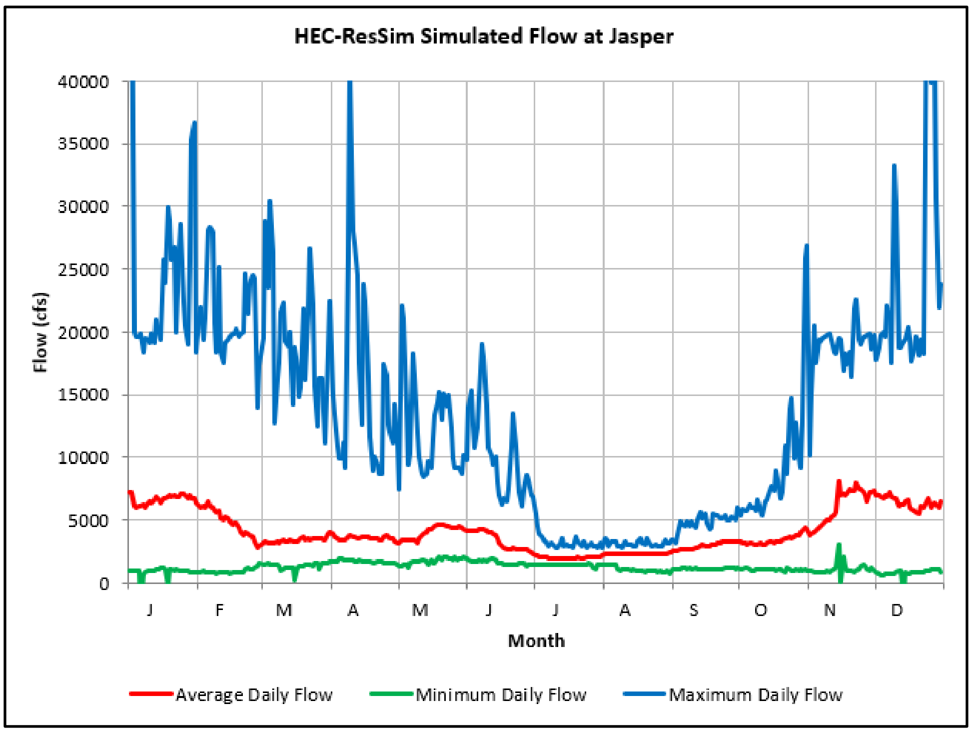

Figure 3.2-31. No-action Alternative Middle Fork Willamette River at Jasper, Oregon Daily Minimum, Average, and Maximum Flows.

Coast Fork Willamette River Subbasin

Cottage Grove Dam and Dorena Dam would continue to operate very similarly because they would maintain the same control point and regulation goals under the NAA (Figure 3.2-32 and Figure 3.2-33, respectively). Although Dorena Reservoir is slightly more than twice as large by volume as Cottage Grove Reservoir, its drainage is also a little more than twice as large.

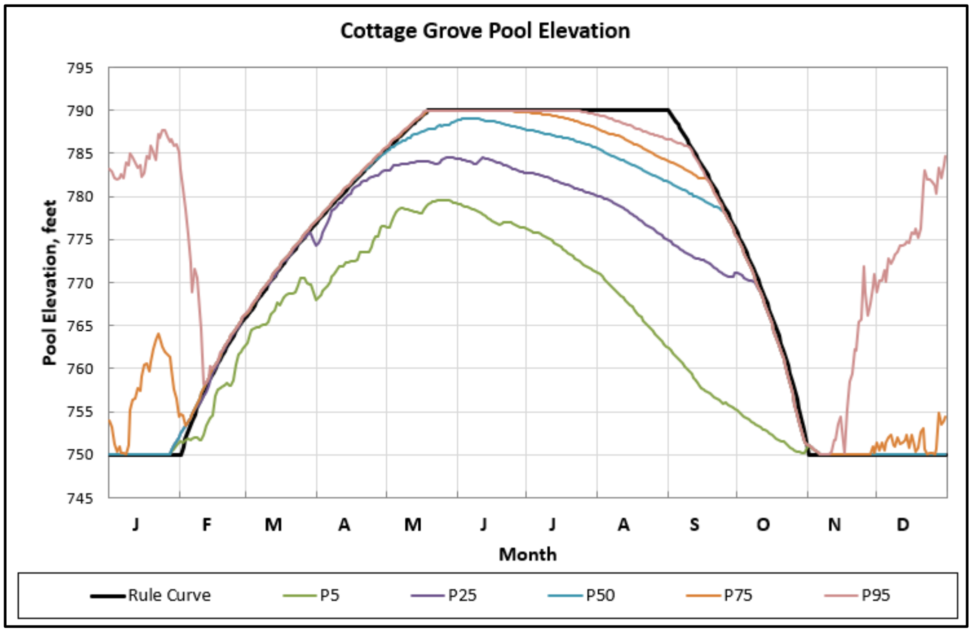

Figure 3.2-32. No-action Alternative Cottage Grove Reservoir Water Surface Elevation Non-exceedance.

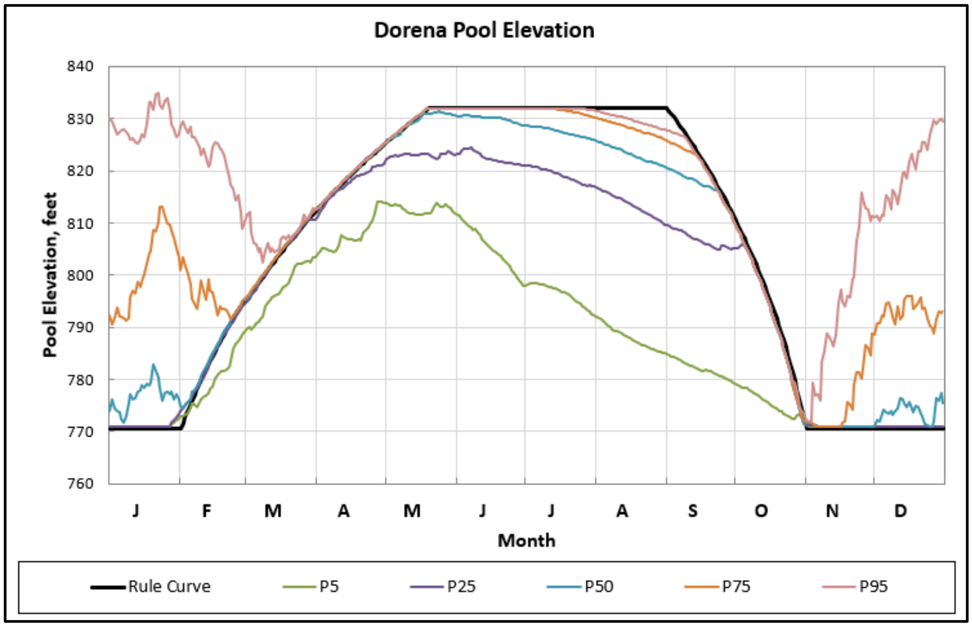

Figure 3.2-33. No-action Alternative Dorena Reservoir Water Surface Elevation Non-exceedance.

The drainage area for Dorena Reservoir is somewhat higher in average elevation, so the inflow into Dorena Reservoir is more variable throughout the winter flood season. Summer storage season is very similar between the two reservoirs. These conditions would not change under the NAA.

The control point for the Coast Fork Willamette River is at Goshen (Figure 3.2-34). Because the Coast Fork is lower in elevation and smaller than the Middle Fork, under the NAA, flows would be lower and minimum base flows much lower as a percentage of the average flow. The rise in average flows in October is a function of the reservoirs releasing water in anticipation of flood season. Average flows would drop at the beginning of November under the NAA as Cottage Grove and Dorena Reservoirs generally get to minimum conservation pool at that time and stop releasing accumulated storage.

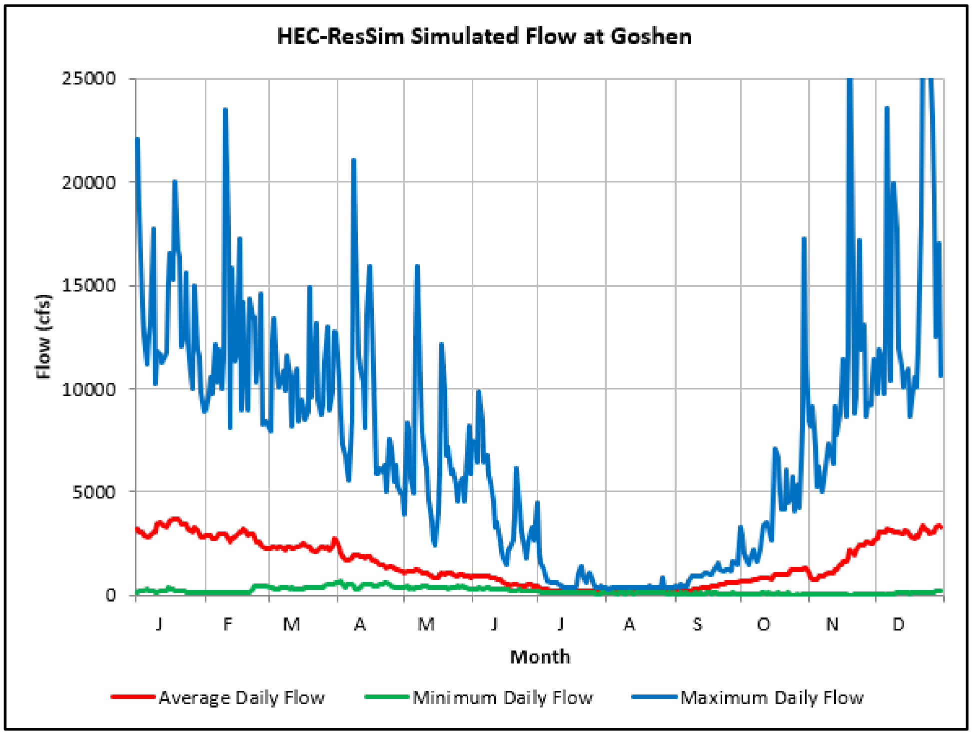

Figure 3.2-34. No-action Alternative Coast Fork Willamette River at Goshen, Oregon Daily Minimum, Average, and Maximum Flows.

Mainstem Willamette River Subbasins

The 2008 NMFS Biological Opinion set minimum flow targets for the Willamette River at Albany and Salem (Figure 3.2-35 and Figure 3.2-36, respectively). The targets shown on both figures are the values set in Abundant and Adequate water years. Deficit years have lower flow targets —shown in the Salem figure—and insufficient years are a sliding scale in between.

Flow target determination is set in cooperation with the WATER forum in compliance with the NMFS Biological Opinion criteria. Across the 1935 to 2019 periods of record there are:

- 45 Abundant water years
- 26 Adequate water years
- 7 Insufficient water years
- 6 Deficit water years

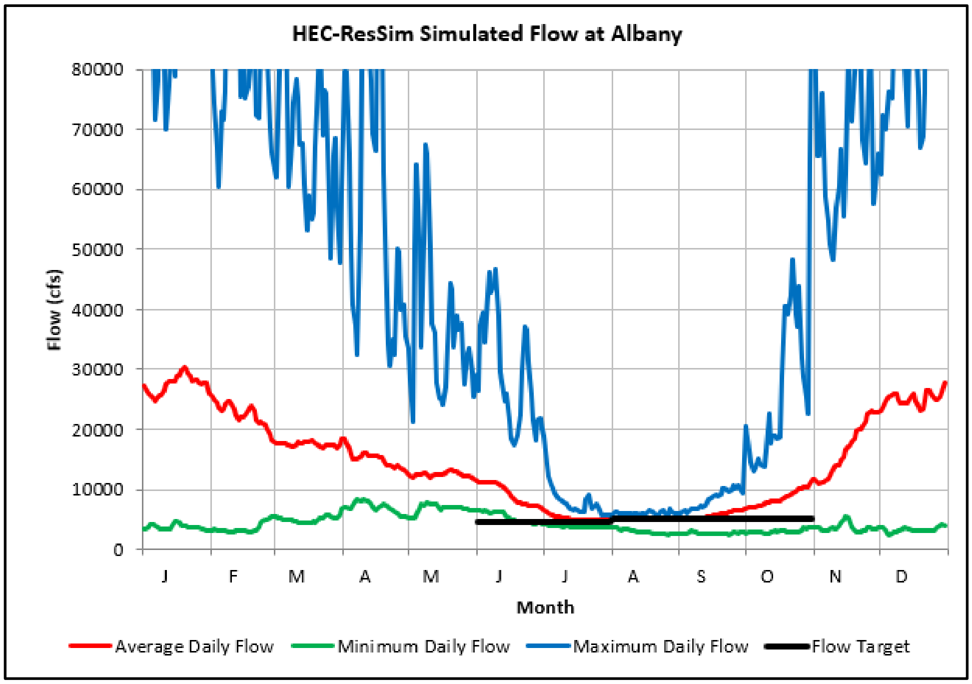

Figure 3.2-35. No-action Alternative Willamette River at Albany, Oregon Daily Minimum, Average, Maximum, and Biological Opinion Target Flows.

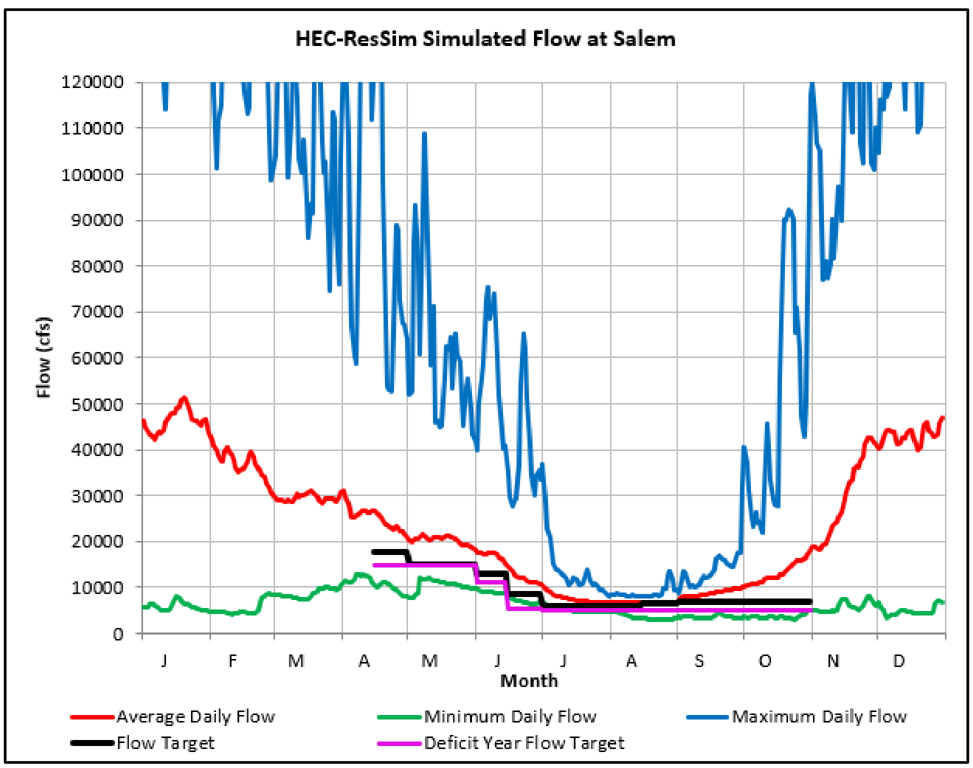

Figure 3.2-36. No-action Alternative Willamette River at Salem, Oregon Daily Minimum, Average, Maximum, and 2008 NMFS Biological Opinion Target Flows.

Because USACE seeks to meet the NMFS 2008 Biological Opinion targets during the summer and fall conservation season as long as possible, the average flow in these months under the NAA would be very close to this minimum flow. Releasing flows above the target would increase the risk of falling below the target later in each water year.

Both the Albany and Salem figures exclude the maximum flood season flows to show more detail in the lower flow summer season.

The minimum flow line would be well below the target at both Salem and Albany under the NAA. Because this line represents the minimum on that date across all water years, no single water year is below the 2008 Biological Opinion targets for as long as the minimum line is represented in Figure 3.2-36. Conditions under the NAA would be below the baseline[4] 2008 Biological Opinion target during the driest years for most of the summer and fall. There would not be adequate stored water to fully supplement basin-wide low flows and, therefore, mainstem flows would not meet the baseline target at either Albany or Salem during dry years under the NAA.

Climate Change Effects under the No-action Alternative

The WVS will likely experience increasing wintertime flow volumes during the 30-year implementation timeframe (Chapter 1, Introduction, Section 1.4, Geographic and Temporal Scale). Some flood magnification (increased severity during flood season) is also likely (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.5, Changes in Winter Atmospheric Rivers, and Section 4.6, Ubiquitous Increases in Flood Magnitude).

Because the WVS system storage will remain about the same, it is likely that flood risk management operations will be challenging over the 30-year implementation timeframe under any alternative. An upward shift in median future inflows may increase both the average reservoir water surface elevation as well as outflows downstream of the WVS dams.

Reservoirs located within higher elevation subbasins, such as Detroit and Cougar Reservoirs, are likely to see higher rainfall and runoff volumes in the winter. Higher projected temperatures in the future would mean less snowpack than currently experienced. A lower snowpack would also contribute less to overall spring flows as the snowpack melts. Lower elevation subbasin dams and reservoirs, such as Fern Ridge and Cottage Grove Dams and Reservoirs, with little or no snowpack, are projected to experience higher wintertime flow volumes but similar peak runoff timing compared to historical conditions.

Increased variability in the spring shoulder months, drier hotter summers, and lower summer baseflow are the most impactful climate change factors affecting conservation season

[4] "Baseline" refers to the typical flow target for a location, which can be modified by the WATER forum during seasonal operations.

operations, which applies to all alternatives. Decreasing spring inflow may result in less reliable refill. Moreover, increased winter and early spring flows may complicate operational ability to initiate refill in the WVS earlier.

Due to decreasing future summer and fall inflows, WVS reservoirs may reach their minimum water surface elevations more frequently. Water surface elevations may decline more rapidly to meet downstream minimum flow targets. The Santiam River and Middle Fork Willamette River Subbasins may be drafted more than other WVS reservoirs. With decreasing summer and fall flows, mainstem Willamette River flow targets may not be met as often if the larger WVS reservoirs empty more frequently in the future.

Alternative 1—Improve Fish Passage through Storage-focused Measures

Alternative 1 is designed to accumulate water in the WVS reservoirs as much as Congressionally authorized and use a greater portion of the total reservoir volume for conservation storage, including portions of the pool currently designated as the inactive and power pools. Compared to the NAA, there would be changes in regulated hydrology throughout the conservation season, as the goal of Alternative 1 is to fill the reservoirs as often as possible and to supply water from storage as long as possible late into the conservation season.

The 2008 NMFS Biological Opinion outlines minimum releases from WVS dams and sets targets at the downstream control points under the NAA (NMFS 2008). Under Alternative 1, these releases and targets would be reduced to Congressionally authorized minimum flows or to a physical operating limit, whichever is greater. The minimum Congressionally authorized flows are lower at Albany and Salem than the Biological Opinion mainstem targets, generally lower across the WVS, and show less seasonal variability. They are also not adaptive, in contrast to the lower-than-baseline flow targets set by the WATER forum in deficit and insufficient years (Section 3.2.1.4, Flow Management Goals).

In general, Alternative 1 would have limited effects during an average or wet year in the Willamette River Basin. USACE would fill the reservoirs during these years while meeting downstream flow targets. Summer flows would sometimes be slightly higher than under the NAA due to the reservoir reaching maximum pool somewhat earlier than normal and, therefore, passing inflow sooner, but flow differences would be minimal compared to the NAA.

Alternative 1 would alter storage in drier than average years, shifting flow releases from April to June into July through October compared to the NAA. This would miss the Biological Opinion flow requirements modeled under the NAA more often, but those misses would occur earlier in the year during the April to June period. Later flow targets from July to October are met more frequently due to the additional accumulated stored water.

A more detailed analysis of Alternative 1 by subbasin is provided below. The reservoir regulation model only considers those measures that affect the water flow volume, location, and timing. Measures that would not affect flow values, such as construction of selective withdrawal structures, are not included in this model or the hydrologic processes results.

The shift of stored water releases to a different season would be very noticeable throughout the Willamette River Basin and would bring long-term changes to the Basin.

Santiam River Subbasin

USACE would fill Detroit Reservoir more often and earlier in the conservation season under Alternative 1 as compared to the NAA (Figure 3.2-37). It would also stay higher later in the year throughout water year types. The effect would be most noticeable in the driest years. The P25 line would reach the maximum pool whereas it would not under the NAA. Also, the P5 line would not reach minimum pool in the fall, in contrast to the NAA where higher minimum flows would deplete storage and operations at Detroit Dam would be forced to only pass inflow when the reservoir reaches minimum conservation pool.

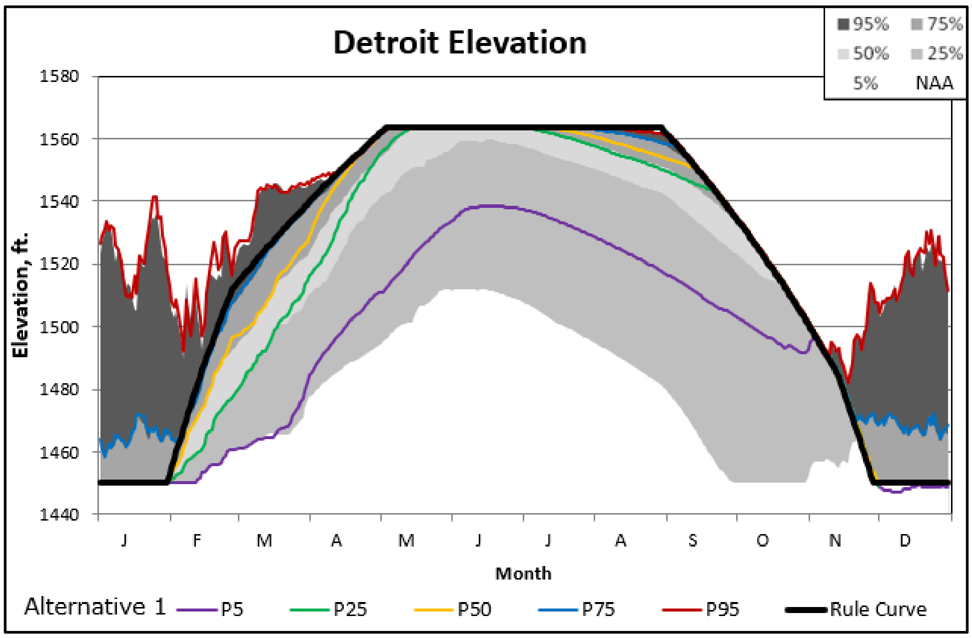

Figure 3.2-37. Alternative 1 Detroit Reservoir Water Surface Elevation Non-exceedance Compared to the No-action Alternative.

USACE would fill Detroit Reservoir more often and remain higher throughout the summer under Alternative 1 because the springtime Congressionally authorized minimum flows would be reduced to 1,050 cfs from a variable schedule of 1,000 cfs to 1,500 cfs. Figure 3.2-38 shows this difference starting in March through June. The fall drawdown from a higher typical pool elevation in preparation for winter flood season would drive the increase in flows in September and October. In other words, more remaining stored water would have to be released in the fall to get to minimum conservation elevation compared to the NAA.

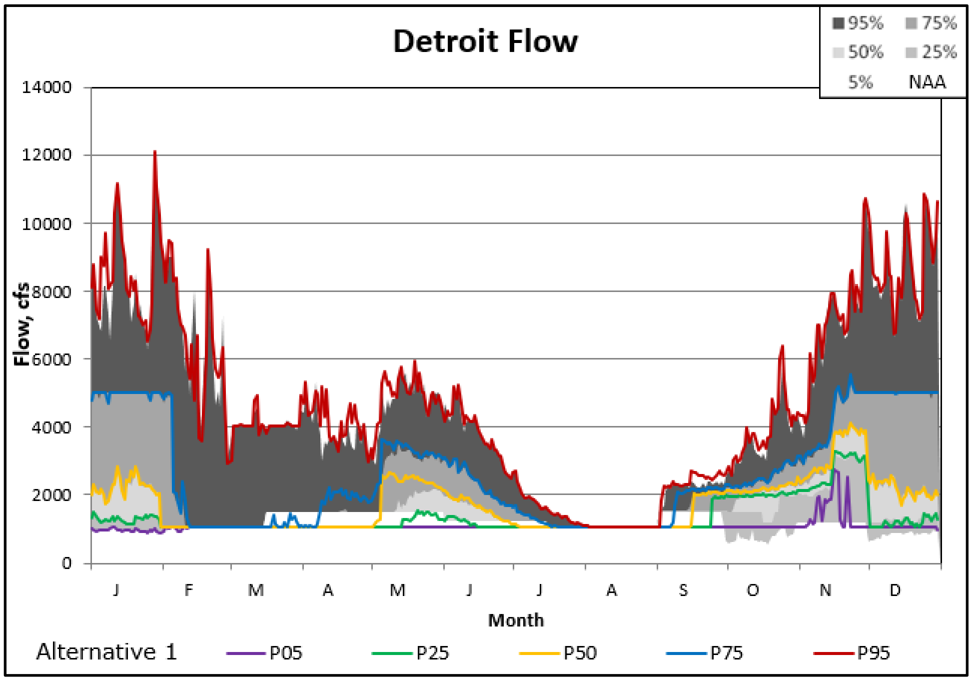

Figure 3.2-38. Alternative 1 Detroit Reservoir Outflow Non-exceedance Compared to the No-action Alternative.

Similar effects would occur at Green Peter Dam as expected at Detroit Dam under Alternative 1. Green Peter Reservoir would remain higher throughout the year and would nearly fill every year—the P5 line comes much closer to the maximum pool than under the NAA (Figure 3.2-39). However, this would be the only a practical difference in the driest years under Alternative 1 because USACE would fill Green Peter Reservoir most of the time under the NAA. The reduction in these flow minimums means that Green Peter Reservoir would remain considerably fuller for longer and able to supply water much later in the year than under the NAA.

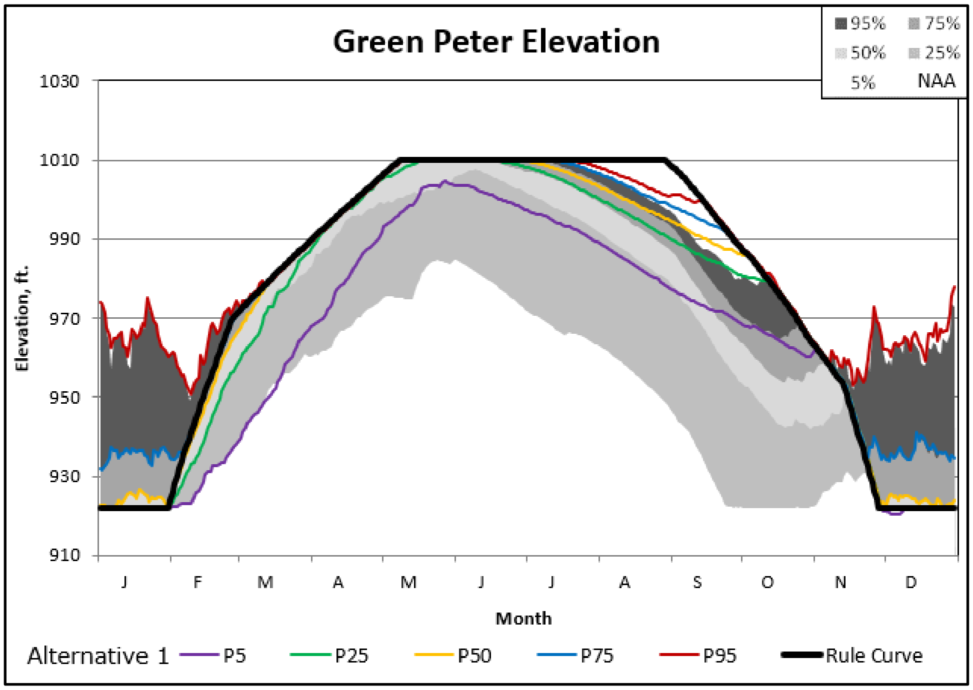

Figure 3.2-39. Alternative 1 Green Peter Reservoir Water Surface Elevation Non-exceedance Compared to the No-action Alternative.

Downstream of Foster Reservoir, which re-regulates Green Peter Reservoir, spring flows would be lower in drier years with the removal of the Biological Opinion targets and about the same in average to wet years under Alternative 1 as compared to the NAA (Figure 3.2-40) (NMFS 2008). The reduction in target flow on the mainstem would account for the lower flow in September. As Green Peter and Foster Reservoirs draft in preparation for flood season, flows would be higher than under the NAA, as the typical reservoir elevation is higher entering October.

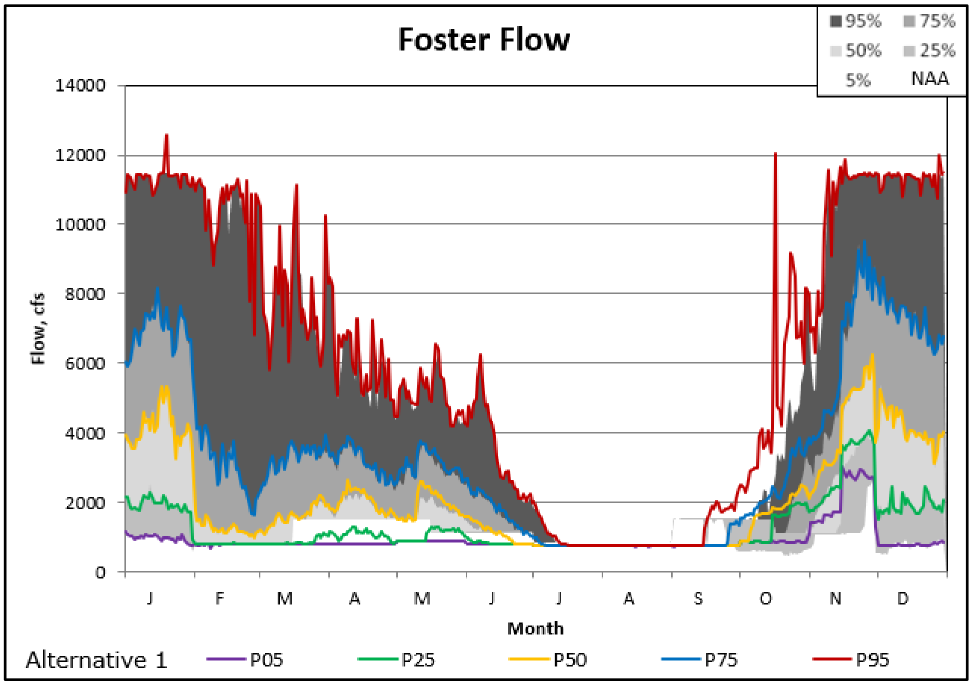

Figure 3.2-40. Alternative 1 Foster Reservoir Outflow Non-exceedance Compared to the No-action Alternative.

At the control point for the Santiam River at Jefferson, the release of stored water would be shifted under Alternative 1 during drier years (Figure 3.2-41). There would be minor differences in wetter years under Alternative 1 as compared to the NAA. The P05 and P25 lines are below the NAA from March through June with lower minimum flows at Salem. This additional water is stored in the reservoir until the fall drawdown, resulting in higher flows in October.

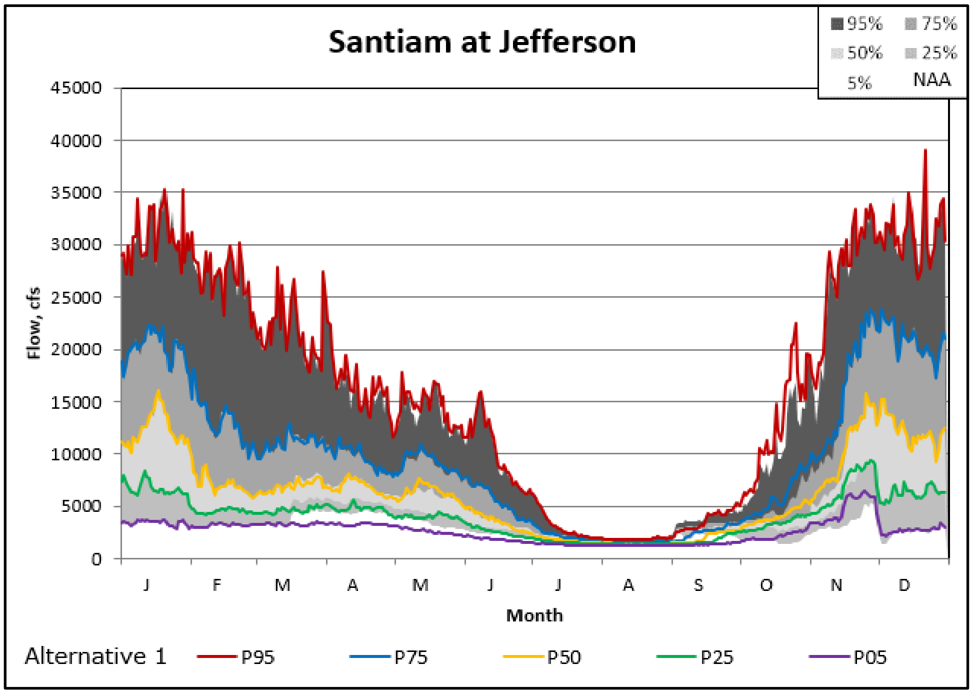

Figure 3.2-41. Alternative 1 Santiam River at Jefferson, Oregon Flow Non-exceedance Compared to the No-action Alternative.

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Long Tom River Subbasin

The water surface elevations within Fern Ridge Reservoir would show negligible changes under Alternative 1 as compared to the NAA (Figure 3.2-42). Downstream flows at Monroe would also remain unchanged under Alternative 1 as compared to the NAA.

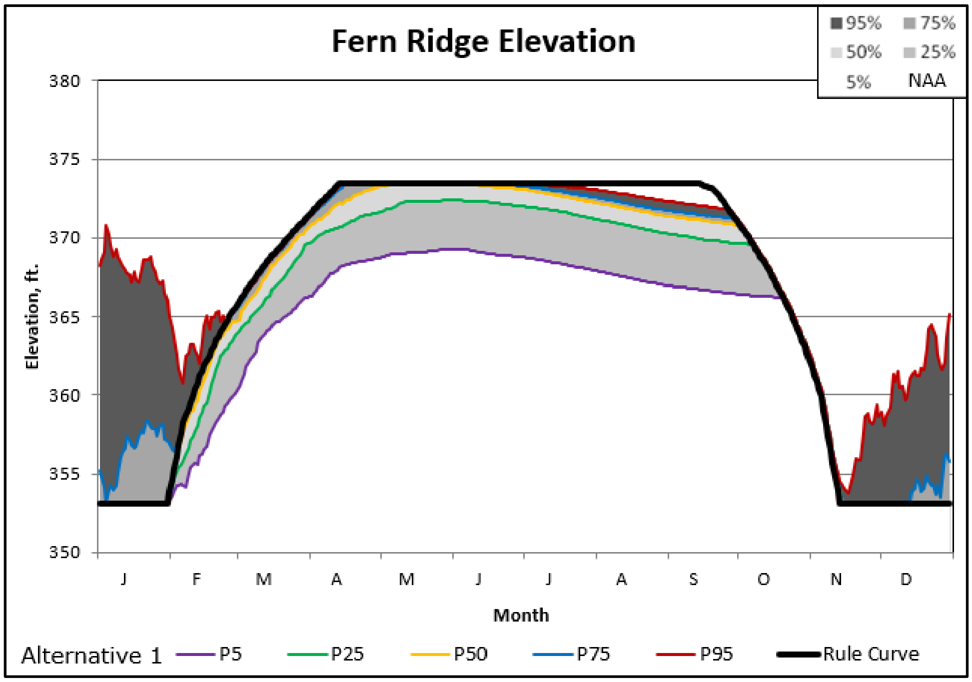

Figure 3.2-42. Alternative 1 Fern Ridge Reservoir Water Surface Elevation Non-exceedance Compared to the No-action Alternative.

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McKenzie River Subbasin

USACE would fill Cougar Reservoir more than 75 percent of years with the reduced flow requirements on the mainstem Willamette River compared with about 50 percent of years under the NAA (Figure 3.2-43). There would be more stored water into the summer in all years under Alternative 1. Operations at Cougar Reservoir could augment instream flows by using the power pool into the fall of dry years. There would be minor differences in the reservoir elevations at Blue River Reservoir under Alternative 1 compared to the NAA in wet years. Reservoir elevations at both reservoirs would be somewhat higher in dry years under Alternative 1 as compared to the NAA.

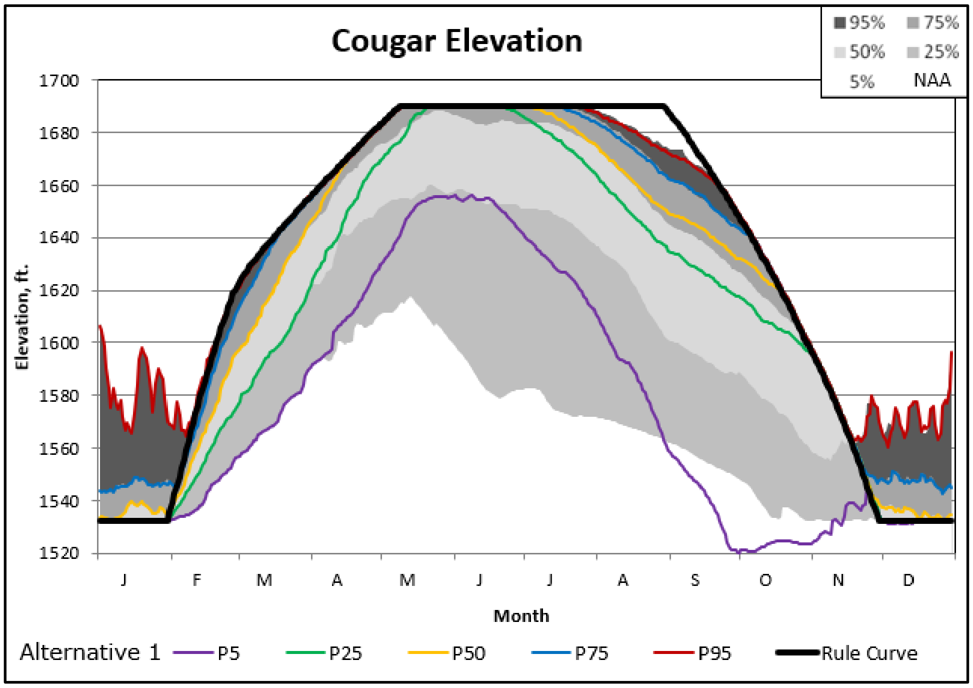

Figure 3.2-43. Alternative 1 Cougar Reservoir Water Surface Elevation Non-exceedance Compared to the No-action Alternative.

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The McKenzie River at Vida, like other control points, would show a shift of stored water releases from the spring to the summer and fall in the dry years and limited differences in wet years as compared to the NAA (Figure 3.2-44). The P5 line would dip below the NAA in October due to the low reservoir elevation at Cougar Reservoir.

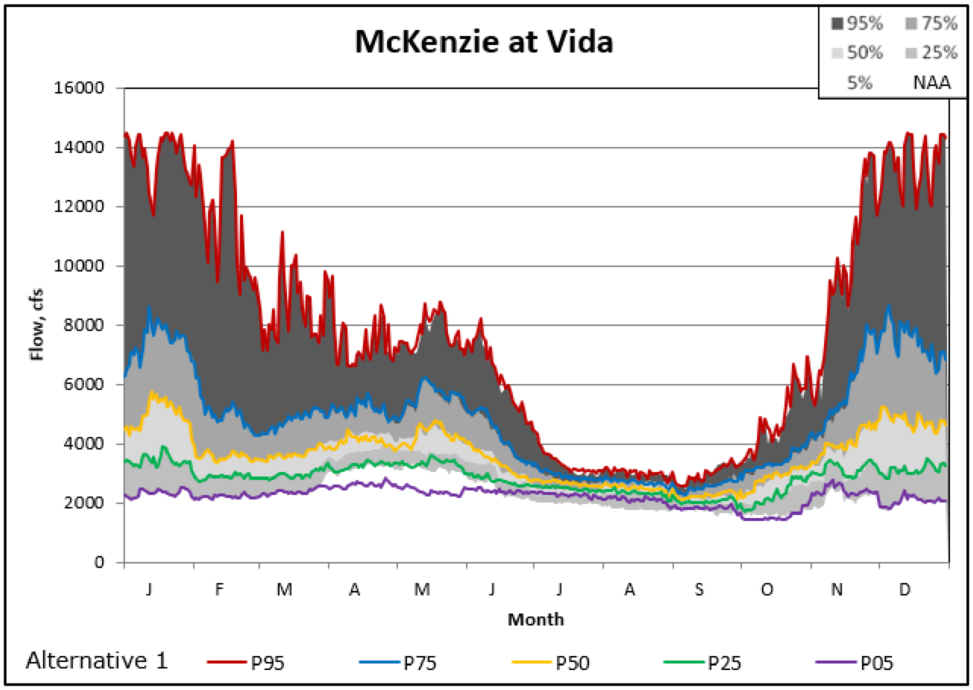

Figure 3.2-44. Alternative 1 McKenzie River at Vida, Oregon Flow Non-exceedance Compared to the No-action Alternative.

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Middle Fork Willamette River Subbasin

USACE would initially fill Hills Creek Reservoir more quickly due to the lower downstream flow targets under Alternative 1 as compared to the NAA. Reservoir elevations would show minor differences during wet years as compared to the NAA (Figure 3.2-45). During dry years, the reservoir would augment instream flows by using the power pool, releasing more water than under the NAA to meet the flow target at Albany. Its capacity would be exhausted in the driest years (P5 line), at which point Lookout Point Reservoir would supply additional water until it too reaches its minimum power pool elevation (Figure 3.2-46). At the downstream control point at Jasper, the dry year water shift would be evident, with lower flows in the spring and higher flows in the summer compared to the NAA (Figure 3.2-47).

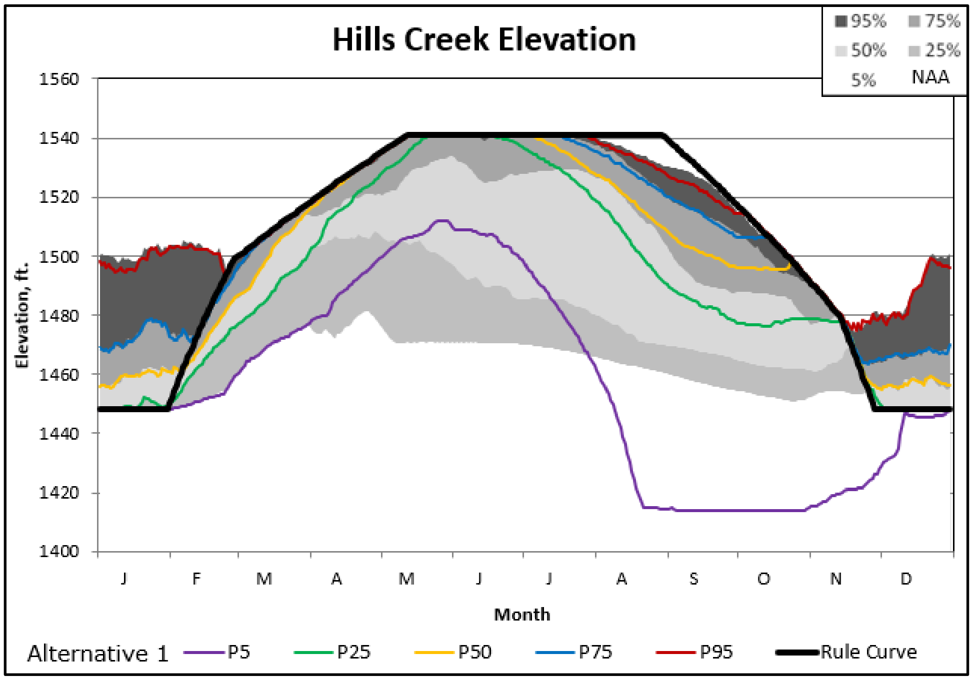

Figure 3.2-45. Alternative 1 Hills Creek Reservoir Water Surface Elevation Non-exceedance Compared to the No-action Alternative.

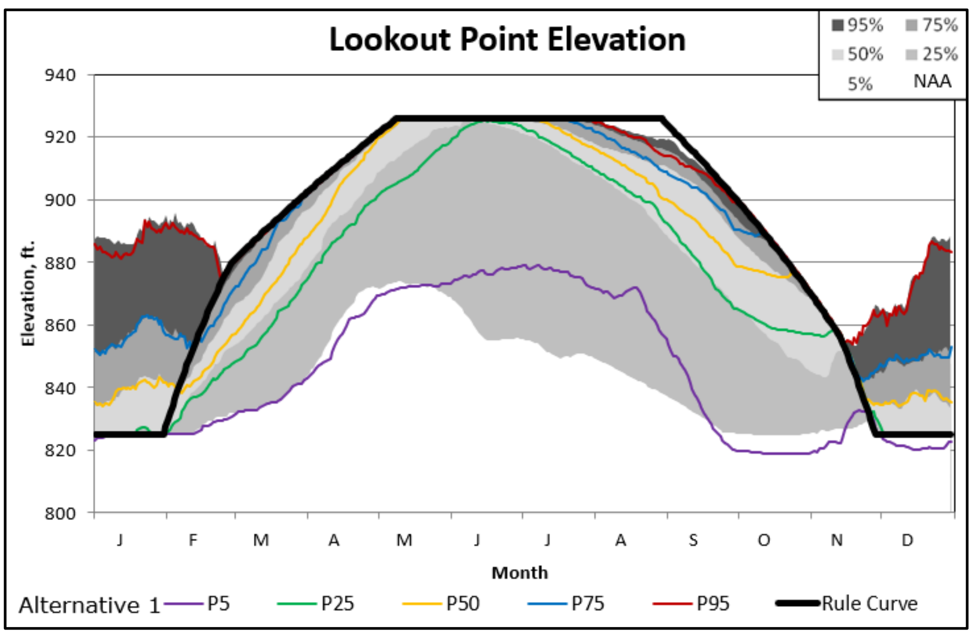

Figure 3.2-46. Alternative 1 Lookout Point Reservoir Water Surface Elevation Non-exceedance Compared to the No-action Alternative.

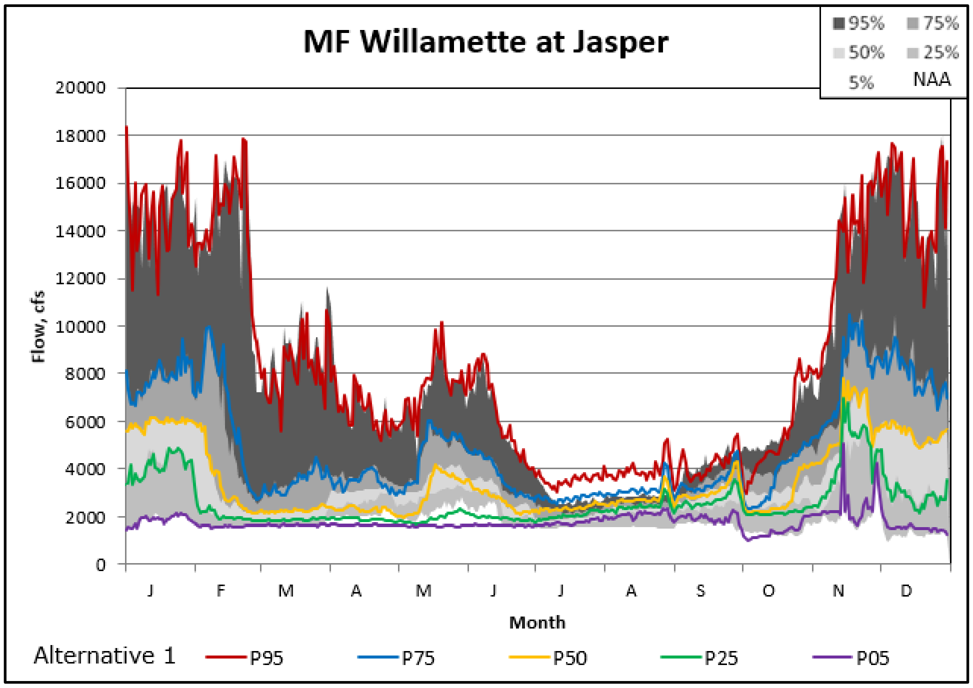

Figure 3.2-47. Alternative 1 Middle Fork Willamette River at Jasper, Oregon Flow Non-exceedance Compared to the No-action Alternative.

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Fall Creek Reservoir elevations would be slightly higher for dry years and show minor changes for wet years under Alternative 1 as compared to the NAA (Figure 3.2-48).

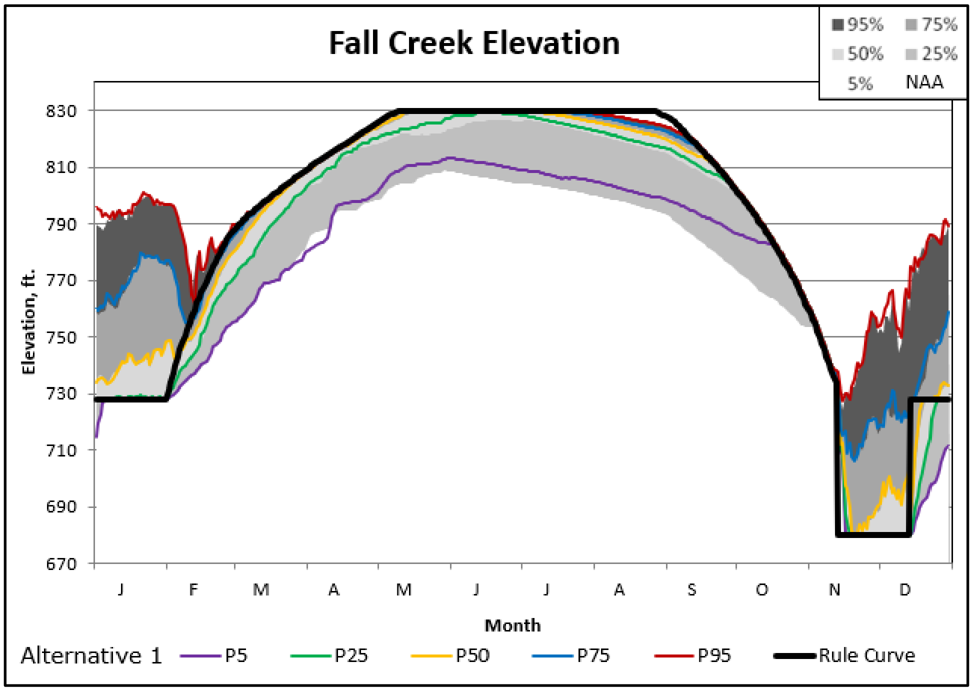

Figure 3.2-48. Alternative 1 Fall Creek Reservoir Water Surface Elevation Non-exceedance Compared to the No-action Alternative.

Coast Fork Willamette River Subbasin

Under Alternative 1, more water would be stored in the Coast Fork Willamette River Subbasin in the spring than under the NAA. This water would be released during the summer and fall in dry years. There would be minor differences in the water stored and released during wet years under Alternative 1 as compared to the NAA.

Reservoir elevations would be higher at both Dorena and Cottage Grove Reservoirs under Alternative 1, except in November and December of the driest years when the reservoirs would augment instream flows by using the inactive pool (Figure 3.2-49 and Figure 3.2-50, respectively). Figure 3.2-51 shows the control point at Goshen. Because the pools would remain higher throughout the summer under Alternative 1, more water would be released during September and October compared to the NAA.

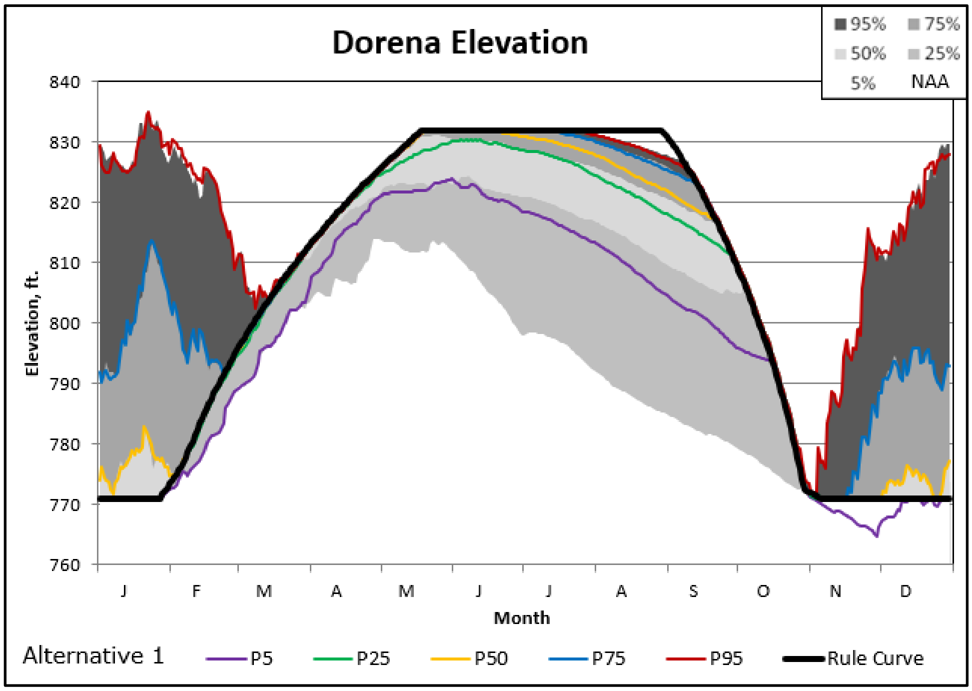

Figure 3.2-49. Alternative 1 Dorena Reservoir Water Surface Elevation Non-exceedance Compared to the No-action Alternative.

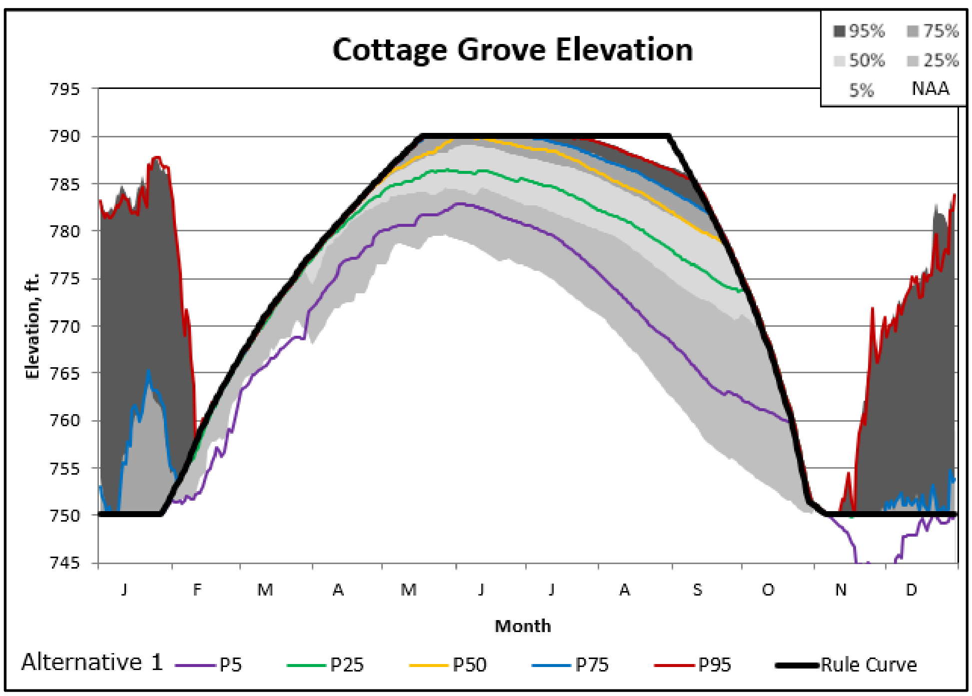

Figure 3.2-50. Alternative 1 Cottage Grove Reservoir Water Surface Elevation Non-exceedance Compared to the No-action Alternative.

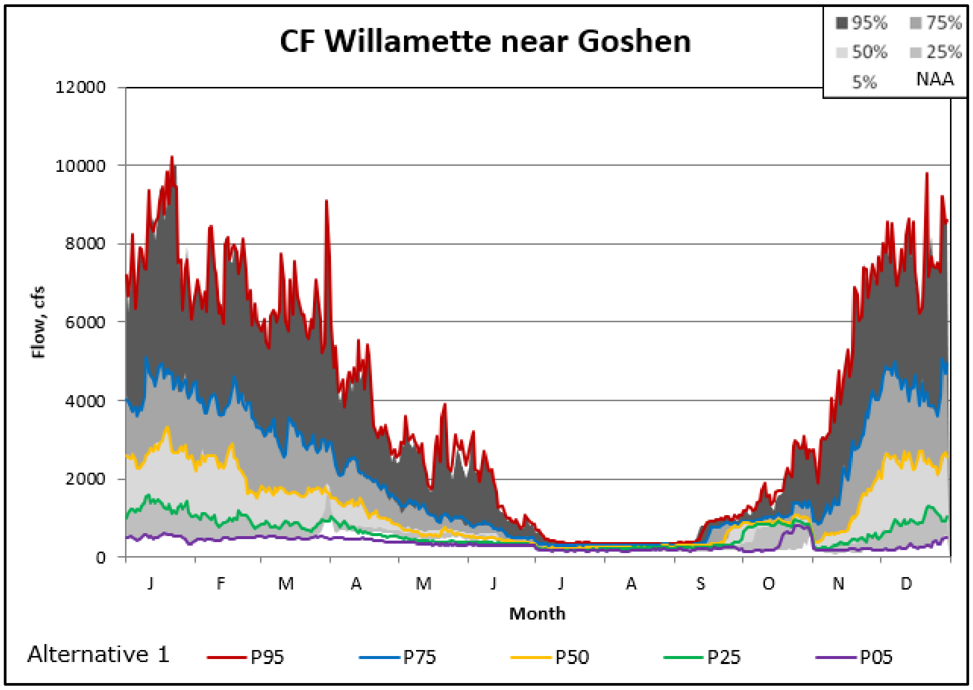

Figure 3.2-51. Alternative 1 Middle Fork Willamette River at Goshen, Oregon Flow Non-exceedance Compared to the No-action Alternative.

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Mainstem Willamette River Subbasins

Alternative 1 would alter the regulated hydrology of the mainstem Willamette River control points during the drier years by reducing minimum flows to the Congressionally authorized minimum flows as compared to the NAA. Because higher flows would be generally above these minimums, there would be limited impact to the average and wet years compared to the NAA.

The P05 and P25 lines would be well below their NAA counterparts from April to June at both Albany and Salem (Figure 3.2-52 and Figure 3.2-53, respectively), with the Congressionally authorized minimum flows lower than the NAA Biological Opinion targets at Salem much more frequently than under the NAA.

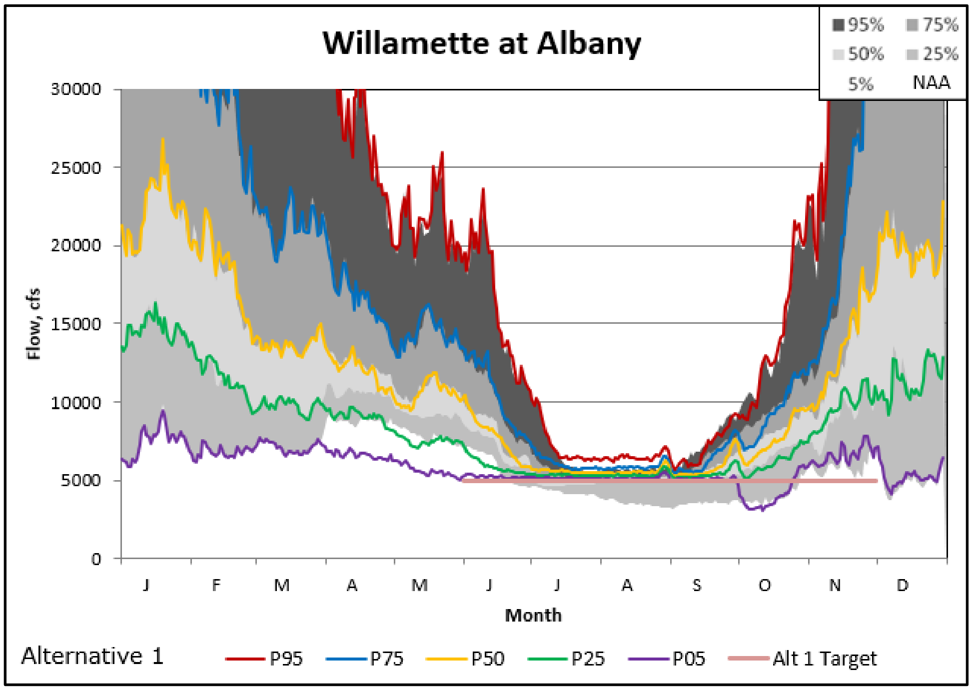

Figure 3.2-52. Alternative 1 Willamette River at Albany, Oregon Flow Non-exceedance Compared to the No-action Alternative.

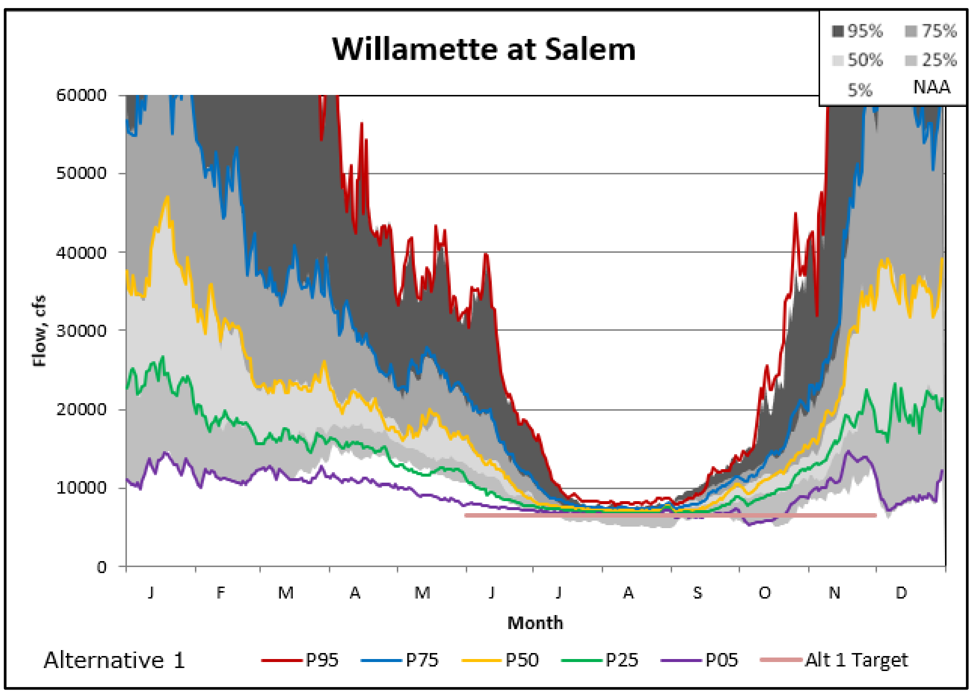

Figure 3.2-53. Alternative 1 Willamette River at Salem, Oregon Flow Non-exceedance Compared to the No-action Alternative.

During dry years, the summer and fall flows would be above the NAA Biological Opinion targets until the driest Octobers, when the Middle Fork Willamette River reservoirs would exhaust their stored water. The Congressionally authorized minimum flows under Alternative 1 would have a lower total volume than the baseline5 Biological Opinion requirements under the NAA but would not be flexible based on expected annual water supply.

Increased flows during the wettest summers (P95 line) would be due to reservoir filling operations earlier in the year and passing more inflow while at the top of the rule curve compared to the NAA.

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Climate Change Effects under Alternative 1

Overall climate change impacts on hydrologic processes in the Willamette River Basin would be the same as those described under the NAA (Section 3.2.2.3, No-action Alternative, Climate Change Effects under the No-action Alternative). The WVS would experience minor differences in wintertime effects from climate change under Alternative 1 as it would under the NAA.

Because the Congressionally authorized minimum flows would be lower than the NAA flow targets under Alternative 1, WVS reservoirs could store more water during the conservation season as compared to the NAA. However, USACE would need to use more of this stored water to meet downstream flow targets with projected increased variability during the spring months, drier hotter summer, and lower summer baseflows. Therefore, under Alternative 1, climate change would drive reservoir water surface elevations lower but remain above projections for the NAA.

Under Alternative 1, most reservoirs would only rarely reach minimum elevation in the fall, meaning they would have additional water to continue to augment downstream flows as compared to the NAA. As projected late spring, summer, and fall flows decrease in the future, the WVS could supply more of the additional stored water to augment stream flows. The lowest reservoir water surface elevations would occur in the driest years, which would be drier than the WVS currently encounters, as the reservoirs are drafted more to meet downstream flow targets under Alternative 1. Additionally, increased reservoir evaporation from increased climate change-induced temperatures would marginally decrease available water from all WVS reservoirs.

END REVISED TEXT

[5] "Baseline" refers to the typical flow target for a location, which can be modified by the WATER forum during seasonal operations.

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Under Alternative 2A, USACE would shift the release of stored water from the spring to the summer and fall, most prominently in dry years. The integrated temperature and habitat flow regime would replace the 2008 NMFS Biological Opinion under the NAA. Briefly, this would modify the base flow targets at a WVS reservoir if it is at more or less than 90 percent of rule curve elevation. Flows would be reduced within a range down to minimums needed for fish survival when reservoirs are under the 90 percent threshold. While these minimums would be less than the Biological Opinion targets under the NAA, these would be adaptive within a water year and could return to levels that would be higher than the Biological Opinion flows if reservoir levels are high.

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At the mainstem Willamette River control points—Albany and Salem—flow targets would be reduced to 4,500 cfs and 5,000 cfs, respectively, as compared to the NAA. The higher Biological Opinion targets, particularly in the spring and early summer, are designed to help migrating fish and keep the river from getting too hot, so substantially more water would be added in the spring. As a replacement, the integrated temperature and habitat flow regime would require additional flow as compared to the NAA based on air temperature, with total flow minimum at Salem ranging from 5,900 cfs to 19,800 cfs. This would allow USACE to store additional water in the WVS when it is not needed to keep the river cool (Chapter 2, Alternatives, Section 2.8.1.1, Integrated Temperature and Habitat Flow Regime (Measure 30a)).

Alternative 2A would alter storage in drier than average years, shifting flow releases from April to June into July through October (P25 and P5/P05 lines in the figures). This would result in lower flows than under the NAA earlier in the year during the April to June period. Flows later in the summer and fall, from July to October, would be higher than under the NAA due to the additional accumulated stored water. Compared to the NAA, flow targets under Alternative 2A would be similar or somewhat lower across the WVS, so reservoir elevations would be somewhat higher than elevations under the NAA.

Green Peter Reservoir would have a deeper fall reservoir drawdown under Alternative 2A; the reservoir operations model shows the consequences of this drawdown at all downstream control points (Section 3.2.2.1, Methodology, Reservoir Operations Model). Specifically, the deeper fall reservoir drawdown means there would be more flow in the late summer and early fall in the South Santiam, Santiam, and Willamette Rivers downstream of the confluence with the Santiam River. Refilling the reservoir to minimum conservation pool would also reduce downstream flows by a relatively small amount through about the middle of January in a typical year compared to the NAA.

USACE would construct structural downstream fish passage in Cougar Reservoir under Alternative 2A and, therefore, the spring and fall reservoir drawdowns would not be as deep as under Alternative 2B (under which the modified diversion tunnel would serve this passage function). The maintenance of storage at Cougar Reservoir would mean that USACE could meet downstream flow targets across most years. Other reservoirs, most notably in the Middle Fork Willamette River Subbasin, would also maintain higher water surface elevations than under the NAA without the need for additional releases to meet downstream flow targets. USACE would also meet the mainstem Willamette River flow targets for the WVS more often with higher Cougar Reservoir storage levels as compared to the NAA.

Although there are structural activities proposed under Alternative 2A at the WVS dams to aid fish survival, many of these would not affect the flow from any WVS dam (structural activities do not appear in the reservoir operations model; Section 3.2.2.1, Methodology, Reservoir Operations Model). An example of this is the water control tower at Detroit Dam, which would allow for greater control of the temperature of the water released from the dam but would not alter the flow rate or outlet used for dam operations. A more detailed analysis of Alternative 2A by subbasin is provided below.

As compared to the NAA, lower spring flows in dry years and higher summer flows in nearly all years would have long-term effects across the Willamette River Basin under Alternative 2A.

END REVISED TEXT

Santiam River Subbasin

USACE would fill Detroit Reservoir more often and narrow the range of reservoir elevations prior to drafting the reservoir for flood season under Alternative 2A as compared to the NAA (Figure 3.2-54). The lowest minimum flow of the integrated temperature and habitat flow regime would be smaller downstream of Detroit Reservoir so USACE could fill the reservoir more often.

These lower flow requirements would only apply when the reservoir is below 90 percent full so would only come into use during drier years. During wetter years, storage would be near the rule curve regardless of the higher flow requirements downstream. Detroit Reservoir would support the volume to supply downstream targets later in the year under Alternative 2A, meeting all its immediate downstream flow targets across all years compared to the NAA.

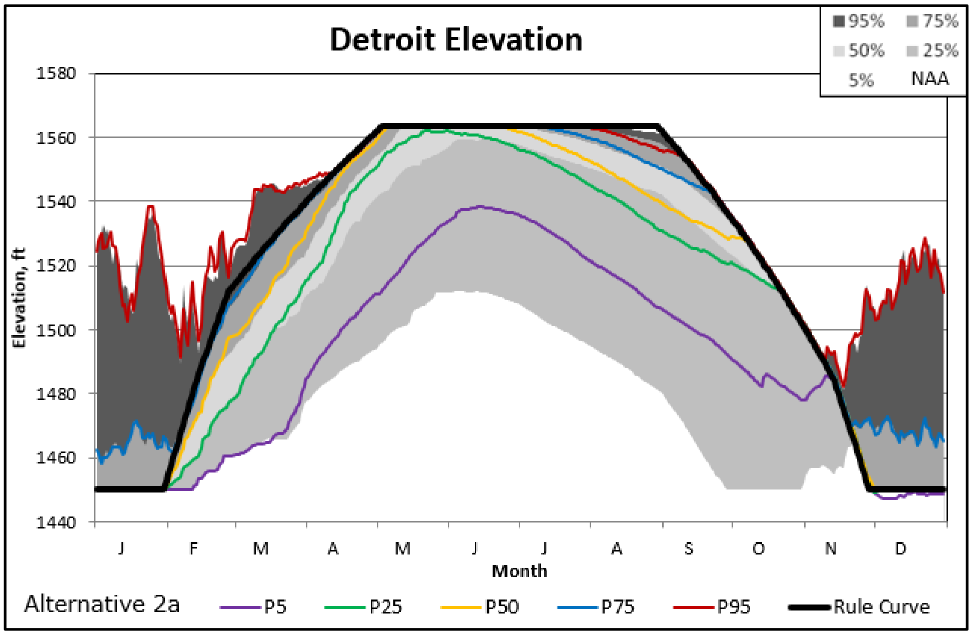

Figure 3.2-54. Alternative 2A Detroit Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

USACE would fill Green Peter Reservoir more often during the conservation season under Alternative 2A as compared to the NAA, despite implementation of a deeper fall reservoir drawdown (Figure 3.2-55). In very dry years, the reservoir elevation would be well below the rule curve through the winter but it would recover to higher levels than under the NAA by summer due to the lower integrated temperature and habitat flow regime targets. However, the percentage of time that Green Peter Reservoir would reach its top of conservation storage would remain about the same because all inflow above that level would be released from the reservoir. Lower reservoir levels would be expected throughout the winter flood season, even during the wettest years.

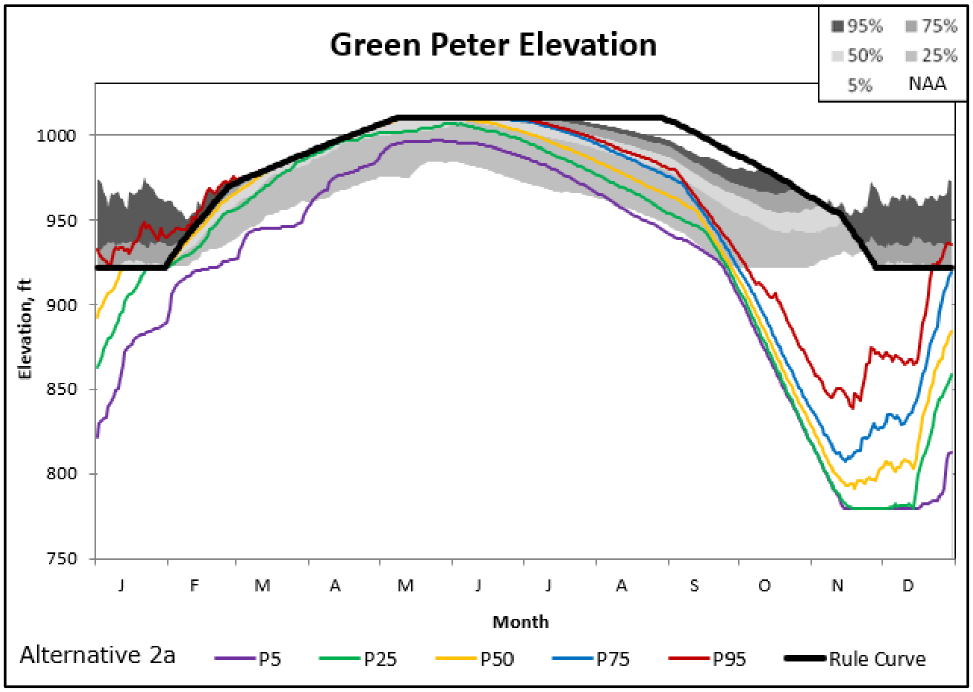

Figure 3.2-55. Alternative 2A Green Peter Reservoir Water Surface Elevation Non-exceedance Compared to the No-action Alternative.

Compared to the NAA, outflow from Foster Dam would meet the integrated temperature and habitat flow regime targets except in November of very dry years when Green Peter Reservoir would have already reached the minimum deeper fall reservoir drawdown elevation (Figure 3.2-56). The increased flows in September would be the result of USACE releasing water from Green Peter Reservoir for the deeper fall reservoir drawdown, which would not occur under the NAA. Immediately downstream, winter flows across all but very wet years would be lower than under the NAA. This would also be due to the Green Peter Reservoir deeper fall drawdown as USACE holds back water to get restore the minimum conservation pool. Foster Reservoir would seldom deviate from the rule curve under Alternative 2A.

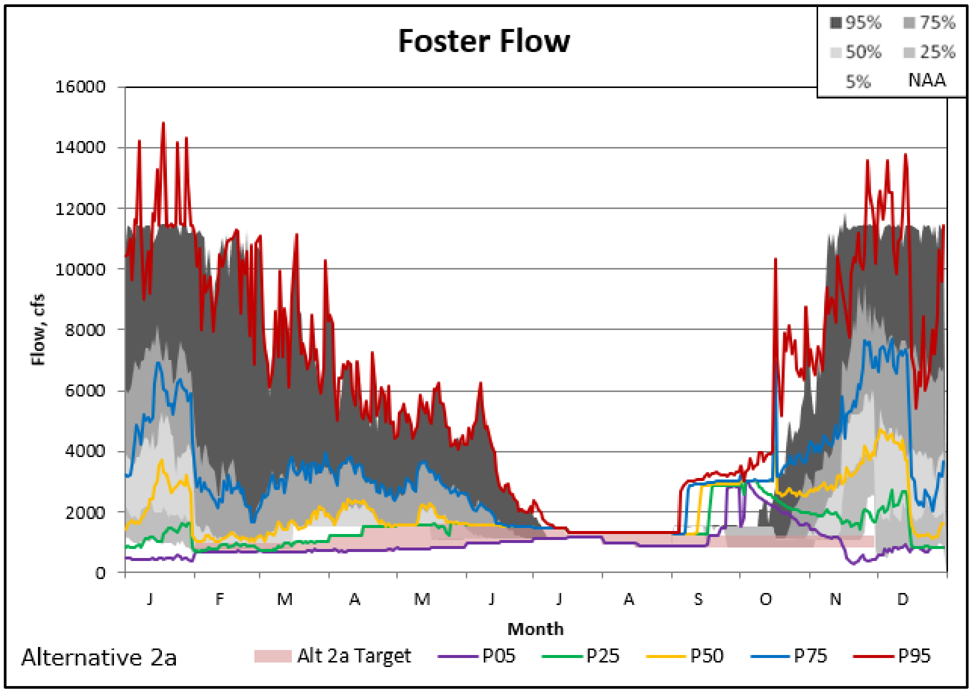

Figure 3.2-56. Alternative 2A Foster Reservoir Flow Non-exceedance as Compared to the No-action Alternative.

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Some of the flow changes at Foster Reservoir as compared to the NAA would carry downstream to the Santiam River at Jefferson, but any potential winter flood management benefits from the deeper fall drawdown at Green Peter Reservoir would no longer be present (Figure 3.2-57). Wet weather flows would show minor changes compared to the NAA during the winter and lower winter flows are only slightly lower, though these flows would already be well below flood stage.

In the spring, lower flows in the driest years would be due to lower requirements of the integrated temperature and habitat flow regime as compared to the NAA, both directly downstream of the dams and mainstem flow targets. Detroit Reservoir, with its higher summer water surface elevations, can supply water throughout the summer, resulting in higher flows than under the NAA. The increased flows in September from the Green Peter Reservoir deeper fall drawdown under Alternative 2A would be evident at Jefferson, which would not occur under the NAA.

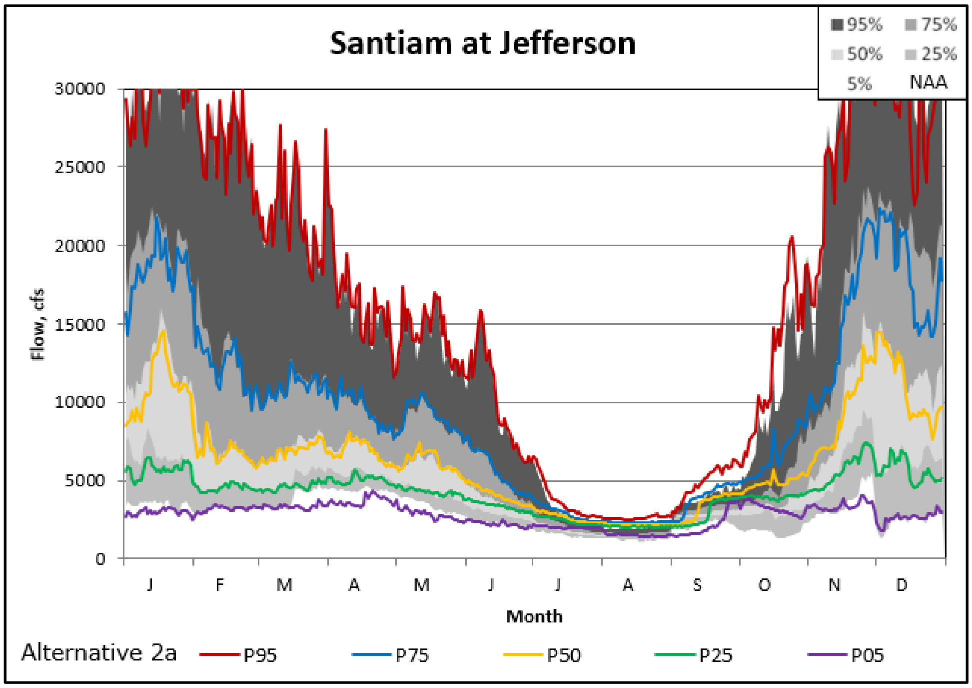

Figure 3.2-57. Alternative 2A Santiam River at Jefferson, Oregon Flow Non-exceedance Compared to the No-action Alternative.

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Long Tom River Subbasin

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Water surface elevations within Fern Ridge Reservoir would show negligible changes under Alternative 2A as compared to the NAA (Figure 3.2-58). Downstream flows at Monroe would also remain unchanged under Alternative 2A as compared to the NAA.

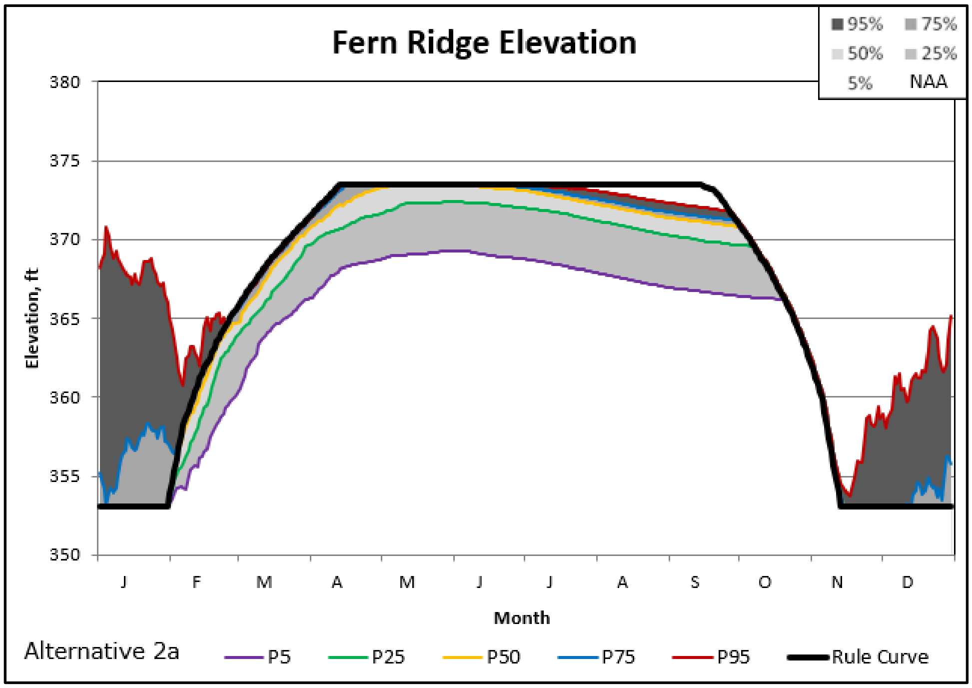

Figure 3.2-58. Alternative 2A Fern Ridge Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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McKenzie River Subbasin

USACE would fill Cougar Reservoir more often under Alternative 2A, which would remain higher in the conservation season except in the driest years compared to the NAA (Figure 3.2-59, P5 line). The additional allowance to augment instream flows by using the power pool below minimum conservation storage elevation would allow USACE to meet the integrated temperature and habitat flow regime target directly downstream of Cougar Dam even in the driest years.

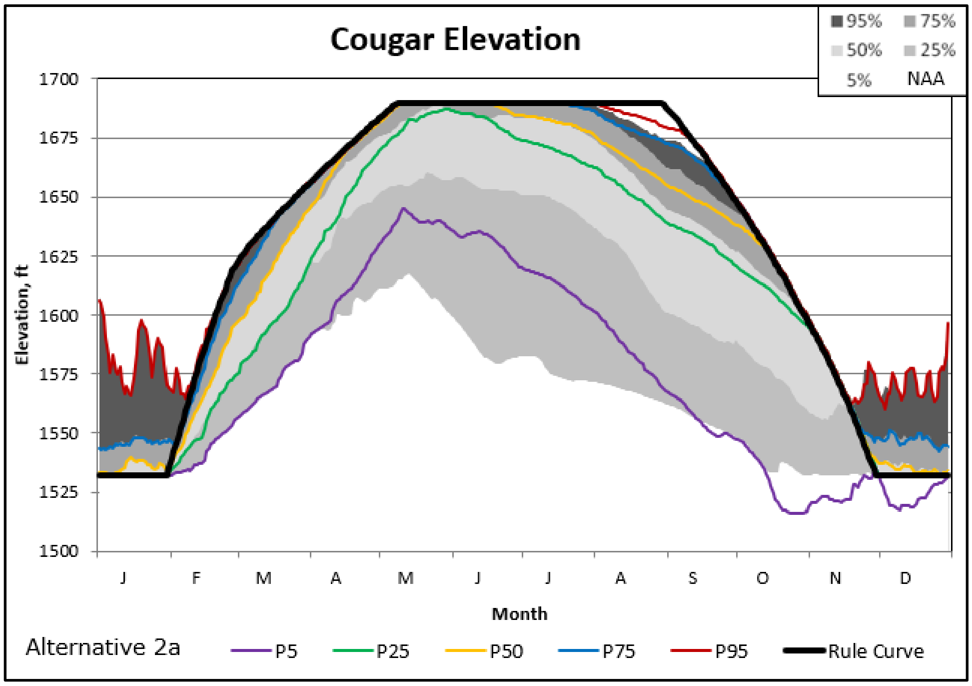

Figure 3.2-59. Alternative 2A Cougar Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

USACE would fill Blue River Reservoir more often as compared to the NAA and would augment instream flows by using the inactive pool only after reaching its minimum conservation storage elevation (Figure 3.2-60). The McKenzie River at Vida would show the effect of the lower downstream integrated temperature and habitat flow regime targets during spring of dry years at the downstream control point for Cougar and Blue River Reservoirs under Alternative 2A (Figure 3.2-61). The driest years (P5 line) would be below the NAA from March to June, but above the NAA from July to October. Summer flow would be less variable under Alternative 2A across all years. Winter flow would remain the same as under the NAA.

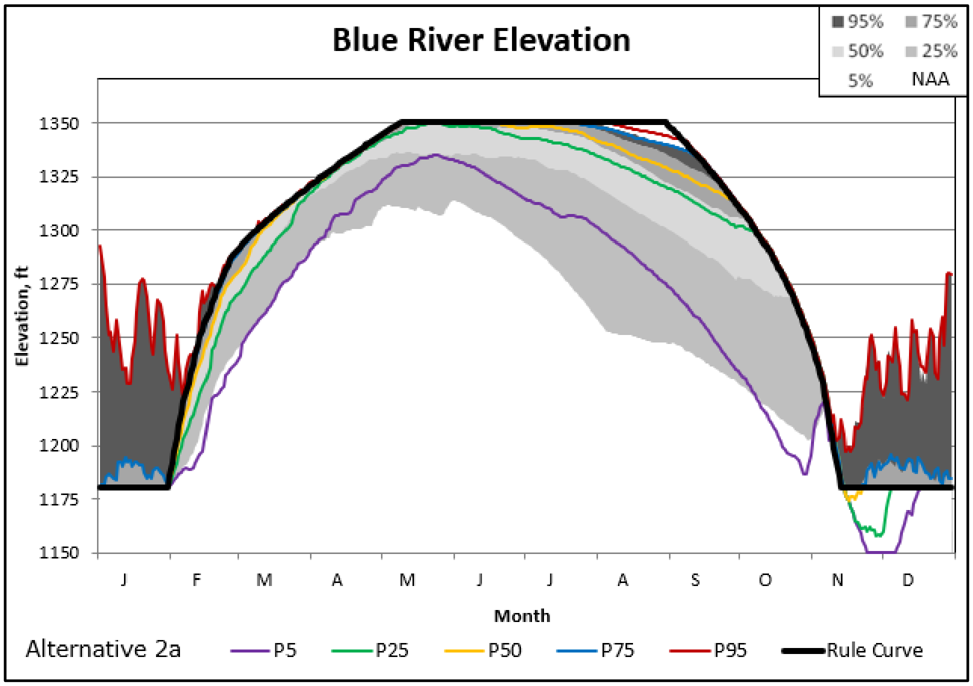

Figure 3.2-60. Alternative 2A Blue River Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

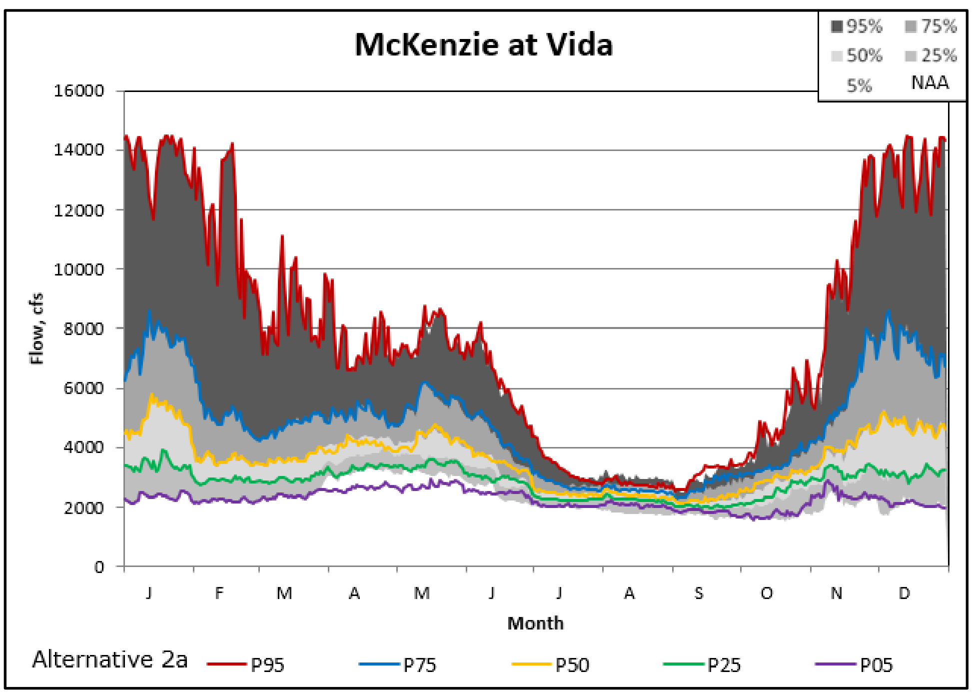

Figure 3.2-61. Alternative 2A McKenzie River at Vida Flow Non-exceedance as Compared to the No-action Alternative.

Middle Fork Willamette River Subbasin

Under Alternative 2A, USACE would initially fill Hills Creek Reservoir more quickly due to the lower integrated temperature and habitat flow regime targets when the reservoir is less than 90 percent full and would remain at similar or higher elevations during wet years compared to the NAA (Figure 3.2-62). During dry years, the reservoir would augment instream flows by using the power pool, with USACE releasing more water to meet the flow target at Albany.

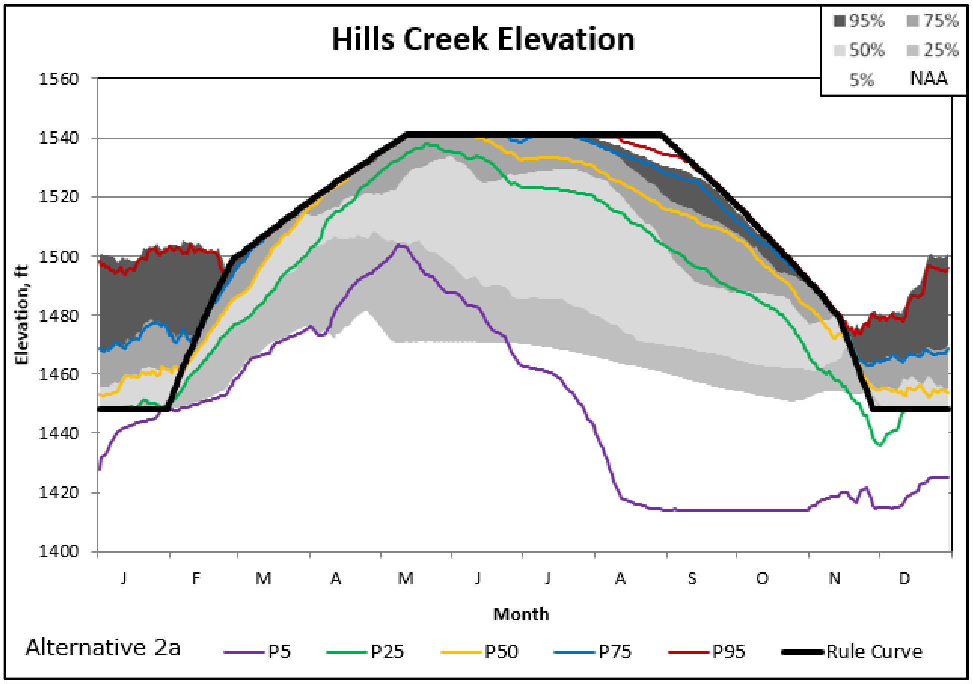

Figure 3.2-62. Alternative 2A Hills Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Hills Creek Reservoir capacity would be exhausted in the driest years, at which point Lookout Point Reservoir would supply additional water, reaching the Alternative 2A minimum in late October (Figure 3.2-63, P5 line). Under Alternative 2A, USACE would miss the integrated temperature and habitat flow regime target more often below Dexter Dam when Lookout Point Reservoir is at its minimum power pool compared to the NAA.

Storage elevations for both Hills Creek and Lookout Point Reservoirs would be slightly higher across all years compared to the NAA. Because Cougar Reservoir would have considerably more storage under Alternative 2A compared to storage under the NAA, USACE would be able to contribute more to downstream flow targets from Cougar Dam, meaning the Middle Fork Willamette River reservoirs would not be operated to make up for this deficit.

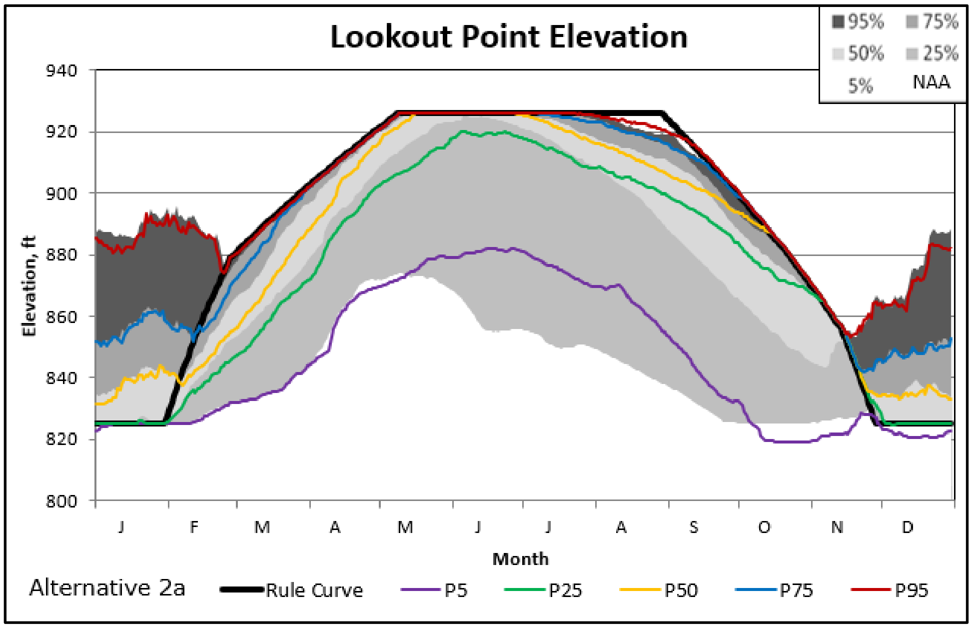

Figure 3.2-63. Alternative 2A Lookout Point Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Conditions at Fall Creek Reservoir under Alternative 2A would differ marginally from the NAA (Figure 3.2-64).

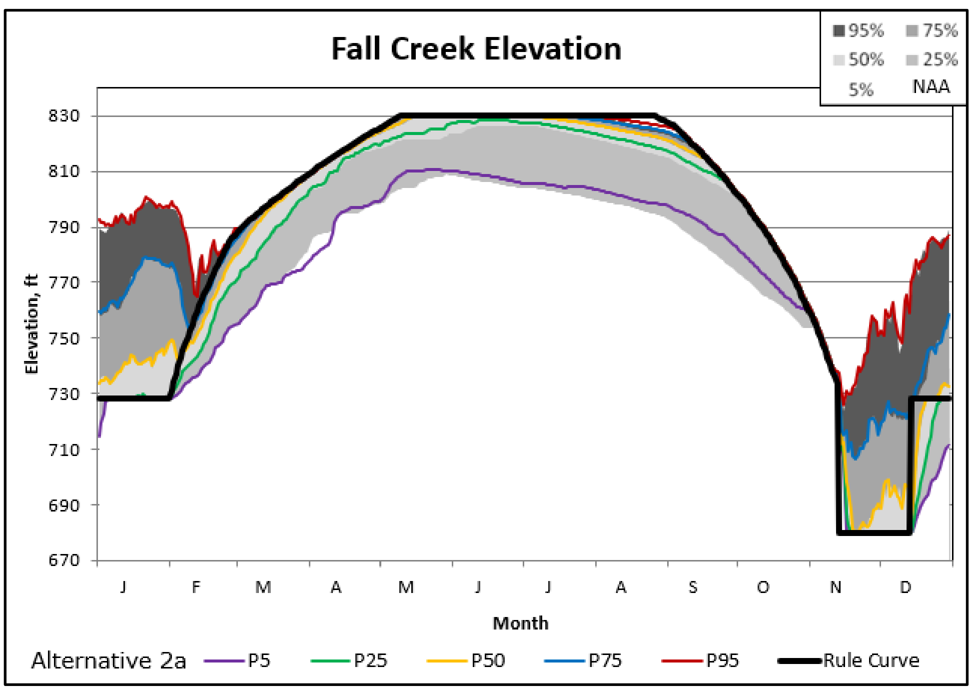

Figure 3.2-64. Alternative 2A Fall Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

At the downstream control point at Jasper, the shift in release of stored water in dry years would be evident, with lower flows in the spring and higher flows in the summer and fall as compared to the NAA (Figure 3.2-65). The increased fall flows during wet years would be due to the reservoirs starting at a higher elevation prior to drafting for flood season than under the NAA. There would be more water to release from the reservoirs under Alternative 2A so there would be a higher flow downstream of the reservoirs as compared to the NAA.

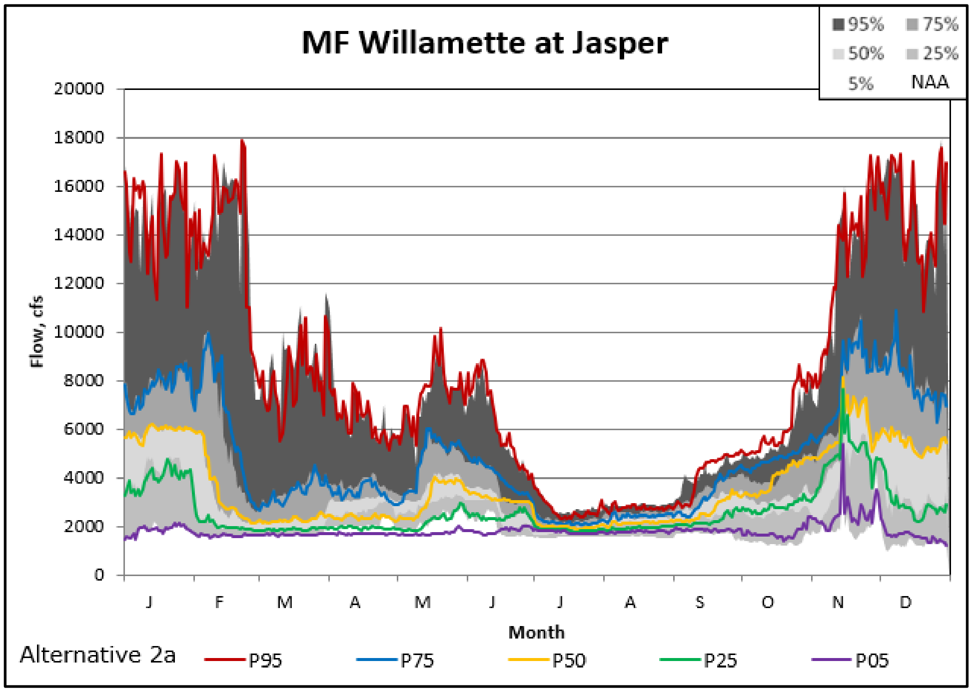

Figure 3.2-65. Alternative 2A Middle Fork Willamette River at Jasper, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Coast Fork Willamette River Subbasin

Under Alternative 2A, more water would be stored in the Coast Fork Willamette River Subbasin in the spring and released during the summer and fall during dry years as compared to the NAA. Conditions in this subbasin would be generally similar to the NAA in wet years.

Reservoir elevations would be somewhat higher at both Dorena Dam and Cottage Grove Dam under Alternative 2A during the late spring and summer, demonstrating similarity to elevations under the NAA at other times (Figure 3.2-66). Because the pools would remain higher throughout the summer under Alternative 2A, USACE would release more water during September and October than under the NAA, increasing flows at Goshen (Figure 3.2-67).

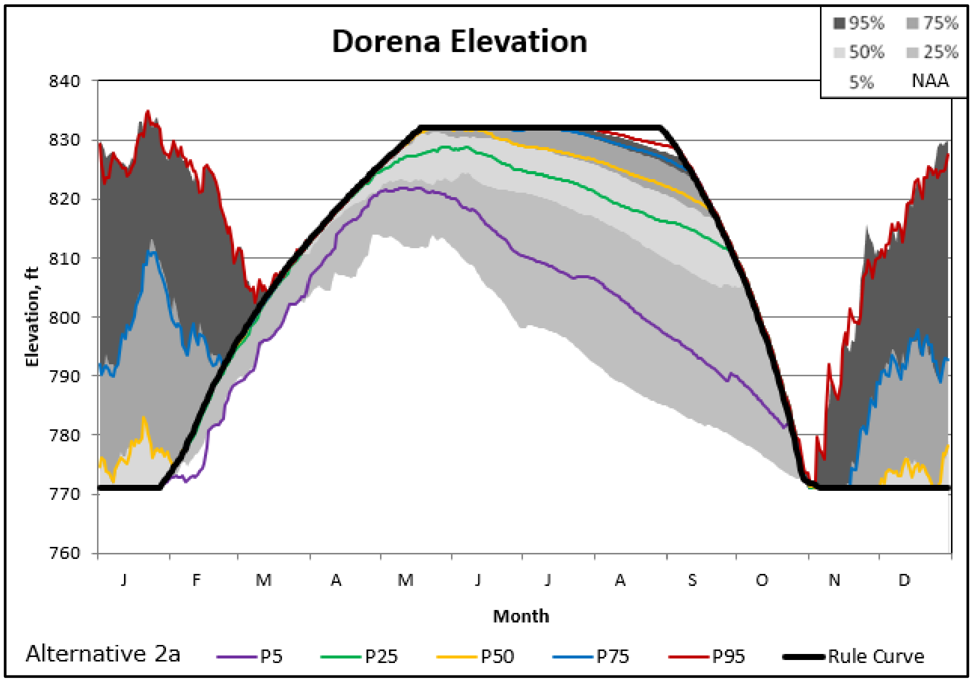

Figure 3.2-66. Alternative 2A Dorena Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

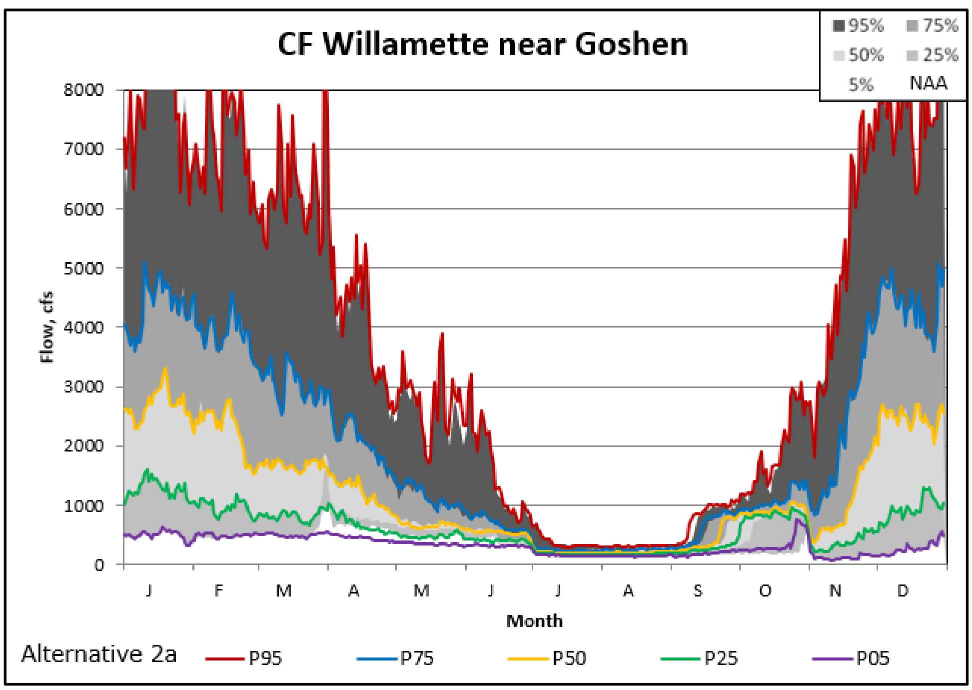

Figure 3.2-67. Alternative 2A Coast Fork Willamette River at Goshen, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Mainstem Willamette River Subbasins

Compared to the NAA, operations under Alternative 2A would alter the regulated hydrology of the mainstem Willamette River control points, whereby USACE would store more water in the spring and release it during the summer. The Willamette River at Albany would show dry years below their NAA equivalents from April to June and a compressed flow regime through the summer, with the higher flow years reduced and the low flow years increased compared to the NAA (Figure 3.2-68).

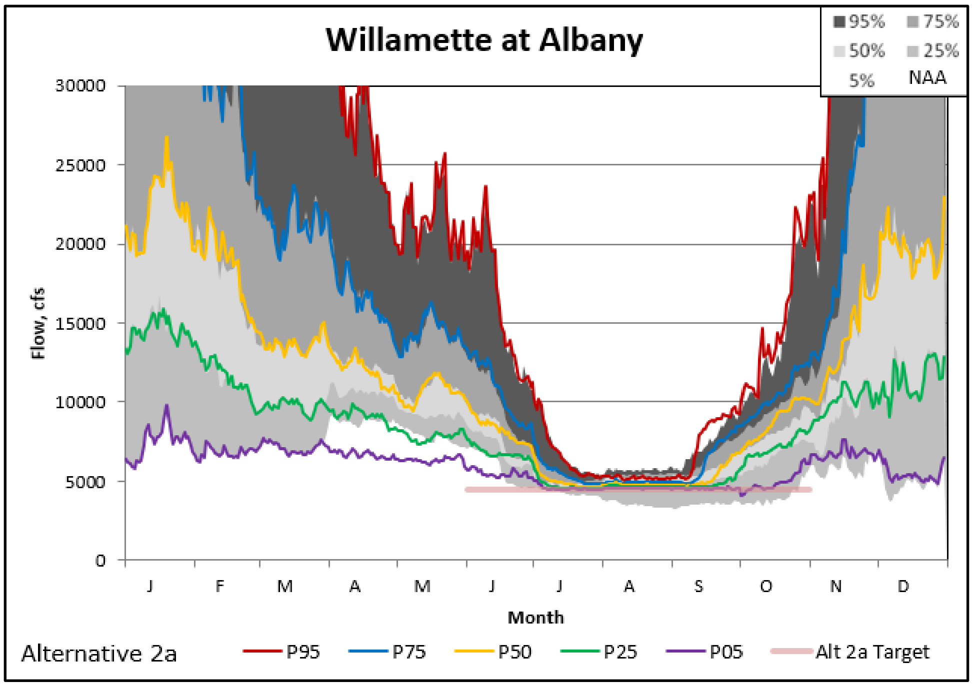

Figure 3.2-68. Alternative 2A Willamette River at Albany, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

USACE would nearly always meet the lower integrated temperature and habitat flow regime target at Albany for the WVS under Alternative 2A, missing only a few days in the fall of the driest years. The increased flow in September and October under this alternative would be due to the WVS higher reservoir levels at the start of the preparation for flood season as compared to the NAA.

Like the Albany control point, the Willamette River at Salem would show reduced flows from April to June of dry years, while meeting the integrated temperature and habitat flow regime variable air-temperature-guided target compared to the NAA (Figure 3.2-69). Summer and fall flows would increase across all years as compared to the NAA.

Increased flows from September to November would be due to the deeper fall reservoir drawdown at Green Peter Reservoir. These increases would be within the river channel (up to 90,000 cfs) and would therefore not impact flood risk.

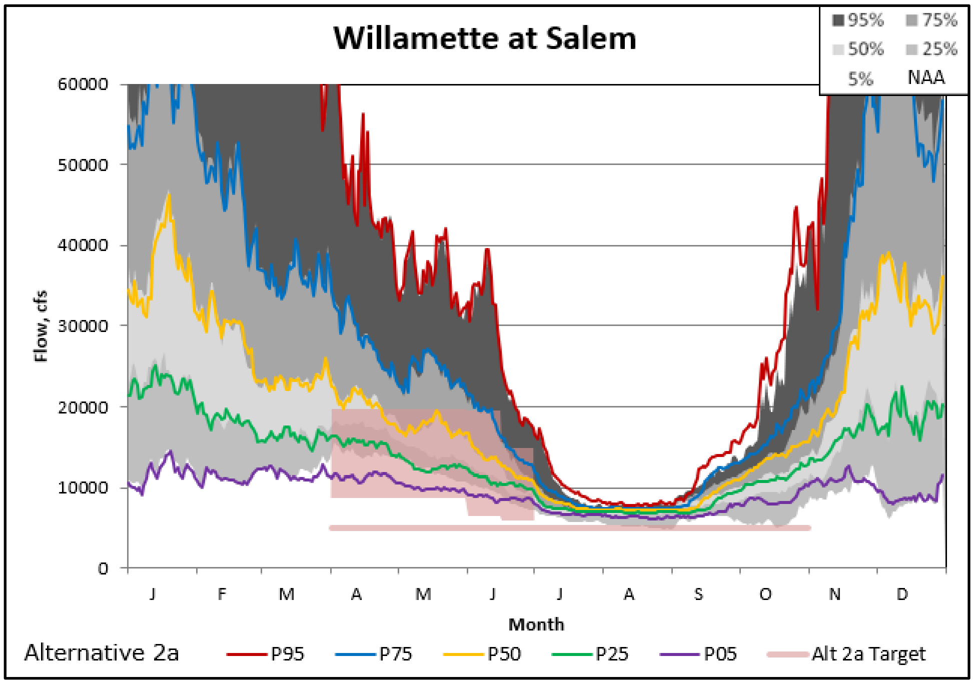

Figure 3.2-69. Alternative 2A Willamette River at Salem, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Interim Operations under Alternative 2A

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The timing and duration of Interim Operations would vary depending on a given alternative. Interim operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations will be implemented in succession with, and not in addition to, action alternative implementation.

END NEW TEXT

Interim Operations effects on hydrologic processes are assessed by subbasin. Only the activities that would affect the flow from a WVS dam were modeled. Other activities as part of the Interim Operations, such as the reintroduction of salmonids into selected river reaches, would not affect flow and were not included in the analyses below.

Appendix B, Hydrologic Processes Technical Information, contains a complete hydrologic operations model explanation. Although there are some additional Interim Operations that would affect flow as compared to the NAA, the most notable operations from the perspective of hydrologic processes are:

- Change in outlet operations at Detroit Dam based on reservoir water surface elevation.
- Deeper fall reservoir drawdown at Green Peter Reservoir and increase in the use of the spillway during the spring.
- Delayed spring refill and earlier reduction in pool elevation at Foster Reservoir.
- Delayed spring refill and deeper fall reservoir drawdown at Cougar Reservoir, with a downstream flow restriction during some drawdown periods.
- Change in outlet operations at Hills Creek Dam based on reservoir water surface elevation.
- Lower spring and summer maximum reservoir elevation at Lookout Point Reservoir and a deeper fall reservoir drawdown. Increased use of the spillway based on reservoir water surface elevation.

Interim Operations are proposed under Alternatives 2A, 2B, 3A, 3B, 4, and 5; therefore, the integrated temperature and habitat flow regime targets were used for these analyses. Briefly, this would modify flow targets at a WVS reservoir if it is at more or less than 90 percent of rule curve elevation. Flows are reduced within a range down to minimums needed for fish survival when reservoirs are under the 90 percent threshold (Chapter 2, Alternatives, Section 2.8.1, Flow Measures).

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Interim Operations would reduce WVS storage in the conservation season as compared to the NAA in the Middle Fork Willamette River Subbasin and McKenzie River Subbasin. The delayed refill or lower maximum pool elevation would require USACE to release WVS water in the spring that would otherwise be stored under the NAA and some other alternatives. This release would result in lower reservoir elevations and outflows throughout the summer and early fall under the Interim Operations.

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On the mainstem Willamette River, Albany would show a greater impact from the lower WVS storage than Salem compared to the NAA. This would be primarily due to USACE releasing water at Detroit and Green Peter Reservoirs to contribute to Salem flow target, whereas Albany is upstream of the Willamette River confluence with the Santiam River.

Santiam River Subbasin

Under the Interim Operations, USACE would fill Detroit Reservoir more often during the conservation use season and would achieve a higher elevation when it does not fill as compared to the NAA (Figure 3.2-70). The integrated temperature and habitat flow regime target is lower than the 2008 NMFS Biological Opinion flows during drier years. More water would be released from storage during average and wetter years, meaning the reservoir water surface elevation would meet the rule curve later in the year at levels above the P50 non-exceedance line compared to the NAA (Figure 3.2-70).

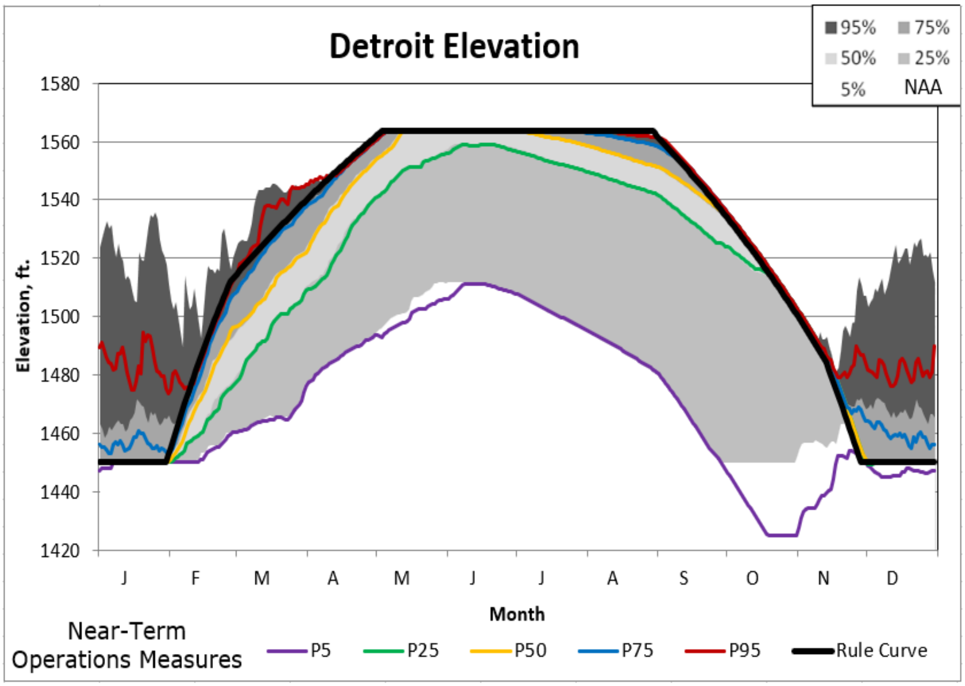

Figure 3.2-70. Interim Operations Detroit Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

USACE would fill Green Peter Reservoir to similar levels in the spring but would release more water and experience lower water surface elevations in the summer and fall as compared to the NAA (Figure 3.2-71). Although the lower integrated temperature and habitat flow regime flow targets downstream of Foster Reservoir would still be in effect for the Interim Operations, USACE would also be required to use the spillway at Green Peter Dam, which would impose a minimum flow of 800 cfs while in use. Over the course of several months, this would lead to lower reservoir elevations and higher flow directly downstream as compared to the NAA.

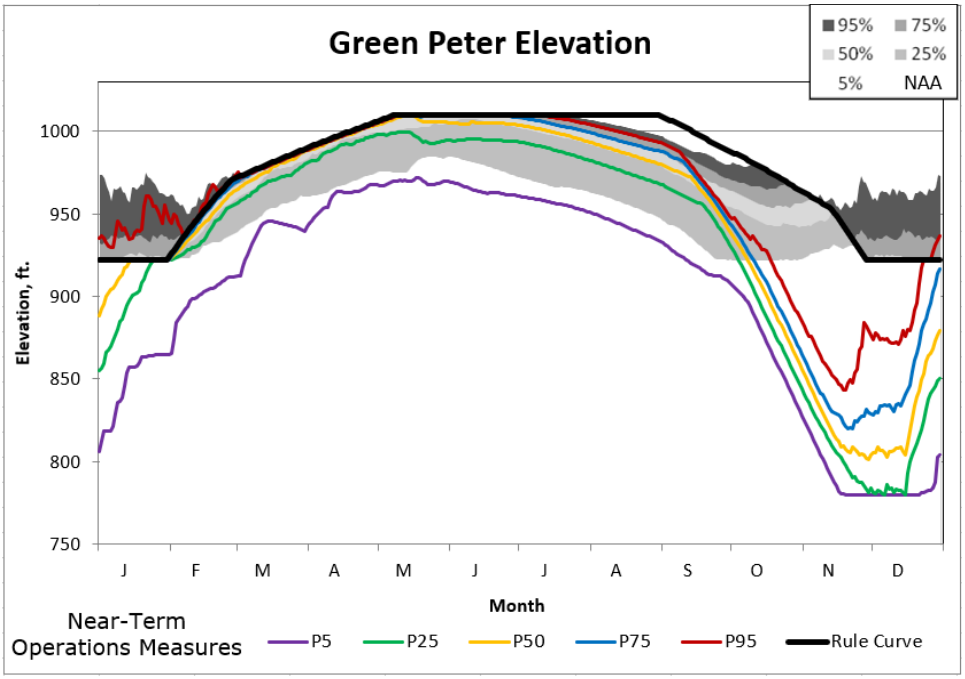

Figure 3.2-71. Interim Operations Green Peter Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

The small dip in reservoir elevation at Green Peter Dam in May is the result of the refill delay at Foster Dam until that time (Figure 3.2-72). Because the usable storage in Foster Reservoir is less than 10 percent that of Green Peter Reservoir (28.3 thousand acre-feet and 312.5 thousand acre-feet, respectively), USACE could operate Green Peter Reservoir to supplement natural flows, prioritizing refill at Foster Reservoir in May.

During drawdowns, USACE would also need to release the water volume originating from Green Peter Reservoir. The additional flow from Green Peter Reservoir during its deeper fall reservoir drawdown, combined with downstream flow restrictions, would typically delay the Foster Reservoir reduction in pool elevation starting in September compared to the NAA.

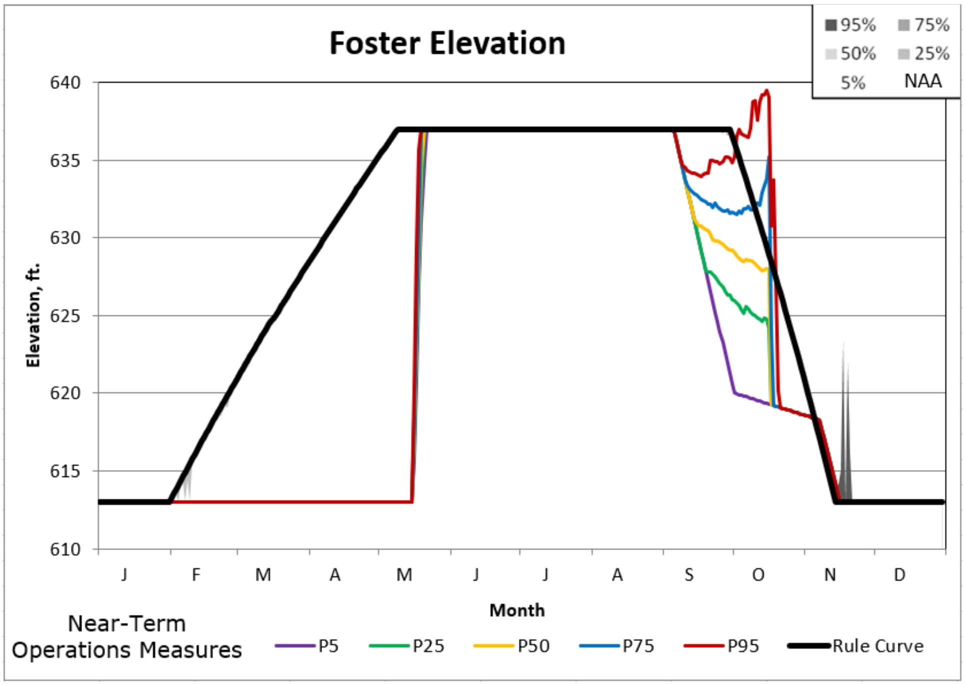

Figure 3.2-72. Interim Operations Foster Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Interim Operations flow comparisons out of Foster Reservoir demonstrate the downstream effects of these operational changes as compared to the NAA (Figure 3.2-73). Although the integrated temperature and habitat flow regime target flows would be in place throughout the year, it would only dictate the flow downstream of Foster during July, August, and very dry February. During other periods, operations would require additional flow above the targets, such as the spillway release from Green Peter Reservoir in the spring or the deeper fall reservoir drawdown in September and October. The refill of Foster Reservoir is also evident in the flow downstream as it would be reduced to minimum during periods in May. The actual operation would probably take place over a longer period than the modeled operation to balance refill with a higher downstream flow.

The lower November flows in the driest years would be a result of Green Peter already being at the minimum drawdown elevation when it still had some water stored in the NAA.

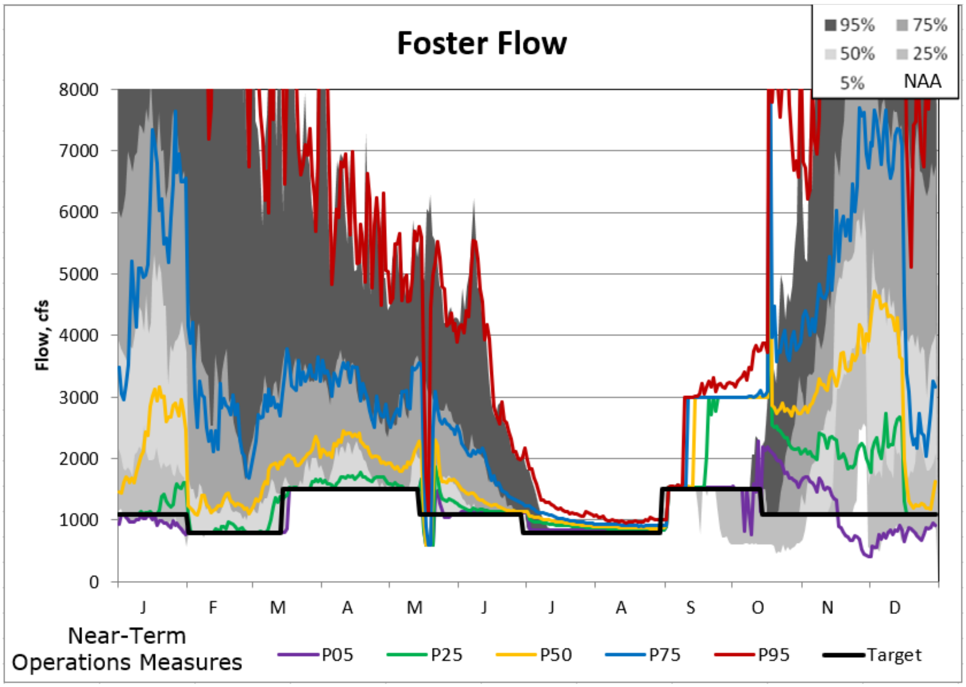

Figure 3.2-73. Interim Operations Foster Reservoir Outflow Non-exceedance as Compared to the No-action Alternative.

Although there would be no specific flow targets further downstream at the combined Santiam control point at Jefferson, revised operations and flow targets from upstream would be evident as compared to the NAA (Figure 3.2-74). Water stored during dry years, principally in Detroit Reservoir from March to June, would be released during the summer.

Upstream summer integrated temperature and habitat flow regime targets would be higher than those in the 2008 NMFS Biological Opinion; therefore, Jefferson would show higher flows in all years compared to the NAA. There would be a small reduction in flow during the refill period at Foster Reservoir during May, although not nearly as pronounced as it would be directly downstream of Foster Dam.

Elevated flows as compared to the NAA during September would be due to the deeper fall reservoir drawdowns from the Interim Operations. The lower November dry-year flows in the South Santiam Subbasin would all be nearly non-existent as compared to the NAA due to contributions from Detroit Reservoir.

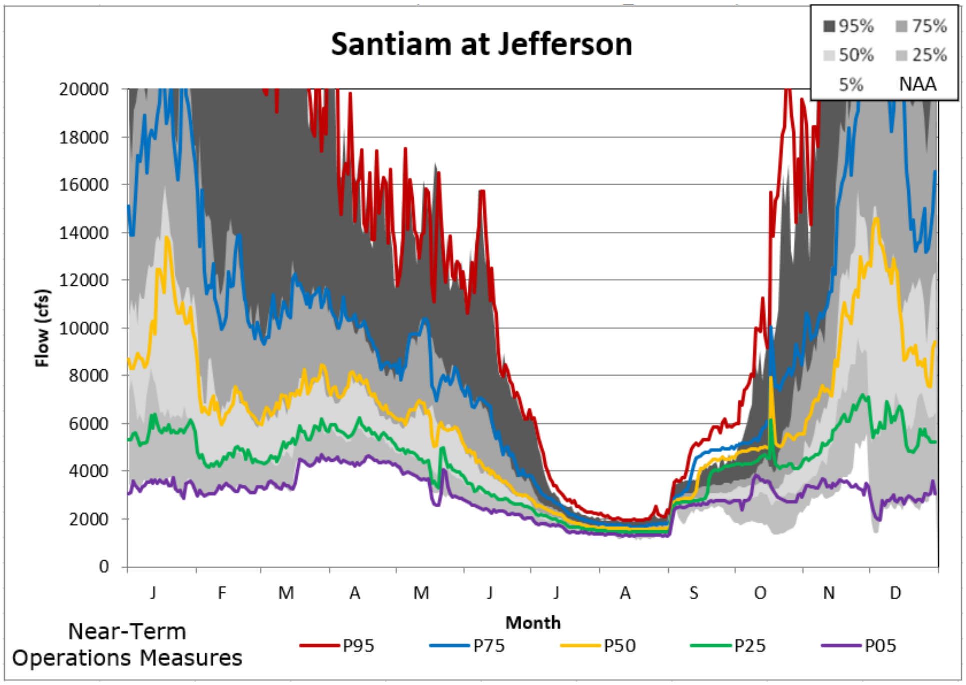

Figure 3.2-74. Interim Operations Santiam River at Jefferson, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

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Long Tom River Subbasin

Water surface elevations within Fern Ridge Reservoir would show negligible changes under the Interim Operations as compared to the NAA (Figure 3.2-75). Downstream flows at Monroe would also remain unchanged under the Interim Operations as compared to the NAA.

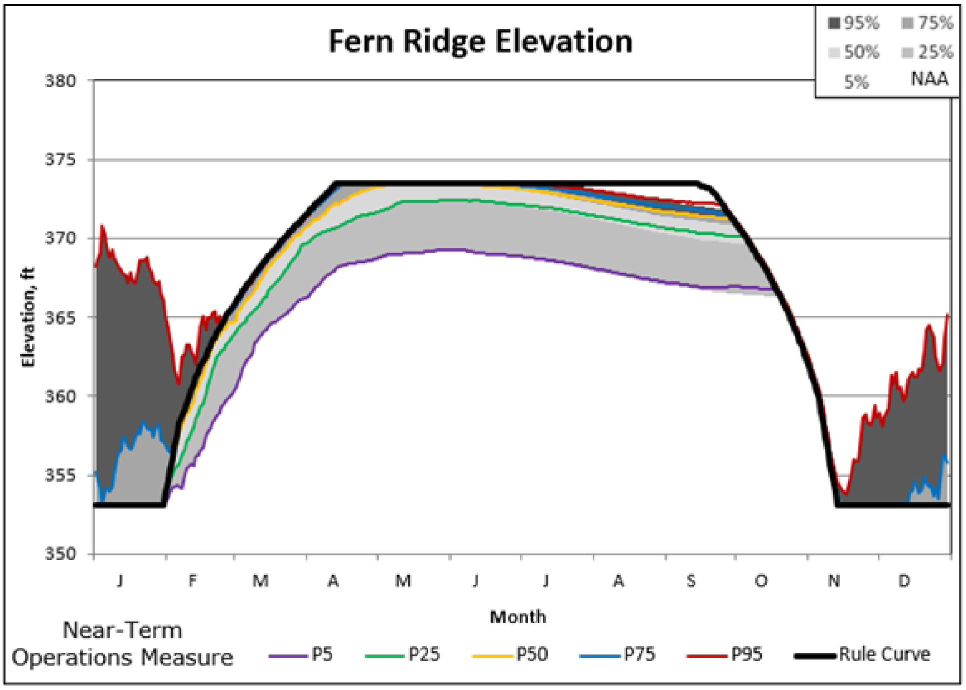

Figure 3.2-75. Interim Operations Fern Ridge Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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McKenzie River Subbasin

Under the Interim Operations, USACE would fill Blue River Reservoir to higher elevations in dry years as compared to the NAA due to the lower spring flow targets in the McKenzie River and Salem (Figure 3.2-76). The Interim Operations would allow USACE to augment instream flows by using the inactive pool at Blue River Reservoir. This would draft the reservoir below minimum conservation elevation during very dry conditions in November.

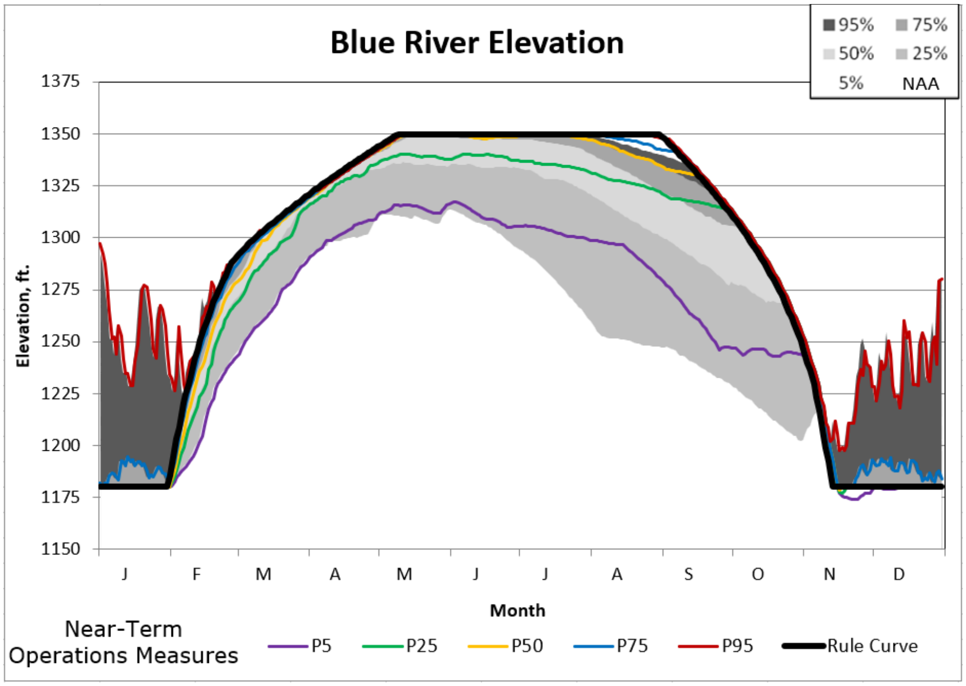

Figure 3.2-76. Interim Operations Blue River Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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USACE would have a drawdown target at Cougar Reservoir below minimum conservation elevation (1,532 feet) during the spring (1,505 feet) and fall (1,520 feet) (Figure 3.2-77). Operations would also limit releases to less than 880 cfs at night for water quality concerns and to 2,700 cfs during the day, resulting in a daily average of 2,000 cfs under the Interim Operations. Consequently, USACE would meet the drawdown target elevations in nearly all years. However, USACE would bring the reservoir above the target during wet years (Figure 3.2-77, P95 line). Cougar Reservoir would be expected to draft within 10 feet of the drawdown target in the spring and the fall for at least a portion of every year.

After the spring drawdown, USACE would fill Cougar Reservoir to the extent allowed by inflow and operational flow requirements under the Interim Operations. Water surface elevation would very rarely reach the maximum conservation pool elevation (1,690 feet). During the driest years, the water surface elevation would not meaningfully fill the reservoir above the spring elevation target. The median peak elevation would be approximately 1,590 feet (Figure 3.2-77, P50 line).

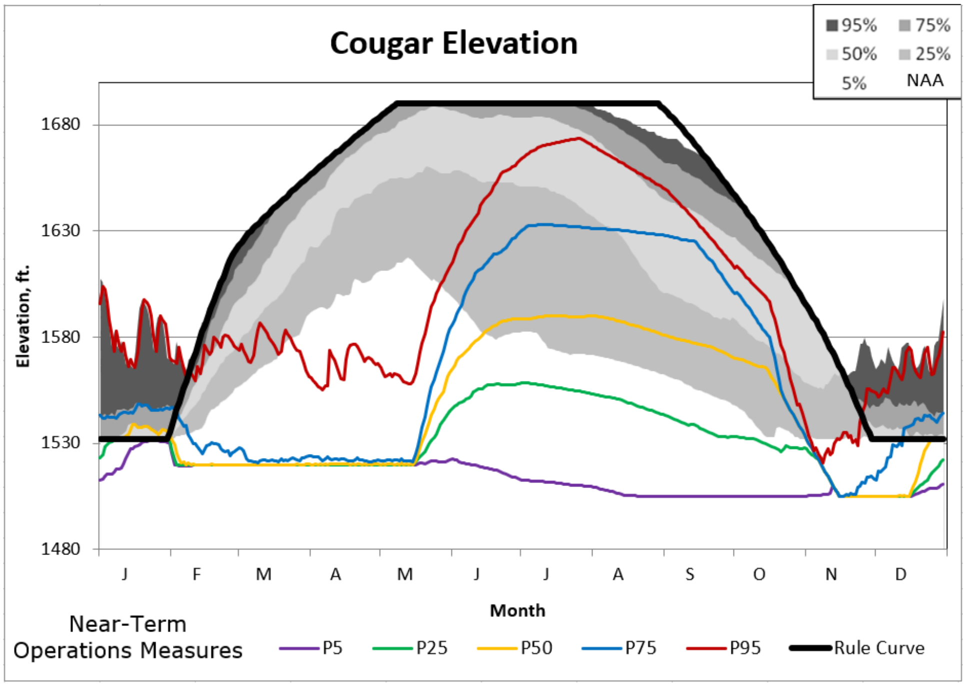

Figure 3.2-77. Interim Operations Cougar Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Under the Interim Operations, USACE would meet or exceed its integrated temperature and habitat flow regime target with the Cougar Dam outflow except during the driest summers and falls when Cougar Reservoir would be at its minimum elevation and only passing inflow (Figure 3.2-78). After the spring delayed refill, flows would be nearly the same across all years as the reservoir would store any inflow in excess of the minimum downstream flow threshold.

In the driest years, USACE would only pass inflow at Cougar Dam from July until early December under the Interim Operations. The minimum downstream flows in these very dry years would be about one-third of the seasonal flow threshold, occurring continuously for several months.

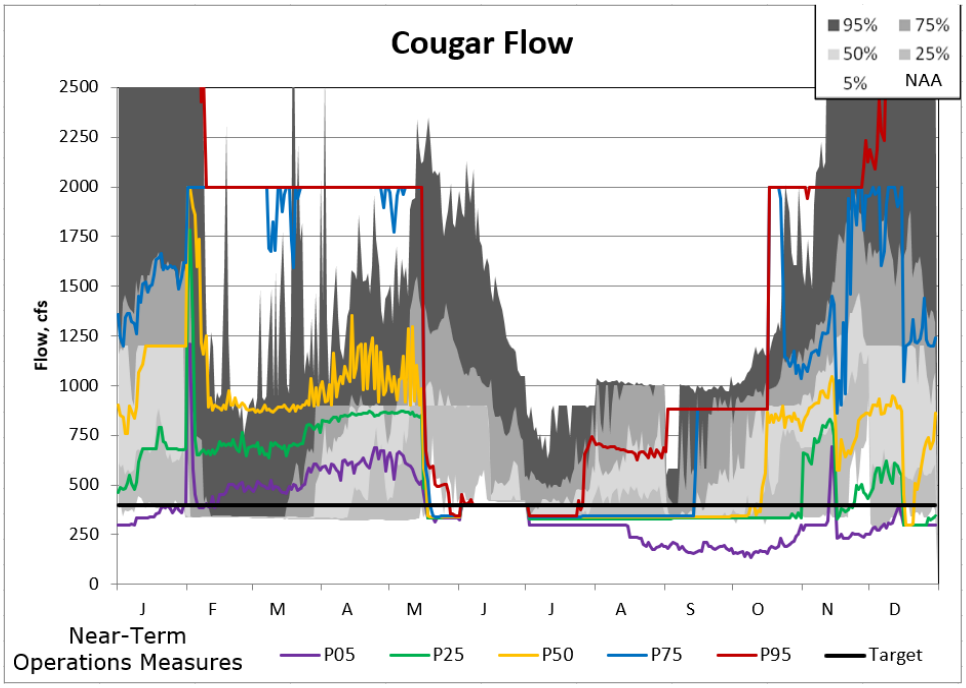

Figure 3.2-78. Interim Operations Cougar Reservoir Outflow Non-exceedance as Compared to the No-action Alternative.

While the August flows at Vida would be somewhat lower across all years, the other flows would be similar when compared to the NAA (Figure 3.2-79). The relatively high summer base flow in the McKenzie River also contributes to the consistency with the NAA. Outflow from the reservoirs is a lower percentage of the total flow on the mainstem McKenzie River.

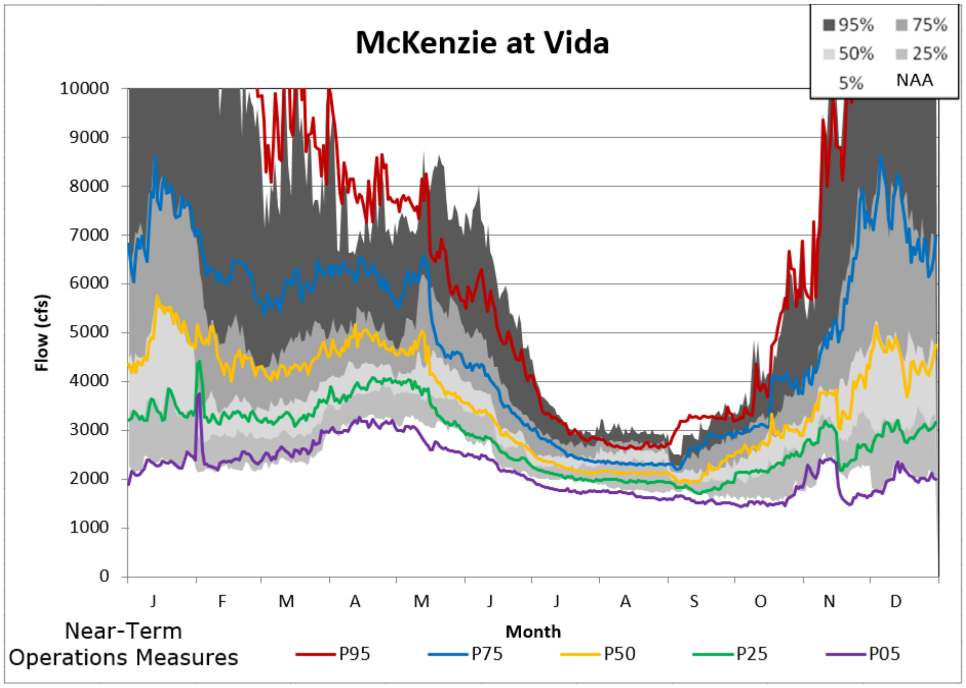

Figure 3.2-79. Interim Operations McKenzie River at Vida, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Middle Fork Willamette River Subbasin

USACE would initially fill Hills Creek Reservoir more slowly than under the NAA due to the mandate under the Interim Operations to prioritize refill at Lookout Point Reservoir (Figure 3.2-80 and Figure 3.2-81, respectively). In other words, early in the year, water stored at Hills Creek Reservoir under the NAA would be released to Lookout Point Reservoir instead.

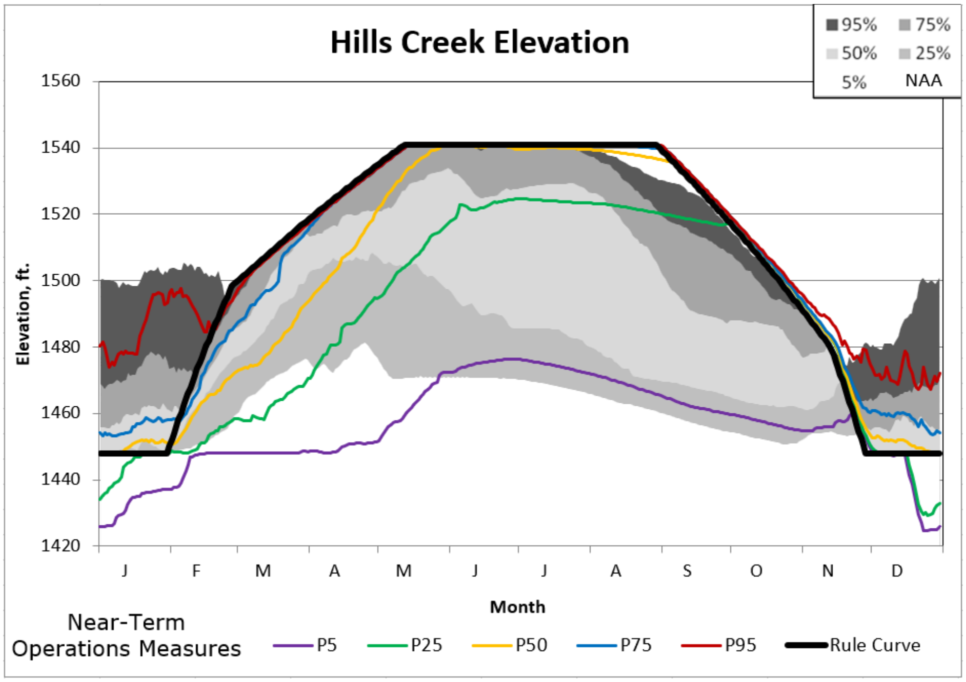

Figure 3.2-80. Interim Operations Hills Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

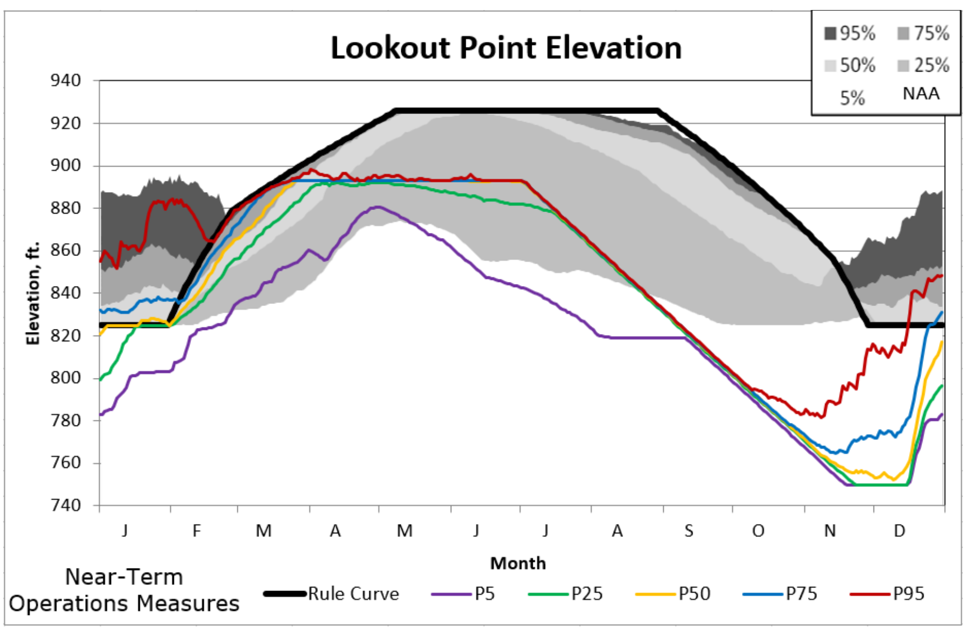

Figure 3.2-81. Interim Operations Lookout Point Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

After Lookout Point Reservoir reaches its lower maximum elevation (893 feet instead of maximum conservation pool of 926 feet), Hills Creek Reservoir operations would fill to higher elevations than under the NAA due to the lower integrated temperature and habitat flow regime targets downstream. USACE would maintain higher elevations into the fall to increase the likelihood that Lookout Point Reservoir would achieve its fall drawdown while drafting at 1 foot per day.

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Under the Interim Operations, USACE would fill Lookout Point Reservoir more often to its lower target elevation than it does to maximum conservation pool under the NAA (Figure 3.2-81). This would be due to supplementary releases from Hills Creek Reservoir and because there would be more volume for each foot of elevation higher in the reservoir.

The deeper fall reservoir drawdown target would be achieved most years, with wet Octobers and Novembers preventing USACE from making the 761-foot target in Lookout Point Reservoir. This would be due to high seasonal inflow and because the lower outlets would not be able to release water fast enough with the pool elevation at low levels.

Interim Operations at Fall Creek Reservoir would be the same as those described under the NAA.

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At the Middle Fork Willamette River at Jasper, the control point for Hills Creek, Lookout Point, and Fall Creek Reservoirs, spring flows would be similar or slightly lower as compared to the NAA in all except the driest years (Figure 3.2-82). Into summer and fall, flow would be somewhat higher compared to the NAA except the driest years. The driest Septembers would show lower flows compared to the NAA as all three upstream storage reservoirs would be at or near their minimum water surface elevation for that period and only able to release inflow.

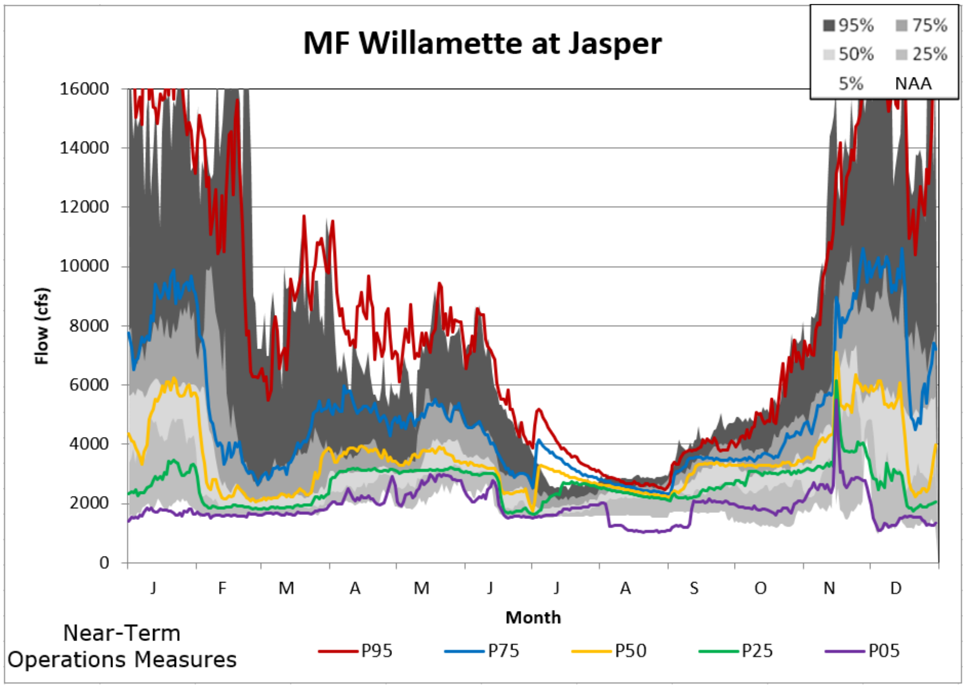

Figure 3.2-82. Interim Operations Middle Fork Willamette River at Jasper, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

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Coast Fork Willamette River Subbasin

Under the Interim Operations, USACE would store more water in the Coast Fork Willamette River Subbasin reservoirs in the spring and release it during the summer and fall during dry years as compared to the NAA. These reservoir conditions would generally be similar to those under the NAA in wet years.

Reservoir elevations would be somewhat higher at both Dorena and Cottage Grove Reservoirs under the Interim Operations during the late spring and summer; elevations would be similar to those under the NAA during other times of the year (Figure 3.2-83). Because the pools would remain higher throughout the summer, more water would be released during September and October compared to the NAA (Figure 3.2-84).

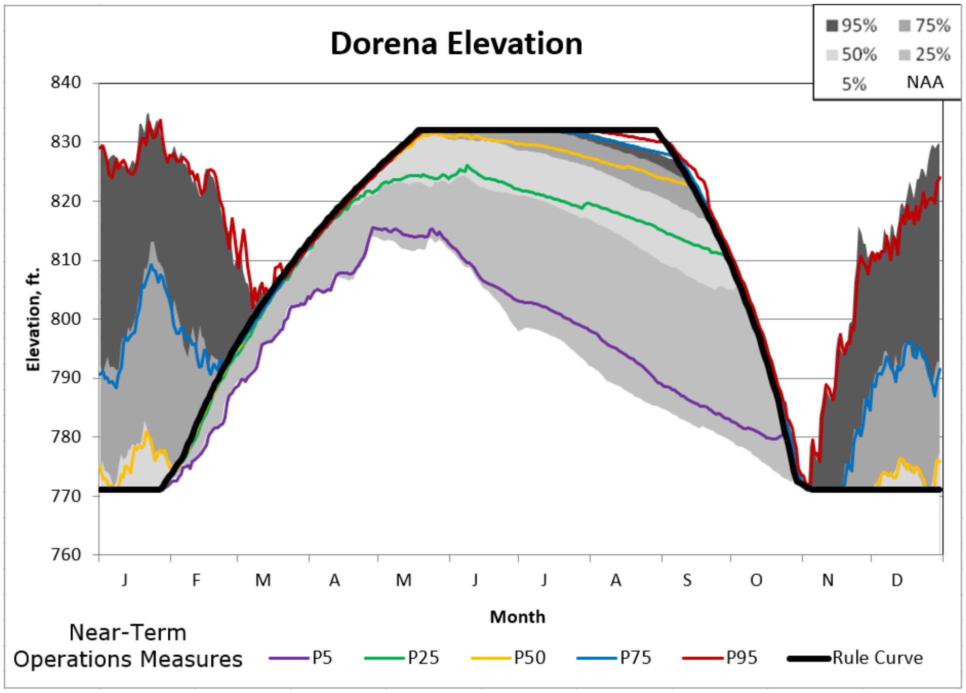

Figure 3.2-83. Interim Operations Dorena Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

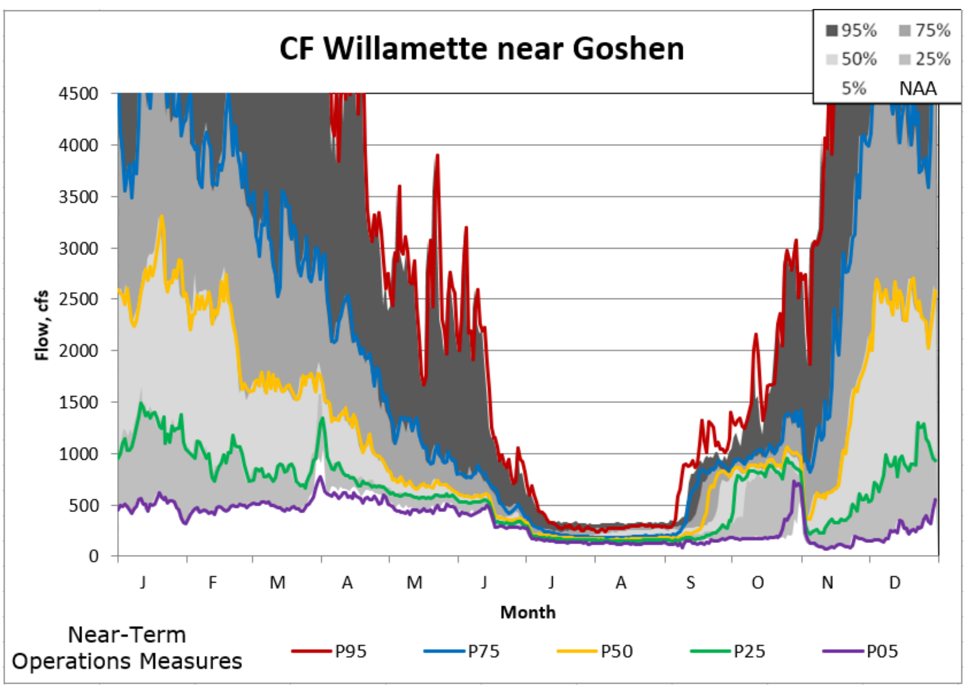

Figure 3.2-84. Interim Operations Coast Fork Willamette River at Goshen, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Mainstem Willamette River Subbasins

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Interim Operations flow targets on the mainstem Willamette River at Albany and Salem are the integrated temperature and habitat flow regime targets, which are lower than the Biological Opinion targets under the NAA (Figure 3.2-85 and Figure 3.2-86, respectively). The Interim Operations would modify the flow target at Salem during warm weather (the flow target region in the figure) (Chapter 2, Alternatives, Section 2.8.1, Flow Measures).

In wet years, the Interim Operations would have consistently similar or slightly higher flow during the springtime at both Albany and Salem as compared to the NAA. The driest years would result in lower flow in the spring due to the lower effective flow target at Salem. A decrease in total upstream storage would result in lower flows across all years at Albany for the Interim Operations as compared to the NAA.

When the largest upstream reservoirs reach their minimum elevation in August of the driest years, flows at Albany would fall below the target and the NAA until Lookout Point Reservoir releases water for its the deeper fall reservoir drawdown (Figure 3.2-85, P05 line). The WVS would miss the flow target at Albany in about half of all years.

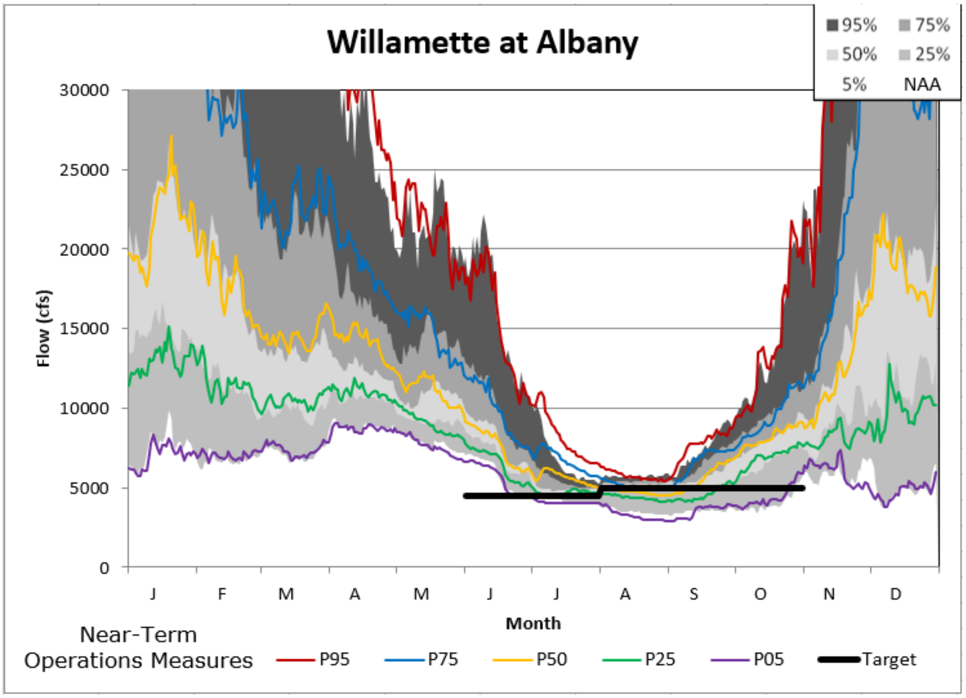

Figure 3.2-85. Interim Operations Willamette River at Albany, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

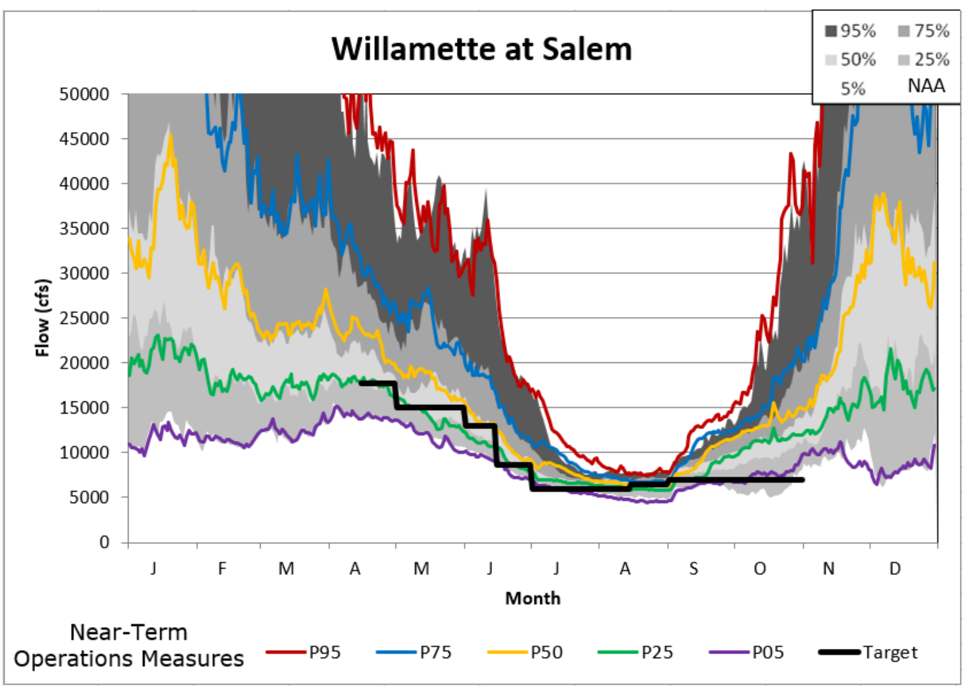

Figure 3.2-86. Interim Operations Willamette River at Salem, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Despite the lower targets of the integrated temperature and habitat flow regime, flow at Salem would be fairly similar to the NAA flow in the spring and summer. Because actual outflows from various dams (e.g., spillway flows at Green Peter Dam) would be higher than would be required to meet minimum flow targets, flows at Salem would behave similar to the higher 2008 NMFS Biological Opinion requirements under the NAA for these periods.

USACE would operate for higher storage in Detroit Reservoir under the Interim Operations across all years as compared to operations under the NAA, allowing for supplementation of the lower storage in the Middle Fork Willamette River reservoirs. Therefore, Salem would meet its target in the driest years in later summer and early fall while Albany may not. Releases for the deeper fall reservoir drawdowns at Green Peter and Lookout Point Reservoirs would demonstrate an increase in flows as compared to the NAA during September and October that would be evident as far downstream as Salem.

Climate Change Effects under Alternative 2A

Overall climate change impacts on hydrologic processes in the Willamette River Basin would be the same as those described under the NAA (Section 3.2.2.3, No-action Alternative, Climate Change Effects under the No-action Alternative). The WVS would experience minor differences in wintertime effects from climate change under Alternative 2A as it would under the NAA.

The deep drawdown at Green Peter Reservoir under Alternative 2A would allow USACE to increase storage in the winter, but any flood risk management implications would be minor and limited to the immediate area in the South Santiam River. Furthermore, projections for flow changes at Green Peter Reservoir are more muted than the higher elevation basins, meaning that it may diminish in importance relative to other WVS reservoirs for flood risk management operations.

During the conservation season, climate change would affect conditions under Alternative 2A similarly to those under the NAA, although operations under Alternative 2A may allow USACE to store and release more water in the spring and summer of dry years as compared to the NAA. Because the Alternative 2A integrated temperature and habitat flow regime minimum targets are lower than the NAA 2008 NMFS Biological Opinion requirements, the reservoirs would store more water during the conservation season as compared to the NAA. However, USACE would operate to use more of this stored water to meet downstream flow targets with projected increased variability in the spring months, drier and hotter summers, and lower summer baseflow resulting from climate change. Therefore, climate change would drive reservoir water surface elevations lower during the 30-year implementation timeframe.

Under Alternative 2A, reservoir operations would sometimes reach minimum elevation during the summer, but less often than operations under the NAA. Consequently, USACE would be able to augment summer flows for longer than under the NAA even with a projected decline in late spring and summer flows. The lowest reservoir water surface elevations would occur in the driest years, which would be drier than the WVS currently encounters, as the reservoirs are drafted more to meet downstream flow targets. Additionally, increased reservoir evaporation from increased climate change-induced temperatures would marginally decrease available water from all WVS reservoirs.

Mainstem Willamette River flow targets would be missed less often under Alternative 2A than the under the NAA.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Under Alternative 2B, USACE would shift stored water releases from the spring to the summer and fall, most prominently in dry years. The integrated temperature and habitat flow regime would replace the 2008 NMFS Biological Opinion under the NAA (Chapter 2, Alternatives, Section 2.8.1.1, Integrated Temperature and Habitat Flow Regime (Measure 30a)).

USACE would alter storage in drier than average years under Alternative 2B, shifting flow releases from April to June into July through October (P25 and P05 lines in the figures below). Flows would be lower than NAA flows during the April to June period. Later flow targets from July to October would be met more frequently due to the additional accumulated stored water under this alternative. Compared to NAA, the spring and early flows would be similar or somewhat lower across the WVS, so reservoir elevations would be somewhat higher than the NAA elevations throughout the conservation season.

END REVISED TEXT

Cougar and Green Peter Reservoirs would experience drawdowns under Alternative 2B. USACE would release water from Cougar Reservoir down to the diversion tunnel elevation in both spring and fall; Green Peter would experience a deeper fall reservoir drawdown. There would be more flow downstream of these two reservoirs during these drawdowns as compared to the NAA.

Because the spring reservoir drawdown at Cougar Reservoir would occur during the NAA refill period, storage at Cougar Reservoir would be reduced. As compared to Alternative 2A, which would not draw down Cougar Reservoir, the reduced storage means that other WVS reservoirs, notably in the Middle Fork Willamette River Subbasin, would be required to release additional water to meet mainstem Willamette River flow targets. Regardless, the flow target at Albany would be missed more often in dry years under Alternative 2B as the larger WVS reservoirs reach their minimum elevations earlier in the year.

Many of the proposed structural activities under Alternative 2B would not affect the flow out of any WVS dam (structural activities do not appear in the reservoir flow model; Section 3.2.2.1, Methodology, Reservoir Operations Model). An example of this is the proposed water temperature control tower at Detroit Dam, which would provide greater control of the temperature of the water released from the dam but would not alter the flow rate or outlet used for dam operations. A more detailed analysis of Alternative 2B by subbasin is provided below.

Lower spring flows in dry years and higher summer flows in nearly all years would have long-term effects on the Willamette River Basin.

Santiam River Subbasin

USACE would fill Detroit Reservoir more often and narrow the range of reservoir elevations prior to drafting the reservoir for flood season under Alternative 2B as compared to the NAA (Figure 3.2-87). The lower tier of the integrated temperature and habitat flow regime requires lower flows downstream of Detroit Dam. Consequently, Detroit Reservoir could be filled more often. Further, the reservoir has more volume to supply to downstream targets later in the year, which would allow USACE to meet all its immediate downstream flow targets across all years under Alternative 2B.

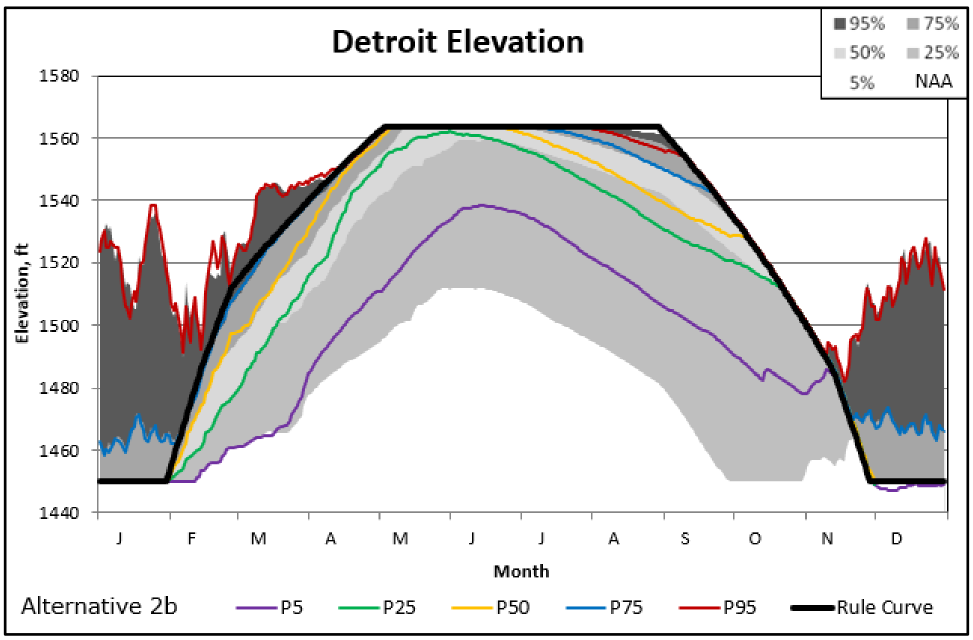

Figure 3.2-87. Alternative 2B Detroit Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

USACE would fill Green Peter Reservoir more often during the conservation season under Alternative 2B as compared to the NAA, despite implementation of a deeper fall reservoir drawdown (Figure 3.2-88). In very dry years, the reservoir elevation would be well below the rule curve through the winter but would recover to higher levels than under the NAA by summer due to the lower integrated temperature and habitat flow regime targets. However, the percentage of time that Green Peter Reservoir would reach the top of conservation storage would remain about the same because all inflow above that level would be released from the reservoir. Lower reservoir levels would be expected throughout the winter flood season, even during the wettest years.

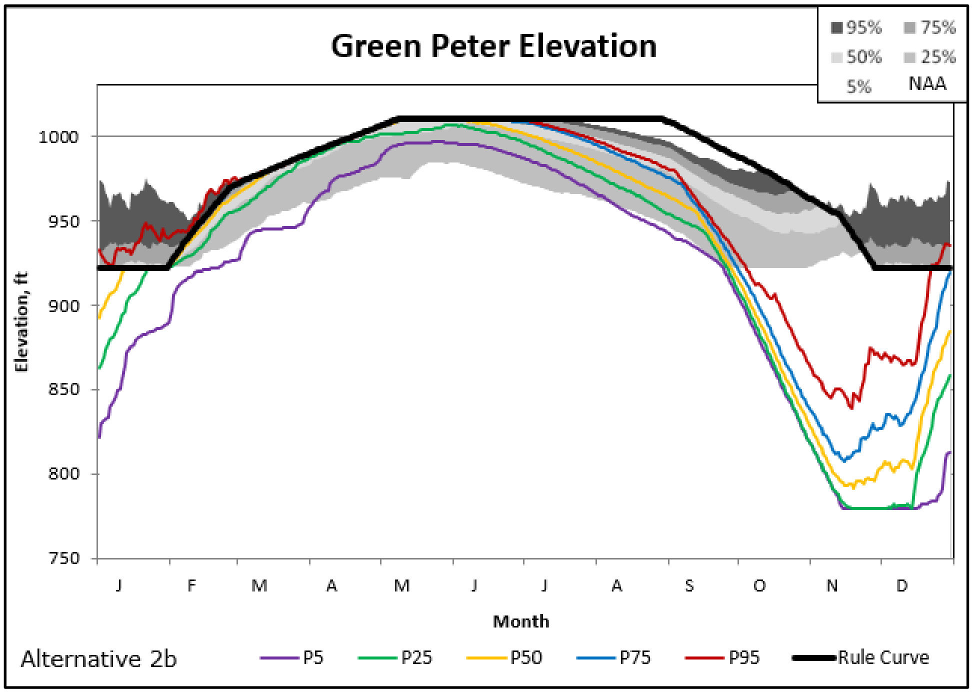

Figure 3.2-88. Alternative 2B Green Peter Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Under Alternative 2B, outflow from Foster Dam would meet the integrated temperature and habitat flow regime targets except in November of very dry years when Green Peter Reservoir would have already reached the minimum deeper fall reservoir drawdown elevation (Figure 3.2-89). The increased flows as compared to the NAA in September are the result of USACE releasing water for the deeper fall reservoir drawdown from Green Peter Reservoir.

Immediately downstream, winter flows across all but very wet years would be lower. This would also be due to the Green Peter Reservoir deeper fall drawdown, as USACE holds back water to get back up to minimum conservation pool. Foster Reservoir would seldom deviate from the rule curve—and the NAA—under Alternative 2B.

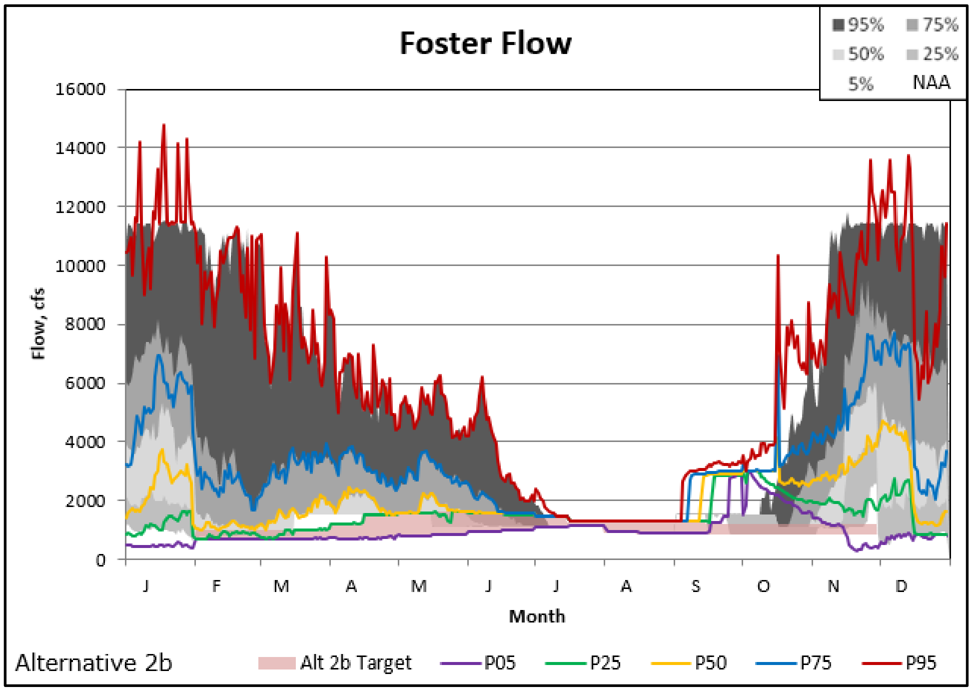

Figure 3.2-89. Alternative 2B Foster Reservoir Flow Non-exceedance as Compared to the No-action Alternative.

The Santiam River at Jefferson would show some of the flow changes at Foster Reservoir as compared to the NAA, but any potential winter flood management benefits from the deeper fall reservoir drawdown at Green Peter Reservoir would no longer be present under Alternative 2B (Figure 3.2-90). Wet weather flows would be very similar to the NAA during the winter, and lower flows would be only slightly lower, although these flows are already well below flood stage.

In the spring, lower flows in the driest years would be due to the lower requirements of the integrated temperature and habitat flow regime, both directly downstream of the dams and mainstem flow targets. Detroit Reservoir, with its higher storage volumes, can supply water throughout the summer, resulting in higher flows than under the NAA. The increased flows in September from the Green Peter Reservoir deeper fall drawdown would be evident at Jefferson under Alternative 2B.

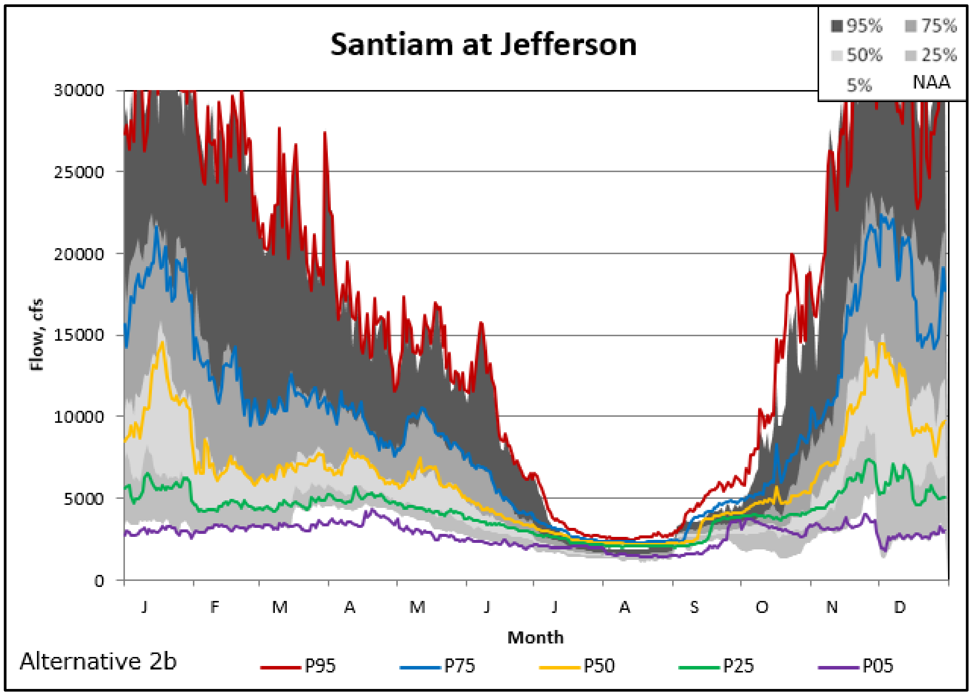

Figure 3.2-90. Alternative 2B Santiam River at Jefferson, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Long Tom River Subbasin

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Water surface elevations within Fern Ridge Reservoir would show negligible changes under Alternative 2B as compared to the NAA (Figure 3.2-91). Downstream flows at Monroe would also remain unchanged under Alternative 2B as compared to the NAA.

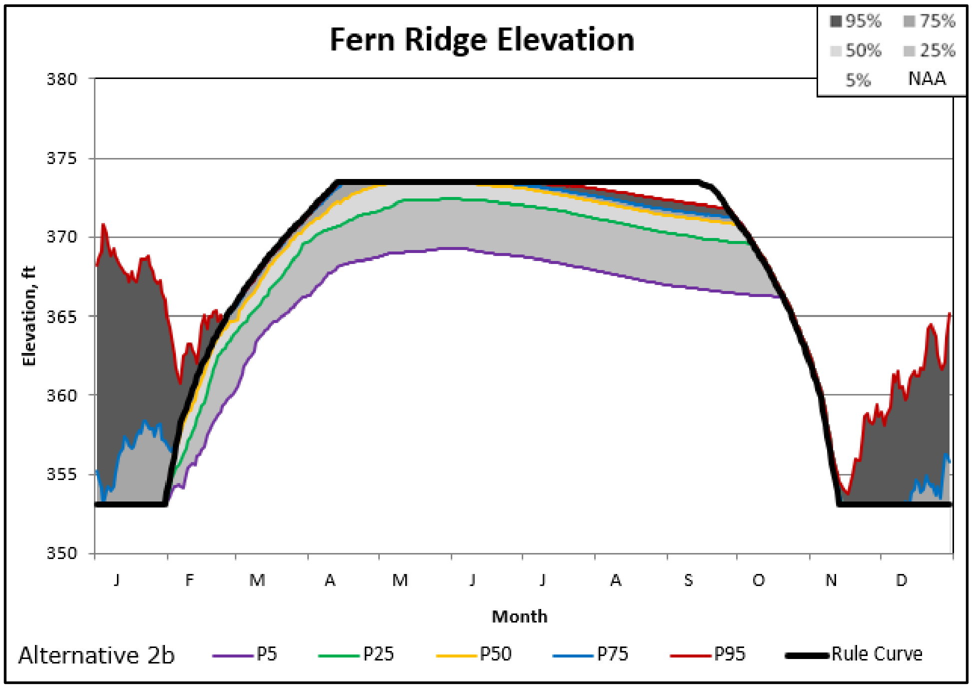

Figure 3.2-91. Alternative 2B Fern Ridge Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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McKenzie River Subbasin

USACE would operate for both a spring and fall Cougar Reservoir drawdown under Alternative 2B, down to 1,330 feet (Figure 3.2-92; Figure 3.2-92a). This would be a substantial drawdown change from the NAA.

Under Alternative 2B, the Cougar Reservoir water surface elevation would only be at or above minimum conservation pool at the end of winter and only the wettest summers (Figure 3.2-92, P95 line). In an average year, USACE would achieve the spring reservoir drawdown target elevation but would not during the fall (Figure 3.2-92, P50 line). USACE would also miss its downstream flow target from Cougar Reservoir when it is at minimum elevation during the summer and fall, sometimes for many months.

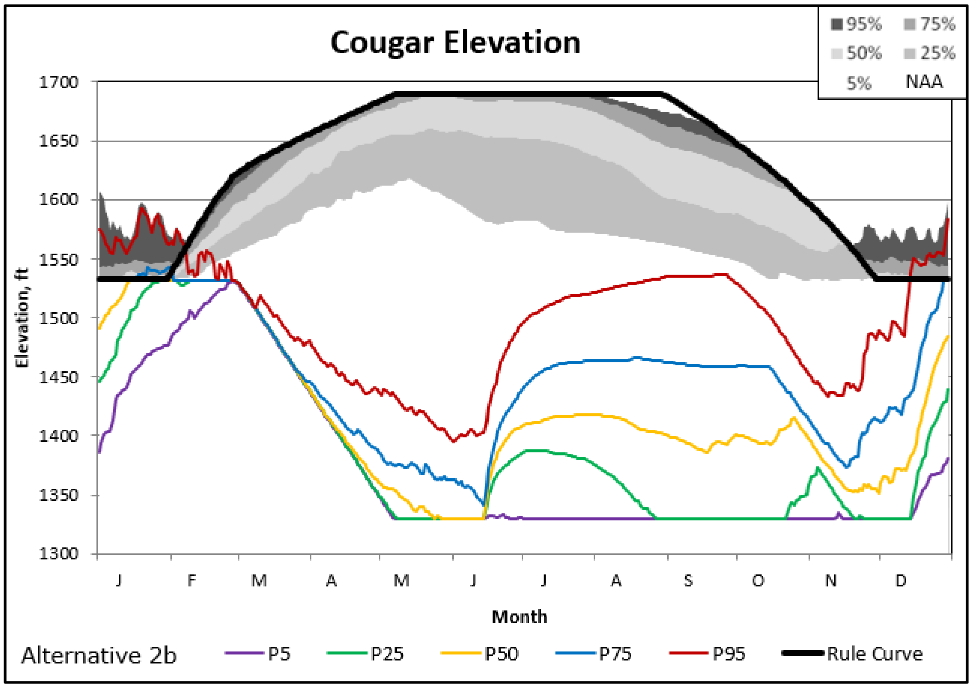

Figure 3.2-92. Alternative 2B Cougar Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

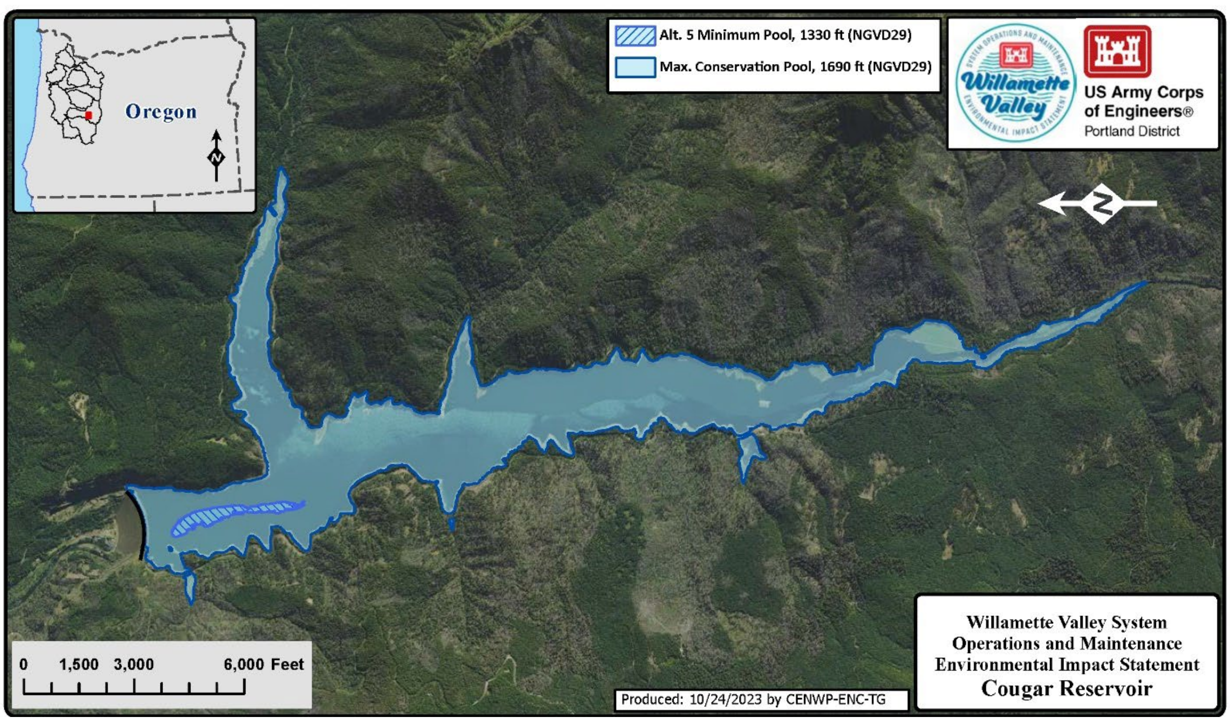

Figure 3.2-92a. Depiction of Minimum Pool Elevation at 1,300 Feet under Alternative 5.

Blue River Reservoir would be filled more often under Alternative 2B operations as compared to the NAA (Figure 3.2-93). USACE operations would use the inactive pool to supplement downstream flow targets during October of the driest years.

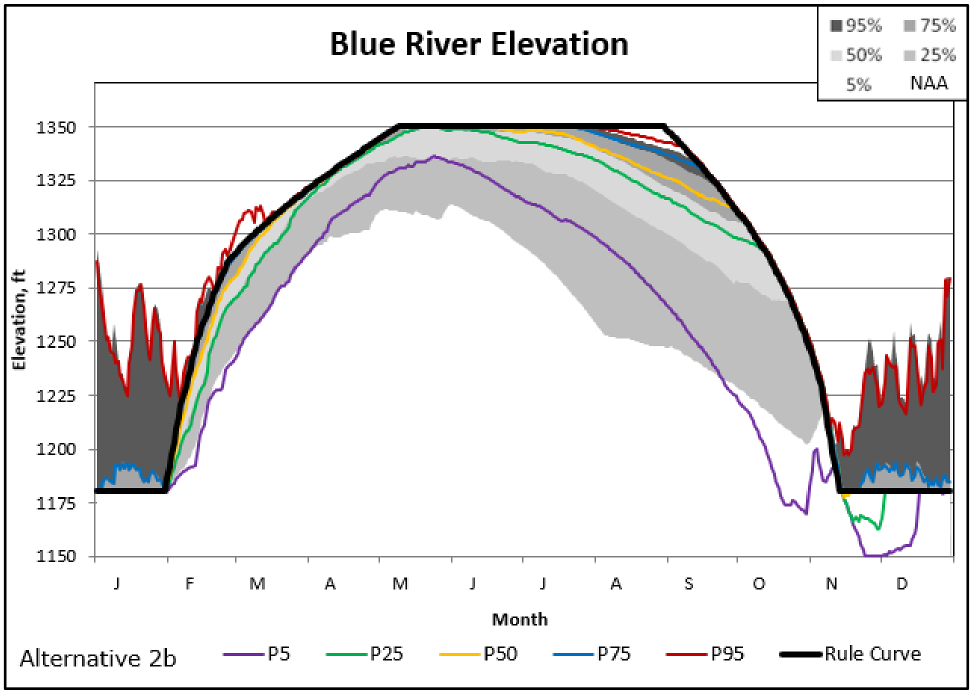

Figure 3.2-93. Alternative 2B Blue River Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

As compared to Alternative 2A, there would be two hydrological process differences due to the Cougar Dam diversion tunnel operation at Blue River Reservoir. USACE would be required to store more water during very wet years at Blue River Reservoir for the McKenzie River at Vida to remain at or below bankfull because Cougar Reservoir would be drafting for the spring reservoir drawdown. Additionally, USACE would augment instream flows by drafting Blue River Reservoir below minimum conservation elevation more often during the fall of very dry years because Cougar Reservoir would not have any accumulated storage during those times under Alternative 2B.

The McKenzie River at Vida would show the effect of the Cougar reservoir drawdowns at this downstream control point for Cougar and Blue River Reservoirs under Alternative 2B (Figure 3.2-94). The higher flows in the spring compared to the NAA would be from operational releases from Cougar Reservoir to reach the diversion tunnel elevation. Lower flows starting in June would be the result of reduced storage in Cougar Reservoir throughout the conservation season, which would not occur under the NAA.

Flow would be only slightly less in the driest years as compared to the NAA due to additional flow from Blue River Reservoir under Alternative 2B. However, as compared to Alternative 2A, in which dry-year flows would be above the NAA, flows would be reduced through the summer and fall.

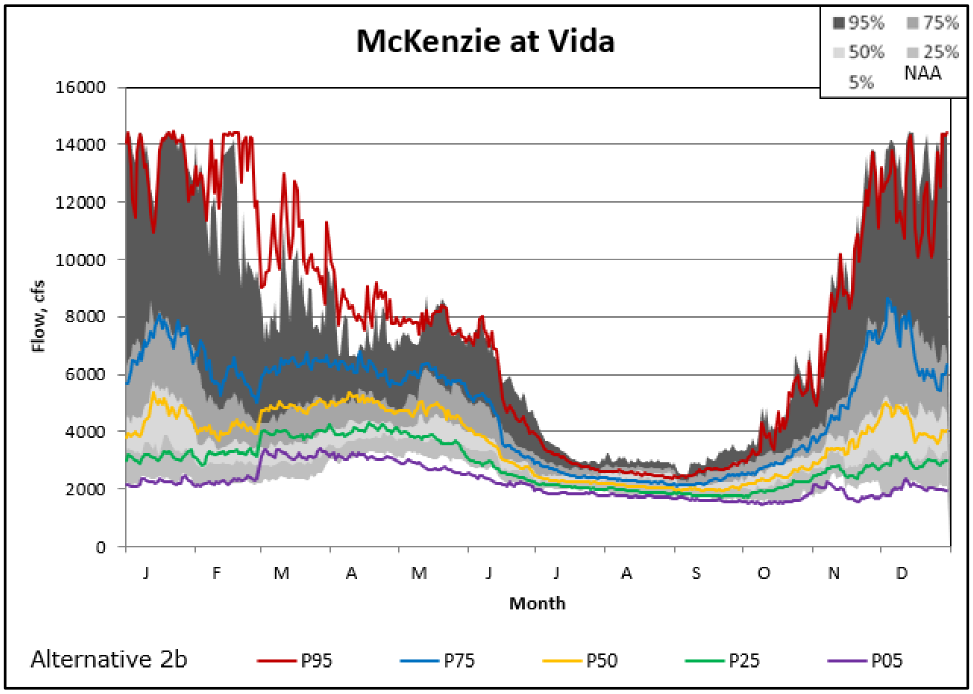

Figure 3.2-94. Alternative 2B McKenzie River at Vida, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Middle Fork Willamette River Subbasin

Hills Creek Reservoir would initially fill more quickly under Alternative 2B operations due to the lower integrated temperature and habitat flow regime targets and would stay at similar or higher elevations during wet years compared to the NAA (Figure 3.2-95). During dry years, USACE would augment instream flows by using the reservoir power pool, releasing more water to meet the flow target at Albany. Hills Creek Reservoir capacity would be exhausted in the driest years (Figure 3.2-95, P05 line), at which point Lookout Point Reservoir would supply additional water and reach its Alternative 2B minimum (Figure 3.2-96).

As compared to Alternative 2A, storage elevations for both Hills Creek and Lookout Point Reservoirs would be slightly lower across all years. Because Cougar Reservoir would have substantially less storage under Alternative 2B as compared to both Alternative 2A and the NAA, USACE would release more water at both reservoirs to meet mainstem flow targets.

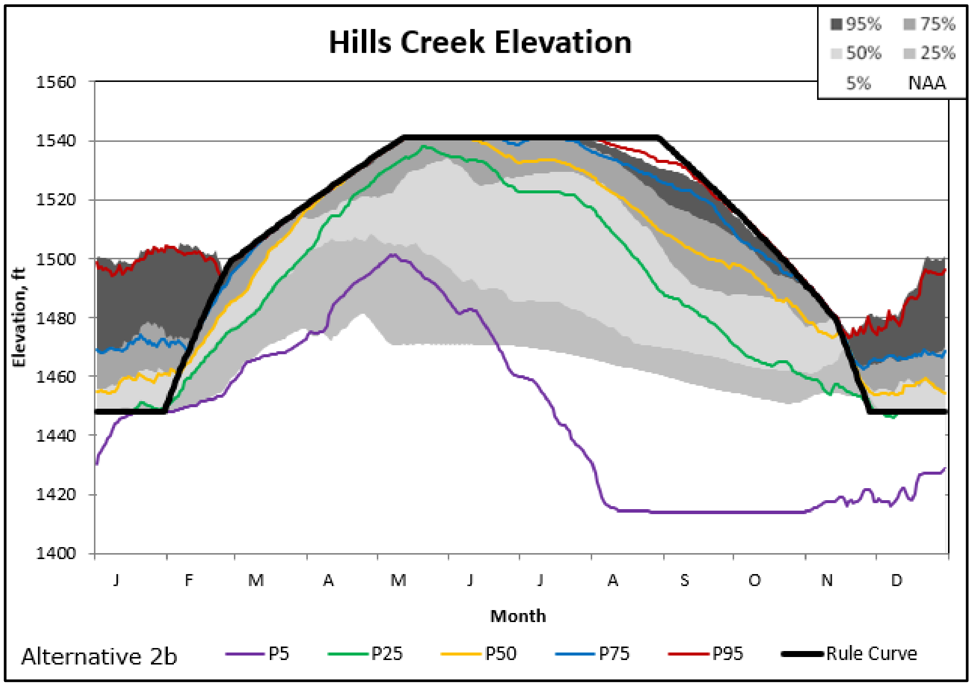

Figure 3.2-95. Alternative 2B Hills Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

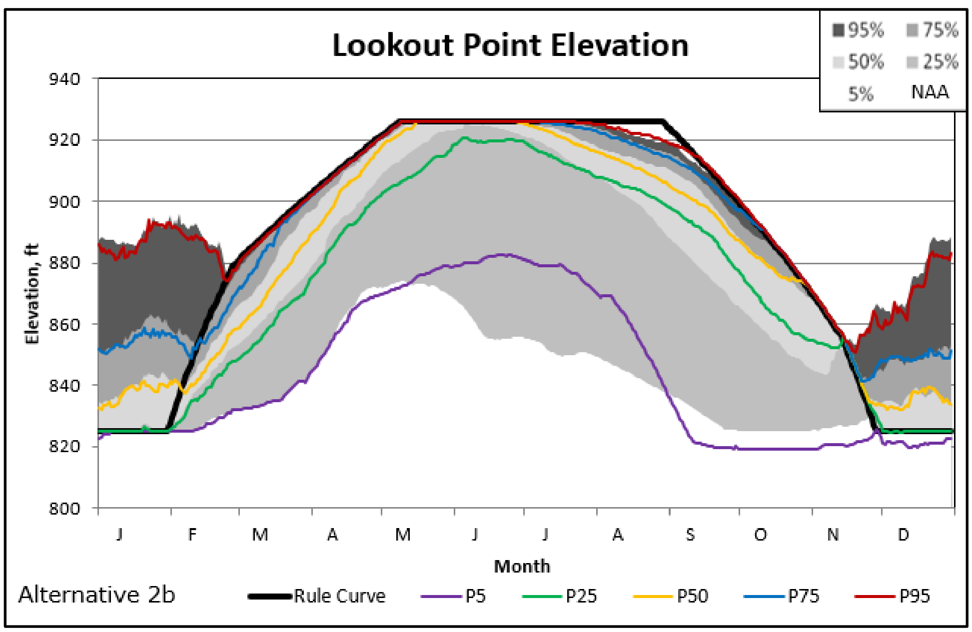

Figure 3.2-96. Alternative 2B Lookout Point Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Operations at Fall Creek Reservoir would result in only marginal differences as compared to the NAA under Alternative 2B (Figure 3.2-97). However, some reservoir elevations would be slightly below elevation levels under Alternative 2A.

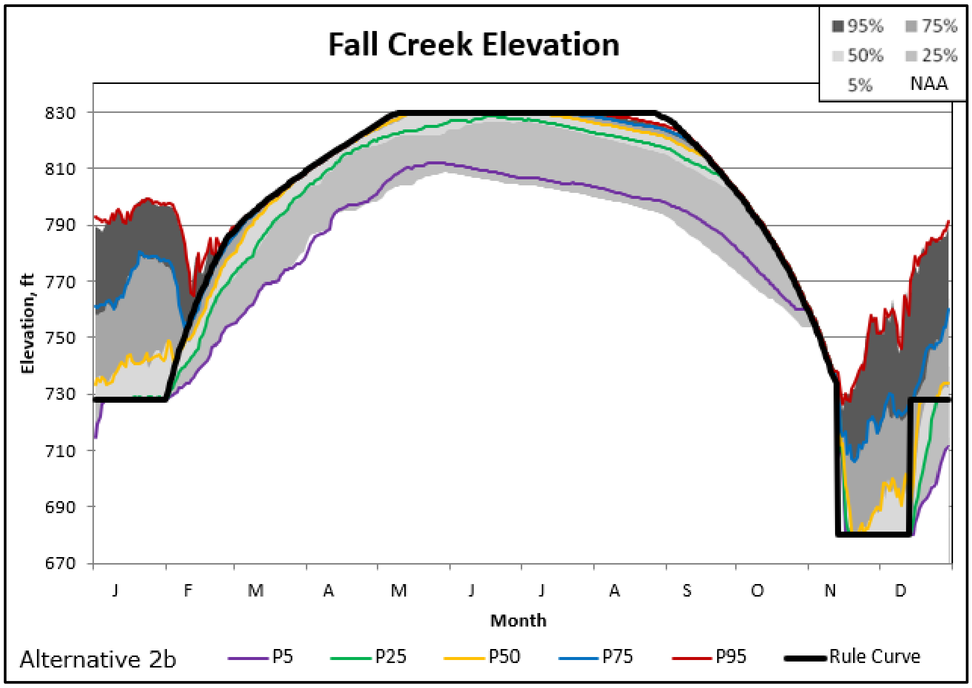

Figure 3.2-97. Alternative 2B Fall Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Under Alternative 2B at the downstream control point at Jasper, the shift in flow releases would be evident, especially in dry years, with lower flows in the spring and higher flows in the summer and fall compared to the NAA (Figure 3.2-98). The increased fall flows during wet years as compared to the NAA would be due to the reservoirs starting at a higher elevation prior to drafting for flood season. There would be more water to release from the reservoirs so there would be higher flows downstream.

In the fall of the driest years (Figure 3.2-98, P05 line), flows would be lower than under Alternative 2A and sometimes below the NAA. Both Hills Creek and Lookout Point Reservoirs would reach their minimum elevations and only release inflow. Lower storage at Cougar Reservoir would require higher releases from the Middle Fork Willamette River WVS reservoirs to meet downstream flow targets. The additional flow requirements as compared to Alternative 2A would be enough to reach that level in the driest years under Alternative 2B.

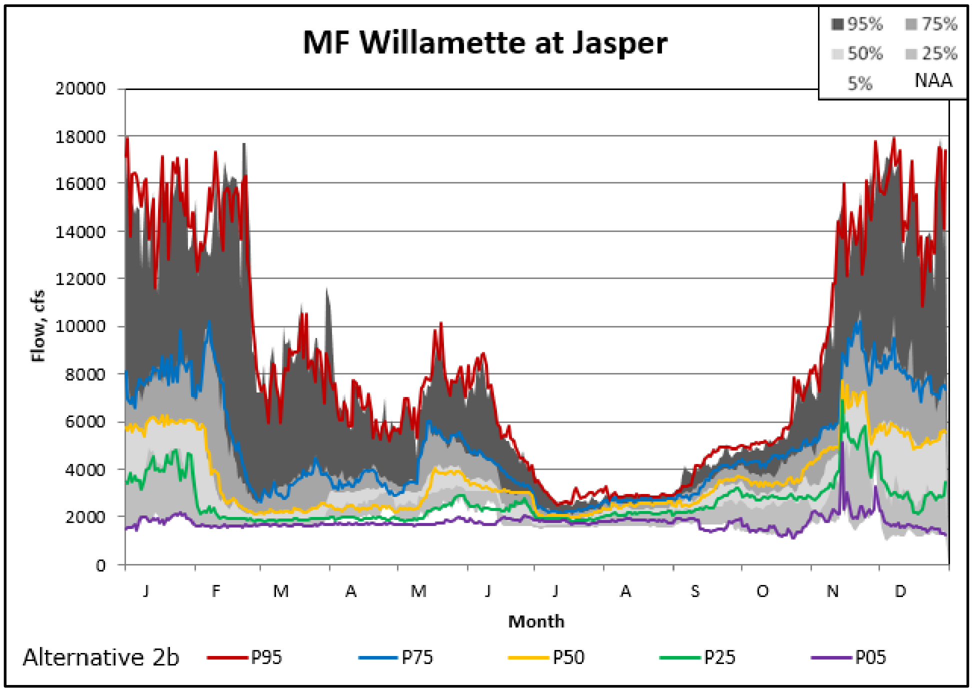

Figure 3.2-98. Alternative 2B Middle Fork Willamette River at Jasper, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Coast Fork Willamette River Subbasin

Under Alternative 2B, the Coast Fork Willamette River Subbasin would store more water in the spring and release it during the summer and fall during dry years. Conditions would be generally similar to the NAA in wet years. Reservoir elevations would be somewhat higher at both Dorena and Cottage Grove Reservoirs under Alternative 2B during the late spring and summer (Figure 3.2-99). Conditions would be similar to the NAA during other times of the year. Because the pools would remain higher throughout the summer, more water would be released during September and October compared to the NAA, increasing flows at Goshen (Figure 3.2-100).

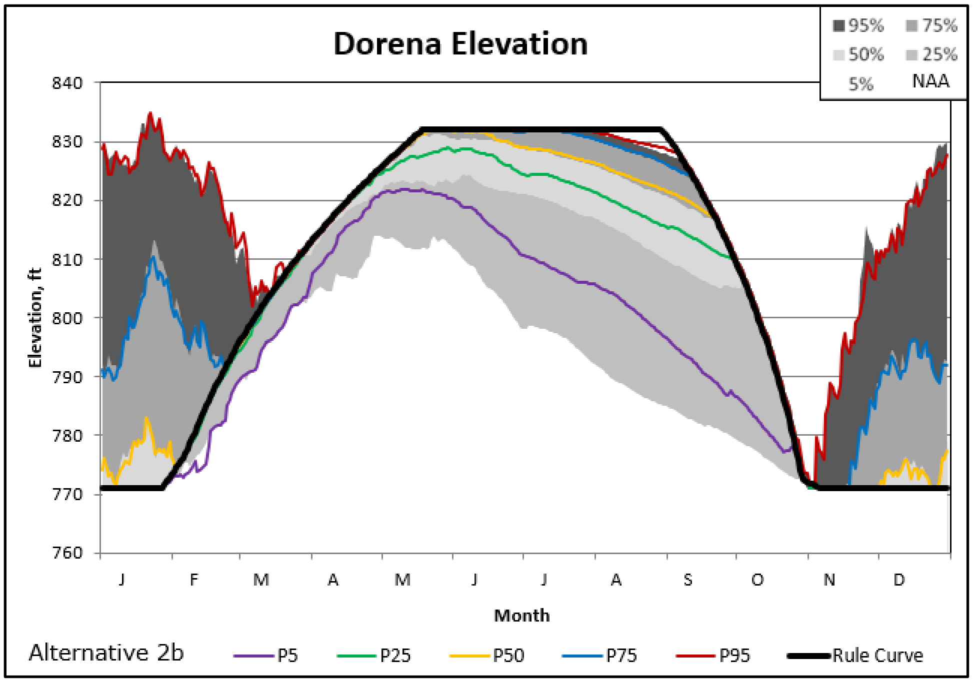

Figure 3.2-99. Alternative 2B Dorena Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

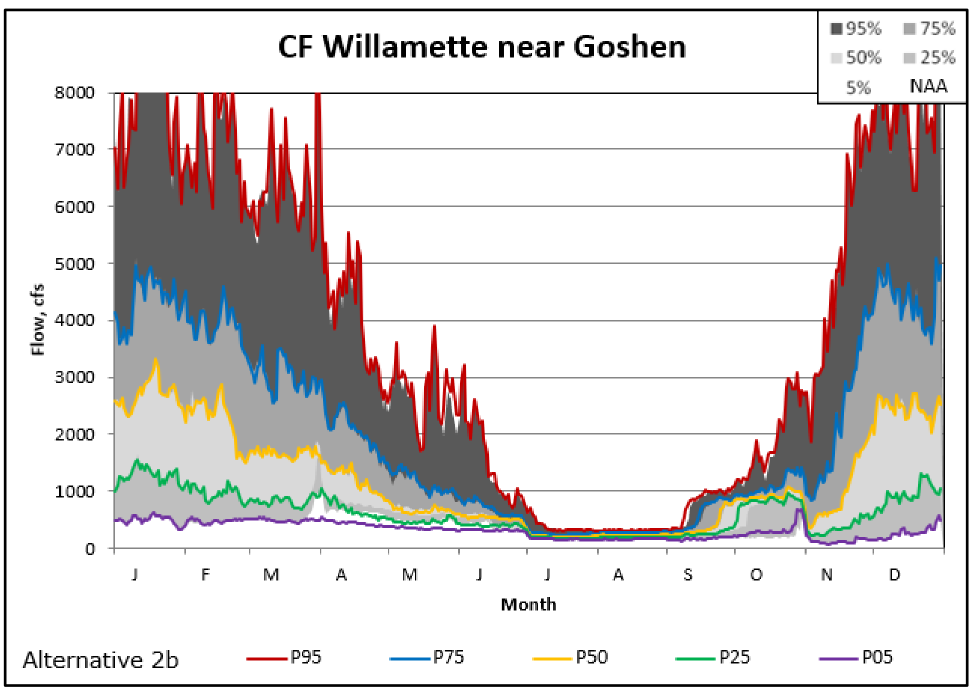

Figure 3.2-100. Alternative 2B Coast Fork Willamette River at Goshen, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Mainstem Willamette River Subbasins

Alternative 2B would alter the regulated hydrology of the mainstem Willamette River control points whereby USACE would store more water in the spring and release it during the summer. The Willamette River at Albany would show dry years below their NAA equivalents from April to June and a compressed flow regime through the summer, with the higher flow years reduced and the low flow years increased (Figure 3.2-101).

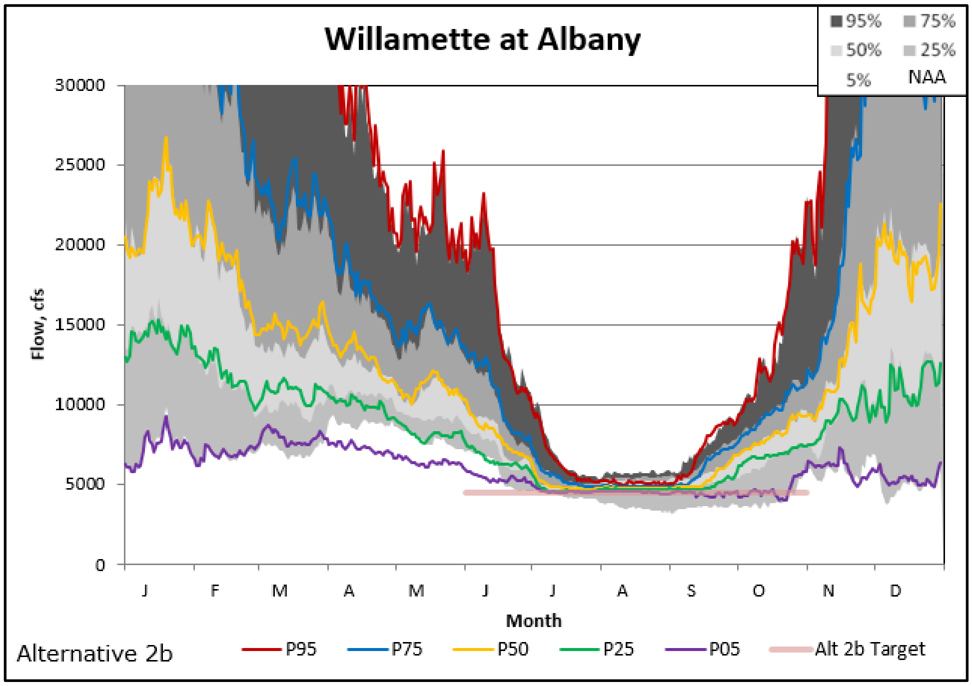

Figure 3.2-101. Alternative 2B Willamette River at Albany, Oregon Flow Non-exceedance as Compared with the No-action Alternative.

USACE would typically meet the lower integrated temperature and habitat flow regime target at Albany, missing during September and October of the driest years. In comparison, Albany would be below the Alternative 2B target for much more time than the same target under Alternative 2A operations due to decreased contributions from Cougar Reservoir.

Like the Albany control point, the Willamette River at Salem would show reduced flows from April to June of dry years, while meeting the integrated temperature and habitat flow regime variable air-temperature-guided target under Alternative 2B (Figure 3.2-102). Summer and fall flows would increase across all years as compared to the NAA, although slightly decreased as compared to Alternative 2A.

The effect of reduced storage at Cougar Reservoir would be considerably less evident at Salem due to the contributions of the Santiam River Subbasin WVS reservoirs. Further, the integrated temperature and habitat flow regime target would nearly always be met under Alternative 2B.

Increased flows from September to November would be due to the deeper fall reservoir drawdown at Green Peter Reservoir as compared to the NAA. These increases would be within the river channel (up to 90,000 cfs); therefore, they would not impact flood risk.

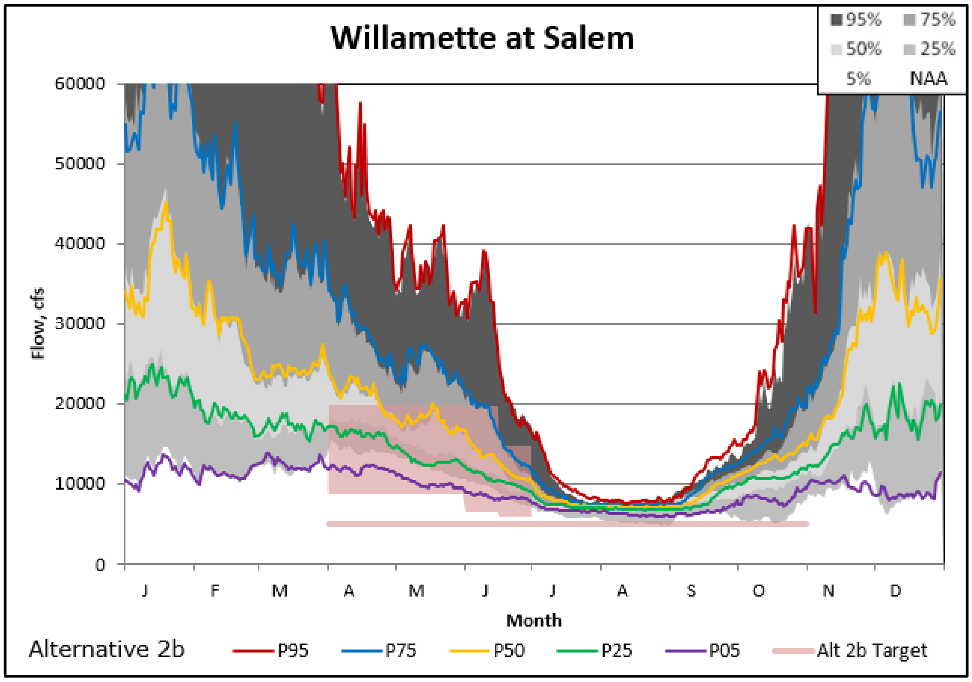

Figure 3.2-102. Alternative 2B Willamette River at Salem, Oregon Flow Non-exceedance as Compared with the No-action Alternative.

Interim Operations under Alternative 2B

Effects to hydrologic processes under the Alternative 2B Interim Operations would be the same as those described under Alternative 2A (Section 3.2.2.3, Alternative 2A, Interim Operations under Alternative 2A).

Climate Change Effects under Alternative 2B

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Overall climate change impacts on hydrologic processes in the Willamette River Basin would be the same as those described under the NAA (Section 3.2.2.3, No-action Alternative, Climate Change Effects under the No-action Alternative). The WVS would experience minor differences in wintertime effects from climate change under Alternative 2B as it would under the NAA.

USACE would fill Green Peter and Cougar Reservoirs to their conservation pool elevation later in the year after deeper fall reservoir drawdowns under Alternative 2B. However, the overall potential benefit may be minimal to future flood risk management operations. While the lower reservoir elevation at Cougar Reservoir at the start of flood season would be potentially beneficial, the storage volume below the minimum conservation elevation would be much less than that above it. Further, climate-driven conversion from snowfall to rain may be more impactful than the additional storage. Projections at Green Peter Reservoir for flow changes are more muted than the higher elevation basins, meaning that it may diminish in importance relative to other WVS reservoirs for flood risk management operations.

During the conservation season, climate change would affect operations under Alternative 2B similarly to Alternative 2A, with the main difference being lower reservoir elevations in the McKenzie River and Middle Fork Willamette River Subbasins and lower flow in the McKenzie River. Because the Alternative 2B integrated temperature and habitat flow regime targets are lower than the NAA 2008 NMFS Biological Opinion requirements, most WVS reservoirs could store more water during conservation season as compared to the NAA. However, USACE would need to use more of this stored water to meet downstream flow targets with projected increased variability in the spring shoulder months, drier hotter summers, and lower summer baseflow.

Under Alternative 2B operations, Cougar Reservoir would likely never fill to minimum conservation elevation due to decreased inflow after its spring reservoir drawdown to the diversion tunnel outside of flood season, which would not occur under the NAA. USACE would need to release more water at Hills Creek and Lookout Point Reservoirs to meet the Albany flow target, substituting for the lack of releases available from Cougar Reservoir.

Across the WVS, reservoirs are projected to have lower water surface elevations, although Cougar, Hills Creek, and Lookout Point Reservoirs would be most affected during the 30-year implementation timeframe. Reservoirs under Alternative 2B would sometimes draft to minimum targeted elevation during the summer, but less often than under the NAA, meaning they would be able to augment summer flows for longer than the NAA operations even with projected declines in late spring and summer flows.

The lowest reservoir water surface elevations would occur in the driest years, which would be drier than the WVS currently encounters, as the reservoirs are drafted more to meet downstream flow targets. USACE would miss the WVS mainstem Willamette River flow target at Albany more often under Alternative 2B than under Alternative 2A due to the reduced system storage. Flows under Alternative 2B would still meet the target more often than under the NAA. Additionally, increased reservoir evaporation from increased climate change-induced temperatures would marginally decrease available water from all WVS reservoirs.

The ability to meet the flow target at Salem under Alternative 2B would remain similar to Alternative 2A because inflow from the Santiam River Subbasin would reduce the impact from a storage deficit at Cougar Reservoir.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

USACE would primarily use operational measures under Alternative 3A to aid fish passage within the Willamette River Basin and minimize required WVS structural modifications. A key consideration under Alternative 3A as compared to the NAA would be the increased use of different flow outlets from the dams to control temperature, with the spillway supplying warmer water from the upper reservoir and the deeper outlets (regulating outlets and turbines) supplying cooler water. Although these different outlet flows are calculated in the reservoir regulation model, they typically do not appear directly in figures presented below because the figures compare total flow with the NAA (Section 3.2.2.1, Methodology, Reservoir Operations Model). The effects of those outlet flow changes—for example, temperature and total dissolved gas differences—are represented as inputs to other modeling, such as the temperature models.

Operations under Alternative 3A would also allow reservoirs to augment instream flows by using the inactive or power pools, drafting below the NAA rule curves to meet minimum flow requirements. This would most frequently occur during the fall of drier years at reservoirs that do not have a deeper fall reservoir drawdown operation.

As described under Alternative 2A, the primary set of flow targets are the integrated temperature and habitat flow regime, which replace the 2008 NMFS Biological Opinion targets under the NAA (Chapter 2, Alternatives, Section 2.8.1.1, Integrated Temperature and Habitat Flow Regime (Measure 30a)).

Under Alternative 3A, USACE would implement spring and fall reservoir drawdowns at some WVS reservoirs for volitional downstream fish passage. The spring drawdown operations would be at Detroit, Lookout Point, and Cougar Reservoirs (to the regulating outlet); the deeper fall reservoir drawdown operations would be at Blue River, Hills Creek, Green Peter, Detroit, Lookout Point, and Cougar Reservoirs. The drawdowns would be typically to the lowest level possible given operational constraints (for example, outlet cavitation limits) or to the lowest achievable pool (Chapter 2, Alternatives, Section 2.8.1, Flow Measures).

The drawdowns would limit the effectiveness of other activities under Alternative 3A. The spring reservoir drawdown can inhibit refill of the reservoirs into the late winter and spring. Because Alternative 3A operations would not fill the reservoirs more often, there would be less available water to augment flows downstream during the summer and fall compared to the NAA. In addition, if the reservoir water surface elevation does not rise to the spillway crest, the dam is unable to discharge water through that outlet, constraining the temperature operations that require the spillway.

As compared to the NAA, Alternative 3A can have the effect of releasing water during the spring and lowering flows in the summer. This would be more pronounced during drier years than in wetter years because a larger portion of the summer flow is stored water from the reservoirs. During an average flow year, Detroit and Cougar Reservoirs would be unable to contribute meaningfully to flow targets downstream.

Neither the NAA flow targets nor the lower integrated temperature and habitat flow regime flow targets under Alternative 3A would be met across the Willamette River Basin during an average flow year. These lower flows would have long-term consequences across the Basin.

Santiam River Subbasin

Under Alternative 3A, USACE would substantially alter the use of Detroit Reservoir for all years, remaining far below the NAA in the spring and summer (Figure 3.2-103). The reservoir elevation would not reach the top of conservation storage in even the wettest years.

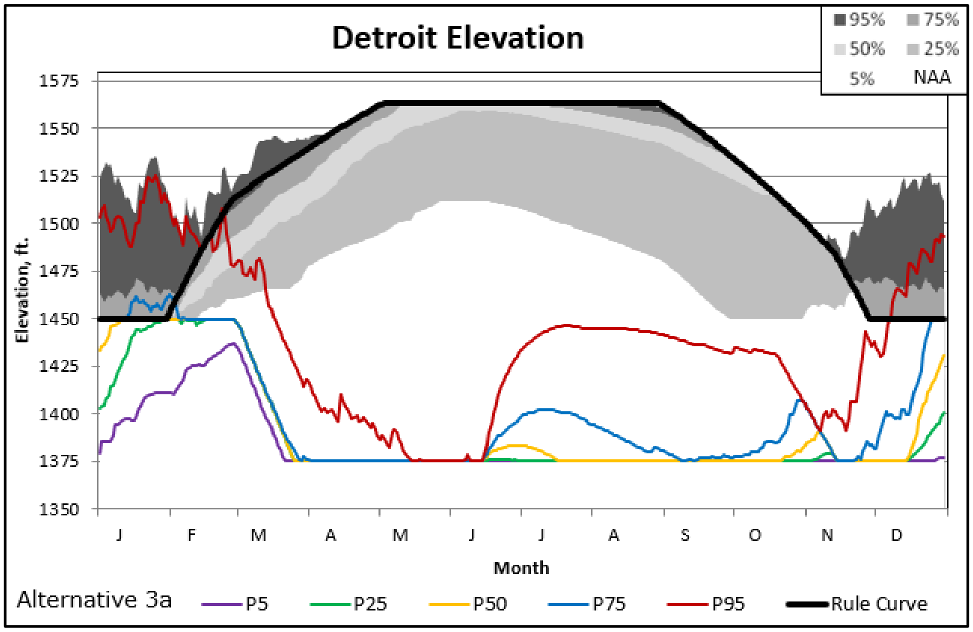

Figure 3.2-103. Alternative 3A Detroit Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

During most years, Detroit Reservoir would not appreciably rise above the spring reservoir drawdown elevation (1,375 feet) while releasing inflow until the next winter, in January on average. Although it is not shown in the figure (as the lines are non-exceedance percentiles), Detroit Reservoir would reach minimum conservation elevation (1,450 feet) once between April and October during the period-of-record run under Alternative 3A.

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The reservoir would usually be lower across the winter season as well as compared to the NAA. Particularly wet winters would force USACE to operate the reservoir back to the NAA elevations, but this would happen late in January or early February. The drawdowns and low summer reservoir elevation would have a stark effect on the flow from Detroit Dam as compared to the NAA. The releases from Detroit would be substantially higher during the spring reservoir drawdown as the reservoir drafts to the minimum elevation of 1,375 feet.

During the summer, passing inflow would not be enough to maintain the minimum downstream integrated temperature and habitat flow regime target in about 75 percent of years (Figure 3.2-104). The average year (Figure 3.2-104, P50 line) would be below the target from mid-June to nearly November, with a typical flow of about 600 cfs (the minimum flow target is 1,050 cfs). The driest years would not reach the minimum flow target from May through December, a much longer time than under the NAA, reaching a minimum flow of about 400 cfs.

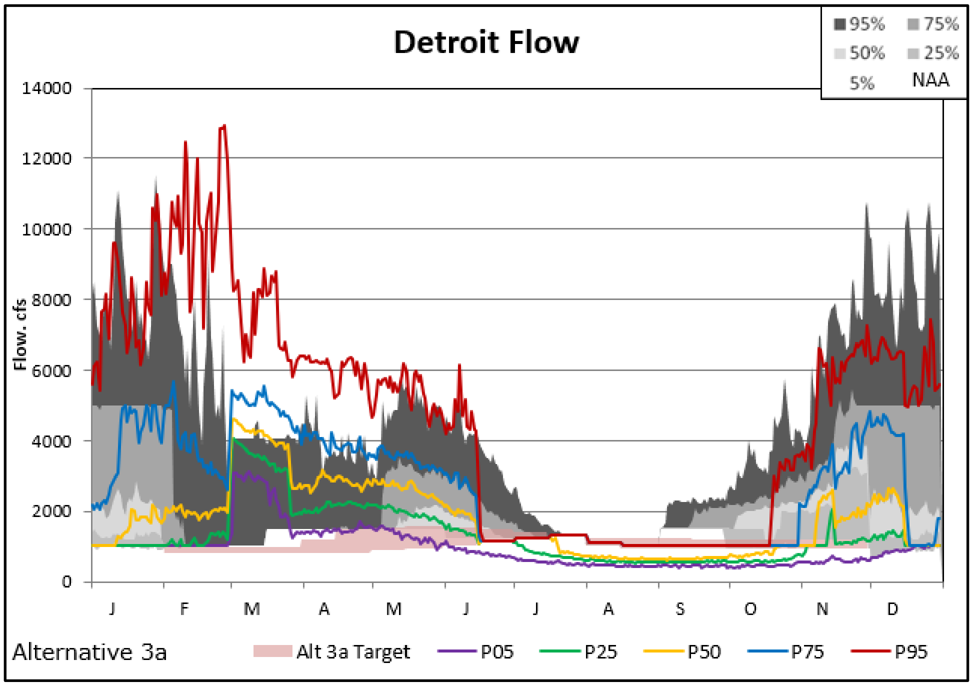

Figure 3.2-104. Alternative 3A Detroit Reservoir Outflow Non-exceedance as Compared with the No-action Alternative.

USACE would operate Green Peter Reservoir with a deeper fall drawdown but would not operate a spring drawdown under Alternative 3A (Figure 3.2-105). The result would be considerably less impact to reservoir elevation during the rest of the year through the spring and summer as compared to the NAA. USACE would release the additional stored water earlier in the summer to meet downstream flow targets and to compensate for the lack of water in Detroit Reservoir, starting about one month earlier than the NAA across water years. The integrated temperature and habitat flow regime targets are lower than the NAA's Biological Opinion targets downstream of Foster Reservoir, so the driest years would peak at a higher elevation under Alternative 3A than under the NAA (Figure 3.2-106, line P05).

Although the target elevation of the deeper fall reservoir drawdown is 780 feet under Alternative 3A, USACE would be unable to draft Green Peter Reservoir that low in slightly more than half of years. This would be due to inflow during wetter than typical years. As the reservoir elevation falls, the capacity of the outlets also falls (i.e., there is less pressure pushing the water out).

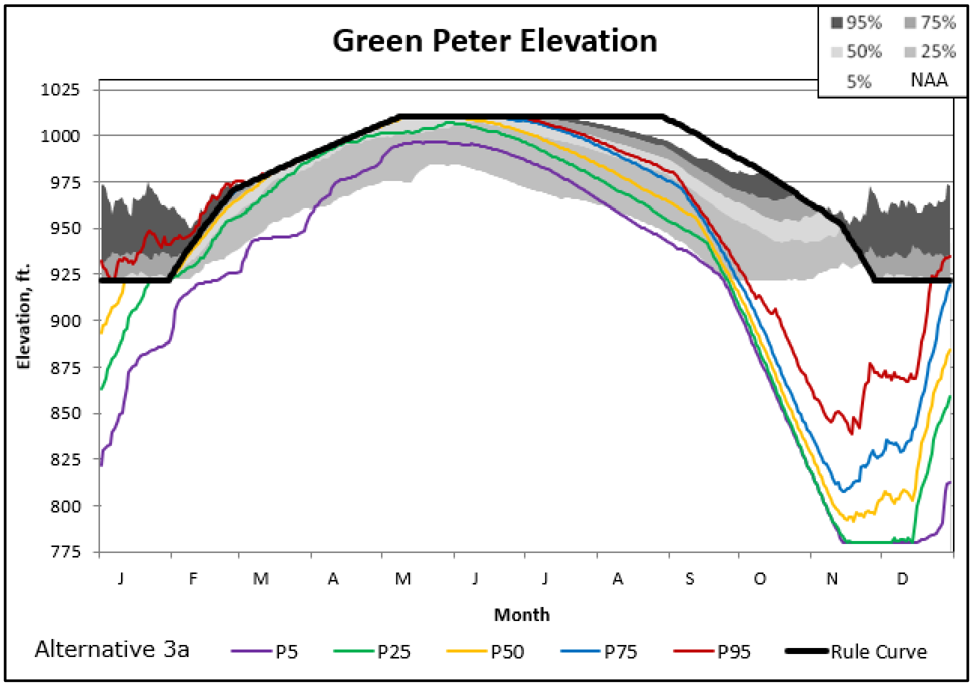

Figure 3.2-105. Alternative 3A Green Peter Reservoir Water Surface Elevation Non-exceedance as Compared with the No-action Alternative.

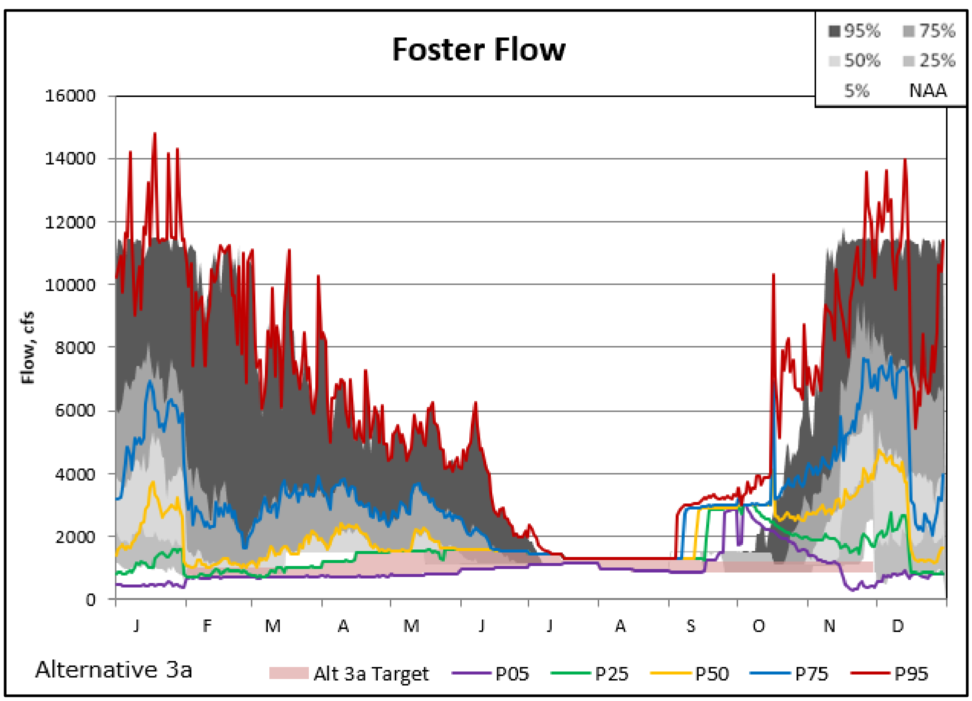

Figure 3.2-106. Alternative 3A Foster Reservoir Flow Non-exceedance as Compared to the No-action Alternative.

Downstream of Foster Reservoir, flow would be similar to the NAA during average to wet years except during the deeper fall drawdown period at Green Peter Reservoir under Alternative 3A. The elevated flows compared to the NAA would be a result of the release from Green Peter Reservoir to reach the low reservoir elevation.

The integrated temperature and habitat flow regime targets would be met throughout the summer and fall under Alternative 3A. The dry years trace the bottom of the targets whereas most of the rest are at the top of the range or above it. Flow would fall below target for about 2 weeks but only in the driest Novembers when Green Peter Reservoir is already at its low elevation.

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The Santiam River at Jefferson would combine the changes at Detroit Reservoir in the North Santiam River Subbasin and Green Peter Reservoir in the South Santiam River Subbasin (Figure 3.2-107). Higher flows would be evident when the reservoirs draft to the drawdowns (principally March and October) as compared to the NAA. Under Alternative 3A, there would be a larger variation in flow in the summer, with more flow in the wettest years and less flow in the driest years compared to the NAA.

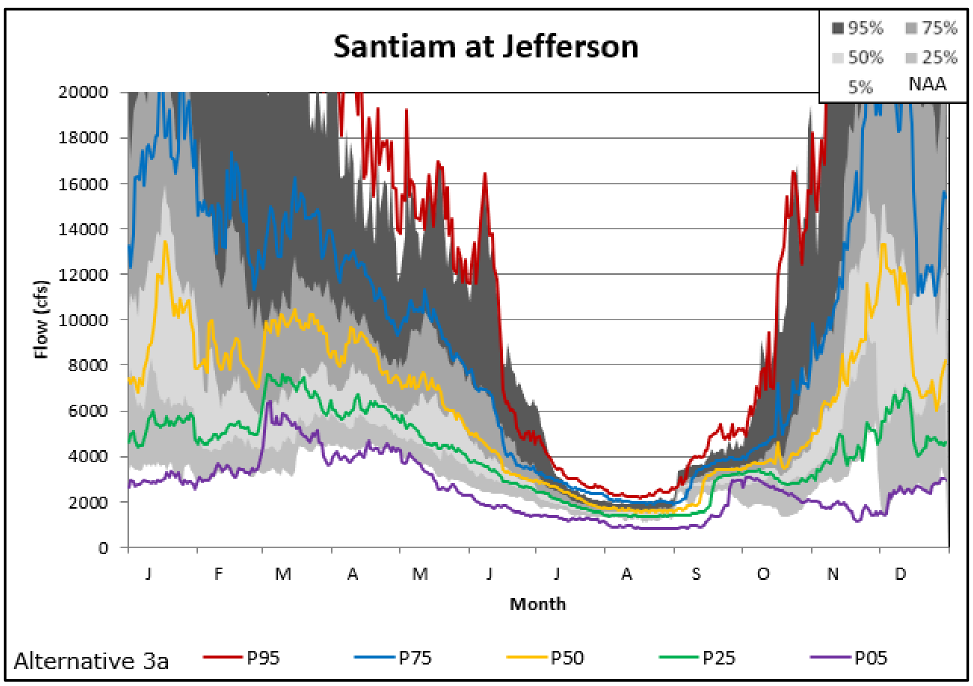

Figure 3.2-107. Alternative 3A Santiam River at Jefferson, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Long Tom River Subbasin

Water surface elevations within Fern Ridge Reservoir would show negligible changes under Alternative 3A as compared to the NAA (Figure 3.2-108). Downstream flows at Monroe would also remain unchanged under Alternative 3A as compared to the NAA.

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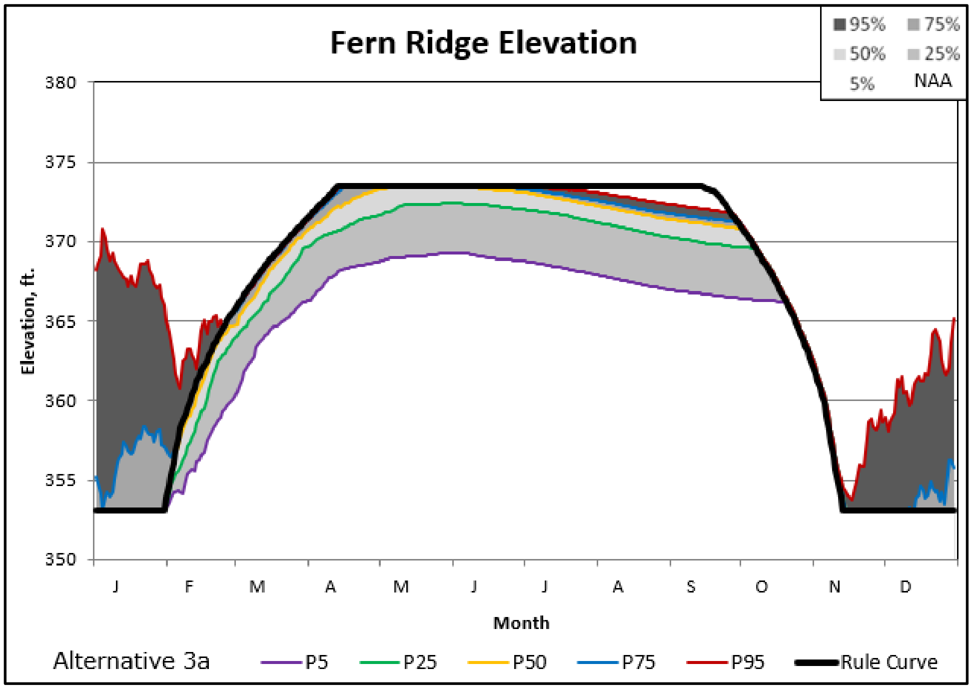

Figure 3.2-108. Alternative 3A Fern Ridge Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

McKenzie River Subbasin

Like Detroit Reservoir in the Santiam Subbasin, there would be both spring and fall drawdowns at Cougar Reservoir under Alternative 3A (Figure 3.2-109). Because the spring reservoir drawdown would last through the typical refill period, Cougar Reservoir would only be able to rise above the drawdown elevation (1,517 feet) during the summer in wetter years, which would not occur under the NAA. The only time Cougar Reservoir would be full under Alternative 3A would be during a flood risk management operation of a particularly rare and large storm in the winter months.

USACE would only be able to meet its minimum downstream flow target of 300 cfs at Cougar Reservoir for the entire summer about 25 percent of the time. USACE would miss this target from August to October during an average year where the P50 line is at minimum reservoir elevation (Figure 3.2-109, line P50).

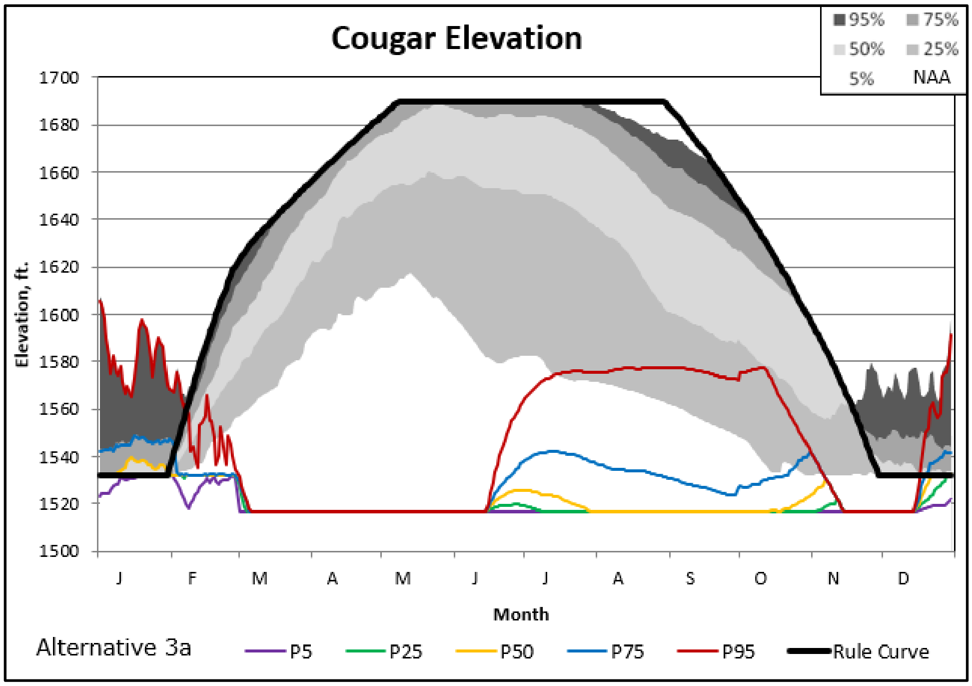

Figure 3.2-109. Alternative 3A Cougar Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

There would be a deeper fall drawdown at Blue River Reservoir, 15 feet below its minimum conservation pool under Alternative 3A (Figure 3.2-110). The spring refill would reach the maximum conservation elevation more often in Blue River Reservoir than under the NAA due to the lower integrated temperature and habitat flow regime targets (Figure 3.2-110, P25 line). USACE would draft the reservoir earlier in the summer than under the NAA to augment some of the flow not available at Cougar Reservoir under Alternative 3A.

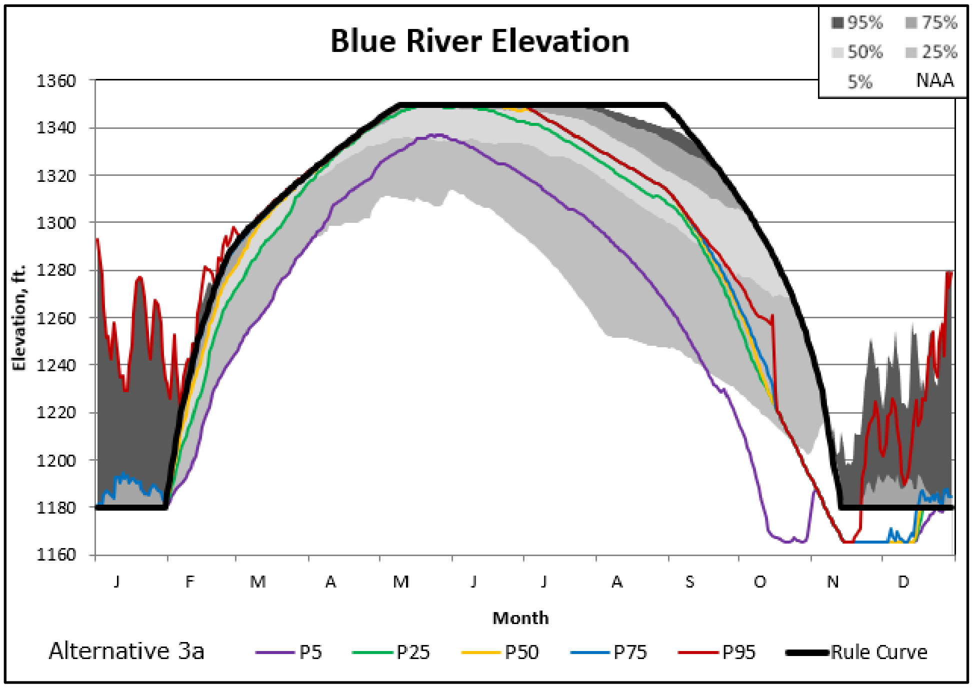

Figure 3.2-110. Alternative 3A Blue River Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Under Alternative 3A, the downstream control point, McKenzie River at Vida, would show the combined effect of more and less available conservation storage at Blue River and Cougar Reservoirs, respectively (Figure 3.2-111). Higher flows during the spring of wet years would occur because USACE would not fill Cougar Reservoir during the conservation season as it would under the NAA. Lower flows during the driest years from April to June would occur because of more filling in Blue River Reservoir while meeting the lower downstream flow targets.

During the summer, Alternative 3A flows would be marginally below the NAA as the increased storage at Blue River Reservoir and no storage at Cougar Reservoir would nearly balance out (Blue River Reservoir is smaller than Cougar Reservoir, so flows would be a bit lower across the summer).

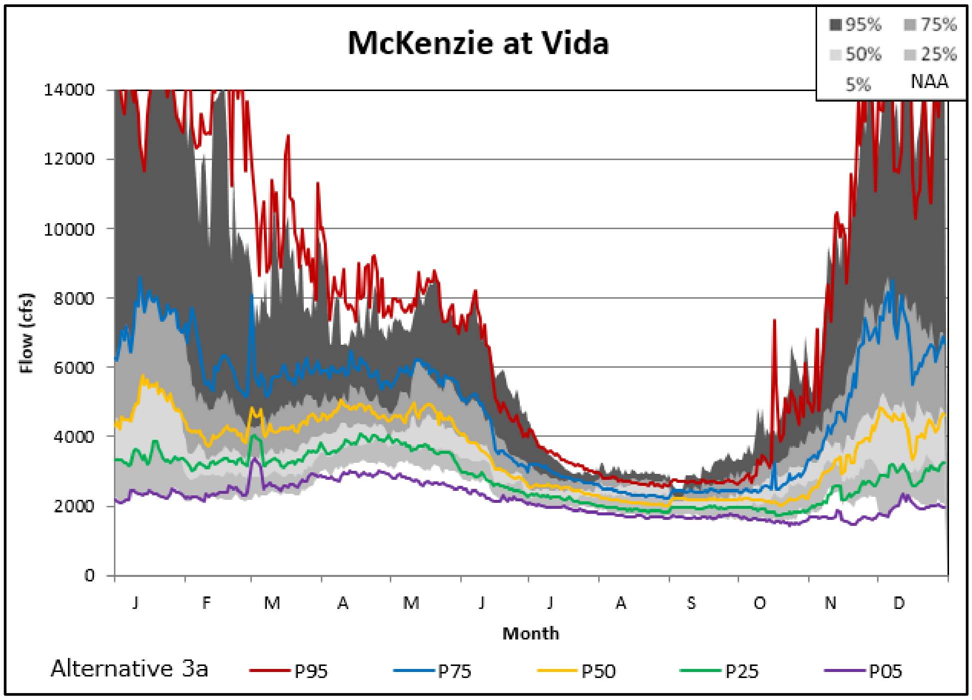

Figure 3.2-111. Alternative 3A McKenzie River at Vida, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Middle Fork Willamette River Subbasin

USACE would operate for deeper fall drawdowns at Hills Creek, Lookout Point, and Fall Creek Reservoirs under Alternative 3A. The deeper fall drawdown at Fall Creek would be an existing operation under the NAA. There would also be a spring drawdown at Lookout Point Reservoir under Alternative 3A.

During the spring conservation storage season, Hills Creek Reservoir would be operated to fill more frequently and to achieve a higher elevation during dry years as compared to the NAA (Figure 3.2-112). The reservoir would then be drafted to meet downstream flow targets, which flow through Lookout Point Reservoir (Figure 3.2-113). The stored water in Hills Creek reservoir would be exhausted around mid-September in an average year.

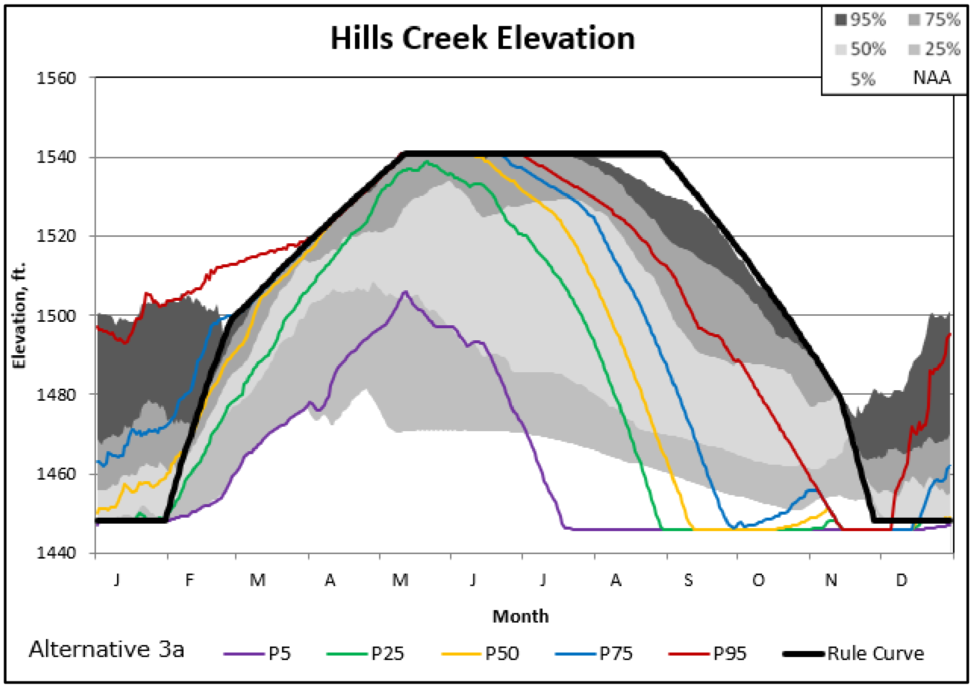

Figure 3.2-112. Alternative 3A Hills Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

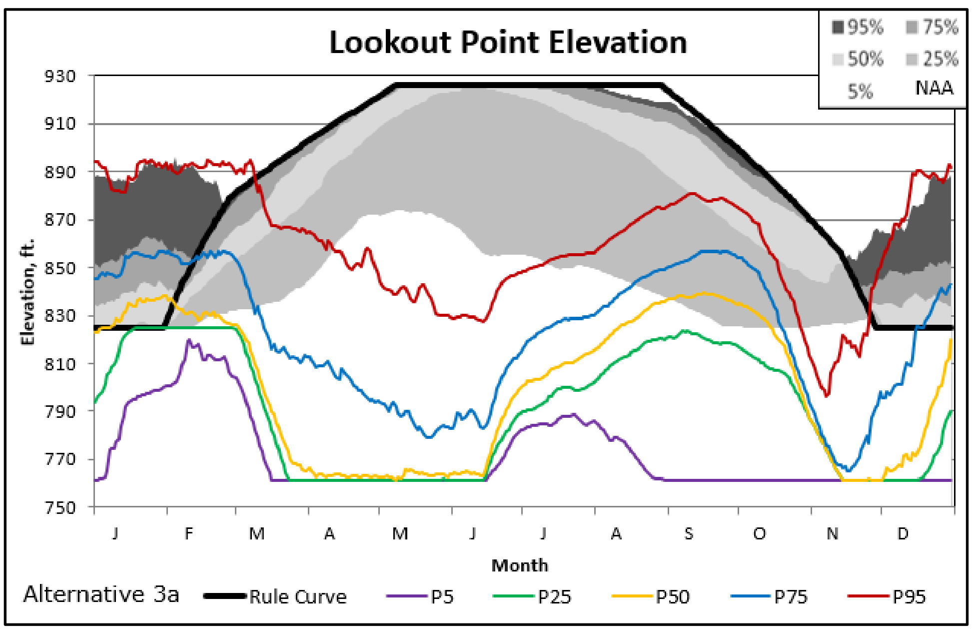

Figure 3.2-113. Alternative 3A Lookout Point Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Despite operating for a spring drawdown as in Detroit Reservoir in the Santiam River Subbasin and in Cougar Reservoir in the McKenzie River Subbasin, Lookout Point Reservoir would be able to fill up to minimum conservation elevation in most years under Alternative 3A. The reservoir would rise from its minimum spring drawdown elevation in the driest years but would return to the minimum in about 2 months (Figure 3.2-113, P5 Line). This would be due to the stored water from Hills Creek Reservoir upstream under Alternative 3A as compared to the NAA. Neither Detroit nor Cougar Reservoirs offer the benefit of refill from water stored in an upstream reservoir.

Under Alternative 3A, USACE would not achieve its spring and fall reservoir drawdown target in Lookout Point Reservoir in about 25 percent of years. Higher inflows during the drawdowns, inflows from Hills Creek Reservoir during the spring, and reduced outlet capacity from the lower reservoir elevation (i.e., there is less pressure pushing the water out) means that Lookout Point Reservoir would remain above the target elevation for the duration of the drawdown periods under Alternative 3A.

Fall Creek Reservoir water surface elevations and outflows would be very similar to the NAA, where operations would continue to implement a fall drawdown to the same elevation as under Alternative 3A (Figure 3.2-114).

The control point for the Middle Fork Willamette River Subbasin WVS dams at Jasper would show the changed flow from the drawdowns and limited augmented flow during the summer under Alternative 3A (Figure 3.2-115). Flow at Jasper would be higher than the NAA across all years from March until May. As summer starts, flow would be drastically reduced as compared to the NAA as operations attempt to refill reservoirs with available inflow.

From June until September, typical wet-year flows would be comparable to driest years under the NAA. During the driest years under Alternative 3A, reservoirs would not return to the NAA elevations until late October. Although Lookout Point and Fall Creek Reservoirs would be above their minimum elevations during this time, this would result in an operational attempt to meter out water throughout the summer within the WVS.

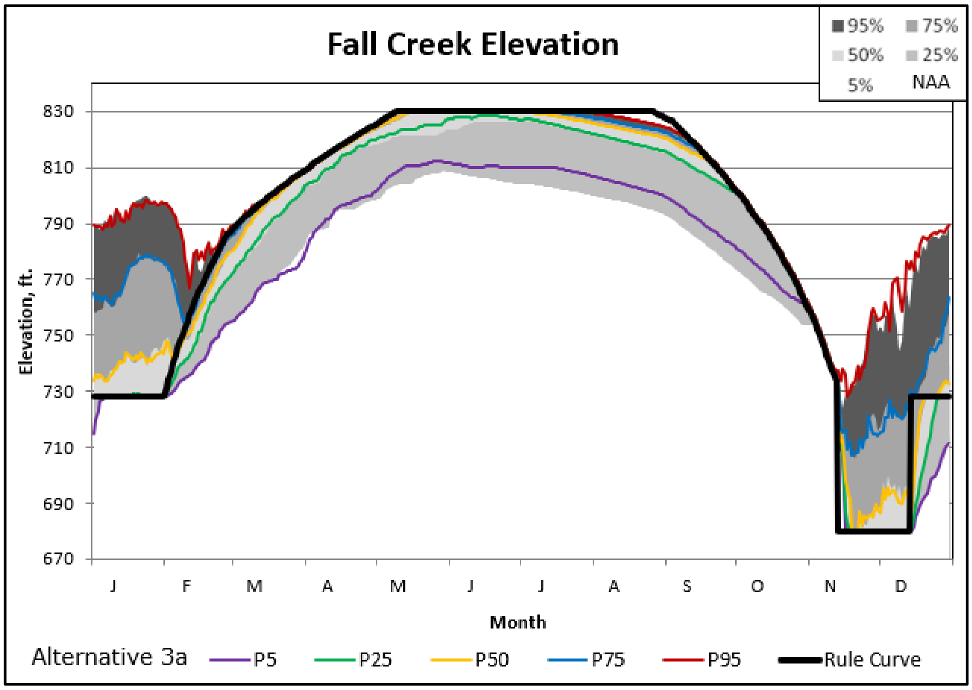

Figure 3.2-114. Alternative 3A Fall Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

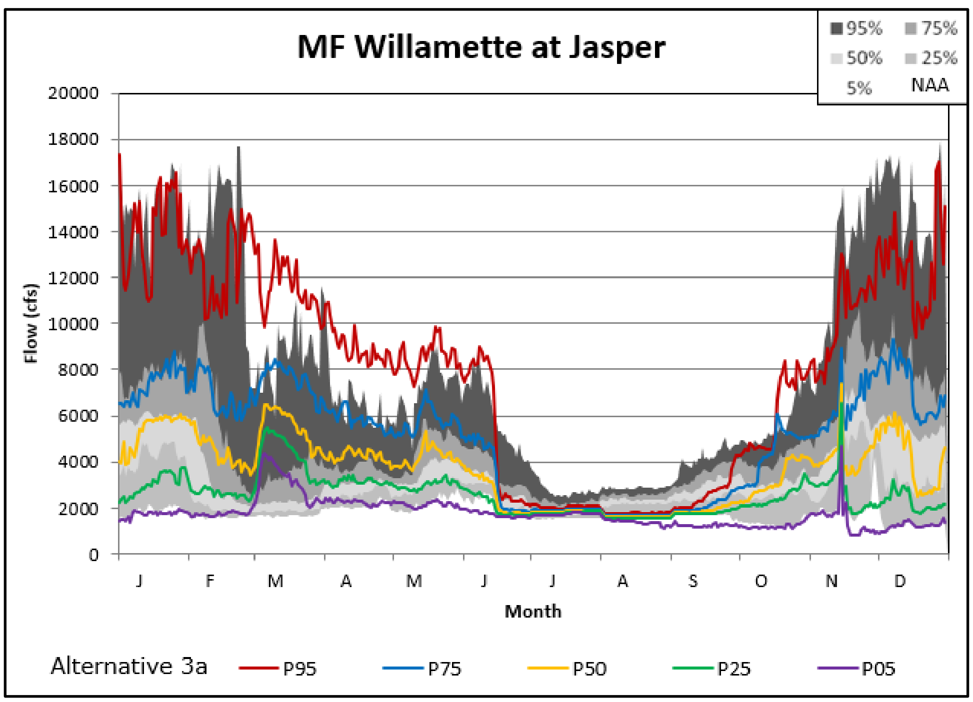

Figure 3.2-115. Alternative 3A Middle Fork Willamette River at Jasper, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Coast Fork Willamette River Subbasin

Dorena and Cottage Grove Reservoir elevations would behave very similarly under Alternative 3A (Figures 3.2-116 and 3.2-117, respectively). Operations under Alternative 3A would refill these reservoirs to slightly higher levels than under the NAA due to the lower integrated temperature and habitat flow regime targets downstream. Reservoir storage would be similar for average and wet years throughout the summer and fall.

Under Alternative 3A, these reservoirs would draft faster from higher initial water surface elevations in dry years as USACE operates the reservoirs to make up for the lower storage elsewhere in the system. In especially dry falls, the reservoirs would augment instream flows by using the inactive pools.

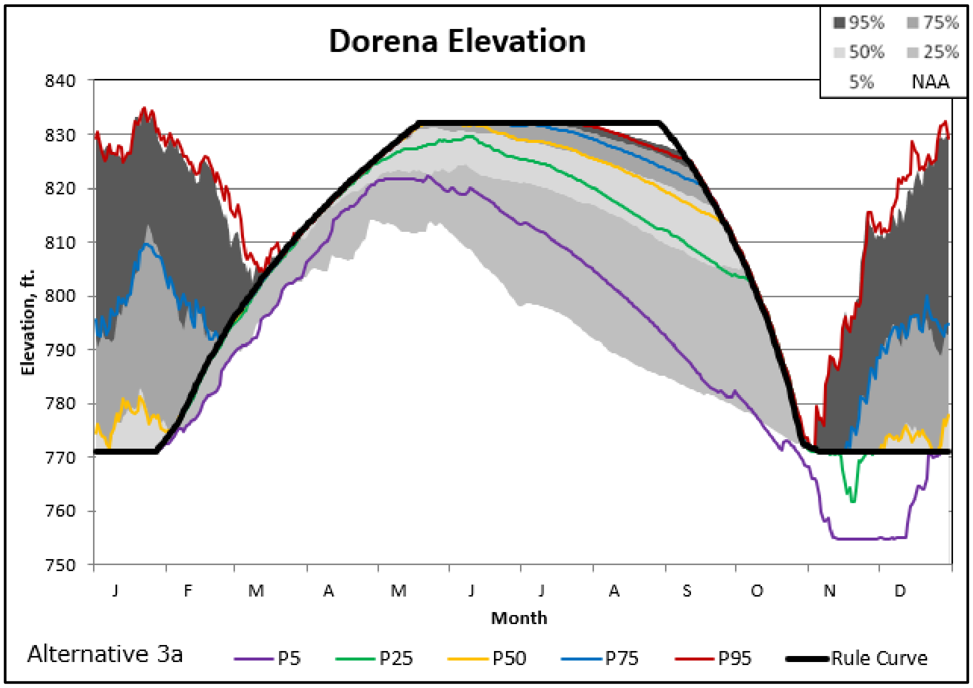

Figure 3.2-116. Alternative 3A Dorena Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

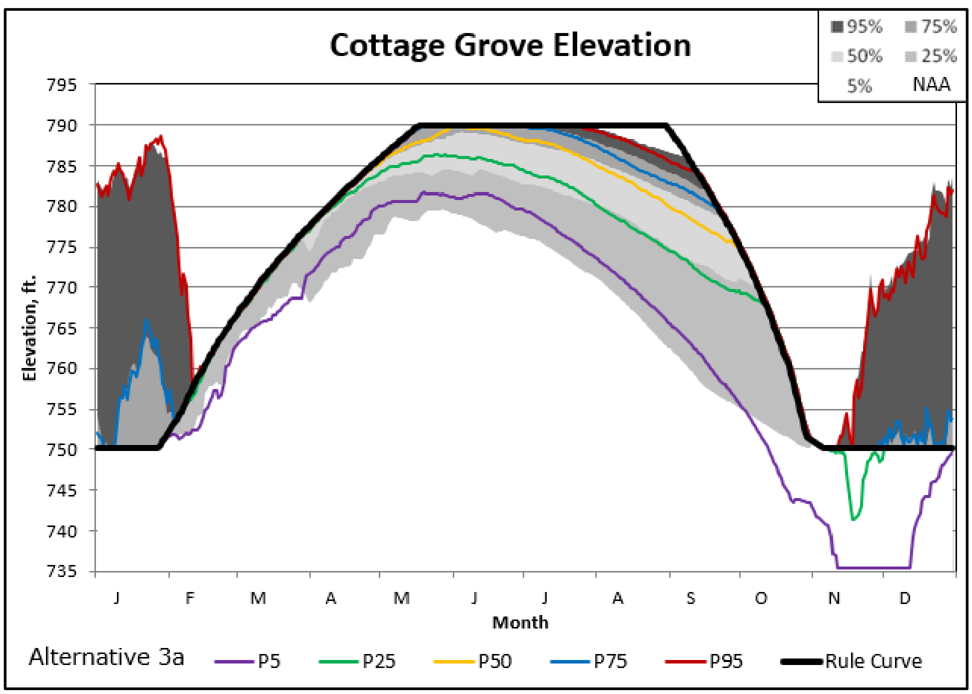

Figure 3.2-117. Alternative 3A Cottage Grove Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

The flow at Coast Fork Willamette River at Goshen would be most different from the NAA in dry years (Figure 3.2-118). Because additional stored water would be accumulated in Dorena Reservoir and Cottage Grove Reservoir under Alternative 3A, the downstream control would experience decreased flow from April to June and increased flow in July to October as the reservoirs would release the stored water. Although there would be minor differences, Alternative 3A and Alternative 3B would be similar at Goshen from a hydrologic perspective.

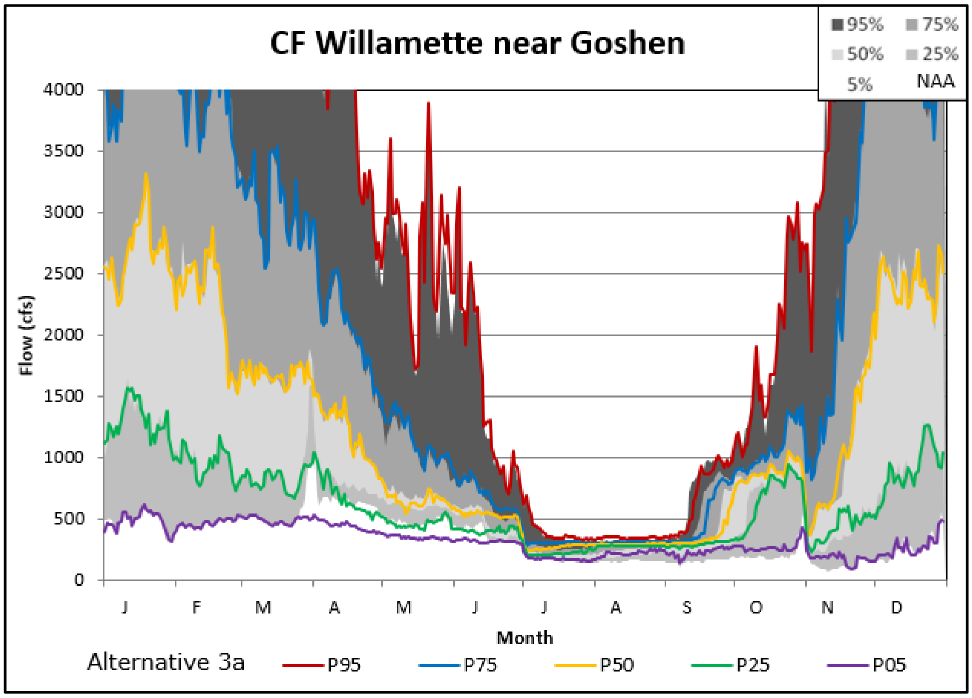

Figure 3.2-118. Alternative 3A Coast Fork Willamette River at Goshen, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Mainstem Willamette River Subbasins

The Alternative 3A flow targets on the mainstem Willamette River at Albany and Salem are the integrated temperature and habitat flow regime, which is lower than the 2008 NMFS Biological Opinion targets under the NAA (Figure 3.2-119 and Figure 3.2-120, respectively). Additionally, operations under Alternative 3A would add flows to the target at Salem during warm weather (the target box in the figure) (Chapter 2, Alternatives, Section 2.8.1, Flow Measures).

In wet years, operations under Alternative 3A would result in consistently higher flow during the springtime at both Albany and Salem as compared to the NAA as storage reservoirs would be maintained lower for spring reservoir drawdown fish passage operations. During the driest years, there would be lower flow in the spring under Alternative 3A due to the lower flow target at Salem.

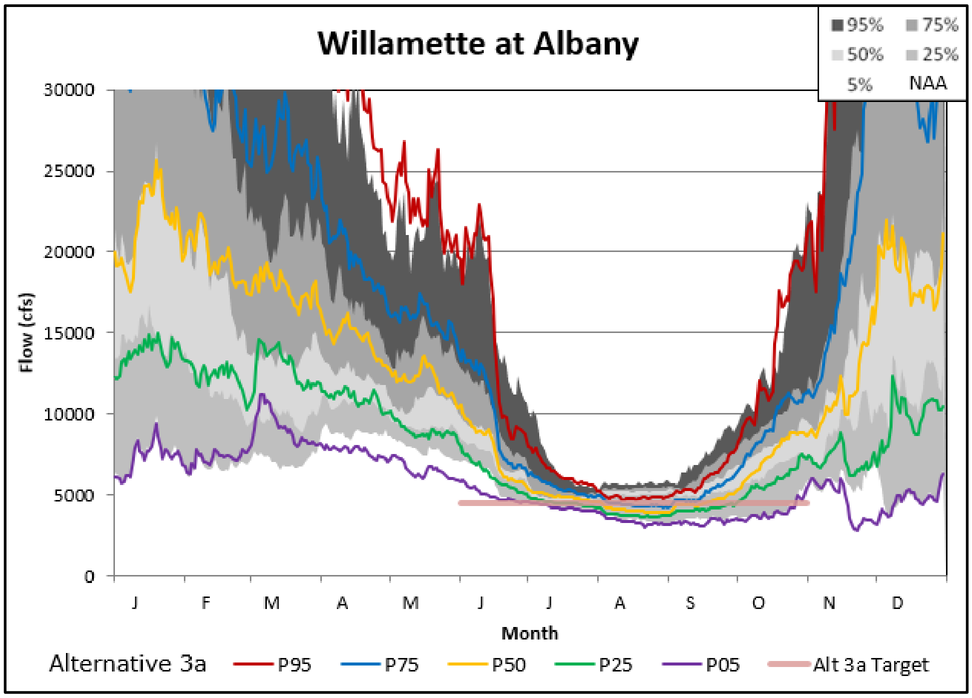

Figure 3.2-119. Alternative 3A Willamette River at Albany, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

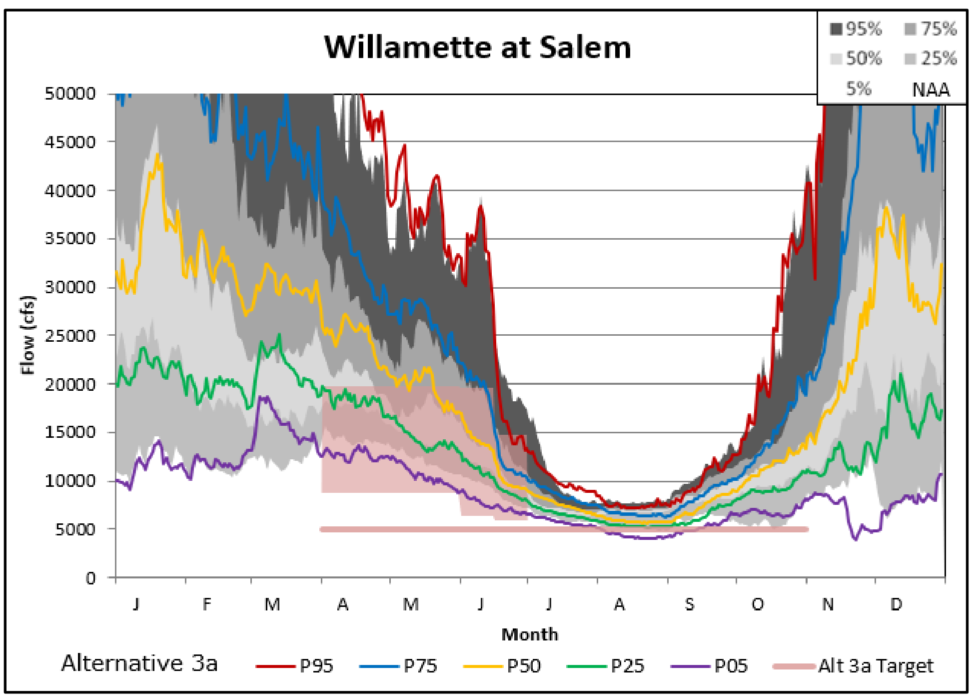

Figure 3.2-120. Alternative 3A Willamette River at Salem, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

After the end of the WVS spring reservoir drawdowns, flows would drop steeply across all years. The lower amount of total system storage means that the system would not meet the flow target at Albany for at least 1 month in more than 75 percent of years (Figure 3.2-119, P75 line). Flows at Salem would more consistently meet the integrated temperature and habitat flow regime target due contributions from Green Peter Reservoir, where a spring reservoir drawdown would not occur under Alternative 3A. Regardless, summer and fall flows would be comparable or lower across similar years in the mainstem Willamette River under Alternative 3A as compared to the NAA.

Interim Operations under Alternative 3A

Effects to hydrologic processes under the Alternative 3A Interim Operations would be the same as those described under Alternative 2A (Section 3.2.2.3, Alternative 2A, Interim Operations under Alternative 2A).

Climate Change Effects under Alternative 3A

Overall climate change impacts on hydrologic processes in the Willamette River Basin would be the same as those described under the NAA (Section 3.2.2.3, No-action Alternative, Climate Change Effects under the No-action Alternative). However, climate change hydrologic factors such as seasonal flow volume shifts may stress the WVS under Alternative 3A operations compared to the NAA.

Specifically, future increases in median wintertime flow volumes and average deceases in summertime baseflows will exacerbate effects already present under Alternative 3A. Climate change effects, and potential implications as discussed below, draw on the climate change projection and trend information provided in Appendix F1, Qualitative Assessment of Climate Change Impacts and Appendix F2, Supplemental Climate Change Information.

Lower reservoir pool elevations and flow releases for downstream flow targets are likely in the future. In addition, spring inflow quantity and timing are projected to be more variable in the future as climate change trends establish. Conversion of snow to wintertime flows and limited or no snowpack is a projected consequence of climate change in the Willamette River Basin.

The projection for drier, warmer, and earlier arriving summers means that the spring reservoir drawdowns would leave the reservoirs even lower than expected NAA conditions under Alternative 3A. Because the spring reservoir drawdowns last past April when inflows would start to decline precipitously, it would be difficult to manage operations at Detroit and Cougar Reservoirs to store water for release later in the year. USACE could store some of the water released from Hills Creek Reservoir in Lookout Point Reservoir, but it is likely to fill much less often as compared to the NAA.

Operations under Alternative 3A would not meet August downstream flow targets at Albany about 75 percent of the time, which would not occur under the NAA. Decreasing summer flow projections indicate that USACE would rarely, if ever, meet the Albany flow target under

Alternative 3A. Salem would be less affected due to flow augmentation from Green Peter Reservoir, but the flow target would be missed more often; existing dry years would be even drier as a result of climate change during the 30-year implementation timeframe.

After the deeper fall reservoir drawdowns, there is additional storage space between the minimum drawdown elevation and the maximum flood storage elevation. It typically takes until middle of January (though timing varies throughout the WVS) for reservoirs to return to their current rule curve elevation. Downstream winter flows could be maintained while this additional storage capacity refills, despite projected increased winter peak flow and volume.

Alternative 3B—Improve Fish Passage through Operations-focused Measures

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

Under Alternative 3B, USACE would primarily use WVS dam operations for fish passage within the Willamette River Basin but with a different suite of operations as compared to Alternative 3A. As under Alternative 3A, USACE would operate under Alternative 3B by use of different flow outlets from the dams to control temperature. Alternative 3B would also allow USACE to augment instream flows as described under Alternative 3A.

The primary set of flow targets are the integrated temperature and habitat flow regime, which replace the 2008 NMFS Biological Opinion under the NAA (Chapter 2, Alternatives, Section 2.8.1.1, Integrated Temperature and Habitat Flow Regime (Measure 30a)).

Under Alternative 3B, USACE would implement spring and fall reservoir drawdowns at some WVS reservoirs for volitional downstream fish passage. The spring reservoir drawdown operations would be at Hills Creek, Green Peter, and Cougar Reservoirs (to the diversion tunnel); the deeper fall drawdown operations would be at Blue River, Hills Creek, Green Peter, Detroit, Lookout Point, and Cougar Reservoirs, which would not occur under the NAA. The drawdowns are typically to the lowest level possible given operational constraints (for example, outlet cavitation limits) or the lowest achievable pool. Both the spring and fall reservoir drawdowns at Cougar Reservoir would make use of the diversion tunnel instead of the regulating outlets and turbines. This would result in a much lower drawdown to 1,330 feet, instead of 1,517 feet as under Alternative 3A. Effectiveness of drawdown limitations are the same as described under Alternative 3A.

Summer flow would be well below the NAA under Alternative 3B. The adaptability of the WVS would be constrained by a reduced ability to refill during the conservation season. All changes to Willamette River Basin hydrology would be long term.

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Santiam River Subbasin

USACE would fill Detroit Reservoir more often during the conservation season and achieve a higher elevation when not full under Alternative 3B as compared to the NAA (Figure 3.2-121). Because USACE does not operate for a spring drawdown at Detroit Reservoir as under Alternative 3A, USACE would meets its downstream flow targets at Detroit Reservoir more consistently throughout the summer (Figure 3.2-122). Only the driest years (P05 line) would be at the minimum flow target, with even the P25 line able to hit the upper bound of the target in the summer.

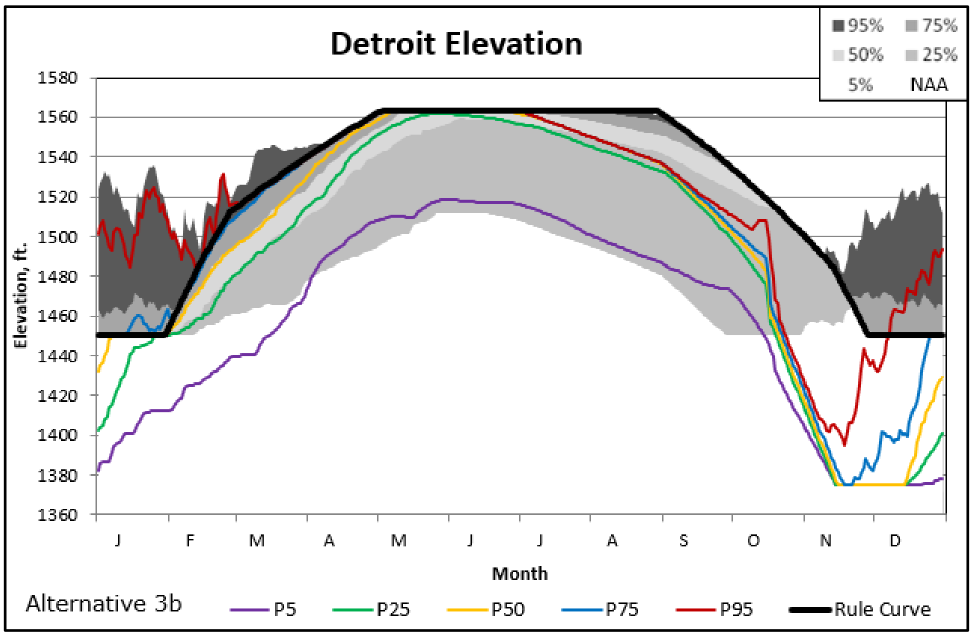

Figure 3.2-121. Alternative 3B Detroit Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

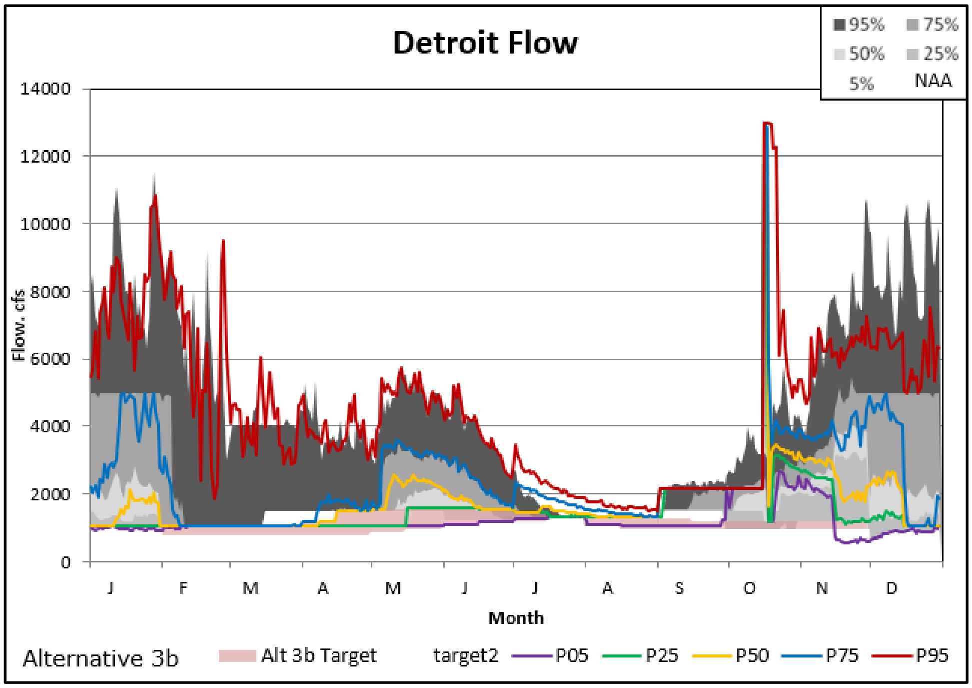

Figure 3.2-122. Alternative 3B Detroit Reservoir Outflow Non-exceedance as Compared to the No-action Alternative.

The steep draft of the reservoir, though still within ramping rate regulations, to meet the deeper fall reservoir drawdown would require a period of bankfull outflows during October, which would not occur under the NAA. WVS operations typically would change more slowly than the maximum allowable, so the flow would be spread out over a longer period if possible. However, USACE would not always achieve the deeper fall reservoir drawdown target elevation at Detroit Reservoir of 1,375 feet under Alternative 3B. Along with reduced outlet capacity, early fall rain events would limit the ability to reach the drawdown target elevation.

Although there would be generally lower flow during some periods downstream of Detroit Reservoir as compared to the NAA, the integrated temperature and habitat flow regime targets would be met more often under Alternative 3B than the 2008 NMFS Biological Opinion targets under the NAA. The largest target miss would occur in late November of the driest years (Figure 3.2-122, P05 line). The reservoir water surface elevation would already be lowered to the deeper fall reservoir drawdown elevation and then would pass inflow for the duration of the operation. The inflow would not be enough to meet the target in these years but would be enough in 75 percent of the period of record (Figure 3.2-122, P25 line).

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

USACE would operate Green Peter Reservoir with both spring and fall reservoir drawdowns to elevation 780 feet under Alternative 3B, substantially changing the typical operating range of the reservoir. These elevations would be achieved about half the time due to higher inflows and decreased outlet capacity. During an average year, the reservoir would pass inflow from August to October, which would typically be below the downstream target streamflow (Figure 3.2-123, P50 line).

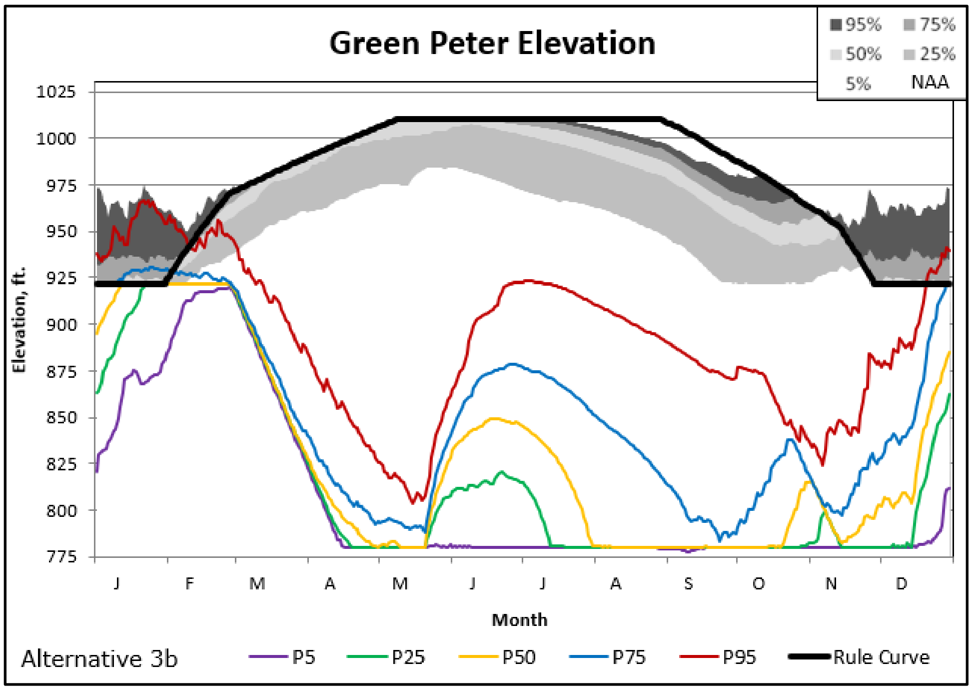

Figure 3.2-123. Alternative 3B Green Peter Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

During an average and drier year, operations at Foster Reservoir would draft down to its minimum pool to supplement downstream flows, whereas Foster Reservoir operations would closely follow its rule curve under the NAA (Figure 3.2-124). Alternative 3B is the only alternative in which this operational scenario would occur.

The Foster Dam pool is less than one-tenth the volume of the Green Peter Dam pool (28.3 thousand acre-feet and 312.5 thousand acre-feet, respectively), so it would reach its minimum pool elevation within a few weeks of starting to draft. In an average year, the Foster Reservoir water surface elevation would start to fall in early August. The reservoir would start to fall in the middle of June during the driest years.

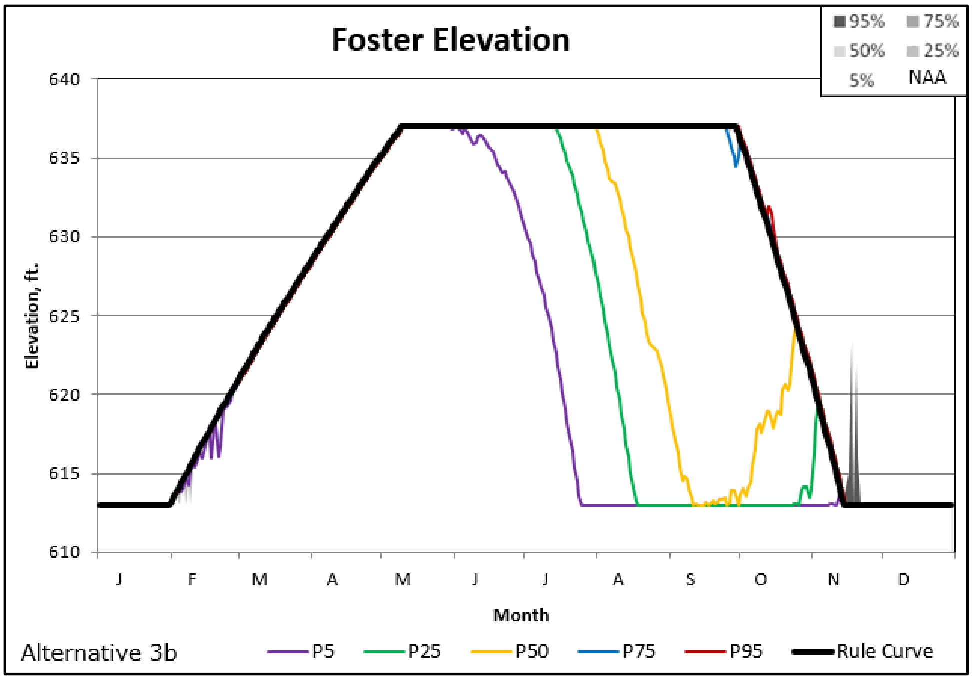

Figure 3.2-124. Alternative 3B Foster Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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The flow downstream of Foster Reservoir (which combines outputs from Foster and Green Peter Reservoirs and the South Santiam River upstream of Foster Reservoir) would change substantially from the downstream flow under the NAA (Figure 3.2-125). Spring flows would be higher across water years as USACE releases water from Green Peter Reservoir for its spring drawdown. Flows would fall suddenly in mid-May as Green Peter Reservoir operations start to refill afterward.

The lower bound of the integrated temperature and habitat flow regime target would only be met in wetter-than-average years under Alternative 3B (Figure 3.2-125, P75 line). The driest years would fall short from May until November, even as operations under Alternative 3B uniquely draft Foster Reservoir's small storage capacity. The typical outflow from Foster Reservoir in the fall for a drier-than-average year would be 100 cfs to 350 cfs, compared to the minimum target flow of 840 cfs under Alternative 3B.

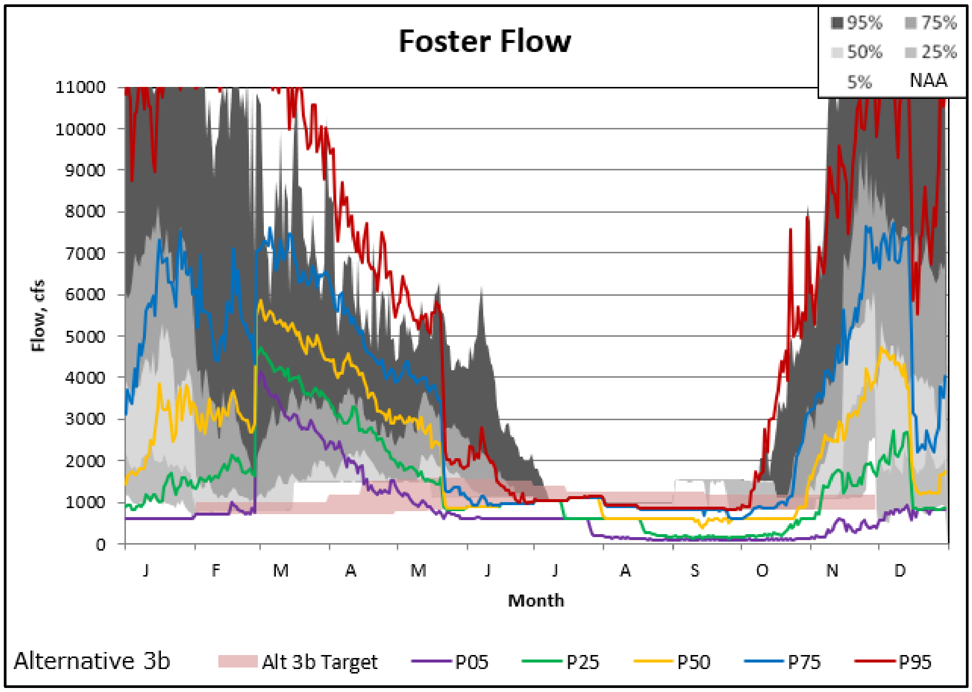

Figure 3.2-125. Alternative 3B Foster Reservoir Outflow Non-exceedance as Compared to the No-action Alternative.

The Santiam River at Jefferson would be affected by the changes at Detroit Reservoir in the North Santiam River Subbasin and at Green Peter Reservoir in the South Santiam River Subbasin under Alternative 3B (Figure 3.2-126). Higher flows would be evident when the reservoirs draft to the drawdowns (principally March at Green Peter Reservoir and October for both reservoirs) compared to the NAA. There would also be a larger variation in summer flow under Alternative 3B, with more flow in the wettest years and less flow in the driest years. The primary driver of seasonal flow variation would be the drawdowns rather than the flow targets for the Jefferson control point.

Although there would be many relatively minor differences, the largest operational difference between Alternative 3A and Alternative 3B would be the larger outflow from Detroit Reservoir in preparation for the deeper fall drawdown. Although there would be a spike in flow in October, it would be well within bankfull flows and unlikely to be the highest flow in any given year.

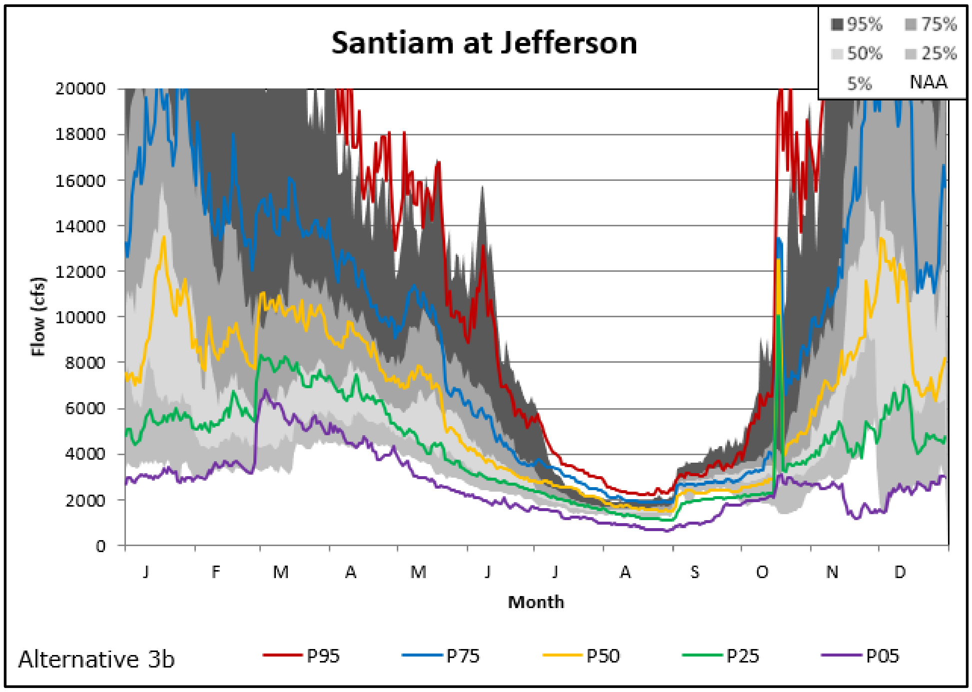

Figure 3.2-126. Alternative 3B Santiam River at Jefferson, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Long Tom River Subbasin

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Water surface elevations within Fern Ridge Reservoir would show negligible changes under Alternative 3B as compared to the NAA (Figure 3.2-127). Downstream flows at Monroe would also remain unchanged under Alternative 3B as compared to the NAA.

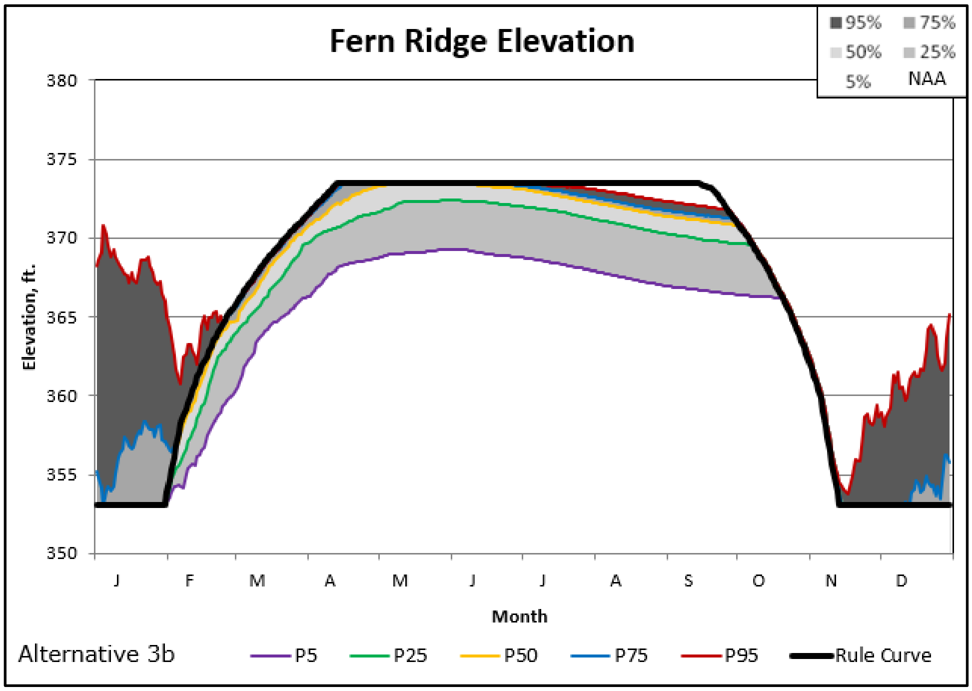

Figure 3.2-127. Alternative 3B Fern Ridge Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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McKenzie River Subbasin

Like Green Peter Reservoir in the Santiam River Subbasin, there would be spring and fall drawdowns at Cougar Reservoir under Alternative 3B (Figure 3.2-128). Although both drawdowns would also occur under Alternative 3A, Alternative 3B operations would draft Cougar substantially lower using the diversion tunnel to elevation 1,330 feet instead of the regulating outlet to elevation 1,517 feet. The reservoir water surface elevation would only be at or above minimum conservation pool at the end of winter and only in the wettest summers, which would be a substantial change from the NAA (Figure 3.2-128, P95 line). The spring reservoir drawdown target elevation would be achieved in an average year, but not the fall elevation (Figure 3.2-128, P50 line).

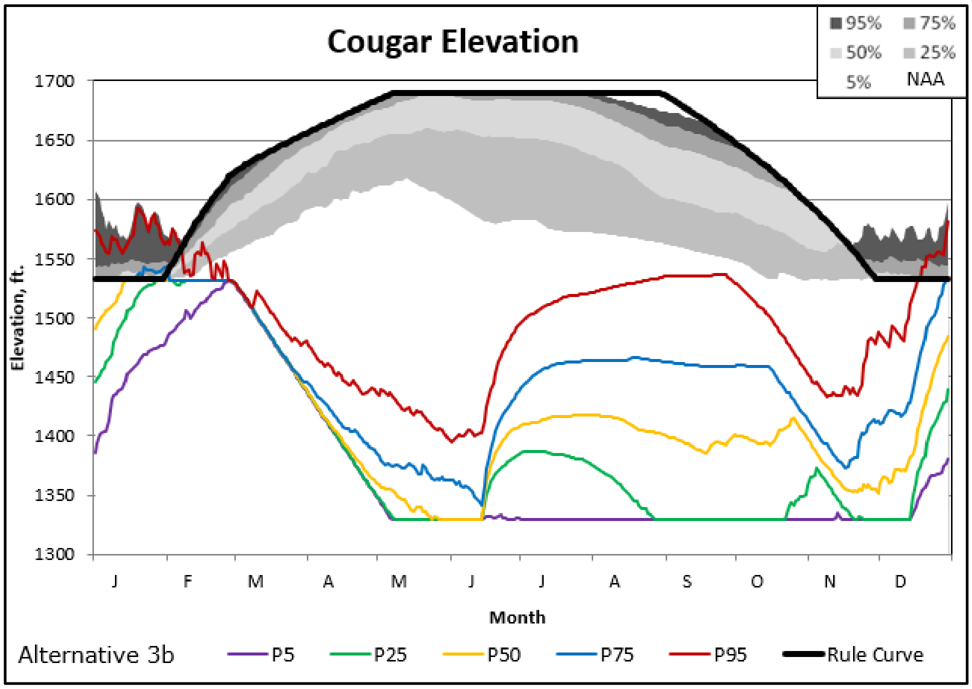

Figure 3.2-128. Alternative 3B Cougar Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

USACE would fill Blue River Reservoir more frequently under Alternative 3B operations as compared to the NAA due to the lower downstream integrated temperature and habitat flow regime targets (Figure 3.2-129). USACE would also draft the reservoir more quickly in the summer to compensate for the lower storage volume available from Cougar Reservoir. Blue River Reservoir would operate to a deeper fall reservoir drawdown to elevation 1,165 feet.

Overall, Alternative 3A and Alternative 3B would be very similar at Blue River Reservoir, except for the driest Octobers. Mainstem flow targets would dictate that USACE continue to augment instream flows by using the inactive pool at Blue River Reservoir under Alternative 3A. Under Alternative 3B, other WVS reservoirs—Lookout Point in particular—would meet this downstream need in the driest years.

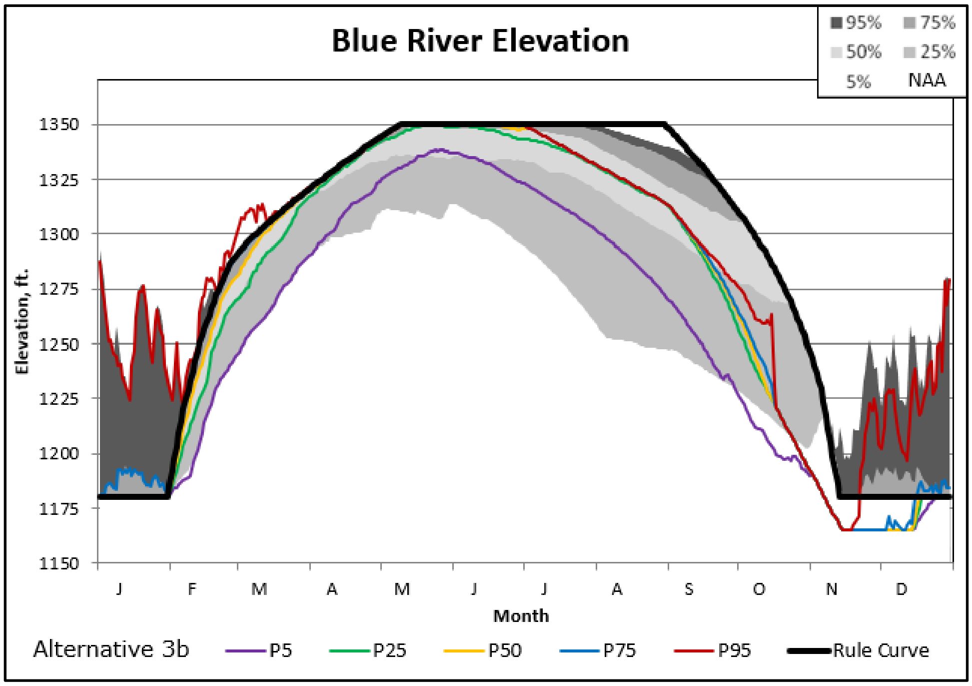

Figure 3.2-129. Alternative 3B Blue River Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

The downstream control point, the McKenzie River at Vida, shows the combined effect of more and less available conservation storage at Blue River and Cougar, respectively, compared to the NAA (Figure 3.2-130). The higher flows during March for all years and continuing into April and May of wet years would result from Cougar Reservoir operations not filling during the conservation season as it would under the NAA. The lower flows during the driest years of April to June would be due to USACE filling Blue River Reservoir more while also meeting the lower minimum downstream integrated temperature and habitat flow regime targets.

During the summer, Alternative 3B flows would be marginally below the NAA as the increased storage at Blue River Reservoir and no storage at Cougar Reservoir nearly balance out (Blue River Reservoir is smaller than Cougar Reservoir, so flows would be a slightly lower across the summer months). Despite the much lower water surface elevations at Cougar Reservoir under Alternative 3B as compared to Alternative 3A, the amount of volume in the reservoir above the minimum elevation (1,330 feet and 1,517 feet under Alternative 3B and Alternative 3A, respectively) would be similar across the summer months. Therefore, combined with the relatively high baseflow in the McKenzie River, the lower drawdown elevation would only have small effects on the summer and fall flow at Vida.

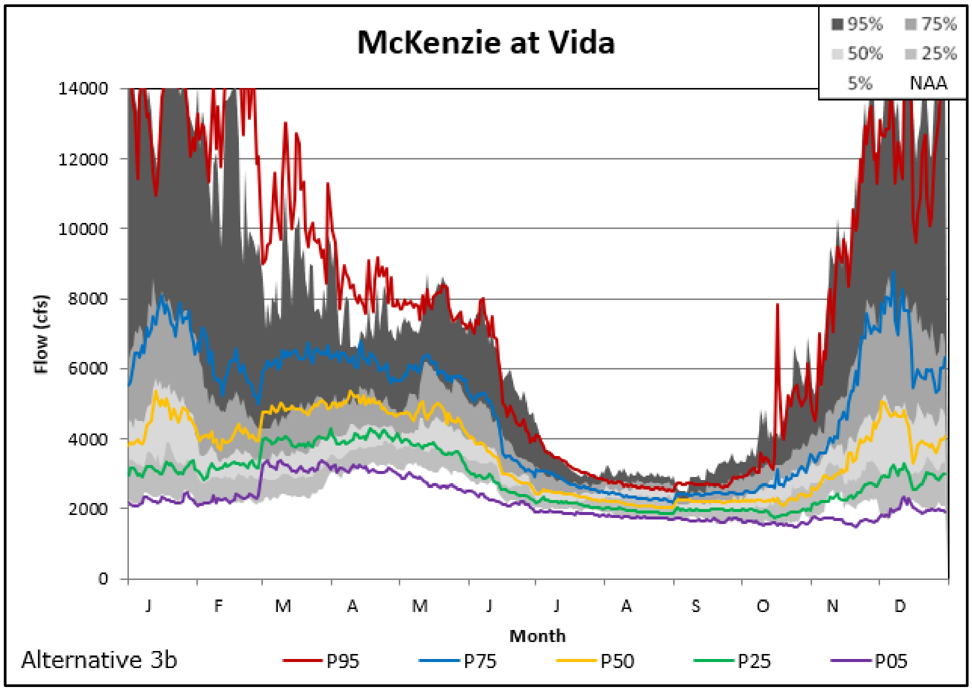

Figure 3.2-130. Alternative 3B McKenzie River at Vida, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Middle Fork Willamette River Subbasin

Under Alternative 3B, USACE would operate Hills Creek, Lookout Point, and Fall Creek Reservoirs for deeper fall drawdowns. The fall drawdown at Fall Creek Reservoir would occur as under the NAA. There would be a spring drawdown at Hills Creek Reservoir under Alternative 3B. As such, Hills Creek Reservoir operations would not fill more than about 10 feet above its minimum elevation 75 percent of years during the summer, which is substantially less frequent than under the NAA (Figure 3.2-131). The drawdown target elevation would be achieved in the wettest years in contrast to deeper drawdowns at other WVS reservoirs (Figure 3.2-131, P95 line).

During spring conservation storage season, USACE would fill Lookout Point Reservoir more frequently and achieve a higher elevation during dry years as compared to the NAA (Figure 3.2-132). This would be due to the lower integrated temperature and habitat flow regime targets. Additionally, the flow passing through Hills Creek Reservoir during the spring drawdown would be stored at Lookout Point Reservoir.

Because a lower amount of water would be stored in the system overall, Lookout Point Reservoir would be drafted earlier than under the NAA. This would occur before releasing water at a higher rate than under the NAA for the deeper fall reservoir drawdown. The drawdown target elevation would usually, but not always, be achieved (Figure 3.2-132, P75 line reaches the target, but the P95 line does not).

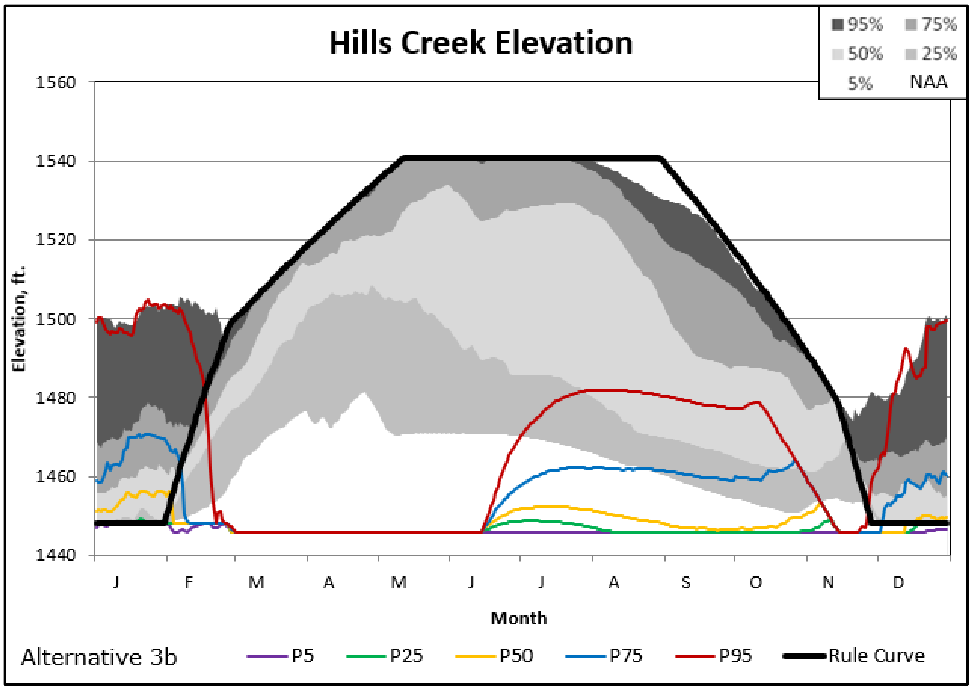

Figure 3.2-131. Alternative 3B Hills Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

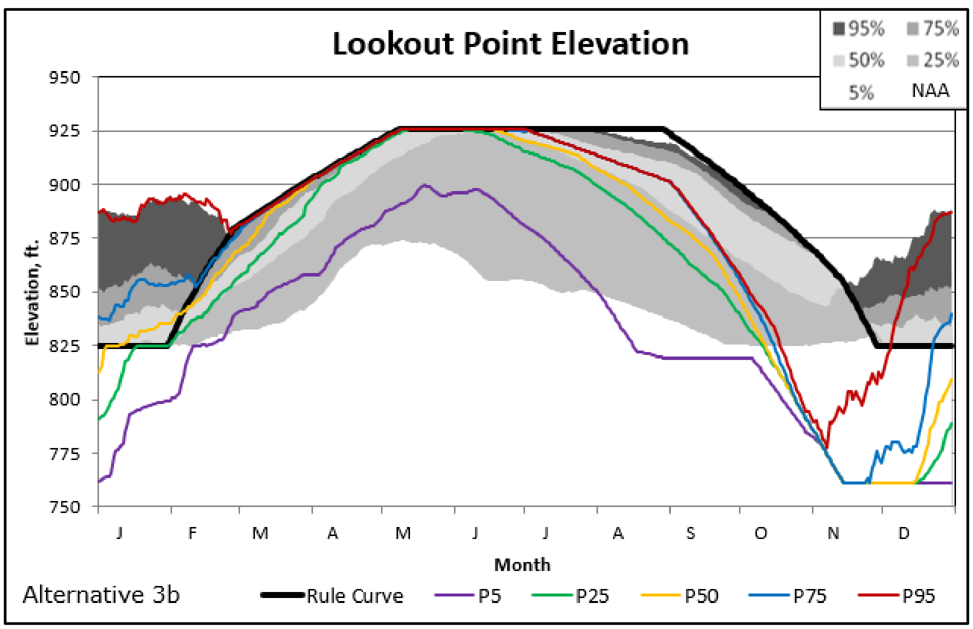

Figure 3.2-132. Alternative 3B Lookout Point Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Fall Creek Reservoir water surface elevations and outflows would be substantially similar to the NAA, where a deeper fall reservoir drawdown would continue to be implemented to the same elevation as under Alternative 3B (Figure 3.2-133).

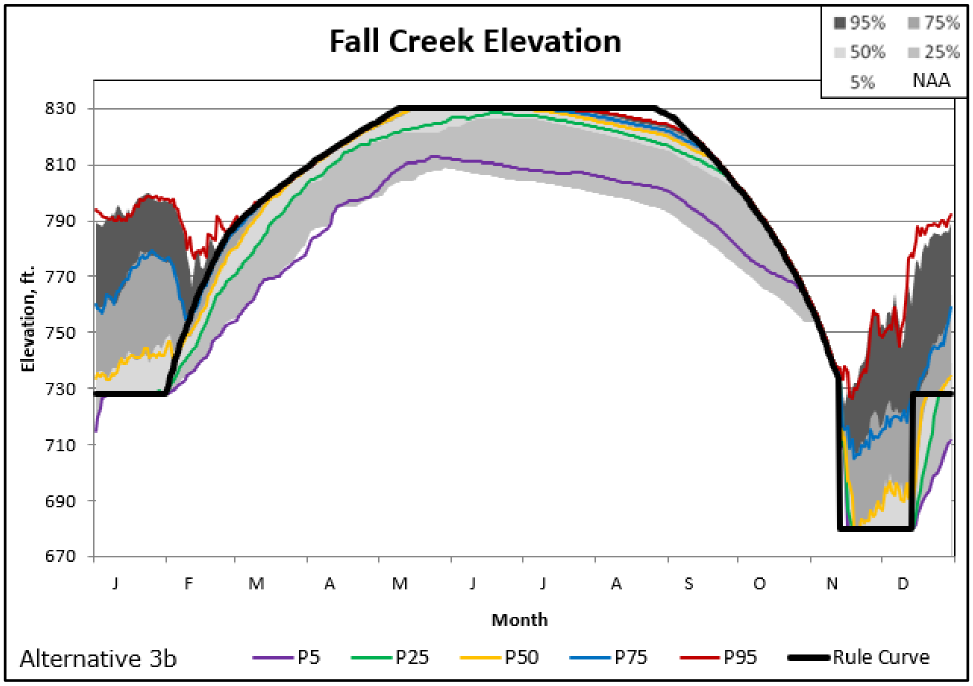

Figure 3.2-133. Alternative 3B Fall Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Flows at the control point for the Middle Fork Willamette River Subbasin WVS dams at Jasper would be more like the NAA under Alternative 3B than under Alternative 3A (Figure 3.2-134). Because Hills Creek Reservoir, which is upstream of Lookout Point Reservoir, would be operated for a spring reservoir drawdown under Alternative 3B, Lookout Point Reservoir could store some of the water that flows from Hills Creek Reservoir during the spring. Lookout Point Reservoir is also more than 40 percent larger than Hills Creek Reservoir (336.4 thousand acre-feet and 234 thousand acre-feet, respectively), so Alternative 3B conservation season storage volumes would be higher compared to Alternative 3A.

The driest year flows during April to June are due to the lower integrated temperature and habitat flow regime targets downstream, which are met under Alternative 3B (Figure 3.2-134, P5 line). The lower flows during the driest August through October periods would coincide with Lookout Point Reservoir reaching its minimum water surface elevation outside of the drawdown target, at which point it would pass inflow. This would be lower than the augmented flow under the NAA.

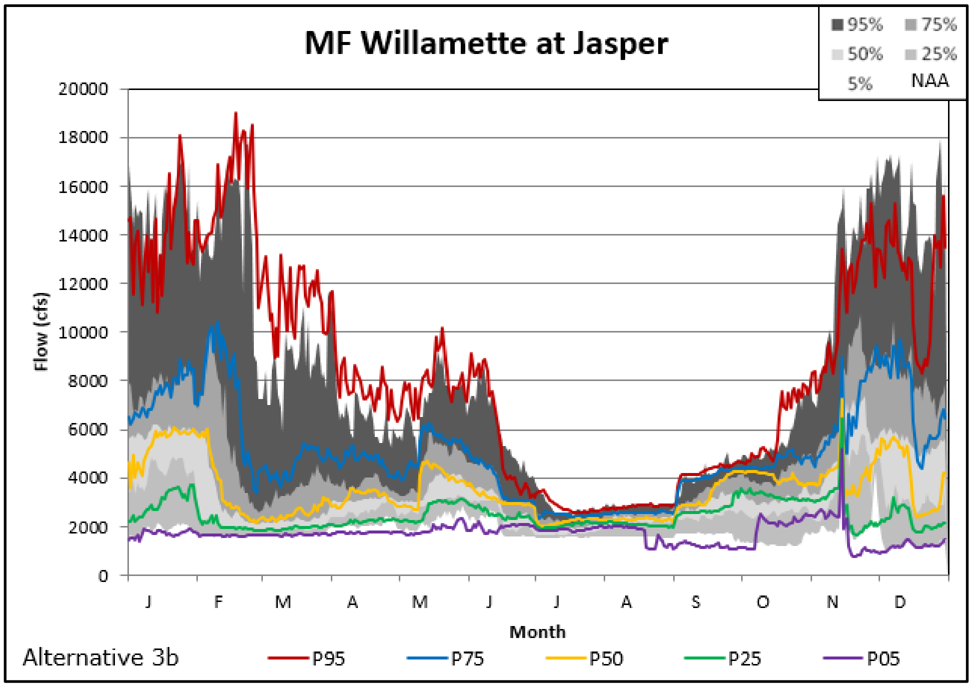

Figure 3.2-134. Alternative 3B Middle Fork Willamette River at Jasper, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Coast Fork Willamette River Subbasin

Dorena and Cottage Grove Reservoir elevations would behave similarly under Alternative 3B, (Figure 3.2-135 and Figure 3.2-136, respectively). Alternative 3B operations would refill these reservoirs to slightly higher levels than under the NAA due to the lower integrated temperature and habitat flow regime targets downstream. Reservoir storage would be similar for average and wet years throughout the summer and fall.

USACE would draft both reservoirs faster from higher initial water surface elevations in dry years as compared to the NAA because these reservoirs make up for the lower storage elsewhere in the WVS. In especially dry falls, the reservoirs would augment instream flows by using the inactive pool. This operation would be activated slightly more often under Alternative 3B as compared to Alternative 3A.

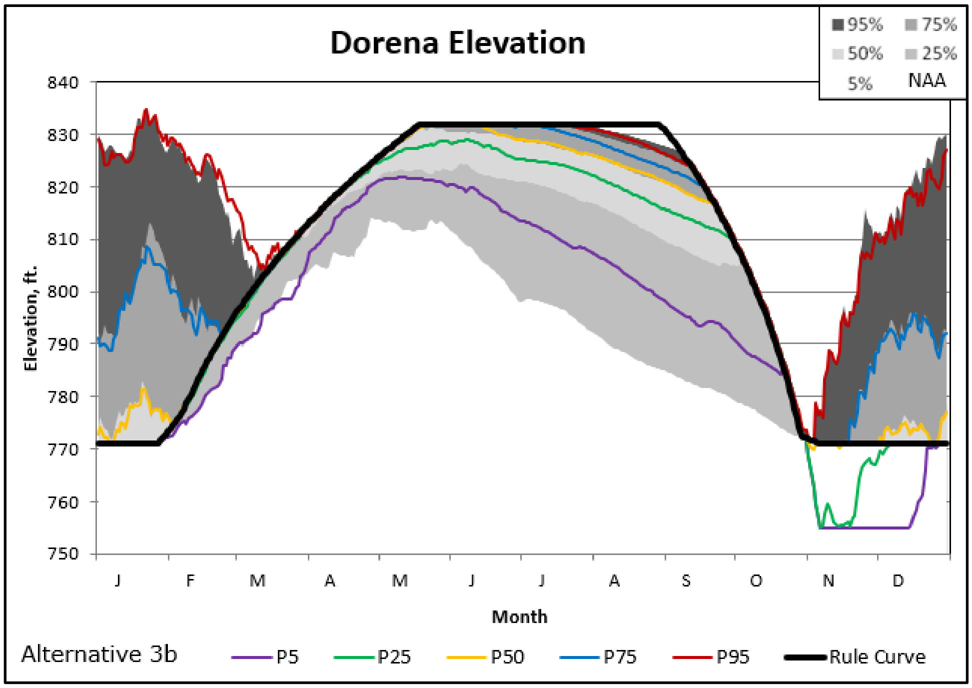

Figure 3.2-135. Alternative 3B Dorena Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

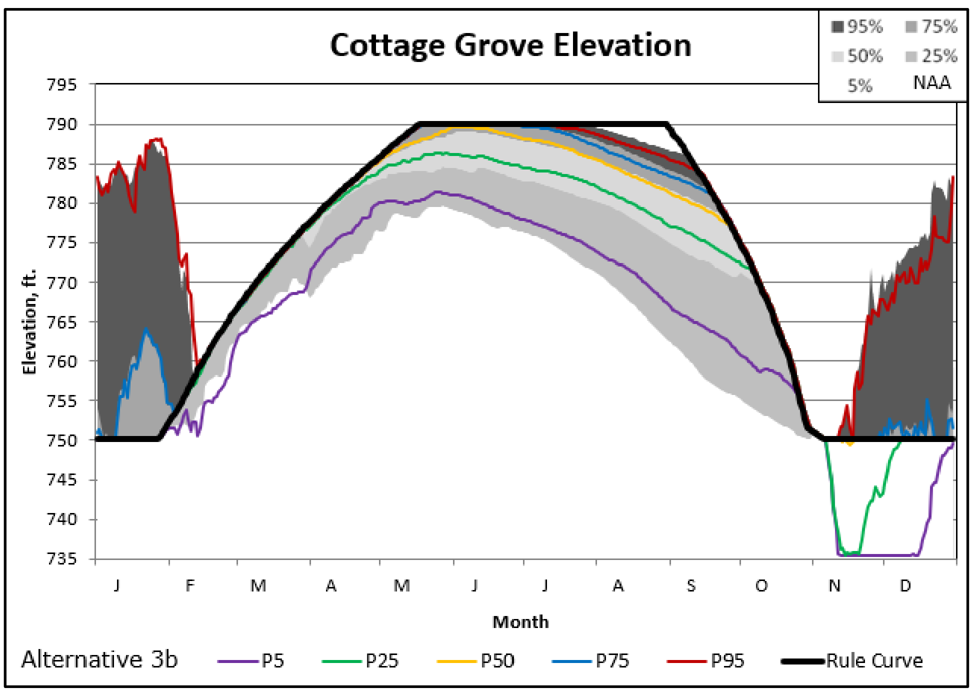

Figure 3.2-136. Alternative 3B Cottage Grove Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

The flow at Coast Fork Willamette River at Goshen would vary most from the NAA in dry years under Alternative 3B (Figure 3.2-137). The additional stored water accumulated in Dorena and Cottage Grove Reservoirs would be evident by the decreased flow from April to June and increased flow in July to October as USACE releases that water. Although there would be minor differences, Alternative 3A and Alternative 3B would be similar at Goshen from a hydrologic perspective.

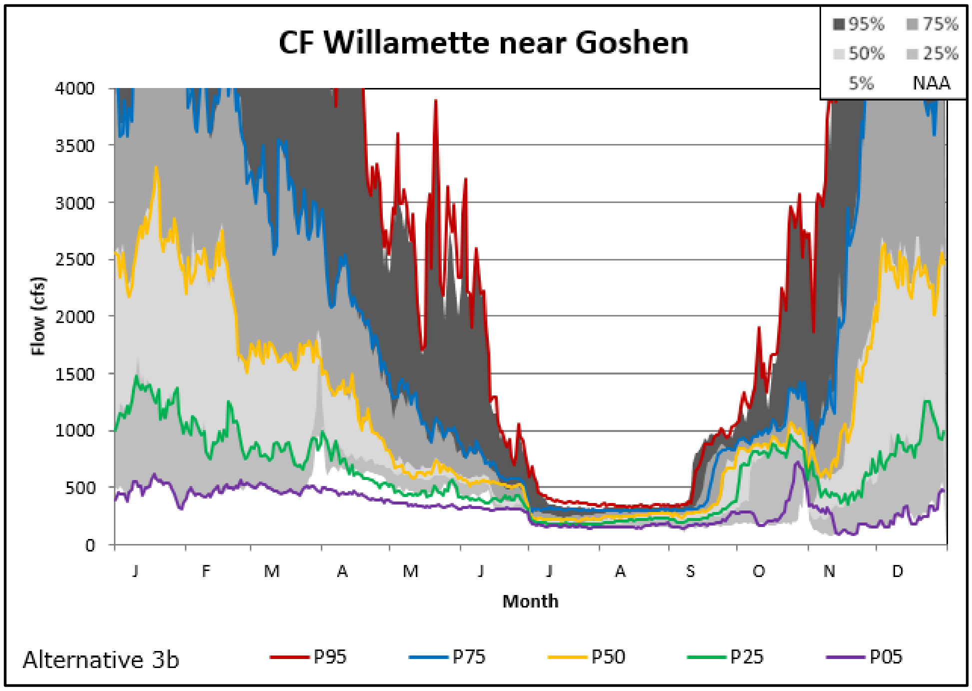

Figure 3.2-137. Alternative 3B Coast Fork Willamette River at Goshen, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Mainstem Willamette River Subbasins

The Alternative 3B flow targets on the mainstem Willamette River at Albany and Salem are the integrated temperature and habitat flow regime targets, which are lower than the 2008 NMFS Biological Opinion targets under the NAA and would modify the target at Salem during warm weather (the target box in the figure) (Figure 3.2-138 and Figure 3.2-139, respectively) (Chapter 2, Alternatives, Section 2.8.1, Flow Measures).

In wet years, operations under Alternative 3B would result in consistently higher flow during the springtime at both Albany and Salem as compared to operations under the NAA. Lower flow in the spring would occur in the driest years due to the lower flow target at Salem.

After the end of the WVS spring reservoir drawdown operations, flows under Alternative 3B would decline across all years, but not as steeply as under Alternative 3A. The integrated temperature and habitat flow regime target would be met more often during dry years than operations under the NAA would meet the 2008 NMFS Biological Opinion target.

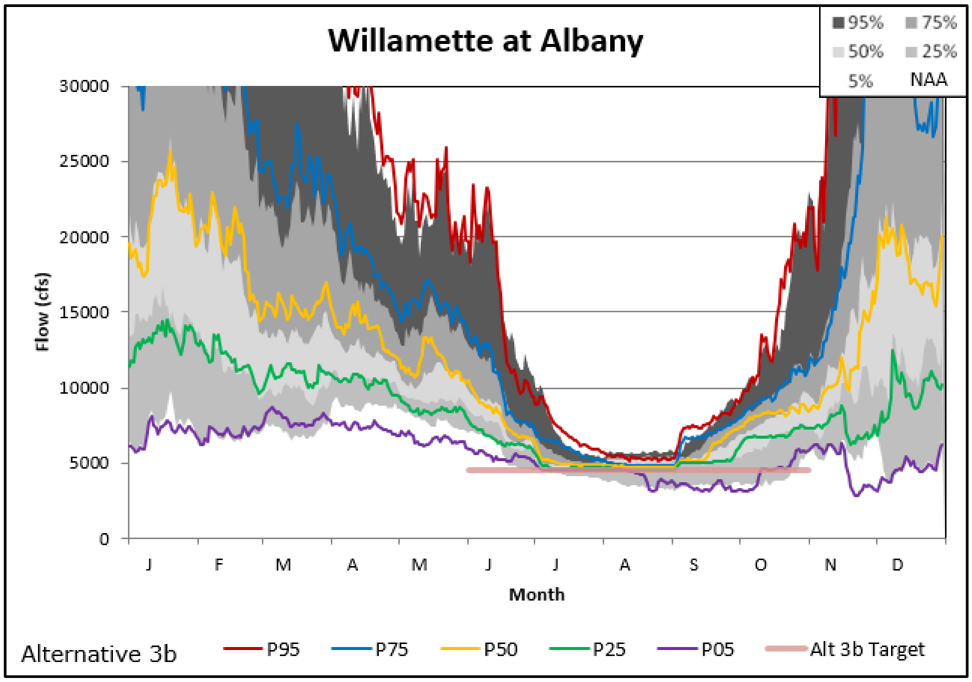

Figure 3.2-138. Alternative 3B Willamette River at Albany, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

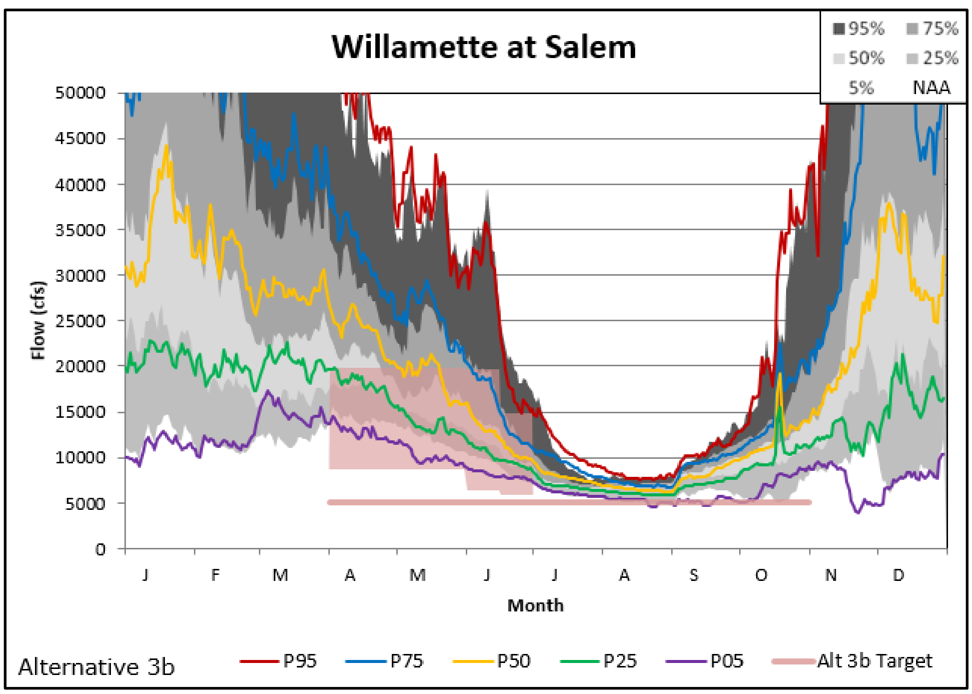

Figure 3.2-139. Alternative 3B Willamette River at Salem, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

During wetter years, lower overall system storage would mean less flow (Figure 3.2-138, P95 and P75 lines) than under the NAA. In the driest years (Figure 3.2-138, P05 line), flows would be below the target for about 2 months less than under the NAA operations. Across all water year types, flows would be higher at Albany under Alternative 3B than under Alternative 3A. This would be largely due to the Middle Fork Willamette River spring reservoir drawdown switching from Lookout Point Reservoir to Hills Creek Reservoir under Alternative 3B; Lookout Point would be able to store some of the water released from Hills Creek Reservoir during its spring drawdown.

Flows at Salem would more consistently meet the integrated temperature and habitat flow regime target under Alternative 3B than under Alternative 3A, also due to the flow contributions of Lookout Point Reservoir. Spring flows would be lower for drier years, as the flow target is lower than under the NAA, and higher for wetter years because USACE would release water from WVS reservoirs with drawdowns that would have been stored under the NAA.

Summer flow at Salem would be generally somewhat less than under the NAA but would only miss the integrated temperature and habitat flow regime target during the driest years (Figure 3.2-139, P05 line) when Lookout Point Reservoir reaches its minimum summer pool. This would coincide with low flows at Albany; however, augmentation from the Santiam River Subbasin means there would be fewer missed target days at Salem.

Interim Operations under Alternative 3B

Effects to hydrologic processes under the Alternative 3B Interim Operations would be the same as those described under Alternative 2A (Section 3.2.2.3, Alternative 2A, Interim Operations under Alternative 2A).

Climate Change Effects under Alternative 3B

Effects to hydrologic processes from climate change under Alternative 3B would be similar to those described under Alternative 3A. Both the Albany and Salem flow targets would be met less frequently over the 30-year implementation timeframe compared to the NAA with projected lower late spring and summer flow. However, these differences would be less severe than under Alternative 3A.

The South Santiam River Subbasin has a lower average elevation, so it is projected to be relatively less affected by decreasing inflows over the 30-year implementation timeframe. Therefore, Green Peter Reservoir could fill more often after its Alternative 3B spring reservoir drawdown as compared to Detroit Reservoir fill (a spring reservoir drawdown would occur at Detroit Reservoir under Alternative 3A). Further, Lookout Point Reservoir can store some of the water released from Hills Creek Reservoir during the spring drawdown under Alternative 3B, increasing its chance of complete refill.

After the deeper fall reservoir drawdowns, there would be additional storage space between the minimum drawdown elevation and the maximum flood storage elevation under Alternative 3B. In contrast, it would typically take until the middle of January (though timing varies throughout the WVS) for reservoirs to return to their current rule curve elevation under the NAA. Downstream winter flows under Alternative 3B could be kept similar to the NAA with this additional storage capacity, despite projected increased winter peak flow and volume from climate change. Conversely, increased reservoir evaporation from increased climate change-induced temperatures would marginally decrease available water from all WVS reservoirs.

Alternative 4—Improve Fish Passage with Structures-based Approach

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From a hydrologic perspective, Alternative 4 operations would be similar to Alternative 1, with a different set of flow targets in the subbasins below the dams and in the mainstem Willamette River. Alternative 4 shifts the release of stored water from the spring into the summer and fall, but integrated temperature and habitat flow regime targets are generally higher and more variable than those in the Congressionally authorized minimum flows under Alternative 1.

The integrated temperature and habitat flow regime would modify the minimum targets at a WVS reservoir if it is at more or less than 90 percent of rule curve elevation under Alternative 4. (Chapter 2, Alternatives, Section 2.8.1.1, Integrated Temperature and Habitat Flow Regime (Measure 30a)).

In general, Alternative 4 would have limited hydrologic process effects during an average or wet year in the Willamette River Basin. USACE operations would fill WVS reservoirs during these years while meeting downstream flow targets. Summer flows would be sometimes slightly higher than under the NAA due to reservoirs reaching maximum pool somewhat earlier. Therefore, the reservoirs would pass additional inflow sooner under Alternative 4, but flow differences would be minimal as compared to the NAA.

Alternative 4 would alter storage in drier than average years, shifting flow releases from April to June into July through October. This would result in less flow compared to the NAA earlier in the year during the April to June period. Later flow targets from July to October would be met more frequently due to the additional accumulated stored water. Compared to Alternative 1, the flows are similar or higher across the WVS, so reservoir elevations would be somewhat lower than under Alternative 1.

Although there would be many structural activities under Alternative 4 at the WVS dams to aid fish survival, many of these would not affect the flow out of any WVS reservoir. Only those structures that affect some aspect of flow, such as outlet choice, are included in this analysis. A detailed analysis of Alternative 4 by subbasin is provided below.

The shift in releases of stored water to a different season under Alternative 4 would be a substantial hydrologic change throughout the Willamette River Basin and would result in long-term changes.

END REVISED TEXT

Santiam River Subbasin

USACE would fill Detroit Reservoir more often during the conservation use season and would achieve a higher elevation in years when it would not reach maximum conservation elevation, as compared to the NAA (Figure 3.2-140). The integrated temperature and habitat flow regime flow target would be lower than under the NAA flows during drier years. More water would be released from storage during average and wetter years; therefore, the reservoir water surface elevation would meet the rule curve later in the year at levels above the P50 non-exceedance line.

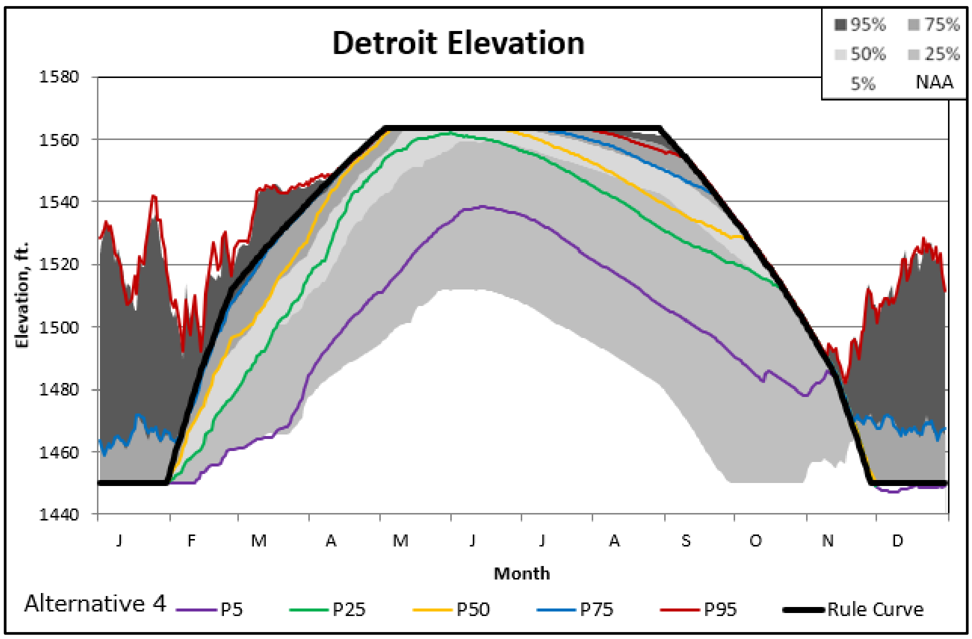

Figure 3.2-140. Alternative 4 Detroit Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

USACE would fill Green Peter Reservoir to about the same levels or higher in the spring; elevations would then be lower in the summer and fall as compared to the NAA elevations (Figure 3.2-141). These differences would be driven by the integrated temperature and habitat flow regime flow targets downstream of Foster Reservoir and how they differ from the 2008 NMFS Biological Opinion flow targets.

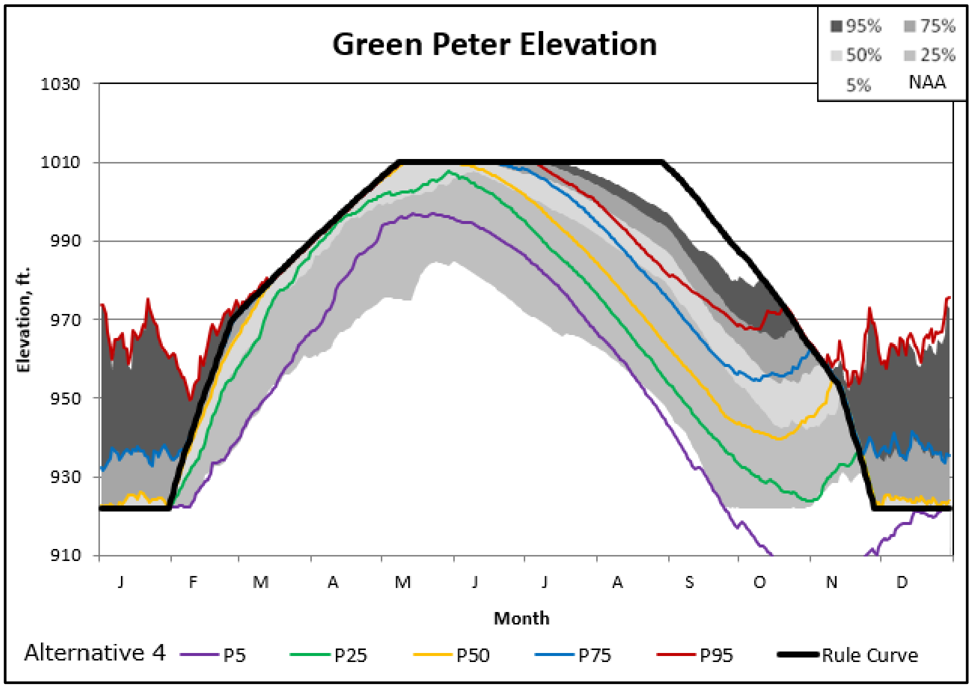

Figure 3.2-141. Alternative 4 Green Peter Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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The flow comparison out of Foster Reservoir shows the shift of water releases from spring to summer and fall in the South Santiam Subbasin under Alternative 4 when compared to the NAA (Figure 3.2-142). The flow from the reservoir would meet the integrated temperature and habitat flow regime target range across the year, though this target is below the NAA 2008 Biological Opinion target during the spring. Moving into summer, USACE would meet the target range throughout the summer under Alternative 4, whereas USACE would be unable to meet the target in October in the driest years under the NAA. When Green Peter Reservoir would be below the minimum conservation pool elevation under Alternative 4, November flows would be below the NAA.

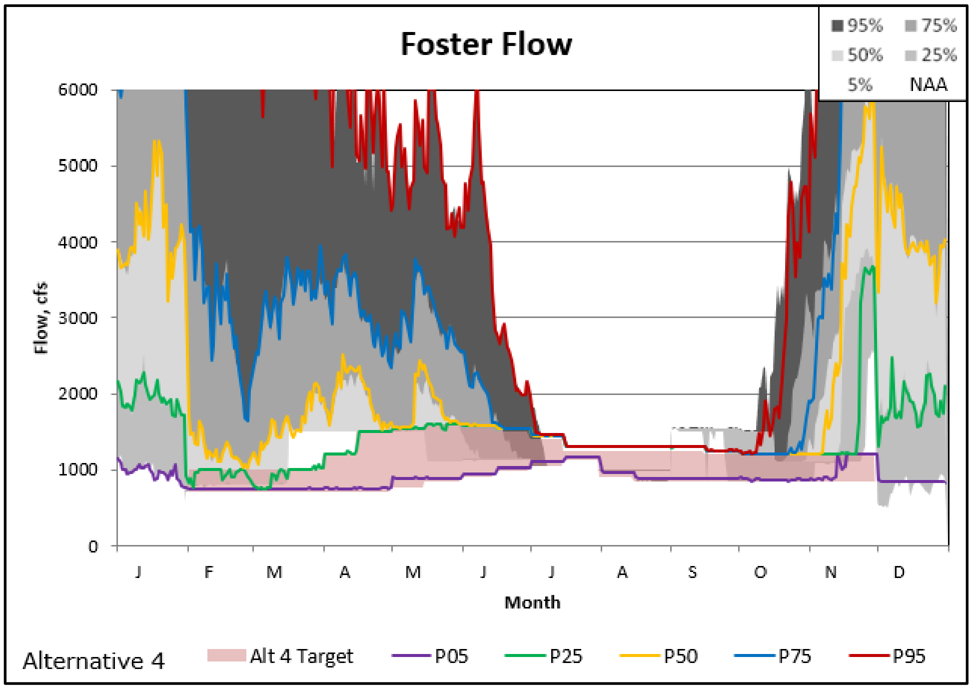

Figure 3.2-142. Alternative 4 Foster Reservoir Outflow Non-exceedance as Compared to the No-action Alternative.

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Although there would not be specific flow targets further downstream to the combined Santiam River control point at Jefferson, the revised flow targets from upstream would be evident under Alternative 4. Water stored during dry years from March to June would be released during the summer. Upstream summer integrated temperature and habitat flow regime targets would be higher than targets under the NAA, so Jefferson would show higher flows in all years (Figure 3.2-143). However, the higher September NAA flows are not included in the integrated temperature and habitat flow regime, so Alternative 4 would continue the summer trends instead of increasing as under the NAA.

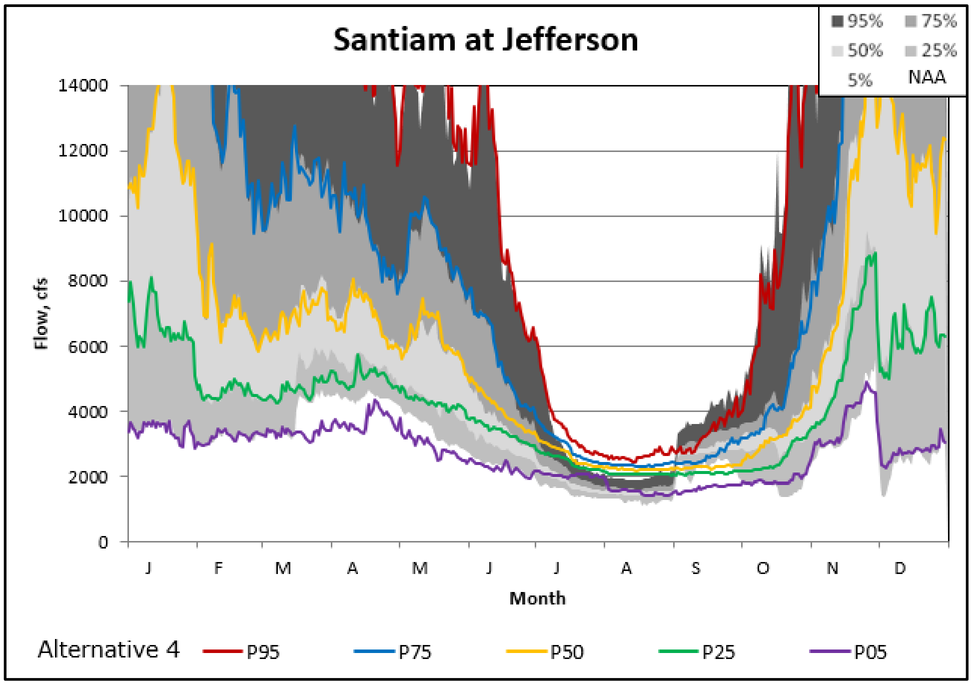

Figure 3.2-143. Alternative 4 Santiam River at Jefferson, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Long Tom River Subbasin

Water surface elevations within Fern Ridge Reservoir would show negligible changes under Alternative 4 as compared to the NAA (Figure 3.2-144). Downstream flows at Monroe would also remain unchanged under Alternative 4 as compared to the NAA.

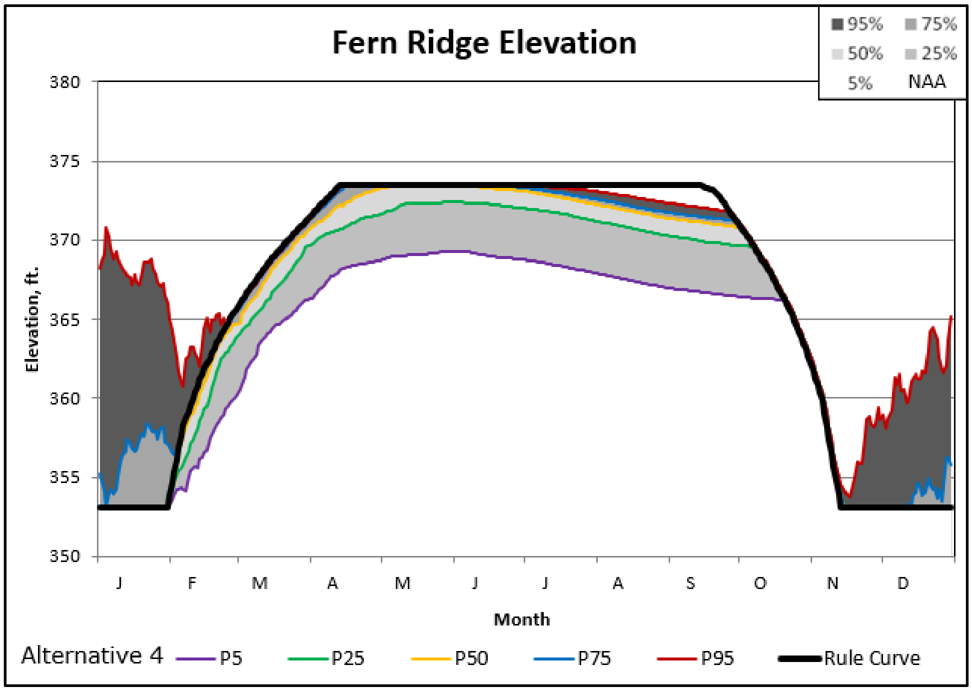

Figure 3.2-144. Alternative 4 Fern Ridge Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

McKenzie River Subbasin

Blue River and Cougar Reservoirs would fill to higher elevations under Alternative 4 operations in dry years due to the lower spring flow targets in the McKenzie River at Salem as compared to the NAA (Figure 3.2-145). USACE would fill both reservoirs in wetter years, so there would be limited difference in all years above the P25 line for the conservation season. Like Alternative 1, Alternative 4 would allow Blue River to augment instream flows by using the inactive pool below minimum conservation elevation and USACE would do so during drier than average Novembers.

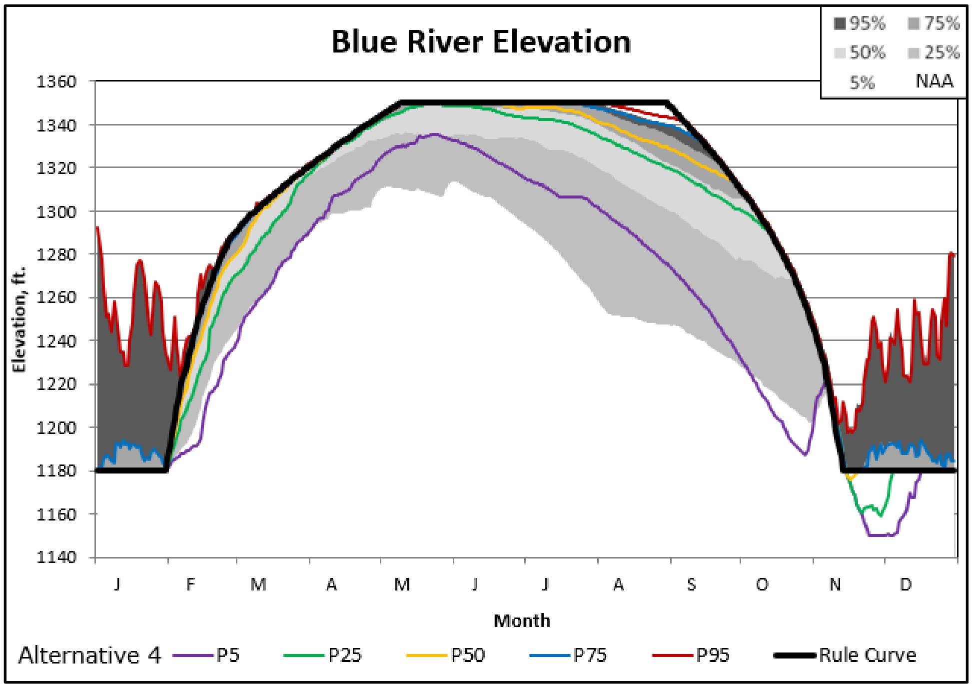

Figure 3.2-145. Alternative 4 Blue River Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Cougar Reservoir outflow would meet or exceed its integrated temperature and habitat flow regime target more often throughout the year than under the NAA operations (Figure 3.2-146). Like Alternative 4 targets at other locations, the flow targets below Cougar Dam would have a lower total volume but would be more variable over the year. Flow changes as compared to the NAA would be limited in wet years and have the effect of shifting flow from spring into summer and fall during dry years under Alternative 4.

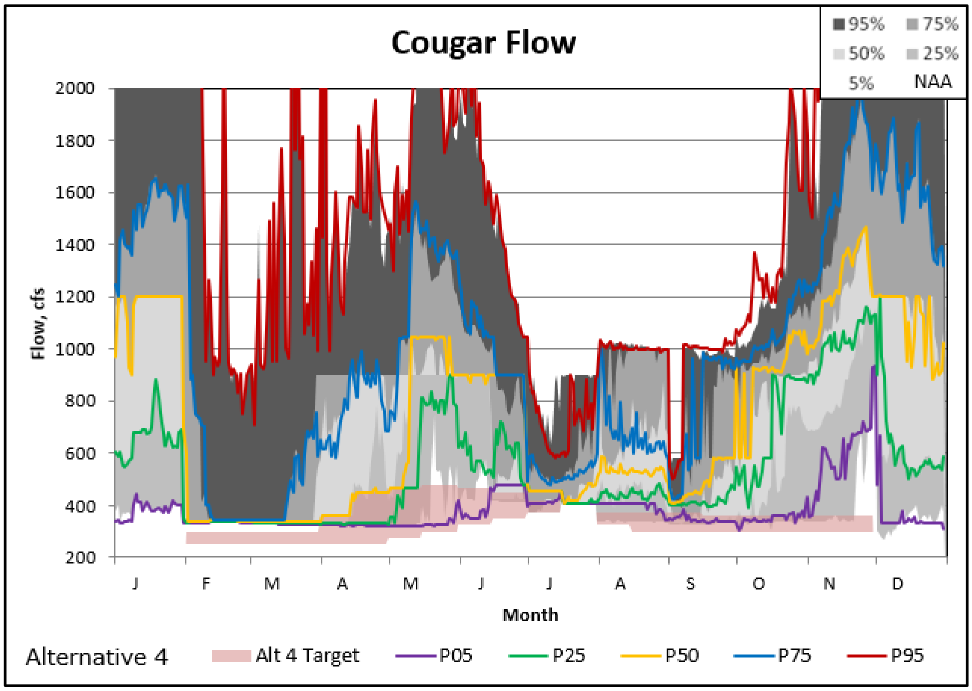

Figure 3.2-146. Alternative 4 Cougar Reservoir Outflow Non-exceedance as Compared to the No-action Alternative.

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The outflow downstream of Cougar Reservoir would be highly variable due to its proximity to the dam, but the variability would be consistent with the NAA (Figure 3.2-147). Further downstream, the McKenzie River at Vida shows the spring to summer flow shift in the drier years as compared to the NAA (Figure 3.2-147, P05 and P25 lines).

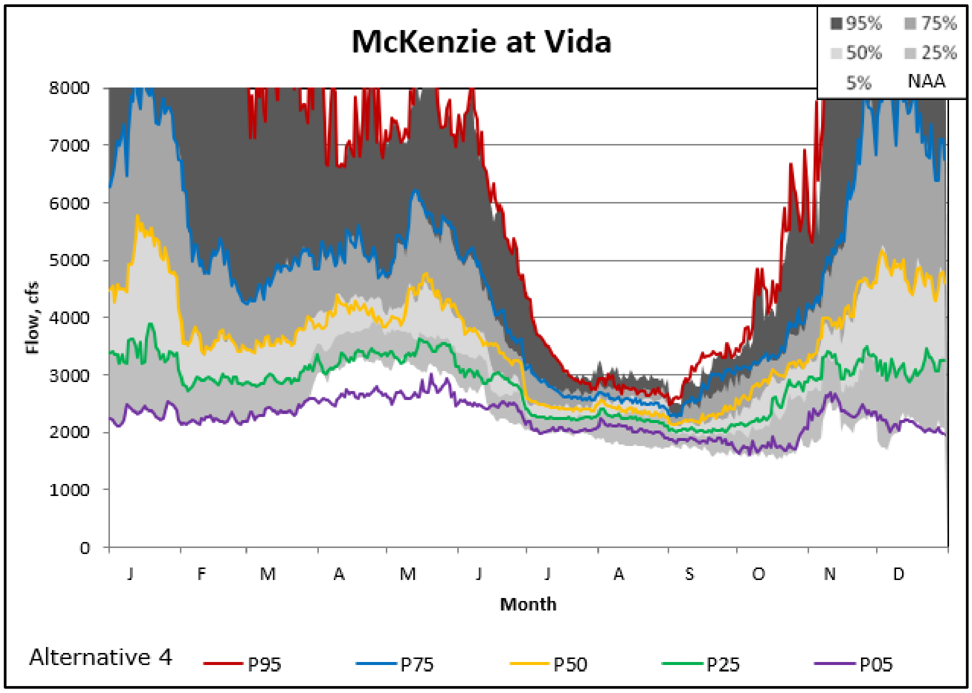

Figure 3.2-147. Alternative 4 McKenzie River at Vida, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Middle Fork Willamette River Subbasin

As under Alternative 1, USACE would initially fill Hills Creek Reservoir more quickly under Alternative 4 operations due to the lower downstream flow targets and would stay at similar elevations during wet years when compared to the NAA (Figure 3.2-148). During dry years, the Hills Creek Reservoir would augment instream flows by using the power pool to meet the flow target at Albany, going below the minimum conservation pool elevation under the NAA. Its capacity would be exhausted in the driest years, at which point Lookout Point Reservoir would supply additional water until it too reaches its minimum (Figure 3.2-149, P5 line).

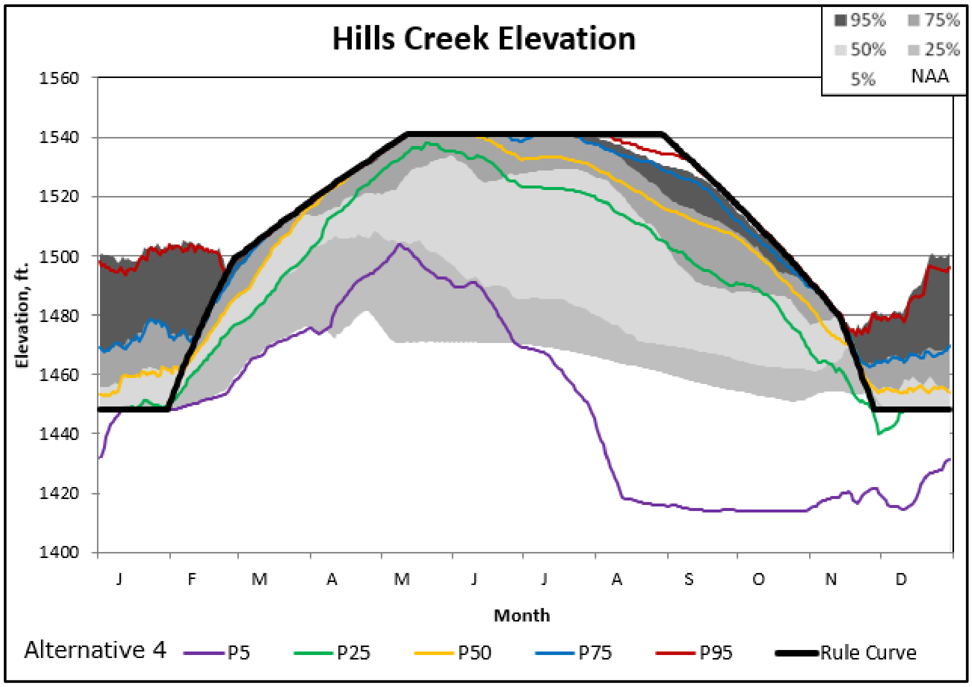

Figure 3.2-148. Alternative 4 Hills Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

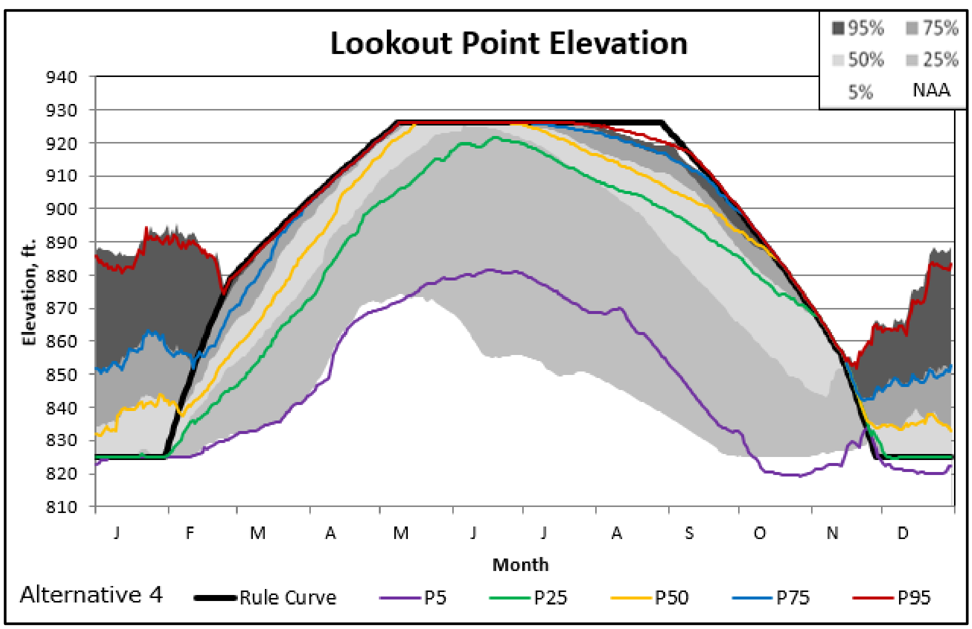

Figure 3.2-149. Alternative 4 Lookout Point Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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Fall Creek Reservoir would be able to provide some additional flow until its mid-November drawdown because water surfaces would be generally above the NAA (Figure 3.2-150).

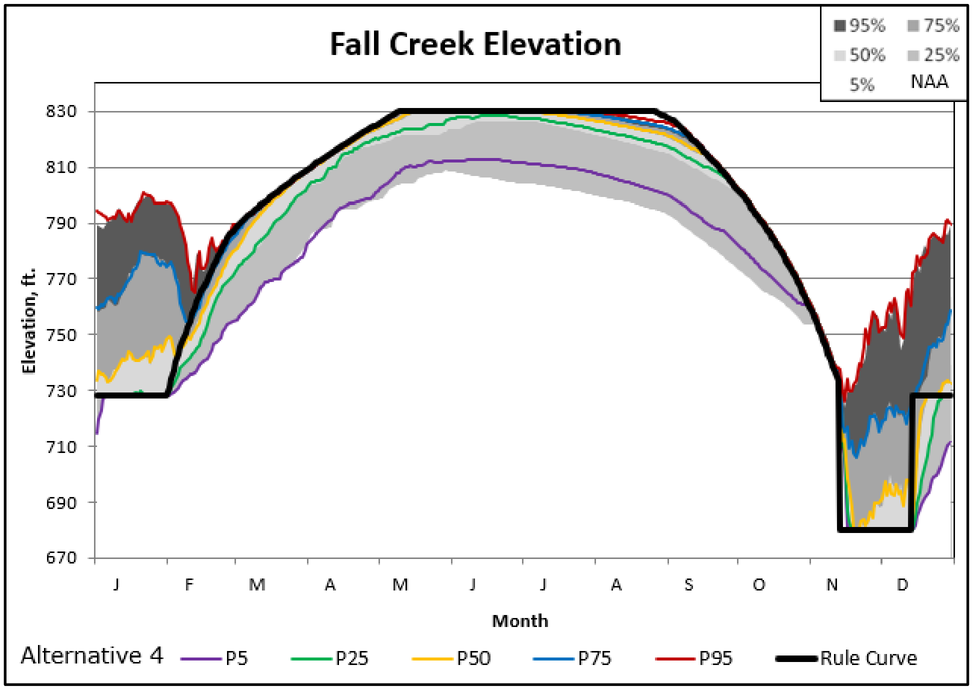

Figure 3.2-150. Alternative 4 Fall Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

At the downstream control point at Jasper, the dry year water release shift would be evident under Alternative 4, with lower flows in the spring and higher flows into the summer and fall compared to the NAA (Figure 3.2-151). Because reservoir pools would usually be at higher elevations leading into flood season, additional releases in October would occur across most water years under Alternative 4.

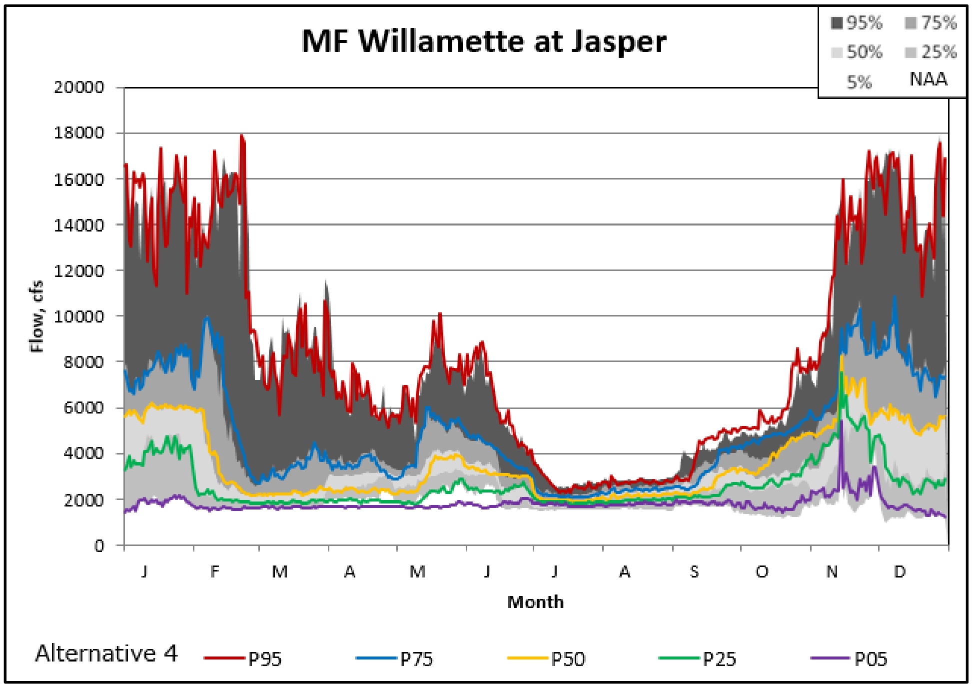

Figure 3.2-151. Alternative 4 Middle Fork Willamette River at Jasper, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Coast Fork Willamette River Subbasin

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Dorena and Cottage Grove Reservoirs would fill more quickly in spring under Alternative 4 operations and have generally higher water surface levels throughout the conservation season as compared to the NAA (Figure 3.2-152). Dorena and Cottage Grove Reservoirs would augment instream flows by using the inactive pool in late fall as they supply water to various points downstream, drawing down below the minimum conservation pool elevation under the NAA.

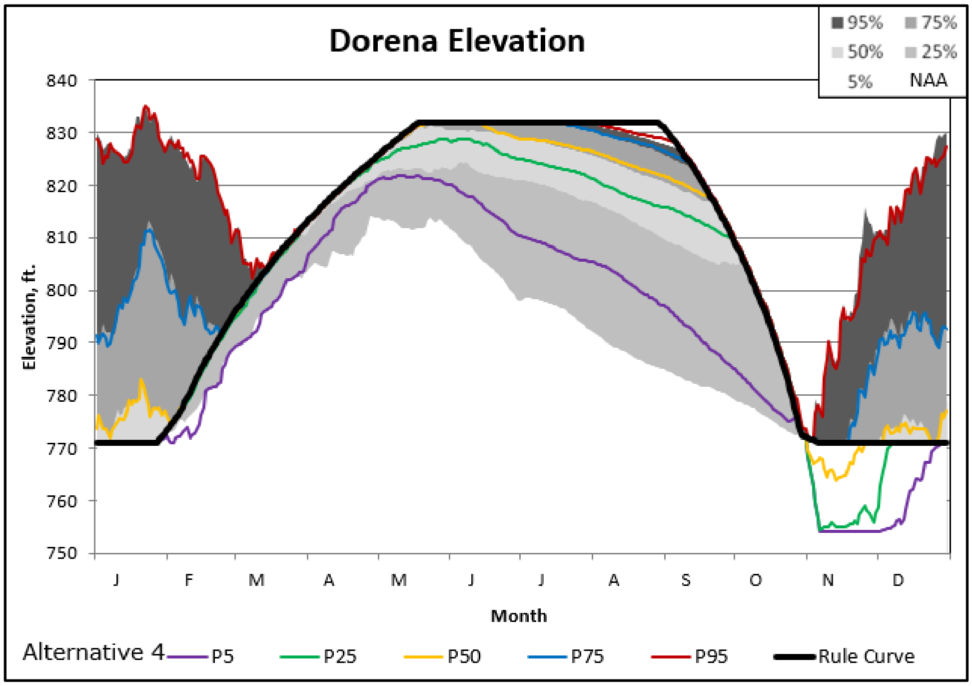

Figure 3.2-152. Alternative 4 Dorena Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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The control point for Dorena and Cottage Grove at Goshen shows the characteristic dry-year shift of flow from spring to fall under Alternative 4 (Figure 3.2-153). Wetter years and summer flows would remain about the same as under the NAA. The P05 and P25 lines at Goshen show the increased November flow using water from below minimum conservation elevation before returning to approximately the same as the NAA in December.

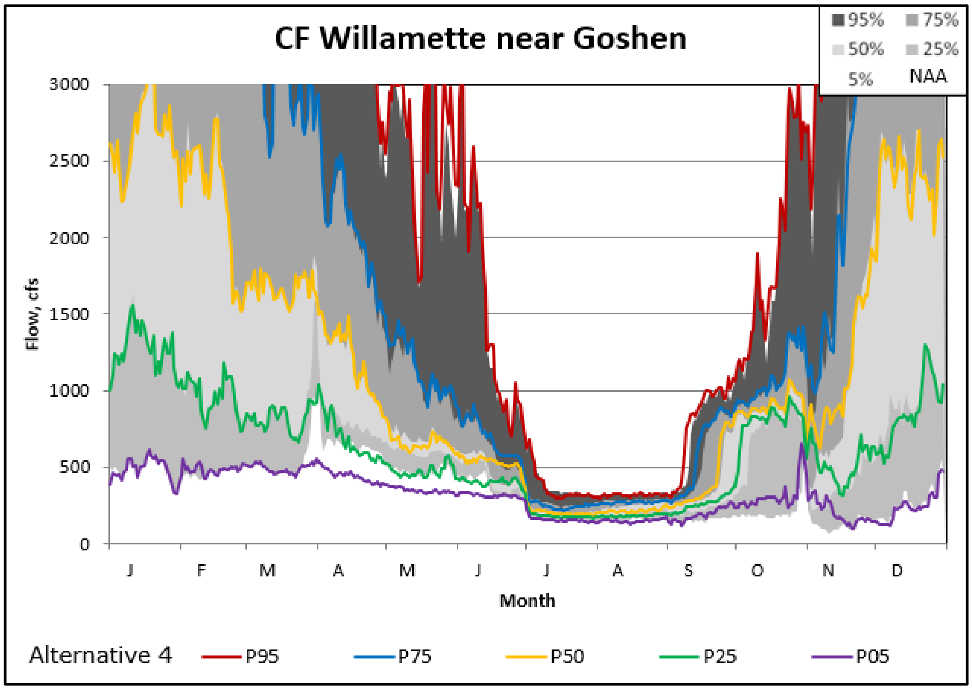

Figure 3.2-153. Alternative 4 Coast Fork Willamette River at Goshen, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Mainstem Willamette River Subbasins

Operations under Alternative 4 would alter the regulated hydrology of the mainstem Willamette River control points mostly during the drier years, with the largest impact to the average and wet years occurring in the fall with slightly higher flows as compared to the NAA. The P05 and P25 lines are well below their NAA counterparts from April to June at Albany (Figure 3.2-154). Although the Albany August-to-October flow target would be reduced as compared to the NAA (to 4,500 cfs from 5,000 cfs), flows would remain above the target much more frequently with water stored in the spring released to augment flows in the late summer and fall.

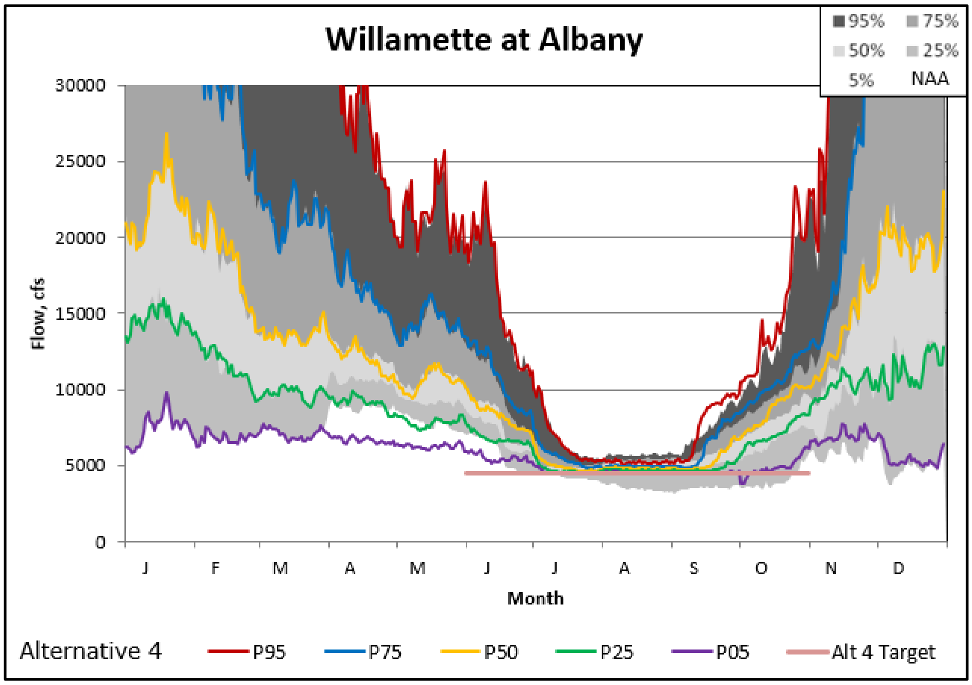

Figure 3.2-154. Alternative 4 Willamette River at Albany, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Under Alternative 4, the integrated temperature and habitat flow regime would alter the flow targets at Salem more than any other location as compared to the NAA. The variable target from April to June (stepped box in Figure 3.2-155) would only be active during hot weather. These higher flows would be designed to maintain cooler rivers for fish survival. The hotter the weather, the higher the flow target within the bounds in Figure 3.2-157. If the weather is cool, the target would revert to the lower Alternative 4 baseline[6] target of 5,000 cfs (Chapter 2, Alternatives, Section 2.8.1, Flow Measures).

Because temperatures required to activate the higher flow targets generally do not last for the entire 3 months, flows at Salem would be lower during dry years for Alternative 4, routinely missing the NAA 2008 NMFS Biological Opinion target but well within the integrated temperature and habitat flow regime targets. As at other upstream locations, Alternative 4 would have higher flows in summer and fall and would achieve its flow target more frequently than the NAA.

[6] "Baseline" refers to the typical flow target for a location, which can be modified by the WATER forum during seasonal operations.

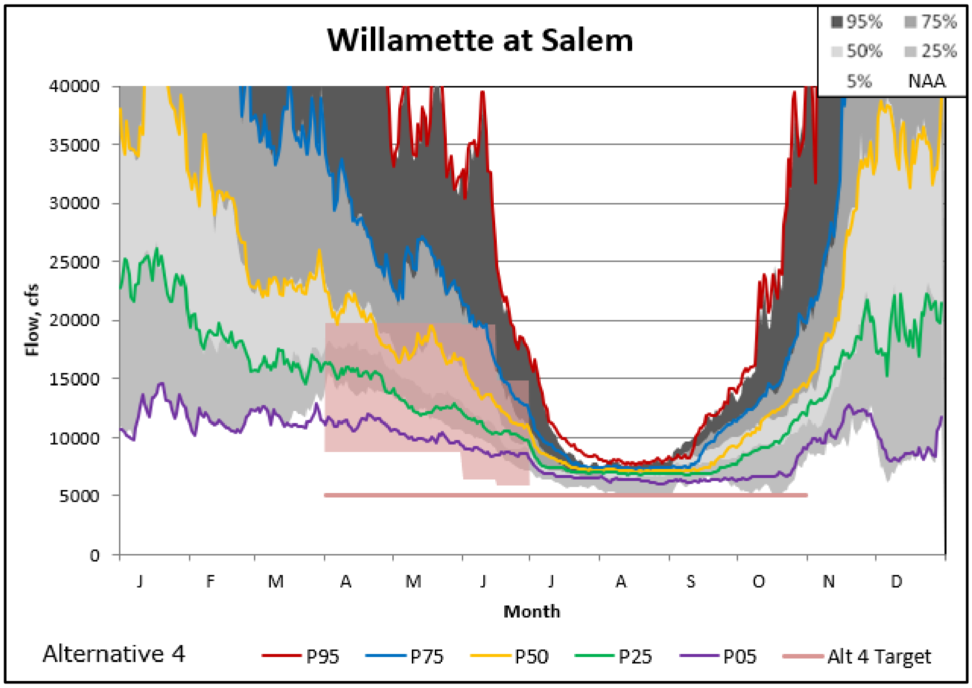

Figure 3.2-155. Alternative 4 Willamette River at Salem, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Summer and fall flows across water year types would be more closely spaced than under the NAA, but this would be mostly due to increased flows in drier years. Increased flows during the wetter falls, the P50 line and above, would be due to preserving more storage during these years and having to release more water in preparation for winter flood season.

Interim Operations under Alternative 4

Effects to hydrologic processes under the Alternative 4 Interim Operations would be the same as those described under Alternative 2A (Section 3.2.2.3, Alternative 2A, Interim Operations under Alternative 2A).

Climate Change Effects under Alternative 4

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Overall climate change impacts on hydrologic processes in the Willamette River Basin would be the same as those described under the NAA (Section 3.2.2.3, No-action Alternative, Climate Change Effects under the No-action Alternative). The WVS would experience minor differences in wintertime effects from climate change under Alternative 4 as it would under the NAA. Most changes would occur early during flood risk management operations as volume balancing returns to the WVS reservoirs' minimum conservation pools from the lower elevations under Alternative 4.

END REVISED TEXT

During the conservation season, climate change would affect Alternative 4 most like Alternative 1, with the main difference being somewhat lower reservoir water surface elevations and flow in the summer of dry years. Because the Alternative 4 integrated temperature and habitat flow regime targets are lower than the NAA 2008 NMFS Biological Opinion requirements, the reservoirs could store more water during the conservation season as compared to the NAA. However, USACE would need to use more of this stored water to meet downstream flow targets with projected increased variability in the spring shoulder months, drier and hotter summers, and lower summer baseflow. Therefore, reservoirs are projected to have lower water surface elevations under Alternative 4 as compared to the NAA.

Reservoir operations under Alternative 4 would sometimes reach minimum elevation during the summer but less often than operations under the NAA. Consequently, operations would augment summer flows for longer than under the NAA even with projected climate change-related declines in late spring and summer flows.

The lowest reservoir water surface elevations would occur in the driest years over the 30-year implementation timeframe, which would be drier than the WVS currently encounters, as the reservoirs are drafted more to meet downstream flow targets. Under Alternative 4, USACE would miss the mainstem Willamette River flow targets more often than under Alternative 1, but much less often than under the NAA. Additionally, increased reservoir evaporation from increased climate change-induced temperatures would marginally decrease available water from all WVS reservoirs.

<u>Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative</u>

Operations under Alternative 5 would shift stored water releases from spring to the summer and fall in the driest years by reducing spring mainstem Willamette River and key tributary targets. These shifts would increase the likelihood that stored water would be available to meet minimum flow targets later in the conservation use season as compared to the NAA.

Foster, Detroit, and Lookout Point Reservoirs would have tributary targets higher than the NAA 2008 NMFS Biological Opinion targets when reservoirs are more than 90 percent full and lower than the NAA when reservoirs are less than 90 percent full. This would increase spring storage in dry years relative to the NAA and provide more storage for use in dry summers.

Spring flow targets at Salem would be lower than 2008 NMFS Biological Opinion dry year targets in years when water supply forecasted flows at Salem are projected to be less than 80 percent of normal under the refined integrated temperature and habitat flow regime targets. This would provide additional spring storage in dry years allowing for targets that closely resemble NAA flow targets to be met in dry summers. Additional minimum flow targets based on the air temperature at Salem would allow USACE to release additional water when needed to cool in-river water temperature (Chapter 2, Alternatives, Section 2.8.1.2, Refined Integrated Temperature and Habitat Flow Regime (Measure 30b)).

Alternative 5 would shift operational releases from April through June to July through October. Flow targets in July through October would be met consistently throughout the year due to the additional accumulated stored water. Lower releases in dry springs would result in higher reservoir elevations in most reservoirs throughout the conservation season, which would not occur under the NAA.

Operations at Cougar and Green Peter Reservoirs include drawdowns under Alternative 5. Flow releases required to meet drawdown targets would result in higher tributary and mainstem flows, particularly in the fall, as compared to the NAA.

Because the spring drawdown at Cougar Reservoir would occur during the NAA refill period, storage at Cougar Reservoir would be reduced. Refill is not initiated until June 15th after most of the reliable spring rain has fallen. As a result of the reduced storage, USACE would not be able to release more than inflow from Cougar Reservoir for portions of the conservation season. Consequently, USACE would be required to release additional water from WVS reservoirs to meet mainstem Willamette River flow targets because of the reduced storage, notably in the Middle Fork Willamette River Subbasin.

Although there are structural activities proposed under Alternative 5 at the WVS dams to aid fish survival, many of these would not affect the flow out of any WVS dam. These do not appear in the reservoir flow model (Section 3.2.2.1, Methodology, Reservoir Operations Model). A more detailed analysis of Alternative 5 by subbasin is provided below.

Lower spring flows in dry years and higher summer flows in nearly all years under Alternative 5 would have long-term effects on the Willamette River Basin.

Santiam River Subbasin

Detroit Reservoir would fill more often under Alternative 5 operations and narrow the range of reservoir elevations prior to drafting the reservoir for flood season (Figure 3.2-156). The lower tier of the refined integrated temperature and habitat flow regime target requires lower flows downstream of Detroit Reservoir in years when the reservoir would not fill under the NAA operations. As a result, more flow would be released later in the conservation season in the driest years. The probability of only being able to pass inflow in extremely dry, low baseflow years is lower than under the NAA.

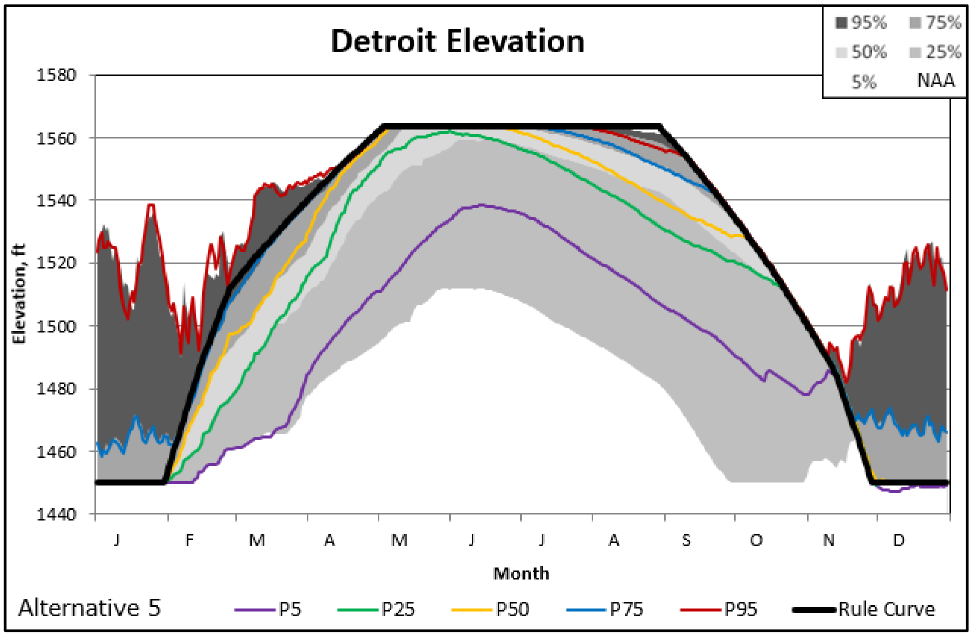

Figure 3.2-156. Alternative 5 Detroit Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Green Peter Reservoir targets 35 feet over the regulating outlet in the fall to promote volitional fish passage (Figure 3.2-157). Occasionally, this would result in USACE beginning the Green Peter Reservoir conservation refill season at a lower elevation under Alternative 5 as compared to the NAA operations. Drawing down to the regulating outlet would be most likely in years with dry summers when the reservoir does not fill. Deeper fall reservoir drawdowns of longer duration would be most likely in years with dry late fall and early winter seasons under Alternative 5.

Outflow from Foster Reservoir and the refined integrated temperature and habitat flow regime targets are shown in Figure 3.2-158. Variable flow targets in the spring target would lower minimum flows when Green Peter Reservoir is less than 90 percent full, resulting in higher conservation season storage in dry years under Alternative 5. A summer and fall flow target of 1,200 cfs would be the same in all years. Higher releases from Foster Reservoir in the fall would be a result of the Green Peter Reservoir deeper fall drawdown.

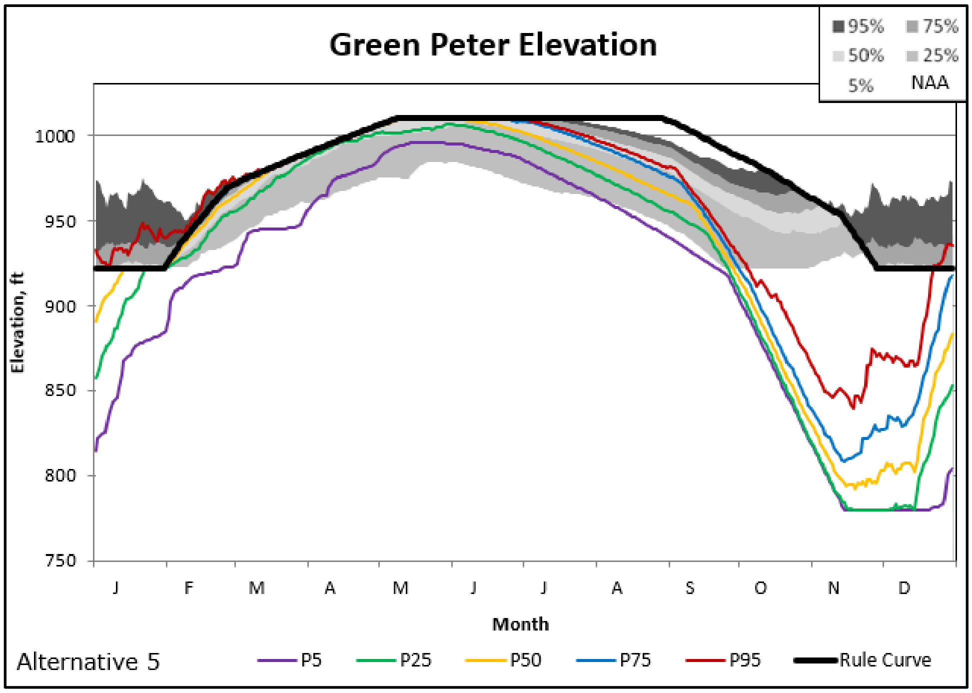

Figure 3.2-157. Alternative 5 Green Peter Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

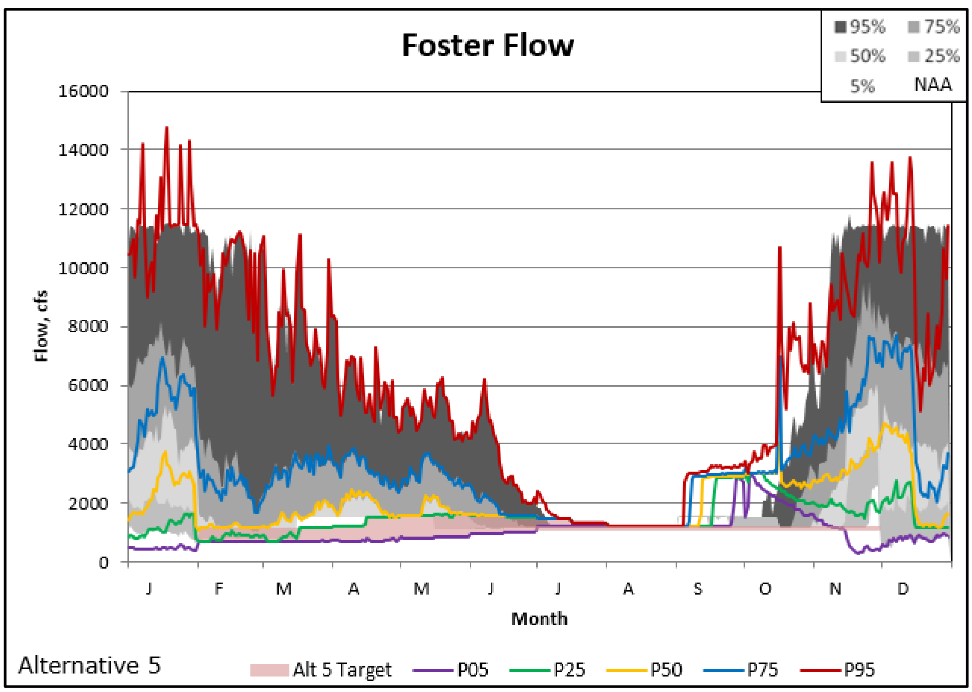

Figure 3.2-158. Alternative 5 Foster Flow Non-exceedance as Compared to the No-action Alternative.

The Santiam River at Jefferson shows some of the flow changes resulting from releases at Foster Reservoir under Alternative 5 (Figure 3.2-161). Lower minimum flow targets would control the outflow from Green Peter Reservoir from March through June in dry years. Higher outflows would be observed in September when USACE draws down Green Peter Reservoir for the volitional fish passage operation while remaining below bankfull. Late fall outflows would typically be lower under Alternative 5 when Green Peter Reservoir is refilling after the deeper fall reservoir drawdown as compared to the NAA.

Lower flows resulting from lower flow targets in dry years in the spring would be observed at Jefferson under Alternative 5 (Figure 3.2-159). Additional reservoir storage would enable higher flows than the NAA at Jefferson beginning in July even though combined minimum flow targets below Detroit and Green Peter Reservoirs would be slightly lower than under the NAA.

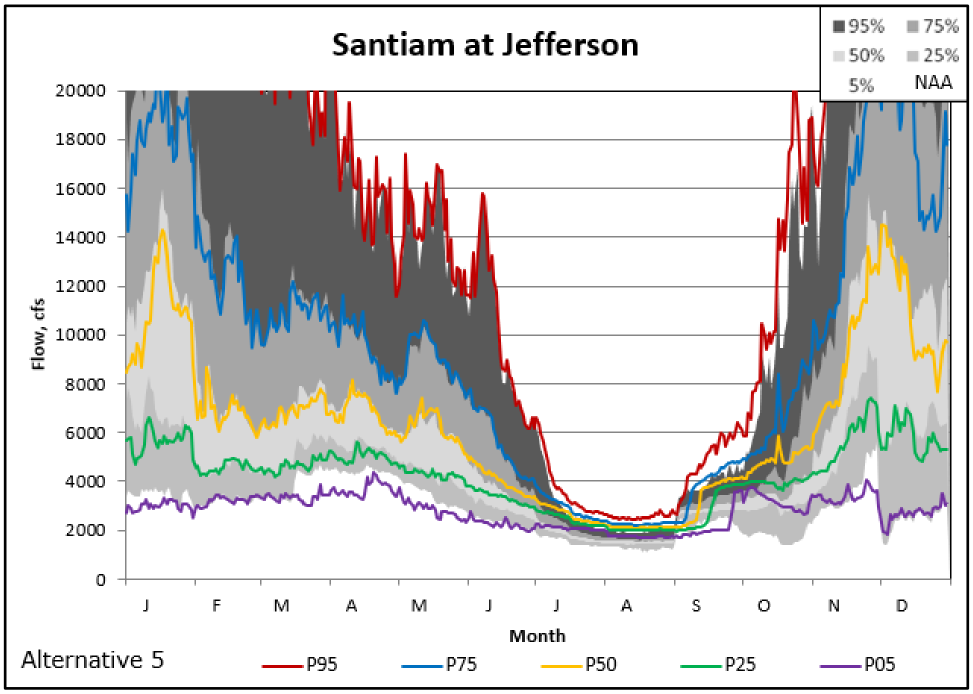

Figure 3.2-159. Alternative 5 Santiam River at Jefferson, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Long Tom River Subbasin

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Water surface elevations within Fern Ridge Reservoir would show negligible changes under Alternative 5 as compared to the NAA (Figure 3.2-160). Downstream flows at Monroe would also remain unchanged under Alternative 5 as compared to the NAA.

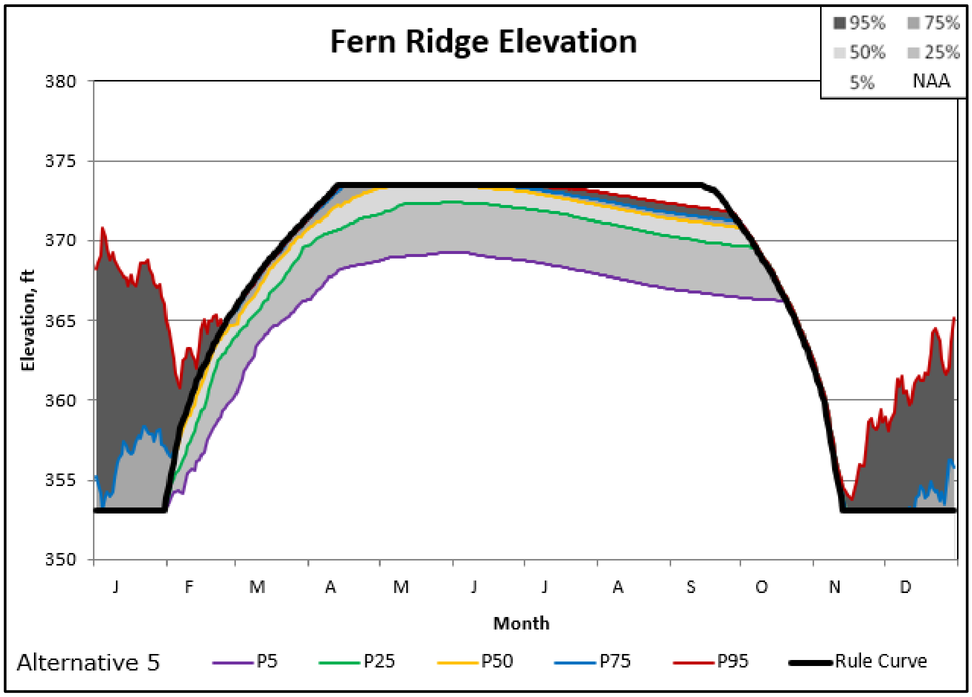

Figure 3.2-160. Alternative 5 Fern Ridge Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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McKenzie River Subbasin

Both spring and fall reservoir drawdowns to 1,330 feet would occur at Cougar Reservoir under Alternative 5 (Figure 3.2-161). Conservation season refill would be delayed until June 15th after all the season's reliable rain has fallen. The reservoir water surface elevation would only rise above the minimum conservation pool at the end of winter and only in the wettest summers.

Spring reservoir drawdowns would reach target elevations in drier-than-average conditions under Alternative 5. Deeper fall reservoir drawdowns are most likely to occur in years with lower-than-average conservation season refill. USACE would release well below the NAA tributary target of 300 cfs from Cougar Reservoir for long durations as a result of the drawdowns.

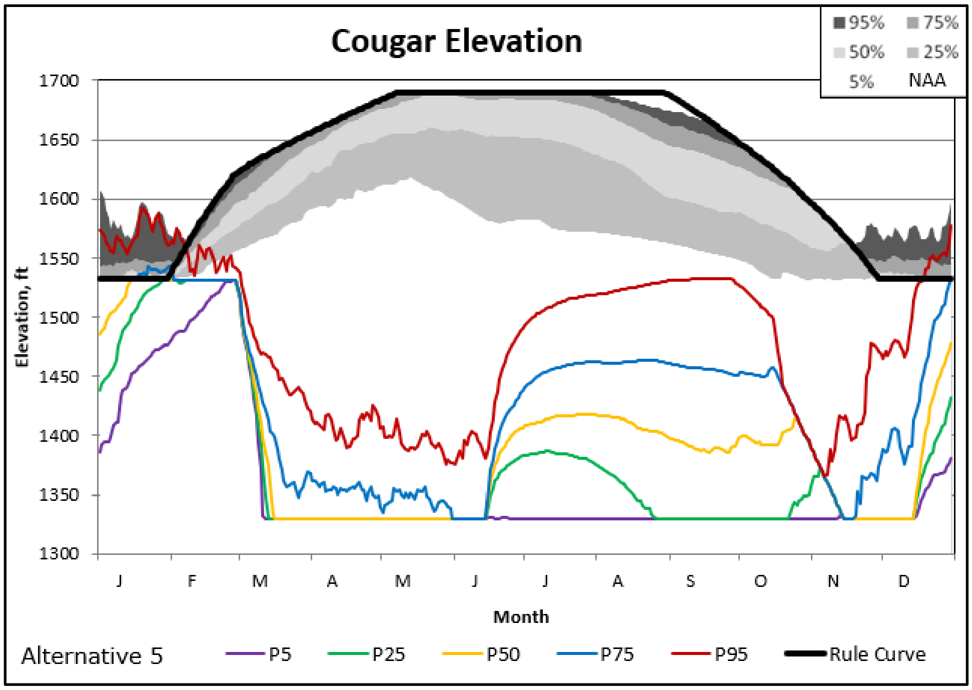

Figure 3.2-161. Alternative 5 Cougar Dam Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

Under Alternative 5, USACE would fill Blue River Reservoir more often as compared to the NAA (Figure 3.2-162). Blue River Reservoir would be required to store more water during very wet years while USACE would draft Cougar Reservoir for its spring drawdown. Consequently, the reservoir would be filled above the rule curve occasionally for the McKenzie River at Vida to remain at or below bankfull. Additionally, Blue River Reservoir would augment instream flows by allowing USACE to use the inactive pool during the fall of very dry years to compensate for the low releases from Cougar Reservoir. Operations under Alternative 5 would, therefore, reach the lower minimum more often than under the NAA.

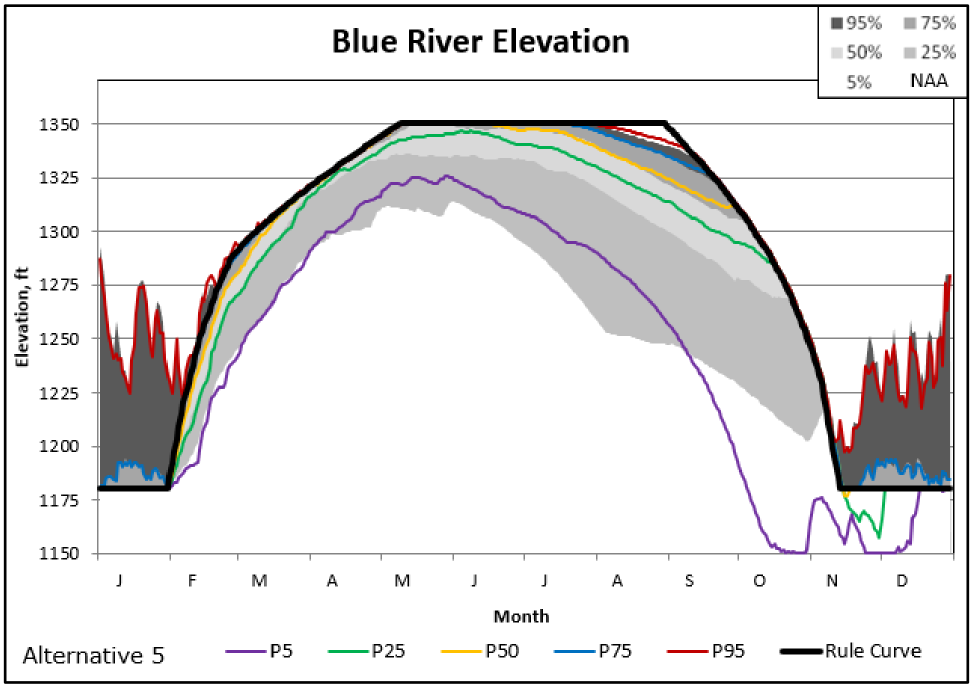

Figure 3.2-162. Alternative 5 Blue River Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

The McKenzie River at Vida would show the effect of the Cougar Reservoir drawdowns downstream to the control point for both Cougar and Blue River as compared to the NAA (Figure 3.2-163). Higher flows in the spring would be the result of operations to release from Cougar Reservoir to reach spring drawdown elevation. Lower flows starting in June would be the result of reduced storage at Cougar Reservoir throughout the conservation season. Operations at Blue River Reservoir would be capable of making up some of the shortfall in releases from Cougar Reservoir.

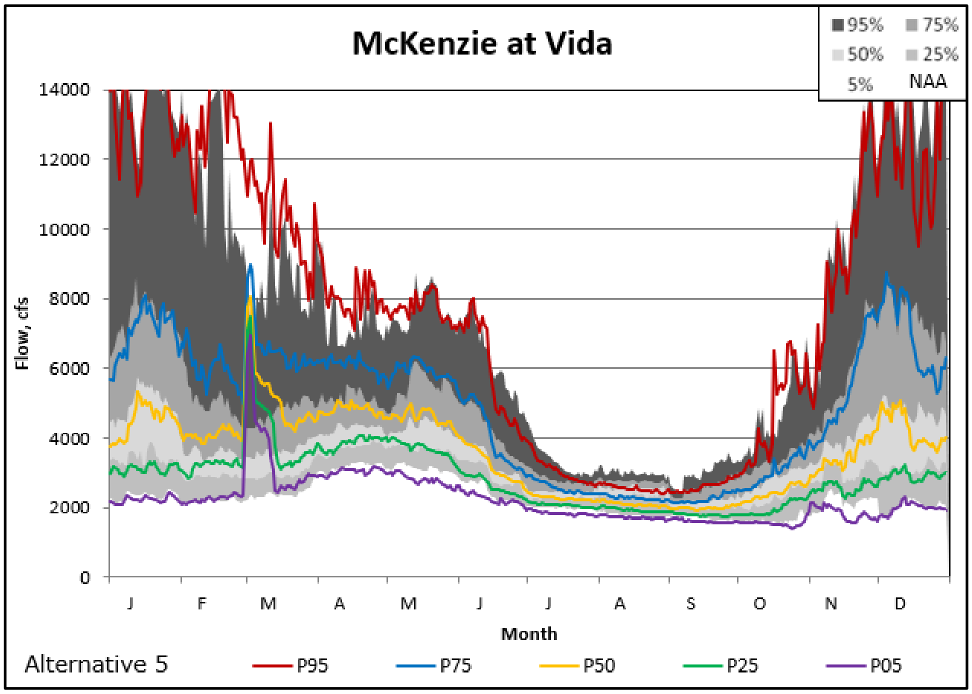

Figure 3.2-163. Alternative 5 McKenzie River at Vida, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Middle Fork Willamette River Subbasin

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USACE would initially fill Hills Creek Reservoir more quickly as compared to the NAA due to the lower refined integrated temperature and habitat flow regime targets and would remain at similar or higher elevations during wet years (Figure 3.2-164). During dry years, the reservoir would augment instream flows by using the power pool. Operations would release more water to meet the flow target at Albany, drafting below the minimum conservation pool under the NAA.

Hills Creek Reservoir capacity would be exhausted in the driest years under Alternative 5 when Lookout Point Reservoir would supply additional water and reach its Alternative 5 minimum (Figure 3.2-165). Both reservoirs would draft to the lower minimum elevations earlier in the driest years than under the NAA.

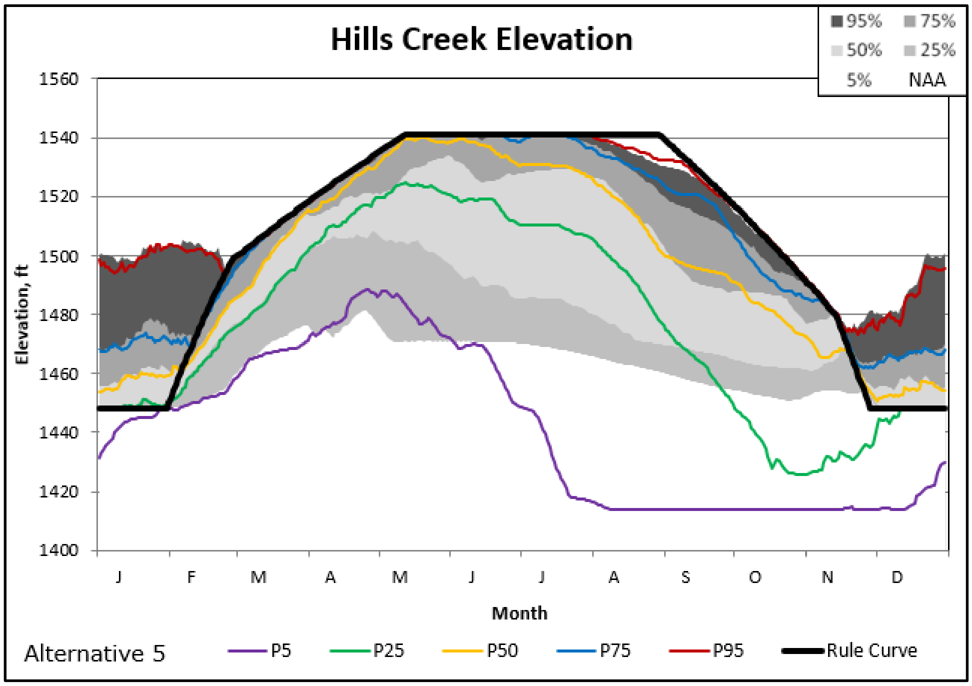

Figure 3.2-164. Alternative 5 Hills Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

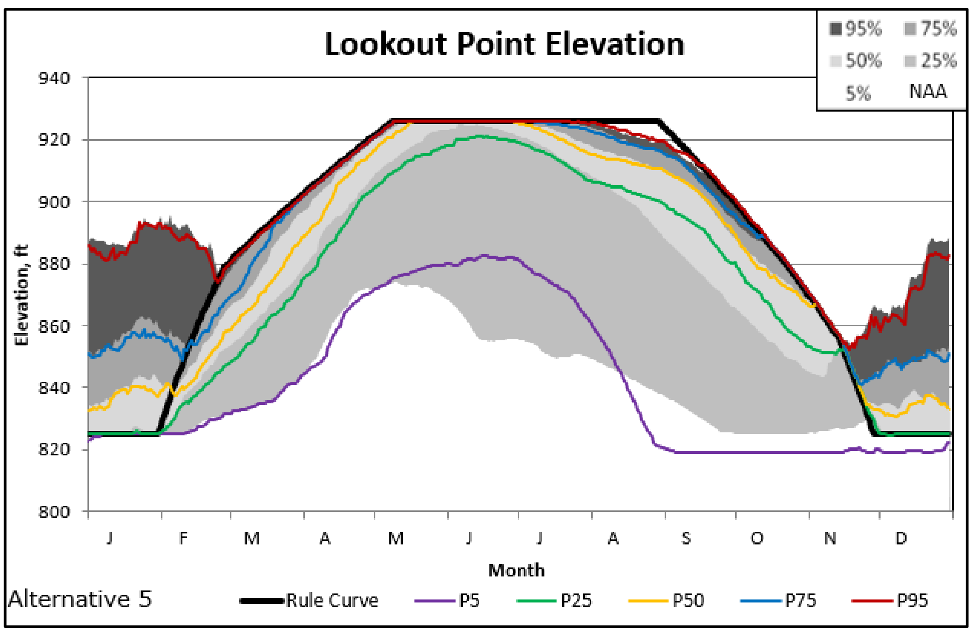

Figure 3.2-165. Alternative 5 Lookout Point Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

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As compared to Alternative 2B, storage elevations for both Hills Creek and Lookout Point Reservoirs would be slightly lower across all years because of the higher refined integrated temperature and habitat flow regime mainstem targets under Alternative 5. Storage elevations would also usually be lower than NAA elevations. Spring mainstem releases under Alternative 5 would be higher than under Alternative 2B. Consequently, the reservoirs would be more likely to run out of storage and pass only inflow in the driest years under Alternative 5.

Fall Creek Reservoir would have the same deep fall reservoir drawdown to the bottom of the reservoir under Alternative 5 as under the NAA (Figure 3.2-166). Therefore, Alternative 5 reservoir releases and elevations would vary only slightly from the NAA.

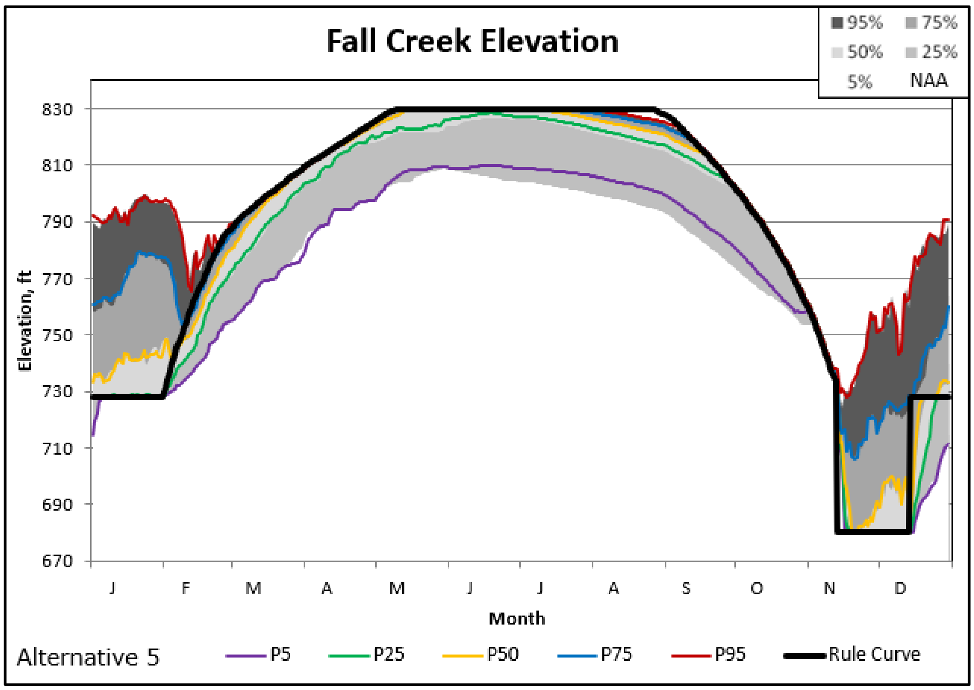

Figure 3.2-166. Alternative 5 Fall Creek Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

At the downstream control point at Jasper, the shift in flow releases would be evident under Alternative 5, especially in dry years, with lower flows in the spring and higher flows in the summer and fall (Figure 3.2-167). The increased fall flows during wet years as compared to the NAA would be due to reservoir operations starting at a higher elevation prior to drafting for flood season. There would be more water to release from the reservoirs so there would be higher flow downstream under Alternative 5.

In the spring of the driest years, refined integrated temperature and habitat flow regime targets at Salem would be lower than the NAA targets. This would result in lower releases from Hills Creek and Lookout Point Reservoirs and lower flows at Jasper under Alternative 5. Fall flows would also be lower in the driest years when Lookout Point and Hills Creek Reservoirs would run out of water as compensation for lack of releases from Cougar Reservoir. This would happen slightly more often under Alternative 5 than under Alternative 2B because of the higher mainstem flow target at Salem. Because the reservoir would empty earlier, fall flows at Jasper in the driest years would be lower under Alternative 5 than under Alternative 2B.

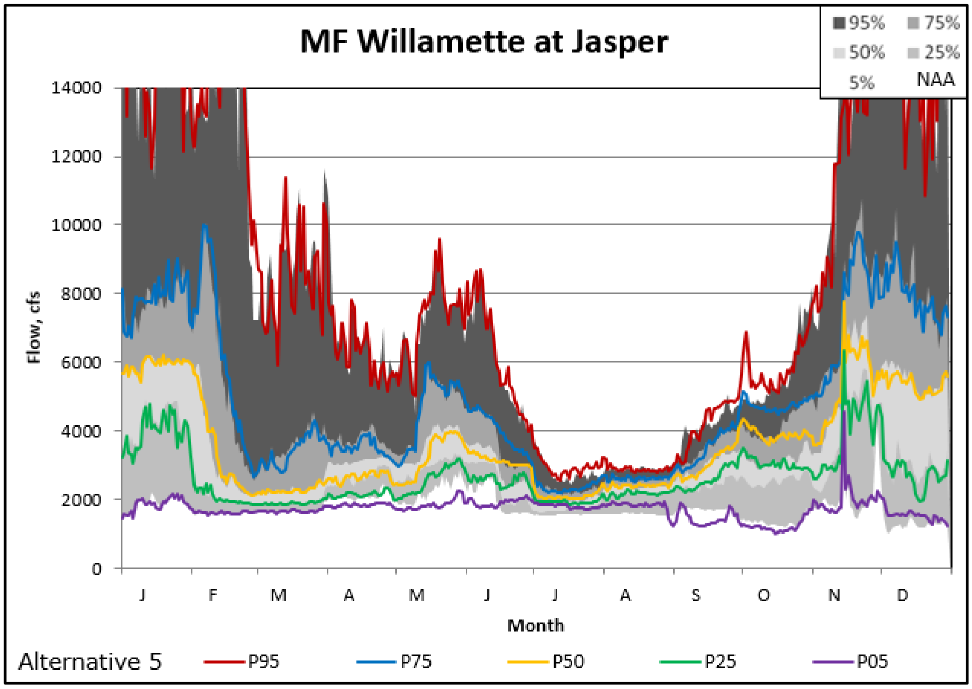

Figure 3.2-167. Alternative 5 Middle Fork Willamette River at Jasper, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Coast Fork Willamette River Subbasin

Under Alternative 5, more water would be stored in the spring and released during the summer and fall during dry years in the Coast Fork Willamette River Subbasin as compared to the NAA. Conditions would be generally similar to the NAA in wet years.

Reservoir elevations would be somewhat higher at both Dorena and Cottage Grove Reservoirs under Alternative 5 during the late spring and summer (Figure 3.2-168). Elevations would be similar to those under the NAA during other times of the year. USACE would release slightly more water in the spring from Dorena and Cottage Grove Reservoirs than under Alternative 2B to meet the higher mainstem target, drafting to lower elevations as a result. However, these operations would not reach minimum conservation pool elevation. Figure 3.2-169 shows the control point at Goshen. Because the pools would stay higher throughout the summer, more water would be released during September and October as compared to the NAA.

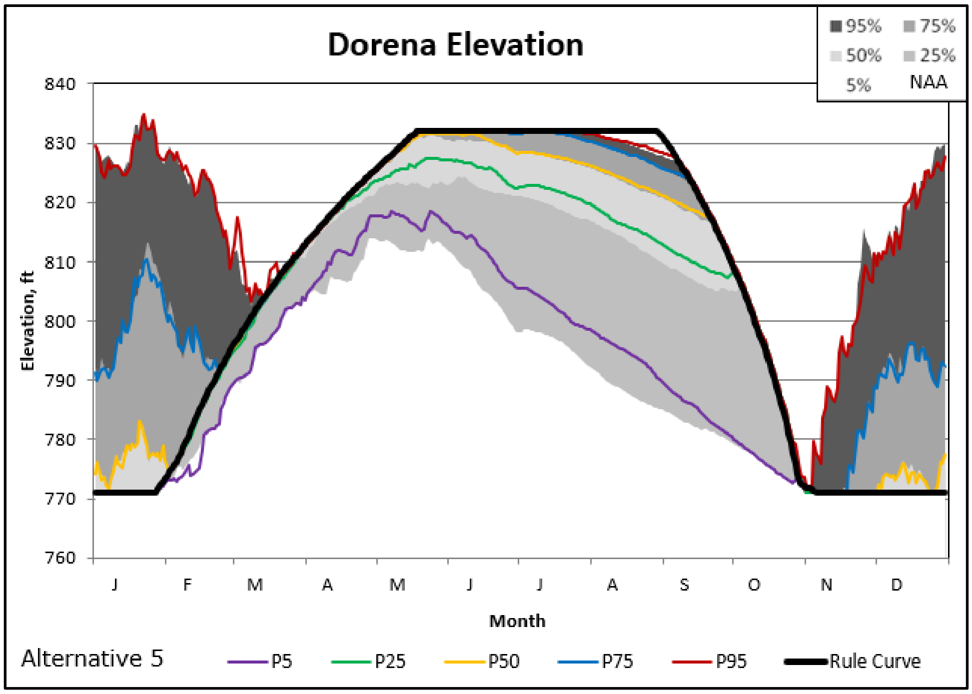

Figure 3.2-168. Alternative 5 Dorena Reservoir Water Surface Elevation Non-exceedance as Compared to the No-action Alternative.

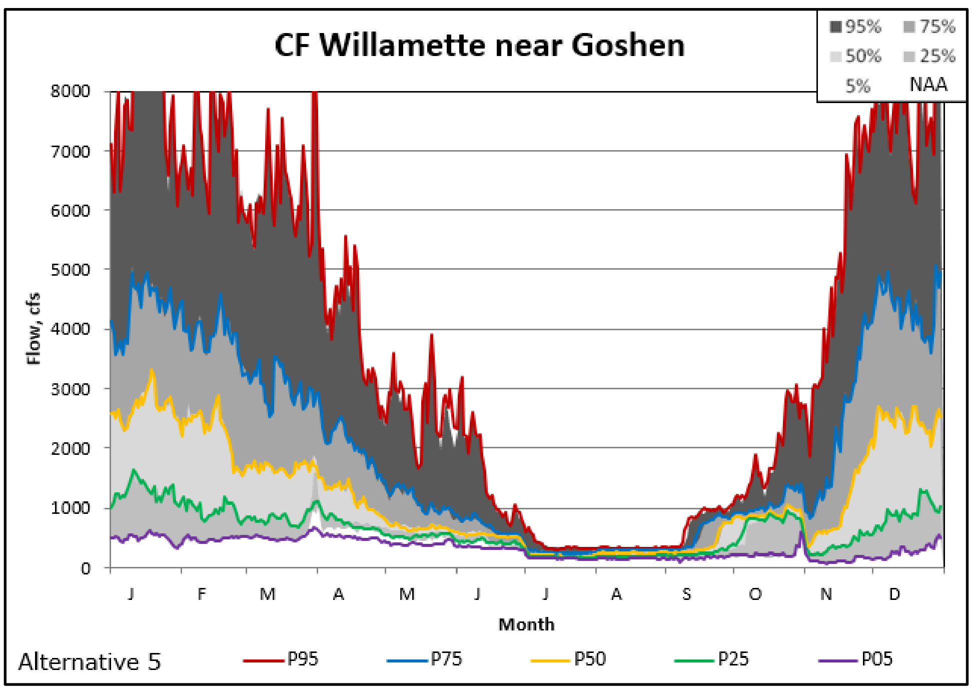

Figure 3.2-169. Alternative 5 Coast Fork Willamette River at Goshen, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

Mainstem Willamette River Subbasins

Operations under Alternative 5 would alter the regulated hydrology of the mainstem Willamette River control points under the refined integrated temperature and habitat flow regime, storing more water in the spring and releasing it during the summer as compared to the NAA. The Willamette River at Albany would show dry years below their NAA equivalents from April to June and a compressed flow regime through the summer, with the higher flow years reduced and the low flow years increased (Figure 3.2-170). USACE would typically meet the flow target at Albany, missing during September and October of the driest years under Alternative 5.

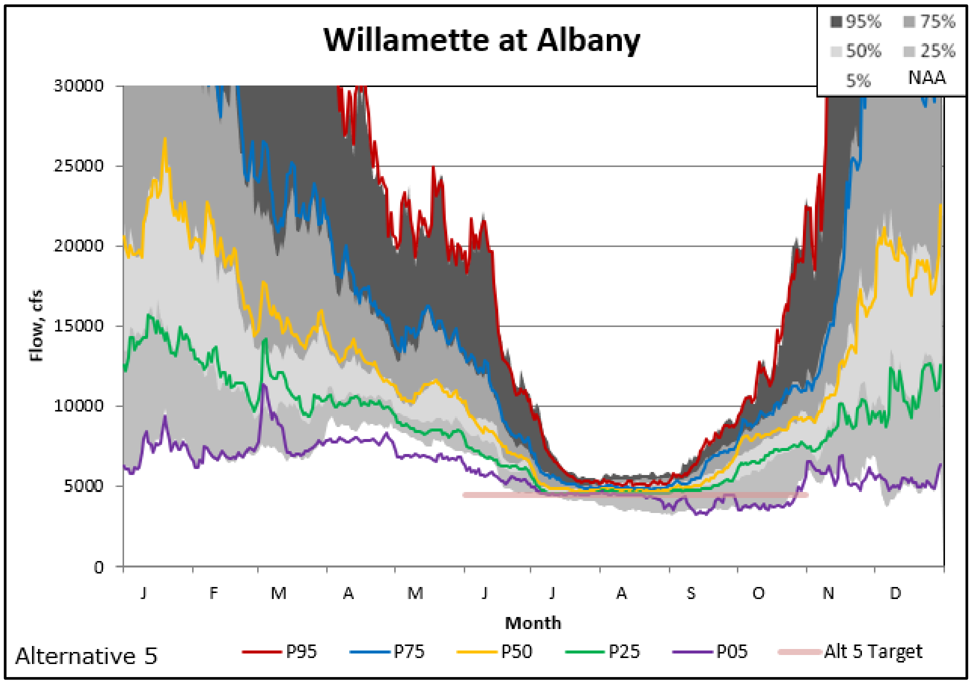

Figure 3.2-170. Alternative 5 Willamette River at Albany, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

As compared to Alternative 2B, flows at Albany would be slightly higher in the spring and more frequently below target in the fall of the driest years. This would be the result of higher spring targets at Salem occasionally causing Lookout Point and Hills Creek Dams to run out of water under Alternative 5.

Like the Albany control point, the Willamette River at Salem would show reduced flows from April to June of dry years while meeting the refined integrated temperature and habitat flow regime target (Figure 3.2-171). Summer and fall flows would increase across all years under Alternative 5 as compared to the NAA.

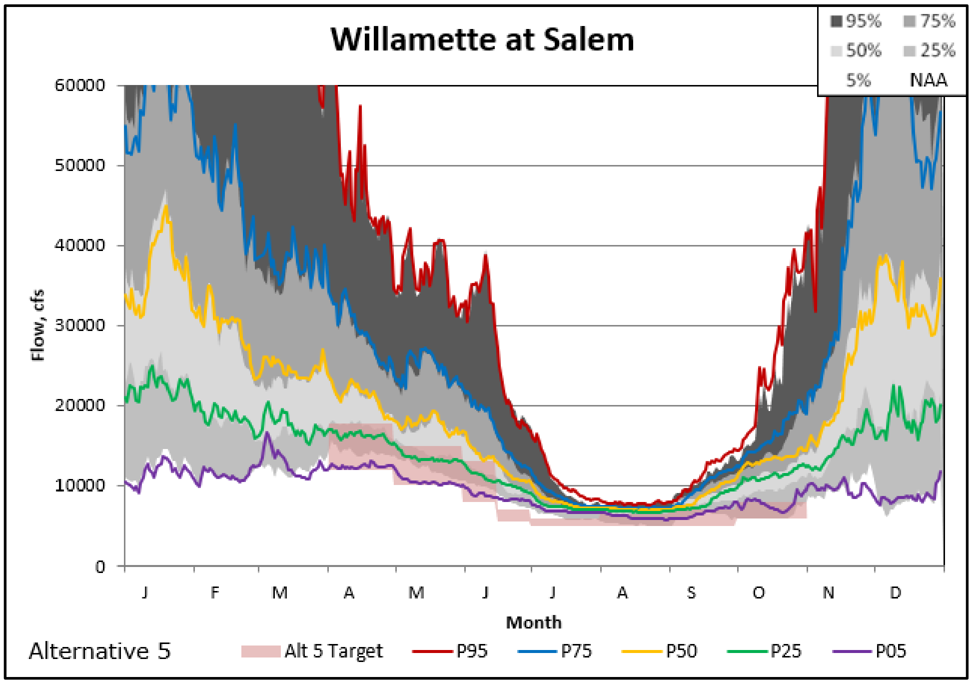

Figure 3.2-171. Alternative 5 Willamette River at Salem, Oregon Flow Non-exceedance as Compared to the No-action Alternative.

The effect of reduced storage at Cougar Reservoir would be much less evident at Salem due to contributions from the Santiam River Subbasin WVS reservoirs. Compared to Alternative 2B, flows in dry springs would be slightly higher reflecting the higher flow targets. Fall flows in dry years would be slightly lower after the higher spring targets exhaust storage at key reservoirs under Alternative 5.

Increased flows from September to November would be due to the deeper fall drawdown at Green Peter Reservoir under Alternative 5. These increases would be within the river channel (bankfull is at 90,000 cfs), meaning they would not impact flood risk.

Interim Operations under Alternative 5

Effects to hydrologic processes under the Alternative 5 Interim Operations would be the same as those described under Alternative 2A (Section 3.2.2.3, Alternative 2A, Interim Operations under Alternative 2A).

Climate Change Effects under Alternative 5

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Overall climate change impacts on hydrologic processes in the Willamette River Basin would be the same as those described under the NAA (Section 3.2.2.3, No-action Alternative, Climate Change Effects under the No-action Alternative). The WVS would experience minor differences in wintertime effects from climate change under Alternative 5 as it would under the NAA.

Drawdowns at Cougar and Green Peter Reservoirs would be operated the same, with the same resulting conditions as under Alternative 2B (Section 3.2.2.3, Alternative 2B, Climate Change Effects under Alternative 2B).

END REVISED TEXT

During the conservation season, climate change would affect operations under Alternative 5 similarly to those under Alternative 2B (Section 3.2.2.3, Alternative 2B, Climate Change Effects under Alternative 2B). The refined integrated temperature and habitat flow regime targets would allow for lower releases in the spring under Alternative 5 as compared to the NAA 2008 NMFS Biological Opinion requirements in the driest years. As a result, some WVS reservoirs could store more water the during conservation season as compared to the NAA. However, USACE would need to use more of this stored water to meet downstream flow targets with projected climate change-related increased variability in the spring shoulder months, drier and hotter summers, and lower summer baseflow during the 30-year implementation timeframe.

Outside of flood season, operations would likely never fill Cougar Reservoir to minimum conservation elevation due to decreased inflow after its spring reservoir drawdown. USACE would need to release more water from Hills Creek and Lookout Point Reservoirs under Alternative 5 to meet the Albany flow target, substituting for the lack of releases available from Cougar Reservoir, which would not occur under the NAA.

Across the WVS, reservoirs are projected to have lower water surface elevations due to climate change, although Cougar, Hills Creek, and Lookout Point Reservoirs would be most affected. Reservoirs under Alternative 5 would sometimes draft to minimum targeted elevation during the summer but less often than under the NAA. Therefore, USACE would be able to augment summer flows for longer than under the NAA even with projected climate change-related declines in late spring and summer flows.

The lowest reservoir water surface elevations would occur in the driest years, which would be drier than the WVS currently encounters, as the reservoirs are drafted more to meet downstream flow targets. Additionally, increased reservoir evaporation from increased climate change-induced temperatures would marginally decrease available water from all WVS reservoirs.

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.3 RIVER MECHANICS AND GEOMORPHOLOGY

3.3 River Mechanics and Geomorphology

THE DEIS RIVER MECHANICS AND GEOMORPHOLOGY SECTION HAS BEEN DELETED IN THE FEIS

Summary of changes from the DEIS:

- **After considering analyses in the DEIS, there is no potential for a significant impact to occur to river mechanics and geomorphology under any of the alternatives, including the No-action Alternative, over the 30-year implementation timeframe. Information on river mechanics and geomorphology existing conditions is needed to understand effects to other resources such as water quality, fish, vegetation, and cultural resources.**
- **Assessing impacts to this resource alone would not provide a comprehensive assessment of effects to the human environment, which are more appropriately analyzed by combining existing conditions regarding shoreline sediment exposure, mobilization, trap efficiency, and supply with potential effects to other resources, such as the turbidity analyses in Section 3.5, Water Quality.**
- **DEIS Section 3.3, River Mechanics and Geomorphology, Affected Environment, has been moved to Appendix C, River Mechanics and Geomorphology. Other data and analyses in Appendix C have also been updated in the FEIS to inform resource analyses in Chapter 3, Affected Environment and Environmental Consequences, as applicable.**
- **See 40 CFR 1500.1(b) (NEPA documents should not "amass needless detail"), id. at (d) ("NEPA's purpose is not to generate paperwork – even excellent paperwork – but to foster excellent action"), 1502.1 (Agencies…shall reduce paperwork and the accumulation of extraneous background data), 1503.4(c) (changes to a DEIS are to be circulated in the FEIS).**

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CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.4 GEOLOGY AND SOILS

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3.4 Geology and Soils

THE GEOLOGY AND SOILS SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **Section 3.4.3.1, Environmental Consequences, Methodology, has been revised for improved readability. Information has been added to clarify the parameters analyzed and the type of impact assessed from these parameters. The environmental effects criteria tables have been updated to reflect this new information.**
- **Effects criteria have been provided for both landslide potential and removal of geologic material in Table 3.4-1 and Table 3.4-2, respectively. Effects criteria have also been revised. Information has been added to the extent and duration of potential impacts in Table 3.4-1.**
- **A summary of all potential effects to geology resources from both landslide potential and movement of geologic material has been provided as Table 3.4-3.**
- **The alternatives analyses have been updated to more clearly link expected natural landslide occurrences with USACE operations and maintenance under each alternative.**
- **DEIS references to Section 3.3, River Mechanics and Geomorphology, has been updated to cross-reference to Appendix C, River Mechanics and Geomorphology Technical Information. DEIS Section 3.3 has been removed from the FEIS.**
- **An analysis of Interim Operations has been added as FEIS Section 3.4.4, Evaluation of Interim Operations under All Action Alternatives Except Alternative 1.**
- **The climate change analysis has been summarized for all alternatives under Section 3.4.5, Climate Change under All Alternatives. Additional references have been added to support expected climate change conditions with cross-referencing to the climate change appendices.**
- **Consistent terminology has been applied and definitions added.**

3.4.1 Introduction

Geology refers to both geologic materials, like soil and rock, and geologic processes, like landslides. Construction of the Willamette Valley System (WVS) resulted in alteration to the geologic materials at the dams due to removal of soil and non-competent rock to construct the dam foundations. After construction, reservoir operations altered geologic processes by creating additional landslide risk due to the fluctuation of water in the reservoirs. The following information describes the Affected Environment and risks related to these activities.

The analysis area for geology and soils includes WVS dam foundations, the areas around dams and reservoirs, and all relevant features described in periodic inspections of each dam by USACE. It also includes the active channel of the Willamette River up to the 1 percent and 0.2 percent annual exceedance probability[1] flood elevation (100- and 500-year flood zones, respectively) for all reaches in the Willamette Valley that contain levees and bank protection works (Figure 3.4-1). Geologic conditions in the Willamette River Basin are also provided as context for the analysis area.

3.4.2 Affected Environment

3.4.2.1 Willamette River Basin

<u>Geologic Physiographic Regions</u>

Western Oregon geology is the product of the Cascadia Subduction Zone and associated arc volcanism, which forms the major geologic regions in the area. The Willamette River Basin encompasses two provinces and three regions that have common topography, rock types and structure, and geologic and geomorphic history. These include the Middle Cascades Mountains physiographic region of the Cascades-Sierra Mountains province (the Cascades) and the Pacific Border province that is subdivided into the Puget Trough section (Willamette Valley) and Oregon Coast Range section (Fenneman and Johnson 1946) (Figure 3.4-2).

[1] The 1 percent and 0.2 percent annual exceedance probability is a flood event that has a 1 percent and 0.2 percent of occurring each year.

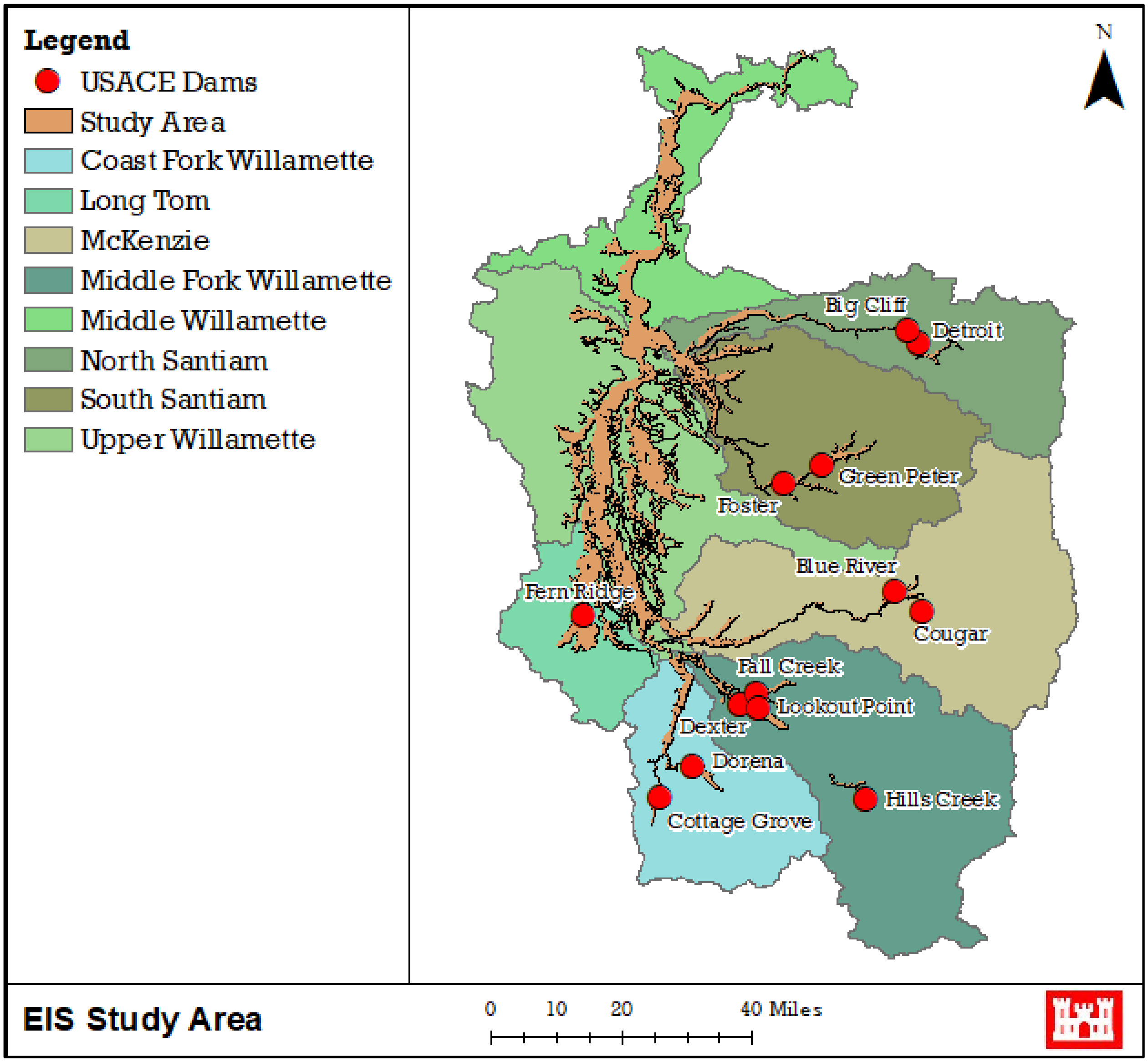

Figure 3.4-1. Geology Analysis Areas for the Willamette River Basin.

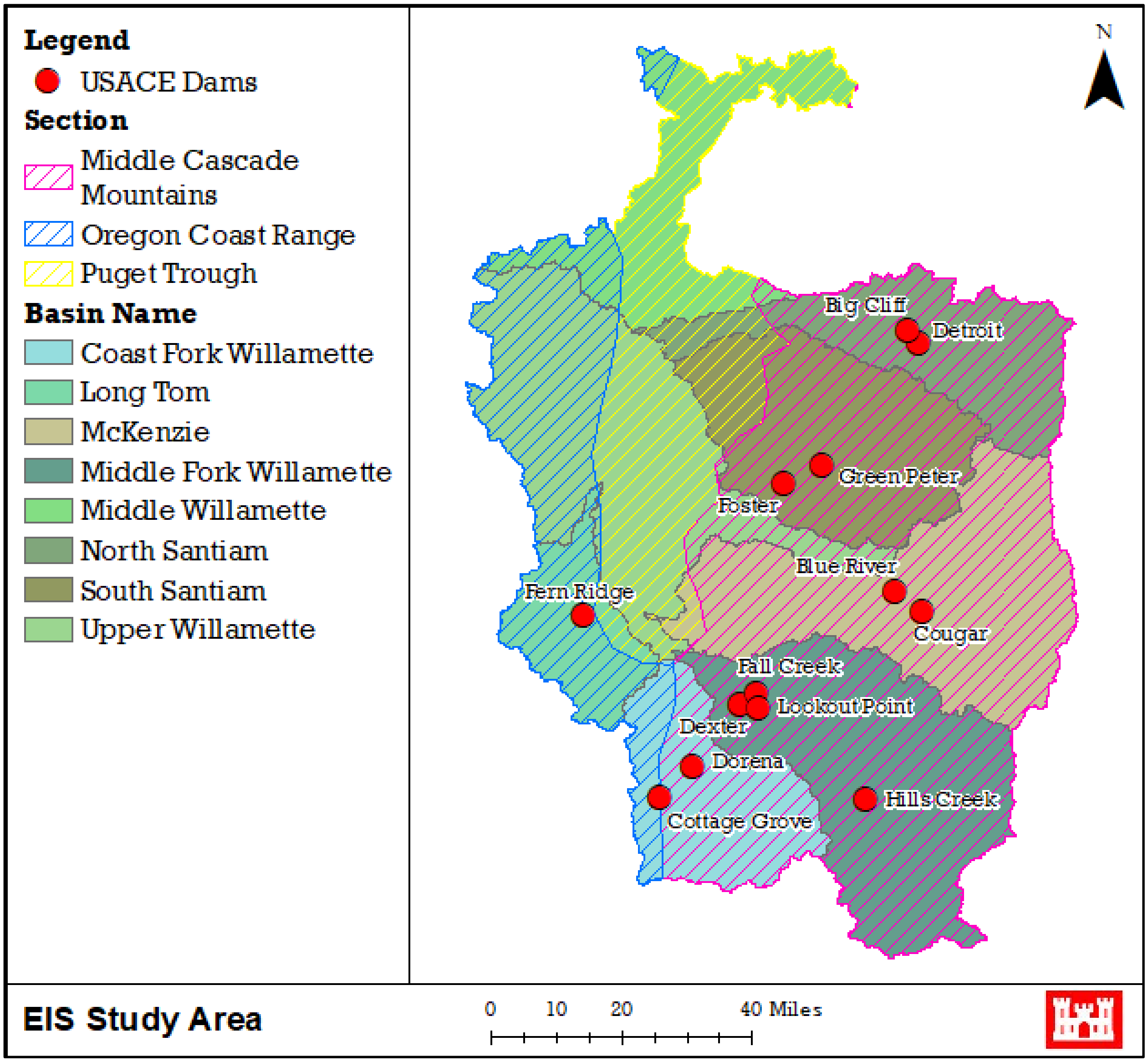

Figure 3.4-2. Geologic Physiographic Regions of the Willamette River Basin.
Source: Fenneman and Johnson 1946

Middle Cascades Mountains Physiographic Region

The Cascades are a volcanic belt of rocks that extend from the Sierra Nevada Mountains in northern California to the Coast Mountains in British Columbia. The volcanic belt is about 80 miles wide in Washington and northern Oregon, but it narrows to about 40 to 50 miles in California.

The Cascades are subdivided into two subprovinces, the Western Cascades and the High Cascades (Sherrod and Smith 2000) (Figure 3.4-3). The Western Cascades is the older Tertiary inactive volcanic belt and forms the base of the range. The second subprovince is the High Cascades, which is an active volcanic belt.

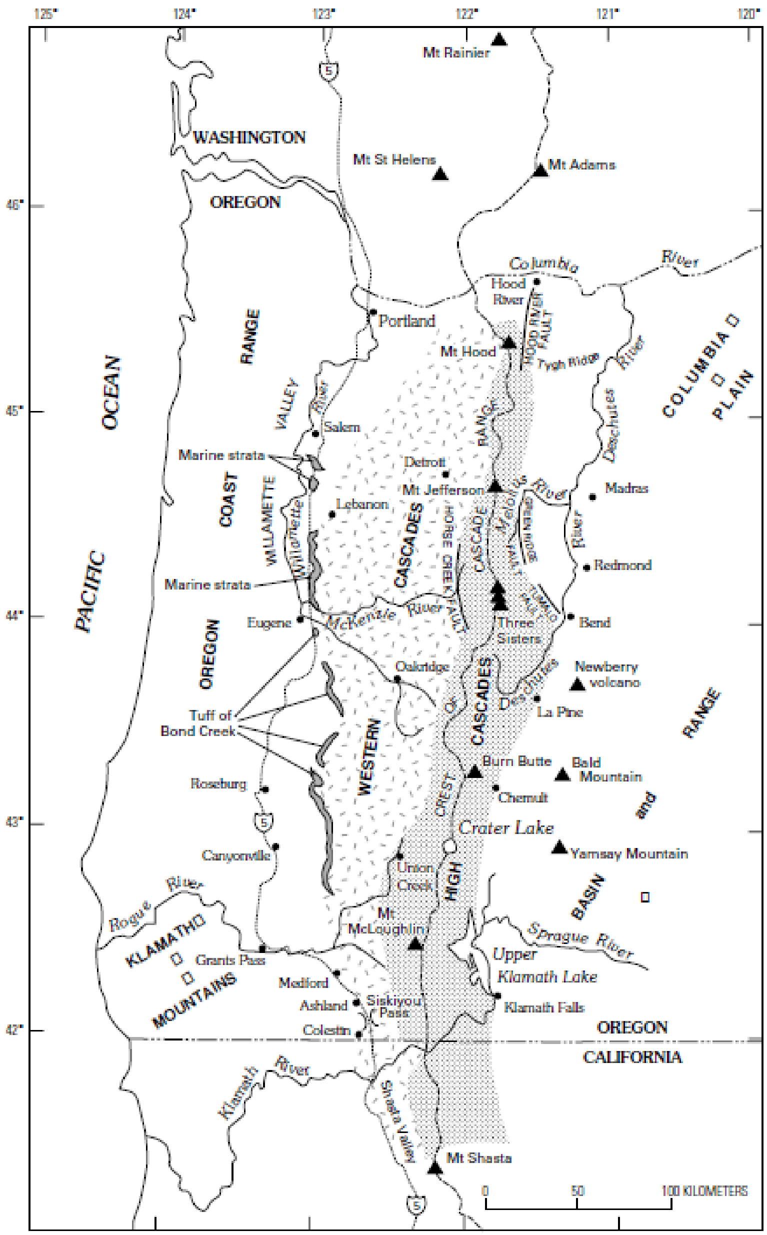

Figure 3.4-3. Distribution of the Western Cascades and High Cascades Subprovinces.

Source: Sherrod and Smith 2000

The Cascades are a thick sequence of volcanic rock that are between 15,000 feet to 30,000 feet vertically. The composition of volcanic rocks ranges from basaltic to rhyolitic lava flows, which are interbedded with explosive pyroclastic[2] fragmental rocks (tuffs, breccias, lapilli tuffs, tuffaceous, ashflows, sandstone, siltstone, and conglomerate associated with volcanic eruptions). Most rocks in the Western Cascades subprovince have a slight hydrothermal alteration from the intrusion of monzonitic and dioritic sills and dikes in the late Miocene age.

[2] Pyroclastics are rocks composed of rock fragments that were produced and ejected by explosive volcanic eruptions and then consolidated.

The volcanic rocks are broken into numerous formations based on similar lithologic characteristics (USACE 2017b).

Oregon Coast Range and Puget Trough Sections of the Pacific Border Province

The Oregon Coast Range is derived from continental arc volcanism and the accretion of marine rocks and sediments along the Cascadia Subduction Zone (McClaughry et al. 2010). Along with volcanic rocks of the Western Cascades subprovince, it forms the basement of the Puget Trough, which is an elongated fore-arc basin that extends from the Puget Sound Lowlands in Washington south to central Oregon (Vaccaro 1997).

The Paleocene age and Eocene age mid-ocean ridge pillow basalts of the Siletz River formation form the basement of the Oregon Coast Range section. The Kings Valley Formation is siltstone-containing volcanic grains from the Siletz River Formation and is interbedded in places with Siletz River Volcanics.

The Eocene age Tyee Formation unconformably overlays the Siletz River Formation and contains sandstone turbidites deposited in a submarine fan and slope environment. The middle Eocene Spencer Formation includes marine sediments ranging in size from sandstone and conglomerate to sandstone and siltstone higher in the formation. The grain size decreases northward from nearshore marine delta and shelf deposits near Eugene, Oregon to deep-water siltstone and claystone facies. The shallow-water marine deposits of the upper Eocene and Oligocene Eugene Formation overlay the Spencer Formation and contain marine sandstone, tuffaceous sandstone and siltstone, and pebbly conglomerate.

Both the Spencer and Eugene formations are interlayered with middle and upper Eocene-aged nonmarine volcaniclastic sedimentary rocks, silicic tuff, and mafic lava strata of the Fisher Formation. The Eugene Formation also interfingers with the upper Eocene and lower Oligocene Keasy Formation, which is composed of marine siltstone and tuffaceous siltstone and mudstone formed from volcanic lithics. The Paleocene- to lower Miocene-aged rocks are cut by a series of upper Eocene to middle-upper Miocene mafic to intermediate composition intrusive bodies, including the Oligocene-aged gabbro and diorite dikes and sills of the Mary’s Peak Intrusives, which form the highest peak in the Coast Range (McClaughry et al. 2010).

Tectonic activity during the Miocene and Pliocene ages uplifted the Coast Range and depressed the Puget Trough, forming a back-arc basin. During the Miocene age, the Columbia River Basalt Group lava flows entered the basin, forming the bedrock of the Willamette River Basin. Sediments from both the Coast and Cascades Mountain Ranges and the Columbia River filled the depression.

Sediment from the Coast Range is generally clay, silt, and fine sand from weathering and erosion of marine sedimentary rocks. Sediment from the Cascades Mountain Range is composed of coarse sand and gravel-sized volcanic clasts. Sediments from the Columbia River are predominantly derived from glacial outwash floods and include exotic quartzite, and granitic and metamorphic clast lithologies. The Missoula Flood deposits are thicker and more extensive in the Portland Basin but extend south past Eugene within the Willamette River Basin.

Volcanic activity near Portland, Oregon in the late Pliocene to early Pleistocene ages formed the Boring Lava Field, which contains shield volcanoes that are typically 100 feet to 200 feet thick but can be more than 600 feet thick. Holocene-aged alluvium in the floodplains of major streams of the foothills in the southern and central Willamette River Basin predominantly contain tens of feet of sand and gravel-sized grains with some silt- and clay-sized particles. Smaller tributaries consist primarily of sand- to clay-size alluvial material. Along the Willamette River, alluvium becomes progressively finer grained and thicker downstream, consisting primarily of 50 feet to 100 feet of sand and silt near Portland (Vaccaro 1997).

Seismicity

The Cascades Subduction Zone is a convergent boundary between the North America plate and the Juan de Fuca/Gorda plates from northernmost California to southernmost British Columbia. A major subduction zone "interplate" earthquake with a magnitude (M_W) between 8.5 and 9.2 on the moment magnitude scale is believed to have occurred about once every 450 to 550 years (USACE 2017d). More frequent events of smaller magnitudes (8.0 M_W) could occur every 200 years along the southern Oregon coast, resulting in strong ground shaking extending inland to the Willamette River Basin. The last event occurred over 300 years ago on January 26, 1700 (USACE 2016b). The Cascades Subduction Zone represents the main seismic source hazard for the WVS.

Other types of seismic events that may occur in western Oregon are deep subcrustal earthquakes that occur in the subducting slab typically at depths between 25 miles and >62 miles, and crustal sources occurring within the North American plate (both along known faults and random seismicity not associated with any known faults).

The other type of earthquakes associated with the Cascades Subduction Zone include "intraplate" earthquakes, which occur within the subducting Juan de Fuca Plate. These earthquakes are generally deep with focal depths of 25 miles or more. The largest historical intraplate earthquakes recorded in the Pacific Northwest were the M_W 7.1 Olympia earthquake in 1949, the M_W 6.8 Nisqually earthquake northeast of Olympia in 2001, and the M_W 6.5 Seattle-Tacoma earthquake in 1965. An intraplate event would likely have an epicenter located along the eastern margin of the Coast Range and possibly beneath the Willamette River Basin (USACE 2017d).

3.4.2.2 Coast Fork Willamette River Subbasin

Overview

The Coast Fork Willamette River Subbasin straddles the Middle Cascades Mountains and Coast Range south of the Puget Trough section (Figure 3.4-2). Unconsolidated deposits make up 81 percent of the surface area within the 1 percent annual exceedance probability floodplain and 99 percent of the surface area within the 0.2 percent annual exceedance probability floodplain.

Most of the bedrock in the Coast Fork Willamette River Subbasin belongs to the Colestin Formation, which is the exposed oldest unit and is typically interfingered with the Eugene Formation; both are overlain by the Little Butte Volcanics. The Colestin Formation is Eocene- and Oligocene-aged Early Western Cascades Volcanics, including the andesite and volcanoclastic sedimentary rocks and tuff of the Fisher Formation and basalt (Hoover 1963).

The upper Eocene and Oligocene Eugene Formation is shallow-water marine deposits containing marine sandstone within the Coast Fork Willamette River Subbasin (McClaughry et al. 2010). The Little Butte Volcanics unit is composed of tuffs, basalt, and andesite flows within the subbasin (Peck 1964). There are no major quaternary faults or folds recorded in the subbasin.

Dorena Dam

In the immediate vicinity of Dorena Dam, the ground surface elevations range from approximately 1,200 feet to 2,000 feet (Figure 3.4-1). Lithologies near Dorena Reservoir consist of a varied and complex stratified volcanic sequence, which includes basalt flows, well-bedded tuffaceous sandstones, tuffaceous pebble to cobble conglomerates, andesite flows and intrusions, tuffs, tuff breccias, and conglomeratic tuffs. Bedrock dips generally 30 degrees toward the east (upstream) and is cut by small basaltic andesite dikes, irregular intrusions, and a large northwest trending fault zone (Figure 3.4-4).

The valley floor is composed of approximately 10 feet to 20 feet of Quaternary river-deposited alluvium overlying bedrock. The upper layer of alluvium near the dam site is an average of 4 feet of low-strength plastic clay and silt underlain by approximately 15 feet of stratified alluvium containing 3-inch minus fraction gravel with 10 percent to 20 percent clay and silt with boulders.

The foundation rock beneath Dorena Dam is predominantly andesite with some lapilli tuff and coarse tuff breccia. Foundation bedrock below the concrete structures consists almost entirely of massive andesite flow rock (USACE 2017d). A large, 32 million square-foot landslide is located immediately upstream of the dam (Walker 2002). Large, ancient landslides are mapped around Dorena Reservoir rim as well as several active small landslides that have damaged infrastructure. Periodic repairs to the roads and railroad around Dorena Reservoir have been needed to address the damage.

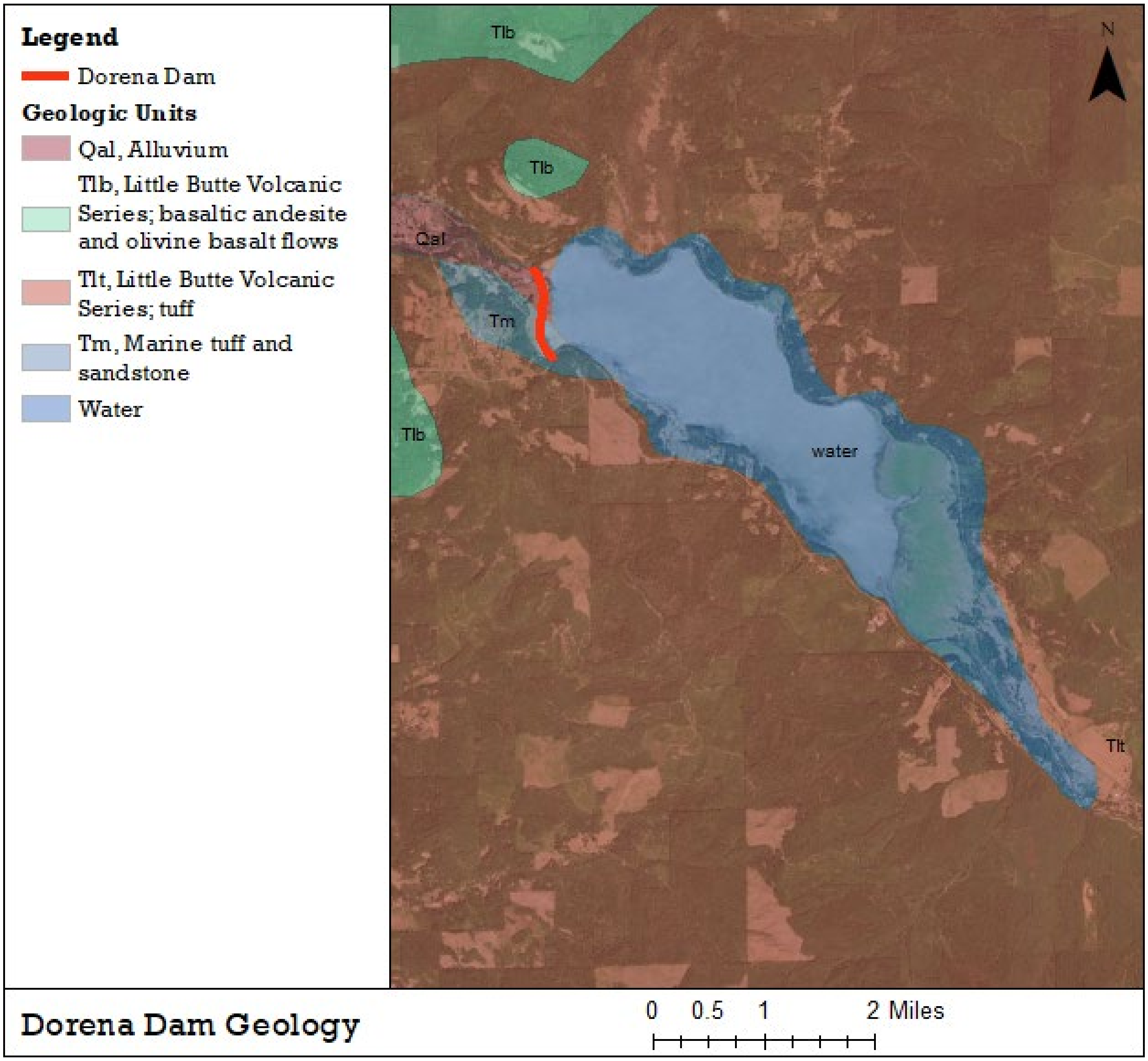

Figure 3.4-4. Geologic Formations and Alluvial Deposits around Dorena Dam.
Source: Peck 1964

Cottage Grove Dam

Cottage Grove Dam and Reservoir are located within the Middle Cascades Mountains physiographic region near the boundary with the Oregon Coast Range. The foothills of the Cascade Range are to the east of the dam and the Coast Range to the west.

Relief ranges up to about 1,500 feet on both sides of the reservoir. The immediate reservoir area has eroded terrain with gently sloping to partially rounded hills (Figure 3.4-5).

The closest mapped quaternary fault to the site is an unnamed fault located near Sutherlin, approximate 12 miles east of Cottage Grove Dam. The Cascadia Subduction Zone is 45 miles to

75 miles west of the dam (USACE 2017b). No landslides have been mapped around the Cottage Grove Reservoir rim (USACE 1981).

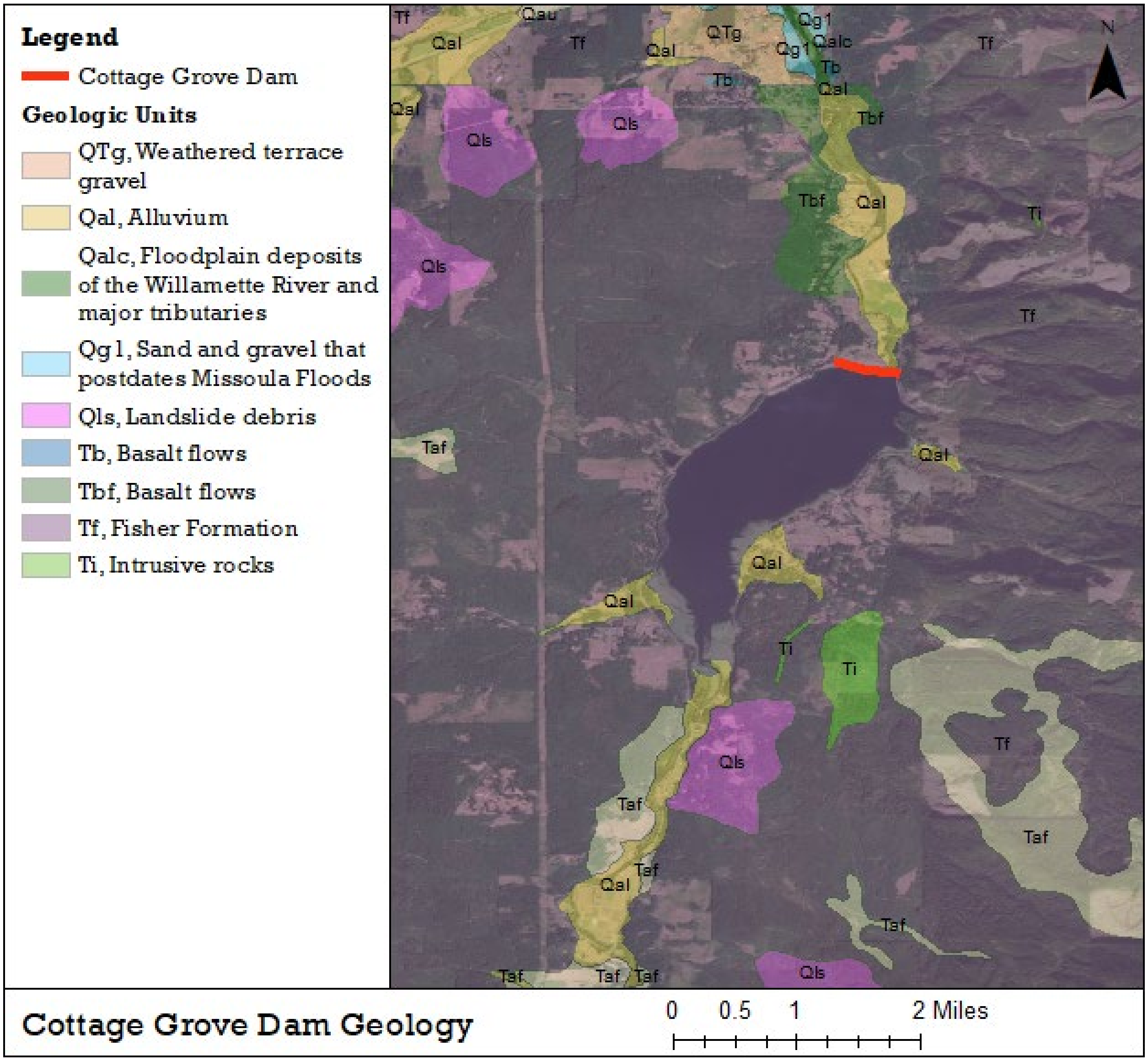

Figure 3.4-5. Geologic Formations and Alluvial Deposits around Cottage Grove Dam.
Source: Hoover 1963

3.4.2.3 Long Tom River Subbasin

<u>**Overview**</u>

The Long Tom River Subbasin is an elongated structural basin filled with thick accumulations of silt-clay, fresh sand, gravel and cobble deposits, and partly decomposed sand, gravel, and cobbles (USACE 2015e). The 1 percent annual exceedance probability and 0.2 percent annual exceedance probability floodplains are dominated by quaternary-aged unconsolidated deposits, which make up 99 percent of the 1 percent annual exceedance probability floodplain and 100 percent of the 0.2 percent annual exceedance probability floodplain.

Eocene-aged deltaic sandstones of the Spencer Formation make up 1 percent of the 100-year floodplain within the subbasin; less than 15 acres of the Eugene Formation and Colestin Formations are present (McClaughry et al. 2010). There are no major quaternary faults or folds recorded in the subbasin.

Fern Ridge Dam

Fern Ridge Dam is located in the Oregon Coast Range physiographic section near the southern end of the Puget Trough (Willamette Valley). Rock formations underlying Fern Ridge Reservoir are exposed in adjacent foothills. Rock strata typically have low eastward dips of 10 degrees to 20 degrees.

Foundation materials beneath the Fern Ridge Dam embankment consist of a thin clay blanket underlain by a thin layer of silty sand, which overlies clayey gravels that extend 80 feet to 100 feet to bedrock (Figure 3.4-6). Foundation rocks are primarily marine tuffaceous sandstones and agglomerates that are intruded by diabase sills and dikes, and there are some inter-bedded continental clastic tuffs and breccias to the southeast. West of the spillway, the embankment sits on highly weathered diabase. The spillway is founded on diabase rock (USACE 2015e).

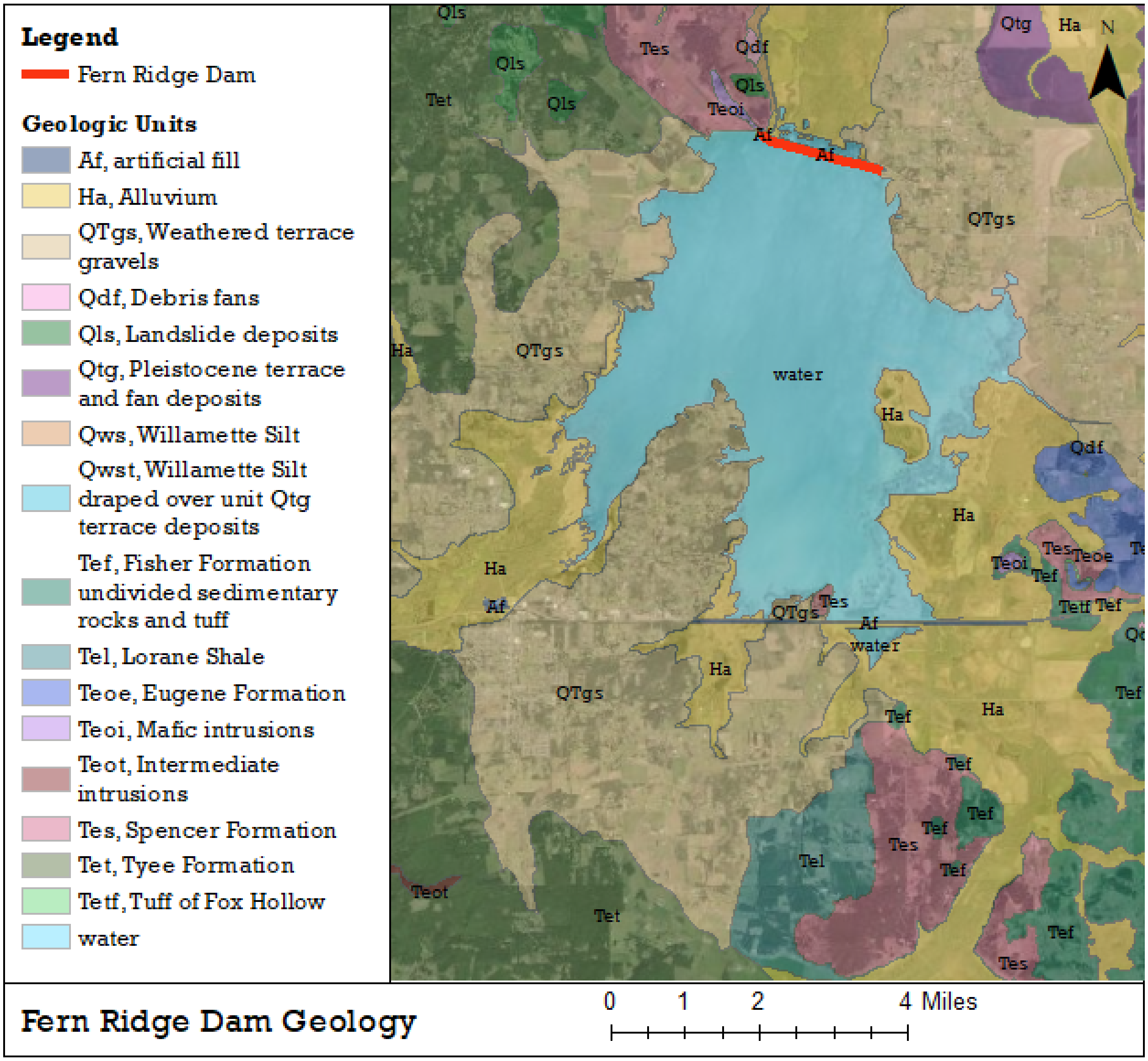

Figure 3.4-6. Geologic Units in the Vicinity of Fern Ridge Dam.

Source: McClaughry et al. 2010

3.4.2.4 McKenzie River Subbasin

Overview

In the McKenzie River Subbasin, unconsolidated deposits make up 95 percent of the 1 percent annual exceedance probability floodplain and 70 percent of the 0.2 percent annual exceedance probability floodplain. Primary surficial bedrock within the floodplain is the Little Butte Volcanic series, including the tuffs of the Mohawk River Caldera and basalts of the Mt. Tom formations (McClaughry et al. 2010).

Miocene-aged granitic intrusions from Late Western Cascades Volcanics are also present in the analysis area. Less than 15 acres of the Eugene Formation and Eocene/Oligocene-aged basaltic intrusive rocks of the Early Western Cascades Volcanics are also present in the 1 percent annual exceedance probability subbasin (McClaughry et al. 2010). The White Branch Fault Zone is a north-to-south-striking normal fault located 13 miles east of Cougar Dam and 17 miles east of Blue River Dam (Personius 2002d).

Cougar Dam

Cougar Dam lies near the fault-controlled boundary between the Western Cascades and the High Cascades geologic provinces. Important geologic features near the dam include Horse Creek Fault, which is about 12 miles east, and the major strato-volcano South Sister, which is 20 miles west of the dam with volcanism less than 1,000 years old.

The oldest rock unit in the dam and reservoir area is the series of bedded pyroclastic deposits of the tuff of Cougar Reservoir, which are dacitic tuffs interbedded with ash flows, rhyodacite, andesites, and fine-grained bedded tuffs referred to as “mudstone” in the original design memorandum (Figure 3.4-7). The pyroclastics form a massive rock unit that is both faulted and gently folded. The tuffs have been intruded by dikes and other irregular basalt or dacite.

Deep drawdowns occurred in Cougar Reservoir from April 2002 to about March 2005 to construct the water temperature control tower and then again in April 2016 for debris removal. There were no incidents of slope failures during these drawdowns.

The largest intrusion at the site follows the footprint of the dam. The lower contact of the intrusion has been eroded through by the McKenzie River (USACE 2017c). A 6 million-square-foot landslide is located 1.3 miles upstream of the dam and extends into the reservoir (Priest et al. 1988). Large- and medium-size landslides are present around Cougar Reservoir, which have experienced small-scale movements resulting in minor rock fall and slumping since completion of the dam construction.

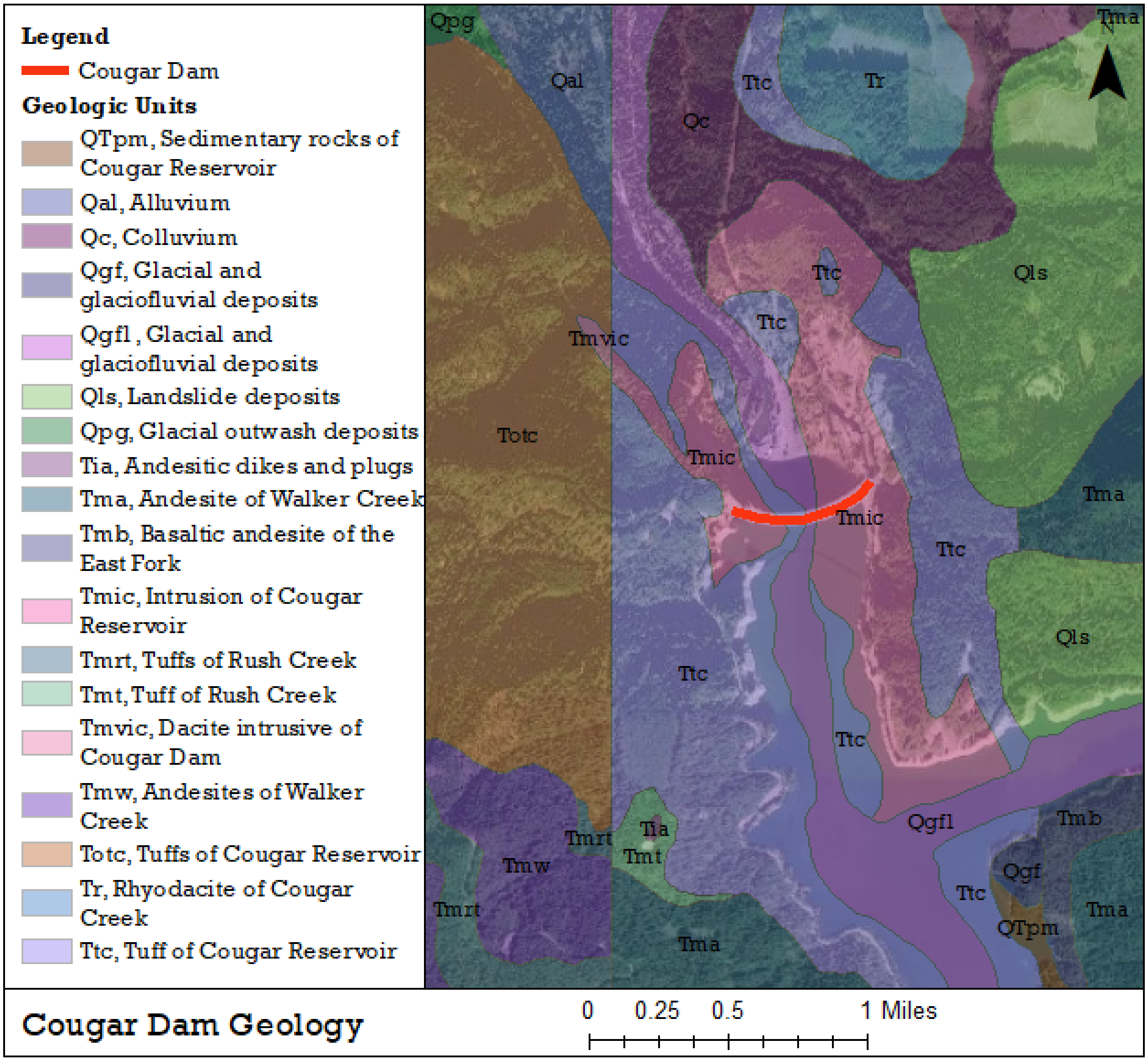

Figure 3.4-7. Geologic Units in the Vicinity of Cougar Dam.
Sources: Priest and Woller 1983; Priest et al. 1988

Blue River Dam

Blue River Dam is located in the Western Cascades physiographic subprovince. The reservoir area is dominated by thick, deformed sequences of Tertiary rocks (Oligocene to Miocene), including pyroclastics, lava flows, and minor intrusions that resulted from several periods of intense volcanism.

The oldest rock units in the area are mudflow (lahar) deposits; massive to bedded, fine-to coarse-grained tuffaceous sedimentary rocks, and volcanic conglomerates, which exhibit low grade metamorphism (Figure 3.4-8). Basaltic dikes intruded the older volcanic deposits. Both the volcanic deposits and dikes are cut by quartz veins associated with the Blue River Mining District hydrothermal system.

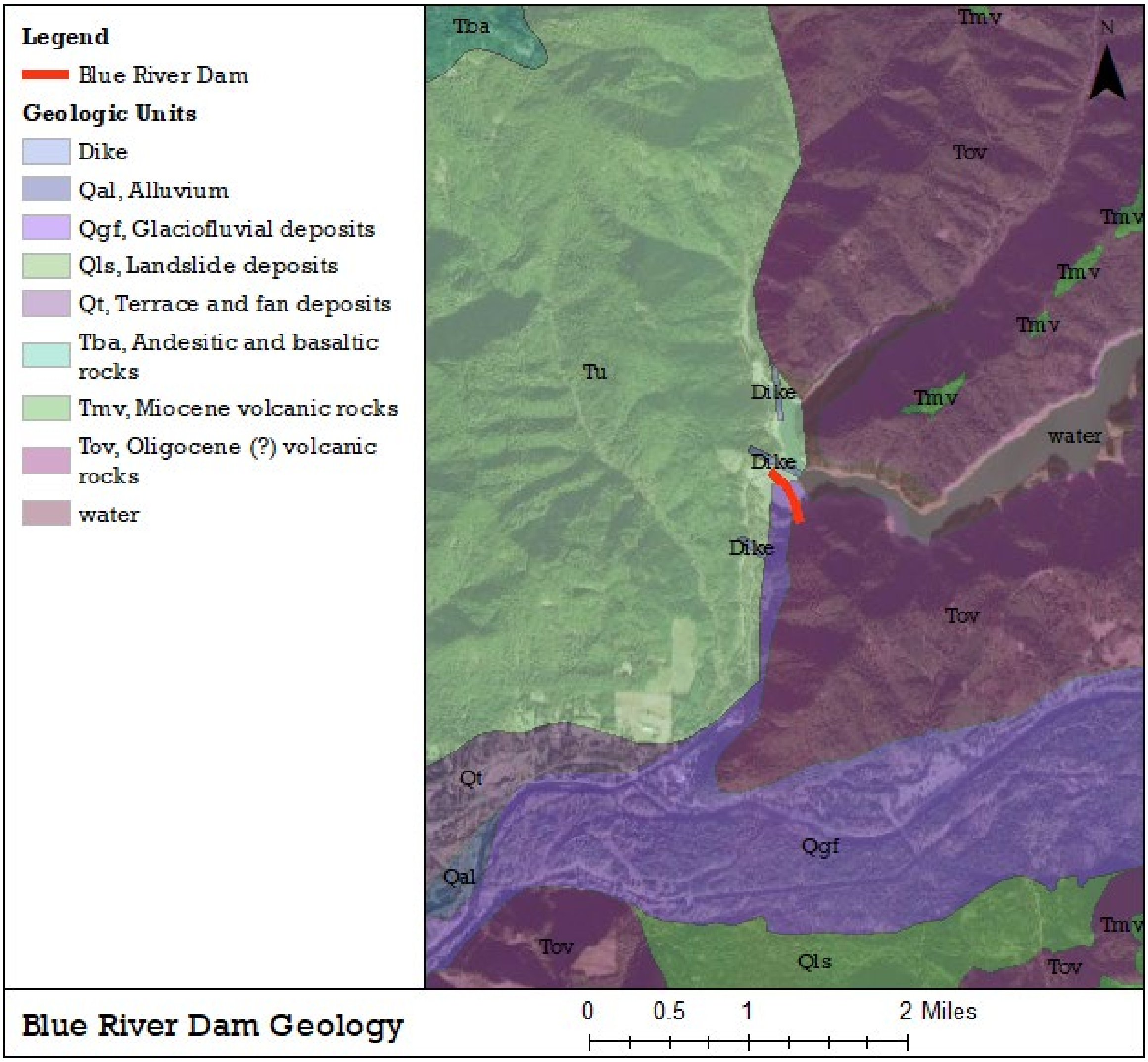

Figure 3.4-8. Geologic Units in the Vicinity of Blue River Dam.
Sources: Brown et al. 1980a; Walker and Duncan 1989

Ridges adjacent to the dam and reservoir are relatively narrow and have a maximum relief of approximately 2,000 feet. About 40,000 years ago, the McKenzie River valley was occupied by an alpine glacier created by the merging of three glaciers from the Three Sisters volcanic mounts. The glacier periodically advanced up the original Blue River drainage, blocked the drainage, and formed a glacial lake.

In the Quaternary period, glacial-influenced stream action created narrow canyons with steep side slopes in the present main dam area and a wider canyon with steep side slopes in the present middle and upper reservoir area. Final retreat of the glacier deposited thick sediments in the area of the present auxiliary dam, resulting in permanent diversion of the river over bedrock near the mouth of Scout Creek, and establishment of current drainage past the area of the main Blue River Dam. The foundation rock is predominantly hard and fresh andesite, contact breccia, and lapilli tuff. The auxiliary dam foundation is primarily composed of stratified glacial lake and alluvial materials with depths up to 150 feet (USACE 2016b).

3.4.2.5 Middle Fork Willamette River Subbasin

Overview

The Middle Fork Willamette River Subbasin is located within the Western Cascades physiographic subprovince. Sedimentary deposits make up 70 percent of the 1 percent annual exceedance probability floodplain and 99 percent of the 0.2 percent annual exceedance probability floodplain. The Little Butte Volcanic Series, including the Mohawk River Caldera and Mt. Tom Formations, form the majority of bedrock (Peck 1964; McClaughry et al. 2010).

Less than 15 acres of Early Western Cascades Volcanics, including intrusive rocks and volcanoclastic sediments of the Mehama Formation, are present. Between Lookout Point and Hills Creek Dam, the Middle Fork Willamette River traces the path of the Upper Willamette River Fault Zone, which strikes northwest to southeast to the east of Hills Creek Reservoir (Personius 2002h).

Lookout Point Dam

The rocks found in the vicinity of Lookout Point Dam range in age from Eocene to Miocene, and consist of tilted sediments, pyroclastic beds, and lava flows. The topography is characterized by narrow valleys and sharp ridges that are mostly unrelated to the underlying bedrock structure. Localized folds within the region form short anticlines and synclines. All bedrock in the Western Cascades has experienced low grade metamorphism.

Overburden in the valley floor consists of a 10- to 20-foot-thick deposit of boulders, cobbles, gravels, sands, silt, and deeply weathered clay talus. The left abutment of the dam is tied into an ancient landslide complex (Figure 3.4-9) (USACE 2019d).

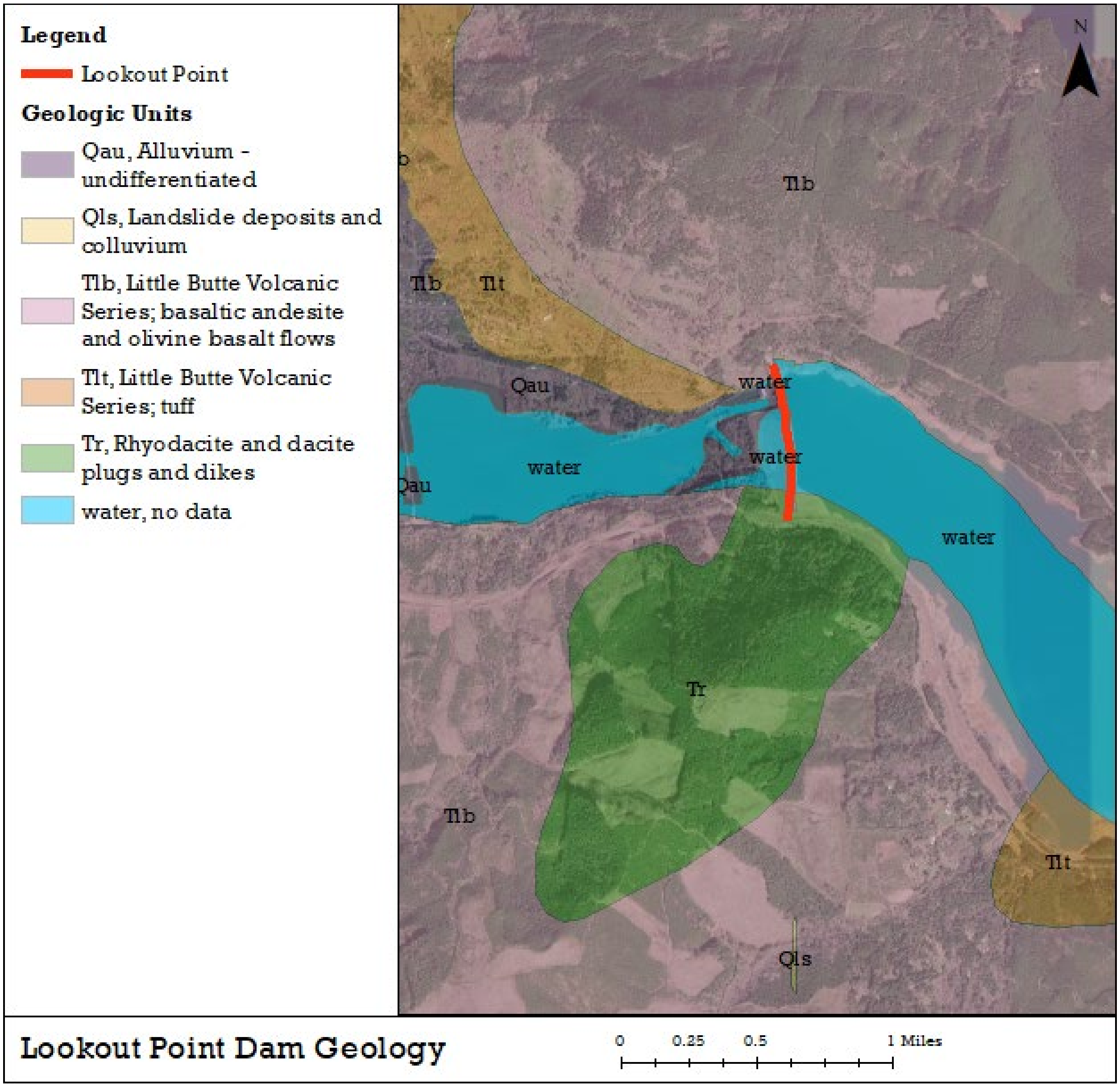

Figure 3.4-9. Geologic Units in the Vicinity of Lookout Point Dam.
Sources: O'Connor et al. 2001; Peck 1964

Deep-seated landslides were induced during the first two drawdown cycles of reservoir operation at Lookout Point Dam after the reservoir was first filled in 1953. Two slides extend into the reservoir and continue to be influenced by fluctuations in the Lookout Point Reservoir. The Minnow Slide is located on the left bank of Lookout Point Reservoir, approximately 0.8 miles to 1.8 miles upstream from the dam; the slide mass extends below the minimum pool (elevation 819 NAVD88). Relocation of the highway and railroad during early construction of Lookout Point Dam reactivated the slide. The Voss Slide is 3 miles upstream of the dam on the left bank. The toe is approximately at elevation 859 feet NAVD88 (75 feet below full pool). The Voss Slide formed during the first pool drawdown in 1955. Measures were taken to stabilize both slopes, but periodic movements of the slide masses have continued to occur (USACE

1981). Deposits of clay and talus are prevalent throughout the valley, and large masses were present on both abutments of the dam site.

Volcanic rocks that form the foundation area fall into two main groups, a porphyritic andesite group and a porphyritic augite basalt group. The porphyritic andesite group is the main lithology in the subbasin.

There are three dominant bedrock joint systems at the site, many of which are also open and contain colloidal clay. The main large fault at the dam site cuts diagonally across the stilling basin (USACE 2019d).

Hills Creek Dam

Hills Creek Dam is located in the central Western Cascade Range. The dam occupies a steep-sided canyon at the confluence of Hills Creek and the Middle Fork of the Willamette River where the original valley was about 700 feet wide.

Hills Creek Dam is founded in Oligocene-Miocene-age tuffs of the Little Butte Volcanic Series. The tuffs have been hydrothermally altered, sheared, and displaced by intrusive rocks. Near the dam, intrusive rocks include small, localized sills, a massive hornblende andesite intrusion in the left abutment, a large dacite dike downstream of the dam centerline and in the right abutment, and a large diabase dike downstream of the dacite dike.

Overburden at the dam site is mainly a gravel-cobble-boulder alluvium that increases in depth from the right abutment to the left abutment (Figure 3.4-10). The upper 10 feet to 15 feet of the gravel is mostly unweathered, hard, and unconsolidated. Deeper alluvium contains a high percentage of weathered and compacted gravel that is permeable.

Outside the original river channel, the floodplain has a blanket of 3 feet to 8 feet of silty sand. Overburden on the left abutment includes deeply weathered lapilli tuff and shallower landslide deposits (USACE 2019c). An 18 million-square-foot landslide is located 0.4 miles southwest of the dam (Walker 2002), and several large landslides are mapped 1 mile east of the dam (Sherrod 1991; Brown et al. 1980b). Both landslides extend into the reservoir and have histories of periodic small-scale movement that requires maintenance of affected roadways.

Hills Creek Dam coincides with the intersection of two major fault zones, the Middle Fork and Hills Creek Faults. The faults are associated with widespread shearing, clay-filled rock joints and fractures, and deep weathering in the dam vicinity. These faults are believed to be inactive based on U.S. Geologic Survey (USGS) mapping, and pre-construction geologic mapping provides no evidence of recent fault activity (USACE 2019c).

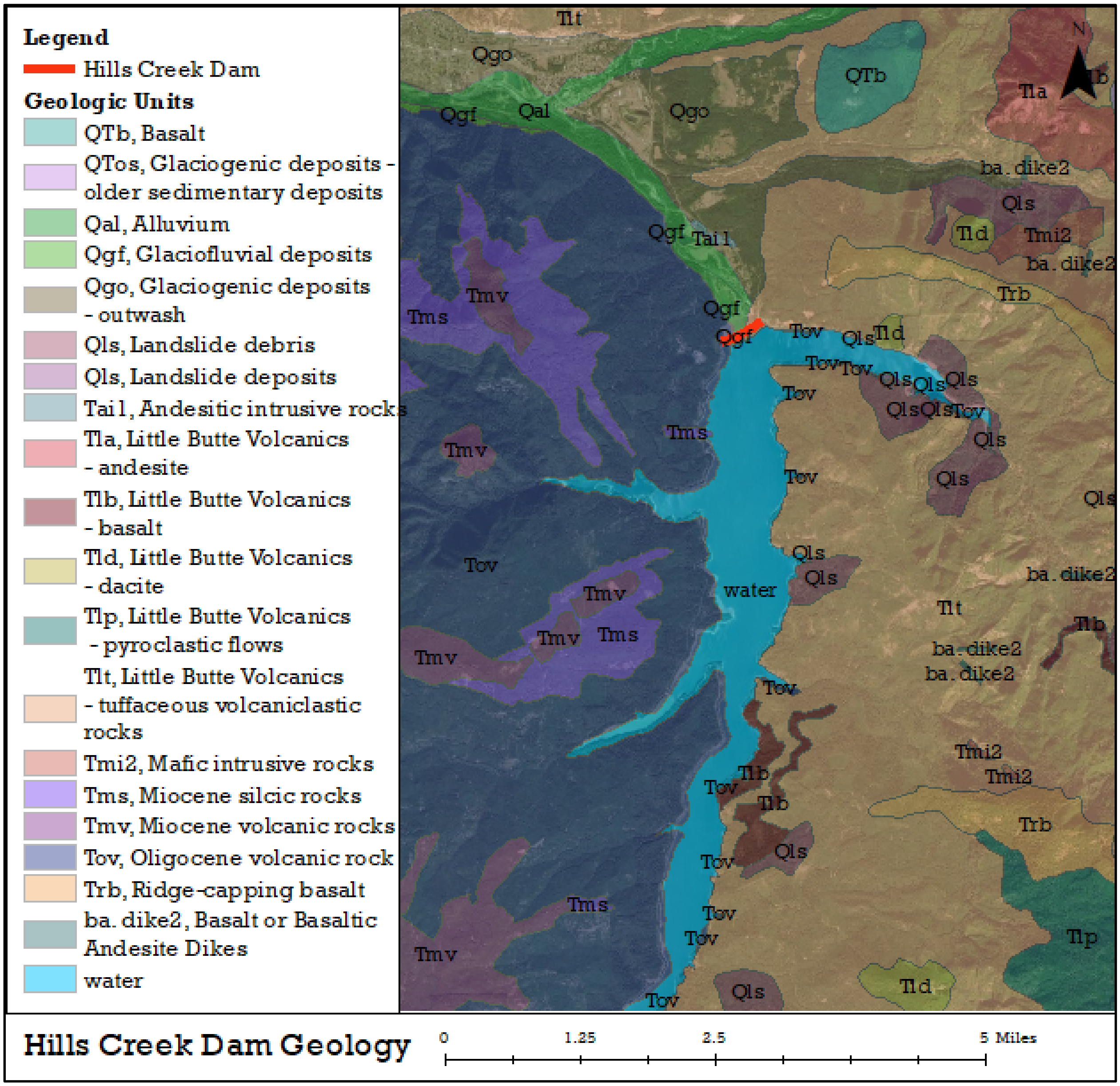

Figure 3.4-10. Geologic Units in the Vicinity of Hills Creek Dam.

Sources: Brown et al. 1980b; Sherrod 1991

Dexter Dam

Bedrock in the concrete structure area of Dexter Dam consists of a series of pyroclastic tuffs and tuff breccia that have been intruded by dense, hard basalt. The surface of the foundation is for the most part a remnant of a basalt flow or flows, which has been eroded deeply enough in places to expose the underlying pyroclastics.

Most of the overburden in the Dexter Dam area is shallow, consisting of loose, sandy gravel containing cobbles and occasional boulders (Figure 3.4-11). Cemented gravel and boulders were encountered in the fault-controlled channel beneath the upstream training wall. The base of the right abutment and the west end of the fishway have shallow residual clays and talus (USACE 2015d). No landslides are mapped within the reservoir area (Walker 2002).

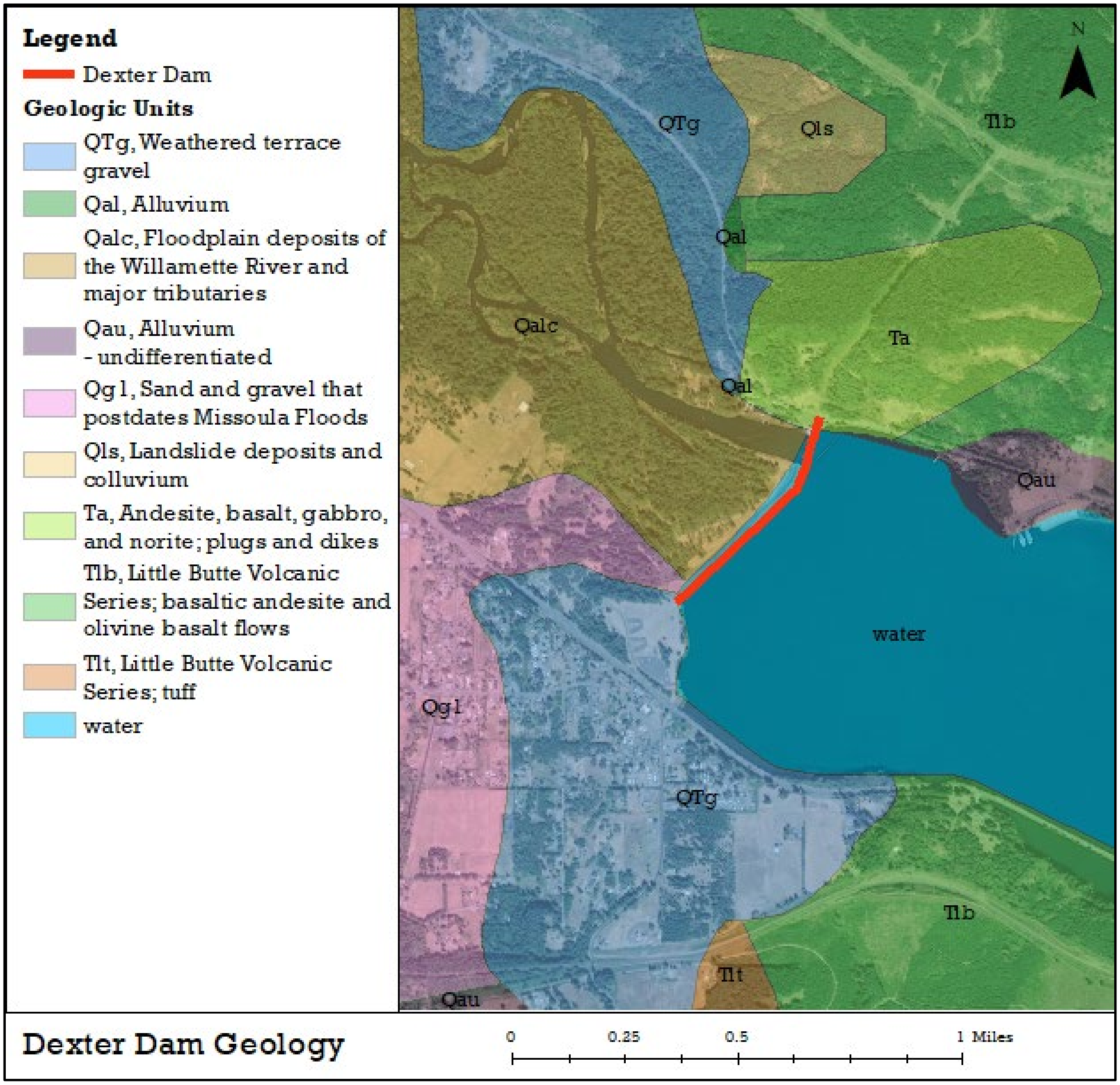

Figure 3.4-11. Geologic Units in the Vicinity of Dexter Dam.

Sources: O'Connor et al. 2001; Peck 1964

There are numerous faults in the embankment foundation, some of which are responsible for steep to near vertical slopes in the foundation surface. The most prominent and extensive fault in the concrete portion of the dam is the Powerhouse Fault, which follows the contact of the pyroclastics and the main body of intrusive basalt. This fault movement was likely produced in the late stages of intrusion after solidification of the magma. Foundation rock beneath the embankment area is a composite series of pyroclastic rocks and basalt flows with occasional intruding fingers of basalt.

A fault zone that transects the embankment dam was uncovered during construction of the dam. The Foundation Report states that indicators of frictional movement between rocks along the two sides of the fault were observed within the alluvial gravels overlying bedrock. USACE initiated a geologic reconnaissance of this fault/lineament in the early 1980s, which suggests that the last activity was in the Early Pleistocene (greater than 100,000 years). There is no confirmed activity on this geologic fault in the last 10,000 years (USACE 2015d).

Fall Creek Dam

The topography within the Fall Creek drainage basin is irregular with much variation observed in slope steepness around the reservoir. Fall Creek Dam is located along the lowermost foothills of the Cascade Range and discharges to the southern extent of the Willamette River Basin. The Willamette Valley slopes within the Basin extend approximately 500 feet to nearly 1,400 feet above the reservoir elevation.

The right abutment is located on an old alluvium-filled river channel. The residual soil consists of sandy silty clay and silty gravel. The decomposed terrace gravels consist of dense, silty, gravelly sand. Left abutment overburden is mostly shallow residual silty soil and slopewash between scattered rock outcrops, with some small local talus deposits. An old gravel terrace is located upstream on the left abutment.

The foundation material in the area of Fall Creek Dam consists of lava flows, intrusive rock masses, fragmental pyroclastic materials, and volcanic derived sandstone, which is the lowest member of the stratigraphic sequence (Figure 3.4-12). The pyroclastic- and volcanic-derived sandstone materials are the dominant rock types. In the dam foundation area, the resistant andesite rock materials are intrusive in origin and form the blufflike abutments, especially on the right abutment.

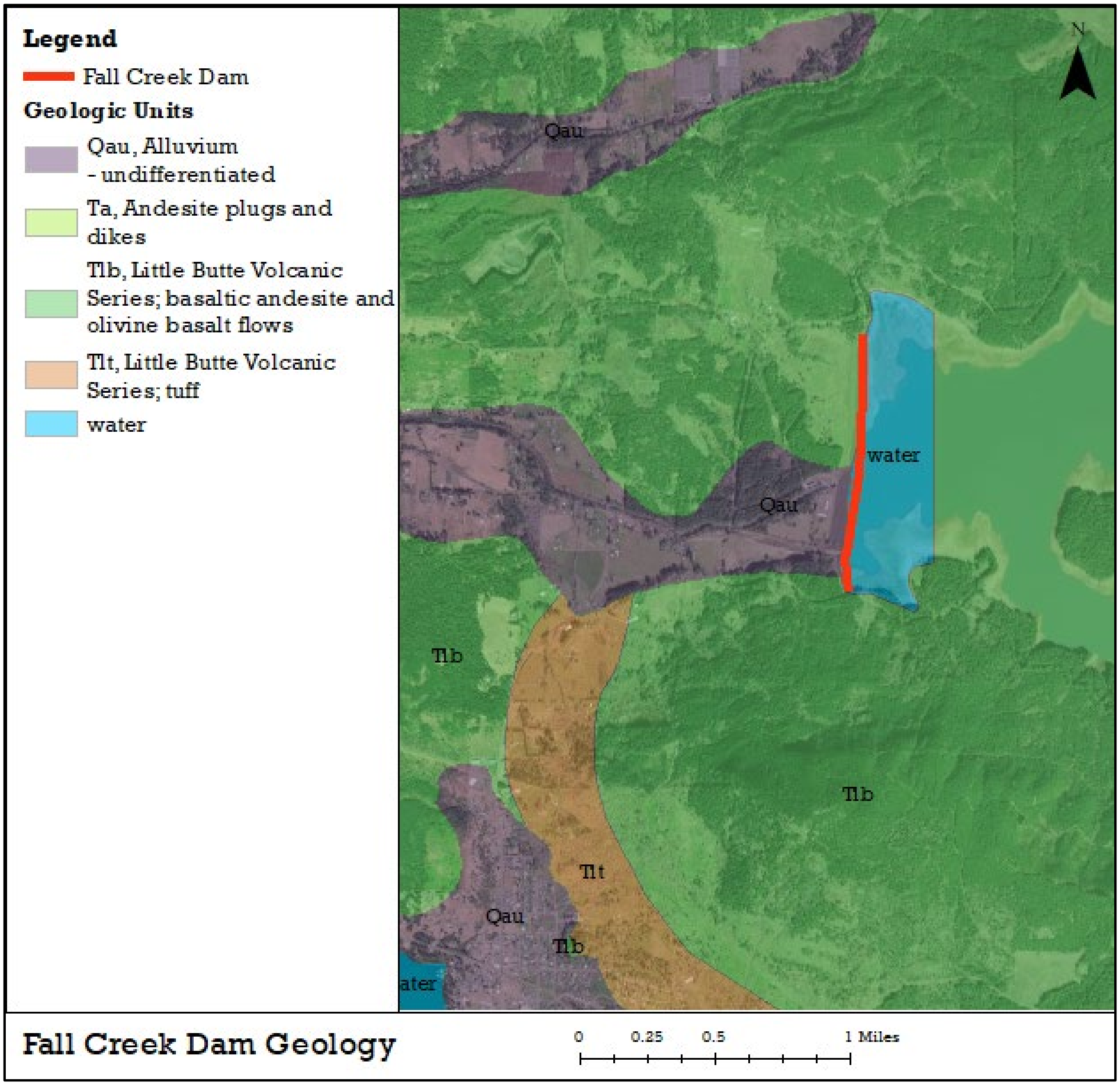

Figure 3.4-12. Geologic Units in the Vicinity of Fall Creek Dam.
Sources: O'Connor et al. 2001; Peck 1964

An intrusive contact zone separates andesite that extends from the intake of the regulating outlet to the dam axis and sandstone that extends to the downstream end of the discharge channel. The dam foundation alignment generally follows this contact. Major rock fractures and joint sets generally trend approximately northeast and northwest with minor fractures and joint sets trending north and east (USACE 2014b).

Historically, downcutting of the Fall Creek and Winberry Creek valleys was periodically interrupted by valley deposition and infilling, as indicated by deeply weathered terrace deposits along the valley walls. Numerous landslide deposits are present along the slopes around Fall Creek Reservoir in deep overburden and/or intensively weathered rocks (USACE 2014b), but no landslides are mapped within the reservoir area (Walker 2002). USACE conducted several drawdowns to near the streambed in most years between 1969 and 1979 and has conducted deep drawdowns of the Fall Creek Reservoir annually since 2010. These drawdowns have not resulted in initiation of landslides.

3.4.2.6 Middle Mainstem Willamette River Basin

Overview

The Middle Mainstem Willamette River Basin is within the western half of the Puget Trough. More than 99 percent of the basin is unconsolidated deposits. Bedrock is composed primarily of the Miocene-aged Columbia River Basalt Group, including the Grande Ronde and Wanapum Formations, and Eocene-aged marine sedimentary rocks of the Keasey Formation (O'Connor et al. 2001; Yeats et al. 1996). Major faults that intersect the basin include the Salem-Eola homocline (Personius 2002b), Newberg Fault (Personius 2002c), Canby-Molalla Fault (Personius 2002e), and Bolton Fault (Personius 2002a).

3.4.2.7 North Santiam River Subbasin

Overview

In the North Santiam River Subbasin, unconsolidated sediments cover 99 percent of the 1 percent annual exceedance probability and 100 percent of the 0.2 percent annual exceedance probability. The majority of the surficial bedrock in the area is from the Little Butte Volcanics and the intermediate rocks of the Late Western Cascades Volcanics, including the andesite volcanic rocks of the Sardine Formation. Less than 16 acres for each formation of the 1 percent annual exceedance probability in the subbasin contains the Columbia River Basalt Group, the Eugene Formation, and the Keasey Formation. The Salem-Eola Hills homocline is mapped at the downstream end of the basin (Personius 2002b).

Detroit Dam

Detroit Dam is founded on Hall Diorite near the roof and northern margin of a 2 to 3 square-mile pluton. It is intruded into the Lower Member of the Sardine volcanic country rock, which is composed of stratified tuffs, tuff breccias, andesite flows, and volcanic sedimentary rocks (Figure 3.4-13). In order of abundance, bedrock at the dam consists of the following: andesite breccia, diorite, aplite, andesite porphyry, hydrothermally altered phases of these rocks, and vein material composed of crushed vein matter, quartz, and traces of hematite, lead, and zinc minerals. The andesite breccia is a hard and brittle rock mass that occurs along the northwestern and western margin of the intrusion and has been altered.

Overburden at Detroit Dam consists of 0 feet to 70 feet of talus, river alluvium, glacial debris, and remnants of old cemented terrace river gravels (USACE 2016c). Many 1 to 10 million-square-foot landslides are mapped extending into the water along the right bank of the reservoir about 4 miles upstream of the dam (Calhoun et al. 2020). These areas are mapped as active landslides since completion of the reservoir (USACE 1983).

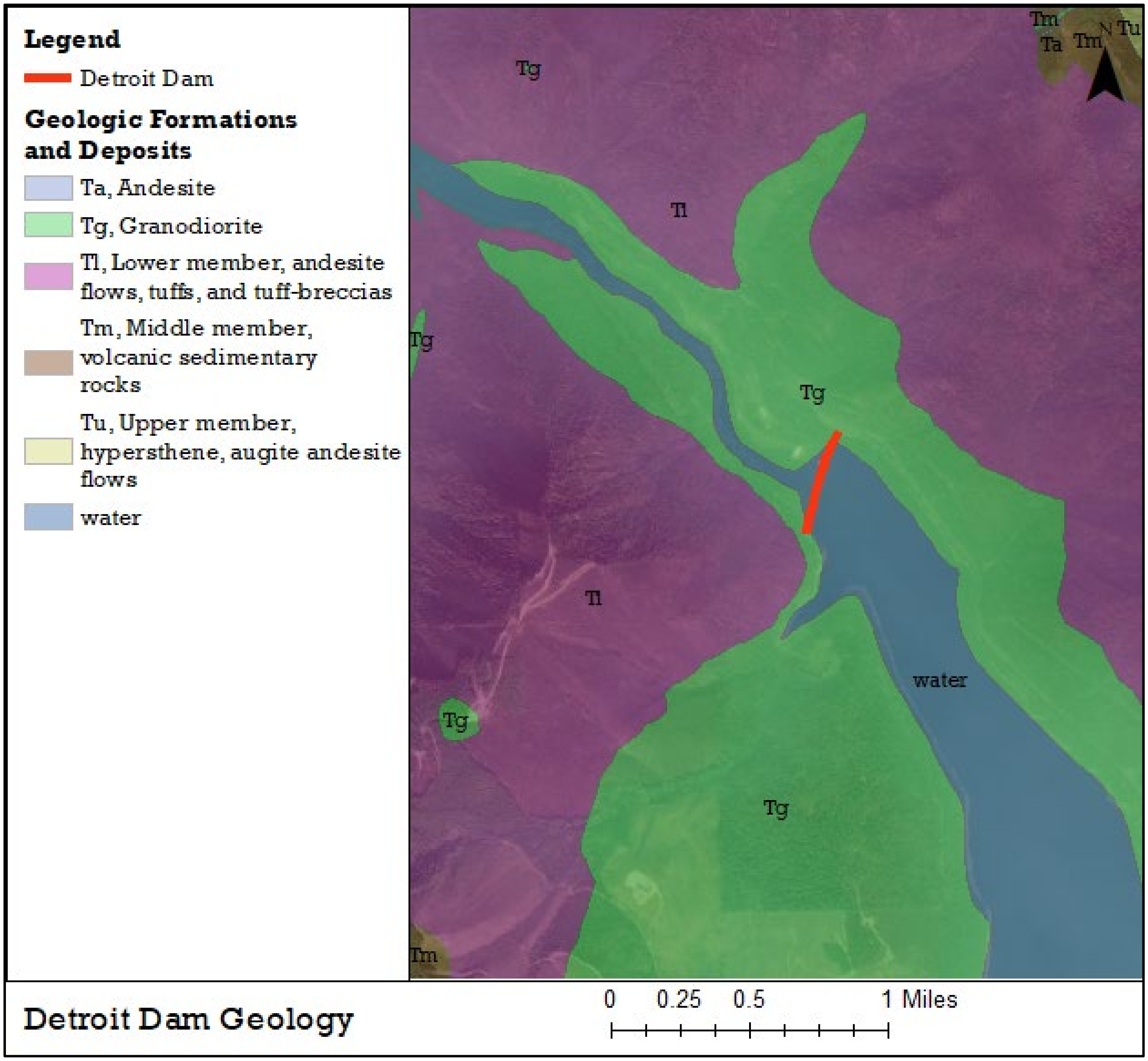

Figure 3.4-13. Geologic Units in the Vicinity of Detroit Dam.
Source: Pungrassami 1969

Primary direction of faults, fissures, shears and joints in the foundation strike northwest, nearly parallel to the dikes of andesite porphyry and the Hall Diorite. The larger northwest-striking shears have been mineralized and presently consist of a few inches to nearly 5 feet of shattered rock in a hard matrix of quartz and epidote. Northeast-striking faults and shears exposed in the foundation are generally tight and fresh. Joints higher up on the abutments and above the dam typically are deeply weathered to clay (USACE 2016c).

Big Cliff Dam

Big Cliff Dam is located in a steep V-shaped canyon, with sides ranging in height from 1,500 feet to 2,500 feet above the stream channel. The channel is slightly more than 50 feet wide, and there is no floodplain. The left abutment is a vertical cliff from which the dam derives its name.

The entire dam site is underlain by massive, sound, andesite lava flows, tuffs, and lapilli tuffs (Figure 3.4-14). The tuffs are overlain by a dense porphyritic andesite flow that reaches a maximum thickness of 200 feet, strikes northwesterly, and dips 20 degrees southwest. The lower 50 feet of this flow is highly brecciated.

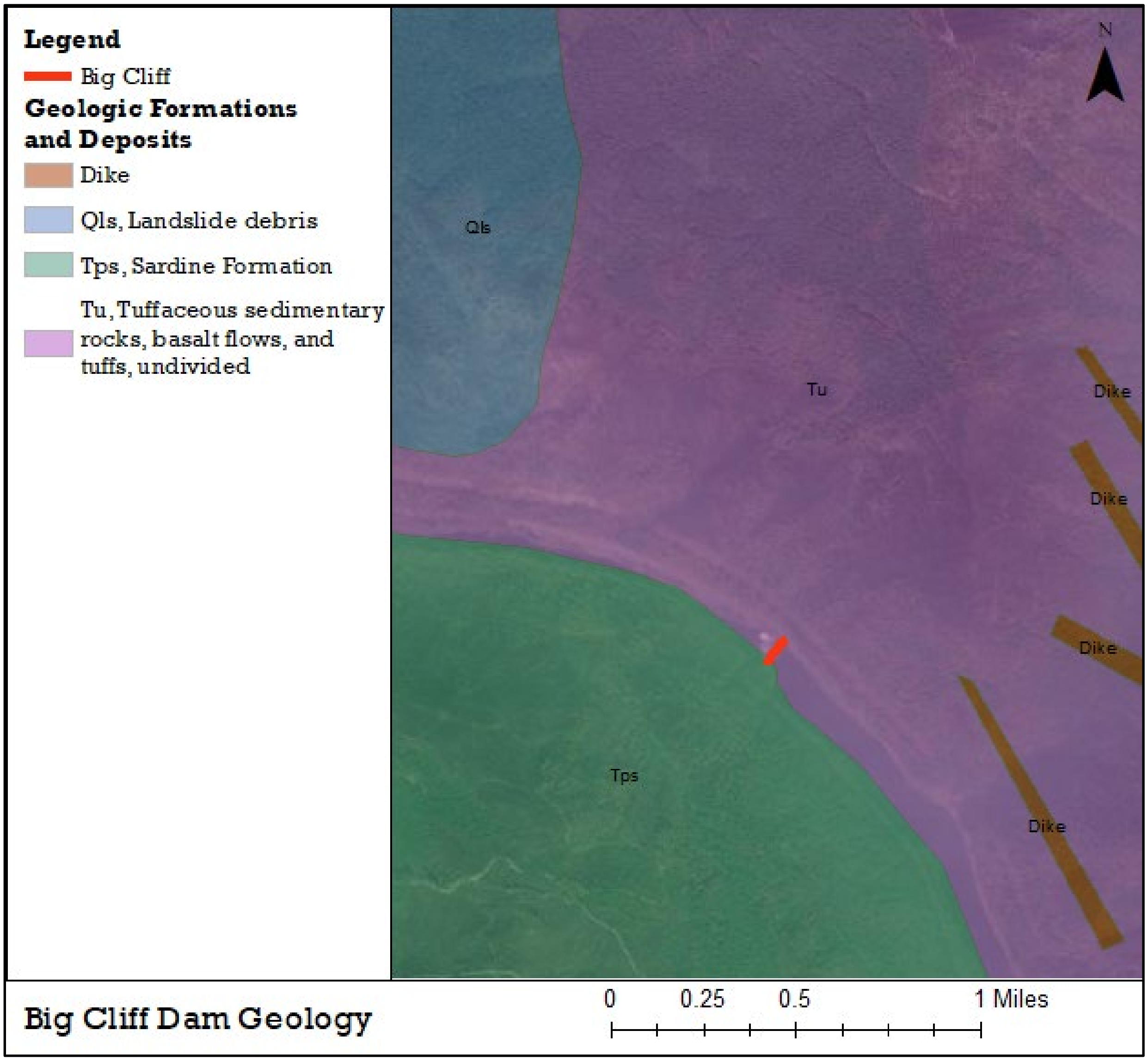

Figure 3.4-14. Geologic Units in the Vicinity of Big Cliff Dam.
Source: Beaulieu 1947

3.4.2.8 South Santiam River Subbasin

Overview

Unconsolidated deposits in the South Santiam River Subbasin make up 73 percent of the 1 percent annual exceedance probability floodplain and 100 percent of the 0.2 percent annual exceedance probability floodplain. Little Butte Volcanics, including the Mt. Tom and Scorpion Mountain Formations, form the majority of bedrock in the area, with a lesser surface area of the Mehama Formation.

Miocene/Pliocene-age terrestrial sedimentary rocks of the early High Cascades Volcanics and Grande Ronde Basalt are also present (Beaulieu 1971; McClaughry et al. 2010; Yeats et al. 1996). There are no major quaternary faults or folds recorded in the subbasin.

Foster Dam

Foster Dam is located in the deeply eroded valley formed by the confluence of the Middle Santiam and South Santiam Rivers. Slopes around Foster Reservoir were formed by rapid down-cutting into alternating layers of strong and weak volcanic rocks. Over-steepened lower valley slopes have a potential for slides, but most slope failures are limited to local overburden accumulations.

The Mehama Formation is exposed in outcrops along the right dam embankment and is capped by basaltic rock units. It is part of the Little Butte Volcanics and consists of undifferentiated sedimentary rocks and tuffs. The sedimentary rocks are mainly indurated (hardened), non-marine volcaniclastic conglomerate, breccias, sandstone, and mudstone (Figure 3.4-15).

The valley is much wider below the juncture of the two rivers and is marked by a sequence of five well-developed, contiguous alluvial terraces consisting of discontinuous layers, lenses, and mixtures of gravel and sand-sized clasts, and low plasticity silt. Valley overburden is primarily deposits of poorly graded, clean gravels near the surface and well graded silty sandy gravel at depths below 15 feet.

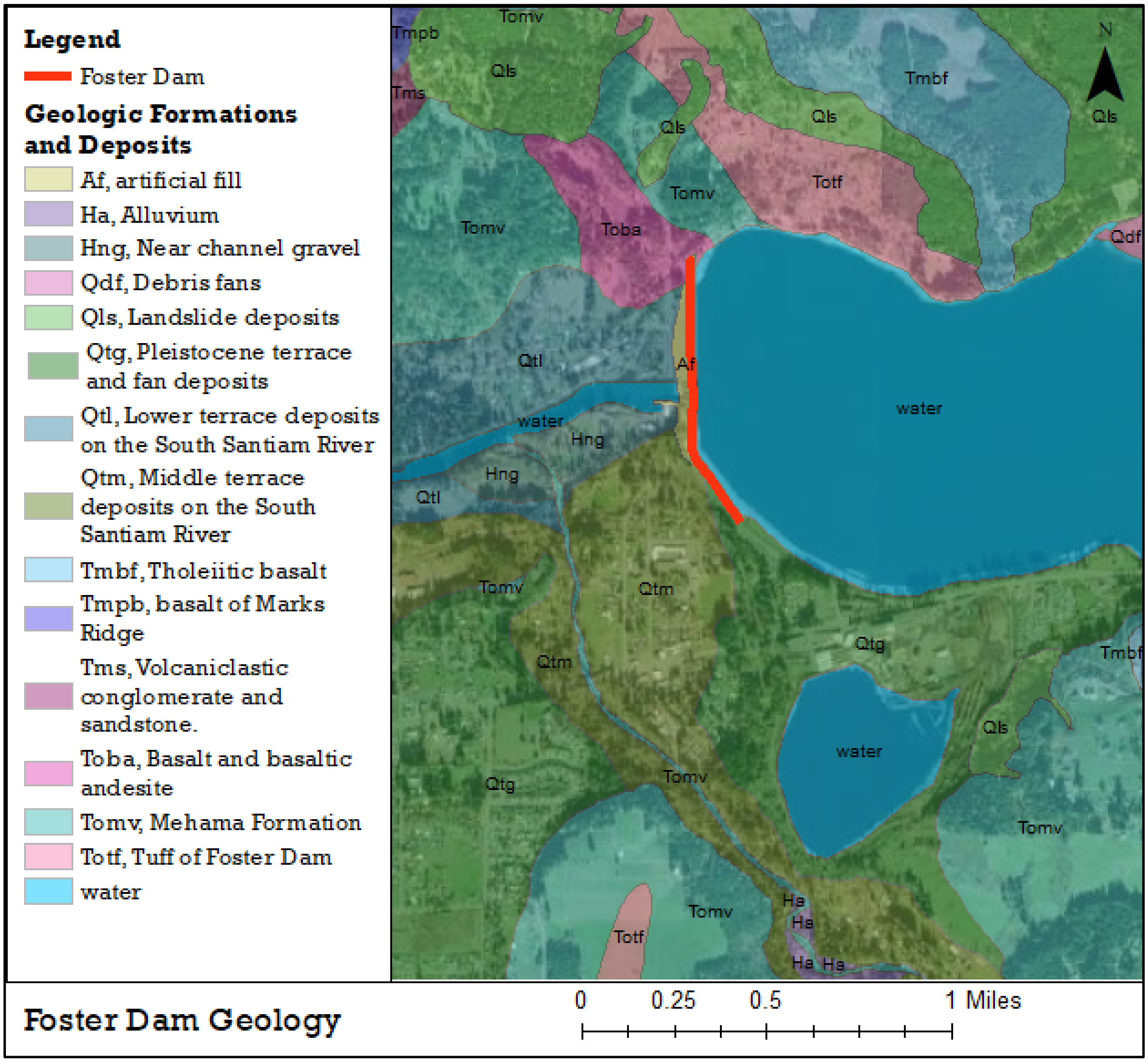

Figure 3.4-15. Geologic Units in the Vicinity of Foster Dam.

Source: McClaughry et al. 2010

Bedrock in the dam foundation area consists of two major rock units and three subunits. The major rock units are the Wiley Creek Tuff and the Foster Basalt. Subunits comprising the Wiley Creek Tuff within the dam site area are the upper Ashy Tuff Member, the middle Sandy Tuff Member, and the lower Lapilli Tuff Member. Stratigraphic boundaries between these members are not always distinct and individual members have considerable lateral variation.

Foster Dam is situated between two northeast trending tertiary aged geologic structures: (1) Foster Lake Anticline and (2) an unnamed syncline. Folded strata in the area are cut by a series of conjugate northwest- and northeast-trending normal faults and several northwest-trending strike-slip faults. Two other normal faults have been mapped near the site: an east-northeast-trending fault approximately 0.5 miles southeast of the site and a north-northeast-trending fault approximately 0.7 miles east of the site associated with Hogback Ridge. Both these faults are down-dropped to the northwest, cut Oligocene- to Miocene-aged rock units, and have been mapped trending through Foster Reservoir (USACE 2015f).

<u>Green Peter Dam</u>

The USGS interprets geologic bedrock at the Green Peter Dam site as predominantly sedimentary (Figure 3.4-16). However, detailed geological investigations at the dam site show bedrock is predominantly volcanic andesite and basaltic lava flows; Tertiary Andesite Lavas approximately 17 to 25 million years old (labeled as Ta3) would be a more appropriate characterization (Figure 3.4-17).

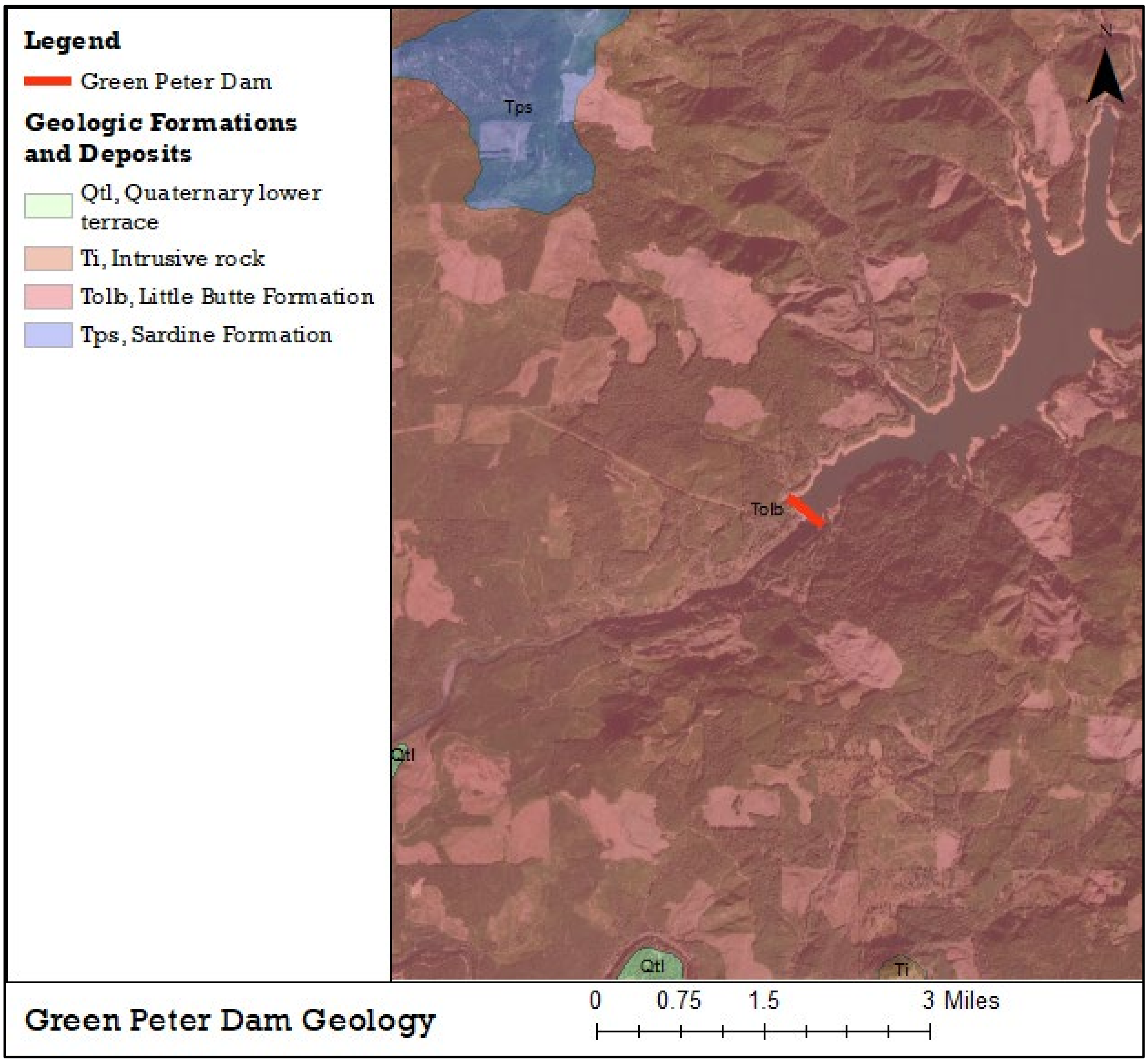

Figure 3.4-16. Geologic Units in the Vicinity of Green Peter Dam.
Source: Beaulieu 1947

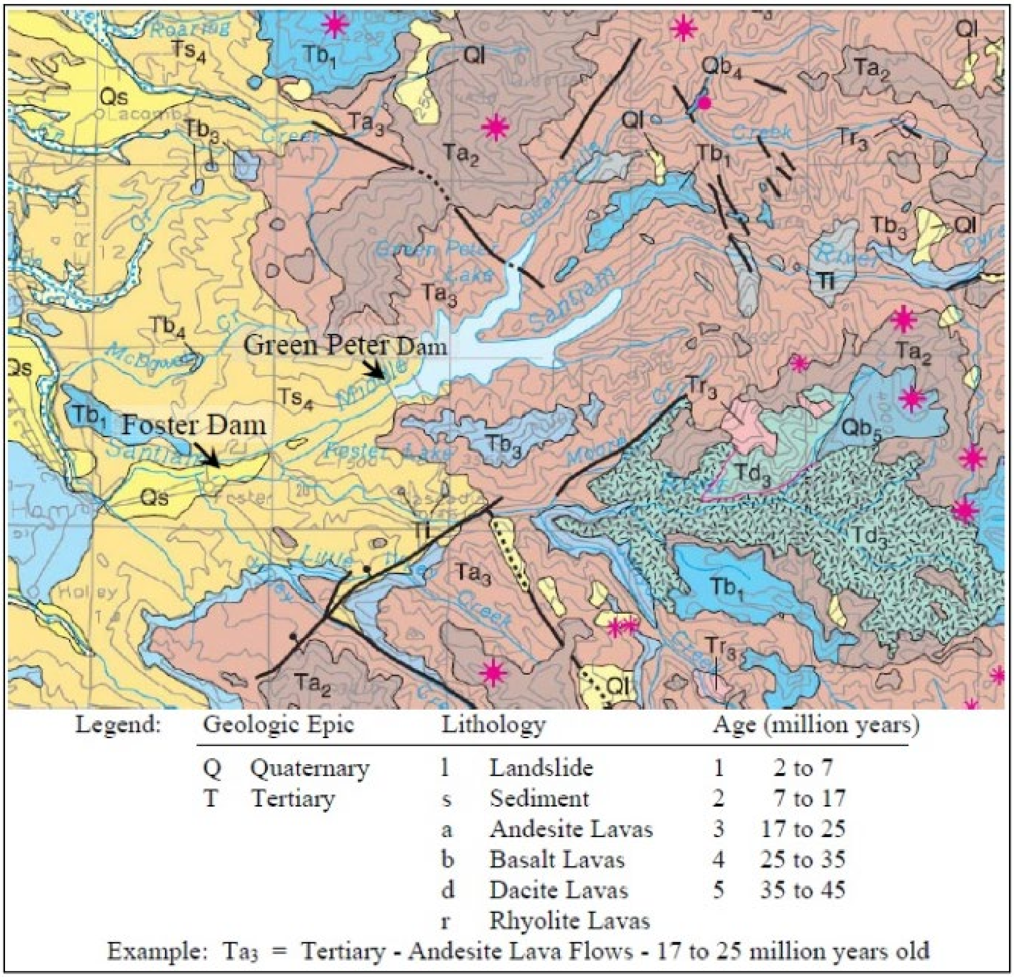

Figure 3.4-17. USACE Interpretation of the Regional Geologic Map Around Green Peter and Foster Dams.

Source: USACE 2015d

Green Peter Dam is most likely located on the flanks of an old shield volcano where the individual lava flows may be separated by volcanic ash/cinders and occasionally by bedded volcanic sediments (Figure 3.4-18).

The dam foundation is constructed in a relatively narrow portion of the Middle Santiam River where the river is downcutting through a layered series of 15 lava flows and 5 interbeds of pyroclastics. The geology through this stretch consists of extensive terrain of ancient landslides. Numerous smaller historical landslides have occurred downstream along the Middle Santiam River.

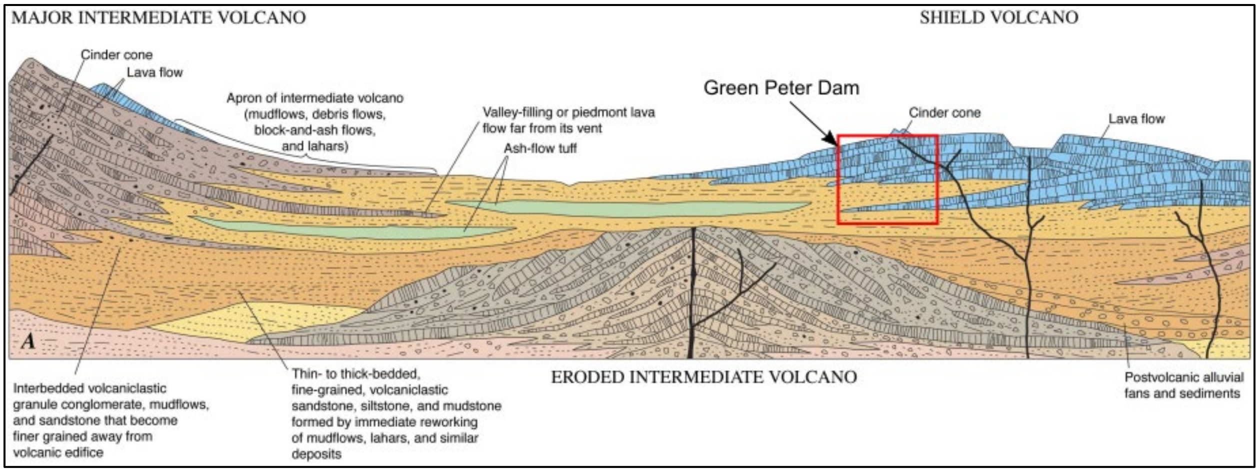

Figure 3.4-18. Hypothetical Regional Geologic Cross Section Around Green Peter and Foster Dams.

Source: Modified from Sherrod and Smith 2020

Overburden at the site consists of 7 feet to 53 feet of soil underlain by up to 24 feet of decomposed rock on both abutments. The dam abuts into rock on both abutments. However, there remains a remnant of an ancient, buried river channel further to the east on the left abutment that is separated from the dam by a bedrock high (USACE 2015g). A 2.5 million-square-foot landslide is mapped directly upstream of the dam on the left abutment; however, contact with the reservoir is inconclusive from available information (Beaulieu 1974).

The flood of December 1963 into January 1964 caried landslide debris down Big Alder Creek into the right abutment working area during construction of Green Peter Dam (USACE 1969). The main body of the Big Alder Creek slide is mapped on the right embankment hillslope above the reservoir (Beaulieu 1974).

3.4.2.9 Upper Willamette River Subbasin

__Overview__

The Upper Willamette River Subbasin spans all three physiographic sections within the Willamette Valley, so bedrock includes marine Coast Range formations, volcanics of the Western Cascades, and large amounts of unconsolidated deposits, which make up 99.7 percent of both the 1 percent and 0.2 percent annual exceedance probability floodplains in the subbasin. Coast Range formations include Eocene-aged marine pillow lavas and sediments of the Siletz River Volcanics, turbidite-derived sedimentary rocks of the Tyee Formation, deltaic sandstones of the Spencer Formation, slope mudstone of the Yamhill Formation, continental shelf sandstone of the Eugene Formation, and Eocene- to Oligocene-aged intermediate intrusions of the Coastal Intrusives Group. Early Western Cascades Volcanics within the subbasin include mafic intrusions; the Mehama Formation; and the Eocene-aged, welded, Tuff of Bond Creek (McClaughry et al. 2010; Yeats et al. 1996). The Owl Creek Fault (Personius 2002f) strikes north to south, paralleling the Willamette River. The Corvallis Fault zone strikes northeast to southwest along the western edge of the subbasin (Personius 2002g).

3.4.3 Environmental Consequences

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

This section discusses the potential direct, indirect, and climate change effects of the alternatives related to geology. The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

Environmental Consequences from geologic resources due to landslides are analyzed as impacts to slope stability and not as potential impacts to infrastructure or as impacts on other resources such as water quality from sediment movement. Information is not available to assess impacts from landslides on WVS infrastructure except for ongoing infrastructure repairs and maintenance related to ongoing slope instability. This is because slope failures are widely varied in location, size, and direction and site-specific information is not available for all slope conditions.

Information on potential sediment movement is available in Appendix C, River Mechanics and Geomorphology Technical Information. Analyses of sediment movement as turbidity is provided in Section 3.5, Water Quality.

END NEW TEXT

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

3.4.3.1 Methodology

This evaluation is based on review of existing geologic reports and qualitative geologic and engineering judgement using known mechanisms of geologic hazards. No new geotechnical or seismic models were developed as part of the alternatives effects analyses. Sediment transport associated with the revetments measure and small-scale impacts to sediment transport from mechanisms like slumping and erosion are discussed in Appendix C, River Mechanics and Geomorphology Technical Information.

Geologic processes develop over the span of hundreds to millions of years, and the influence of operational changes from a dam to the geologic environment is limited. Only geologic conditions likely to cause impacts over the 30-year implementation timeframe under each alternative were analyzed. Anticipated effects resulting from climate change under each alternative were also analyzed (see also Section 3.4.5, Climate Change under All Alternatives).

Environmental Consequences are assessed for potential effects from construction and for two geologic parameters: (1) activation of landslides due to deep drawdown and (2) removal of geologic material. Environmental consequences are summarized as one of four degrees of potential effect (negligible, minor, moderate, and major).

Activation of Landslides Due to Deep Drawdowns

Landslides could be activated by deep fall reservoir drawdowns from inactive and power pool water releases for fish passage (Measure 40), augment instream flows by using the power pool (Measure 304), augment instream flows by using the inactive pool (Measure 718), and deep spring reservoir drawdown for downstream fish passage (Measure 720). Under existing conditions, water releases from the inactive and power pools are rare and only occur during times of extreme drought or during special operations; therefore, landslide activity under existing conditions is rare (Table 3.4-1).

Table 3.4-1. Effects Criteria for Activation of Landslides due to Deep Drawdowns.

Degree of Adverse or Beneficial Effect	Criteria
None/Negligible	• The potential for minimum pool elevation reductions to induce landslides is low or would not occur because: ○ No or only small landslides are mapped in contact with the reservoir pool, *or* ○ The shoreline exposure metric calculated in Appendix C, River Mechanics and Geomorphology Technical Information, is less than negative 5 feet (0 to less than -5 feet).
Minor	• The shoreline exposure metric calculated in Appendix C, River Mechanics and Geomorphology Technical Information, is more than negative 5 feet (e.g., -6 feet, -7 feet, etc.), *and* • Landslides of medium or large surface area mapped in connection with the reservoir do not have a history of movement since the beginning of reservoir operation. • *Therefore,* there is a potential for minimum pool elevation reductions to induce landslides, but, based on a history of landslide stability around the reservoir, there is no evidence indicating reservoir slopes are anticipated to respond to reservoir fluctuations with failure.

Degree of Adverse or Beneficial Effect	Criteria
Moderate	• The shoreline exposure metric calculated in Appendix C, River Mechanics and Geomorphology Technical Information, is more than negative 5 feet (e.g., -6 feet, -7 feet, etc.), *and* • Landslides of medium or large surface area are mapped in connection with the reservoir that have a history of movement since the beginning of reservoir operation. • *Therefore,* there is a potential for minimum pool elevation reductions to induce landslides, and stability history of the landslides around the reservoir indicate that slope failure can be anticipated to occur in response to reservoir fluctuations.
Major	• An increase in the shoreline exposure metric of more than negative 5 feet (e.g., -6 feet, -7 feet, etc.) due to reservoir drawdown is calculated in Appendix C, River Mechanics and Geomorphology Technical Information, *and* • Landslides of medium or large surface area mapped in connection with the reservoir have a history of movement since the beginning of reservoir operation*, and* • There is likelihood that minimum pool elevation reduction would induce landslides supported by a site-specific study.
Duration	**Criteria**
Short-term	• Alteration lasts for the duration of small construction projects and is continuous for less than 2 years.
Medium-term	• Alteration is limited to the duration of large construction projects and is continuous for a period of 2 to 5 years.
Long-term	• Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (e.g., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently.
Extent	**Criteria**
Local	• Effects would be confined to the area near a dam and reservoir.
Regional	• Effects would be perceived throughout a single county, multiple counties, or the entire Willamette River Basin.
Statewide	• Effects would be perceived throughout the entire state.

When a reservoir level drops more quickly than the pore water[3] can drain, the water remaining in the unconsolidated bank material, that was at a steady state with the reservoir water, suddenly has pore water pressures[3] exceeding atmospheric pressure. If water cannot drain quickly enough for pore water pressures to dissipate, for example if the slope is composed of clay or silt, the slope experiences higher shear stress and there is the potential for slope instability (Wieczorek 1996).

For example, it was observed during the intentional breach of Condit Dam that exposure of unvegetated slopes during the full drawdown of the reservoir resulted in slumping of the bank that progressed upstream and caused slope failures through the lower approximate 2,100 feet of the reservoir (Wilcox et al. 2014). There are no proposed reservoir drawdown rates under any alternative that would result in drawdowns as rapid as those experienced at Condit Dam, but the progressive failure of exposed, unvegetated shoreline soils that were previously saturated and are prone to erosion from surface water runoff and slumping due to extended reservoir drawdown would be a potential major effect under alternatives with deep drawdown measures.

Additionally, small-scale erosion from surface water runoff and slumping of the newly exposed, unvegetated reservoir slopes, assessed in Appendix C, River Mechanics and Geomorphology Technical Information, could progressively destabilize areas of existing weakness, like historical landslides, under alternatives with deep drawdowns. The presence of historical landslides is used as a proxy for the potential of slope failure for the alternatives effects analyses. Most types of landslides have a high probability of reoccurring in areas that have experienced previous landslides (Highland and Bobrowsky 2008).

Small-scale landslides (defined in the analyses as the resulting landslide body having a surface area extent of less than 100,000 square feet) are commonly caused by heavy rains and are part of the normal geological process. It would be difficult to detect whether a small-scale landslide is induced by a reservoir operation or by natural processes.

Medium (100,000 square feet to 10,000,000 square feet) and large (greater than 10,000,000 square feet) landslides are likely to have a greater impact on dam safety and critical infrastructure than small-scale landslides. For this reason, the presence of medium and large landslides was used to indicate a higher likelihood of adverse consequences occurring.

Typically, the most dangerous time for reservoir slope failure is at initial filling and the period of refilling after the first two cycles of rapid drawdown. This is because the increase in water pressure within the slope increases pore water pressure and reduces the effective strength of the reservoir slope, allowing slopes that are already vulnerable to movement to fail (Wieczorek 1996). Landslides that experienced movement during or since initial filling are considered more

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[3] Pore water is groundwater that exists in gaps between individual particles in soil or rock. Pore water pressure refers to the pressure of groundwater held within soil or rock.

likely to have adverse consequences than historical landslides that have not shown indications of failure vulnerability.

Over the lifetime of WVS operations, a deep drawdown has not initiated a landslide that results in a medium or large earth movement. Cougar Reservoir was drawn down to below elevation 1,510 feet North American Vertical Datum of 1988 (NAVD88)[4] without incident between December 20, 2012, and January 12, 2013 (USACE 2013b).

Fall Creek Reservoir has been drawn down to the elevation of the original river channel (680 feet NAVD88) annually in the late fall since 2010 without incident (USACE 2016k). Although the WVS does not have a history of catastrophic slope failure during drawdown, the presence of landslides that extend into the reservoir indicates that the potential for future slope failure cannot be eliminated.

<u>Removal of Geologic Material</u>

Analyses of environmental effects on geologic resources will be conducted when site-specific details are prepared for construction associated with alternative measures.

Direct effects from construction on geology and soils include local removal of geologic materials permanently due to excavation and temporarily due to dredging. Some permanent removal of a detectable volume of sediment and bedrock for construction activities would be required.

It is also possible that removal of materials during excavation and dredging could over-steepen the toe of an existing plane of weakness, indirectly leading to failure. However, this potential risk is usually mitigated through geotechnical design. Consequently, over-steepening potential from excavation and dredge activities is not addressed under the alternatives analyses.

The environmental effects criteria for landslide activation and geologic material movement are provided in Table 3.4-1 and Table 3.4-2, respectively. A summary of effects to geology resources from these two parameters is provided in Table 3.4-3.

[4] North American Vertical Datum of 1988 (NAVD 88) consists of an agreed upon leveling network on the North American Continent that affixed to a single origin point on the continent and is used to standardize elevation references.

Table 3.4-2. Effects Criteria for Removal of Geologic Material.

Degree of Adverse or Beneficial Effect	Criteria
None/Negligible	• No construction measures would result in removal of geologic materials.
Minor	• Geologic materials would be removed from the dam site or reservoir as the result of a construction measure, but removal amounts would be small and localized to a limited area.
Moderate	• Geologic materials would be removed from the dam site or reservoir as the result of a construction measure at a scale that would be measurable and localized to a limited area.
Major	• Geologic materials would be removed adjacent to a dam site or reservoir as the result of a construction measure at a substantial scale and localized to a limited area.
Duration	**Criteria**
Short-term	• Alteration lasts for the duration of small construction projects and is continuous for less than 2 years.
Medium-term	• Alteration is limited to the duration of large construction projects and is continuous for a period of 2 to 5 years.
Long-term	• Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects.

END REVISED TEXT

THE DEIS HAS BEEN MODIFIED TO INCLUDE THE FOLLOWING SUMMARY TABLE IN THE FEIS

Table 3.4-3. Summary of Effects on Geologic Resources as Compared to the No-action Alternative[1,2].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Cottage Grove (Coast Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Dorena (Coast Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Fern Ridge (Long Tom River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Blue River (McKenzie River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate	Same as No-action Alternative	Same as No-action Alternative
Cougar (McKenzie River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	• Landslides Negligible • Removal Moderate	• Landslides Moderate • Removal Moderate	• Landslides Moderate • Removal Moderate	• Landslides Moderate • Removal Moderate	• Landslides Negligible • Removal Moderate	• Landslides Moderate • Removal Moderate
Dexter (Middle Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Fall Creek (Middle Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Hills Creek (Middle Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	• Landslides Moderate • Removal Moderate	• Landslides Moderate • Removal Moderate	• Landslides Negligible • Removal Moderate	Same as No-action Alternative
Lookout Point (Middle Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate	• Landslides Moderate • Removal None	• Landslides Moderate • Removal None	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate
Big Cliff (North Santiam River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Detroit (North Santiam River Subbasin)	• Landslides Negligible • Removal None	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate	• Landslides Moderate • Removal None	• Landslides Moderate • Removal None	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Foster (South Santiam River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Green Peter (South Santiam River Subbasin)	• Landslides Negligible • Removal None	• Landslides Negligible • Removal Moderate	• Landslides Minor • Removal Moderate	• Landslides Minor • Removal Moderate	• Landslides Minor • Removal Moderate	• Landslides Minor • Removal Moderate	Same as NAA	• Landslides Minor • Removal Moderate
Duration	• Long-term for landslide events • Permanent for removal of geologic material	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative

[1] Degree of landslide effects describes risk of landslide activation.

[2] The extent of effects would be local under all alternatives.

3.4.3.2 Alternatives Analyses

No-action Alternative

Coast Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns

Under the No-action Alternative (NAA), small-scale landslides that cause short-term infrastructure damage and require repairs would continue to occur at each dam over the 30-year implementation timeframe. Large landslides are mapped around the Dorena Reservoir. However, the potential for USACE operations to affect landslide activity at both dams in the Coast Fork Subbasin would be negligible. This is because Dorena and Cottage Grove Reservoirs would be operated to reach the bottom of the conservation pool, but operations would not go below the minimum pool elevation under the NAA. Consequently, additional shoreline exposure is not anticipated under USACE operations, which would minimize the risk of landslide activation.

Long Tom River Subbasin

Activation of Landslides due to Deep Drawdowns

There are no mapped landslides around the Fern Ridge Reservoir. Further, there would be no potential to activate landslides in the Long Tom River Subbasin due to USACE operations under the NAA. Specifically, Fern Ridge Reservoir would continue to be operated to the existing rule curve and not go below the minimum conservation pool elevation and would therefore not contribute to landslide activation in the subbasin.

McKenzie River Subbasin

Activation of Landslides due to Deep Drawdowns

Under the NAA, small-scale landslides that cause short-term infrastructure damage and require repairs would continue to occur at each dam over the 30-year implementation timeframe. There are large landslides mapped around Cougar Reservoir. However, the Cougar and Blue River Reservoirs elevations would not be operated below the minimum pool elevation, even in dry years, and additional shoreline exposure is not anticipated. Therefore, the effect of future operations on landslide activation would be negligible.

Middle Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns

Medium and large landslides are mapped around both Hills Creek and Lookout Point Reservoirs and have a history of movement. The potential for USACE operations to activate landslides around Hills Creek and Lookout Point Reservoirs under the NAA would be the same as described for the Coast Fork Willamette River Subbasin (above).

Since 2010, Fall Creek Reservoir has been drawn down annually to elevation 680 feet NAVD88, which is below the rule curve minimum pool. However, because no medium or large landslides are mapped around the reservoir, the landslide-related effect around Fall Creek Reservoir under the NAA would be negligible. Small-scale landslides that cause short-term infrastructure damage and require repairs would continue to occur at each dam over the 30-year implementation timeframe.

North and South Santiam River Subbasins

Activation of Landslides due to Deep Drawdowns

Under the NAA, small-scale landslides that cause short-term infrastructure damage and require repairs would continue to occur at each dam over the 30-year implementation timeframe. There are large landslides mapped around Detroit and Foster Reservoirs, medium landslides mapped around Green Peter Reservoir, and no landslides mapped around Big Cliff Reservoir. However, the potential for landslide activity from USACE operations at all four dams in the North and South Santiam River Subbasins would be negligible. This is because Detroit and Green Peter Reservoirs would not be operated below the minimum conservation pool, even in the driest years, and the regulation of Big Cliff and Foster Reservoirs would follow the rule curve closely in all years under the NAA. Consequently, additional shoreline exposure is not anticipated under USACE operations, which would minimize the risk of landslide activation.

Removal of Geologic Material Effects in all Subbasins

Under the NAA, there would be no removal of geologic materials due to routine activities and construction projects at any dam or reservoir over the 30-year implementation timeframe; therefore, there would be no adverse effect in any subbasin.

Alternative 1—Improve Fish Passage through Storage-focused Measures

Coast Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts to geologic resources from landslide activity and material removal under Alternative 1 in the Coast Fork Willamette River Subbasin would be the same as those described under the NAA.

Long Tom River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts to geologic resources from landslide activity and material removal under Alternative 1 in the Long Tom River Subbasin would be the same as those described under the NAA.

McKenzie River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts to geologic resources from landslide activity and material removal under Alternative 1 in the McKenzie River Subbasin would be the same as those described under the NAA.

Middle Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns

Impacts to geologic resources from landslide activity under Alternative 1 in the Middle Fork Willamette River Subbasin would be the same as those described under the NAA.

Removal of Geologic Material

Unlike operations under the NAA, construction activities would occur under Alternative 1 to construct a selective withdrawal structure (Measure 105) and to construct structural downstream fish passage (Measure 392) at Lookout Point Dam. A site-specific design plan was not prepared at the time the alternatives were analyzed. However, foundation preparation activities are anticipated to be similar to those proposed in the 2019 Detroit Reservoir downstream fish passage and selective withdrawal structure design documentation report (USACE 2019t).

In its design report, USACE estimated removal of approximately 8,000 cubic yards of silt and near-surface weathered rock to create an approximately 2,000-square-foot foundation for the selective withdrawal structure and removal of approximately 9,000 cubic yards of material for the floating fish screen structure moorings. The construction activities at Lookout Point Dam and Reservoir would require measurable localized rock excavation, which would have a moderate direct effect on the geologic composition at the dam due to removal of geologic material upstream of the dam compared to the NAA.

Construction activities would be short-term because geologic material would not continue to be removed after construction-related earthwork is completed. However, unlike the NAA, material excavated during construction would be permanently removed, which would be a long-term effect to geologic resources under Alternative 1.

North and South Santiam River Subbasins

Activation of Landslides due to Deep Drawdowns

Impacts to geologic resources from landslide activity under Alternative 1 in the North and South Santiam River Subbasins would be the same as those described under the NAA.

Removal of Geologic Material

Unlike operations under the NAA, construction activities would occur under Alternative 1 to install a selective withdrawal structure at Green Peter and Detroit Dams (Measure 105), construct an adult fish facility at Green Peter Dam (Measure 722), and construct structural downstream fish passage at Detroit, Foster, and Green Peter Dams (Measure 392). At Detroit Dam and Reservoir, construction of the selective withdrawal structure would require removal of approximately 8,000 cubic yards of silt and near-surface weathered rock to create an approximately 2,000-square-foot foundation for the intake tower. Construction of the structural downstream fish passage would require removal of approximately 4,000 cubic yards of talus deposits to lay back the slopes above the floating screen structure and approximately 5,000 cubic yards of silt and weathered-near surface rock to create a foundation for the floating fish screen structure moorings.

A site-specific design plan was not available for the Green Peter Dam selective withdrawal structure and downstream fish passage structure at the time the alternatives were analyzed, but activities are anticipated to be similar to construction at Detroit Dam. Similarly, there were no site-specific designs proposed for construction of adult fish facilities at any dam when the alternatives were analyzed. However, based on designs for the Dexter Dam adult fish facility upgrade (USACE 2013d), excavation of approximately 10,000 cubic yards of overburden and weathered near-surface rock to create hatchery pools, trenches for pipes, and facility buildings can be anticipated at Green Peter Dam. The magnitude, scale, and duration of effects due to these construction activities at each dam would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin (above).

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Coast Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts to geologic resources from landslide activation and material removal under Alternative 2A in the Coast Fork Willamette River Subbasin would be the same as those described under the NAA.

Long Tom River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts to geologic resources from landslide activation and material removal under Alternative 2A in the Long Tom River Subbasin would be the same as those described under the NAA.

McKenzie River Subbasin

Activation of Landslides due to Deep Drawdowns

Impacts to geologic resources from landslide activity under Alternative 2A in the McKenzie River Subbasin would be the same as those described under the NAA.

Removal of Geologic Material

Unlike the NAA, construction of a structural downstream fish passage would occur under Alternative 2A at Cougar Dam (Measure 392). Construction of the structural downstream fish passage at Cougar Dam and Reservoir would require removal of approximately 10,000 cubic yards of rock near the existing water temperature control tower to allow the floating fish screen to operate at low pool elevations (USACE 2019s). The magnitude, scale, and duration of effects due to these construction activities would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

Middle Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns

Impacts to geologic resources from landslide activity and material removal under Alternative 2A in the Middle Fork Willamette River Subbasin would be the same as those described under the NAA.

Removal of Geologic Material

Unlike operations under the NAA, construction activities would occur under Alternative 2A to construct structural downstream fish passage at Lookout Point Dam (Measure 392). The magnitude, scale, and duration of effects due to these construction activities would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

North and South Santiam River Subbasins

Activation of Landslides due to Deep Drawdowns

Unlike the NAA, minimum pool elevation reductions would occur under Alternative 2A at Green Peter Dam. Specifically, USACE would augment instream flows by using the power pool at Green Peter and Detroit Reservoirs and conduct a deeper fall reservoir drawdown for fish passage (Measure 304 and Measure 40, respectively). These measures would allow reservoir drawdown to within 25 feet of the top of the regulating outlet at Green Peter Dam.

These operations would result in drawdowns below the minimum rule curve in dry years at Detroit Dam and in all years at Green Peter Dam under Alternative 2A as compared to the NAA. A resulting increase in shoreline exposure due to reservoir drawdown is expected at Green Peter Reservoir as compared to the NAA but is not anticipated to occur at Detroit Reservoir (Appendix C, River Mechanics and Geomorphology Technical Information).

As under the NAA, small-scale landslides that cause short-term infrastructure damage and require repairs would continue to occur at each dam under Alternative 2A over the 30-year implementation timeframe. However, the potential of the drawdown to activate landslides from operations at Green Peter Dam would be minor under Alternative 2A because moderate-sized landslides adjacent to Green Peter Reservoir do not have a history of movement. Therefore, the stability history of landslides around Green Peter Reservoir has demonstrated that reductions in minimum pool elevations and surface exposure due to drawdown do not have the potential to induce slope failures.

Removal of Geologic Material

Unlike the NAA, this alternative includes constructing a selective withdrawal structure at Detroit Dam and constructing structural downstream fish passage at Foster and Detroit Dams (Measure 105 and Measure 392, respectively). The magnitude, scale, and duration of effects due to these activities at each dam would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Coast Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts under Alternative 2B in the Coast Fork Willamette River Subbasin would be the same as those described under the NAA.

Long Tom River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts under Alternative 2B in the Long Tom River Subbasin would be the same as those described under the NAA.

McKenzie River Subbasin

Activation of Landslides due to Deep Drawdowns

Unlike operations under the NAA, Alternative 2B includes augmenting instream flows by using the inactive pool at both Blue River and Cougar Reservoirs (Measure 718). Deep reservoir drawdowns for fish passage would allow drawdown to within 25 feet of the Cougar Dam diversion tunnel during the fall season and spring season (Measure 40 and Measure 720, respectively). These operations would cause reservoir drawdowns below the rule curve at Blue River Dam in dry years and below the rule curve at Cougar Dam in all years. A resulting increase in shoreline exposure due to reservoir drawdown is expected at Cougar Reservoir as compared to NAA operations but is not anticipated at Blue River Reservoir (Appendix C, River Mechanics and Geomorphology Technical Information).

As under the NAA, small-scale landslides that cause short-term infrastructure damage and require repairs would continue to occur at both dams over the 30-year implementation timeframe. Compared to the NAA, there is the potential for moderate effects to geologic resources because USACE operations would interact with large landslides that have a history of movement along the upstream rims surrounding Cougar Reservoir. Stability history of landslides around Cougar Reservoir has demonstrated that reductions in minimum pool elevations and shoreline exposure due to drawdowns have the potential to induce slope failures.

Removal of Geologic Material

Unlike the NAA, this alternative includes constructing a tower and bridge to allow operations and maintenance access to the diversion tunnel at Cougar Dam (Measure 40). Site-specific construction information was not developed at the time the alternatives were analyzed. However, it is anticipated that foundation preparation for the tower and bridge footings would involve removal of a substantial volume of sediment and weathered rock. The magnitude, scale, and duration of effects due to these activities would the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

Middle Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns

Impacts to geologic resources from landslide activity under Alternative 2B in the Middle Fork Willamette River Subbasin would be the same as those described under the NAA.

Removal of Geologic Material

Unlike operations under the NAA, construction activities would occur under Alternative 2B to construct structural downstream fish passage at Lookout Point Dam (Measure 392). The magnitude, scale, and duration of effects due to these construction activities would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

North and South Santiam River Subbasins

Activation of Landslides due to Deep Drawdowns

Measures and impacts to geologic resources from landslide activation under Alternative 2B in the North and South Santiam River Subbasins would be the same as those described under Alternative 2A for the North and South Santiam River Subbasins.

Removal of Geologic Material

Unlike the NAA, this alternative includes constructing a selective withdrawal structure at Detroit Dam (Measure 105), constructing an adult fish facility at Green Peter Dam (Measure 722), and constructing structural downstream fish passage at Foster and Detroit Dams (Measure 392). Impacts to geologic resources from material removal under Alternative 2B in the North and South Santiam River Subbasins would be the same as those described under Alternative 1 for the Middle Fork Willamette River Subbasin.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

Coast Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts to geologic resources from landslide activity and material removal under Alternative 3A in the Coast Fork Willamette River Subbasin would be the same as those described under the NAA.

Long Tom River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts under Alternative 2B in the Long Tom River Subbasin would be the same as those described under the NAA.

McKenzie River Subbasin

Activation of Landslides due to Deep Drawdowns

Unlike operations under the NAA, minimum pool elevation reductions would occur under Alternative 3A. Specifically, USACE would augment instream flows by using the inactive pool at Blue River Reservoir and would augment instream flows by using the power pool at Cougar Reservoir (Measure 718 and Measure 304, respectively). Deep fall reservoir drawdowns to within 25 feet of the regulating outlet for fish passage would occur in the fall and spring at Cougar Dam (Measure 40 and Measure 720, respectively). These operations would cause reservoir drawdowns below the minimum rule curve at Blue River Dam in dry years and every year at Cougar Dam. This would result in increased shoreline exposure as compared to NAA operations at Cougar Dam but would not increase shoreline exposure at Blue River Reservoir (Appendix C, River Mechanics and Geomorphology Technical Information).

Impacts to geologic resources from landslide activation due to deep drawdowns in the McKenzie River Subbasin would be the same under Alternative 3A as described under Alternative 2B.

Removal of Geologic Material

Unlike operations under the NAA, construction activities would occur under Alternative 3A to construct an adult fish facility at Blue River Dam (Measure 722). Impacts to geologic resources from material removal under Alternative 3A in the McKenzie River Subbasin would be the same as those described under Alternative 1 for the Middle Fork Willamette River Subbasin.

Middle Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns

Unlike the NAA, minimum pool elevation reductions would occur under Alternative 3A. Specifically, USACE would augment instream flows by using the power pool at Lookout Point and Hills Creek Reservoirs (Measure 304), augment instream flows by using the inactive pool on an as-needed basis (Measure 718), conduct a deep drawdown at Fall Creek Reservoir (same as under the NAA), operate for deeper fall reservoir drawdowns at both Lookout Point and Hills Creek Reservoirs (Measure 40), and operate for a deep spring reservoir drawdown at Lookout Point Reservoir (Measure 720).

Impacts to landslide activity from operations at Fall Creek Dam under Alternative 3A are expected to be the same as the NAA because the proposed operations would result in the same drawdown as operations under the NAA. Operations would result in reservoir drawdowns below the rule curve in all years at Lookout Point and Hills Creek Dam. A resulting increase in shoreline exposure due to reservoir drawdown is therefore expected at both Lookout Point Reservoir and Hills Creek Reservoir as compared to the NAA.

The average change in reservoir elevation would be only approximately 6 feet deeper than under the NAA operations at Hills Creek Reservoir. Therefore, the increase in shoreline exposure would be minor, and the potential of drawdown to activate landslides from operations at Hills Creek Dam would be negligible (Appendix C, River Mechanics and Geomorphology Technical Information).

As under the NAA, small-scale landslides that cause short-term infrastructure damage and require repairs would continue to occur at each dam under Alternative 3A over the 30-year implementation timeframe. The potential of the drawdown to activate landslides from operations at Hills Creek and Lookout Point Dams would be moderate under Alternative 3A because large- and moderate-sized landslides adjacent to Hills Creek and Lookout Point Reservoirs have a history of movement. The stability history of landslides around Hills Creek and Lookout Point Reservoirs has demonstrated that reductions in minimum pool elevations and surface exposure due to drawdowns have the potential to induce slope failures.

Removal of Geologic Material

Unlike operations under the NAA, construction activities would occur under Alternative 3A to construct an adult fish facility at Hills Creek Dam (Measure 722). The magnitude, scale, and duration of effects due to these construction activities would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

North and South Santiam River Subbasins

Activation of Landslides due to Deep Drawdowns

Unlike the NAA, minimum pool elevation reductions would occur under Alternative 3A. Specifically, USACE would augment instream flows by using the power pool at Green Peter and Detroit Reservoirs (Measure 304), conduct deep fall reservoir drawdowns at Detroit and Green Peter Dams (Measure 40), and operate for deep spring reservoir drawdowns at Detroit Dam (Measure 720).

The deep reservoir drawdowns would involve reducing the reservoir elevation to within 25 feet of the regulating outlet. Such operations would result in drawdowns below the minimum rule curves under Alternative 3A as compared to the NAA at Green Peter and Detroit Reservoir in all years. A resulting increase in shoreline exposure due to reservoir drawdown is expected at both Green Peter and Detroit Reservoirs as compared to the NAA (Appendix C, River Mechanics and Geomorphology Technical Information).

As under the NAA, small-scale landslides that cause short-term infrastructure damage and require repairs would continue to occur at each dam under Alternative 3A over the 30-year implementation timeframe. The stability history of landslides around Detroit Reservoir has demonstrated that reductions in minimum pool elevations and surface exposure due to drawdowns have the potential to induce slope failures. Therefore, the potential for landslide activation at Detroit Dam would be moderate under Alternative 3A because large landslides are mapped adjacent to this reservoir with a history of movement since the beginning of reservoir operations.

Impacts to geologic resources from landslide activation under Alternative 3A at Green Peter Dam would be the same as those described under the Alternative 2A.

Removal of Geologic Material

Unlike the NAA, Alternative 3A includes constructing an adult fish facility below Green Peter Dam (Measure 722). The magnitude, scale, and duration of effects due to these construction activities would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

Alternative 3B—Improve Fish Passage through Operations-focused Measures

Coast Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts to geologic resources from landslide activity and material removal under Alternative 3B in the Coast Fork Willamette River Subbasin would be the same as those described under the NAA.

Long Tom River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts to geologic resources from landslide activity and removal of geologic material under Alternative 3B in the Long Tom River Subbasin would be the same as those described under the NAA.

McKenzie River Subbasin

Activation of Landslides due to Deep Drawdowns

Unlike operations under the NAA, minimum pool elevation reductions would occur under Alternative 3B. Specifically, USACE would augment instream flows by using the inactive pool at Blue River and Cougar Reservoirs (Measure 718). Deep reservoir drawdowns to within 25 feet of the diversion tunnel for fish passage would occur in the fall and spring at Cougar Dam (Measure 40 and Measure 720).

These operations would cause reservoir drawdowns below the respective rule curves at both dams in dry years at Blue River Dam and all years at Cougar Dam. This would result in increased shoreline exposure as compared to NAA operations at Cougar Reservoir but would not increase shoreline exposure at Blue River Reservoir (Appendix C, River Mechanics and Geomorphology Technical Information).

Impacts to geologic resources from landslide activation due to deep drawdowns in the McKenzie River Subbasin would be the same under Alternative 3B as described under Alternative 2B.

Removal of Geologic Material

Unlike operations under the NAA, construction activities would occur under Alternative 3B to construct a tower and bridge to allow operations and maintenance access to the diversion tunnel at Cougar Dam for routine use of the diversion tunnel for fish passage (Measure 40 and Measure 720). Impacts to geologic resources from material removal under Alternative 3B in the McKenzie River Subbasin would be the same as those described under Alternative 1 for the Middle Fork Willamette River Subbasin.

Middle Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns

Unlike operations under the NAA, minimum pool elevation reductions would occur under Alternative 3B. Specifically, USACE would augment instream flows by using the power pool at Lookout Point and Hills Creek Reservoirs (Measure 304), augment instream flows by using the inactive pool at Fall Creek Reservoir (Measure 718), allow deeper fall reservoir drawdowns at both Lookout Point and Hills Creek Reservoirs (Measure 40), and operate for a deep spring reservoir drawdown at Hills Creek (Measure 720).

Impacts to landslide activity from operations at Fall Creek Dam under Alternative 3A are expected be the same as the NAA because the proposed operations would result in the same drawdown as the NAA. Operations at Lookout Point and Hills Creek Dams would result in reservoir drawdowns below the minimum rule curve in all years. A resulting increase in shoreline exposure due to reservoir drawdown is expected at both Lookout Point and Hills Creek Reservoirs as compared to NAA operations (Appendix C, River Mechanics and Geomorphology Technical Information).

As under the NAA, small-scale landslides that cause short-term infrastructure damage and require repairs would continue to occur at each dam under Alternative 3B over the 30-year implementation timeframe. Impacts to geologic resources from landslide activation under Alternative 3B at Hills Creek and Lookout Point Dams would be the same as those described under the Alternative 3A.

Removal of Geologic Material

Unlike operations under the NAA, construction activities would occur under Alternative 3B to construct an adult fish facility at Hills Creek Dam (Measure 722). The magnitude, scale, and duration of effects due to these construction activities would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

North and South Santiam River Subbasins

Activation of Landslides due to Deep Drawdowns

Unlike the NAA, minimum pool elevation reductions would occur under Alternative 3B. Specifically, USACE would augment instream flows by using the power pool at Green Peter and Detroit Reservoirs (Measure 304), allow deeper fall reservoir drawdowns at Detroit and Green Peter Reservoirs (Measure 40), and operate for deep spring reservoir drawdowns at Green Peter Reservoir (Measure 720).

The deep reservoir drawdown measures would involve reducing the reservoir elevation to within 25 feet of the regulating outlet. Such operations would result in drawdowns of the reservoir below the minimum rule curve under Alternative 3B as compared to the NAA in all years at Detroit and Green Peter Dams. A resulting increase in shoreline exposure due to reservoir drawdown is expected at both Green Peter and Detroit Reservoirs as compared to NAA operations (Appendix C, River Mechanics and Geomorphology Technical Information).

Impacts to geologic resources from landslide activation under Alternative 3B in the North and South Santiam River Subbasins would be the same as those described under Alternative 3A.

Removal of Geologic Material

Measures and impacts to geologic resources from landslide activation and removal of geologic material under Alternative 3B in the North and South Santiam River Subbasins would be the same as those described under Alternative 3A for the North and South Santiam River Subbasins.

Alternative 4—Improve Fish Passage with Structures-based Approach

Coast Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Impacts to geologic resources from landslide activity and material removal under Alternative 4 in the Coast Fork Willamette River Subbasin would be the same as those described under the NAA.

Long Tom River Subbasin

Activation of Landslides due to Deep Drawdowns and Material Removal

Impacts to geologic resources from landslide activity and material removal under Alternative 4 in the Long Tom River Subbasin would be the same as those described under the NAA.

McKenzie River Subbasin

Activation of Landslides due to Deep Drawdowns

Impacts to geologic resources from landslide activity and material removal under Alternative 4 in the McKenzie River Subbasin would be the same as those described under the NAA.

Removal of Geologic Material

Unlike the NAA, construction of a structural downstream fish passage would occur at Cougar Dam (Measure 392). The magnitude, scale, and duration of effects due to these construction activities would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

Middle Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns

Impacts to geologic resources from landslide activity under Alternative 4 in the Middle Fork Willamette River Subbasin would be the same as those described under the NAA because there would be no deep drawdown operations.

Removal of Geologic Material

Unlike the NAA, under Alternative 4, a selective withdrawal structure would be constructed at Hills Creek and Lookout Point Dams (Measure 105), an adult fish facility would be constructed at Hills Creek Dam (Measure 722), and structural downstream fish passage would be constructed at both Lookout Point and Hills Creek Dams (Measure 392). The magnitude, scale, and duration of effects due to these construction activities at each dam would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

North and South Santiam River Subbasins

Activation of Landslides due to Deep Drawdowns

Impacts to geologic resources from landslide activity under Alternative 4 in the North and South Santiam River Subbasins would be the same as those described under the NAA.

Removal of Geologic Material

Unlike operations under the NAA, construction activities would occur under Alternative 4 to build a selective withdrawal structure at Detroit Dam (Measure 105), construct an adult fish facility below Green Peter Dam (Measure 722), and construct structural downstream fish passage at Foster and Detroit Dams (Measure 392). The magnitude, scale, and duration of effects at each dam would be the same as those described under Alternative 1 at the Middle Fork Willamette River Subbasin.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

All Subbasins

Activation of Landslides due to Deep Drawdowns and Removal of Geologic Material

Activities in all subbasins under Alternative 5 would be similar to those under Alternative 2B with respect to potential drawdown-related and construction-related effects on geologic resources. Consequently, impacts to geologic resources from landslide activation or removal of material under Alternative 5 in all subbasins would be the same as those described under Alternative 2B.

3.4.4 Interim Operations under All Action Alternatives Except Alternative 1

The timing and duration of Interim Operations would vary depending on a given alternative. Interim operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations will be implemented in succession with, and not in addition to, action alternative implementation.

3.4.4.1 Coast Fork Willamette River Subbasin and Long Tom River Subbasin

Activation of Landslides due to Deep Drawdowns

Interim Operations would not reduce pool levels in reservoirs in the Coast Fork Willamette River or Long Tom River Subbasins below the rule curve or active pool. Consequently, there would be no effect on geologic resources from landslide activity in these subbasins.

3.4.4.2 McKenzie River Subbasin

Activation of Landslides due to Deep Drawdowns

Unlike operations under the NAA, minimum pool elevation reductions would occur under the Interim Operations. Specifically, USACE would conduct spring and fall drawdown for fish passage at Cougar Reservoir to a target elevation of 1,505 feet and delay reservoir refill and regulating outlet prioritization for improved downstream fish passage at Cougar Dam. These operations would cause reservoir drawdowns below the rule curve at Cougar Reservoir in all years. This would result in increased shoreline exposure as compared to NAA operations at Cougar Dam (Appendix C, River Mechanics and Geomorphology Technical Information).

Impacts to geologic resources from landslide activation due to deep drawdowns in the McKenzie River Subbasin would be the same under the Interim Operations as described under Alternative 2B.

3.4.4.3 Middle Fork Willamette River Subbasin

Activation of Landslides due to Deep Drawdowns

Unlike operations under the NAA, minimum pool elevation reductions would occur under the Interim Operations. Specifically, USACE would conduct a deep drawdown to a target elevation of 761 feet NAVD88, 50 feet over the top of the penstock at Lookout Point Dam.

These operations would result in drawdowns below the minimum rule curve in all years at Lookout Point Dam under the Interim Operations as compared to the NAA. A resulting increase in shoreline exposure due to reservoir drawdown is expected at Lookout Point Reservoir as compared to the NAA (Appendix C, River Mechanics and Geomorphology Technical Information).

As under the NAA, small-scale landslides that cause short-term infrastructure damage and require repairs would continue to occur at each dam under the Interim Operations over the 30-year implementation timeframe. The potential of the drawdown to activate landslides from operations at Fall Creek Dam would be negligible under the Interim Operations because, although an increase in shoreline exposure is anticipated at Fall Creek Reservoir, there are no large- or moderate-sized landslides mapped in contact with the Fall Creek Reservoir.

The stability history of the slopes around Fall Creek Reservoir has demonstrated that the slopes are resistant to landslide activity. Impacts to geologic resources from landslide activity under the Interim Operations at Lookout Point Dam would be the same as those described under Alternative 3A.

3.4.4.4 North and South Santiam River Subbasins

Activation of Landslides due to Deep Drawdowns

Unlike operations under the NAA, minimum pool elevation reductions would occur under the Interim Operations. Specifically, USACE would conduct a deep drawdown of the reservoir to within 35 feet of the regulating outlet invert at Green Peter Dam.

This operation would result in a drawdown below minimum rule curve in all years at Green Peter Dam under the Interim Operations as compared to the NAA. A resulting increase in shoreline exposure due to reservoir drawdown is expected at Green Peter Reservoir as compared to the NAA (Appendix C, River Mechanics and Geomorphology Technical Information).

Impacts to geologic resources from landslide activity under the Interim Operations in the North and South Santiam River Subbasin would be the same as those described under Alternative 2A.

Removal of Geologic Material in All Subbasins

Impacts to geologic resources from material removal in all subbasins under the Interim Operations would be the same as under the NAA because there would be no excavation of materials under any proposed measure.

3.4.5 Climate Change under All Alternatives

Under all alternatives, increased variability in spring precipitation may result in less reliable reservoir refill (Section 3.2, Hydrologic Processes) (Warner et al. 2015) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.5, Changes in Winter Atmospheric Rivers;

Appendix F2, Supplemental Climate Change Information, Section 3.1.2, Precipitation). Additionally, due to decreasing future summer and fall inflows, WVS reservoirs may reach minimum water surface elevations more frequently during the 30-year implementation timeframe than under existing climate conditions. The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

Drawdown may be more rapid to meet downstream minimum flow targets as climate conditions change, which would present some landslide risk to infrastructure and reservoirs that have existing planes of weakness. If a lack of precipitation due to climate change causes a need for deep drafts to maintain outflows it may result in increased shoreline exposure, which may allow small-scale failures of newly exposed, unvegetated, erodible sediment to propagate into existing failures, resulting in reactivation of large-scale material movements.

Under the action alternatives with deep drawdown measures, climate change would increase the probability of landslides due to deep drawdowns by two mechanisms: increasing the annual probability that major precipitation events would occur coincident with deep drawdown, and increasing the frequency of wildfires (Fleishman 2023) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.8, Summary of Projected Trends in Climate; Appendix F2, Supplemental Climate Change Information, Section 3.1.5, Wildfire Danger).

Depending on the alternative measures, climate change is likely to enhance landslide risk at Cougar, Detroit, Dorena, Green Peter, Hills Creek, and Lookout Point Dams under the action alternatives compared to the NAA.

Due to decreasing future summer and fall inflows, USACE operations may reach minimum water surface elevations at the WVS dams more frequently and sooner in the year, which would increase the duration of shoreline exposure. This would increase the potential for erosion to undercut and destabilize slopes, which could result in an increased risk of slope failure during the next refill/drawdown cycle. Drawdowns under the action alternatives may also be more rapid to meet downstream minimum flow targets, which would mean a higher pore pressure differential between the slope and atmosphere could occur, increasing the risk of slope failure.

Under all alternatives, the WVS will likely experience increasing wintertime flow volumes during the 30-year implementation timeframe because of larger precipitation events and more precipitation falling as rain instead of snow than under existing conditions (Section 3.2, Hydrologic Processes). Intense rainfall is a triggering event for shallow landslides (Wieczorek 1996). If large events were to occur coincident with deep drawdowns, the exposed shoreline may saturate and cause shallow landslides that progress into larger debris flows and reactivate larger landslides in vulnerable slopes.

Increased variability in the spring rainfall; drier, hotter summers; and lower summer baseflow would increase potential for wildfires to impact WVS reservoir rims (Fleishman 2023) (Appendix

F1, Qualitative Assessment of Climate Change Impacts, Section 4.8, Summary of Projected Trends in Climate; Appendix F2, Supplemental Climate Change Information, Section 3.1.5, Wildfire Danger). Wildfires can produce a water repellent soil layer that increases overland flow through burned forested areas (Wieczorek 1996) and may lead to erosive undercutting of the exposed shoreline and saturation of unvegetated soils, which could lead to slope failure.

Photo by Lauren Bennett (USACE Media Images Database)

Hills Creek Dam.

US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.5 WATER QUALITY

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3.5 Water Quality

THE WATER QUALITY SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **An overview of the Affected Environment has been added as FEIS Section 3.5.1.**
- **Updated information has been provided on the rationale for Clean Water Act Section 303(d) Oregon State listings (FEIS Table 3.5-1).**
- **Additional information has been provided on monitoring at Black Butte Mine. Subbasin and Environmental Protection Agency Black Butte Mine clarifications have been made in the sediment sampling and analysis summary table (FEIS Table 3.5-9).**
- **Additional information has been added to Table 3.5-1 in the Affected Environment description to include State of Oregon mercury criteria and data collected by the Environmental Protection Agency in 2023.**
- **Additional information has been added to describe turbidity, data collection requirements, and to clarify the subbasin descriptions that represent operations until 2023 in FEIS Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Turbidity.**
- **Additional information has been added regarding studies and data collection through 2023 in the North Santiam River Subbasin, South Santiam River Subbasin, and Middle Fork Willamette River Subbasin in FEIS Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Turbidity.**
- **Cross references to Appendix D, Water Quality Analysis, have been included in the Affected Environment descriptions of harmful algal blooms to assist readers in locating additional information on synoptic surveys and cyanobacteria data.**
- **Figure 3.5-23, Photograph of USACE Fall Creek Dam Fish Horns, has been added.**
- **Cross references to the drinking water analysis in relation to turbidity and cyanobacteria have been added to the Affected Environment descriptions.**
- **The Affected Environment and Environmental Consequences sections have been updated to include information on the Mainstem Willamette River under all alternatives.**

Summary of changes from the DEIS, continued:

- **The methodology for analyzing harmful algal blooms under each alternative has been revised in FEIS Section 3.5.3.1, Methodology, Harmful Algal Blooms and Cyanobacteria Qualitative Methodology.**
- **A summary of adverse and beneficial improvements under the action alternatives has been added to FEIS Section 3.5.3.2, Alternatives Analyses.**
- **The Environmental Consequences analyses have been modified to include analyses of each water quality parameter under each alternative analysis in FEIS Section 3.5.3.2, Alternatives Analyses.**
- **The alternatives analyses were modified to compare action alternatives to the No-action Alternative impact assessment rather than demonstrating a degree of change between 2019 conditions and each action alternative parameter (FEIS Section 3.5.3.2, Alternatives Analyses). For example, adverse water temperature conditions under the No-action Alternative were compared to expected temperature conditions under each alternative rather than demonstrating how much temperature change would occur between 2019 conditions and an alternative. The "change" analyses did not demonstrate actual effects under a given alternative (i.e., a minor change in temperature does not necessarily equate to minor water quality impacts).**
- **Information has been added to clarify how the No-action Alternative and 2024 existing conditions are distinguished because of Court-ordered injunction measures in Section 3.5.3.2, Alternatives Analyses, No-action Alternative. An explanation of the analysis approach for comparison to the No-action alternative because of the injunction measures is also provided.**
- **The turbidity analysis for Fall Creek Reservoir has been revised in Section 3.5.3.2, Alternatives Analyses, No-action Alternative, Turbidity, in all Subbasins.**
- **The Near-term Operations Measures analyses have been combined for all action alternatives except Alternative 1 in Section 3.5.4, Interim Operations under All Action Alternatives Except Alternative 1. Additional information has been provided. The term "Near-term Operations Measures" has been changed to "Interim Operations" throughout the EIS.**
- **The climate change analyses have been combined for all alternatives in Section 3.5.5, Climate Change.**
- **Effect summaries under each alternative have been moved to FEIS Section 3.5.6, Summary of Effects.**
- **Terminology has been defined in footnotes. Symbols used in tables are defined below tables. Additional cross-referencing has been provided.**

3.5.1 Introduction

Operation of the Willamette Valley System (WVS) has direct effects on water quality in reservoirs and downstream of each dam. This section describes the relationship between the dams and water quality and analyzes potential effects to water quality under each alternative.

3.5.2 Affected Environment

The Affected Environment for water quality is described as existing conditions for water quality parameters, which include temperature, total dissolved gas (TDG), harmful algal blooms, turbidity, and mercury. Existing sediment quality conditions within the Willamette Valley System (WVS) is also a component of the Affected Environment, all of which are described by subbasin.

More information on existing conditions for water temperature and TDG are available than for turbidity, harmful algal blooms, and mercury. Consequently, the Affected Environment description below contains more detailed information for water temperature and TDG than for the other parameters where data are unavailable and parameter conditions are unknown. Regulations affecting water quality parameters are first outlined for context.

The analysis area for assessing water quality existing conditions and effects encompasses all reservoirs and Mainstem Willamette River associated with USACE-managed WVS dams in the Willamette River Basin to the Willamette Falls in Oregon City, Oregon.

Note that for improved readability, all figures and tables depicting existing conditions are placed at the end of a subsection or subbasin description.

3.5.2.1 Water Quality Regulations

Federal Clean Water Act and Oregon State Regulations

The Clean Water Act Section 303(d) requires each state to prepare a list of impaired water bodies that do not meet state water quality standards. Under the State of Oregon Administrative Rules (OAR) 340-041, the Oregon Department of Environmental Quality (ODEQ) implements the Water Quality Standards and Total Maximum Daily Loads (TMDLs) for Oregon waters.

> **What is Water Quality?**
>
> Water quality consists of chemical and physical properties that are an integral part in determining the health of a waterbody. Regulations and guidelines established to protect U.S. waters and species include the Federal Water Pollution Control Act (1948), which was amended and replaced by to the Clean Water Act (1972), as amended, and the Endangered Species Act (ESA) (1973).

A TMDL is a load allocation of a pollutant implemented to reduce the pollutant impairment of a waterbody and to meet water quality standards. Water quality standards in the State of Oregon are listed for pH, bacteria, dissolved oxygen, temperature, TDG, total dissolved solids, turbidity, nuisance phytoplankton, and toxic substances.

In 1998, ODEQ added Willamette River Basin rivers and streams to the 303(d) list of impaired waters for exceeding standards for biological criteria, temperature, and bacteria. The 303(d) list included dissolved oxygen in 2012 and turbidity in 2018. ODEQ prepared an Integrated Report of impaired water bodies, including those downstream of USACE-managed WVS dams, by pollutant and initial year listed and assessed year (Table 3.5-1 located at the end of Section 3.5.2, Affected Environment, for readability) (ODEQ 2022).

ODEQ and EPA further addressed water quality impairments in the Willamette Basin in 2006 by finalizing the Willamette Basin TMDLs for temperature, mercury, and bacteria. In 2019, ODEQ issued the Final Revised Willamette Basin Mercury TMDL (ODEQ 2019a). These TMDLs highlight impaired rivers and streams of the Willamette River Basin and set guidelines designed to restore water quality by establishing limits on pollutants to meet water quality standards.

All Willamette River Basin subbasins and the Mainstem Willamette River have TMDL load allocations set by the state for mercury, and 9 of the 12 Subbasins have load allocations for temperature and bacteria. USACE-operated dams are in 6 of the 12 subbasins within the Willamette River Basin, and TMDL load allocations were set by the state for temperature of water released below these dams. At the time the alternatives were analyzed, there were no dissolved oxygen or turbidity TMDLs for the Willamette River Basin.

The Annual Willamette Basin Water Quality Reports, from 2009 to present, detail implemented water quality measures describing reservoir temperature targets, temperature TMDLs, TDG, and other water quality (USACE 2011b; USACE 2012b; USACE 2013e; USACE 2014c; USACE 2015m; USACE 2016d; USACE 2017f; USACE 2018c; USACE 2019e; USACE 2020d; USACE 2021f; USACE 2022f).

Oregon State Harmful Algal Bloom Guidelines

The Oregon Health Authority implements cyanobacteria toxin guidelines and threshold levels for recreation and drinking waters for the public (OHA 2019). Information provided by the Oregon Health Authority with current and archived algae bloom recreational advisories includes Willamette Valley reservoirs (OHA 2023). Oregon Health Authority is notified if levels are above the toxin threshold following USACE staff water sampling. The Oregon Health Authority then assesses the need for a public advisory for a particular water body.

Oregon State Turbidity Regulations

Turbidity regulations are defined by the State as no more than a 10 percent cumulative increase in natural stream turbidities. Increases are to be measured relative to a control point immediately upstream of the turbidity-causing activity (OAR 340-041-0036).

Oregon State Mercury Guidelines and Federal Regulations

Federal and state agencies prepare mercury guidelines and advisories for human fish consumption limits (EPA and FDA 2022; OHA 2022b). As of February 4, 2021, the ODEQ and the U.S. Environmental Protection Agency (EPA) have issued a revised 2019 Willamette Basin Mercury TMDL; the previous TMDL was issued in 2006 (ODEQ 2019a; EPA 2011).

Endangered Species Act Biological Opinions

In addition to Federal and state regulations and guidelines, the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) issued their respective Willamette Project Biological Opinions in 2008 (NMFS 2008; USFWS 2008). The NMFS Biological Opinion identifies Reasonable and Prudent Alternatives that address multiple interim and long-term water quality improvement objectives and is referred to as the 2008 Biological Opinion in this water quality section.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING TABLE

Table 3.5-1. Clean Water Act Section 303d-listed Impaired Waterbodies Downstream of the Willamette Valley System Dams[1].

Waterbody	Description	Pollutant[2]	Period	Parameter Category	Rationale	Assessed 2022	Year Assessed	Year Listed
Coast Fork Willamette River	Cottage Grove Dam to Row River	Dissolved Oxygen	Spawn	4A	State of Oregon: OAR-340-041-0016 1(b) ODEQ: 2018: 5 of 8 samples where dissolved oxygen is < 11 mg/L and 95% saturation.	No	2018	2018
Coast Fork Willamette River	Row River to confluence with Willamette River	Dissolved Oxygen	Spawn	4A	STATE OF OREGON: OAR-041-0016 2 and Table 21 ODEQ: Attaining: 0 total excursions is <= 4 needed to list. 18 total sample dates. Does not meet delisting requirements.	Yes	2022	2012
Fall Creek	Fall Creek Dam to confluence with Middle Fork Willamette River	Dissolved Oxygen	Year round	5	STATE OF OREGON: OAR 340-41-0016. ODEQ: Impaired: 2 excursions of alternate minimum criteria. 0 valid excursions of 7-mi mean (7-day minimum mean) metric. 0 valid excursions of 30-D metric.	Yes	2022	2022
Fall Creek	Fall Creek Dam to confluence with Middle Fork Willamette River	Dissolved Oxygen	Spawn	5	STATE OF OREGON: OAR 340-41-0016 ODEQ: Impaired – 47 valid excursions of 7-D metric.	Yes	2022	2022
Lower Blue River	Blue River Dam to confluence with McKenzie River	Dissolved Oxygen	Spawn	5	STATE OF OREGON: OAR 340-41-0016 ODEQ: Impaired – 114 valid excursions of 7-D metric.	Yes	2022	2022
Middle Fork Willamette River	Salt Creek to North Fork Middle Fork Willamette River	Dissolved Oxygen	Spawn	5	STATE OF OREGON: OAR-340-041-0016 1(b) ODEQ: 2018: 3 of 5 samples where dissolved oxygen is < 11 mg/L and 95% saturation.	No	2018	2018
Middle Fork Willamette River	Hills Creek Dam to Salt Creek	Dissolved Oxygen	Spawn	5	STATE OF OREGON: OAR 340-41-0016 ODEQ: Attaining: 0 total excursions is <= 2 needed to list. 11 total sample dates. Does not meet delisting requirements.	Yes	2022	2018
Middle Fork Willamette River	Dexter Dam to Lost Creek	Dissolved Oxygen	Spawn	5	STATE OF OREGON: OAR-340-041-0016 1(b) ODEQ: 2018: 4 of 5 samples where dissolved oxygen is < 11 mg/L and 95% saturation.	No	2018	2018
Middle Fork Willamette River	Fall Creek to confluence with Willamette River	Dissolved Oxygen	Spawn	5	STATE OF OREGON: OAR 340-41-0016 ODEQ: Impaired – 14 valid excursions of 7-D metric.	Yes	2022	2012
North Santiam River	Big Cliff Dam to Little North Santiam River	Dissolved Oxygen	Spawn	5	STATE OF OREGON: OAR 340-41-0016 ODEQ: Impaired – 98 valid excursions of 7-D metric.	Yes	2022	2022
South Fork McKenzie River	Cougar Dam to confluence with McKenzie River	Dissolved Oxygen	Spawn	5	STATE OF OREGON: OAR 340-41-0016 ODEQ: Impaired – 71 valid excursions of 7-D metric.	Yes	2022	2022
Willamette River	Confluence of Middle Fork Willamette River and Coast Fork Willamette River to Luckiamute River	Dissolved Oxygen	Spawn	5	STATE OF OREGON: OAR 340-41-0016 ODEQ: Impaired – 12 valid excursions of 7-D metric.	Yes	2022	2012

Waterbody	Description	Pollutant[2]	Period	Parameter Category	Rationale	Assessed 2022	Year Assessed	Year Listed
Long Tom River	Fern Ridge Dam to confluence with Willamette River	Turbidity	N/A	5	STATE OF OREGON: OAR 340-041-0036 ODEQ: Impaired: 2016: 140 high turbidity days. 2017: 125 high turbidity days. 2016: 23 high turbidity days.	Yes	2022	2018
North Santiam River	Little North Santiam River to South Santiam River	Turbidity	N/A	5	STATE OF OREGON: OAR 340-041-0036 ODEQ: Impaired: 2019: 35 high turbidity days. 2019: 37 high turbidity days. 2019: 11 high turbidity days. 2019: 59 high turbidity days. 2019: 15 high turbidity days.	Yes	2022	2022
Row River	Dorena Dam to confluence with Coast Fork Willamette River	Turbidity	N/A	5	STATE OF OREGON: OAR 340-041-0036 ODEQ: Impaired: 2016: 146 high turbidity days. 2017: 163 high turbidity days. 2018: 83 high turbidity days.	Yes	2022	2018
Santiam River	Confluence of North Santiam River and South Santiam River to confluence with Willamette River	Turbidity	N/A	5	STATE OF OREGON: OAR 340-041-0036. ODEQ: Impaired: 2017: 17 high turbidity days. 2019: 66 high turbidity days. 2020: 30 high turbidity days. 2017: 55 high turbidity days. 2019: 50 high turbidity days. Same rationale as described for the Long Tom River.	Yes	2022	2022
Coast Fork Willamette River	Cottage Grove Dam to Row River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028. ODEQ: Impaired: 220 valid excursions of criteria. 36 excursions marked invalid due to air temperature exclusion rule.	Yes	2022	2018
Coast Fork Willamette River	Row River to confluence with Willamette River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028. ODEQ: 2004 Data: [DEQ/SECOR] LASAR 10380 River Mile 11.7: From 6/2/2001 to 9/27/2002, 195 days with 7-day-average maximum > 18° Celsius. [DEQ/SECOR] LASAR 10381 River Mile 18.9: From 6/2/2001 to 9/27/2002, 158 days with 7-day-average maximum > 18° Celsius.	No	2010	2010
Fall Creek	Fall Creek Dam to confluence with Middle Fork Willamette River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028. ODEQ: Impaired: 168 valid excursions of criteria. 25 excursions marked invalid due to air temperature exclusion rule.	Yes	2022	2010
Fall Creek	Fall Creek Dam to confluence with Middle Fork Willamette River	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 280 valid excursions of 13° Celsius criteria. Four excursions marked invalid due to air temperature exclusion rule – 1,367 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018
Green Peter Lake	Lake/Reservoir Unit	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028. ODEQ: 2004 Data: [DEQ] LASAR 23805 River Mile 16.2: From 6/11/2000 to 9/16/2000, 56 days with 7-day-average maximum > 18°Celsius.	No	2010	2010

Waterbody	Description	Pollutant[2]	Period	Parameter Category	Rationale	Assessed 2022	Year Assessed	Year Listed
Lower Blue River	Blue River Dam to confluence with McKenzie River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 118 valid excursions of criteria. Two excursions marked invalid due to air temperature exclusion rule. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018
Lower Blue River	Blue River Dam to confluence with McKenzie River	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 161 valid excursions of 13° Celsius criteria. 0 excursions marked invalid due to air temperature exclusion rule – 1,054 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018
McKenzie River	Lower Blue River to Ennis Creek	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028. ODEQ: 2004 Data: [DEQ/SECOR] LASAR 26770 River Mile 48.8: From 6/16/2001 to 8/31/2002, 0 days with 7-day-average maximum > 16° Celsius. [DEQ/SECOR] LASAR 26757 River Mile 15: From 7/10/2001 to 8/31/2002, 98 days with 7-day-average maximum > 16° Celsius.	No	2010	2010
McKenzie River	Lower Blue River to Ennis Creek	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 Carried forward from previous listing.	No	2010	2010
Middle Fork Willamette River	Hills Creek Dam to Salt Creek	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 93 valid excursions of criteria. Five excursions marked invalid due to air temperature exclusion rule. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2022
Middle Fork Willamette River	Hills Creek Dam to Salt Creek	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 187 valid excursions of 13°Celsius criteria. Two excursions marked invalid due to air temperature exclusion rule – 1,093 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2022
Middle Fork Willamette River	North Fork Middle Fork Willamette River to Sweeney Creek	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 228 valid excursions of criteria. 100 excursions marked invalid due to air temperature exclusion rule. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018

Waterbody	Description	Pollutant[2]	Period	Parameter Category	Rationale	Assessed 2022	Year Assessed	Year Listed
Middle Fork Willamette River	North Fork Middle Fork Willamette River to Sweeney Creek	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 155 valid excursions of 13° Celsius criteria. Two excursions marked invalid due to air temperature exclusion rule – 1,100 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018
Middle Fork Willamette River	Dexter Dam to Lost Creek	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 155 valid excursions of 13° Celsius criteria. Two excursions marked invalid due to air temperature exclusion rule – 1,100 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018
Middle Fork Willamette River	Dexter Dam to Lost Creek	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 155 valid excursions of 13° Celsius criteria. Two excursions marked invalid due to air temperature exclusion rule – 1,100 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018
Middle Fork Willamette River	Fall Creek to confluence with Willamette River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028. ODEQ: Impaired: 417 valid excursions of criteria. 110 excursions marked invalid due to air temperature exclusion rule. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018
Middle Fork Willamette River	Fall Creek to confluence with Willamette River	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 399 valid excursions of 13° Celsius criteria. 23 excursions marked invalid due to air temperature exclusion rule – 1,360 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018
Middle Santiam River	Green Peter Dam to Foster Lake	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 31 valid excursions of 13° Celsius criteria. 0 excursions marked invalid due to air temperature exclusion rule – 978 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018
North Santiam River	Big Cliff Dam to Little North Santiam River	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 11 valid excursions of 13° Celsius criteria. 0 excursions marked invalid due to air temperature exclusion rule—1,431 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010

Waterbody	Description	Pollutant[2]	Period	Parameter Category	Rationale	Assessed 2022	Year Assessed	Year Listed
North Santiam River	Little North Santiam River to South Santiam River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 309 valid excursions of criteria. 121 excursions marked invalid due to air temperature exclusion rule and low flow exclusion before being finalized. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010
North Santiam River	Little North Santiam River to South Santiam River	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 14 valid excursions of 13° Celsius criteria. 0 excursions marked invalid due to air temperature exclusion rule – 88 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010
Row River	Dorena Dam to confluence with Coast Fork Willamette River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 184 valid excursions of criteria. 30 excursions marked invalid due to air temperature exclusion rule. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010
Santiam River	Confluence of North Santiam River and South Santiam River to confluence with Willamette River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 255 valid excursions of criteria. 117 excursions marked invalid due to air temperature exclusion rule. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010
Santiam River	Confluence of North Santiam River and South Santiam River to confluence with Willamette River	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028. ODEQ: Impaired: 51 valid excursions of 13° Celsius criteria. 0 excursions marked invalid due to air temperature exclusion rule – 978 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010
South Fork McKenzie River	Cougar Dam to confluence with McKenzie River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 90 valid excursions of criteria. 38 excursions marked invalid due to air temperature exclusion rule. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2018
South Fork McKenzie River	Cougar Dam to confluence with McKenzie River	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 32 valid excursions of 13° Celsius criteria. 16 excursions marked invalid due to air temperature exclusion rule – 1 407 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010

Waterbody	Description	Pollutant[2]	Period	Parameter Category	Rationale	Assessed 2022	Year Assessed	Year Listed
South Santiam River	Foster Dam to North Santiam River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 16 valid excursions of criteria. Seven excursions marked invalid due to air temperature exclusion rule. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010
South Santiam River	Foster Dam to North Santiam River	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 22 valid excursions of 13° Celsius criteria. 2 excursions marked invalid due to air temperature exclusion rule – 1,346 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010
Willamette River	Confluence of Middle Fork Willamette River and Coast Fork Willamette River to Luckiamute River	Temperature	Year round	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 866 valid excursions of criteria. 318 excursions marked invalid due to air temperature exclusion rule. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010
Willamette River	Confluence of Middle Fork Willamette River and Coast Fork Willamette River to Luckiamute River	Temperature	Spawn	5	STATE OF OREGON: OAR 340-041-0028 ODEQ: Impaired: 388 valid excursions of 13° Celsius criteria. 0 excursions marked invalid due to air temperature exclusion rule – 2,957 total results. Same rationale as described for the Fall Creek year-round period.	Yes	2022	2010
Cottage Grove Lake	Big River to Cottage Grove Lake	Mercury (total)		4A	STATE OF OREGON: OAR 340-041-0033. ODEQ: 2018: 3 of 20 samples > criteria	No	2012	2012
Coast Fork Willamette River	Row River to confluence with Willamette River	Methylmercury		4A	STATE OF OREGON: OAR 340-041-0033 ODEQ: 2018: Geomean > 0.04 mg/kg (0.454).	No	2018	2012
Cottage Grove Lake	Lake/Reservoir Unit	Methylmercury		4A	STATE OF OREGON: OAR 340-041- Previous Data: OSHD Fish Consumption Advisory based on 10% of fish tested exceeding USFDA commercial fish standard of methylmercury (1.0 ppm) and a range of 0.22 ppm to 1.79 ppm.	No	2012	2012
Dorena Lake	Lake/Reservoir Unit	Methylmercury		4A	STATE OF OREGON: OAR 340-041-0033. Record ID: 6774 Previous Data: Elevated levels measured in fish tissue of 37 ppm. Consumption Health Advisory issued 2/25/97.	No	2012	2012
McKenzie River	Ennis Creek to confluence with Willamette River	Methylmercury		4A	STATE OF OREGON: OAR 340-041-0033 ODEQ: 2018: Geomean > 0.04 mg/kg (0.278).	No	2018	2012
Middle Fork Willamette River	Fall Creek to confluence with Willamette River	Methylmercury		4A	STATE OF OREGON: OAR 340-041-0033 ODEQ: 2018: Geomean > 0.04 mg/kg (0.289).	No	2018	2010

Waterbody	Description	Pollutant[2]	Period	Parameter Category	Rationale	Assessed 2022	Year Assessed	Year Listed
Santiam River	Confluence of North Santiam River and South Santiam River to confluence with Willamette River	Methylmercury		4A	STATE OF OREGON: OAR 340-041-0033 ODEQ: 2018: Geomean > 0.04 mg/kg (0.284).	No	2018	2012
South Santiam River	Foster Dam to North Santiam River	Methylmercury		4A	STATE OF OREGON: OAR 340-041-0033 ODEQ: 2018: Arithmetic mean > 0.04 mg/kg (0.0532).	No	2018	2018
Willamette River	Confluence of Middle Fork Willamette River and Coast Fork Willamette River to Luckiamute River	Methylmercury		4A	STATE OF OREGON: OAR 340-041-0033 ODEQ: 2018: Geomean > 0.04 mg/kg (0.346).	No	2018	2012
Blue River Lake	Lake/Reservoir Unit	Harmful Algal Blooms		5	STATE OF OREGON: OAR 340-041-0007.	No	2010	2010
Detroit Lake	Lake/Reservoir Unit	Harmful Algal Blooms		5	STATE OF OREGON: OAR 340-041-0007.	No	2010	2010
Dexter Reservoir	Lake/Reservoir Unit	Harmful Algal Blooms		5	STATE OF OREGON: OAR 340-041-0007.	No	2010	2010
Dorena Lake	Lake/Reservoir Unit	Harmful Algal Blooms		5	STATE OF OREGON: OAR 340-041-0007.	No	2010	2010
Fern Ridge Lake	Lake/Reservoir Unit	Harmful Algal Blooms		5	STATE OF OREGON: OAR 340-041-0007	Yes	2022	2022
Hills Creek Lake	Lake/Reservoir Unit	Harmful Algal Blooms		5	STATE OF OREGON: OAR 340-041-0007 2018 Data: From: 5/15/2008 – 7/16/2008	No	2018	2010
Lookout Point Lake	Lake/Reservoir Unit	Harmful Algal Blooms		5	STATE OF OREGON: OAR 340-041-0007. Record ID: 23204	No	2010	2010

ODEQ = Oregon Department of Environmental Quality

OAR = Oregon Administrative Rule

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

ug/L = micrograms per liter

NTU = nephelometric turbidity unit

% = percent

< = less than

$\geq$ = greater than or equal to

N/A = Not Applicable

[1] Adapted from ODEQ 2022 Integrated Report including Willamette Valley TMDL. Department of Environmental Quality TMDL information can be found here: 2022 Integrated Report Fact Sheet (https://www.oregon.gov/deq/wq/Documents/IR2022FactSheet.pdf) and Integrated Report Database (https://rstudioconnect.deq.state.or.us/2022_IR_Database/). Methodology for ODEQ Rationale for each pollutant for 303d listing can be found here: https://www.oregon.gov/deq/wq/Documents/IR22AssessMethod.pdf.

Information was copied verbatim from the source and contains typographical errors.

[2] Temperature criteria are listed as "period" and are associated with fish life stages. Mercury criteria are listed by water column and as found in fish tissue. Turbidity criteria are listed by water column.

3.5.2.2 Water Quality Parameter Overview and Subbasin Conditions

ALL FIGURES AND TABLES PERTAINING TO PARAMETER DESCRIPTIONS HAVE BEEN MOVED TO THE END OF EACH SUBBASIN DESCRIPTION

Temperature

Downstream water temperatures affected by WVS dams disrupt fish spawning and rearing life stages because water is too cool in the summer/spring and too warm in the fall/winter for survival (Figure 3.5-1 and Figure 3.5-2, respectively). In the reservoirs, thermal stratification occurs in summer, with warmer water near the surface and cooler water at the bottom. In the fall, a lake or reservoir may "turn over" meaning surface water will cool to temperatures less than water at the bottom, which displaces water at the bottom due to density properties of water and temperature. Currently, dam operations utilize various outlets and spillways to mix temperatures and provide more normative downstream temperatures.

The State of Oregon and three Resource Agencies[1] (i.e., NMFS, USFWS, ODFW) develop temperature TMDLs and temperature targets throughout the year to coincide with life cycle stages of ESA-listed fish. Currently, ESA-listed fish, such as the Upper Willamette River (UWR) spring Chinook salmon, UWR winter steelhead, and bull trout, have been identified in the Willamette River Subbasins (USACE 2020b).

Construction of the WVS dams has disrupted natural thermal and flow regimes of the subbasin rivers (Gregory et al. 2007). Water temperatures below WVS dams have been identified as one of the limiting factors preventing the recovery of UWR spring Chinook salmon and UWR steelhead (USACE 2000; Taylor and Garletts 2007; Angilletta et al. 2008; NMFS 2008; Oregon Department of Fish and Wildlife (ODFW) and NMFS 2011). Water temperatures are monitored by USACE-funded U.S. Geological Survey (USGS) gages that may be located upstream (inflow) and downstream (outflow) of a dam and reservoir.

[1] "Resource Agencies" is a term referencing agencies with fisheries expertise and/or responsibility for fishery resources in the Willamette River Basin, including USACE, BPA, NMFS, USFWS, ODFW, and ODEQ.

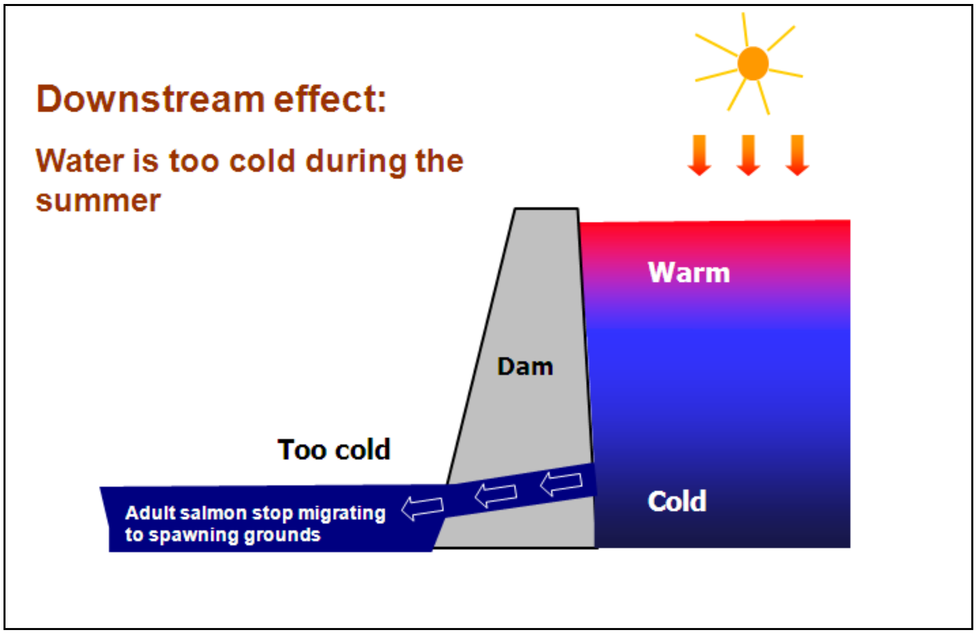

Figure 3.5-1. Influence of Typical Dam Operations on Downstream Water Temperatures during the Conservation Season.

Source: USACE 2020b

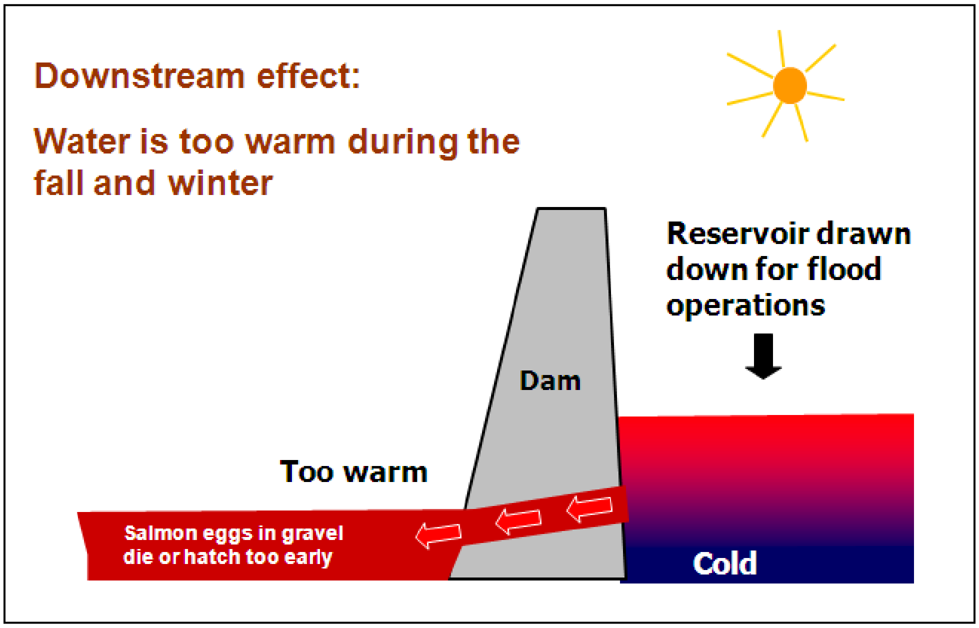

Figure 3.5-2. Influence of Typical Dam Operations on Downstream Water Temperatures during Reservoir Drawdown for Flood Damage Reduction.

Source: USACE 2020b

Temperature Conditions in the North Santiam River Subbasin

Detroit Reservoir is a warm monomictic lake[2] that thermally stratifies during the spring, summer, and fall months. From June through mid-September, the dam provides interim water temperature management downstream using a blend of releases from the spillway, regulating outlets, and turbines. During the summer months, the upper layer of water warms due to radiative heating. Water is much cooler near the regulating outlets. The real-time reservoir temperature thermistor string[3] can be accessed through the USACE public website (USACE 2022d).

The blending of the two water layers provides downstream temperature management. Water quality considerations shape operation of the reservoirs unless the system is being operated for flood risk management. USACE-funded USGS gages for monitoring temperature are located above and below Detroit Reservoir for temperature and TDG monitoring (Figure 3.5-3).

The State of Oregon TMDL temperature targets for waters downstream of the Detroit and Big Cliff Dams were developed with basin experts in 2006 (Table 3.5-2). In 2016, the North Santiam temperature task group was created to assess thermal regimes in the North Santiam River Subbasin.

Interim temperature targets for Detroit and Big Cliff Dams were modified from the 2008 Biological Opinion and agreed upon by the North Santiam temperature task group, becoming effective on June 1, 2017. These same temperature targets were also applied in 2018 and beyond. Temperature targets developed by the Resource Agencies consider various factors like estimated fish emergence timing and spawning time variability to generate yearly targets as shown in (Table 3.5-2).

Water of varying temperatures released from Detroit Dam mix in Big Cliff Reservoir. A gage is located 0.75 miles below Big Cliff Reservoir near Niagara, Oregon, which is the compliance point for water temperature releases from both dams.

In a typical year, water temperature targets are met during the summer and early fall months, but trend higher than targets in the late fall and early winter (Figure 3.5-4). Outflow temperatures are very close to the TMDL temperature targets, except for October and November (Figure 3.5-5 and Figure 3.5-6). This is because Detroit Reservoir is a large body of water and takes longer to warm in the spring and cool in the fall as compared to unregulated river systems. Therefore, a thermal lag is produced resulting in late fall/early winter water

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[2] A warm monomictic lake is defined as able to circulate freely once a year in the winter at or above 39.2°F (4°C) and is stably stratified for the remainder of the year; not ice-covered (Wetzel 2001).

[3] Temperature thermistor strings are water quality equipment that measure reservoir temperature (i.e., temperature at set depths).

temperature objectives not being met. It is not until mid-winter that the reservoir loses all heat gained from the summer season and downstream water temperatures are again achieved.

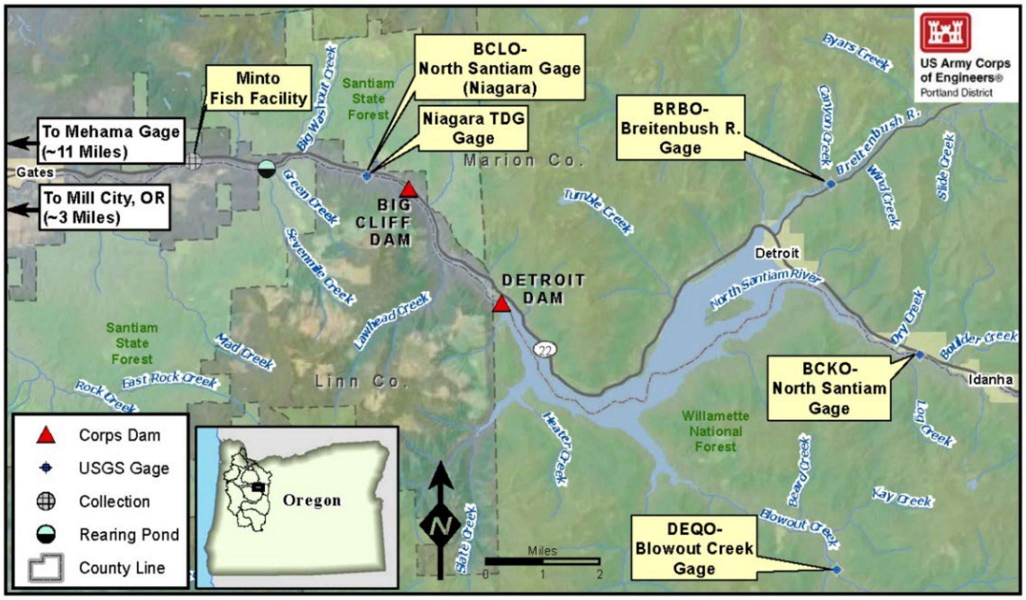

Figure 3.5-3. Reservoir on the Breitenbush and North Santiam Rivers and Blowout Creek, and Downstream from Big Cliff Dam to the Minto Fish Facility.

Source: USACE 2021f

Table 3.5-2. Detroit/Big Cliff Dams Downstream Water Temperature 2020 Resource Agency Targets (Daily Average)* and ODEQ 2006 TMDL Targets (7-day Average).

Month	Current Resource Agency Target Temperature Range Maximum/Minimum °F*		Prior Resource Agency Target Temperature Range Maximum/Minimum °F		ODEQ 2006 TMDL Target Temperatures °F
January	42	38	40.1	40.1	
February	42	38	42.1	41.0	No Allocation Needed
March	44	42	42.1	41.0	
April	46	42	45.1	43.2	41.7
May	50	46	49.1	46.0	45.1
June	54	48	56.1	51.1	49.5
July	55	52	61.2	54.1	55.0
August	55	52	60.3	54.1	55.0
September	54	48	56.1	52.3	51.6
October	52	46	<50.0	<50.0	45.9

Month	Current Resource Agency Target Temperature Range Maximum/Minimum °F*		Prior Resource Agency Target Temperature Range Maximum/Minimum °F		ODEQ 2006 TMDL Target Temperatures °F
November	46	42	<50.0	<50.0	45.9
December	46	41	41.0	41.0	No Allocation Needed

Source: USACE 2021f

ODEQ = Oregon Department of Environmental Quality

TMDL = Total Maximum Daily Load

°F = degrees Fahrenheit

< = less than

*Daily average 2020 Resource Agency target temperatures proposed by ODFW (2017) and approved in 2017 and 2018 by the North Santiam Temperature Task Group (USACE, BPA, ODFW, NMFS, USFWS, and ODEQ) for downstream of Detroit and Big Cliff Dams.

On July 20, 2018, the maximum 2018 Resource Agency targets were revised to 60°F through August.

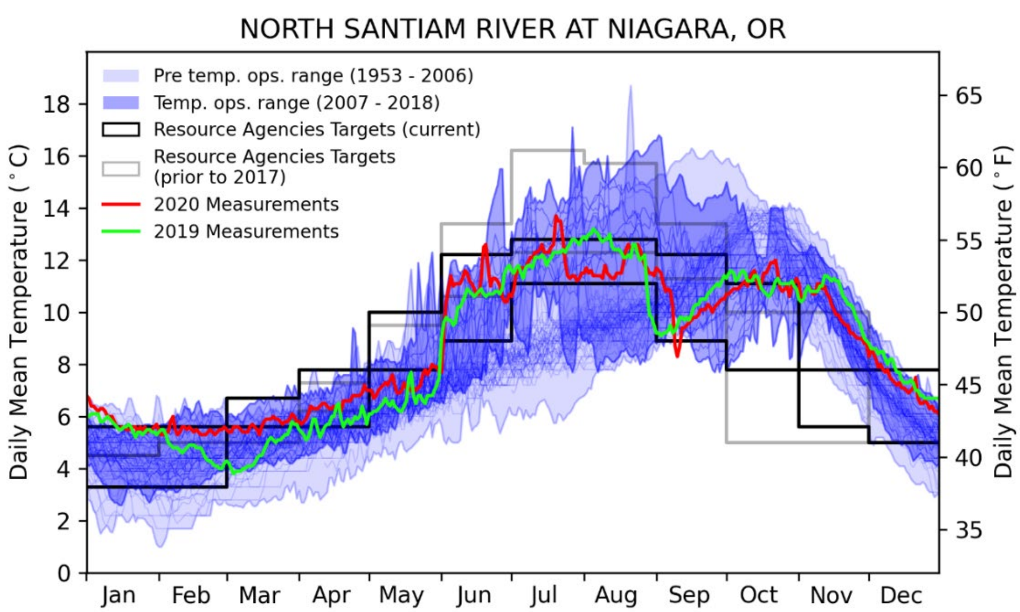

Figure 3.5-4. Detroit/Big Cliff Reservoirs Daily Mean 2019 and 2020 Outflow Temperatures.

Source: USACE 2021f

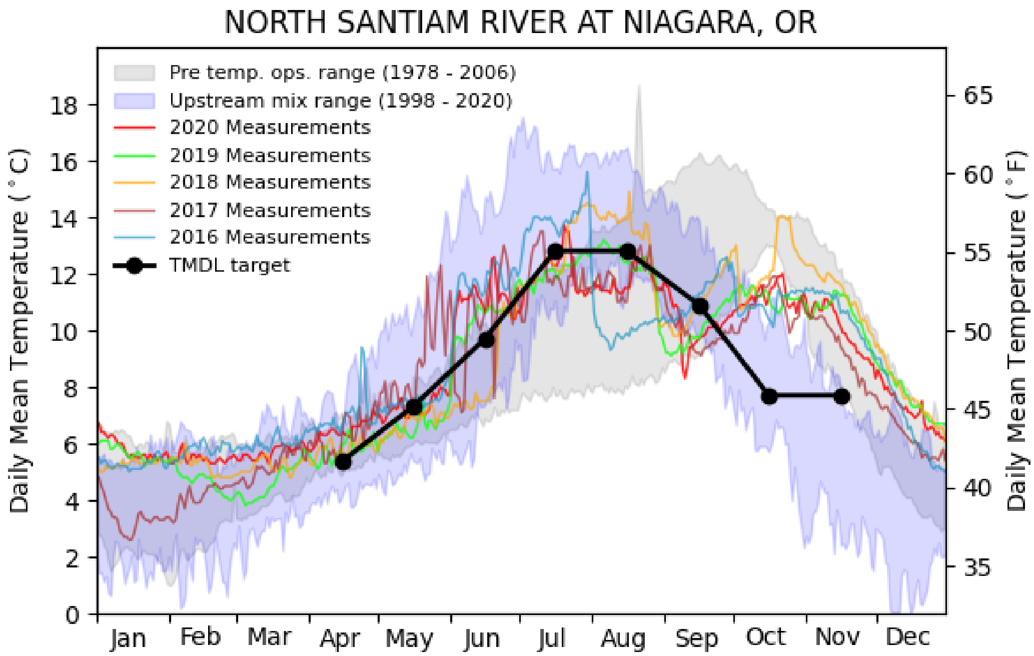

Figure 3.5-5. Detroit/Big Cliff Reservoirs Daily Mean Outflow Temperatures during Temperature Control Operation Years.

Source: USACE 2021f

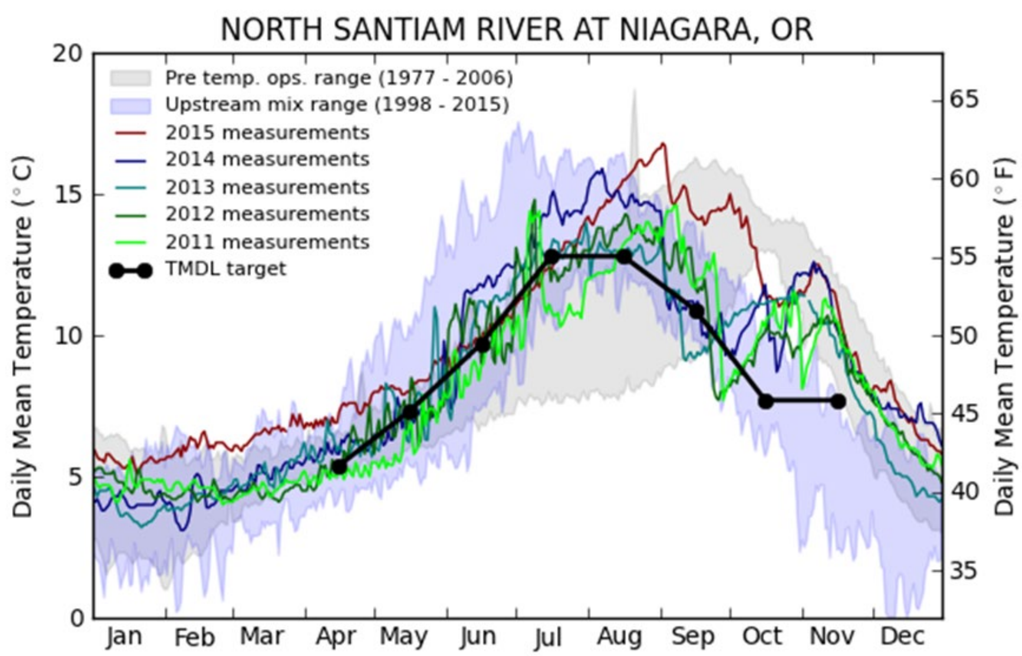

Figure 3.5-6. Detroit/Big Cliff Reservoirs Daily Mean Outflow Temperatures during Temperature Control Operation Years.

Source: USACE 2016d

Temperature Conditions in the South Santiam River Subbasin

The 2008 Biological Opinion considers elevated water temperatures caused by dam operations a primary limiting factor for the egg/emergence component of the UWR spring Chinook salmon life stages in the South Santiam River due to premature hatching and emergence (NMFS 2008). Water temperatures can also affect other life stages, including upstream migration of UWR spring Chinook salmon and UWR steelhead (USACE 2018c). There are no annual interim temperature control operations at Green Peter Reservoir.

In late May 2020, a special study released warm water from Green Peter Dam to increase temperatures and trigger a biological response for UWR spring Chinook salmon at the Foster Dam adult fish facility ladder (USACE 2020c). Water temperatures increased by 4°F to 5°F over a 3-week period; high UWR spring Chinook salmon returns and collections at the adult fish facility were then observed. Additionally, there was an outage of an auxiliary water supply pump during this period. The pump acts to recirculate cool turbine water near the entrance of the Foster Dam fish ladder. The outage also improved temperatures prompting an upstream migration response from fish in the tailrace (Figure 3.5-7). The results of the study indicated improved temperatures were needed to better operate the adult fish facility at Foster Dam (USACE 2020c).

Currently, there are three USACE-funded USGS gages located at Middle Santiam River upstream of Green Peter Reservoir, Quartzville Creek upstream of Green Peter Reservoir, and Middle Santiam River downstream of Green Peter Reservoir (Figure 3.5-8). Temperature targets for the South Santiam River Subbasin utilized targets developed by the Resource Agencies for the North Santiam and McKenzie Subbasins (Table 3.5-3). However, the South Santiam River Subbasin has warmer upstream and cooler downstream temperatures as compared to the North Santiam River Subbasin.

Typically, Green Peter Reservoir temperatures meet Resource Agency targets and temperature TMDLs from February to May and tend to be cooler from June to September. Temperatures are above the target from October to December (Figure 3.5-9 through Figure 3.5-11). In-reservoir thermistor strings were deployed in 2010 and continue to collect temperature data (USACE 2022d).

THE DEIS HAS BEEN REVISED TO ADD THE FOLLOWING INFORMATION IN THE FEIS

A USGS study provided operational scenarios using CE-QUAL-W2 models to assess water temperature downstream of Green Peter and Foster Dams. One scenario indicated dam operations at Green Peter Dam were more effective at modifying water temperature releases from Foster Dam, which may be due to the size and height of Green Peter Dam and the use of outlets to release varied water temperatures (Sullivan 2021).

END NEW TEXT

Foster Reservoir is a re-regulating dam and a smaller reservoir as compared to Green Peter Reservoir. Generally, unregulated flow from the South Santiam River above Foster Dam provides warmer water and Green Peter Reservoir provides cooler water from the powerhouse discharge. As such, Foster Reservoir water temperatures stratify in the late spring and summer.

The current Foster Dam fish passage facility was modified in 2014 in response to the 2008 Biological Opinion (NMFS 2008). Research in 2017 determined that water temperature from the adult fish facility ladder entrance is too cold compared to historical or ambient river temperatures to attract UWR spring Chinook salmon from May through June, which delays collection and passage (Keefer et al. 2018a).

Interim water temperature management operations are currently being conducted to improve water temperatures for upstream fish migration, attraction to the adult fish ladder, and for the Foster Dam adult fish facility. Temperature management includes use of the Foster Dam fish weir to skim warm water off the surface of Foster Reservoir for release downstream. USGS gages are located on the South Santiam River near the town of Cascadia, Oregon, and downstream of Foster Reservoir (Figure 3.5-8) (refer to USGS Data: http://or.water.usgs.gov/cgi-bin/grapher/table_setup.pl). These gages monitor water temperature and other water quality parameters.

Foster Reservoir temperatures are typically in range of Resource Agency targets and temperature TMDLs from February through June and October through November. Temperatures are lower from July until September (Figure 3.5-12 through Figure 3.5-14); consequently, there is a need for Foster Reservoir temperature management operations.

In-reservoir thermistor strings were deployed in 2010 and continue to collect temperature data (USACE 2022d). Data provided by the gages are being used for water quality modeling efforts utilizing CE-QUAL-W2[4] to inform operational temperature management plans.

[4] CE-QUAL-W2 is a two-dimensional (longitudinal/vertical) hydrodynamic reservoir and river model (Wells 2019).

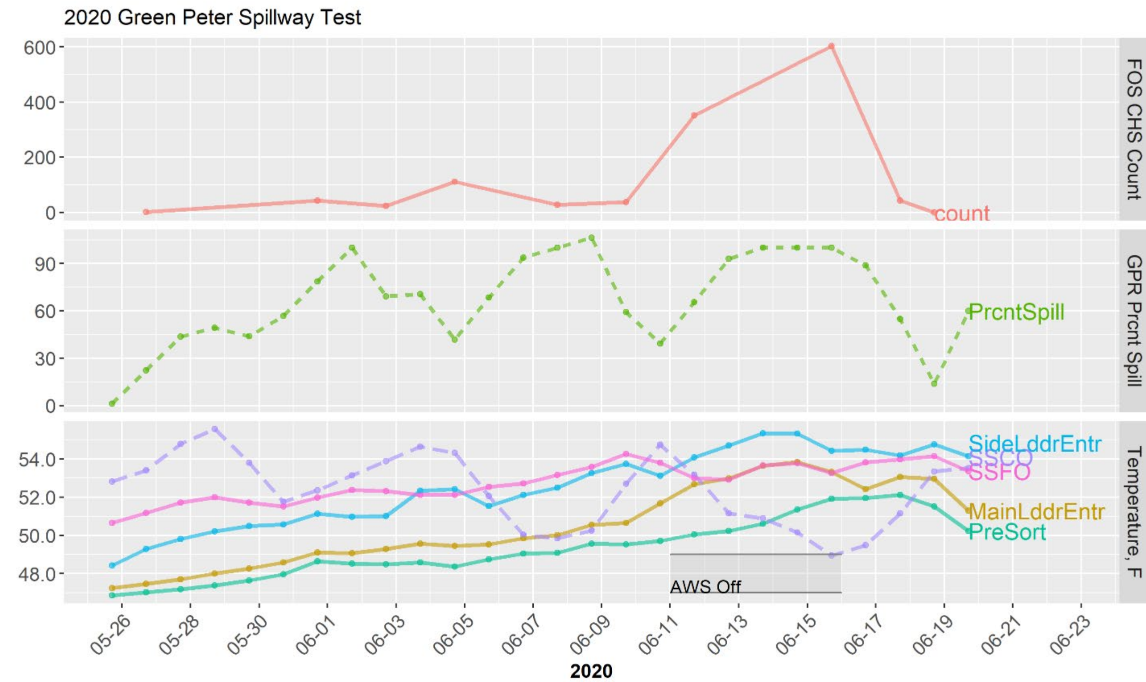

Figure 3.5-7. 2020 Foster Dam Fish Spring Chinook Collection, Green Peter Dam Spill Operation (percent of total flow), and Foster Dam Fish Ladder Water Temperatures May 26, 2020 to June 16, 2020.

FOS CHS Count = Foster Dam adult fish facility Chinook salmon return fish count

GPR Percent Spill = Green Peter Dam spillway flow as a percentage

SideLddrEntr = water temperature at the entrance to the adult fish facility on the Foster Dam spillway side

SSCO = water temperature at South Santiam River below Cascadia, Oregon

SSFO = water temperature at South Santiam River near Foster Dam

MainLddrEntr = water temperature at the main entrance to the adult fish facility near the penstock outfall

PreSortwater = temperature in the adult fish facility fish ladder above the entrance, near the holding tank

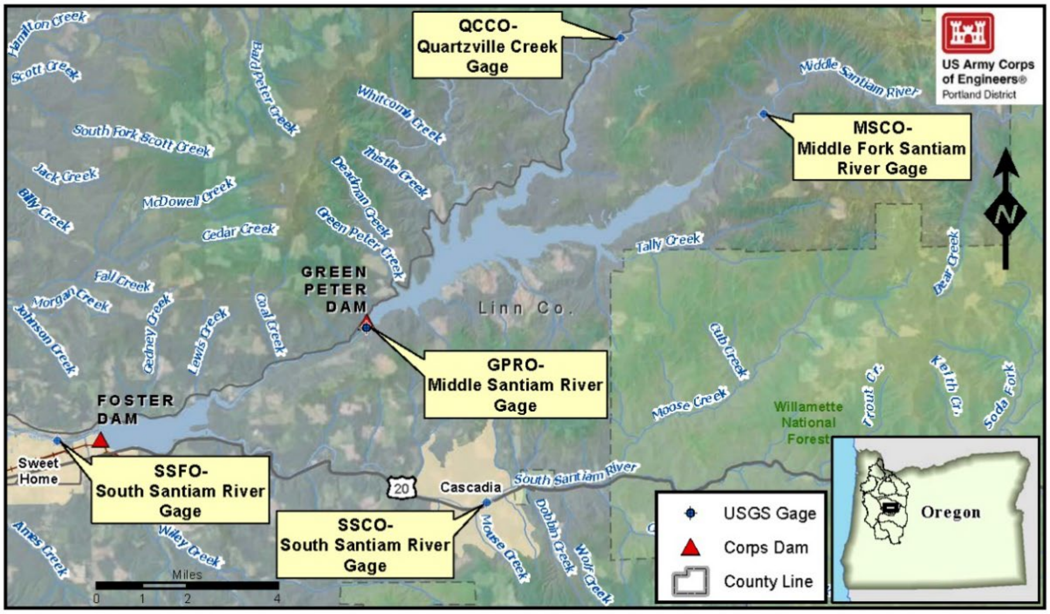

Figure 3.5-8. Water Temperature U.S. Geological Survey Gage Locations: Upstream of Green Peter Reservoir on Quartzville Creek and the Middle Santiam River, Upstream of Foster Reservoir on South Santiam River, and Downstream of Green Peter and Foster Dams.

Source: USACE 2021f

Table 3.5-3. Resource Agency Water Temperature Targets for Green Peter and Foster Dams (Daily Average)* and ODEQ 2006 TMDL Targets (7-day Average).

Month	Resource Agency Target Temperature Range Maximum/Minimum °F*		ODEQ 2006 TMDL Target Temperatures °F
January	40.1	40.1	No Allocation Needed
February	42.1	41.0	
March	42.1	41.0	
April	45.1	43.2	43.0
May	49.1	46.0	46.8
June	56.1	51.1	54.3
July	61.2	54.1	65.1
August	60.3	54.1	64.4
September	56.1	52.3	59.9
October	<50.0	<50.0	54.7

Month	Resource Agency Target Temperature Range Maximum/Minimum °F*		ODEQ 2006 TMDL Target Temperatures °F
November	<50.0	<50.0	54.7
December	41.0	41.0	No Allocation Needed

Source: USACE 2021f

< = less than

ODEQ = Oregon Department of Environmental Quality

TMDL = Total Maximum Daily Load

°F = degrees Fahrenheit

*Daily average target temperatures originally developed by the Resource Agencies (NMFS, USFWS, ODFW) for the McKenzie River below Cougar Dam (October and November slightly modified for the North / South Santiam River).

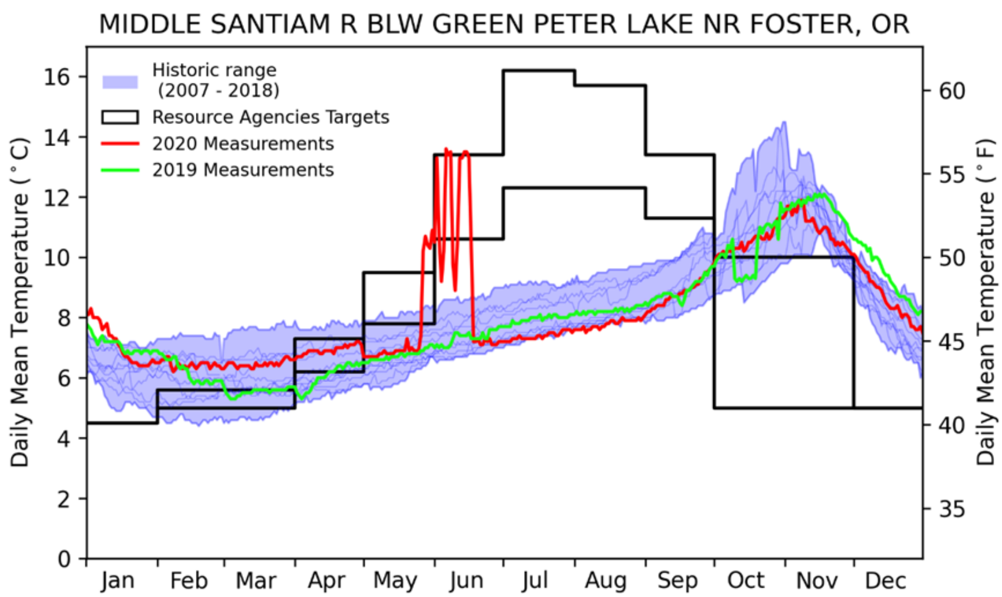

Figure 3.5-9. Middle Santiam River below Green Peter Reservoir near Foster, Oregon; Green Peter Reservoir Daily Mean 2019 and 2020 Outflow Temperatures Compared to Resource Agency Target Temperatures and Historical Temperature Ranges.

Source: USACE 2021f

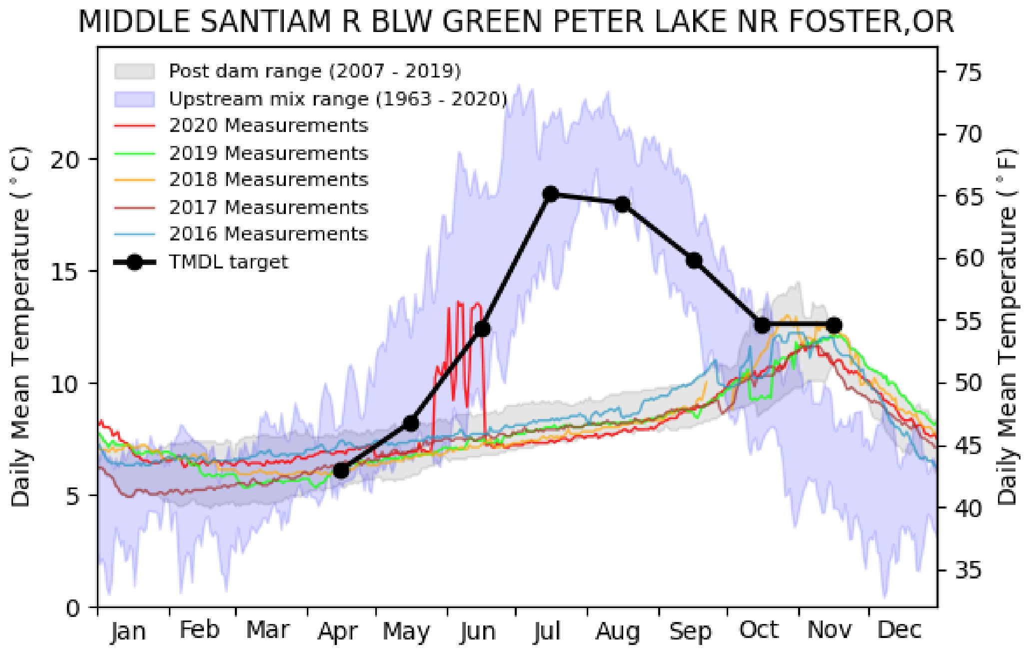

Figure 3.5-10. Middle Santiam River below Green Peter Reservoir near Foster, Oregon; Green Peter Reservoir Daily Mean Outflow Temperatures.

Source: USACE 2021f

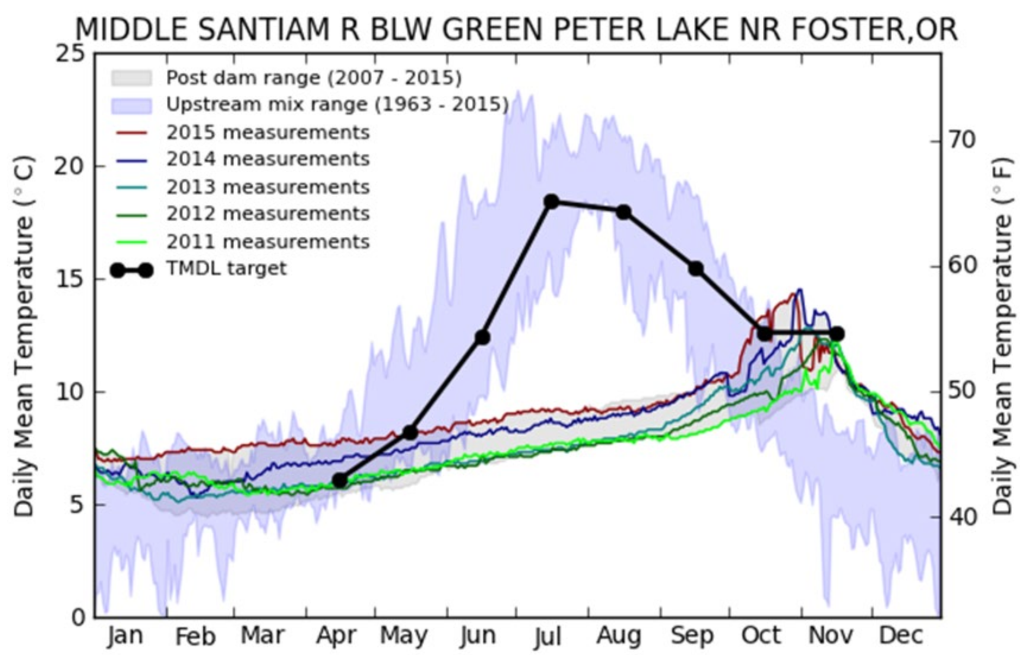

Figure 3.5-11. Middle Santiam River below Green Peter Reservoir near Foster, Oregon; Green Peter Reservoir Daily Mean Outflow Temperatures.

Source: USACE 2016d

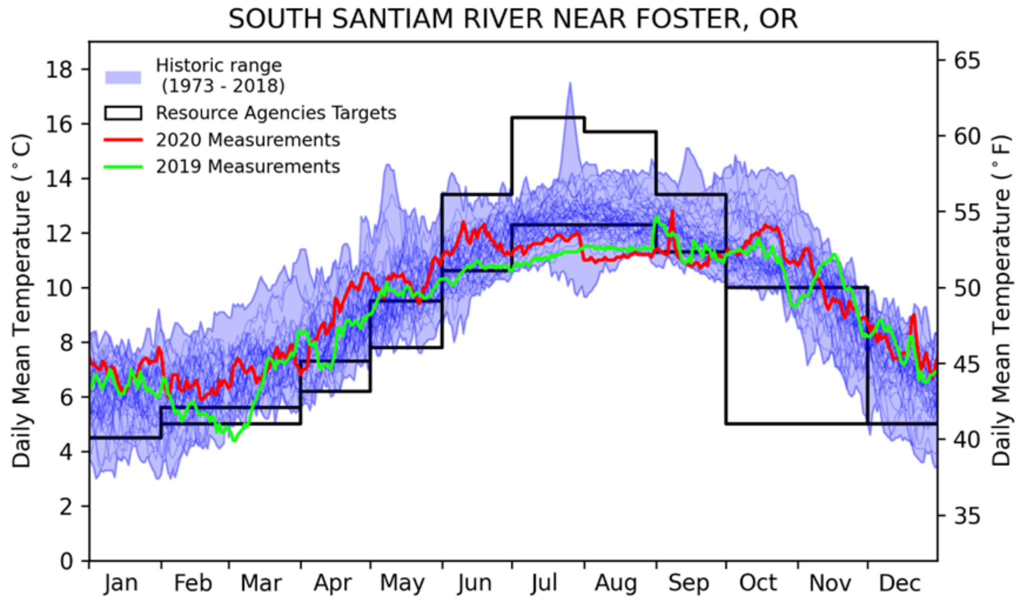

Figure 3.5-12. Foster Reservoir Daily Mean 2019 and 2020 Outflow Temperatures Compared to Resource Agency Target Temperatures and Historical Temperature Ranges.

Source: USACE 2021f

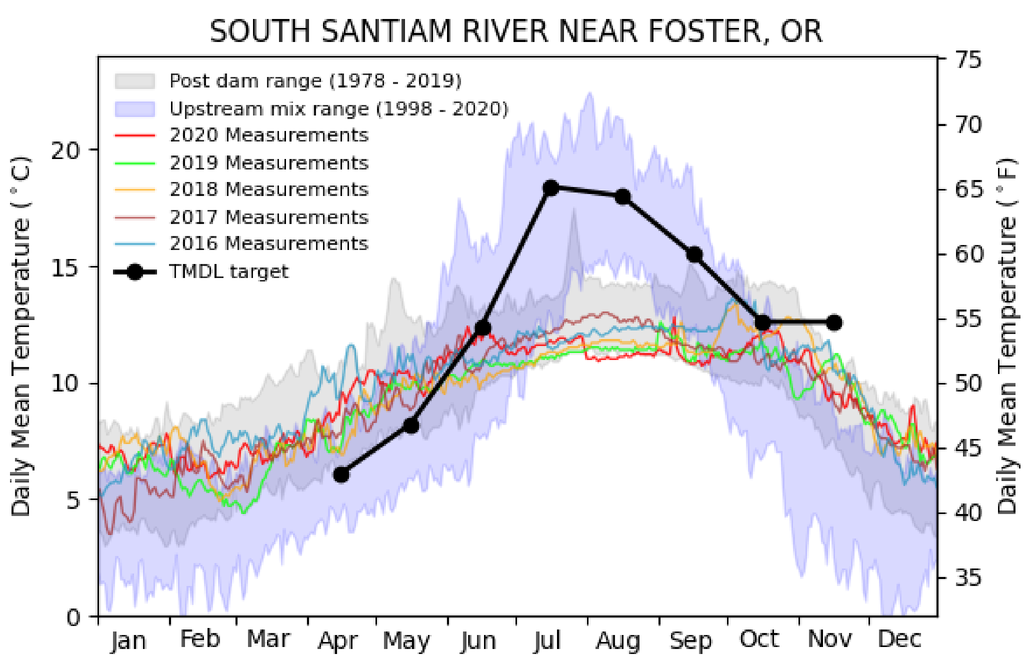

Figure 3.5-13. Foster Reservoir Daily Mean Outflow Temperatures.

Source: USACE 2021f

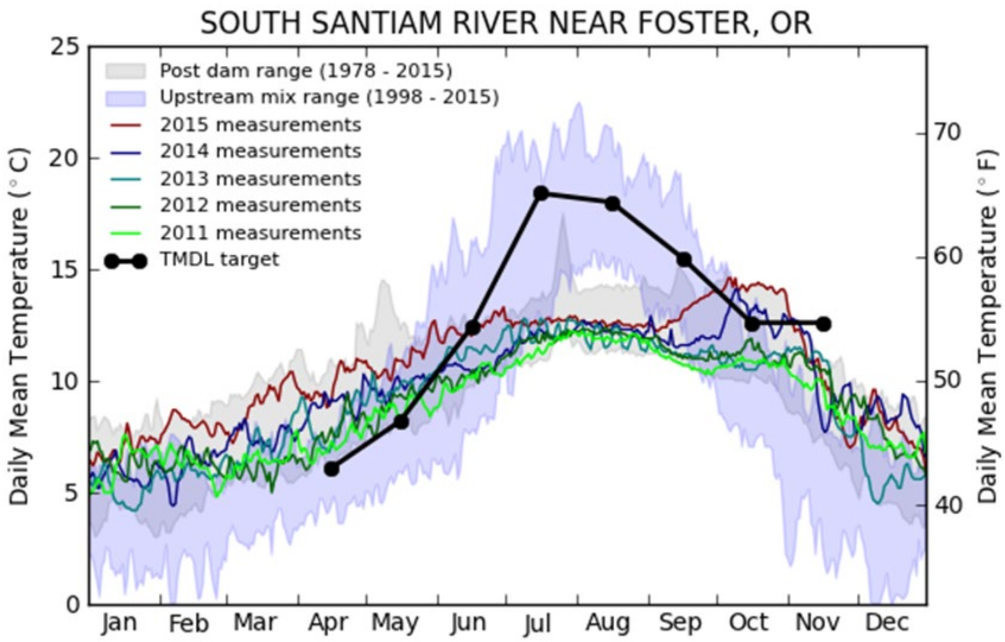

Figure 3.5-14. Foster Reservoir Daily Mean Outflow Temperatures.
Source: USACE 2016d

Temperature Conditions in the McKenzie River Subbasin

Construction began on a water temperature control tower in 2002 at Cougar Reservoir with completion in 2005. The control tower enables USACE to manage downstream water temperatures for ESA-listed species. USGS temperature gages are located upstream and downstream of the reservoir (Figure 3.5-15). Data from these USACE-funded gages are available on the USGS' public website (https://or.water.usgs.gov/cgi-bin/grapher/table_setup.pl).

There are no temperature management capabilities at Blue River Dam because there is one set of regulating outlets and a spillway, which is limited for emergency use only. Temperature gages are located upstream and downstream of Blue River Dam (Figure 3.5-16).

Resource Agency temperature targets were developed for Cougar and Blue River Dams (Table 3.5-4). McKenzie River-estimated fish emergence times, which are generated yearly based on spawning time variability, are also considered when meeting the temperature targets.

Since 2005, the outflow water temperatures of Cougar Reservoir have generally met the Resource Agency targets utilizing the water temperature control tower at Cougar Reservoir as compared to pre-temperature control tower results (Figure 3.5-17). Outflow temperatures are closest to the TMDLs from April through June (Figure 3.5-18 and Figure 3.5-19).

Thermistor strings were deployed in Cougar Reservoir in 2007 and continue to collect temperature data. The real-time reservoir temperature thermistor string can be accessed through the USACE public website (USACE 2022d).

Thermistor strings are not deployed in Blue River Reservoir. Typically, Blue River Reservoir outflow water temperatures are nearest to the Resource Agency targets and TMDLs from February through May and warmer from August through November (Figure 3.5-20 through Figure 3.5-22).

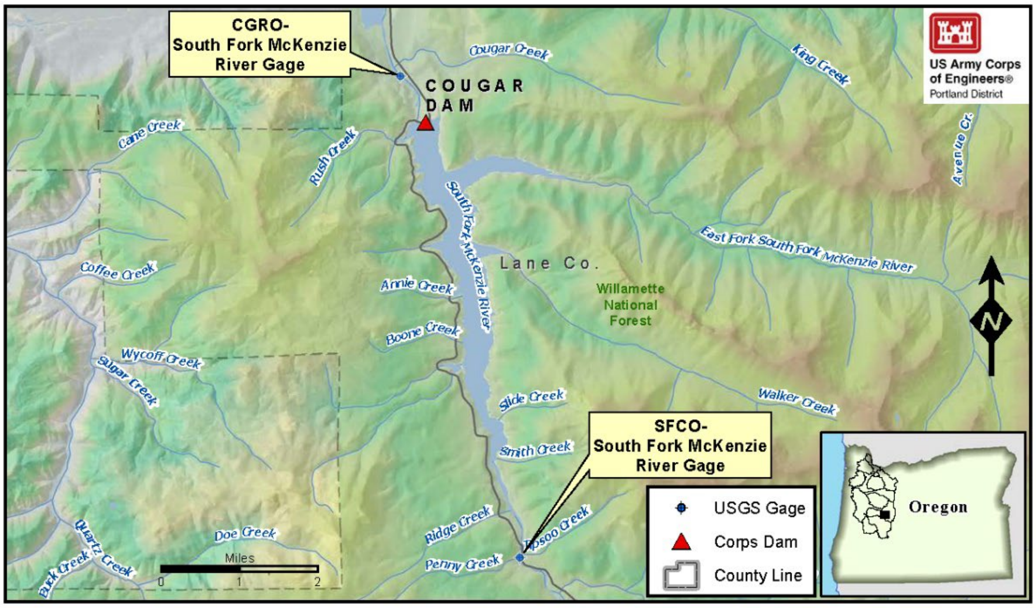

Figure 3.5-15. Water Temperature U.S. Geological Survey Gage Locations: Upstream and Downstream of Cougar Dam and Reservoir on the South Fork of McKenzie River (total dissolved gas also collected downstream).

Source: USACE 2021f

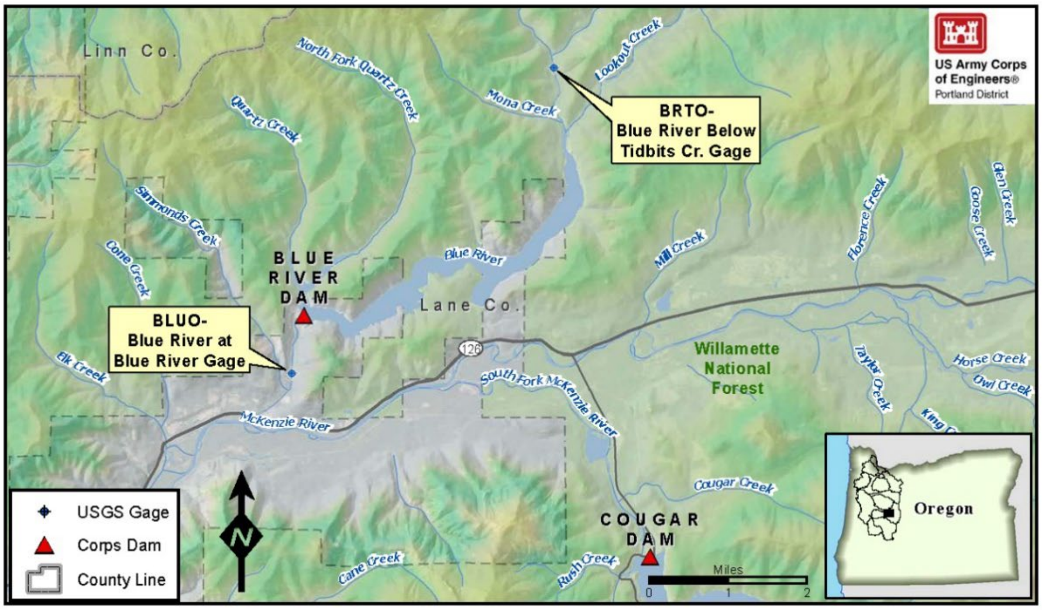

Figure 3.5-16. Water Temperature U.S. Geological Survey Gage Locations: Upstream and Downstream of Blue River and Reservoir on South Fork of the McKenzie River.

Source: USACE 2021f

Table 3.5-4. Resource Agency Cougar Dam Downstream Water Temperature Targets (Daily Average)* and ODEQ 2006 TMDL Targets (7-day average).

Month	Resource Agency Target Temperature Range Maximum/Minimum °F*		ODEQ 2006 TMDL Target Temperatures °F	
			Cougar Dam	Blue River Dam
January	40.1	40.1	No Allocation Needed	No Allocation Needed
February	42.1	41.0		
March	42.1	41.0		
April	45.1	43.2	41.9	41.9
May	49.1	46.0	45.9	45.7
June	56.1	51.1	50.0	49.8
July	61.2	54.1	53.1	52.2
August	60.3	54.1	51.6	51.1
September	56.1	52.3	49.1	49.1
October	49.1	47.1	45.0	45.0

Month	Resource Agency Target Temperature Range Maximum/Minimum °F*		ODEQ 2006 TMDL Target Temperatures °F	
			Cougar Dam	Blue River Dam
November	44.1	43.2	45.0	45.0
December	41.0	41.0	No Allocation Needed	No Allocation Needed

Source: USACE 2021f

ODEQ = Oregon Department of Environmental Quality

TMDL = Total Maximum Daily Load

°F = Degrees Fahrenheit

*Daily average target temperatures developed in 1984 by the Resource Agencies (NMFS, USFWS, ODFW) for the McKenzie River below Cougar Dam.

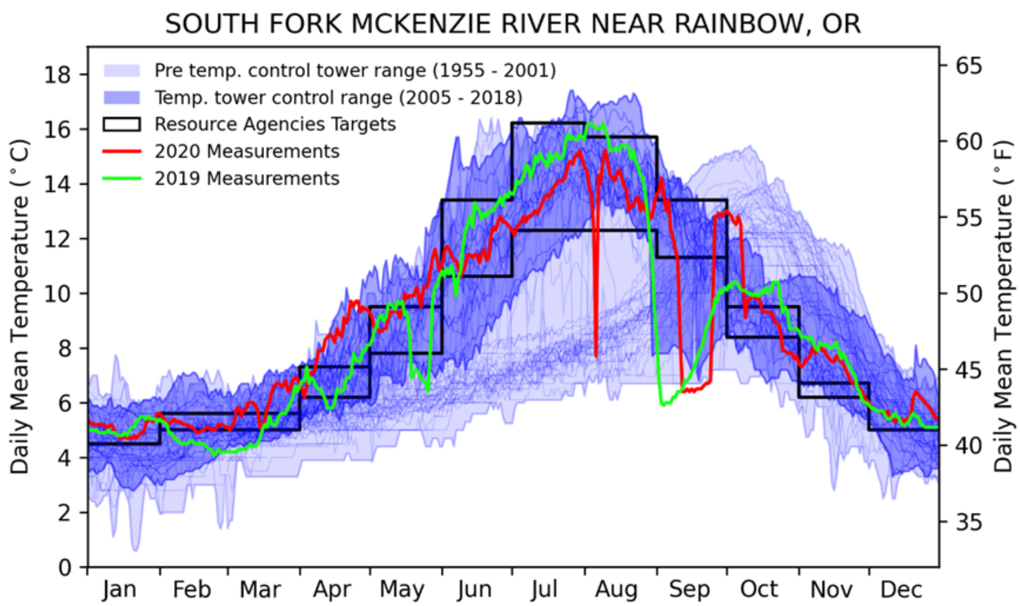

Figure 3.5-17. Cougar Reservoir Daily Mean 2019 and 2020 Outflow Temperatures Compared to Resource Agency Target Temperatures and Temperature Ranges before and during Temperature Tower Operation Years.

Source: USACE 2021f

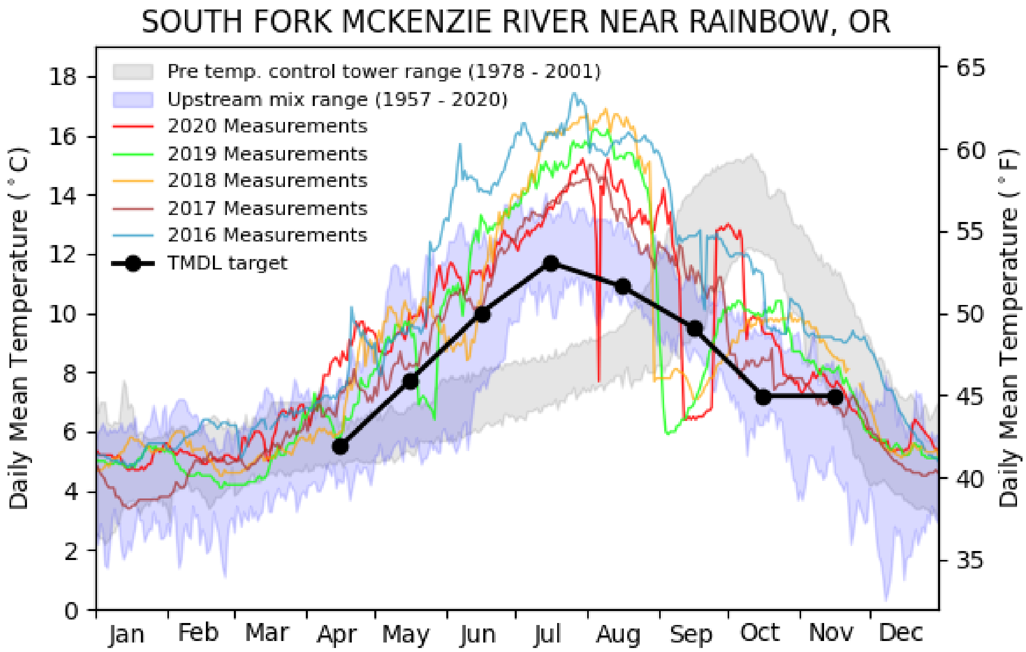

Figure 3.5-18. Cougar Reservoir Daily Mean Outflow Temperatures during Temperature Control Tower Performance Years.

Source: USACE 2021f

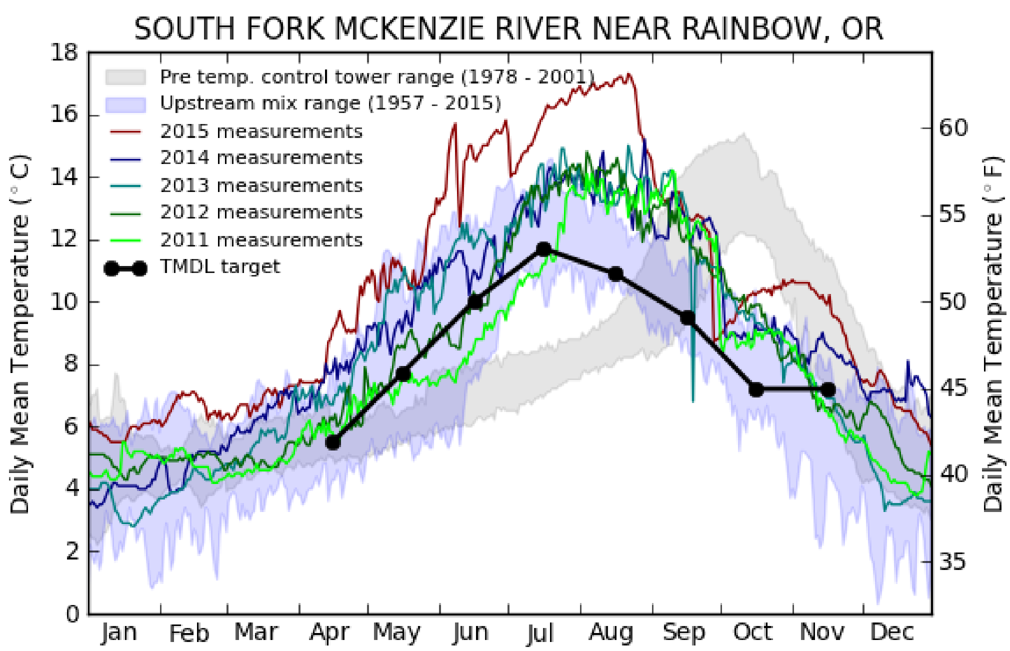

Figure 3.5-19. Cougar Reservoir Daily Mean Outflow Temperatures during Temperature Control Tower Performance Years.

Source: USACE 2016d

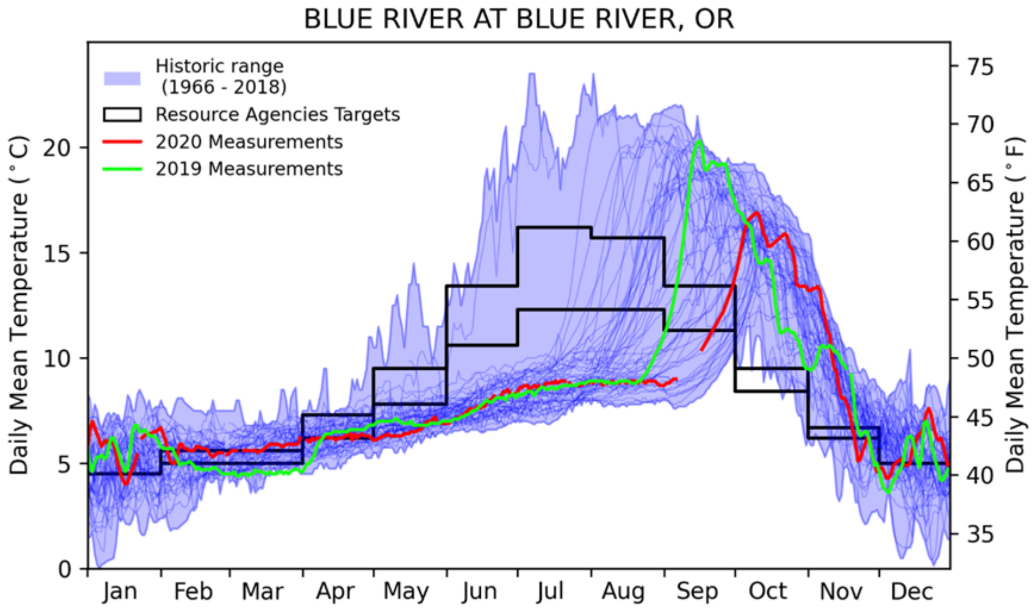

Figure 3.5-20. Blue River Reservoir Daily Mean 2019 and 2020 Outflow Temperatures Compared to Cougar Dam Resource Agency Target Temperatures and Historical Temperature Range.

Source: USACE 2021f

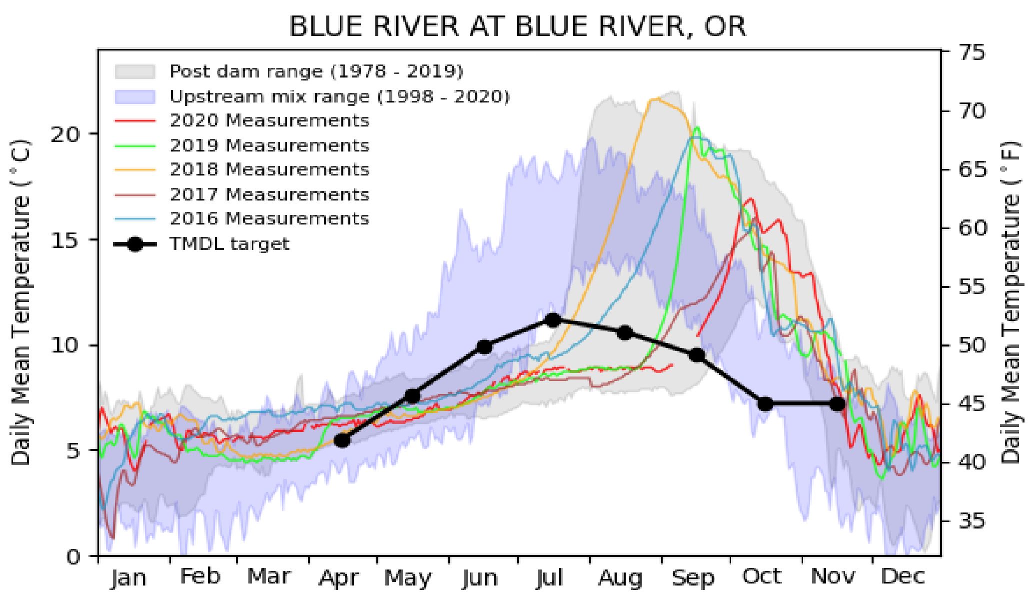

Figure 3.5-21. Blue River Reservoir Daily Mean Outflow Temperatures.

Source: USACE 2021f

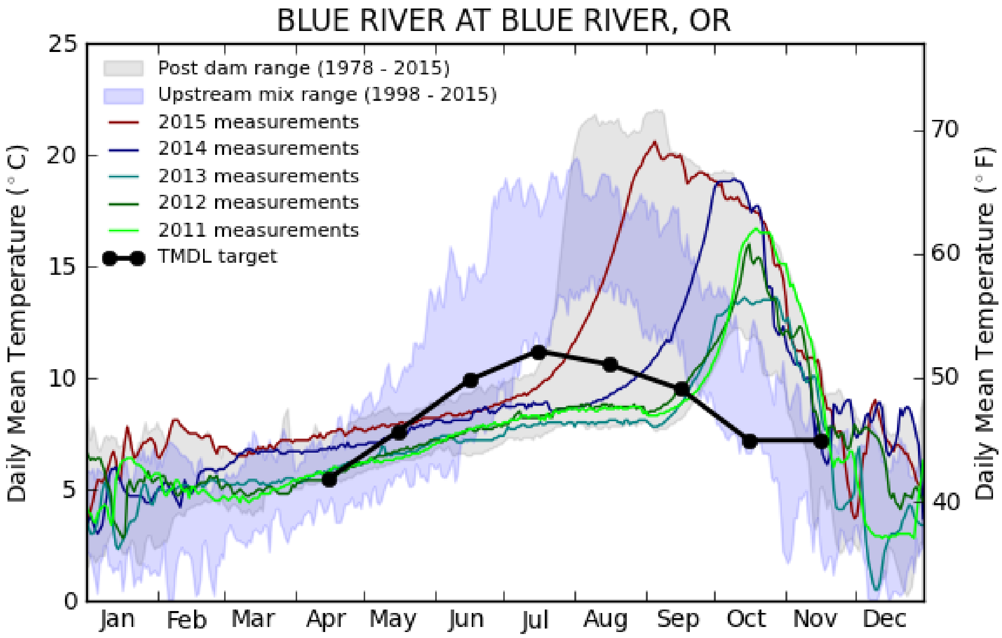

Figure 3.5-22. Blue River Reservoir Daily Mean Outflow Temperatures.
Source: USACE 2016d

Temperature Conditions in the Middle Fork Willamette River Subbasin

Interim temperature management operations were not being conducted at Hills Creek, Lookout Point, or Dexter Reservoirs at the time the alternatives were analyzed. However, informal temperature operations are implemented at Fall Creek Reservoir from approximately March through October by utilizing the existing fish horn structures[5].

The primary use of the fish horns is to attract UWR spring Chinook salmon and UWR steelhead to the adult fish facility and secondarily for temperature (Figure 3.5-23). The nine, tiered fish horns are located at varying elevations and can provide water to the adult fish facility. Fish horns include:

- 3 fish horns at 720 feet
- 3 fish horns at 765 feet
- 3 fish horns at 800 feet

[5] A fish horn is an outlet that was originally constructed for fish passage to the adult fish facility; however, these structures resulted in low survivability.

Figure 3.5-23. Photograph of U.S. Army Corps of Engineers Fall Creek Dam Fish Horns.
Source: USACE 2021f

There is limited ability at Fall Creek Dam to affect downstream temperatures due to structural limitations (i.e., fish horn elevations); operations are modified based on environmental conditions and inflow temperatures. Different sized fish horns within tiers are used to help fish transition into the next tier. This transitioning assists with temperature blending between the fish horn tiers.

The Fall Creek Dam spillway gates are not used for temperature management because operations may cause scouring downstream. Scouring could negatively impact western pond turtle and Oregon chub habitat present downstream.

Water temperature management operations were implemented at Lookout Point Dam from 2012 until 2014 by utilizing the spillway and powerhouse penstock for UWR spring Chinook salmon habitat. These operations and model simulations did not result in favorable downstream water temperatures. This is because inflow water temperatures are warmer, as compared to Detroit or Cougar Dams. In addition, results from modeling analyses indicated only a 1-day difference in egg emergence timing using the regulating outlet because it is relatively close to the powerhouse outlet at only 56 feet (USACE 2015c).

The Hills Creek Dam spillway is used for emergency operations only, as its use would cause water to inundate the powerhouse below the dam. Therefore, no temperature management operations are currently conducted using the spillway.

In-reservoir thermistor strings are deployed in Hills Creek, Lookout Point, Dexter, and Fall Creek Reservoirs. Hills Creek Reservoir and Lookout Point Reservoir thermistor strings were deployed in 2010 and were deployed in Dexter and Fall Creek Reservoirs in 2014 (USACE 2022d). USGS gages measure water temperature upstream and downstream of these reservoirs (Figure 3.5-24).

Resource Agency temperature targets were developed for Hills Creek, Lookout Point, Dexter, and Fall Creek Reservoirs (Table 3.5-5). The Resource Agencies also consider estimated Middle Fork Willamette River fish emergence times, which are generated yearly based on spawning time variability for temperature targets.

Historical temperature ranges at Hills Creek Reservoir have not exceeded 65°F in the summer, which is the optimal temperature for fish migration and holding (Figure 3.5-25). Fish life cycle timeframes overlap with temperature thresholds for holding, spawning, incubation, and migration (Figure 3.5-25). Temperatures at Hills Creek Reservoir met most of the temperature targets from 2016 to 2020 in the spring and summer (except July) but were lower than the TMDLs in the summer from 2011 to 2015 (Figure 3.5-26 and Figure 3.5-27). Hills Creek Reservoir downstream temperatures were warmer than the temperature TMDL in the fall from 2011 to 2015 and 2016 to 2020.

Outflow temperatures at Lookout Point and Dexter Dams can reach close to 70°F in the summer; optimal temperatures for fish migration and holding are approximately 50°F to 60°F (Figure 3.5-28). The outflow temperatures are generally close to the temperature TMDL targets for Lookout Point and Dexter Dams, except from October through November when temperatures are higher (Figure 3.5-29 and Figure 3.5-30). At Fall Creek Reservoir the outflow temperatures are generally closest to the Resource Agency targets and temperature TMDLs from February through May (Figure 3.5-31, Figure 3.5-32, Figure 3.5-33).

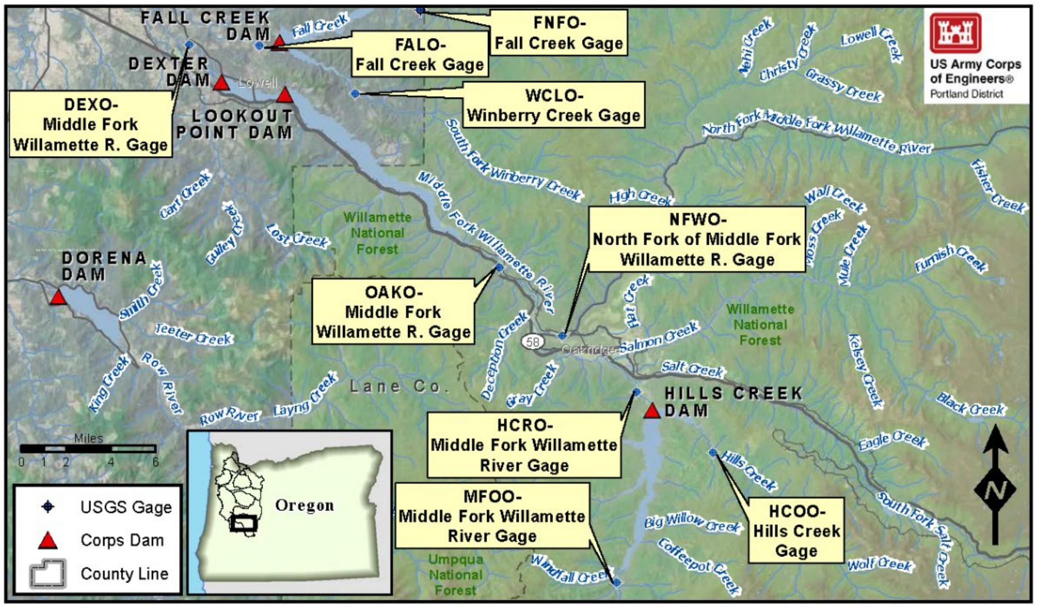

Figure 3.5-24. Water Temperature U.S. Geological Survey Gage Locations: Upstream and Downstream of Hills Creek, Lookout Point/Dexter, and Fall Creek Dams.

Source: USACE 2021f

Table 3.5-5. Resource Agency Fall Creek Dam Surrogate Downstream Water Temperature Targets (Daily Average)* and Hills Creek, Lookout Point/Dexter, and Fall Creek Dam and ODEQ 2006 TMDL Targets (7-day average).

Month	Resource Agency Target Temperature Range Maximum/Minimum ˚F*		ODEQ 2006 TMDL Target Temperatures ˚F		
			Hills Creek	Lookout Point/Dexter	Fall Creek
January	40.1	40.1	No Allocation Needed		
February	42.1	41.0			
March	42.1	41.0			
April	45.1	43.2	42.4	43.7	43.7
May	49.1	46.0	46.0	47.5	47.5
June	56.1	51.1	51.8	55.8	54.0
July	61.2	54.1	57.6	63.3	60.6
August	60.3	54.1	56.5	61.7	60.4
September	56.1	52.3	54.5	61.7	60.4
October	<50.0	<50.0	49.3	50.4	51.1

Month	Resource Agency Target Temperature Range Maximum/Minimum ˚F*		ODEQ 2006 TMDL Target Temperatures ˚F		
			Hills Creek	Lookout Point/Dexter	Fall Creek
November	<50.0	<50.0	49.3	50.4	51.1
December	41.0	41.0	No Allocation Needed		

Source: USACE 2021f

ODEQ = Oregon Department of Environmental Quality

TMDL = Total Maximum Daily Load

°F = Degrees Fahrenheit

*Daily average target temperatures originally developed by the Resource Agencies (NMFS, USFWS, ODFW) for the McKenzie River below Cougar Dam (October and November slightly modified for the North Santiam River).

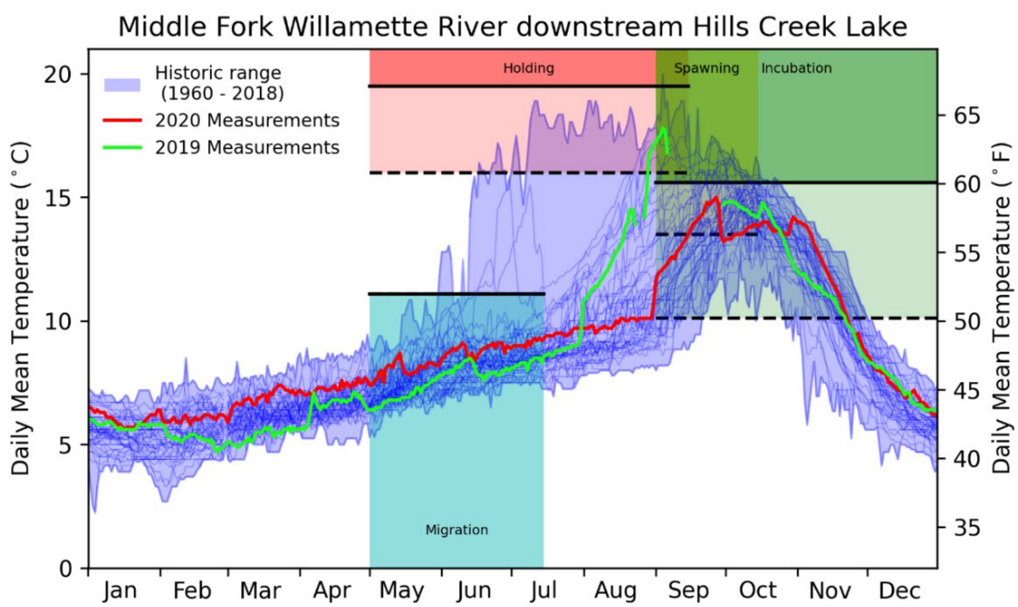

Figure 3.5-25. Hills Creek Reservoir Daily Mean 2019 and 2020 Outflow Temperatures Compared to Water Quality Evaluation Criteria and Historical Temperature Range.

Source: USACE 2021f

Note: Dashed line represents chronic temperatures. Solid line represents acute temperatures.

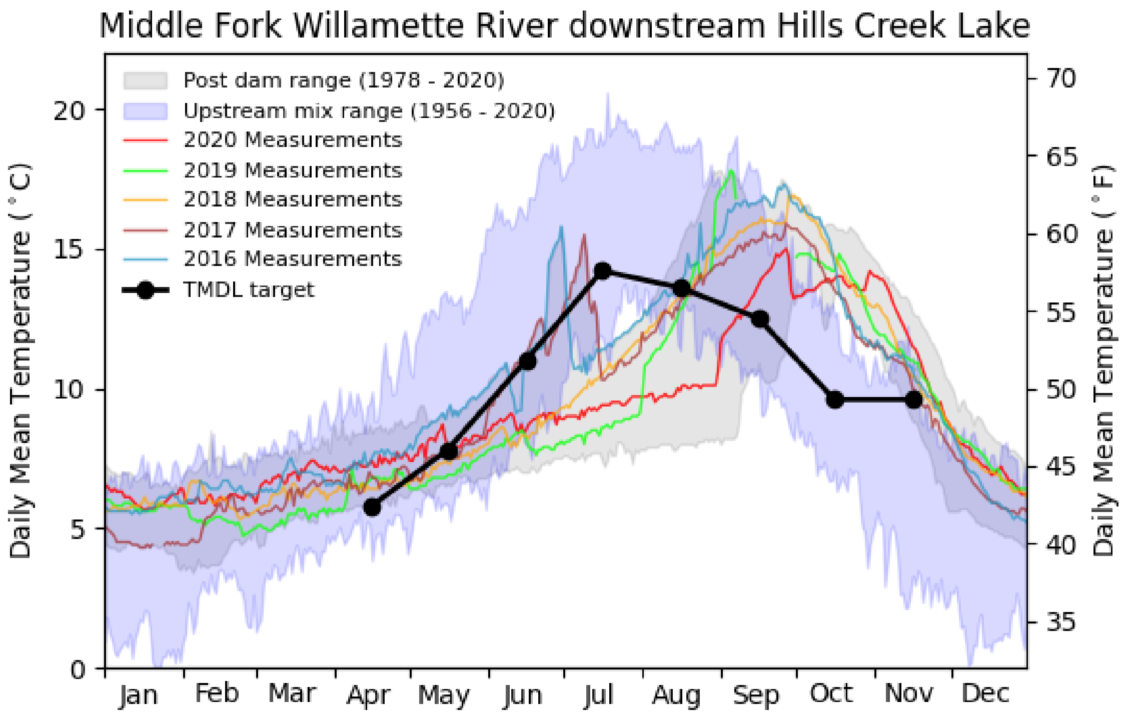

Figure 3.5-26. Hills Creek Reservoir Daily Mean Outflow Temperatures (2016–2020).
Source: USACE 2021f

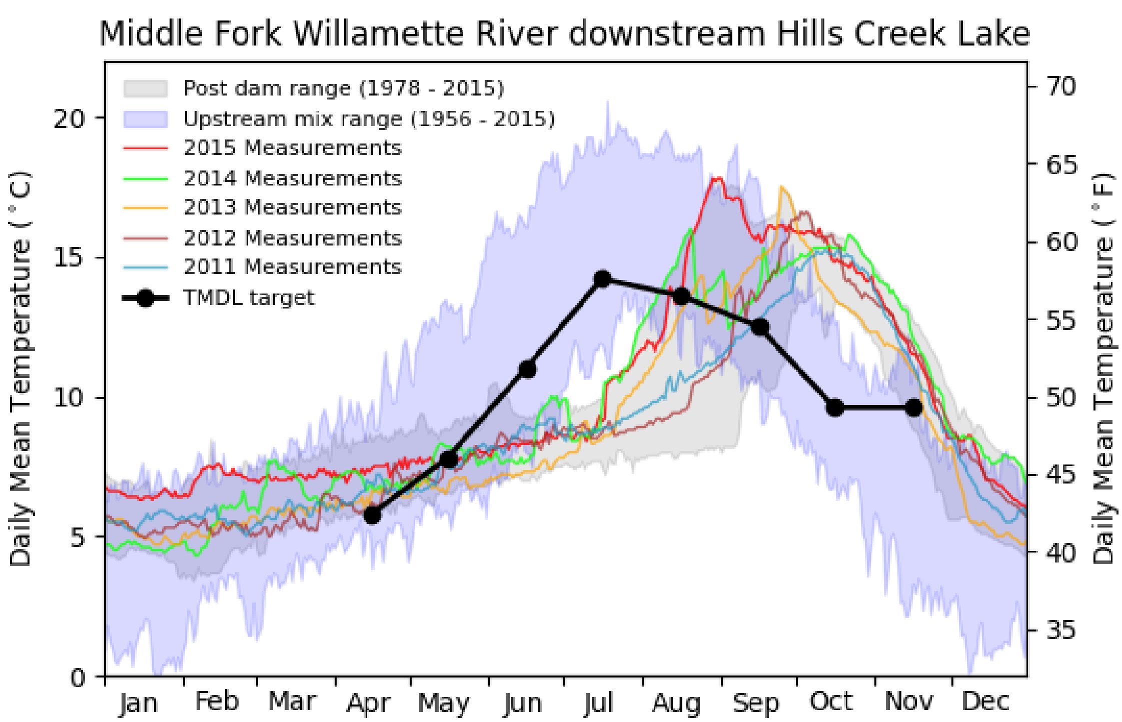

Figure 3.5-27. Hills Creek Reservoir Daily Mean Outflow Temperatures (2011–2015).
Source: USACE 2016d

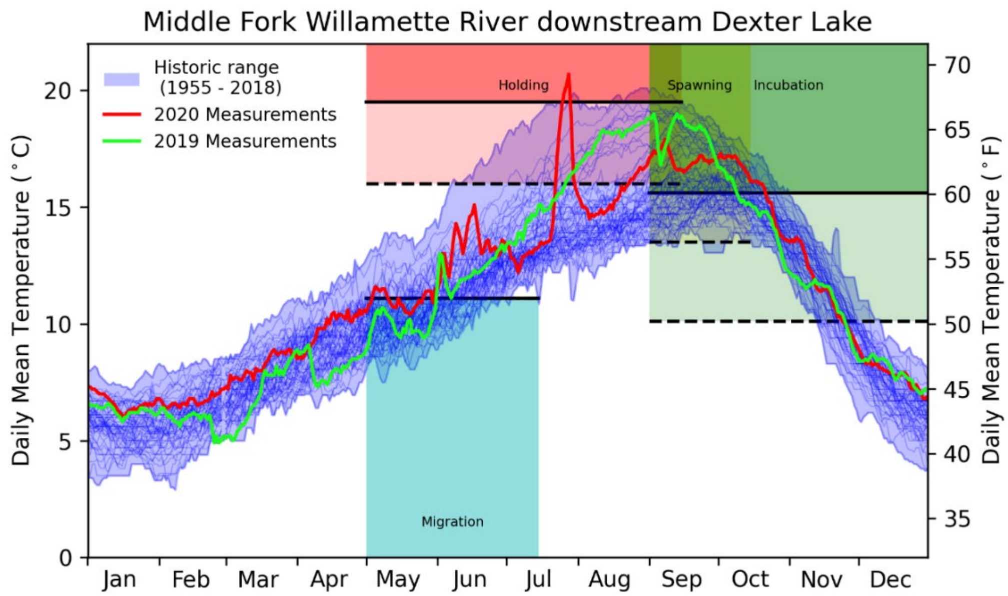

Figure 3.5-28. Lookout Point/Dexter Reservoirs Daily Mean 2019 and 2020 Outflow Temperatures Compared to Water Quality Evaluation Criteria and Historical Temperature Range.

Source: USACE 2021f

Note: Dashed line represents chronic temperatures. Solid line represents acute temperatures.

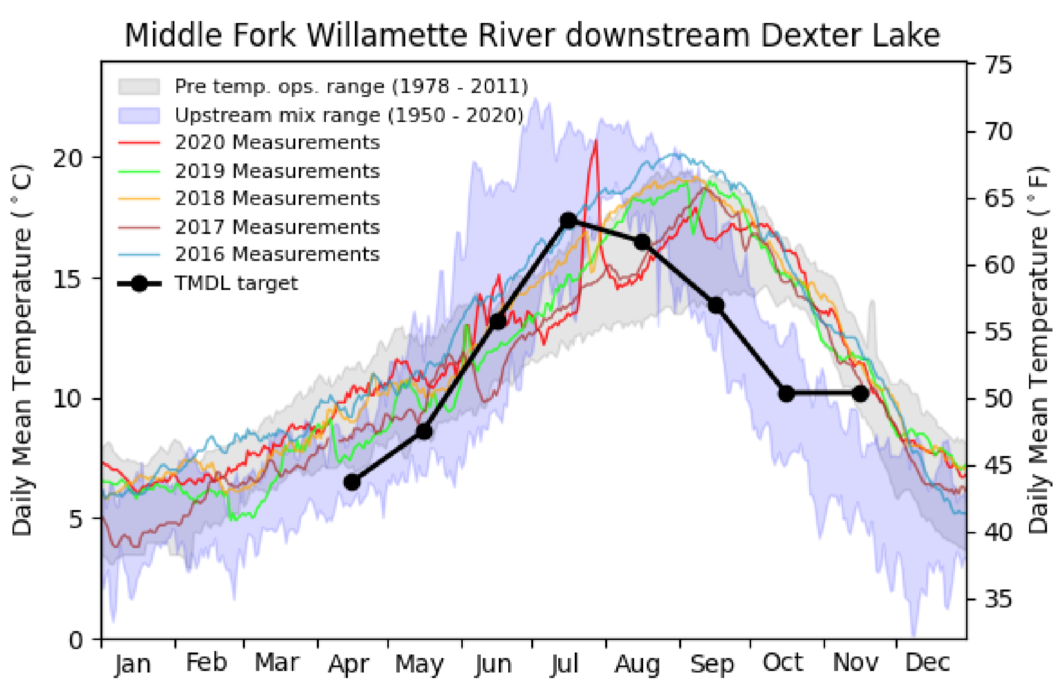

Figure 3.5-29. Lookout Point/Dexter Reservoirs Daily Mean Outflow Temperatures (2016–2020).

Source: USACE 2021f

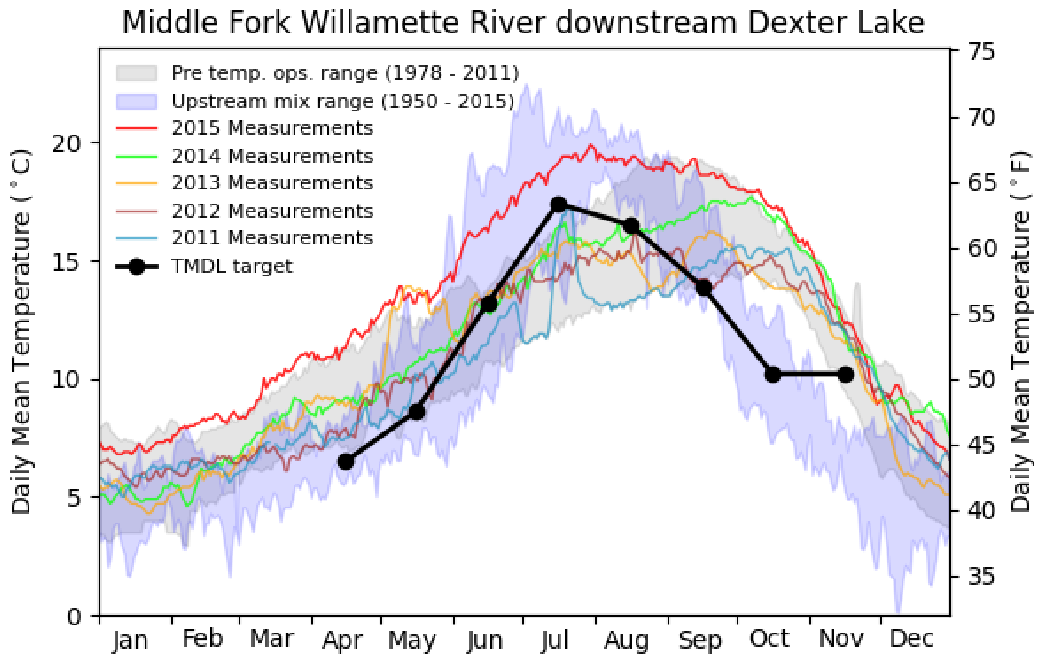

Figure 3.5-30. Lookout Point/Dexter Reservoirs Daily Mean Outflow Temperatures (2011–2015).

Source: USACE 2016d

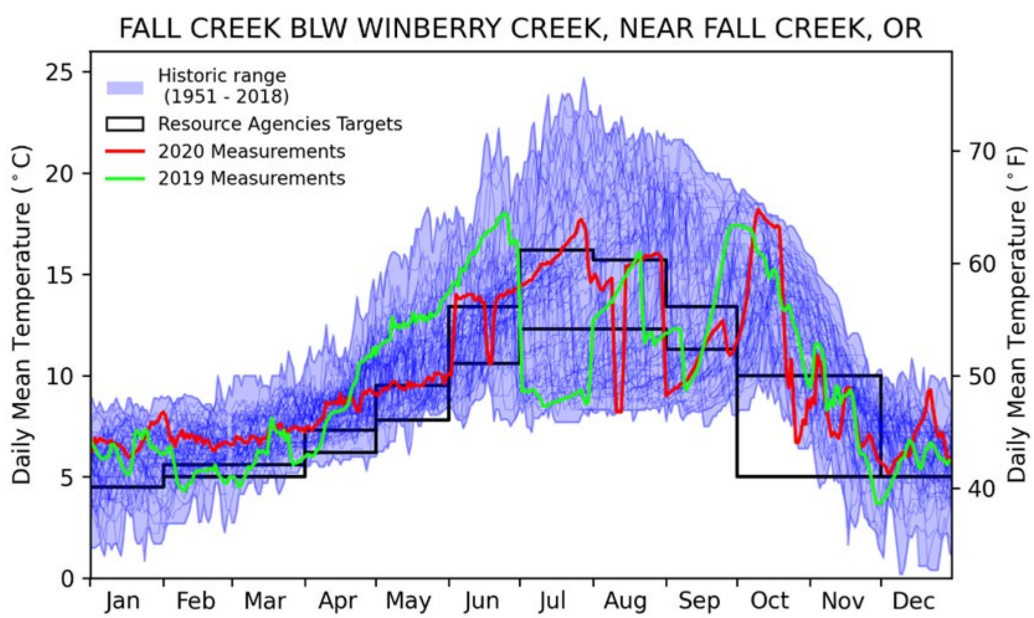

Figure 3.5-31. Fall Creek below Winberry Creek, near Fall Creek, Oregon; Fall Creek Reservoir Daily Mean 2019 and 2020 Outflow Temperatures Compared to Resource Agency Target Temperatures and Historical Temperature Range (1951–2018).

Source: USACE 2021f

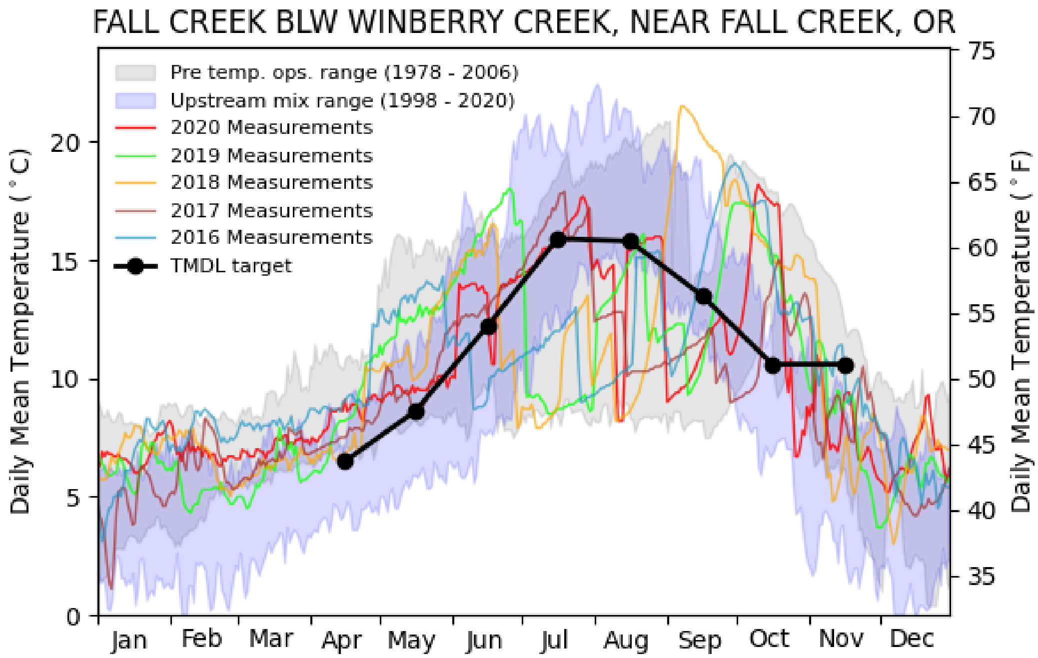

Figure 3.5-32. Fall Creek below Winberry Creek, near Fall Creek, Oregon; Fall Creek Reservoir Daily Mean Outflow Temperatures (2016–2020).

Note: USACE 2021f

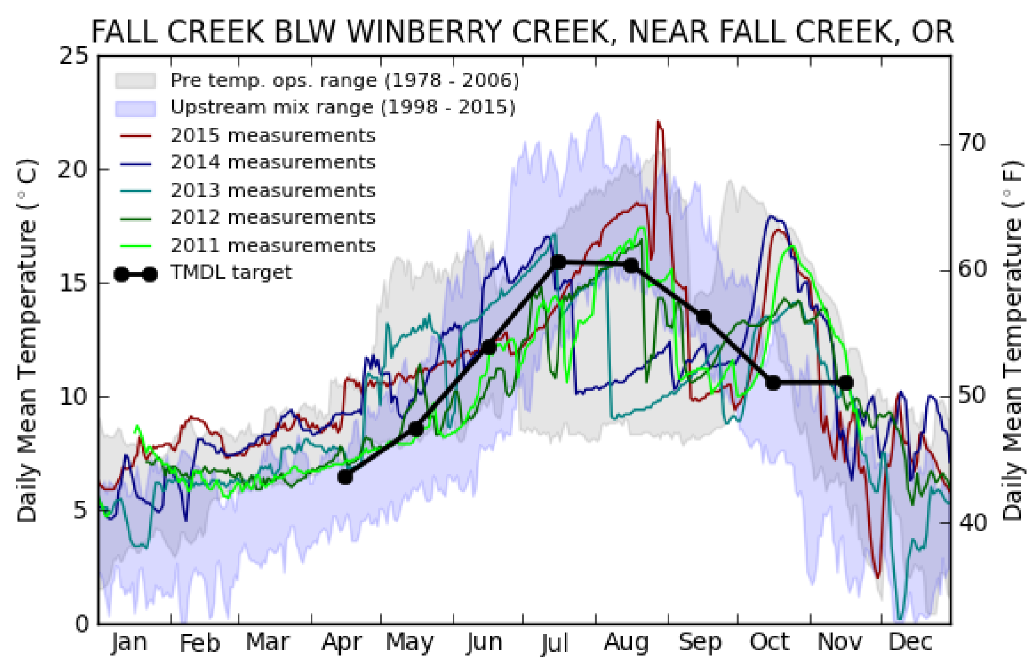

Figure 3.5-33. Fall Creek below Winberry Creek, near Fall Creek, Oregon; Fall Creek Reservoir Daily Mean Outflow Temperatures (2011–2015).

Source: USACE 2016d

Temperature Conditions in the Coast Fork Willamette River and Long Tom River Subbasins

Temperature management operations are not conducted at Cottage Grove, Dorena, and Fern Ridge Reservoirs. USACE-funded USGS gages monitor temperature at inflow points and outflow points of Cottage Grove, Dorena, and Fern Ridge Reservoirs (Figure 3.5-34) (refer to http://or.water.usgs.gov/cgi-bin/grapher/table_setup.pl). There are no Resource Agency temperature targets developed for these reservoirs, although there are temperature TMDLs (Table 3.5-6). Additionally, there are no thermistor strings deployed at these reservoirs to provide temperature stratification data.

Typically, Cottage Grove Reservoir outflow temperatures are warmest in August and begin to cool in late September (Figure 3.5-35). Outflow temperatures at Cottage Grove Reservoir have been closest to the TMDL targets from April through May and October through November. However, summer temperatures are generally cooler than the TMDL except in 2015 when the target was briefly met (Figure 3.5-36 and Figure 3.5-37).

Dorena Reservoir outflow temperatures are generally warmest in late August and begin to cool by early October (Figure 3.5-38). Summer outflow temperatures at Dorena Reservoir are cooler than the TMDL targets, as observed from 2011 to 2020 (Figure 3.5-39 and Figure 3.5-40).

Fern Ridge outflow temperatures are typically warmest in August and begin to cool in September (Figure 3.5-41). Outflow temperatures are warmer than the TMDL targets, as observed from 2011 to 2020 (Figure 3.5-42 and Figure 3.5-43).

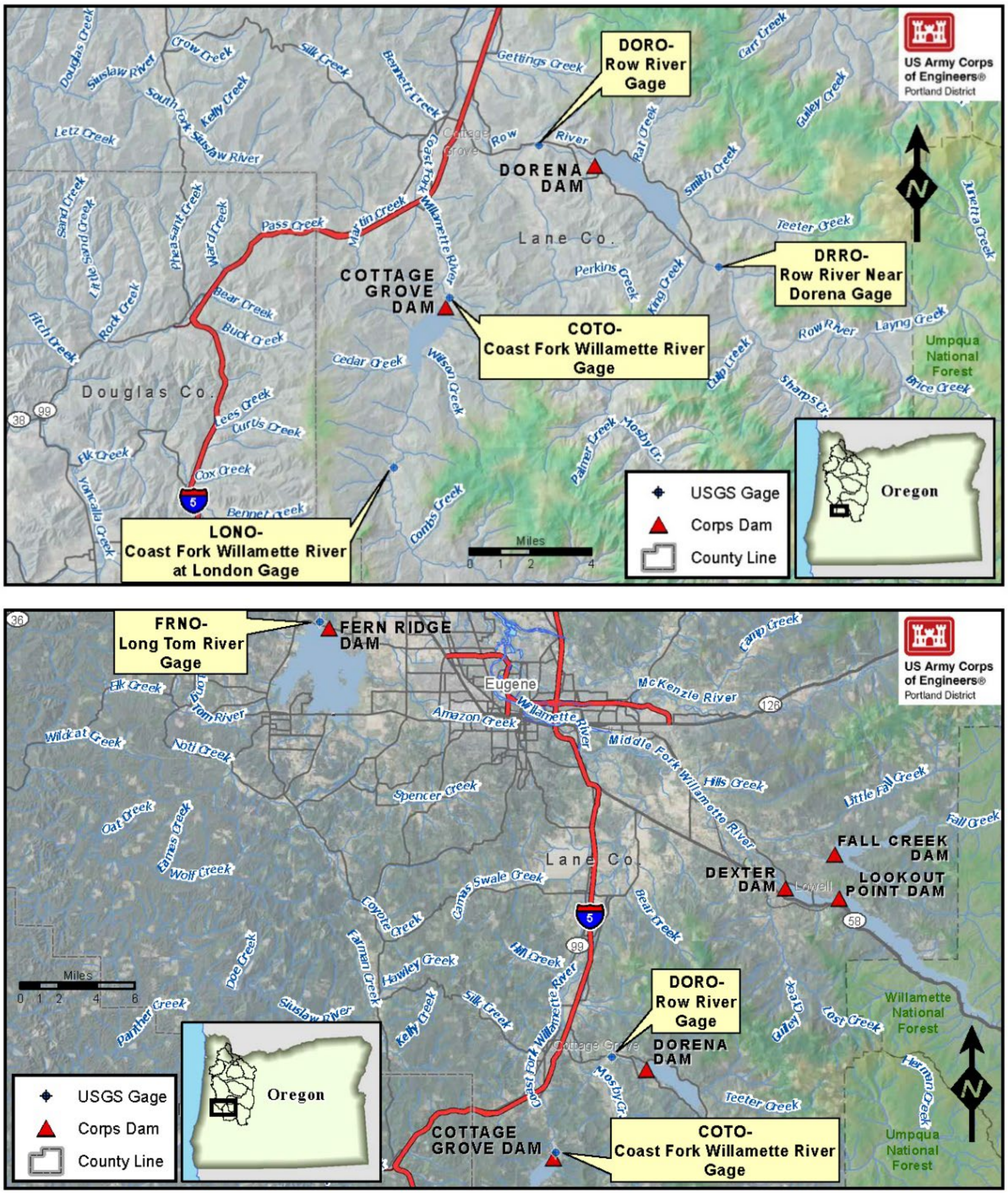

Figure 3.5-34. Water Temperature U.S. Geological Survey Gage Locations: Downstream of Cottage Grove and Dorena Dams (top) and Fern Ridge Dam (bottom).

Source: USACE 2021f

Table 3.5-6. Cottage Grove, Dorena, and Fern Ridge Dams Downstream Water Temperature Targets from ODEQ 2006 TMDL Targets (7-day average).

Month	ODEQ 2006 TMDL Target Temperatures °F		
	Cottage Grove	Dorena	Fern Ridge
January	No Allocation Needed		
February			
March			
April	48.9	47.8	48.2
May	52.5	51.4	51.4
June	59.9	61.7	58.3
July	67.8	72.1	62.1
August	64.9	68.7	60.8
September	61.5	64.8	57.2
October	56.3	59.5	46.4
November	No Allocation Needed		
December			

Source: USACE 2021f

ODEQ = Oregon Department of Environmental Quality

TMDL = Total Maximum Daily Load

°F = Degrees Fahrenheit

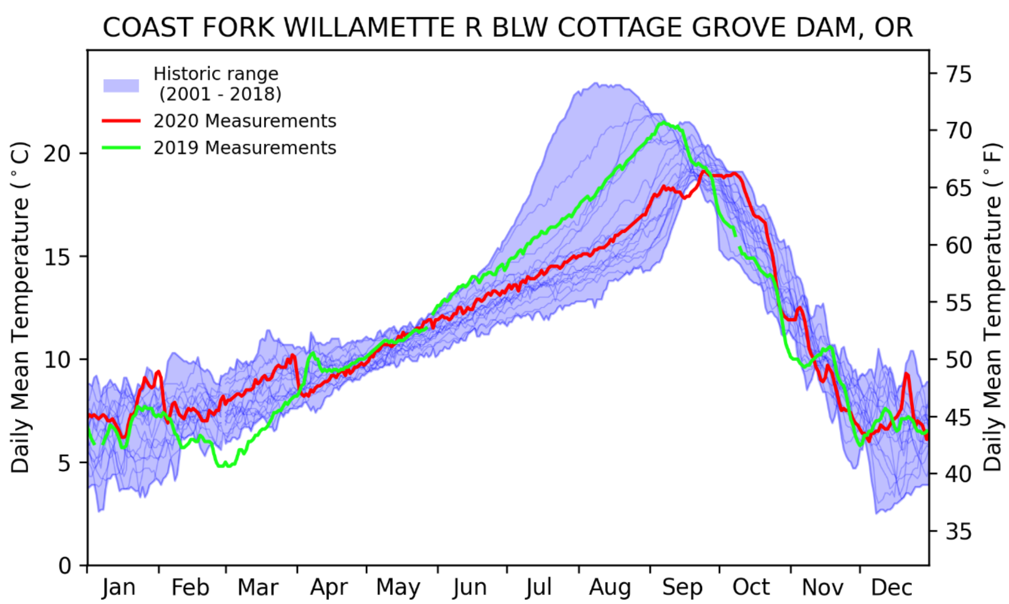

Figure 3.5-35. Coast Fork Willamette River below Cottage Grove Dam, Oregon; Cottage Grove Reservoir Daily Mean Outflow Temperatures.

Source: USACE 2021f

Note: Measured in the Coast Fork Willamette River for 2020, Daily Mean 2019, and 2020 Outflow Temperatures Compared to Historical Temperature Range (2001–2018).

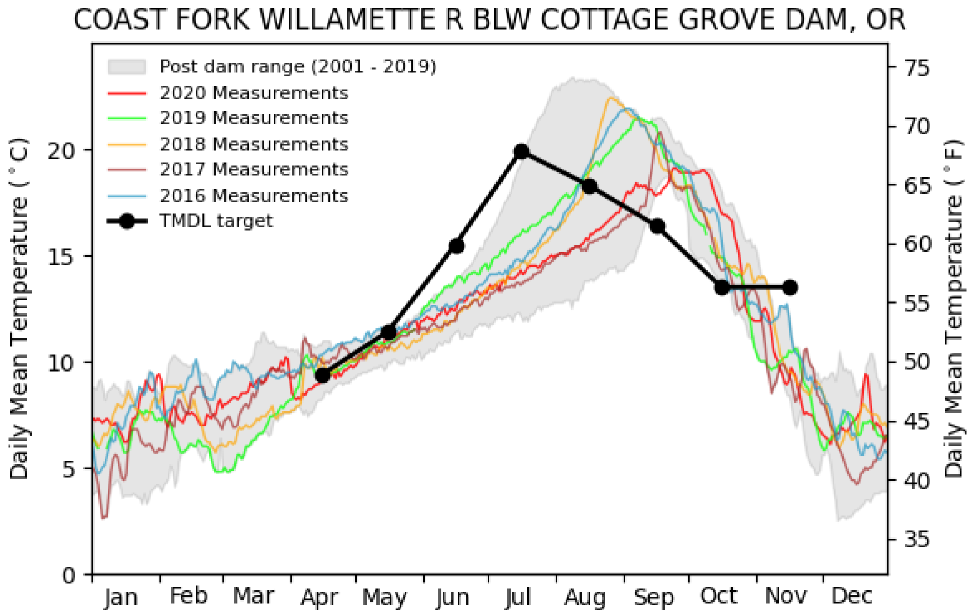

Figure 3.5-36. Coast Fork Willamette River below Cottage Grove Dam, Oregon; Cottage Grove Reservoir Daily Mean Outflow Temperatures (2016–2020).

Source: USACE 2021f

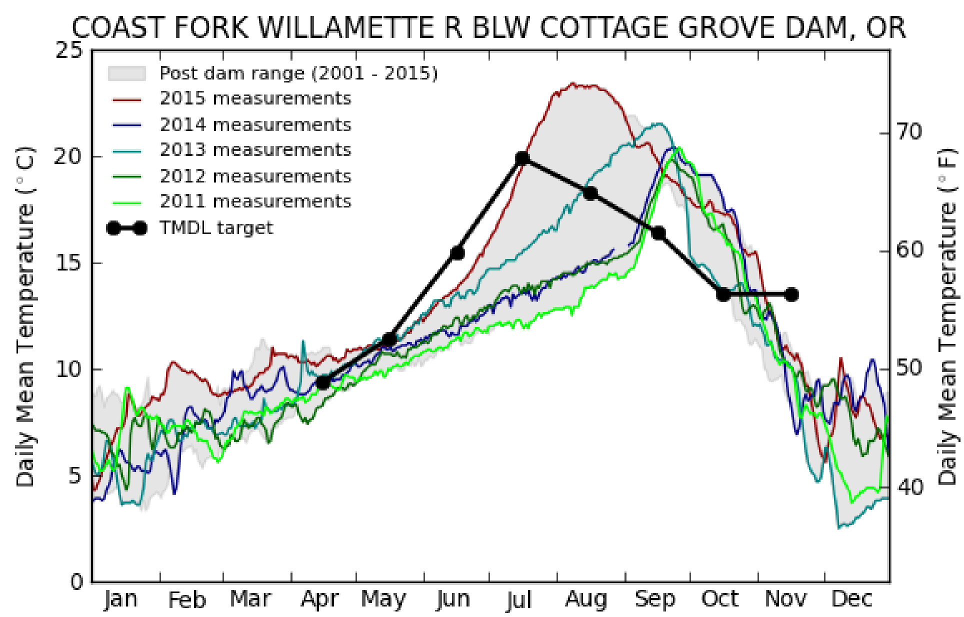

Figure 3.5-37. Coast Fork Willamette River below Cottage Grove Dam, Oregon; Cottage Grove Reservoir Daily Mean Outflow Temperatures (2011–2015).

Source: USACE 2016d

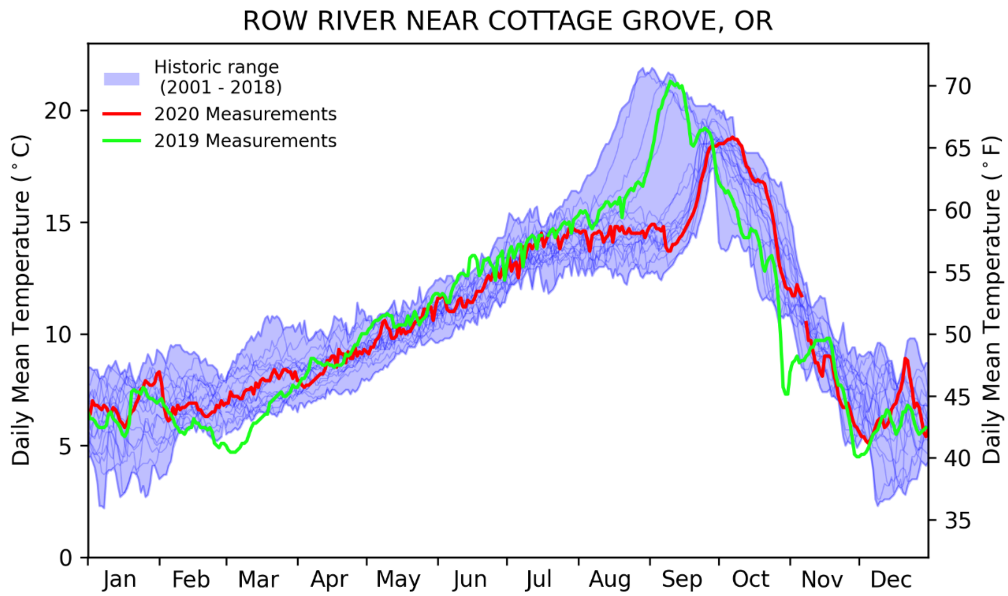

Figure 3.5-38. Dorena Reservoir Daily Mean Outflow Temperatures.

Source: USACE 2021f

Note: Measured in the Row River for 2020, Compared to ODEQ TMDL Monthly Median Target Temperatures (top), Daily Mean 2019, and 2020 Outflow Temperatures compared to Historical Temperature Range (2001–2018) (bottom).

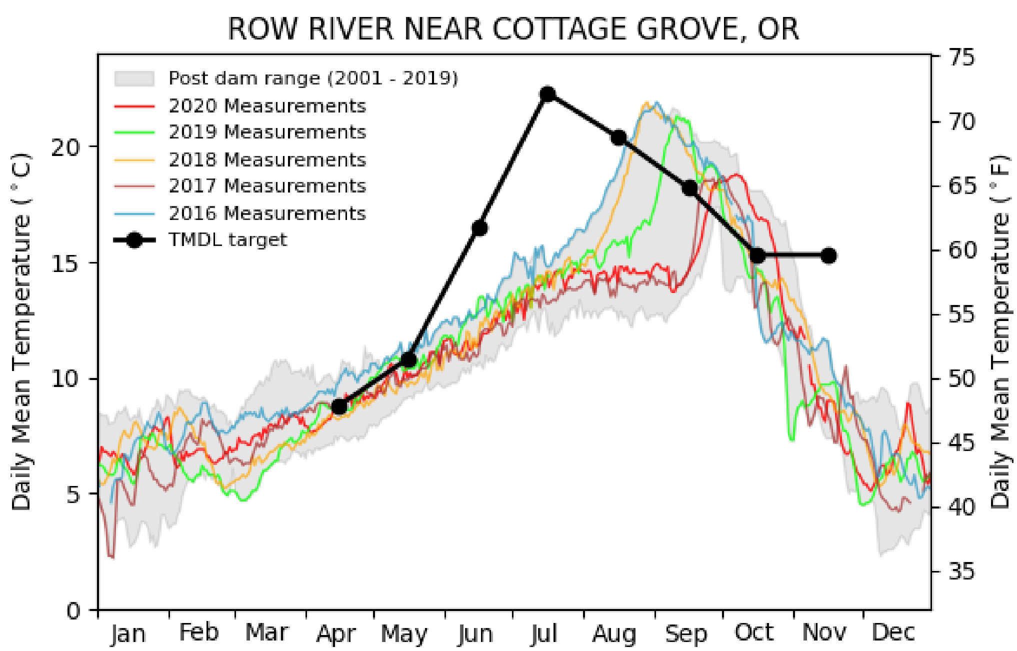

Figure 3.5-39. Dorena Reservoir Daily Mean Outflow Temperatures (2016–2020).

Source: USACE 2021f

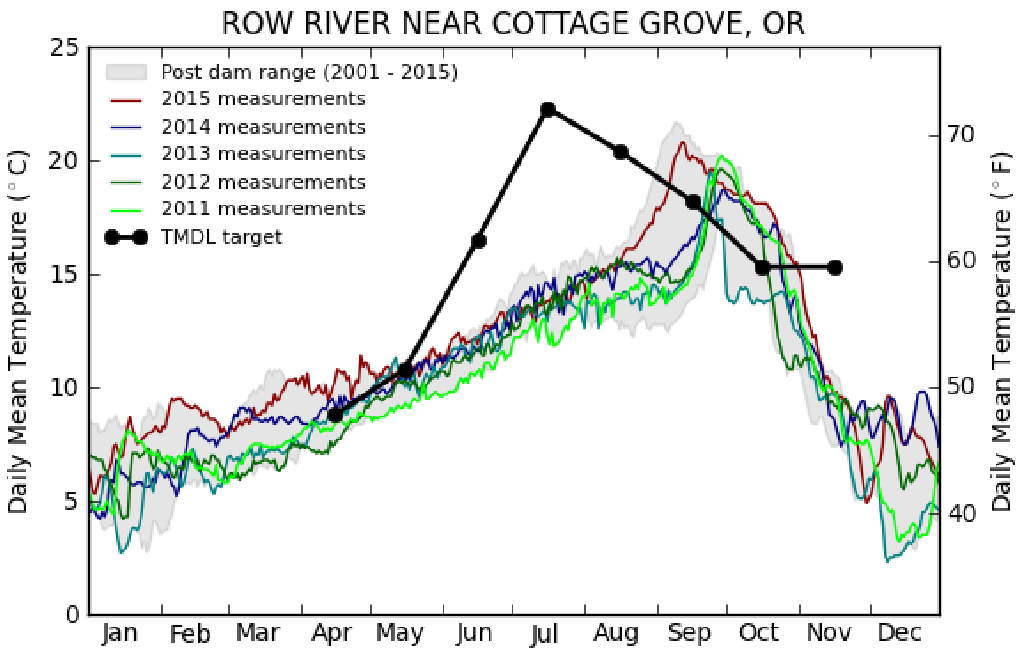

Figure 3.5-40. Dorena Reservoir Daily Mean Outflow Temperatures (2011–2015).
Source: USACE 2016d

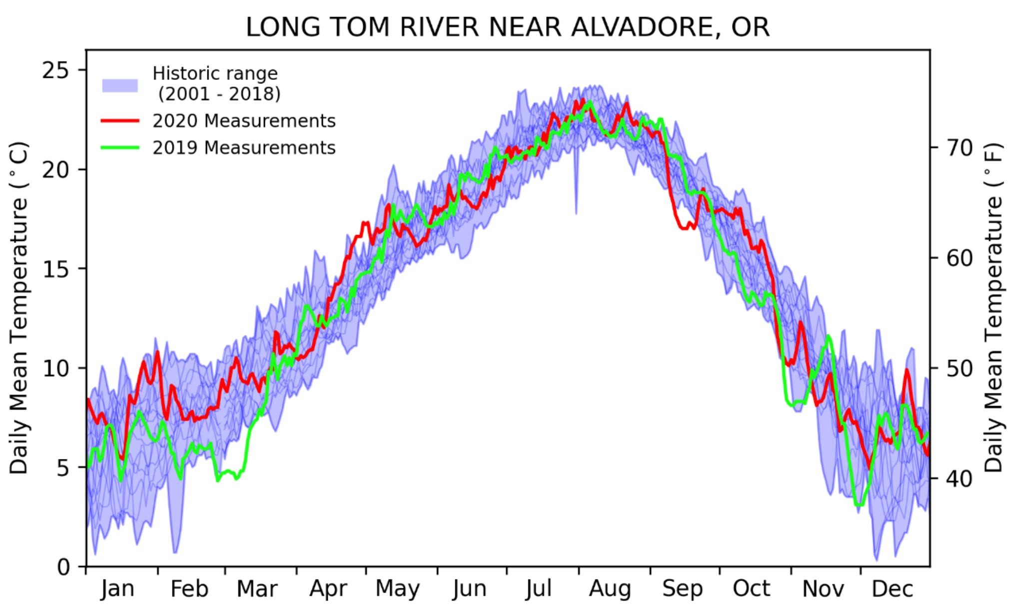

Figure 3.5-41. Fern Ridge Reservoir Daily Mean Outflow Temperatures.
Source: USACE 2021f

Note: Measured in the Long Tom River for 2020, Daily Mean 2019, and 2020 Outflow Temperatures Compared to Historical Temperature Range (2001–2018).

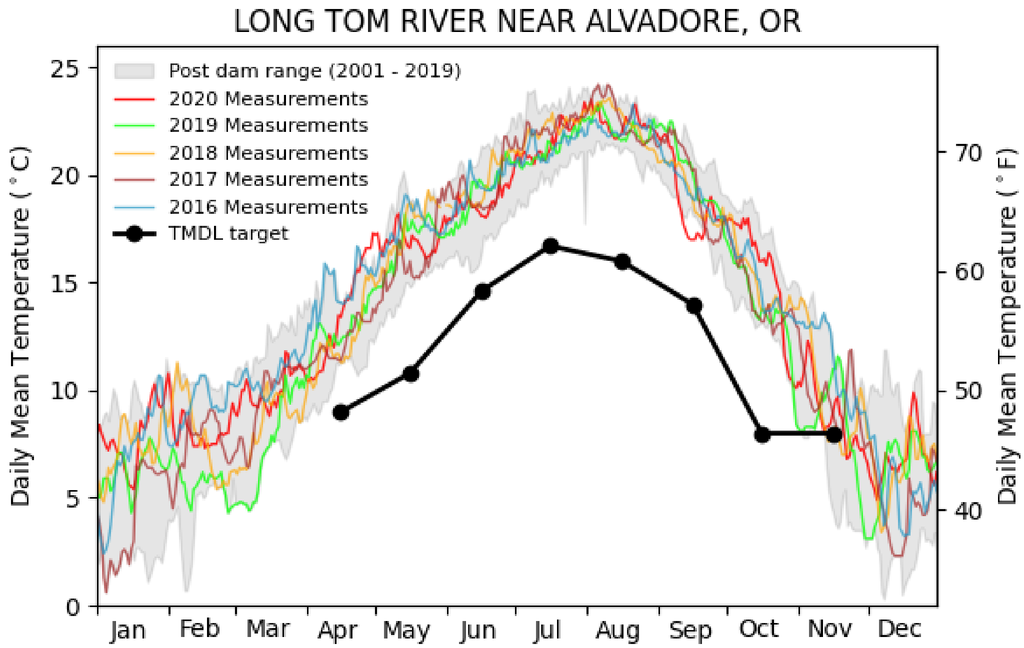

Figure 3.5-42. Fern Ridge Reservoir Daily Mean Outflow Temperatures (2016–2020).

Source: USACE 2021f

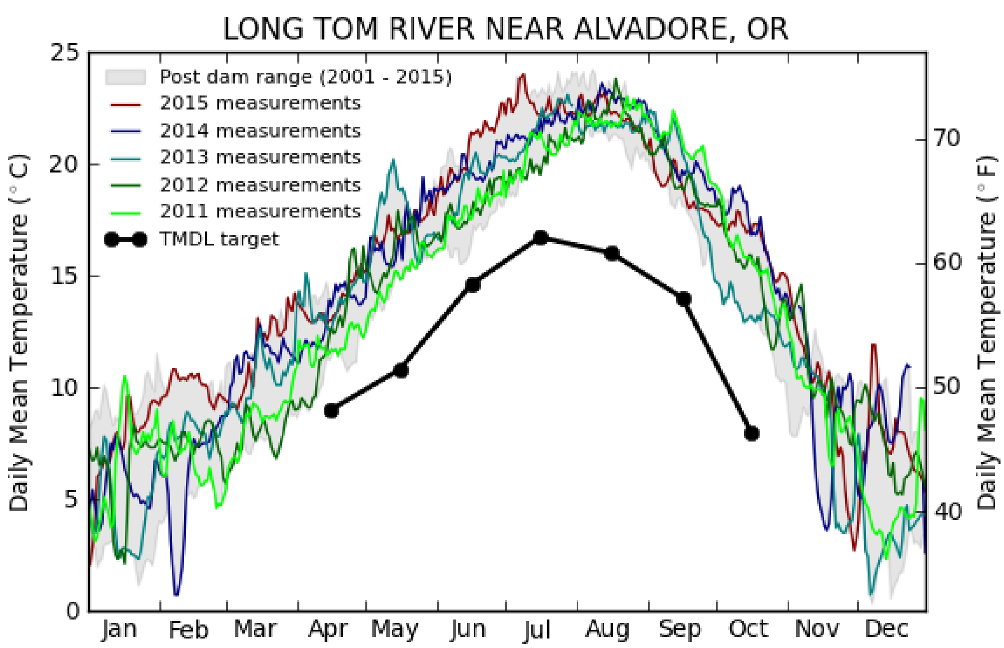

Figure 3.5-43. Fern Ridge Reservoir Daily Mean Outflow Temperatures (2011–2015).

Source: USACE 2016d

THE DEIS HAS BEEN REVISED TO ADD THE FOLLOWING INFORMATION IN THE FEIS

Temperature Conditions in the Mainstem Willamette River

Water management operations are conducted downstream of the WVS dams to cool water temperatures and to augment flows to meet respective targets on the Mainstem Willamette River (Section 3.5.3.2, Mainstem Willamette River)[6]. Forecasted air temperatures and pulsed releases from various reservoirs to maintain or to reduce mainstem flow temperatures may be conducted during summer heatwaves. For example, a short-term flow increase was coordinated with the WATER Flow Management and Water Quality forum (WATER forum)[7] during a forecasted heat wave in late June 2020 to help mitigate heat stress on spring Chinook salmon migrating in the Mainstem Willamette River near Salem, Oregon (USACE 2021f).

USGS flow-temperature regression equations for the Willamette River can be used to help manage flows for temperature (Stratton Garvin et al. 2022). Use of CE-QUAL-W2 two-dimensional flow and water-quality model to inform flow and temperature management strategies has also been studied by USGS (Rounds and Stratton Garvin 2022; Stratton Garvin and Rounds 2022).

The Annual Willamette Water Quality Report has described conditions on the Mainstem Willamette River for flow and temperatures every year since 2009 (USACE 2021f). For example, maximum temperatures for 2020 occurred in the last week of July, and in the first week of August for the most downstream location in Portland, Oregon (Table 3.5-7; Figure 3.5-44; Figure 3.5-45). River temperatures became progressively warmer at each location further downstream on the mainstem river (Table 3.5-7). Warmer temperature fluctuations also corresponded to a period of warmer-than-average air temperature and greater-than-average solar radiation (Figure 3.5-46).

The flow and temperature of major rivers in the Willamette River Basin can be summarized with a Sankey diagram where the width of the polygon is proportional to the flow and the color represents the temperature (Figure 3.5-47).

Table 3.5-7. Daily Mean Temperature Analysis for Gages on the Mainstem Willamette River, 2020.

Willamette River Gage	Period of Data	2020 Max Temperature °C (°F)	Day of Max Temperature in 2020	Annual Record Temperature °C (°F)	Annual Record Date
Harrisburg	1961 to 2020	21.2 (70.6)	29-30-Jul	22.3 (72.4)	3-Jul-2015

[6] USACE will coordinate with NMFS if augmentation is needed to meet the 2008 Biological Opinion flow or temperature targets for ESA-listed fish on the Mainstem Willamette River.

[7] Flow management team includes Grande Ronde, NMFS, USFWS, USFS, BPA, OWRD, ODFW, ODEQ.

Willamette River Gage	Period of Data	2020 Max Temperature °C (°F)	Day of Max Temperature in 2020	Annual Record Temperature °C (°F)	Annual Record Date
Albany	2001 to 2020	23 (73.4)	30-Jul	23.7 (74.7)	3-Jul-2015
Keizer	2000 to 2020	23.7 (74.7)	22-Jul	25.3 (77.5)	29-Jul-2009
Newberg	2001 to 2020	23.9 (75.0)	31-Jul	26.2 (79.2)	30-Jul-2009 4-Jul-2015
Portland	1975 to 2020	24.5 (76.1)	5-Aug	26.2 (79.2)	9-Jul-2015

Source: USACE 2021f

°C = degrees Celsius

°F = degrees Fahrenheit

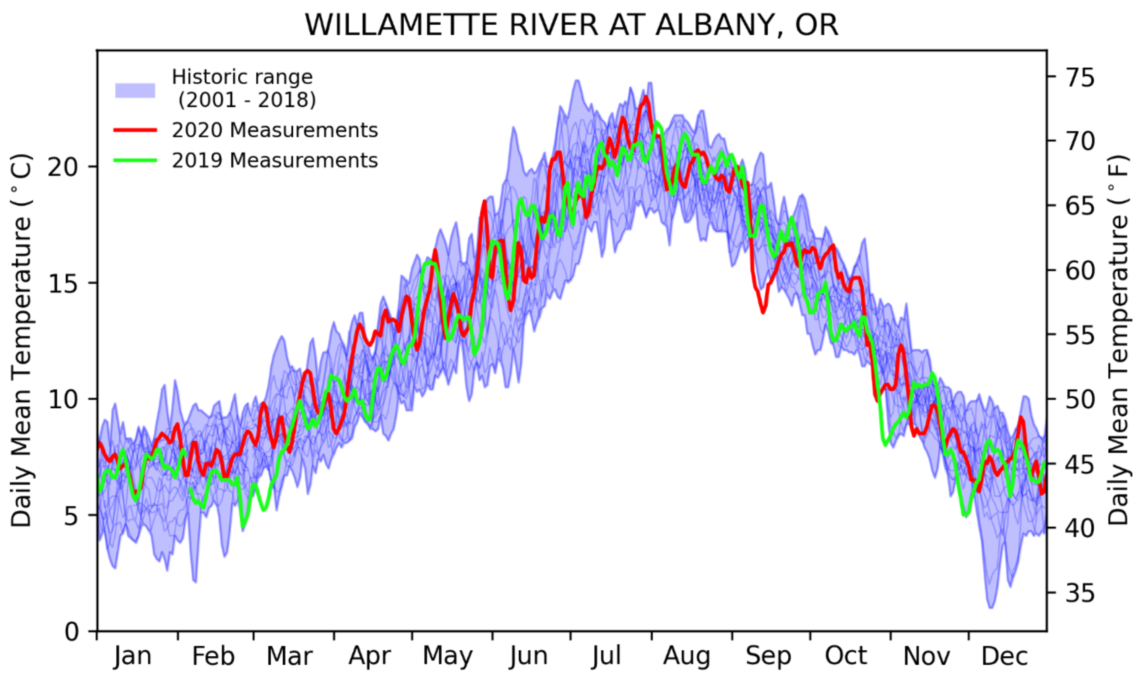

Figure 3.5-44. Daily Mean Temperatures for 2019 and 2020 Compared to the Period of Record (2001–2018) for the Willamette River Site at Albany, Oregon.

Note: This site is described as ALBO.

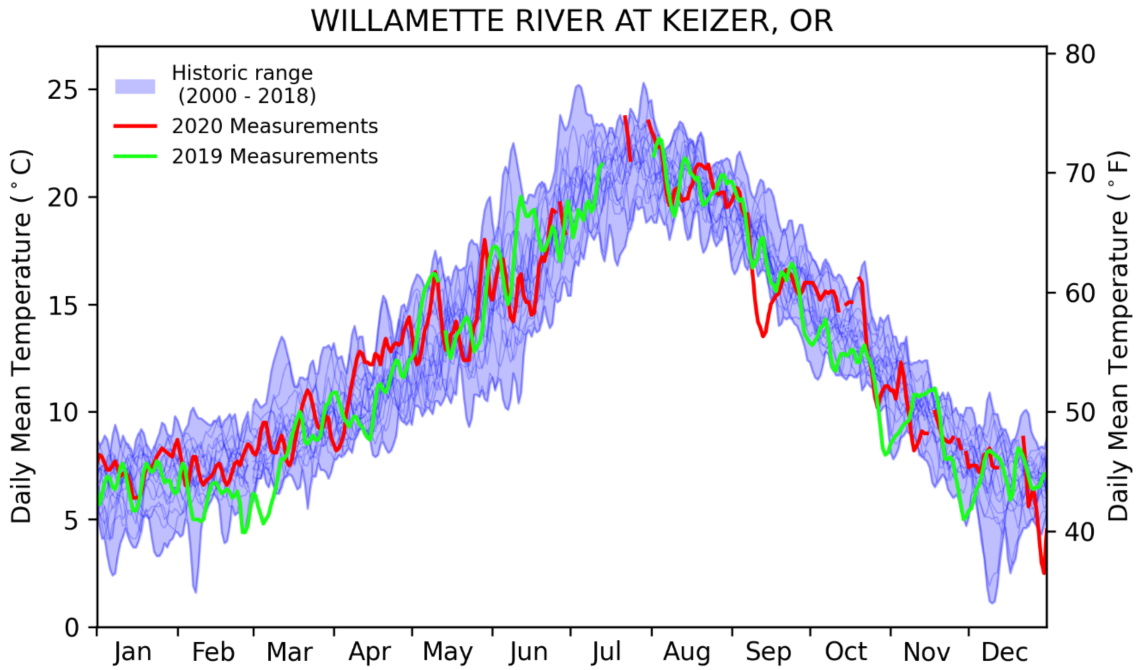

Figure 3.5-45. Daily Mean Temperatures for 2019 and 2020 Compared to the Period of Record (2000–2018) for the Willamette River Site at Keizer, Oregon.

Note: This site is described as SLMO.

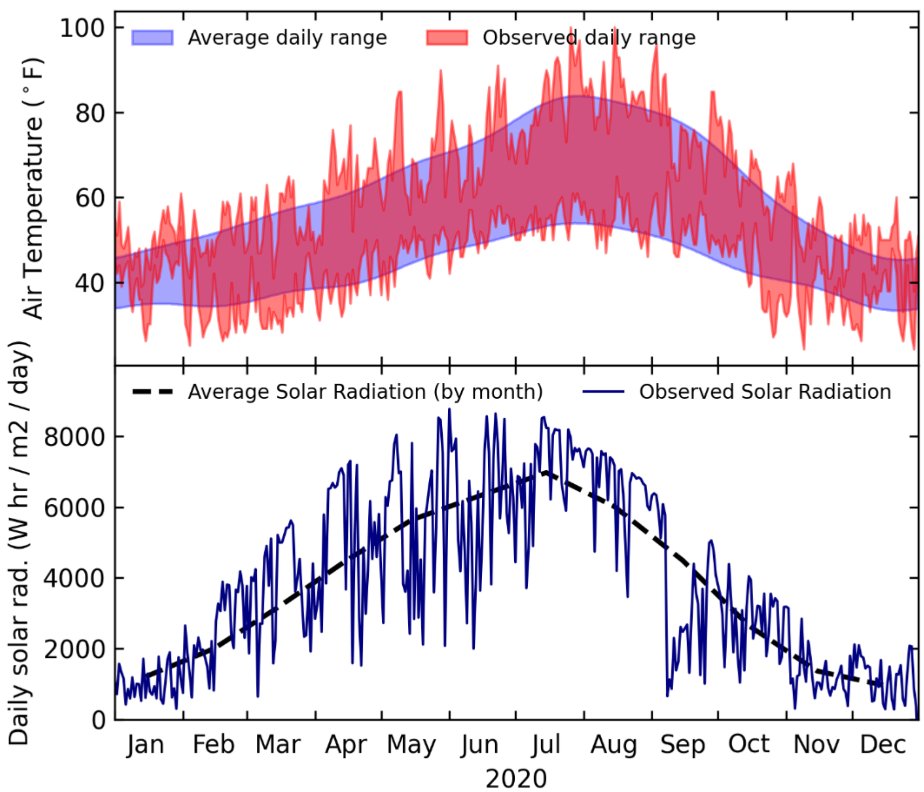

Figure 3.5-46. Air Temperature (degrees Fahrenheit) recorded in Salem, Oregon (top figure) and Solar Radiation Conditions (watts per hour per meter squared per day) Recorded in Eugene, Oregon (bottom figure) 2020.

Note: Long-term averages are included (light blue shaded area is daily [top], and dashed black line is monthly [bottom]) for reference.

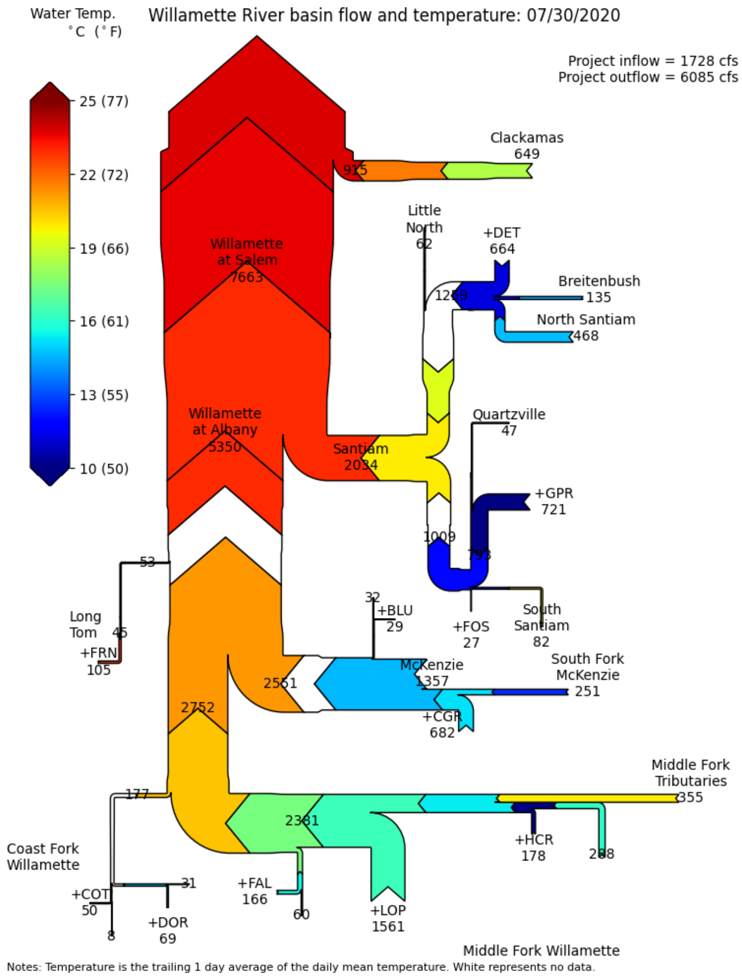

Figure 3.5-47. Sankey Representation of Flow and Temperature in the Willamette Basin, July 30, 2020.

Source: USACE 2021f

DET = Detroit, FOS = Foster, GPR = Green Peter, BLU = Blue River, CGR = Cougar, HCR = Hills Creek, LOP = Lookout Point, FAL = Fall Creek, DOR = Dorena, and COT = Cottage Grove (Re-regulation dams are not included)

Notes:

Flow is reported at various locations (cfs).

Reservoirs are labeled with a three-letter code and a '+' if augmenting flow (outflow > inflow) and a '-' if storing flow (inflow < outflow).

The color of each section is based on the temperature measured at the downstream gage location that the section represents. For example, the polygon at the top of the diagram is based on flow and temperature measured at the Willamette River at Portland, downstream of the Clackamas River confluence.

The color of the polygon that is labeled with a reservoir represents the temperature of reservoir outflow. Water being released from Hills Creek Dam is 55 °F (13 °C) and the outflow of Hills Creek is

178 cfs greater than the inflow. The polygon changes width when the discharge is different than the sum of represented inputs due to ungaged tributaries and withdrawals.

The position in the river network is preserved; geographic relationship and cardinal direction are also preserved, when practical.

END NEW TEXT

Total Dissolved Gas

TDG is a measure of dissolved atmospheric gases in water. The primary gases that make up TDG are oxygen, nitrogen, and carbon dioxide.

TDG levels are dependent on a variety of factors, including discharge rate (flow), pressure (depth), and water temperature. TDG is monitored by USACE-funded USGS gages.

Elevated TDG can be created by the entrainment of air as water is released through regulating outlets or spillway operations. Water released through dam outlets plunges into the tailrace, entraining and forcing air into solution, which can cause elevated TDG concentrations in the river below.

TDG levels above 110 percent saturation can adversely affect juvenile salmonids through gas bubble trauma, an effect similar to underwater diving decompression sickness or “the bends” (Mesa et al. 2000). However, studies indicate TDG levels up to 120 percent may not impact salmonids during less sensitive life stages, depending on depth compensation and other factors (McGrath et al. 2006). Fish residing in shallow or near-surface depths at certain stages of their life cycle are at risk (Maynard 2008).

> Except when stream flow exceeds the ten-year, seven-day average flood, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection may not exceed 110 percent of saturation. However, in hatchery-receiving waters and other waters of less than two feet in depth, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection may not exceed 105 percent of saturation (OAR 340-041-0031).

ODFW monitors water quality to comply with National Pollutant Discharge Elimination System permits for hatchery operations in the analysis area.

Total Dissolved Gas Conditions in the North Santiam River Subbasin

TDG exceeding the water quality standards greater than the Oregon standard of 110 percent can be observed downstream of Detroit and Big Cliff Dams when water is released through the non-turbine outlets. TDG is monitored in real-time at the USGS gage (identified as BCLO) located 0.75 miles below Big Cliff Reservoir near Niagara, Oregon (Figure 3.5-3).

A TDG study was conducted within the North Santiam River in 2010 (June through November) (USACE 2011b). TDG saturation measurements were recorded at Detroit and Big Cliff Dam tailraces; Niagara, Oregon; Minto adult fish facility; and Mehama, Oregon. This study determined that TDG produced by USACE dams is elevated above state water quality standards on occasion from spill and maintenance operations and is typically observed downstream, nearest the dams. However, TDG will de-gas as water moves downstream, typically returning to background levels by the time water reaches Mehama, Oregon, 20 miles downstream of the dams (Figure 3.5-48) (USACE 2011b).

Exceedances generally occur in the fall and spring months when water is released for flood risk management due to precipitation events (Figure 3.5-49). As an example, in May 2013, TDG levels reached 120 percent TDG for 13 days because of high flows and spill at Detroit and Big Cliff Dams for flood risk management.

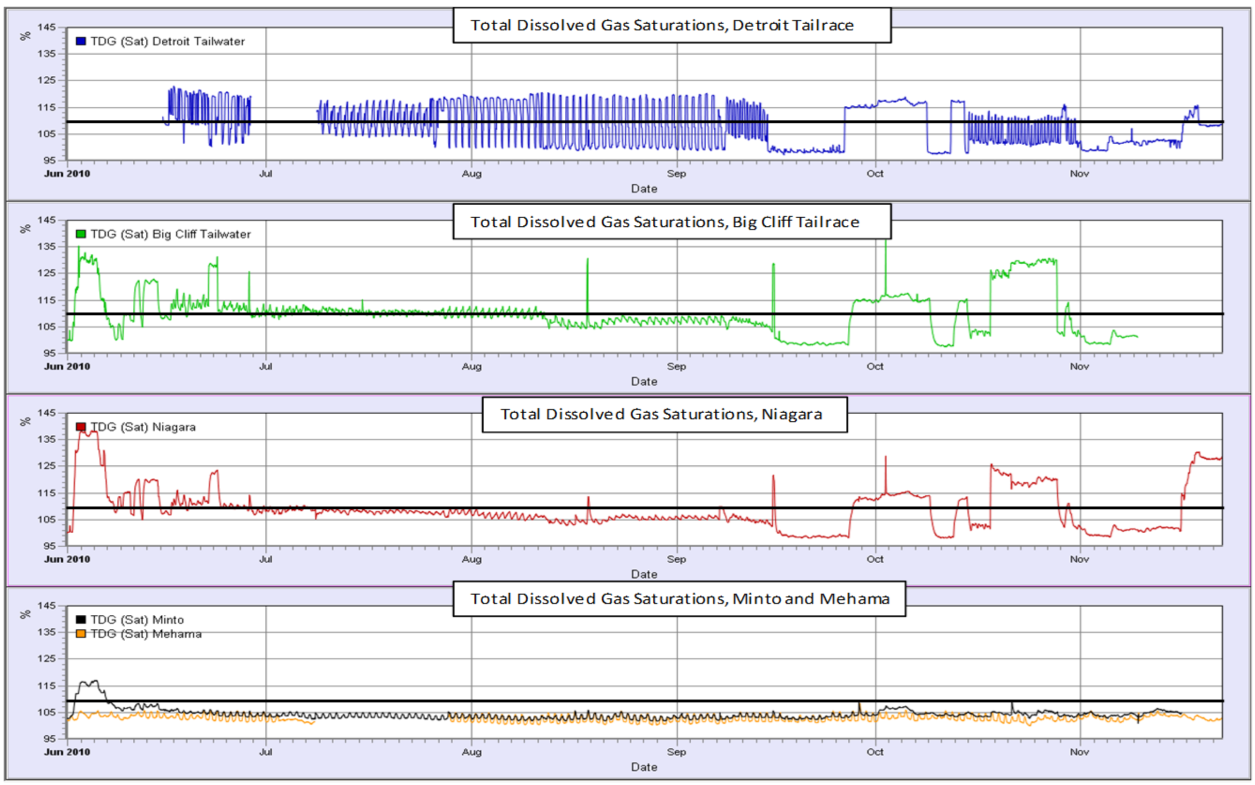

Figure 3.5-48. Total Dissolved Gas Saturation Measured in the Detroit and Big Cliff Tailraces and Near Niagara, Minto, and Mehama, Oregon on the North Santiam River, June through November, 2010.

Source: USACE 2011b

Note: Black line denotes Oregon criteria for TDG of 110 percent level.

`	2020			2019			2018		
MONTH	MAX % TDG	DAYS	REASON	MAX % TDG	DAYS	REASON	MAX % TDG	DAYS	REASON
Jan	135	7	3, 4, 7	---	---	---	132	1	3
Feb	126	4	3, 4	---	---	---	---	---	---
Mar	118	3	7	118	28	1, 7	117	1	1
Apr	115	15	7	131	23	1, 3, 4	---	---	---
May	120	1	1	---	---	---	127	1	1, 3
Jun	118	9	6	---	---	---	121	13	1, 6
Jul	119	14	1, 6	---	---	---	120	3	1, 6
Aug	118	13	1, 6	118	2	1	118	2	1
Sep	118	23	1	121	1	1	---	---	---
Oct	122	31	1	118	4	1	125	17	1, 6
Nov	128	30	1, 2, 3, 4	126	13	3, 6	120	2	1
Dec	119	21	2, 3, 4	116	3	7	---	---	---
Total days		171			74			40	
	2017			2016			2015		
MONTH	MAX % TDG	DAYS	REASON	MAX % TDG	DAYS	REASON	MAX % TDG	DAYS	REASON
Jan	123	2	1	126	14	3, 4	125	5	3
Feb	132	15	1, 3	---	---	---	112	5	3
Mar	138	31	1	115	6	1	121	18	1
Apr	129	14	1, 4	127	27	1	---	---	---
May	130	30	3, 4	125	17	1	119	4	1
Jun	126	25	1, 6	122	7	1, 6	---	---	---
Jul	117	8	1, 6	116	9	6	---	---	---
Aug	---	---	---	---	---	---	---	---	---
Sep	112	1	7	118	1	1, 7	112	2	6
Oct	129	15	3, 5	126	22	3, 6	120	23	6
Nov	120	19	3, 6	124	11	3, 6	114	4	6
Dec	---	---	---	125	12	1, 3	136	20	3, 4
Total days		160			126			81	
	2014			2013			2012		
MONTH	MAX % TDG	DAYS	REASON	MAX % TDG	DAYS	REASON	MAX % TDG	DAYS	REASON
Jan	---	---	---	127	4	1, 3, 4	132	31	1, 3, 7
Feb	131	11	3, 4	123	28	1, 7	132	15	1, 3
Mar	133	21	3, 4	123	24	1, 7	128	27	1
Apr	129	24	1	116	6	2	132	30	1, 7
May	133	31	1	120	13	3, 4	131	29	1, 7
Jun	122	24	1, 6	112	16	6	129	29	1, 7
Jul	112	16	6	125	16	6	117	19	7
Aug	111	6	6	119	1	6	---	---	---
Sep	122	1	1	124	4	1, 7	124	5	1, 7
Oct	130	5	1, 7	129	2	3	127	8	1, 7
Nov	122	4	1, 7	130	20	3	130	28	1, 7
Dec	136	19	3, 4	128	10	3	129	31	1, 7
Total days		162			144			252	
Notes:	An exceedance is considered any percent of Total Dissolved Gas greater than Oregon Standard of 110%. TDG data measurements began in June 2011 downstream of Detroit Dam.								
[1]	Spill @ Big Cliff with Unit Out of Service (OOS) (i.e., due to wild fires in 2020)								
[2]	Spill @ Detroit for Downstream Fish Passage Testing								
[3]	High flows and Spill @ Big Cliff for Flood Management								
[4]	High flows and Spill @ Detroit for Flood Management								
[5]	Spill @ Big Cliff with Unit OOS for Environmental Study SOR								
[6]	Spill @ Detroit for Temperature Control Operations								
[7]	Spill @ Detroit with Unit OOS (i.e., spillway repairs in Dec. 2019)								

Figure 3.5-49. Big Cliff Dam Total Dissolved Gas Exceedances Greater than the Oregon State Standard of 110 Percent Saturation (hourly).

Source: USACE 2021f

Note: Measured near Niagara, Oregon, 2012–2020.

Total Dissolved Gas Conditions in the South Santiam Subbasin

TDG is monitored downstream of Green Peter Dam and Foster Dam. The sensor downstream of Foster Dam was installed in May 2015 and downstream of Green Peter Dam in March 2022. Detailed TDG analysis can be found in Appendix D, Water Quality Analysis, Chapter 2, Total Dissolved Gas.

Elevated TDG levels can occur when the outflow of water exceeds powerhouse capacity and the spillway is utilized for the additional discharge (Figure 3.5-50). As an example, April 2019 TDG levels in Foster Reservoir reached 121 percent for 10 days because of spill operations for flood risk management from a precipitation event.

	2020			2019			2018		
MONTH	MAX % TDG	DAYS	REASON	MAX % TDG	DAYS	REASON	MAX % TDG	DAYS	REASON
Jan	117	2	1	115	1	1	---	---	
Feb	---	---		---	---		---	---	
Mar	---	---		---	---		112	1	1,2
Apr	---	---		121	10	1	114	5	1
May	116	14	1	---	---		113	4	1,2
Jun	115	7	1	---	---		---	---	
Jul	---	---		---	---		---	---	
Aug	---	---		---	---		---	---	
Sep	---	---		---	---		---	---	
Oct	---	---		---	---		---	---	
Nov	114	2	1	---	---		---	---	
Dec	119	3	1	---	---		---	---	
Total days		28			11			10	
	2017			2016			2015		
MONTH	MAX % TDG	DAYS	REASON	MAX % TDG	DAYS	REASON	MAX % TDG	DAYS	REASON
Jan	---	---		---	---		---	---	
Feb	114	3	1	---	---		---	---	
Mar	121	18	1,2	112	1	1	---	---	
Apr	118	11	1,2	113	3	1,2	---	---	
May	117	16	1,2	114	11	1,2	---	---	*
Jun	---	---		---	---		---	---	
Jul	---	---		---	---		---	---	
Aug	---	---		---	---		---	---	
Sep	---	---		---	---		---	---	
Oct	---	---		117	9	1,2	---	---	
Nov	117	5	1	122	15	1,2	---	---	
Dec	119	2	1	---	---		124	20	1
Total days		55			39			20	
Notes:	An exceedance is considered any percent of Total Dissolved Gas greater than Oregon Standard of 110%. TDG data measurements began in May 2015 downstream of Foster Dam.								
[*]	TDG sensor installed								
[1]	Spill								
[2]	Unit Out of Service (OOS)								

Figure 3.5-50. Foster Reservoir Total Dissolved Gas Exceedances Greater than the Oregon State Standard of 110 Percent Saturation.

Note: Measured near Sweet Home, Oregon, 2015–2020.

Total Dissolved Gas Conditions in the McKenzie River Subbasin

The operation of Cougar Dam can lead to TDG exceeding the water quality standards above the state water quality standards when water is released through the regulating outlets (Figure 3.5-51). For Example, in April 2017, TDG levels reached 117 percent for 25 days due to spill and maintenance operations.

TDG is monitored at the USGS gaging station below Cougar Reservoir near Rainbow, Oregon (identified as CGRO) (Figure 3.5-15). TDG is not monitored below Blue River Dam because there is a lower conservation value for UWR Chinook salmon downstream of the dam (noting that the distance downstream of the Blue River Dam to the McKenzie River is approximately 2 miles (USACE 2009a; NMFS 2008).

In 2006, USACE conducted a 2-day spill operation to study regulating outlets and powerhouse variable outflow discharges and TDG response (USACE 2007). The study measured TDG at five locations below Cougar Dam and one location in the forebay of Cougar Dam[8]. The study concluded TDG was higher in the regulating outlet channel with flows higher than 575 cubic feet per second (cfs), which produced TDG above the state water quality standard. However, TDG saturation decreased downstream because of de-gassing and mixing of turbine and regulating outlet releases.

[8] Site locations = (1) on the right bank of the powerhouse, (2) right bank in the regulating outlet channel, (3) right bank 590.5 feet (180 m) below the confluence of powerhouse and regulating outlet releases, (4) the right bank adjacent to the USGS gage, (5) the right bank 2.8 miles (4.5 km) downstream of Cougar Dam.

	2020			2019			2018		
MONTH	**MAX % TDG**	**DAYS**	**REASON**	**MAX % TDG**	**DAYS**	**REASON**	**MAX % TDG**	**DAYS**	**REASON**
Jan	120	16	1	115	13	1	117	2	1
Feb	---	---		---	---		---	---	
Mar	---	---		---	---		---	---	
Apr	114	3	1	113	2	1	---	---	
May	---	---		117	12	1	116	12	1,2
Jun	---	---		---	---		---	---	
Jul	---	---		---	---		---	---	
Aug	---	---		---	---		---	---	
Sep	114	2	1	---	---		---	---	
Oct	---	---		---	---		---	---	
Nov	---	---		---	---		---	---	
Dec	116	12	1	---	---		---	---	
Total days		33			27			14	
	2017			**2016**			**2015**		
MONTH	**MAX % TDG**	**DAYS**	**REASON**	**MAX % TDG**	**DAYS**	**REASON**	**MAX % TDG**	**DAYS**	**REASON**
Jan	---	---		120	19	1,2	---	---	
Feb	---	---		119	29	1,2	---	---	
Mar	117	4	1	117	3	1,2	---	---	
Apr	117	25	1,2	---	---		---	---	
May	117	31	1,2	---	---		---	---	
Jun	114	5	1,2	---	---		---	---	
Jul	---	---		---	---		---	---	
Aug	---	---		---	---		---	---	
Sep	---	---		---	---		---	---	
Oct	---	---		112	4	1,2	---	---	
Nov	117	7	1	115	10	1,2	113	1	1
Dec	---	---		117	21	1,2	119	20	1,2
Total days		72			86			21	
	2014			**2013**			**2012**		
MONTH	**MAX % TDG**	**DAYS**	**REASON**	**MAX % TDG**	**DAYS**	**REASON**	**MAX % TDG**	**DAYS**	**REASON**
Jan	---	---		---	---		---	---	
Feb	---	---		---	---		---	---	
Mar	113	1	1	---	---		---	---	
Apr	113	1	1	---	---		---	---	
May	116	5	1	112	3	1	114	1	* 1
Jun	112	1	1	---	---		114	16	1
Jul	---	---		---	---		112	6	1
Aug	111	1	1	---	---		112	2	1
Sep	---	---		113	1	1	111	1	1
Oct	---	---		---	---		---	---	
Nov	114	3	1	115	4	1	119	17	1
Dec	---	---		---	---		117	14	1
Total days		12			8			57	
Notes:	An exceedance is considered any percent of Total Dissolved Gas greater than Oregon Standard of 110% (>110.5%). TDG data measurements began in May 2012 downstream of Cougar Dam.								
[*]	TDG sensor installed								
[1]	Spill								
[2]	Unit Out of Service (OOS)								

Figure 3.5-51. Cougar Dam Total Dissolved Gas Exceedances Greater than the Oregon State Standard of 110 Percent Saturation (hourly).

Note: Measured near Rainbow, Oregon, 2012–2020.

Total Dissolved Gas Conditions in the Middle Fork Willamette River Subbasin

The Middle Fork Willamette River downstream of Dexter Dam has been monitored for TDG since 2015 (Figure 3.5-52). The operation of Dexter Dam can lead to TDG exceeding the water quality standards above the state water quality standards. For example, in March 2017, TDG levels reached 118 percent for 18 days due to spill operations.

TDG sensors have been installed directly downstream of Lookout Point Dam (February 2022) and downstream of Hills Creek Dam (May 2022). Detailed TDG analysis can be found in Appendix D, Water Quality Analysis, Chapter 2, Total Dissolved Gas.

The spillway is used to pass excess flow when outflows exceed the powerhouse capacity at Lookout Point Dam. This can lead to TDG exceeding the water quality standards above state water quality standards downstream.

USACE conducted a TDG study from August 2012 until May 2013 at 12 sites in the Middle Fork Willamette River (Figure 3.5-53, Figure 3.5-54, Figure 3.5-55, Figure 3.5-56) (USACE 2014c). Hills Creek Reservoir did not produce TDG levels above the state criteria of 110 percent (Figure 3.5-54). The forebay of Lookout Point Dam did not have elevated TDG; however, discharge from the regulating outlet, spillway, and powerhouse (backwater effect from spillway) resulted in TDG above 110 percent (Figure 3.5-55).

Dexter Reservoir forebay TDG concentrations exceeded 110 percent when the Lookout Point Dam spillway TDG concentrations were also exceeding the state standard. Comparable results were observed between the Dexter Dam powerhouse and forebay concentrations (Figure 3.5-55). Flow through the Dexter Dam spillway can increase TDG and is dependent on spillway-to-powerhouse flow (Figure 3.5-56).

The study concluded that excess TDG, generated from Lookout Point and Dexter Dams, generally dissipates to background levels within approximately 8 miles downstream of the Fall Creek confluence on the Middle Fork Willamette River. As of 2024, TDG has not been monitored at Fall Creek Dam; therefore, existing conditions for TDG levels are unknown.

	2020			2019			2018		
MONTH	**MAX % TDG**	**DAYS**	**REASON**	**MAX % TDG**	**DAYS**	**REASON**	**MAX % TDG**	**DAYS**	**REASON**
Jan	113	4	1	114	12	1	---	---	
Feb	112	1	1	---	---		---	---	
Mar	112	1	1	---	---		---	---	
Apr	112	6	1	119	23	1,2	---	---	
May	---	---		116	31	1,2	114	3	1
Jun	111	1	1	116	25	1,2	---	---	
Jul	---	---		112	2	1	---	---	
Aug	---	---		---	---		---	---	
Sep	113	3	1	---	---		---	---	
Oct	---	---		---	---		---	---	
Nov	---	---		---	---		---	---	
Dec	---	---		---	---		---	---	
Total days		16			93			3	
	2017			**2016**			**2015**		
MONTH	**MAX % TDG**	**DAYS**	**REASON**	**MAX % TDG**	**DAYS**	**REASON**	**MAX % TDG**	**DAYS**	**REASON**
Jan	---	---		111	1	1	---	---	
Feb	---	---		---	---		---	---	
Mar	118	18	1	112	10	1,2	---	---	
Apr	115	30	1	---	---		---	---	
May	---	---		---	---		---	---	*
Jun	---	---		---	---		111	12	1,2
Jul	---	---		---	---		---	---	
Aug	---	---		---	---		---	---	
Sep	---	---		---	---		---	---	
Oct	---	---		---	---		---	---	
Nov	---	---		---	---		---	---	
Dec	---	---		---	---		115	7	1
Total days		48			11			19	
Notes:	An exceedance is considered any percent of Total Dissolved Gas greater than Oregon Standard of 110%. TDG data measurements began in May 2015 downstream of Dexter Dam.								
[*]	TDG sensor installed								
[1]	Spill								
[2]	Unit Out of Service (OOS)								

Figure 3.5-52. Dexter Total Dissolved Gas Exceedances Greater than the Oregon State Standard of 110 Percent Saturation (hourly).

Note: Measured near Lowell, Oregon, 2015–2020.

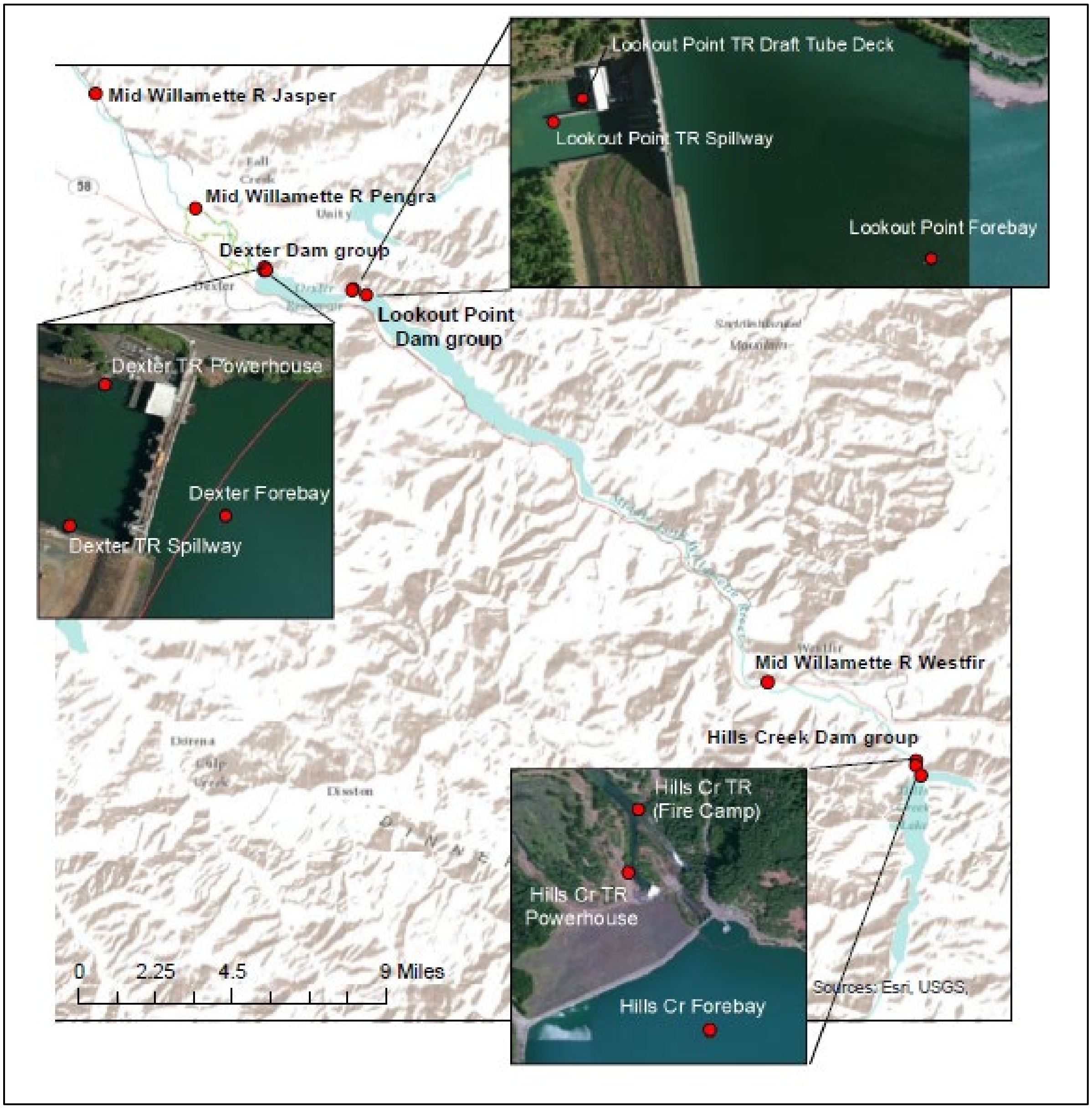

Figure 3.5-53. Sampling Locations for 2012–2013 Middle Fork Willamette River Total Dissolved Gas Study.

Source: USACE 2014c

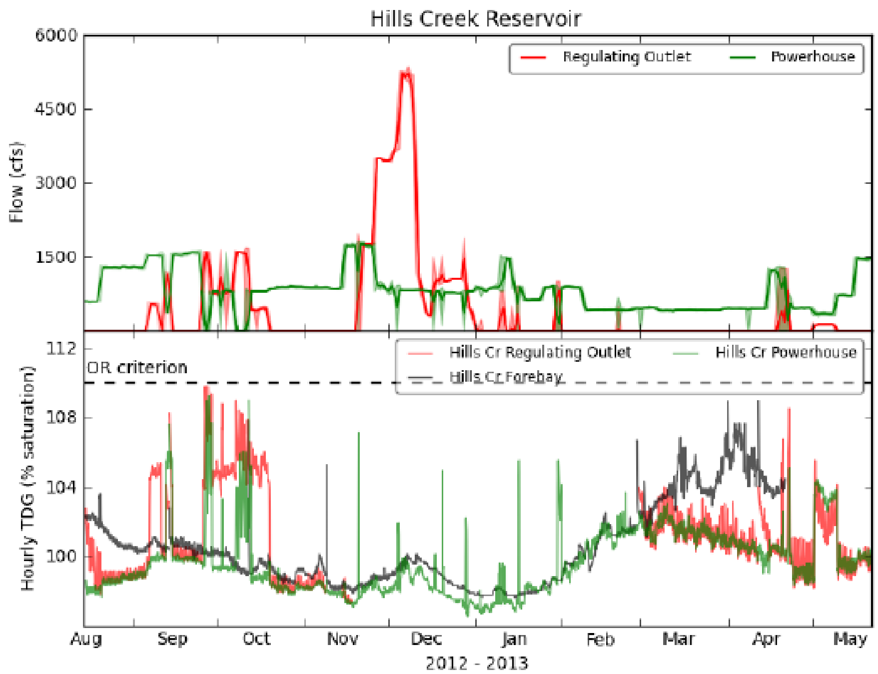

Figure 3.5-54. Hills Creek Dam Operations and Total Dissolved Gas Measurements, 2012–2013.

Source: USACE 2014c

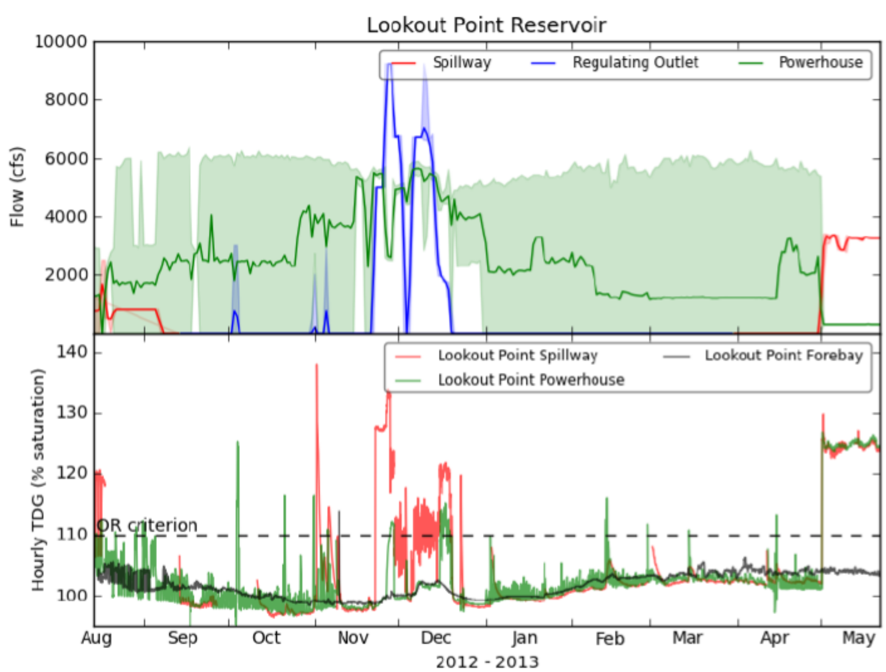

Figure 3.5-55. Lookout Point Dam Operations and Total Dissolved Gas Measurements, 2012–2013.

Source: USACE 2014c

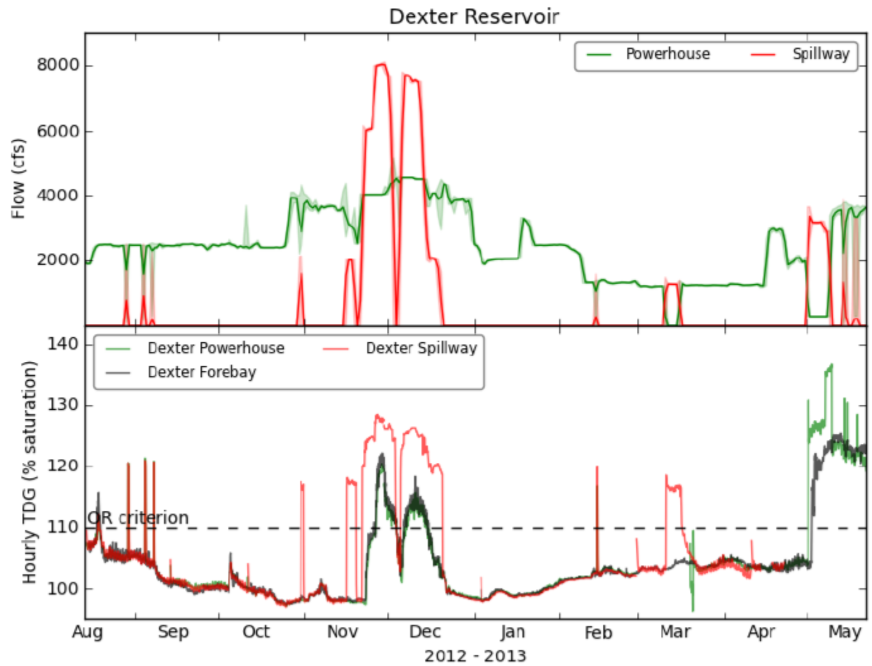

Figure 3.5-56. Dexter Dam Operations and Total Dissolved Gas Measurements, 2012-2013.

Source: USACE 2014c

Total Dissolved Gas Conditions in the Coast Fork Willamette River and Long Tom River Subbasins

TDG is not monitored at Cottage Grove, Dorena, or Fern Ridge Reservoirs.

The ODEQ 2004/2006 Integrated Report database does not identify any streams in the Coast Fork Willamette River Subbasin that are water quality limited due to high TDG concentrations (ODEQ 2006). However, a juvenile salmonid study final report done for Dorena Lake Dam Hydroelectric Project by the firm Symbiotics (2005) measured TDG in the deep bottom waters of Dorena Reservoir as well as in the Row River just below the existing outlet gates at Dorena Dam. TDG levels deep in the reservoir exceeded ODEQ's 110 percent maximum saturation standard during February and March. Symbiotics also concluded that aeration through the dam's outlet gates causes TDG below the dam to exceed DEQ's standard in July and August. There are no other data on TDG concentrations in areas of the Coast Fork Willamette River Subbasin used for listed anadromous salmonids (NMFS 2008).

THE DEIS HAS BEEN MODIFIED TO ADD OR REVISE THE FOLLOWING INFORMATION IN THE FEIS

Total Dissolved Gas Conditions in the Mainstem Willamette River

TDG is not monitored on the Mainstem Willamette River. TDG gages are located downstream of WVS dams and reservoirs where there are known TDG issues.

Turbidity

Turbidity is a water quality parameter that can be qualitatively useful in understanding the clarity of water. Turbidity is defined as the visual property of water and implies a reduction or lack of clarity that results from the presence of suspended particles, such as inorganic particles (Wetzel 2001). Turbidity usually consists of inorganic particles and originates by soil erosion from the catchment basin and from re-suspension of bottom sediments (Nolen et al. 1985). When particles from the surrounding land are washed into the river it can make the water a murky brown color, indicating water turbidity has increased. Turbidity is caused by the presence of suspended and dissolved matter, such as clay, silt, finely divided organic matter, plankton and other microscopic organisms, organic acids, and dyes (Anderson 2004).

Turbidity is an indicator of ecosystem health because it indicates the amount of suspended material in the water column. High concentrations of particulate matter affect light penetration in water and ecological productivity, recreational values, and habitat quality, and cause reservoirs to fill in faster. Suspended sediment is known to cause detrimental changes in fish gill structure, and long-term turbidity exposure is detrimental to growth productivity (Cumming and Herbert 2016). Although immediate impacts to fish may occur, sediment transport downstream of dams as a result of deep drawdown operations could also provide habitat benefits for aquatic life over time (Section 3.8, Fish and Aquatic Habitat).

Turbidity measurements are influenced by factors beyond sediment in motion-sediment transport rates, and grain size distribution cannot be directly deduced from turbidity data alone. Suspended sediment sampling is required to quantify the mass (suspended sediment concentration) of mineral material in suspended transport. Suspended sediment sampling and laboratory work is also required to determine grain size distributions of sediment in transport.

While increased turbidity levels can exist during storm events, WVS reservoirs trap sediment from the upstream watershed and reduce turbidity downstream of the dams during high-flow events. However, increased turbidity levels can arise during dam maintenance operations. During storm events, bank erosion can increase sediment transport causing elevated turbidity.

Turbidity monitoring is conducted ad-hoc and as necessary to ensure sediment load is minimal. Turbidity monitoring was not conducted year-round by USACE when the alternatives were analyzed.

Turbidity conditions under operations until 2024 are described below.

Turbidity Conditions in the North Santiam River Subbasin

USGS studied turbidity events that occurred in the North Santiam River due to high precipitation events from 1999 until 2004 (Sobieszcyk et al. 2007). Results concluded there is an increased likelihood of turbidity transportation by stormwater runoff due to the topography and sediment characteristics of the area.

A study conducted from 1998 to 2000 investigated turbidity-suspended sediment concentration relationships in three tributary inputs to the Detroit Reservoir in the North Santiam River Subbasin (Uhrich and Bragg 2003). Unregulated western Cascade Mountain tributaries are capable of yielding concentrations in excess of 100 milligrams per liter and turbidity in excess of 100 nephelometric turbidity units (NTUs). Reservoirs in the Willamette River Subbasin are substantial traps of sediment delivered from upstream tributaries, effectively reducing the amount of suspended and bed sediment delivered to downstream reaches.

A USGS study conducted from 2005 to 2008 indicated that two-thirds of sediment input into Detroit Reservoir originated from the upper North Santiam River Subbasin; two-thirds of sediment transported past Geren Island (located downstream of Detroit and Big Cliff Dams) originated from the Little North Santiam River Subbasin (Bragg and Uhrich 2010). Eighty percent of sediment transport occurred from November until January.

Turbidity Conditions in the South Santiam River Subbasin

Green Peter Reservoir is not listed in the ODEQ 2022 Final Integrated CWA 303(d) database[9] for exceedances of the water quality criteria for turbidity. Although Foster Reservoir is listed on the ODEQ 2022 Final Integrated CWA 303(d) database and indicates exceedances of the water quality criteria for turbidity, data shows 45 days or less of high turbidity days per year.

USACE operations began to gradually draw down Green Peter Reservoir for the fall deep drawdown operation for improved volitional downstream passage in August 2023. The target elevation of 780 feet was reached on November 2, 2023. This was the first year since Green Peter Dam became operational (in 1967) that USACE had drawn down Green Peter Reservoir to this extent. In past years, USACE did not intentionally draw down Green Peter Reservoir below 887 feet because that is the minimum elevation necessary to generate power (i.e., the minimum power pool).

Green Peter Reservoir was held at elevation 780 feet (+/- 3 feet) until early December 2023 when the Willamette River Basin experienced multiple, large atmospheric river storms. During these events, inflows peaked to over 27,000 cfs upstream of Green Peter Reservoir. Consequently, USACE shifted operations by limiting outflows from Green Peter Reservoir and storing water in the reservoir to reduce downstream flooding at Waterloo and Jefferson, Oregon. In just a few days, the Green Peter Reservoir elevation rose over 100 feet. Stored

[9] ODEQ 303(d) Integrated Report Database (https://rstudioconnect.deq.state.or.us/2022_IR_Database/).

floodwater was evacuated at a maximum draft rate until the drawdown period ended on December 16, 2023; after which, Green Peter Reservoir was refilled to its minimum conservation elevation as inflows allowed.

The Green Peter drawdown led to increased turbidity in the Middle Fork Willamette and South Santiam Rivers. This was due to the upper reservoir shifting from lake to river conditions, cutting a new channel through the sediment that had accumulated in the bottom of the reservoir over decades.

Turbidity was monitored in real-time downstream of Green Peter and Foster Dams throughout the drawdown, and this monitoring continued throughout the remainder of 2023 and 2024. Based on initial, provisional information from USGS in early 2024, turbidity levels peaked to 1,380 formazin nephelometric units (FNU) directly downstream of Green Peter Dam when the reservoir was first drawn down in early November, followed by a second notable spike in turbidity in early December during a heavy rain event. Elevated levels of turbidity were measured downstream to Waterloo and observed even further downstream where the North and South Santiam Rivers converge and beyond.

Downstream communities reported that turbidity associated with the Green Peter Reservoir deep drawdown impacted drinking water facilities. The City of Sweet Home requested to alter operations because of turbidity to accommodate the limitations of its water treatment system (operating for extended hours and changing how water is treated). USACE engaged in multiple meetings with the Cities of Sweet Home and Lebanon and attended a public meeting to discuss the drawdown, share data collected to-date, and listened to citizen concerns.

Turbidity levels indicate that sediment from the drawdown at Green Peter Dam is being transported below Foster Dam to the confluence of the South and North Santiam Rivers. As of 2024, it is uncertain if this sediment is impacting Chinook salmon eggs in gravels (i.e., redds) below Foster Dam. Impacts from elevated turbidity on downstream spawning beds was monitored during the drawdown of Cougar Reservoir when the water temperature control tower was completed in 2005 (Anderson 2007). NTU levels as high as 1,420 were reported below Cougar Dam, briefly, then averaged below 100 NTUs. Monitoring demonstrated minor impacts on Chinook salmon redds located downstream of Cougar Dam.

Turbidity Conditions in the McKenzie River Subbasin

USACE conducted a Water Quality study in 1996 at Cougar Reservoir, Blue River Reservoir, and in the McKenzie River from April through September. This study was in response to a proposed selective withdrawal structure (Hains 1997). The study collected in-situ field parameters and water samples for chemical analyses (chlorophyll, dissolved organic carbon, turbidity, alkalinity). The study observed that surface waters were less turbid throughout the season, and turbidity was maintained at bottom water depths in both reservoirs.

At Blue River Reservoir, outflows released turbid bottom water, which then decreased in-reservoir bottom turbidity. At Cougar Reservoir, turbid waters were located at bottom water depths although an intermediate depth intake released waters with less turbid waters, as compared to Blue River Reservoir conditions.

A spring flood event occurred in February prior to the study initiation, which had the greatest effect on Blue River Reservoir turbidity at the outflow station. Turbidity in the McKenzie River was observed to be less turbid, 0.3 NTU above the reservoirs studied. Increases up to 2.0 NTU were observed below Cougar and Blue River Dams.

USGS conducted a study on drawdown operations at Cougar Reservoir that encompassed sediment and Dichlorodiphenyltrichloroethane (also known as DDT) transport downstream in the McKenzie River. The study was conducted from 2002 to 2004 (Anderson 2007) during construction of the selective withdrawal structure (i.e., temperature tower). This construction required a low water elevation (drawdown) in Cougar Reservoir.

Study results indicated that turbidity levels and suspended sediment increased in the South Fork and McKenzie Rivers from spring 2002 until December 2003 due to erosion of deltaic[10] sediments during the Cougar Reservoir drawdown. However, sediment transport decreased in 2004 (Anderson 2007).

Turbidity Conditions in the Middle Fork Willamette River Subbasin

Exceedances of the water quality criteria for turbidity[11] are not listed for Hills Creek, Lookout Point, Dexter, and Fall Creek Reservoirs in the ODEQ 2022 Final Integrated CWA 303(d) database. However, turbidity has been documented at Hills Creek Reservoir and indicates sediment load enters the reservoir during major storm events in winter months (Youngberg et al. 1971; Scheidt and Nichols 1976; USACE 1979; Gregory et al. 2007). This suggests turbidity exceedances may occur episodically and are not long-term, sustained events.

USACE implemented targeted fish passage in 2023 with a drawdown to elevation 750 feet, which was reached on November 2, 2023 in Lookout Point Reservoir. As in Green Peter Reservoir, this is the first year since Lookout Point Dam became operational in 1954 that USACE has drawn down Lookout Point Reservoir to this extent. The lowest known elevation in Lookout Point Reservoir previously was 817 feet in 1995 to support upgrades to the Signal Point boat ramp. Typically, USACE does not draw down Lookout Point Reservoir below the minimum power pool elevation of 819 feet or the minimum conservation pool elevation of 825 feet.

Lookout Point Reservoir was held at elevation 750 feet (+/- 3 feet) until early December 2023 when multiple, large atmospheric river storms came through the Willamette River Basin causing inflows to peak to over 14,000 cfs into Lookout Point Reservoir. Consequently, modified

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[10] Deltaic is defined as pertaining to or characterized by a delta. A delta is a nearly flat alluvial tract of land at the mouth of a river, commonly forming a triangular or fan-shaped plain. It is crossed by many river tributaries that do not return to the mainstem river. Deltas are formed by the accumulation of sediment supplied by its associated river (Bates and Jackson 1984).

[11] ODEQ 303(d) Integrated Report Database (https://rstudioconnect.deq.state.or.us/2022_IR_Database/).

operations were implemented by limiting outflows from Lookout Point Reservoir to hold the Willamette River at Harrisburg, Oregon below bankfull. Subsequently, Lookout Point Reservoir elevation rose over 70 feet in a few days. Stored floodwater was evacuated at a maximum draft rate until the drawdown ended on December 16, 2023.

The Lookout Point Reservoir drawdown led to increased turbidity, as the upper reservoir turned into a river channel from sediment that had accumulated in the bottom of the reservoir over decades. Turbidity was monitored in real time downstream of Lookout Point and Dexter Dams throughout the drawdown; this monitoring continued throughout 2023 and 2024.

Based on initial, provisional information from USGS provided in early 2024, turbidity levels peaked to 2,710 FNU directly downstream of Lookout Point Dam when the reservoir was first drawn down in early November followed by a second notable spike in turbidity in early December when multiple, large atmospheric river storms came through the Willamette River Basin. For comparison, turbidity downstream of Lookout Point Reservoir during the winter normally ranges from 5 to 100 FNU. Inflows into Lookout Point Reservoir peaked to over 14,000 cfs during the December 2023 rain event. Lookout Point Reservoir was refilled to minimum conservation elevation by December 20 as high inflows continued.

At Fall Creek Reservoir, a deep reservoir drawdown to facilitate volitional downstream fish passage has occurred annually since 2012. Model results of drawdowns demonstrate minimal impacts to juvenile UWR spring Chinook salmon; however, incomplete refill may reduce growth potential (Johnson et al. 2016; Hamilton et al. 2022).

A USGS study was conducted at Fall Creek Reservoir to monitor and evaluate suspended sediment transport, bedload, and dissolved oxygen in 2012 and 2013. A calculated suspended sediment budget for 72 days concluded that 16,300 tons of deposition occurred in the reaches of Fall Creek and the Middle Fork Willamette River (Schenk and Bragg 2014).

Further USGS evaluation of sediment transport, turbidity, and dissolved oxygen occurred during drawdown operations for volitional fish passage at Fall Creek Reservoir from 2013 to 2018. In general, sediment transport from the reservoir decreased and was variable after the first couple of yearly drawdown operations. Turbidity levels increase as reservoir drawdown occurs (Schenk and Bragg 2021) (see Section 3.22, Visual Resources, for photographs of drawdown conditions). Data indicate that suspended sediment concentrations greater than 1,000 milligram per liter and turbidity greater than 1,000 FNU are observed during the initial year of drawdown.

USACE implemented two extended deep drawdowns at Fall Creek Reservoir in 2023. The first deep drawdown occurred on October 16; the early initiation was due to low reservoir elevations and small amounts of storage behind Fall Creek Dam in the fall. The second deep drawdown occurred on December 1 and was implemented through early January 2024. However, due to heavy rainfall and the need for flood risk management operations, USACE was unable to maintain Fall Creek Reservoir at elevation 680 feet for the entire duration of the drawdown.

Turbidity was monitored downstream of Fall Creek Reservoir during the 2023 extended deep drawdowns. Based on initial, provisional information from USGS in early 2024, turbidity levels were nominal during the first drawdown of Fall Creek Reservoir in October 2023. This likely occurred because the reservoir was drawn down to elevation 700 feet versus the injunction-targeted level of elevation 680 feet, an elevation known to liberate sediment. During the second drawdown, which occurred when multiple, large atmospheric river storms came through the Willamette River Basin, turbidity peaked to 2,720 FNU directly downstream of Fall Creek Dam. Turbidity levels reduced following the December rain event, fluctuating between 0 and 500 FNU with the exceptions of a few larger spikes.

Turbidity Conditions in the Coast Fork Willamette River and Long Tom River Subbasins

Cottage Grove Reservoir is not listed in the ODEQ 2022 Final Integrated CWA 303(d) database, and there is no indication of exceedances of the water quality criteria for turbidity. However, the Row River below Dorena Reservoir, Fern Ridge Reservoir, and the Long Tom River below Fern Ridge Reservoir have been listed on the Oregon 303(d) list for exceeding turbidity levels.

From the last ODEQ assessment of Fern Ridge Reservoir in 2010, the reservoir is typically clearest in May and June; then water clarity is reduced in August making it unsafe for swimming (ODEQ 2022b). The Long Tom River was assessed in 2022 and experienced high turbidity days exceeding the water quality criteria for turbidity.

Turbidity Conditions in the Mainstem Willamette River

The Willamette River is not listed in the ODEQ 2022 Final Integrated CWA 303(d) database and does not indicate exceedances of the water quality criteria for turbidity.

Harmful Algal Blooms or Cyanobacteria

Harmful algal blooms[12] refer to noticeable growth of photosynthetic organisms that are found in freshwater systems such as rivers, lakes, reservoirs, and streams. Harmful algal blooms are a natural occurrence in freshwater ecosystems, but also occur in marine and brackish waters (mixtures of fresh and salt water), are important to nutrient cycles, and support the aquatic food web (Burford et al. 2019).

Harmful algal blooms may produce compounds, known as cyanotoxins, that are harmful or toxic to people, fish, shellfish, aquatic mammals, and birds (Gilbert et al. 2005; NOAA 2021). Harmful algal blooms can also create taste or odor compounds that can interfere with recreational function and the use of lakes and reservoirs for drinking water (NOAA 2021) (Appendix D, Water Quality Analysis, Chapter 4, Other In-Reservoir Water Quality Background Information).

[12] Harmful algal blooms can include different organisms such as phytoplankton, benthic algae, macroalgae, diatoms, and cyanobacteria.

Since 2005, Oregon Health Authority has posted advisories based on sample results that exceed the cyanotoxin threshold levels in Oregon waters for drinking water (Table 3.5-8). Harmful algal bloom advisories have been issued at USACE-managed reservoirs (Figure 3.5-57).

The criteria for harmful algal blooms have evolved from 2005 to present (Figure 3.5-58). Currently, if microcystin exceeds 8 µg/L (*Microcystis* sp.), the Health Authority will post an advisory for the water body. Advisories are posted on the Oregon Heath Authority Cyanobacteria (Harmful Algae) Blooms public website. Advisories are updated as further water testing is conducted until the toxin levels are reduced below the Health Authority toxin threshold (OHA 2022a)[13].

Further research is needed to determine factors that assist in cyanotoxin production suppression. Operations at dams with deep outlets, such as many in the WVS (e.g., Detroit, Green Peter, Foster, Hills Creek, Lookout Point Dams) can avoid releasing reservoir surface water, when conditions allow, that may contain cyanotoxins, having a beneficial effect on downstream water quality.

Additionally, USACE has placed informational signage near boat ramp areas to bring awareness to the public regarding harmful algal blooms. USACE also reviews Landsat satellite imagery of reservoirs for potential algae bloom activity, which is publicly provided on the USACE Water Management Water Quality Reports website (USACE 2022c).

Table 3.5-8. Environmental Protection Agency 10-day Health Advisories for Drinking Water.

10-day Health Advisories	Level
Microcystins	
Children pre-school age and younger (under 6 years old)	0.3 µg/L
School-age children (6 years and older)	1.6 µg/L
Cylindrospermopsin	
Children pre-school age and younger (under 6 years old)	0.7 µg/L
School-age children (6 years and older)	3.0 µg/L

Source: EPA Harmful Algal Blooms and Drinking Water Factsheet (EPA 2016b)

µg/L = micrograms per liter

[13] Harmful algal blooms are not recorded for the Mainstem Willamette River because the river does not have a reservoir storage function enabling algal bloom growth.

Willamette Valley System Reservoirs																				
OHA Harmful Algae Bloom Advisories by Year and Duration in Days																				
Reservoir	**2023**	**2022**	**2021**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**
Detroit	–	–	–	–	–	50	14	–	6	–	–	–	–	–	–	–	14	–	–	–
Big Cliff	–	–	–	–	–	21	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Foster	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Green Peter	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fern Ridge	–	–	–	–	–	–	–	–	–	–	125	54	–	–	–	–	–	–	–	–
Blue River	–	–	–	–	–	–	–	–	–	–	–	–	–	25	–	–	–	–	–	–
Cougar	–	–	–	–	–	–	–	–	–	–	–	–	35	–	–	–	–	–	–	–
Fall Creek	–	–	–	–	–	–	–	–	–	–	–	–	101	–	–	–	–	–	–	–
Dexter	–	–	–	–	–	–	–	–	–	–	78	95	56	40	46	34	–	–	–	–
Lookout Point	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	52	–
Hills Creek	–	–	–	–	–	–	–	–	–	–	–	–	–	–	58	62	26	20	65	–
Cottage Grove	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dorena	–	–	–	–	–	9	–	–	–	–	61	84	35	24	71	33	–	–	–	–

Figure 3.5-57. Oregon Health Authority Harmful Algae Bloom Advisory by Duration of Days in Willamette River Reservoirs (based on toxin level guidance).

Source: OHA 2023

	OHA Algae Bloom Toxin Threshold Levels in Recreational Waters			
Year Implemented	Cyanotoxins (µg/L)			
	Microcystin	Cylindrospermopsin	Anatoxin-a	Saxitoxin
2019 to present	8	15	15	8
2018	4	8	8	4
2016	10	20	20	10
2015	10	6	20	10
2012	10	6	20	100
2006	≥ 8		When detected	
2005	Cell density: 100,000 cells/mL for total toxigenic cyanobacteria or 40,000 cells/mL for *Microcystis* or *Planktothrix*			

Figure 3.5-58. Oregon Health Authority Toxin Level Thresholds in Oregon Recreational Waters.

Source: OHA 2019

Harmful Algal Bloom Conditions in the North Santiam River Subbasin

Harmful algal blooms occur frequently in Blowout Creek and Heater Creek arms of Detroit Reservoir. Detroit Reservoir was listed on the Oregon Health Authority algae bloom advisory in 2018, 2017, 2015, and 2007. Big Cliff Reservoir was listed on the advisory in 2018 (Figure 3.5-57).

In May 2018, the City of Salem, Oregon public water utility analyzed routine water samples within Detroit Reservoir, which revealed high cyanotoxin levels. The City of Salem supplies drinking water daily to approximately 197,000 customers and draws water from the North Santiam River (City of Salem 2020).

The City's water intake is located at Geren Island, which is approximately 28 miles downstream of Detroit Reservoir. Due to the public health concern, water temperature control operations (releases near reservoir surfaces) were delayed by USACE in 2018 for 3 weeks. During this event, USACE and the City performed rigorous field monitoring and sampling until toxin levels were reduced to below the Oregon Health Authority toxin threshold (Figure 3.5-58). The dominant observed species was *Dolichospermum* sp. (formerly *Anabaena* sp.).

The City of Salem conducts routine monitoring and, in collaboration with USACE and USGS, currently has a water quality platform deployed in Detroit Reservoir used to study factors that may increase algae growth. The U.S. Forest Service also collects water samples in Detroit Reservoir for cyanobacteria toxin analyses.

Harmful Algal Bloom Conditions in the South Santiam River Subbasin

There have been no known harmful algal blooms present in Green Peter and Foster Reservoirs; as such, no advisories have been issued by the Oregon Health Authority (Figure 3.5-57). Species such as *Anabaena* sp., *Aphanizomenon* sp., and *Microcystis* sp. have been identified from water samples collected during the summer and early fall.

Harmful Algal Bloom Conditions in the McKenzie River Subbasin

Both Cougar and Blue River Reservoirs have experienced harmful algal blooms, although Oregon Health Authority advisories have been rare (25 days in 2010 at Blue River Reservoir; 35 days in 2011 at Cougar Reservoir). In general, water samples collected at these reservoirs have identified known toxin producers, including *Anabaena* sp. and *Aphanizomenon* sp., during the summer and early fall. Toxins such as microcystin and cylindrospermopsin have been found within Blue River and Cougar Reservoirs, which prompted the Oregon Health Authority to include them on its advisory list in 2010 and 2011 (Figure 3.5-57).

The Eugene [Oregon] Water Electric Board (EWEB) provides electricity and water services to approximately 200,000 customers and conducts routine sampling and laboratory analyses of water collected within both reservoirs and along the McKenzie River (EWEB 2017). The water intake for EWEB is located on River Mile 15 on the McKenzie River (OHA 2012).

At the time the alternatives were analyzed, USACE was collaborating with USGS, the City of Salem, and EWEB to collect water quality information within Cougar and Detroit Reservoirs. The equipment is housed on a floating platform within each reservoir. Data collected will be analyzed to compare Cougar Reservoir and Detroit Reservoir results for algae blooms and potential sources.

Harmful Algal Bloom Conditions in the Middle Fork Willamette River Subbasin

Harmful algae bloom advisories have been issued by the Oregon Health Authority for all four reservoirs in this subbasin, most recently at Dexter Reservoir in 2013 for 78 days (Figure 3.5-57). Fall Creek Reservoir was listed on the Oregon Health Authority advisory in 2011 for 101 days, Hills Creek Reservoir for 58 days in 2009, and Lookout Point Reservoir for 52 days in 2005. Typically, the dominant species identified included *Gloeotrichia* sp., *Dolichospermum* sp., and *Aphanizomenon* sp., which may produce microcystin and cylindrospermopsin toxins.

USACE contracted Portland State University to produce a CE-QUAL-W2 model utilizing physical parameters and potential algae bloom response within Dexter Reservoir (Cervarich et al. 2020). Analyses included scenarios for climate change and structural changes (i.e., power intake, Lowell Covered Bridge, and the curtain weir at the bridge). Results showed the simulated algae bloom was eliminated with structural changes and intensified with climate change scenarios (Cervarich et al. 2020).

Harmful Algal Bloom Conditions in the Coast Fork Willamette River and Long Tom River Subbasins

Cottage Grove, Dorena, and Fern Ridge Reservoirs have experienced algal blooms; however, not all blooms have been toxic and listed by an Oregon Health Authority advisory (Figure 3.5-57). Cottage Grove Reservoir has not been under a cyanotoxin advisory, although USACE collected samples in 2016 and 2019.

Dorena Reservoir was listed in the Oregon Health Authority advisories from 2008 to 2013 and in 2018, 7 years in total. Fern Ridge Reservoir was last under an advisory for 54 days in 2012 and 125 days in 2013. Observed species in these reservoirs included *Gloetrichia* sp., *Aphanizomenon* sp., *Dolichospermum* sp., and *Microcystis* sp. The most common toxins have been microcystin and cylindrospermopsin.

Harmful Algal Bloom Conditions on the Mainstem Willamette River

A USGS study of algal blooms on the Willamette River documented the chemical and physical processes that may promote algal growth (Rickert et al. 1977a). For purposes of the USGS study, the Mainstem Willamette River starts at the Coast Fork and Middle Fork Rivers and extends to Willamette Falls; the mainstem is not studied further downstream. To USACE's knowledge, harmful algal blooms have not been reported or listed on the Oregon Health Authority advisory website on the Mainstem Willamette River upstream of Willamette Falls.

Mercury

USACE operates WVS reservoir elevations by following the rule curve[14] based on operational requirements and time of year (Chapter 1, Introduction, Section 1.11, System Operation and Annual Operation Planning). Consequently, a reservoir drawdown operation for flood risk management can expose lakebed sediments. As the reservoir refills, sediments are covered with water and organic matter. The drying and rewetting of sediments from changing water levels may increase microbial species within the sediment and the mercury methylation[15] process (Willacker et. al 2016; Eckley et al. 2015).

> The degree to which water level fluctuations affect mercury methylation at a particular location is expected to vary depending on a host of site-specific conditions such as: the quantity and quality of organic carbon, the microbial community structure and abundance, whether sulfate or other electron acceptors become limited during the year, and the nature of inorganic mercury speciation and associations with solid phase sediment (Eckley et al. 2017).

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[14] A rule curve is seasonal reservoir elevation targets or restrictions, represented graphically as a line, that guides reservoir operations.

[15] Methylation is the introduction of a methyl radical into a substance (Merriam-Webster 2023). Mercury is methylated by anaerobic microorganisms such as sulfate-reducing bacteria in water and sediment (Eckley et al. 2015).

Water quality criteria for mercury as a toxic pollutant is defined as:

Aquatic life chronic criteria for Total Mercury is defined as 0.012 µg/L or 12 parts per billion, while the human health consumption criteria for methylmercury in fish tissue is 0.040 mg/kg or 40 parts per million (OAR 340-041-8033).

Mercury can come from naturally occurring processes such as deposits within volcanic rock or man-made processes such as atmospheric deposition and mining activities (Park et al. 1997; Ambers et al. 2001; Hammerschmidt et al. 2006). Main forms of mercury are elemental, inorganic, and organic. Atmospheric deposited mercury (elemental) can be converted to methylmercury by microbial groups that are potential mercury methylators (Gustin et al. 2020).

Biomagnification[16] of mercury has been studied in the aquatic food web from plankton to fish species (Kidd et al. 2012; Hall et al. 1997). Methylmercury (MeHg) is an organic form of mercury that has harmful health effects for humans and wildlife (Chételat et al. 2020; Willacker et al. 2020; Clarkson and Magos 2006; Scheuhammer et al. 2007). Methylmercury is a neurotoxin, and consuming fish that has methylmercury in their tissues is a main exposure for humans and wildlife (Hall et al. 1997; Jackson et al. 2016; Sandheinrich et al. 2011).

Mercury Conditions in the Coast Fork Willamette River Subbasin

Mercury has been identified and studied within Cottage Grove and Dorena Reservoirs (Park and Curtis 1997; Ambers and Hygelund 2001; Curtis 2003; Curtis et al. 2013; Hope and Rubin 2005; Eagles-Smith et al. 2016). Mercury contamination in the Cottage Grove Reservoir originates from the Black Butte Mine, which is approximately 9.3 miles (15 km) upstream of the reservoir (Eckley et al. 2015). The Black Butte Mine was utilized for cinnabar mining to produce quicksilver (liquid mercury), but operations were ceased in the late 1960s. However, mercury-contaminated soil from Black Butte Mine has been transported downstream and deposited within Cottage Grove Reservoir. The mine is on the 2010 EPA Superfund National Priorities List.

Anaerobic (absence of oxygen) bacteria can convert mercury to methylmercury, which can be released and accumulate in aquatic organisms and fish (Eckley et al. 2017). The EPA has completed a one-time, critical removal action and one non-time-critical removal action during early-action work at the mine site (EPA 2020a). In 2021, the EPA began sampling the area to re-assess conditions within Cottage Grove Reservoir and previous Black Butte cleanup actions; this action is ongoing (CDM Smith 2022).

Dorena Reservoir also contains mercury due to mining activities from the Bohemia Mining District, located approximately 18 miles (30 km) upstream of the reservoir (Hygelund 2000). However, mining activities conducted were different from those at the Black Butte Mine in that quicksilver was utilized for gold and silver recovery. These mining activities resulted in lower contamination levels into Dorena Reservoir as compared to Cottage Grove Reservoir

[16] Biomagnification is the concentration of toxins in an organism because of its ingesting other plants or animals in which the toxins are more widely disbursed.

(Ambers and Hygelund 2001). Signs are posted by the Oregon Health Authority at the reservoir boat ramps to educate the public of fish consumption guidelines.

Background Mercury Conditions at Willamette Valley System Reservoirs

The EPA, CDM Smith, and USGS conducted mercury sampling in Hills Creek, Lookout Point, Dexter, Fall Creek, Fern Ridge, Foster, and Detroit Reservoirs as part of the ongoing Superfund cleanup of the Cottage Grove area. The sampling was conducted during 2023 to define background mercury conditions compared to Cottage Grove Reservoir (Eagles-Smith et al. 2022). All water samples collected at these reservoirs were below the total mercury freshwater aquatic life chronic criteria of 0.012 ug/L (12 ng/L) for wildlife exposure (Silvertooth 2024) (Appendix D, Water Quality Analysis, Chapter 4, Other In-Reservoir Water Quality Background Information).

Sediment Quality

Overview

Sediment is defined as mineral and/or organic material that is eroded, transported, and deposited by wind, water, and/or glacial erosion. Sediment can be composed of clay, silt, sand, gravel, and large-sized rocks as well as organic matter derived from plants, animals, fungi, etc.

When wetted, sediment composed of fine-grained mineral particles (silts and clays) and organic matter are capable of adsorbing ions (i.e., bind/hold). They are also able to adsorb contaminants. Manmade contaminants such as pesticides and polychlorinated biphenyls (PCBs) and naturally occurring contaminants (generated from the erosion of volcanic rocks) are hydrophobic ("water-fearing") and are adsorbed and sequestered in the sediment rather than readily dissolving in water. As such, contaminants sequestered in the sediment do not typically impact the water quality in the overlying water column unless they occur at very high concentrations.

Once adsorbed, contaminants can persist in the sediment for years, long after they are no longer detectable in water. Although many of these manmade chemicals were banned decades ago, they are still found in lakebed and streambed sediment, sometimes at concentrations high enough to be a risk to aquatic organisms.

In the Northwest region, the Sediment Evaluation Framework for the Pacific Northwest is used to evaluate sediment quality in the states of Oregon, Washington, and Idaho (NWRSET 2018). This guidance was developed for use in these three states by Federal agencies[17], the state water quality agencies, and the Washington Department of Natural Resources.

[17] USACE, Northwestern Division; Environmental Protection Agency, Region 10; National Marine Fisheries Service; U.S. Fish and Wildlife Service; Oregon Department of Environmental Quality; Washington Department of Ecology; Idaho Department of Environmental Quality.

Per the Evaluation Framework, the area of interest (i.e., dam and reservoir area or dredge area) is identified and sediment sampling objectives are defined. Sediment samples are collected from the area of interest and sent to laboratories for analysis. Up to nearly 60 contaminants are analyzed. The bulk sediment concentrations are measured and compared to freshwater thresholds ("screening levels") that are protective of benthic and epibenthic fauna.

The sediment chemical screening levels presented in the Evaluation Framework are primarily used to evaluate Federal and non-Federal navigational dredging projects. However, guidance thresholds may also be used to assess the quality of sediments stored behind reservoirs or connected to dam operations where sediments may be excavated and discharged into wetlands or waterways.

A synoptic study of bottom sediments of the Willamette River was conducted by USGS in 1973 to analyze trace metal concentrations (Rickert et al. 1977b). A map included in the study identified historical mines for copper, gold, silver, lead, and zinc near the Coast Fork Willamette River; Middle Fork Willamette River; and the McKenzie, South Santiam, and North Santiam River Subbasins. Two mercury mine sites were also identified, one near the Coast Fork Willamette River above Cottage Grove Reservoir and one mercury mine site from the Oak Grove Fork of the Clackamas River.

Sediment samples were collected on the Mainstem Willamette River and analyzed for trace metals such as zinc, lead, copper, chromium, mercury, and cadmium to assess inputs from natural versus pollution sources. The study concluded that accumulated metal concentrations in the Willamette River did not pose an immediate ecological threat.

A 1992 until 1994 study was then conducted, which included water and sediment sampling in the Willamette River at approximately 50 sites (Harrison et al. 1995). The report contains trace-element, organic compounds (such as pesticides, volatile and semi-volatile organic, and dioxin and furan compounds), and nutrient concentration data from the water column, suspended sediment, and bed sediment samples on the Willamette River.

END NEW OR REVISED TEXT

Sediment Quality in the Willamette Valley System

USACE has conducted sediment sampling in 11 of the 13 WVS reservoirs. Blue River and Hills Creek Reservoirs have not been sampled because of resource constraints; no future sampling is anticipated. Sampling occurred between 2002 and 2021 and was analyzed to determine the presence or absence of sediment-borne contaminants (Table 3.5-9).

Sediments in the 11 reservoirs were analyzed for grain-size distribution, total organic carbon content, heavy metals, and organochlorine pesticides. The metals analysis was performed because of the volcanic nature of the soils contributing sediment to the reservoirs and the occurrence of mines above some of the reservoirs.

Analyses for other contaminant groups are typically performed if contaminant chemicals might be present in sediment due to a nearby source (semi-volatile organic compounds including polynuclear aromatic hydrocarbons, phthalates, phenols, and miscellaneous extractable compounds; polychlorinated biphenyls).

Differences exist between the Sediment Evaluation Framework (Table 3.5-9) and the ODEQ 303d Rationale (Table 3.5-1). These differences may be due to the updated TMDL, sampling locations, and screening limits.

The EPA began sediment sample collection in 2021 from Cottage Grove Reservoir relating to the Black Butte Mine clean up. Sampling is ongoing and 2021 results are pending (CDM Smith 2022) (Section 3.5.2.2, Water Quality Parameters and Subbasin Conditions, Mercury Conditions in the Coast Fork Willamette River and Long Tom River Subbasins).

Pesticide Contaminants in Sediment

Pesticide analyses are performed where there is a history of aerial application to control invasive plant species. To date, none of the in-water sediment samples collected have shown contaminant concentrations above the regional Evaluation Framework freshwater screening levels. Pesticides were detected in forested soils adjacent to Cougar Reservoir during the 2002 sediment sampling event; however, pesticides were not detected above the regional sediment quality guidelines in reservoir sediments.

Table 3.5-9. Summary of Sediment Sampling and Analyses at the 13 Willamette Valley Reservoirs, Willamette River Basin, Oregon.

Subbasin	WVS Dams and Reservoirs	Year Sampled	Parameters Analyzed (Number of Samples)	Above Sediment Evaluation Framework (SEF) Freshwater (FW) Screening Levels (SL)	Notes
North Santiam	Detroit	2010	Metals, PAHs, SVOCs, OC pesticides, PCBs (3 samples at RO)	No	Bis(2-ethylhexyl) phthalate (common in plastics) detected above the SEF FW SL, but dismissed as a laboratory-generated contaminant
		2013	G.S., metals, OC pesticides (5 samples in pool)	No	–
	Big Cliff	2013	G.S.	No	Sediment coarse-grained, so no chemical analysis was performed
South Santiam	Green Peter (Middle Santiam)	2013	G.S., metals, OC pesticides (8 samples)	No	–
	Foster (South Santiam)	2013	G.S., metals, OC pesticides (4 samples)	No	–
McKenzie	Cougar (South Fork McKenzie)	2002	G.S., metals, DDX, phthalates, PAHs (28 samples: 1 downstream, 2 upland upstream, 25 in pool)	No (in pool) No (downstream) Yes (in upland)	Most samples coarse-grained; 17 samples submitted for DDX analysis. DDE and DDT concentrations in an upland sample collected upstream of reservoir exceeded the SEF FW SLs
		2012	G.S., metals, OC pesticides (3 composite samples in pool)	No	–
	Blue River	NOT SAMPLED			
Middle Fork Willamette River	Hills Creek	NOT SAMPLED			
	Lookout Point	2013	G.S., metals, OC pesticides (7 samples in pool)	No	–
	Dexter	2013	G.S., metals, OC pesticides (1 composite sample in pool)	No	–

Subbasin	WVS Dams and Reservoirs	Year Sampled	Parameters Analyzed (Number of Samples)	Above Sediment Evaluation Framework (SEF) Freshwater (FW) Screening Levels (SL)	Notes
Fall Creek	Fall Creek	2012	G.S., metals, OC pesticides (3 composite samples in pool)	No	–
Long Tom	Fern Ridge	2005	G.S., metals, DDX, PCBs, PAHs (9 samples)	No	9 samples total in pool; 4 along the dam face
Row River	Dorena	2017	G.S., metals, OC pesticides (2 composite samples in pool)	No	Metals below SEF FW SLs; no pesticides detected
Coast Fork Willamette River	Cottage Grove	2021	G.S., metals	Results pending	Black Butte Mine Superfund Site upstream of Cottage Grove. EPA is sampling reservoir sediment to determine contamination extent, started in 2021 and ongoing.

Data are available upon request.

SEF FW SL = Sediment Evaluation Framework Freshwater Benthic Toxicity Screening Levels from the 2018 Sediment Evaluation Framework for the Pacific Northwest (Northwest Regional Sediment Evaluation Team (RSET) 2018)

G.S. = grain size

Metals = Antimony (Sb), Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), Silver (Ag), Zinc (Zn); DDX = Dichlorodiphenyltrichloroethane (DDT) and Dichlorodiphenyldichloroethane (DDD), Dichlorodiphenyldichloroethylene (DDE; DDT breakdown products)

OC pesticides = organochlorine pesticides (DDX, chlordane compounds, aldrin, dieldrin, lindane)

PAHs = polynuclear aromatic hydrocarbons; SVOCs = semi-volatile organic compounds

PCBs = polychlorinated biphenyls

3.5.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives on water quality in the analysis area (Section 3.5.2, Affected Environment). The discussion includes the methodology used to assess effects, an analysis of effects by alternative, and a summary of the anticipated effects.

3.5.3.1 Methodology

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The degree of impact on water quality parameters described in Section 3.5.2, Affected Environment, are assessed qualitatively and discussed descriptively (e.g., slight, moderate[18], substantial). Specified criteria to describe the degree of effect are not provided because criteria based on collected data would be speculative (e.g., defining minor or major effects descriptions that correlate to a specific parameter condition), and data are not available for all parameters or dams. Further, water quality conditions would remain adverse with varying degrees of adversity or improvement depending on the alternative. Therefore, descriptions of these effects are more informative and accurate than attempting to assign specific criteria to adverse or beneficial effects.

All effects on water quality parameters from dam operations are considered direct effects unless otherwise indicated.

Water temperature and TDG parameters were modeled and described below with additional detail in Appendix D, Water Quality Analysis, Chapters 1 and 2. Turbidity, harmful algal blooms (also known as cyanobacteria), and mercury parameters were qualitatively analyzed under each alternative, incorporating information from Appendix C, River Mechanics and Geomorphology Technical Information; Appendix B, Hydrological Processes, Section 3.2; and the climate change appendices, Appendix F1, Qualitative Assessment of Climate Change Impacts, and Appendix F2, Supplemental Climate Change Information.

The analysis methodology applied to each parameter is first described below. The environmental consequences of water quality parameters were compared between the No-action Alternative (NAA) and the action alternatives following the methodology information.

Hatcheries in the analysis area are funded by USACE and managed by ODFW. While hatcheries can result in effects on localized and downstream water quality near the hatcheries, none of

[18] "Negligible" is defined in its common use as "too slight or small in amount to be of importance" (Cambridge Dictionary). "Minor" is defined as comparatively unimportant (Merriam-Webster Dictionary). "Slight" is defined in its common use as "small of its kind, or in amount" (Merriam-Webster Dictionary). "Moderate" is defined in its common use as "average in amount, intensity, quality, or degree" (Oxford Languages). "Substantial is defined in its common use as "considerable in quantity, great [in amount]" (Merriam-Webster Dictionary).

the alternatives would alter management affecting water quality at hatcheries as compared to the NAA.

Water Temperature Modeling

Water temperature modeling criteria under the NAA differs from water temperature modeling criteria under the action alternatives. Specifically, the Resource Agency temperature targets were applied to the NAA, while modified temperature targets were applied to the action alternatives. The CE-QUAL-W2 model was applied to simulate water temperatures resulting from the various measures within each alternative. The CE-QUAL-W2 model optimizes water releases from various outlets to meet the designated temperature targets (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data For Water Quality Effects Analysis).

Water temperature was not simulated at Blue River, Fall Creek, Dorena, Cottage Grove, or Fern Ridge Reservoirs. CE-QUAL-W2[19] models do not exist for Blue River or Fern Ridge Reservoirs. At Dorena and Cottage Grove Reservoirs, there would be only a slight difference in operation among the action alternatives as compared to the NAA. At Fall Creek Reservoir, CE-QUAL-W2 modeling was not determined a high priority effort to assess effects under the action alternatives because operations are typically motivated by flood risk management and downstream fish passage with limited ability to affect downstream temperature with current outlet configurations.

Each modeled year represented a different climatological condition: wet year (2011), dry year (2015), and average year (2016). CE-QUAL-W2 reservoir water temperature model output was analyzed for each of the 3 years in each reservoir and immediately downstream (Appendix D, Water Quality Analysis, Section 1.2.2, Model Configuration). Inflow[20], inflow water temperature, air temperature, barometric pressure, wind speed, wind direction, and gate-specific outflow data were used as inputs for each simulation.

To assess effects under the NAA and each action alternative, the hourly water temperature below each dam was used in a calculation of the 7-day Average of the Daily Max (7dADM) water temperature (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data For Water Quality Effects Analysis). The 7dADM water temperature was then compared to the temperature targets at each location to describe the degree of effect on water quality from temperature. The 7dADM of a stream is utilized for life stages of fish species, for example UWR spring Chinook salmon, UWR steelhead, and bull trout, in determining temperature thresholds (OAR 340-041-0028 (4)) (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Temperature).

[19] CE-QUAL-W2 is a two-dimensional (longitudinal/vertical) hydrodynamic reservoir and river model (Wells 2019).

[20] Reservoir Inflows: most runoff to a reservoir is via river tributaries (high stream orders); penetration into stratified strata complex (over-, inter-, and underflows); often flow is directed along old riverbed valleys (Wetzel 2001).

Temperature data are presented in Appendix D, Water Quality Analysis, Section 1.6, Supporting Data For Water Quality Effects Analysis. Modeling description and results are defined below as “Days Near Temperature Target” and “Summer Extremes.”

Days Near Temperature Target

This represents the number of days when the 7dADM water temperature was within 2°F of the temperature target during two timeframes: April to August and September to March as well as the entire year. Temperature targets used in this analysis are those applied in the CE-QUAL-W2 model (Appendix D, Water Quality Analysis, Section 1.4, Temperature Targets).

In most cases, temperature targets used in CE-QUAL-W2 modeling provides an optimal reference point for the natural thermal regime. However, the temperature target at Cougar Reservoir (CGRO) is the 2008 Biological Opinion target (Resource Agency target), which is warmer than simulations during deep drafting of Cougar Reservoir under Alternatives 2B, 3B, and 5 (Table 3.5-10) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Interim Operations were qualitatively assessed for the FEIS temperature analyses. Results from the CE-QUAL-W2 model prepared for the DEIS analyses were considered in development of expected Interim Operations conditions of the 30-year implementation timeframe (Appendix D, Chapter 1, Water Temperature Analysis, Section 1.5.9 and Section 1.6.9).

Table 3.5-10. Average Annual Days within 2 Degrees Fahrenheit of Temperature Target.

Gage Location	NAA	Alt 1	Alt 2A	Alt 2B	Alt 3A	Alt 3B	Alt 4	Alt 5	Interim Operations*
HCRO	69	63	67	63	142	103	157	55	76
DEXO	79	86	84	88	85	110	81	85	86
CGRO	238	248	216	182	186	178	221	177	202
SSFO	126	95	122	123	133	99	128	118	95
GPRO	99	250	183	184	181	105	142	179	99
BCLO	184	282	283	284	170	186	284	283	200

Gage locations:

HCRO = Hills Creek Reservoir, Middle Fork Willamette River Subbasin

DEXO = Dexter Reservoir, Middle Fork Willamette River Subbasin

CGRO = Cougar Reservoir, McKenzie River Subbasin

SSFO = Foster Reservoir, South Santiam River Subbasin

GPRO = Green Peter Reservoir, South Santiam River Subbasin

BCLO = Big Cliff Reservoir, North Santiam River Subbasin

* Interim Operations analysis is based on DEIS CE-QUAL-W2 modeling. CE-QUAL-W2 Interim Operations modeling results were not available for the FEIS. More information can be found in Appendix D, Chapter 1, Water Temperature Analysis, Section 1.5.9 and Section 1.6.9.

Summer Extremes

This represents the number of days when the 7dADM water temperature is below 18°C (64.4°F) (Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis). The 18°C (64.4°F) thresholds correspond to the Oregon State biologically based numeric Water Quality Temperature Standard for salmon and trout rearing and migration (OAR 340-041-0028) and represents "Optimal" conditions for juveniles and adult Chinook salmon as described in White et al. (2022).

Table 3.5-11. Average Days below 18°C (64.4°F) per Year.

Gage Location	NAA	Alt 1	Alt 2A	Alt 2B	Alt 3A	Alt 3B	Alt 4	Alt 5	Interim Operations
HCRO	347	341	333	326	331	301	319	316	339
DEXO	165	156	169	169	135	159	150	168	162
CGRO	226	226	226	226	226	226	226	220	202
SSFO	205	170	208	208	209	160	224	212	220
BCLO	224	224	224	224	180	224	224	224	224
ALBO	130	125	130	130	121	128	126	131	129
SLMO	132	124	132	130	125	130	127	133	132

Gage locations:

HCRO = Hills Creek Reservoir, Middle Fork Willamette River Subbasin

DEXO = Dexter Reservoir, Middle Fork Willamette River Subbasin

CGRO = Cougar Reservoir, McKenzie River Subbasin

SSFO = Foster Reservoir, South Santiam River Subbasin

GPRO = Green Peter Reservoir, South Santiam River Subbasin

BCLO = Big Cliff Reservoir, North Santiam River Subbasin

ALBO = Albany, Mainstem Willamette River

SLMO = Salem, Mainstem Willamette River

Total Dissolved Gas Modeling

TDG model development utilized empirical models based on measured TDG and operations data. The TDG model was used to provide TDG estimates for the period between 1936 and 2019 (referred to as the period of record in Appendix D, Water Quality Analysis, Chapter 2, Total Dissolved Gas).

Dam releases from non-turbine outlets (defined as “spill”) are known to produce elevated TDG. The average number of days with spill per year are compared between the NAA and each alternative and dam (Appendix D, Water Quality Analysis, Chapter 2, Total Dissolved Gas). Locations and alternatives with relatively higher TDG are identified. Generally, TDG is generated initially at the high-head dam when spill occurs (e.g., Detroit Dam) and can increase downstream if spill occurs at the downstream re-regulating dam (e.g., Big Cliff Dam).

Available data from Detroit/Big Cliff, Green Peter/Foster, Lookout Point/Dexter, Hills Creek, and Cougar Dams were utilized to simulate TDG utilizing the Willamette TDG (WILTDG) model. Modeling analyses were not conducted for Fall Creek and Blue River Dams because dam operations are not known to result in elevated TDG.

Impacts at Green Peter, Hills Creek, and Lookout Point Dams are under-estimates; extensive TDG data from spillgate operations at these dams did not exist at the time the alternatives in this EIS were analyzed. The number of days with spill may be an appropriate proxy metric for effects at these locations (Appendix D, Water Quality Analysis, Chapter 2, Total Dissolved Gas).

The WILTDG model was adapted from the Columbia River System TDG model. The Columbia System Total Dissolved Gas (commonly referred to as SYSTDG) is an empirical (data-driven) model depending primarily on spill outflow (non-turbine releases) and power outflow (turbine releases) at each dam. The period of record used by the HEC-ResSim modeling was applied to the WILTDG model at the locations listed above under each alternative (Appendix D, Water Quality Analysis).

The WILTDG model output includes estimated TDG based on dam and reservoir operations and the annual number of days above 110 percent (Table 3.5-12) (Appendix D, Water Quality Analysis, Chapter 2, Total Dissolved Gas). TDG results are compared to the State of Oregon water quality standards (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Total Dissolved Gas).

Table 3.5-12. Average Number of Days that Total Dissolved Gas Levels are above 110 Percent.

Gage Location	NAA	Alt 1	Alt 2A	Alt 2B	Alt 3A	Alt 3B	Alt 4	Alt 5	Interim Operations
DEX	20	5	20	20	53	62	5	20	52
LOP	0	0	0	0	0	0	0	0	15
HCR	19	18	18	18	13	19	18	18	16
CGR	57	16	54	27	77	26	17	15	135
FOS	32	20	126	126	127	69	19	126	73
GPR	12	13	151	151	151	62	117	151	79
BCL	148	31	80	80	312	226	37	80	295
DET	115	39	39	39	307	203	39	39	276

Gage locations:

DEX = Dexter Reservoir, Middle Fork Willamette River Subbasin

LOP = Lookout Point Reservoir, Middle Fork Willamette River Subbasin

HCR = Hills Creek Reservoir, Middle Fork Willamette River Subbasin

CGR = Cougar Reservoir, McKenzie River Subbasin

FOS = Foster Reservoir, South Santiam River Subbasin

GPR = Green Peter Reservoir, South Santiam River Subbasin

BCL = Big Cliff Reservoir, North Santiam River Subbasin

DET = Detroit Reservoir, North Santiam River Subbasin

USACE has updated TDG regression equations for tailwaters below Big Cliff, Cougar, Foster, and Dexter Dams using data from 2011 to 2020. The equations will assist in real-time WVS operations and allow a quantified comparison of TDG resulting from operations in the

Willamette Valley under any alternative (Appendix D, Water Quality Analysis, Chapter 2, Total Dissolved Gas).

The TDG analysis for Interim Operations was qualitatively assessed for the FEIS analyses. Results from the model and methodology for the DEIS analyses were considered in development of expected Interim Operations conditions over the 30-year implementation timeframe (Appendix D, Water Quality Analysis, Chapter 2, Total Dissolved Gas, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity Qualitative Methodology

The turbidity analyses are qualitative and based on field data collected during deep drawdown operations and fine-grained sediment information provided in Appendix C, River Mechanics and Geomorphology Technical Information, Chapter 2, Alternative Comparison Summaries.

For this qualitative analysis, it was assumed that sediment supply from rivers upstream of WVS dams, or tributaries to the WVS-impacted reaches that are not downstream of a WVS reservoir, would be the same under any action alternative as under the NAA (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Turbidity, Sediment Quality).

Harmful Algal Blooms and Cyanobacteria Qualitative Methodology

The harmful algal bloom analyses are qualitative and based on harmful algal bloom occurrence from monthly synoptic surveys and reservoir analyses (Appendix D, Water Quality Analysis, Chapter 4, Other In-Reservoir Water Quality Background Information, Section 4.3) (Appendix C, River Mechanics and Geomorphology Technical Information, Chapter 2, Alternative Comparison Summaries, Head-of-Reservoir, Sediment Re-entrainment). The analyses also incorporate information from Appendix F1, Qualitative Assessment of Climate Change Impacts, and Appendix F2, Supplemental Climate Change Information.

Metrics were utilized to describe potential availability of nutrients and algae blooms associated with sediment under any alternative. Metrics include sediment movement into the reservoir (head-of-reservoir) and sediment that could pass through a storage reservoir (reservoir-supplied sediment) (Appendix C, River Mechanics and Geomorphology Technical Information, Chapter 2, Alternative Comparison Summaries, Head-of-Reservoir, Sediment Re-entrainment).

Head-of-Reservoir Metric

The transition from riverine to reservoir conditions can shift upstream and downstream considerable distances at dams that have large amounts of storage volume and operate over a wide range of elevations throughout the year. The head-of-reservoir sediment mobilization metric indicates the potential for changes in sediment scour and deposition patterns in the most upstream portion of storage reservoirs as they may impact nutrient availability within sediments for algae.

Sediment Entrainment Metric

The sediment re-entrainment metric estimates the potential for changes for reservoir supplied sediment under each alternative as compared to the NAA in the amount of sediment that can deposit within or pass through the storage reservoirs. Wind-wave erosion on stored fines and rarely exposed banks are also drivers for changes in sediment supply internal to the reservoir.

Mainstem Willamette River

The Mainstem Willamette River was not analyzed for harmful algal bloom effects under any alternative because the metrics used to describe the potential increase of algal blooms are for storage-based dams (i.e., reservoir storage); the Mainstem Willamette River is not a reservoir and does not store water (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Harmful Algal Blooms).

Mercury Qualitative Methodology

The mercury analyses are qualitative and based on reservoir analyses provided in Appendix C, River Mechanics and Geomorphology Technical Information, Chapter 2, Alternative Comparison Summaries, Reservoir-supplied Sediment. The analyses also incorporate information from Appendix F1, Qualitative Assessment of Climate Change Impacts, and Appendix F2, Supplemental Climate Change Information.

The reservoir-supplied sediment metric is included in the run-of-river and free-flowing reach metric for sediment supply. This metric is used to describe the potential effect or increases in sediment supply internal to the reservoir from bed sediments passing downstream through a dam.

It is acknowledged that anoxic conditions[21] are also a factor in the methylation of mercury due to the role of sulfate-reducing bacteria and nutrient loading (Chen et al. 1997; Dent et al. 2014). Currently, USACE does not have the capability to simulate dissolved oxygen in the available models; however, dissolved oxygen is typically above 50 percent at most reservoirs throughout the summer, except for Fern Ridge, Fall Creek, Dorena, and Cottage Grove Reservoirs where periods of low dissolved oxygen can exist for some periods (typically late summer) (Appendix D, Water Quality Analysis, Chapter 4, Other In-Reservoir Water Quality Background Information). Qualitative mercury methylation impacts are best estimates based on current understanding of dissolved oxygen, mercury data, methylation data, and methylation potential at each reservoir at the time the alternatives were analyzed.

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[21] Anoxia is a condition of no, or at times very little, dissolved oxygen in marine or freshwater systems (Diaz 2016).

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3.5.3.2 Alternatives Analyses

Overall, effects on water quality from water temperature, TDG, turbidity, harmful algal blooms, and mercury under any alternative are summarized as direct, adverse impacts at some time during a given year over the 30-year implementation timeframe. However, measures incorporated into some of the action alternatives would provide benefits to water quality parameters, therefore resulting in improvements in water quality conditions over the 30-year implementation timeframe when compared to the NAA. It is assumed that adverse conditions would continue although temperature targets would be met to varying degrees depending on the alternative.

For example, although temperature targets would be mostly met under some alternatives, impacts to water quality from temperature conditions would remain adverse because targets would not be fully met. Additionally, temperature simulations demonstrate beneficial improvements from temperature management measures included under the action alternatives. However, such improvements would not be possible during extremely hot and dry conditions under some action alternatives. Such extreme environmental conditions are included in the analyses to foster informed decision-making but do not diminish the overall beneficial improvements to ongoing adverse water quality conditions under the action alternatives.

Topography and sediment characteristics in the North Santiam River Subbasin have a relatively high likelihood of turbidity, which would continue during the 30-year implementation timeframe under all alternatives. At Fern Ridge Reservoir, the typical annual turbidity increases during August would continue to have an adverse effect under all alternatives (ODEQ 2022a). All subbasins may experience temporary, substantial, adverse effects from turbidity caused by large atmospheric river storm events, upstream landslides in the watershed, land management practices, or wildfire during the 30-year implementation timeframe under all alternatives.

A summary of effects in each subbasin is provided in Tables 3.5-13 through 3.5-18 at the end of this section (Section 3.5, Water Quality).

<u>Construction and Routine and Non-routine Maintenance under All Action Alternatives</u>

Effects on water quality may occur as part of specific construction activities during alternative implementation and would be the same under any alternative involving construction. Qualitative effects on water quality parameters from construction are analyzed at the programmatic level. Site-specific project details for each construction measure would be determined during a construction implementation phase.

Direct effects from construction of selective withdrawal structures at Detroit, Lookout Point, Green Peter, and Hills Creek Dams and the proposed long drawdown at Cougar Dam to construct the outlet works for routine use of the diversion tunnel under all action alternatives may limit temperature management, increase turbidity, and result in TDG exceeding the water quality standard levels. These construction activities would likely have short-term (generally less than 2 years), temporary, direct adverse effects on water quality parameters. Indirect effects are uncertain and require site-specific construction details before an assessment of impacts can be made.

Similarly, routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation). There would not likely be direct adverse impacts on water quality from routine maintenance activities because most would occur on dam structures and not require activities that would affect water quality throughout a reservoir or downstream of a dam.

Non-routine, major maintenance activities may temporarily adversely affect water supply from construction. Major maintenance would require site-specific NEPA review prior to initiation at any location in the analysis area. Additional analyses are not provided under each alternative.

No-action Alternative

Water quality effects under the NAA would be a continuation of water quality conditions from operations of the WVS up to the 2019 data collection period (Section 3.5.2, Affected Environment). The Affected Environment describes conditions through 2024 to provide the best available information on water quality condition in the analysis area. However, the NAA is an analysis of 2019 operations. The NAA is referenced as 2019 water quality conditions under each alternative analysis, which is defined to include conditions leading up to and including 2019 WVS operations.

Anticipated monthly mean water temperature at each major stream gage location immediately below the WVS dams under the NAA are shown in Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis (excluding the Coast Fork Willamette River and Long Tom River tributaries).

Turbidity in All Subbasins

Under the NAA, sediment-related processes are anticipated to occur in all subbasins as described up to 2019 conditions, resulting in adverse effects on water quality from turbidity. WVS reservoirs can trap sediment from the upstream watershed during high-flow events, which can moderate adverse effects by reducing turbidity downstream of the dams. Trapping sediment would be a beneficial effect.

Under the NAA, there would be a deep fall drawdown at Fall Creek Reservoir resulting in temporary elevation of suspended sediment levels discharged from the dam (USGS 2023). Minor, short-term, adverse effects from temporary elevated turbidity may occur under the NAA at this location over the 30-year implementation timeframe.

Dam operations under the NAA would not cause measurable adverse effects on water quality from turbidity in the Mainstem Willamette River. There is no indication that water quality criteria for turbidity are exceeded under existing conditions with ongoing WVS operations. Therefore, NAA operations would alter this water quality condition in the Mainstem Willamette River.

Although continuation of both adverse and beneficial effects to turbidity would occur under the NAA during the 30-year implementation timeframe, the degree of effect on water quality would have minor variation across subbasins depending on geography, climate conditions, and seasonal reservoir operations affecting turbid water conditions in the analysis area (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions) (Appendix C, River Mechanics and Geomorphology Technical Information, Chapter 2, Alternative Comparison Summaries).

Harmful Algal Blooms in All Subbasins

Under the NAA, head-of-reservoir sediment mobilization and sediment re-entrainment are anticipated to occur in all subbasins as described up to 2019 conditions (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions) (Appendix C, River Mechanics and Geomorphology Technical Information, Chapter 2, Alternative Comparison Summaries). Operations at dams with deep outlets would continue to avoid releasing surface water that may contain cyanotoxins when conditions allow, having a beneficial effect on downstream water quality. Due to the potential for harmful algal blooms to occur at some reservoirs in some years and under various conditions, a slight, adverse effect from harmful algal blooms is expected under the NAA over the 30-year implementation timeframe.

Mercury in All Subbasins

Under the NAA, operations would not change from 2019 conditions; therefore, water storage patterns, seasonal elevations, sediment loading, and sediment properties would likely remain the same for the 30-year implementation timeframe. Shoreline exposure and reservoir-supplied sediment supply under typical, annual, NAA operations would have the potential for mercury methylation through the wetting and drying of shoreline bed sediments at some sites, as with 2019 conditions.

Dissolved oxygen is expected to remain above 50 percent in most reservoirs throughout the summer season under the NAA, which would prevent mercury methylation from occurring over the 30-year implementation timeframe. However, periods of low dissolved oxygen could occur in Fern Ridge, Fall Creek, Dorena, and Cottage Grove Reservoirs. These low dissolved oxygen periods would occur typically in late summer and have increased potential for mercury methylation (Appendix D, Water Quality Analysis, Chapter 4, Other In-Reservoir Water Quality Background Information). Therefore, moderate[22] adverse effects on water quality from

[22] "Moderate" is not used as a specified criteria in this analysis. It is defined here in its common use as "average in amount, intensity, quality, or degree" (Oxford Languages).

mercury are expected at Fern Ridge, Fall Creek, Dorena, and Cottage Grove Reservoirs, while slight adverse effects from mercury are expected at all other WVS reservoirs under the NAA.

No analysis has been conducted for shoreline exposure on the Mainstem Willamette River because no storage operations occur on the mainstem (Section 3.5.3.1, Methodology, Mercury Qualitative Methodology). However, due to the slight potential for some methylation of mercury in the upstream WVS reservoirs and downstream conveyance under the NAA, there would be a slight adverse effect from mercury on water quality in the Mainstem Willamette River under the NAA.

North Santiam River Subbasin

Water Temperature

Under the NAA, there would be a moderate adverse effect to water quality from temperature conditions in the North Santiam River Subbasin.

- Modeled water temperatures below Detroit and Big Cliff Dams would be within 2°F of the temperature target for 126 days per year on average as compared to 365 days in a year.
- Modeled water temperatures below Detroit and Big Cliff Dams would be below the 64.4°F temperature threshold for 224 days per year on average as compared to 365 days in a year (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Under the NAA, temperature targets would be met in the spring and summer because the spillway gate at Detroit Dam would be operated to release warmer surface water. However, under the NAA, temperature targets would not be met in the fall and winter because, while this operation would assist in limiting the amount of warm water that has accumulated during the summer, warm water would still be released in the fall when the reservoir is drafted, thereby not meeting temperature targets.

Overall, operations and maintenance under the NAA would result in continuation of an adverse effect on water quality from temperature conditions in the North Santiam River Subbasin during the 30-year implementation timeframe. However, exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and on specific dam operations. For example, water temperatures would mostly meet the temperature targets in the North Santiam River Subbasin.

Total Dissolved Gas

Under the NAA, there would be a moderate adverse effect on water quality because TDG levels would continue to be above 110 percent, thereby exceeding water quality standards. This would result from spill operations for flood risk and water temperature management, which would continue as described under the Affected Environment at both dams in the North

Santiam River Subbasin (i.e., Detroit and Big Cliff Dams) (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Total Dissolved Gas Conditions in the North Santiam Subbasin).

Under the NAA, the average number of days per year above 110 percent TDG exceedance of the water quality standard below Detroit Dam is modeled to be 115 days and 148 days below Big Cliff Dam. These exceedances would typically coincide with spill operations for flood risk management and temperature operations (Table 3.5-12) (Appendix D, Water Quality Analysis, Chapter 2, Total Dissolved Gas).

Although an adverse effect on water quality from TDG exceeding the water quality standards would continue under the NAA, exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations. For example, adverse effects may only occur during a few months of a given year based on target achievement for the North Santiam River Subbasin.

South Santiam River Subbasin

Water Temperature

Under the NAA, there would be a moderate adverse effect to water quality from temperature conditions in the South Santiam River Subbasin. Adverse effects would be greater below Green Peter Dam than below Foster Dam because:

- Modeled water temperatures below Foster Dam would be below the 64.4°F temperature threshold for 205 days per year on average and would be within 2°F of the temperature target for 126 days per year on average as compared to 365 days in a year.
- Modeled water temperatures would be within 2°F of the temperature target below Green Peter Dam for 99 days per year on average as compared to 365 days in a year (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Overall, there would be limited temperature management capabilities under the NAA at Green Peter Dam where released water would be below the temperature target in spring and summer and above the target in the fall. Spillway and weir operations at Foster Dam would assist with releasing warmer, more seasonal surface water during the summer for upstream migration.

Under the NAA, temperature targets would not be met in the fall and winter because while spillway and weir operations would assist in limiting the amount of warm water that has accumulated during the summer, warm water would be released in the fall when the reservoirs are drafted, thereby not meeting temperature targets.

Overall, operations and maintenance under the NAA would result in continuation of substantial adverse effects on water quality in the Middle Santiam River from temperature conditions below Green Peter Dam during the 30-year implementation timeframe. However, water temperatures would mostly meet the temperature targets in the South Santiam River below Foster Dam.

Total Dissolved Gas

Under the NAA, there would be a slight adverse effect on water quality in the South Santiam River Subbasin because TDG levels would continue to be above 110 percent, thereby exceeding water quality standards. This would result from spill operations for flood risk and water temperature management, which would continue as described at both dams in this subbasin up to 2019 conditions (i.e., Green Peter and Foster Dams) (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Total Dissolved Gas Conditions in the South Santiam River Subbasin).

Under the NAA, the average number of days per year above 110 percent TDG exceeding the water quality standards below Green Peter Dam is modeled to be 12 days and below Foster Dam to be 32 days. Green Peter impacts are underestimated as TDG data from spillgate operations did not exist when the alternatives were analyzed. These exceedances would typically coincide with spill operations for flood risk management and temperature operations (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Although an adverse effect on water quality from TDG exceeding the water quality standards would continue under the NAA, exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations. For example, adverse effects may only occur during a few months of a given year based on target achievement for the South Santiam River Subbasin.

McKenzie River Subbasin

Water Temperature

Under the NAA, there would be a slight adverse effect to water quality from temperature conditions in the McKenzie River Subbasin. However, operation of the water temperature control tower at Cougar Dam would result in benefits to water quality downstream of Cougar Dam during the 30-year implementation timeframe.

- Modeled water temperatures below Cougar Dam would be below the 64.4°F temperature threshold for 226 days per year on average and temperature would be within 2°F of the temperature target 238 days per year on average as compared to 365 days in a year (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

The water temperature control tower would continue to control water releases and outflows until reaching the forebay elevation of 1,561 feet under the NAA. Temperature targets would not be met in the fall and winter because there would be limited control once the reservoir is below 1,561 feet elevation. Warm water would be released in the fall when Cougar Reservoir is drafted, thereby not meeting temperature targets.

- Blue River Dam does not have a selective withdrawal structure; however, state water temperature targets are met for most of the year from February through May (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions).

Overall, operations and maintenance under the NAA would result in continuation of adverse effects on water quality from temperature conditions in the McKenzie River Subbasin. Although the water temperature control tower at Cougar Dam would continue to provide a benefit to water temperature conditions downstream of Cougar Dam, water temperature targets would not be met at all locations in the McKenzie River Subbasin at all times over the 30-year implementation timeframe.

Total Dissolved Gas

Under the NAA, there would be a moderate adverse effect on water quality in the McKenzie River Subbasin because TDG levels would continue to be above 110 percent, thereby exceeding water quality standards. This would result from spill operations for flood risk and water temperature management, which would continue as described under the Affected Environment (i.e., Cougar Dam) (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Total Dissolved Gas Conditions in the McKenzie Subbasin).

Under the NAA, the average number of days per year exceeding the water quality standard for TDG (above 110 percent) below Cougar Dam is modeled to be 57 days. These exceedances would typically coincide with spill operations for flood risk management and temperature operations (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis). There is no TDG analysis for Blue River Dam because there are no TDG gages to provide data for this river (Section 3.5.3.1, Methodology, Total Dissolved Gas Modeling).

Overall, operations and maintenance under the NAA would result in continuation of adverse effects on water quality in the McKenzie River Subbasin because of the continuation of TDG water quality standard exceedances. However, exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations. For example, adverse effects may only occur during a few months of a given year based on target achievement for the McKenzie River Subbasin.

Middle Fork Willamette River Subbasin

Water Temperature

Under the NAA, there would be a moderate adverse effect to water quality from temperature conditions in the Middle Fork Willamette River Subbasin because water temperatures would not meet temperature targets most of the year below Hills Creek Dam, Lookout Point/Dexter Dam, and Fall Creek Dam.

Operations under the NAA would mostly meet modeled temperatures because water temperature does not typically increase above 64.4°F during the summer and mostly meets the temperature targets for fish migration and holding at Hills Creek Dam. Hills Creek Dam has limited temperature control capabilities; warm surface water that accumulates in the summer would be released in the fall each year under the NAA.

- Modeled water temperatures below Hills Creek Dam would be below the 64.4°F temperature threshold for 347 days per year on average and would be within 2°F of the temperature target for 69 days per year on average as compared to 365 days in a year (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Modeled water temperatures below Lookout Point/Dexter Dams would be below the 64.4°F temperature threshold for 165 days per year on average or be within 2°F of the temperature target for 79 days per year on average as compared to 365 days in a year (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis). This is because of limited temperature control capabilities at Lookout Point and Dexter Dams due to their lower elevation in the subbasin. Both dams contribute to warm summer maximum release temperature. Additionally, accumulated warm surface water in the summer would be released in the fall each year below Dexter Dam.
- A model analysis of 2019 conditions was not performed for Fall Creek Dam (Section 3.5.3.1, Methodology, Water Temperature Modeling). Adverse effects are observed due to structural limitations (i.e., fish horn elevations) needed to blend water temperatures and would continue in the subbasin under the NAA (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Temperature Conditions in the Coast Fork Willamette River and Long Tom River Subbasins). Regardless, due to the informal temperature operations utilizing the fish horns, temperature targets would mostly be met throughout the year under the NAA during the 30-year implementation timeframe.

Overall, operations and maintenance under the NAA would result in continuation of moderate adverse effects on water quality from temperature conditions during the 30-year implementation timeframe. However, exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and on specific dam operations.

Total Dissolved Gas

Under the NAA, there would be a slight adverse effect on water quality in the Middle Fork Willamette River Subbasin because TDG levels would continue to be above 110 percent, thereby exceeding the state water quality standard. This would result from spill operations for flood risk and water temperature management, which would continue as described under the

Affected Environment (i.e., Hills Creek, Lookout Point, Dexter, and Fall Creek Dams) (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Total Dissolved Gas Conditions in the Middle Fork Willamette River Subbasin).

Under the NAA, the average number of days per year above 110 percent TDG exceeding the water quality standards below Hills Creek Dam is modeled to be 10 days, 0 days below Lookout Point Dam, and 20 days below Dexter Dam. These exceedances would typically coincide with spill operations for flood risk management and temperature operations and have a slight adverse effect (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Effects on water quality from TDG below Fall Creek Dam cannot be determined because there is no TDG gage to provide existing data or analysis (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Total Dissolved Gas Conditions in the Middle Fork Willamette River Subbasin). However, operations under the NAA are expected to continue as under 2019 conditions; therefore, effects on water quality from TDG at Fall Creek Dam would be the same as those described under the NAA over the 30-year implementation timeframe.

Overall, operations and maintenance under the NAA would result in continuation of adverse effects on water quality in the Middle Fork Willamette River Subbasin because of the continuation of TDG water quality standard exceedances. However, exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations. For example, adverse effects may only occur during a few months of a given year based on target achievement for the Middle Fork Willamette River Subbasin.

Coast Fork Willamette River and Long Tom River Subbasins

Water Temperature

As of 2024, TMDL water temperature targets are identified, but there are no 7dADM state water temperature targets for the Coast Fork Willamette River and Long Tom River Subbasins; therefore, there is no model analysis of water temperature for either subbasin (Section 3.5.3.1, Methodology, Water Temperature Modeling). Effects are qualitatively based on TMDL temperature targets, which occur from April through November.

Under the NAA, there would be a moderate adverse effect to water quality; however, water temperatures would mostly meet TMDL temperature targets in the Coast Fork Willamette River and Long Tom River Subbasins. These effects would likely occur throughout the year. This is because there would be no water temperature management operations implemented. Adverse effects on water temperatures would occur because stream temperatures would exceed the TMDL temperature target in the fall in this subbasin (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Temperature Conditions in the Coast Fork Willamette River and Long Tom River Subbasins).

Overall, operations and maintenance under the NAA would result in continuation of an adverse effect on water quality from temperature conditions during the 30-year timeframe. However, exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and on specific dam operations. For example, water temperatures would mostly meet the temperature targets in the Coast Fork Willamette River and Long Tom River Subbasins.

Total Dissolved Gas

Effects on water quality from TDG below Cottage Grove, Dorena, or Fern Ridge Dams cannot be determined because there are no TDG gages to provide existing data or analyses (Section, 3.5.3.1, Methodology, Total Dissolved Gas Modeling). However, operations under the NAA are expected to continue as under 2019 conditions; therefore, effects on water quality from TDG below these dams would be the same as described under the NAA over the 30-year implementation timeframe (Section 3.5.2.2, Water Quality Parameter Overview and Subbasin Conditions, Total Dissolved Gas Conditions in the Coast Fork Willamette River and Long Tom River Subbasin).

Mainstem Willamette River

Water Temperature

There are no WVS dams located on the Mainstem Willamette River; however, water releases downstream of the WVS dams can assist in temperature regulation on the Willamette River. Temperature targets are only available for summer extremes (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Under the NAA, there would be a slight, adverse effect on water quality from temperature conditions; however, water temperatures would mostly meet temperature targets on the Mainstem Willamette River.

- Modeled water temperatures on the Mainstem Willamette River near Albany would be below the 64.4°F temperature threshold for 130 days per year on average as compared to 365 days in a year.
- Modeled water temperatures on the Mainstem Willamette River near Salem would be below the 64.4°F temperature threshold for 132 days per year on average as compared to 365 days in a year.

Both sites on the Mainstem Willamette River observe warmest temperatures in July and August.

Overall, operations and maintenance under the NAA would result in continuation of an adverse effect on water quality from temperature conditions on the Mainstem Willamette River during the 30-year implementation timeframe. However, exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and on specific dam operations.

Total Dissolved Gas

TDG is presumed not to be adverse on the mainstem river because TDG is a water quality parameter most affected by dam operations. Gages are typically located downstream of WVS dams where they are placed to record TDG. There are no dam operations or, to USACE's knowledge, TDG gages on the Mainstem Willamette River. Consequently, there are no data to provide trends in TDG levels related to the Mainstem Willamette River. Although TDG levels and associated effects in the Mainstem Willamette River cannot be determined, TDG under NAA operations are assumed to be the same as existing, non-adverse conditions.

Alternative 1—Improve Fish Passage through Storage-focused Measures

North Santiam River Subbasin

Water Temperature

As under the NAA, operations under Alternative 1 would result in adverse effects to water quality during times of year when temperature targets are not met. However, unlike the NAA, a selective withdrawal structure would be operated at Detroit Dam under Alternative 1 resulting in beneficial effects to water quality from improved temperature conditions downstream of Detroit and Big Cliff Dams and substantially fewer adverse effects as compared to the NAA. Temperature targets would be met more often during an average year under Alternative 1 as compared to the NAA.

Specifically, under Alternative 1 as compared to the NAA:

- Modeled water temperatures below Detroit and Big Cliff Dams would be within 2°F of the water temperature target more often as compared to the NAA by 97 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Exceedance of the 64.4°F temperature threshold would remain the same as under the NAA.

Total Dissolved Gas

Under Alternative 1, there would be a trend toward more beneficial effects to water quality from TDG impacts in the North Santiam River Subbasin than under the NAA. Operations under Alternative 1 would include structural improvements to reduce TDG and construction of a selective withdrawal structure at Detroit Dam. The selective withdrawal structure would reduce the need to manage water temperature through spill operations. Subsequently, a reduction of spill operations at Detroit Dam under Alternative 1 would also reduce the average number of days per year above 110 percent TDG exceedance of the water quality standard and would result in substantially fewer adverse effects as compared to the NAA.

Specifically, under Alternative 1 as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Detroit Dam by 77 days per year on average.
- There would be a decrease in TDG exceedance of the water quality standard below Big Cliff Dam by 117 days per year on average resulting in an approximate 60 percent to 80 percent reduction of TDG levels compared to the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

While reductions in TDG are expected from operations under Alternative 1, there would be an adverse effect on water quality from ongoing TDG levels during the 30-year implementation timeframe regardless of beneficial trends toward meeting TDG targets as compared to the NAA in the North Santiam River Subbasin.

Turbidity

Under Alternative 1, effects on water quality from turbidity would be the same as those described under the NAA. Outflow and storage operations under Alternative 1 as compared to NAA operations are not expected to affect head-of-reservoir sediment mobilization or sediment trap efficiency in Detroit Reservoir.

Harmful Algal Blooms

Under Alternative 1, effects on water quality from harmful algal blooms would be slightly more adverse compared to the NAA during the 30-year implementation timeframe. Operations under Alternative 1 as compared to NAA operations may reduce releases of deeper reservoir water. These operations would avoid releasing surface water that may contain cyanotoxins during dry years in Detroit Reservoir when a harmful algal bloom exists.

Mercury

Under Alternative 1, effects on water quality from mercury would be slightly more adverse than under the NAA during the 30-year implementation timeframe. Outflow and storage operations under Alternative 1 as compared to NAA operations may increase the amount of shoreline exposure during late summer of dry years in Detroit Reservoir, which would contribute to mercury methylation.

South Santiam River Subbasin

Water Temperature

Adverse effects on water quality from temperature conditions in the South Santiam River Subbasin would continue as under the NAA; however, these effects would trend toward a beneficial effect on water temperature below Green Peter Dam due to the proposed selective withdrawal structure under Alternative 1 and slightly fewer adverse effects as compared to the NAA.

As under the NAA, adverse effects would occur below Foster Dam at certain times of year because total outflow water temperature from Foster Dam would be affected by upstream operations at Green Peter Dam. This effect would result in warmer summer temperatures and cooler fall temperatures, which would result in a slightly less adverse effect as compared to the NAA.

Specifically, under Alternative 1 as compared to the NAA:

- Modeled water temperatures below Green Peter Dam would be within 2°F of the water temperature target more often as compared to the NAA by 151 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

- Modeled water temperatures below Foster Dam would be within 2°F of the water temperature target less often as compared to the NAA by 31 days per year on average. Modeled water temperatures below Foster Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 35 days per year on average.

Total Dissolved Gas

Under Alternative 1, adverse effects on water quality from TDG would occur during some times of the year, but operations under Alternative 1 would result in beneficial effects to water quality. Beneficial effects would occur because, although TDG levels would be above 110 percent, the average number of days per year above 110 percent TDG exceedance of the water quality standard below the Santiam River Dams would be slightly less adverse as compared to operations under the NAA in the South Santiam River Subbasin.

Improvements in TDG would result from structural improvements to reduce TDG under Alternative 1 and construction of a selective withdrawal structure at Green Peter Dam. Green Peter Dam impacts are underestimated because TDG data from spillgate operations did not exist when the alternatives were analyzed. There would be an overall reduction in TDG exceedance of the water quality standard below the South Santiam River dams under Alternative 1 as compared to the NAA.

Specifically, under Alternative 1 as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Green Peter Dam by 1 day per year on average.
- There would be a decrease in TDG exceedance of the water quality standard below Foster Dam by 12 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 1 would result in adverse effects on water quality regardless of a slight improvement in meeting TDG targets as compared to the NAA in the South Santiam River Subbasin because TDG standards would not be met at all times.

Turbidity

Under Alternative 1, effects on water quality from turbidity would be the same as those described under the NAA during the 30-year implementation timeframe. Outflow and storage operations under Alternative 1 are not expected to affect head-of-reservoir sediment mobilization or sediment trap efficiency in Green Peter Reservoir.

Harmful Algal Blooms

Under Alternative 1, effects on water quality from harmful algal blooms would be slightly more adverse compared to the NAA during the 30-year implementation timeframe. Operations under Alternative 1 as compared to NAA operations may reduce releases of deeper reservoir water. These operations would avoid releasing surface water that may contain cyanotoxins during dry years in Green Peter Reservoir when a harmful algal bloom exists.

Mercury

Under Alternative 1, effects on water quality from mercury would be slightly more adverse compared to the NAA during the 30-year implementation timeframe. Outflow and storage operations under Alternative 1 as compared to NAA operations may increase the amount of shoreline exposure during late summer of dry years in Green Peter Reservoir and contribute to mercury methylation.

McKenzie River Subbasin

Water Temperature

Under Alternative 1, effects on water quality from temperature conditions in the McKenzie River Subbasin would continue to be adverse during times of the year when temperature targets are not met as under NAA operations. However, adverse effects would trend toward a beneficial effect because of a slightly less adverse effect from water temperatures downstream of Cougar Dam that would occur because of the lower downstream flow requirement resulting in more days with access to the temperature control tower in drier years as compared to the NAA.

Specifically, under Alternative 1 as compared to the NAA:

- Modeled water temperatures below Cougar Dam would be within 2°F of the water temperature target more often as compared to the NAA by 10 days per year on average.
- Exceedance of the 64.4°F temperature threshold below Cougar Dam would be the same as under the NAA (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Total Dissolved Gas

Adverse effects on water quality from TDG when TDG standards are not met would continue under Alternative 1 operations in the McKenzie River Subbasin as under NAA operations. However, Alternative 1 operations would result in slightly fewer adverse effects to TDG conditions below Cougar Dam as compared to the NAA.

TDG levels would be above 110 percent under Alternative 1, but the average number of days above 110 percent TDG exceedance of the water quality standard below Cougar Dam would be less as compared to the NAA. This slight improvement would result from structural improvements to reduce TDG under Alternative 1.

Specifically, under Alternative 1 as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Cougar Dam by 41 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, TDG Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 1 would result in adverse effects on water quality in the McKenzie River Subbasin regardless of a slight improvement in meeting TDG targets as compared to the NAA.

Turbidity

Under Alternative 1, effects on water quality from turbidity would be the same as those described under the NAA during the 30-year implementation timeframe. Outflow and storage operations under Alternative 1 as compared to NAA operations are not expected to affect head-of-reservoir sediment mobilization or sediment trap efficiency in Blue River and Cougar Reservoirs.

Harmful Algal Blooms

Under Alternative 1, effects on water quality from harmful algal blooms would be slightly more adverse compared to the NAA during the 30-year implementation timeframe. Operations under Alternative 1 as compared to NAA operations may reduce releases of deeper reservoir water. These operations would avoid releasing surface water that may contain cyanotoxins during dry years in Blue River and Cougar Reservoirs when a harmful algal bloom exists.

Mercury

Under Alternative 1, effects on water quality from mercury would be slightly more adverse compared to the NAA during the 30-year implementation timeframe. Outflow and storage operations under Alternative 1 as compared to NAA operations may increase the amount of shoreline exposure during late summer of drier years in Blue River and Cougar Reservoirs, which would contribute to mercury methylation.

Middle Fork Willamette River Subbasin

Water Temperature

Under Alternative 1, effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue to be adverse, similar to effects described under the NAA. Minimal improvements in temperature conditions would occur under Alternative 1 operations. The differences in the number of days that temperatures would meet targets would not alter the overall adverse effect on water quality from temperature in this subbasin.

Specifically, under Alternative 1 as compared to the NAA:

- Modeled water temperatures below Hills Creek Dam would be within 2°F of the water temperature target less often as compared to the NAA by 6 days per year on average. Modeled water temperatures below Hills Creek Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 6 days per year on average.
- Modeled water temperatures below Lookout Point/Dexter Dams would be within 2°F of the water temperature target more often as compared to the NAA by 7 days per year on average. Modeled water temperature targets below Lookout Point/Dexter Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 9 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Effects below Fall Creek Dam would be the same as those described under the NAA.

Total Dissolved Gas

Under Alternative 1, effects on water quality from TDG would be the same as those described under the NAA below Hills Creek and Fall Creek Dams. Slight improvements in TDG conditions would occur under Alternative 1 due to structural improvements to reduce TDG exceedance of the water quality standard at Lookout Point and Dexter Dams and construction of a selective withdrawal structure at Lookout Point Dam. The differences in the number of days that TDG levels meet targets would be minimal and would not alter the overall adverse effect on water quality from TDG in this subbasin (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Specifically, under Alternative 1 as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Hills Creek Dam by 1 day per year on average.
- TDG could not be estimated immediately below Lookout Point Dam; however, there would be a decrease in TDG exceedance of the water quality standard below Dexter Dam by 15 days per year on average (Table 3.5 12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).
- Effects below Fall Creek Dam would be the same as those described under the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity

Under Alternative 1, effects on water quality from turbidity would be the same as those described under the NAA. Outflow and storage operations under Alternative 1 as compared to NAA operations are not expected to affect head-of-reservoir sediment mobilization or sediment trap efficiency in Hills Creek, Lookout Point, and Fall Creek Reservoirs. Seasonal turbidity from stormwater runoff due to upstream landslides in the watershed, land management practices, wildfire, topography, and sediment characteristics in the Middle Fork Willamette River Subbasin, would continue during the 30-year implementation timeframe under Alternative 1 as under the NAA.

Harmful Algal Blooms

Under Alternative 1, effects on water quality from harmful algal blooms would be slightly more adverse compared to the NAA. Outflow and storage operations under Alternative 1 as compared to NAA operations may reduce the ability to release deeper reservoir water in drier years. These operations would avoid releasing surface water that may contain cyanotoxins during dry years in Hills Creek, Lookout Point, and Fall Creek Reservoirs during harmful algal blooms.

Mercury

Under Alternative 1, effects on water quality from mercury would be slightly more adverse compared to the NAA during the 30-year implementation timeframe. Outflow and storage operations under Alternative 1 as compared to NAA operations may increase the amount of shoreline exposure during late summer of drier years in Hills Creek, Lookout Point, and Fall Creek Reservoirs, which would contribute to mercury methylation.

Coast Fork Willamette River and Long Tom River Subbasins

Water Temperature and Total Dissolved Gas

Under Alternative 1, effects on water quality from temperature conditions in the Coast Fork Willamette River and Long Tom River Subbasins would continue to be adverse, similar to effects described under the NAA (Table 3.5-10, Table 3.5-11, Table 3.5-12) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 1, effects on water quality from turbidity, harmful algal blooms, and mercury would be the same as those described under the NAA.

Mainstem Willamette River

Water Temperature

Under Alternative 1, effects on water quality from temperature conditions in the Mainstem Willamette River would continue to be adverse, similar to effects described under the NAA. Slight improvements in temperature conditions would occur under Alternative 1 operations, but the differences in the number of days that temperatures would meet targets would be minimal and would not alter the overall adverse effect on water quality from temperature.

Specifically, under Alternative 1 as compared to the NAA:

- Modeled water temperatures on the Mainstem Willamette River at Albany would be below the 64.4°F temperature threshold less often as compared to the NAA by 5 days per year on average.
- Modeled water temperatures on the Mainstem Willamette River at Salem would be below 64.4°F temperature threshold less often as compared to the NAA by 8 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 1 would result in continuation of adverse effects on temperature targets and, therefore, water quality in the Mainstem Willamette River.

Total Dissolved Gas

Under Alternative 1, effects on water quality from TDG in the Mainstem Willamette River would be the same as those described under the NAA. There may be differences in the number of days of TDG levels meeting targets; however, this would not alter the overall adverse effect on water quality from TDG (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 1, impacts to water quality from turbidity, harmful algal blooms, and mercury in the Mainstem Willamette River would be the same as those described under the NAA.

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

North Santiam River Subbasin

Water Temperature

As under the NAA, operations under Alternative 2A would result in adverse effects to water quality during times of year when temperature targets are not met. However, unlike the NAA, a selective withdrawal structure would be operated at Detroit Dam resulting in beneficial effects to water quality from improved temperature conditions downstream of Detroit and Big Cliff Dams. Temperature targets would be met more often during an average year under Alternative 2A and result in substantially fewer adverse effects as compared to the NAA.

Specifically, under Alternative 2A as compared to the NAA:

- Modeled water temperatures below Detroit and Big Cliff Dams would be within 2°F of the water temperature target more often as compared to the NAA by 98 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Exceedance of the 64.4°F temperature threshold would remain the same as under the NAA.

Total Dissolved Gas

Under Alternative 2A, there would be a beneficial effect to water quality from TDG due to a decrease in the average number of days per year above 110 percent TDG exceedance of the water quality standard compared to the NAA. This improvement would result from reduction of spill operations due to construction of the selective withdrawal structure at Detroit Dam, thereby reducing the need for temperature management through operational spill and resulting in substantially fewer adverse effects as compared to the NAA.

Specifically, under Alternative 2A as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Detroit Dam by 76 days per year on average.
- There would be a decrease in TDG exceedance of the water quality standard below Big Cliff Dam by 68 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 2A, effects on water quality from turbidity, harmful algal blooms, and mercury would be the same as described under Alternative 1.

South Santiam River Subbasin

Water Temperature

Adverse effects on water quality from temperature conditions in the South Santiam River Subbasin would continue as under the NAA. However, these effects would trend toward a beneficial effect on water temperature below Green Peter Dam due to use of the regulating outlet in the fall and spillway operations in the spring and summer for surface spill.

Slight improvements in temperature conditions would occur below Foster Dam at certain times of the year under Alternative 2A operations that include modifications to existing outlets at Foster Dam, such as the fish weir and the warm water supply pipe to the Foster Dam fish ladder. Temperature targets would be met slightly more often during an average year under Alternative 2A and result in slightly fewer adverse effects as compared to the NAA. However, differences in the number of days that temperatures would meet targets would be minimal and would not alter the overall adverse effect on water quality from temperature in this subbasin.

Specifically, under Alternative 2A as compared to the NAA:

- Modeled water temperatures below Green Peter Dam would be within 2°F of the water temperature target more often as compared to the NAA by 84 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Modeled water temperatures below Foster Dam would be within 2°F of the water temperature target less often as compared to the NAA by 4 days per year on average. Modeled water temperatures below Foster Dam would be below the 64.4°F temperature threshold more often as compared to the NAA by 3 days per year on average.

Total Dissolved Gas

Under Alternative 2A, there would be a substantially more adverse effect to water quality from TDG as compared to the NAA in the South Santiam River Subbasin. The increase in TDG exceedance of the water quality standard would be observed downstream of Green Peter and

Foster Dams. This would be due to an increase in spill operations at Green Peter Dam in the spring (fish passage operation) and summer (temperature management operation). There would be no TDG abatement measure implemented under Alternative 2A.

Specifically, under Alternative 2A as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Green Peter Dam by 139 days per year on average.
- There would be an increase in TDG exceedance of the water quality standard below Foster Dam by 94 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity

Under Alternative 2A, effects on water quality from turbidity would be substantially more adverse than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 2A would cause an increase in sediment and turbidity levels downstream of Green Peter and Foster Reservoirs because of the deep fall drawdown at Green Peter Reservoir, increasing the potential for bank erosion and sloughing as compared to NAA operations.

While some fine-grained sediment that enters Foster Reservoir from Green Peter Reservoir may partially settle, most fine-grained sediment would pass through Foster Reservoir and be transported downstream. This would likely result in temporary increased turbidity during deeper Green Peter Reservoir drawdowns as compared to operations under the NAA. This adverse effect is expected to lessen overtime as the exposed banks and channel stabilize.

Harmful Algal Blooms

Under Alternative 2A, effects on water quality from harmful algal blooms would be moderately more adverse than those described under the NAA during the 30-year implementation timeframe as a result of combined adverse and beneficial effects. Operations under Alternative 2A, as compared to NAA operations, would cause an increase in sediment and nutrient loading into Green Peter Reservoir from the increased bank erosion and sloughing because of deeper drawdowns.

Operations under Alternative 2A as compared to NAA operations may reduce releases of deeper reservoir water. These operations would avoid releasing surface water that may contain cyanotoxins during dry years in Green Peter Reservoir when a harmful algal bloom exists. However, the reduced storage in Green Peter Reservoir would reduce residence time[23] in the reservoir, thereby decreasing the potential time that harmful algal blooms would be a concern.

[23] Residence time is the average amount of time that water spends in a lake.

Mercury

Under Alternative 2A, effects on water quality from mercury would be moderately more adverse than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 2A, as compared to NAA operations, would cause an increase in sediment and potential mercury loading into Green Peter Reservoir because of the increased potential for bank erosion and sloughing from the deeper drawdowns.

Impacts on water quality from mercury methylation would depend on anoxic conditions and the level of mercury in Green Peter and Foster Reservoirs at any given time. Dissolved oxygen monitoring downstream of Green Peter Dam during deep drawdown operations in fall of 2023 did not result in values below 80 percent saturation. Therefore, any potential increases of anoxic water (or associated mercury methylation) from deep drawdown operations are expected to have low magnitude and be short-lived. However, shoreline exposure is expected to increase under Alternative 2A operations, which would increase the likelihood of the methylation process if anoxic conditions were to develop in Green Peter Reservoir compared to NAA operations.

McKenzie River Subbasin

Water Temperature

Under Alternative 2A, effects on water quality from temperature conditions in the McKenzie River Subbasin would continue to be adverse during times of the year when water temperature targets are not met, similar to effects described under the NAA. A slight increase in adverse temperature conditions downstream of Cougar Dam would occur under Alternative 2A operations. However, differences in the number of days that temperatures would meet targets would be minimal and would not alter the overall adverse effect on water quality from temperature in this subbasin with a slight adverse effect similar to the NAA.

Specifically, under Alternative 2A as compared to the NAA:

- Modeled water temperatures below Cougar Dam would be within 2°F of the water temperature target less often as compared to the NAA by 22 days per year on average.
- Exceedance of the 64.4°F temperature threshold below Cougar Dam would be the same as under the NAA (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Total Dissolved Gas

Under Alternative 2A, effects on water quality from TDG in the McKenzie River Subbasin would be the same as those described under the NAA, a moderate adverse effect. There may be differences in the number of days of TDG levels meeting targets; however, this would not alter overall adverse effects on water quality from TDG in this subbasin (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 2A, water quality effects from turbidity, harmful algal blooms, and mercury in the McKenzie River Subbasin would be the same as those described under Alternative 1.

Middle Fork Willamette River Subbasin

Water Temperature

Under Alternative 2A, effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue to be adverse, similar to effects described under the NAA. Slight increases in adverse temperature conditions would occur under Alternative 2A downstream of Hills Creek Dam. However, slight decreases in adverse temperature conditions would occur under Alternative 2A downstream of Dexter Dam. Differences in the number of days that temperatures would meet targets would be minimal and would not alter the overall adverse effect on water quality from temperature in this subbasin.

Specifically, under Alternative 2A as compared to the NAA:

- Modeled water temperatures below Hills Creek Dam would be within 2°F of the water temperature target less often as compared to the NAA by 2 days per year on average. Modeled water temperatures below Hills Creek Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 14 days per year on average.
- Modeled water temperatures below Lookout Point/Dexter Dams would be within 2°F of the water temperature target more often as compared to the NAA by 5 days per year on average. Modeled water temperature below Lookout Point/Dexter Dams would be below 64.4°F temperature threshold more often as compared to the NAA by 4 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Effects below Fall Creek Dam would be the same as those described under the NAA.

Total Dissolved Gas

Under Alternative 2A, effects on water quality from TDG would be the same as those described under the NAA in the Middle Fork Willamette River Subbasin. Slight improvements in TDG conditions would occur under Alternative 2A, but differences in the number of days that TDG levels meet targets would be minimal and would not alter the overall adverse effect on water quality from TDG in this subbasin (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Specifically, under Alternative 2A as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Hills Creek Dam by 1 day per year on average.

- TDG could not be estimated immediately below Lookout Point Dam; however, there would be no change in TDG exceedance of the water quality standard below Dexter Dam (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).
- Effects below Fall Creek Dam would be the same as those described under the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 2A, effects on water quality from turbidity, harmful algal blooms, and mercury in the Middle Fork Willamette River Subbasin would be the same as those described under Alternative 1.

Coast Fork Willamette River and Long Tom River Subbasins

Water Temperature and Total Dissolved Gas

Under Alternative 2A, effects on water quality from temperature conditions and TDG in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA. There may be differences in the number of days where water temperature standards would be met or in the number of days TDG meets targets; however, this would not alter the overall adverse effect on water quality from temperature conditions and TDG in these subbasins (Table 3.5-10, Table 3.5-11, Table 3.5-12) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 2A, effects on water quality from turbidity, harmful algal blooms, and mercury in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA.

Mainstem Willamette River

Water Temperature and Total Dissolved Gas

Under Alternative 2A, effects on water quality from temperature conditions and TDG in the Mainstem Willamette River would be the same as those described under the NAA. There may be differences in the number of days TDG target levels are met; however, this would not alter the overall adverse effect on water quality from TDG (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 2A, effects on water quality from turbidity, harmful algal blooms, and mercury in the Mainstem Willamette River would be the same as those described under the NAA.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

North Santiam River Subbasin

Water Temperature

As under the NAA, operations under Alternative 2B would result in adverse effects to water quality during times of year when temperature targets are not met. However, unlike the NAA, a selective withdrawal structure would be operated at Detroit Dam under Alternative 2B resulting in beneficial effects to water quality from improved temperature conditions downstream of Detroit Dam and Big Cliff Dam. Consequently, substantially fewer adverse effects on water quality would occur in the North Santiam River Subbasin as compared to the NAA. Temperature targets would be met more often during an average year under Alternative 2B as compared to the NAA.

Specifically, under Alternative 2B as compared to the NAA:

- Modeled water temperatures below Detroit and Big Cliff Dams would be within 2°F of the water temperature target more often as compared to the NAA by 100 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Exceedance of the 64.4°F temperature threshold would remain the same as under the NAA.

Total Dissolved Gas

Under Alternative 2B, there would be a beneficial effect to water quality from TDG due to a decrease in the average number of days per year above 110 percent TDG exceedance of the water quality standard compared to the NAA. This improvement would result from reduction of spill operations due to construction of the selective withdrawal structure at Detroit Dam. However, there would be no additional measures to reduce TDG levels below Detroit Dam and Big Cliff Dam in the North Santiam River Subbasin under Alternative 2B where TDG levels would continue to have adverse effects on water quality from spill during flood risk management operations as under the NAA.

Specifically, under Alternative 2B as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Detroit Dam by 76 days per year on average.

- There would be a decrease in TDG exceedance of the water quality standard below Big Cliff Dam by 68 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 2B, effects on water quality from turbidity, harmful algal blooms, and mercury in the North Santiam River Subbasin would be the same as those described under Alternative 1.

South Santiam River Subbasin

Water Temperature

Adverse effects on water quality from temperature conditions in the South Santiam River Subbasin would continue as under the NAA. However, these effects would trend toward a beneficial effect on water temperature below Green Peter Dam due to use of the regulating outlet in the fall and spillway for surface spill in the spring (fish passage operation) and summer (temperature management operation) under Alternative 2B.

Slight improvements in temperature conditions would occur below Foster Dam at certain times of the year under Alternative 2B operations that include modifications to existing outlets at Foster Dam, such as the fish weir and the warm water supply pipe to the Foster Dam fish ladder. Temperature targets would be met slightly more often during an average year under Alternative 2B and result in slightly fewer adverse effects as compared to the NAA. However, differences in the number of days that temperatures would meet targets would be minimal and would not alter the overall adverse effect on water quality from temperature in this subbasin.

Specifically, under Alternative 2B as compared to the NAA:

- Modeled water temperatures below Green Peter Dam would be within 2°F of the water temperature target more often as compared to the NAA by 85 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Modeled water temperatures below Foster Dam would be within 2°F of the water temperature target less often as compared to the NAA by 3 days per year on average. Modeled water temperatures would be below the 64.4°F temperature threshold more often by 3 days per year on average.

Total Dissolved Gas

Under Alternative 2B, there would be a substantially more adverse effect to water quality from TDG as compared to the NAA in the South Santiam River Subbasin. The increase in TDG exceedance of the water quality standard would be observed downstream of Green Peter and Foster Dams. This would be due to an increase in spill operations at Green Peter Dam in the spring (fish passage operation) and summer (temperature management operation). There would be no TDG abatement measures implemented under Alternative 2B.

Specifically, under Alternative 2B as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Green Peter Dam by 139 days per year on average.
- There would be an increase in TDG exceedance of the water quality standard below Foster Dam by 94 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 2B, effects on water quality from turbidity, harmful algal blooms, and mercury in the South Santiam River Subbasin would be the same as those described under Alternative 2A.

McKenzie River Subbasin

Water Temperature

Unlike NAA operations, Alternative 2B would result in beneficial changes in water temperature conditions downstream of Cougar Dam. There would be an improvement to water temperature in the McKenzie River Subbasin because downstream conditions would nearly mimic upstream conditions under Alternative 2B operations. Temperature targets would be met more often during an average year under Alternative 2B and result in substantially fewer adverse effects as compared to the NAA.

Under Alternative 2B, water temperatures would decrease relative to the NAA. Decreased temperatures would be attributed to annual deep drawdowns, decreased time that water would be held in Cougar Reservoir (i.e., reduced heating in the reservoir), and use of the diversion tunnel as the primary outlet. The diversion tunnel is the deepest outlet at Cougar Dam and has the potential to release deep, cold water when reservoir levels are below the regulating outlet intake.

While modeled temperatures below Cougar Dam would generally be below the maximum of the temperature target (64.4°F), the substantially fewer adverse effects on water temperature would be due to reduced reservoir heating during a deep drawdown. Consequently, there would be a beneficial effect on water temperature as compared to the NAA.

Specifically, under Alternative 2B as compared to the NAA:

- Modeled water temperatures below Cougar Dam would be within 2°F of the water temperature target less often as compared to the NAA by 56 days per year on average.

- Exceedance of the 64.4°F temperature threshold below Cougar Dam would be the same as under the NAA (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Total Dissolved Gas

Under Alternative 2B, there would be an adverse effect to water quality from TDG. However, there would be an improvement to water quality because, although TDG levels would be above 110 percent TDG exceedance of the water quality standard, the average number of days per year above 110 percent would be fewer as compared to the NAA. This improvement would result from a decrease in spill operations and reduction in TDG exceedance of the water quality standard below Cougar Dam under Alternative 2B and have a moderately less adverse effect as compared to the NAA.

Specifically, under Alternative 2B as compared to the NAA:

- There would be a decrease of TDG exceedance of the water quality standard below Cougar Dam by 30 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 2B would result in adverse effects on water quality regardless of an improvement in meeting TDG targets in the McKenzie River Subbasin as compared to the NAA.

Turbidity

Under Alternative 2B, effects on water quality from turbidity would be substantially more adverse at Cougar Reservoir than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 2B would cause an increase in sediment and turbidity levels downstream of Cougar Reservoir because of deeper drawdowns to near original streambed elevations, increasing bank erosion and sloughing as compared to NAA operations. Most fine-grained sediment would pass through Cougar Reservoir and be transported downstream, likely resulting in seasonal increased turbidity downstream during deeper drawdowns in the McKenzie River Subbasin compared to the NAA.

Under Alternative 2B, effects on water quality from turbidity in Blue River Reservoir would be the same as those described under Alternative 1.

Harmful Algal Blooms

Under Alternative 2B, adverse and beneficial effects on water quality from harmful algal blooms would occur. However, total effects on water quality from harmful algal blooms would be moderately more adverse at Cougar Reservoir than those described under the NAA during the

30-year implementation timeframe. Operations under Alternative 2B, as compared to NAA operations, would cause an increase in sediment and nutrient loading into Cougar Reservoir from the increased bank erosion and sloughing resulting from deeper drawdowns.

Outflow and storage are expected to decrease substantially during summer at Cougar Reservoir under Alternative 2B as compared to the NAA, which may reduce the ability to release deeper reservoir water and to avoid releasing surface water (where cyanotoxins may exist) in Cougar Reservoir during harmful algal blooms. However, the reduced storage in Cougar Reservoir would reduce residence time in the reservoir, thereby decreasing the potential time that harmful algal blooms would be a concern.

Under Alternative 2B, effects on water quality from harmful algal blooms in Blue River Reservoir would be the same as those described under Alternative 1.

Mercury

Under Alternative 2B, effects on water quality from mercury would be moderately more adverse at Cougar Reservoir than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 2B would result in deeper drawdowns, increasing the potential for bank erosion and sloughing in Cougar Reservoir. Consequently, deeper drawdowns would increase sediment and potential mercury loading as compared to NAA operations.

Impacts on water quality from mercury methylation would depend on anoxic conditions and the level of mercury in Cougar Reservoir at any given time. Shoreline exposure is expected to increase under Alternative 2B operations, which would increase the likelihood of the methylation process if anoxic conditions were to develop in Cougar Reservoir compared to the NAA.

Under Alternative 2B, effects on water quality from mercury in Blue River Reservoir would be the same as those described under Alternative 1.

Middle Fork Willamette River Subbasin

Water Temperature

Under Alternative 2B, effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue to be adverse, similar to effects described under the NAA. Slight increases in adverse temperature conditions would occur under Alternative 2B operations, but differences in the number of days that temperatures would meet targets would be minimal and would not alter the overall adverse effect on water quality from temperature in this subbasin.

Specifically, under Alternative 2B as compared to the NAA:

- Modeled water temperatures below Hills Creek Dam would be within 2°F of the water temperature target less often as compared to the NAA by 6 days per year on average. Modeled water temperatures below Hills Creek Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 21 days per year on average.
- Modeled water temperatures below Lookout Point/Dexter Dams would be within 2°F of the water temperature target more often as compared to the NAA by 9 days per year on average. Modeled water temperature targets below Lookout Point/Dexter Dams would be below the 64.4°F temperature threshold more often as compared to the NAA by 4 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Effects below Fall Creek Dam would be the same as those described under the NAA.

Total Dissolved Gas

Under Alternative 2B, effects on water quality from TDG would be the same as those described under the NAA in the Middle Fork Willamette River Subbasin. Slight improvements in TDG conditions would occur under Alternative 2B, but the differences in the number of days that TDG levels meet targets would be minimal and would not alter the overall adverse effect on water quality from TDG in this subbasin (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Specifically, under Alternative 2B as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Hills Creek Dam by 1 days per year on average.
- TDG could not be estimated immediately below Lookout Point Dam; however, there would be no change in TDG exceedance of the water quality standard below Dexter Dam (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).
- Effects below Fall Creek Dam would be the same as those described under the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 2B, effects on water quality from turbidity, harmful algal blooms, and mercury in the Middle Fork Willamette River Subbasin would be the same as those described under Alternative 1.

Coast Fork Willamette River and Long Tom River Subbasins

Water Temperature and Total Dissolved Gas

Under Alternative 2B, effects on water quality from temperature conditions and TDG in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA. There may be differences in the number of days where water temperature standards would be met or in the number of days TDG meets targets; however, this would not alter the overall adverse effect on water quality from temperature conditions and TDG in these subbasins (Table 3.5-10, Table 3.5-11, Table 3.5-12) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 2B, effects on water quality from turbidity, harmful algal blooms, and mercury in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA.

Mainstem Willamette River

Water Temperature and Total Dissolved Gas

Under Alternative 2B, effects on water quality from temperature conditions and TDG in the Mainstem Willamette River would be the same as those described under the NAA. There may be differences in the number of days of temperature conditions and TDG levels meeting targets; however, this would not alter the overall adverse effect on water quality from temperature and TDG (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 2B, impacts to water quality from turbidity, harmful algal blooms, and mercury in the Mainstem Willamette River would be slightly more adverse than those described under the NAA. This would be due to deeper drawdowns in many WVS reservoirs, increasing the likelihood of sediment, harmful algal blooms, and mercury being passed downstream of these dams within the Willamette River Basin. These adverse effects would be re-occurring over the 30-year implementation timeframe during deep drawdown operational periods.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

North Santiam River Subbasin

Water Temperature

Under Alternative 3A, as compared to the NAA, there would be a moderate increase in adverse effects on water quality because there would be an increase in days when temperature targets would not be met. The spring drawdown for downstream fish passage would result in warmer downstream temperatures from May through October, thereby increasing adverse conditions. Adverse conditions would occur downstream of Detroit and Big Cliff Dams in hot, dry years compared to operations under the NAA.

Specifically, under Alternative 3A as compared to the NAA:

- Modeled water temperatures below Detroit and Big Cliff Dams would be within 2°F of the water temperature target less often as compared to the NAA by 14 days per year on average.
- Modeled water temperatures below Detroit and Big Cliff Dams would be below the 64.4°F temperature threshold less often as compared to the NAA by 44 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Total Dissolved Gas

Under Alternative 3A, there would be a substantial increase of adverse effects to water quality from TDG exceedance of the water quality standard in the North Santiam River Subbasin as compared to the NAA. The increase in TDG exceedance of the water quality standard would be due to an increase in spill operations.

At Detroit Dam, the regulating outlets would be operated for fish passage and temperature management in the spring and fall; the spillway, if available, would be operated for temperature management in the summer. However, water would continue to be spread over multiple spillway gates, which would reduce TDG exceedance of the water quality standard at Detroit and Big Cliff Dams under Alternative 3A.

Specifically, under Alternative 3A as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Detroit Dam by 192 days per year on average.
- There would be an increase in TDG exceedance of the water quality standard below Big Cliff Dam by 164 days per year on average.

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 3A would result in adverse effects on water quality from TDG in the subbasin (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity

Under Alternative 3A, effects on water quality from turbidity would be substantially more adverse for most months of the year compared to those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3A would cause an increase in sediment and turbidity levels downstream of Detroit Reservoir because of deeper drawdowns within the reservoir, increasing the potential for bank erosion and sloughing as compared to NAA operations. While some fine-grained sediment that enters Big Cliff Reservoir from Detroit Reservoir may partially settle, most fine-grained sediment would pass through Big Cliff Reservoir and result in temporary increased turbidity downstream during deeper Detroit Reservoir drawdowns as compared to NAA operations.

Harmful Algal Blooms

Under Alternative 3A, adverse and beneficial effects on water quality from harmful algal blooms would occur. However, total effects would be moderately more adverse for most months of the year compared to those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3A would cause an increase in sediment and nutrient loading into Detroit Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Outflow and storage are expected to decrease substantially during the summer at Detroit Reservoir under Alternative 3A as compared to NAA, which may reduce the ability to release deeper reservoir water and to avoid releasing surface water (where cyanotoxins may exist) in Detroit Reservoir during harmful algal blooms. However, selective management of the upper and lower regulating outlet could maintain the ability to manage upper and lower reservoir releases. The reduced storage in Detroit Reservoir would reduce residence time in the reservoir, thereby decreasing the potential time that harmful algal blooms would be a concern.

Mercury

Under Alternative 3A, effects on water quality from mercury would be moderately more adverse for most months of the year compared to those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3A would result in deeper drawdowns, increasing the potential for bank erosion and sloughing in Detroit Reservoir. Consequently, deeper drawdowns would increase sediment and potential mercury loading as compared to NAA operations.

Impacts on water quality from mercury methylation would depend on anoxic conditions and the level of mercury in Detroit and Big Cliff Reservoirs at any given time. Shoreline exposure is expected under Alternative 3A operations, which would increase the likelihood of the methylation process if anoxic conditions were to develop in Detroit Reservoir compared to the NAA.

South Santiam River Subbasin

Water Temperature

Under Alternative 3A, adverse effects on water quality from temperature conditions in the South Santiam River Subbasin would continue as under the NAA. However, these effects would trend toward a beneficial effect on water temperature below Green Peter Dam due to use of the regulating outlet in the fall and spillway in the spring and summer for surface spill.

Slight improvements in temperature conditions would occur below Foster Dam at certain times of the year under Alternative 3A operations that include modifications to existing outlets at Foster Dam, such as the fish weir and the warm water supply pipe to the Foster Dam fish ladder. Temperature targets would be met slightly more often during an average year in the South Santiam River Subbasin under Alternative 3A and result in slightly fewer adverse effects as compared to the NAA. However, differences in the number of days that temperatures would meet targets would be minimal and would not alter the overall adverse effect on water quality from temperature in this subbasin.

Specifically, under Alternative 3A as compared to the NAA:

- Modeled water temperatures below Green Peter Dam would be within 2°F of the water temperature target more often as compared to the NAA by 82 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Modeled water temperatures below Foster Dam would be within 2°F of the water temperature target more often as compared to the NAA by 7 days per year on average. Modeled water temperatures below Foster Dam would be below 64.4°F temperature threshold more often as compared to the NAA by 4 days per year on average.

Total Dissolved Gas

Under Alternative 3A, there would be a substantially more adverse effect to water quality from TDG as compared to the NAA in the South Santiam River Subbasin. The increase in TDG exceedance of the water quality standard would be observed downstream of Green Peter and Foster Dams. This would be due to an increase in spill operations at Green Peter Dam in the spring (fish passage operation) and summer (temperature management operation). There would be no TDG abatement measures implemented under Alternative 3A. There would be an increase in spill operations for temperature management and reservoir drawdown operations that would increase TDG exceedance of water quality standards.

Specifically, under Alternative 3A as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Green Peter Dam by 139 days per year on average.
- There would be an increase in TDG exceedance of the water quality standard below Foster Dam by 95 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 3A, effects on water quality from turbidity, harmful algal blooms, and mercury in the South Santiam River Subbasin would be the same as those described under Alternative 2A.

McKenzie River Subbasin

Water Temperature

Under Alternative 3A, effects on water quality from temperature conditions in the McKenzie River Subbasin would continue to be adverse during times of the year when water temperature targets are not met, similar to effects described under the NAA. Slightly more adverse effects to water temperature conditions downstream of Cougar Dam would increase under Alternative 3A operations as compared to NAA operations. This increase in adverse effect would occur because temperature targets would be met less often as compared to the NAA.

Specifically, under Alternative 3A as compared to the NAA:

- Modeled water temperatures below Cougar Dam would be within 2°F of the water temperature target less often as compared to the NAA by 52 days per year on average.
- Exceedance of the 64.4°F temperature threshold would be the same as under the NAA (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Total Dissolved Gas

Under Alternative 3A, there would be an increase in adverse effects to water quality from TDG in the McKenzie River Subbasin as compared to the NAA. Slightly more adverse effects would be due to an increase in spill frequency and because no TDG abatement measures would be implemented at Cougar Dam under Alternative 3A as compared to the NAA.

Specifically, under Alternative 3A as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Cougar Dam by 20 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 3A would result in adverse effects on water quality from TDG in the subbasin.

Turbidity

Under Alternative 3A, effects on water quality from turbidity would be slightly more adverse at Cougar Reservoir than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3A would cause a slight increase in sediment and turbidity levels downstream of Cougar Reservoir because of lower pool levels, increasing the potential for bank erosion and sloughing as compared to NAA operations. Most fine-grained sediment would pass through Cougar Reservoir and be transported downstream, likely resulting in temporary increased turbidity downstream during deeper drawdowns compared to NAA operations.

Under Alternative 3A, effects on water quality from turbidity in Blue River Reservoir would be the same as those described under Alternative 1.

Harmful Algal Blooms

Under Alternative 3A, adverse and beneficial effects on water quality from harmful algal blooms would occur. However, total effects on water quality from harmful algal blooms would be moderately more adverse at Cougar Reservoir than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3A would cause a slight increase in sediment and nutrient loading into Cougar Reservoir because of lower pool levels, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Outflow and storage are expected to decrease moderately during summer at Cougar Reservoir under Alternative 3A as compared to the NAA. These operations would reduce the ability to release deeper reservoir water and, therefore, avoid releasing surface water that may contain cyanotoxins during dry years in Cougar Reservoir during harmful algal blooms. However, the reduced storage in Cougar Reservoir would reduce residence time in the reservoir, thereby decreasing the potential time that harmful algal blooms would be a concern.

Under Alternative 3A, effects on water quality from harmful algal blooms in Blue River Reservoir would be the same as those described under Alternative 1.

Mercury

Under Alternative 3A, effects on water quality from mercury in Cougar and Blue River Reservoirs would be the same as those described under Alternative 1.

Middle Fork Willamette River Subbasin

Water Temperature

Adverse effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue as under the NAA. However, effects would trend toward a beneficial effect on water temperature because temperature targets would be met more often under Alternative 3A operations and result in moderately fewer adverse effects below Hills Creek Dam and slightly fewer adverse effects below Lookout Point and Dexter Dams as compared to the NAA.

Specifically, under Alternative 3A as compared to the NAA:

- Modeled water temperatures below Hills Creek Dam would be within 2°F of the water temperature target more often as compared to the NAA by 73 days per year on average. Modeled water temperatures below Hills Creek Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 16 days per year on average.
- Modeled water temperatures below Lookout Point/Dexter Dams would be within 2°F of the water temperature target more often as compared to the NAA by 6 days per year on average. However, modeled water temperatures below Lookout Point/Dexter Dams would be below the 64.4°F temperature threshold less often as compared to the NAA by 30 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Effects below Fall Creek Dam would be the same as described under the NAA.

Total Dissolved Gas

Under Alternative 3A, there would be an adverse effect to water quality from TDG in the Middle Fork Willamette River Subbasin similar to the NAA. There would be a slightly less adverse effect downstream of Hills Creek Dam and a moderately increased adverse effect downstream of Dexter Dam as compared to the NAA. These effects may be due to an increase in spill frequency and TDG abatement measures implemented under Alternative 3A.

Specifically, under Alternative 3A as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Hills Creek Dam by 6 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).
- TDG could not be estimated immediately below Lookout Point Dam; however, there would be an increase in TDG exceedance of the water quality standard below Dexter Dam by 33 days per year on average.
- Effects below Fall Creek Dam would be the same as those described under the NAA.

There may be differences in the number of days of TDG levels meeting targets; however, this would not alter the overall adverse effect on water quality from TDG in the subbasin.

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 3A would result in adverse effects on water quality regardless of a slight improvement in meeting TDG targets as compared to the NAA.

Turbidity

Under Alternative 3A, effects on water quality from turbidity in Hills Creek Reservoir would be the same as those described under the NAA.

Under Alternative 3A, effects on water quality from turbidity would be substantially more adverse at Lookout Point Reservoir than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3A would cause an increase in sediment and turbidity levels downstream of Lookout Point Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations. While some fine-grained sediment entering Dexter Reservoir from Lookout Point Reservoir may partially settle, most fine-grained sediment would pass through Dexter Reservoir and result in temporarily increased turbidity downstream during deeper Lookout Point Reservoir drawdowns compared to NAA operations.

Harmful Algal Blooms

Under Alternative 3A, effects on water quality from harmful algal blooms in Hills Creek Reservoir would be the same as those described under Alternative 1.

Under Alternative 3A, effects on water quality from harmful algal blooms would be moderately more adverse at Lookout Point Reservoir than those described under the NAA during the 30-year implementation timeframe as a result of combined adverse and beneficial effects. Operations under Alternative 3A would cause an increase in sediment and nutrient loading into Lookout Point Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Outflow and storage are expected to decrease substantially during summer at Lookout Point Reservoir under Alternative 3A as compared to the NAA**.** These operations would reduce the ability to release deeper reservoir water and, therefore, avoid releasing surface water that may contain cyanotoxins in Lookout Point Reservoir during harmful algal blooms. However, the reduced storage in Lookout Point Reservoir would reduce residence time in the reservoir, thereby decreasing the potential time that harmful algal blooms would be a concern.

Mercury

Under Alternative 3A, effects on water quality from mercury methylation in Hills Creek Reservoir would be the same as those described under Alternative 1.

Under Alternative 3A, effects on water quality from mercury would be moderately more adverse at Lookout Point Reservoir than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3A would cause an increase in sediment and potential mercury loading into Lookout Point Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Impacts on water quality from mercury methylation would depend on anoxic conditions and the level of mercury in Lookout Point and Dexter Reservoirs at any given time. Shoreline exposure is expected to increase under Alternative 3A operations, which would increase the likelihood of the methylation process if anoxic conditions were to develop in Lookout Point Reservoir compared to the NAA.

Coast Fork Willamette River and Long Tom River Subbasins

Water Temperature and Total Dissolved Gas

Under Alternative 3A, effects on water quality from temperature conditions and TDG would be the same as described under the NAA. There may be differences in the number of days where water quality standards for water temperature and TDG would be met; however, this would not alter the overall adverse effect on water quality from temperature conditions and TDG in these subbasins (Table 3.5-10, Table 3.5-11, Table 3.5-12) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 3A, effects on water quality from turbidity, harmful algal blooms, and mercury in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA.

Mainstem Willamette River

Water Temperature

Under Alternative 3A, effects on water quality from temperature conditions in the Mainstem Willamette River would continue to be adverse during times of the year when water temperature targets are not met. Adverse conditions would increase as compared to the NAA. The slightly more adverse effects would occur because of an increase in days exceeding the 64.4°F temperature threshold as compared to the NAA (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Specifically, under Alternative 3A as compared to the NAA:

- Modeled water temperatures on the Mainstem Willamette River at Albany would be below the 64.4°F temperature threshold less often as compared to the NAA by 9 days per year on average.
- Modeled water temperatures on the Mainstem Willamette River at Salem would be below 64.4°F temperature threshold less often as compared to the NAA by 7 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 3A would result in continuation of adverse effects on water quality from temperature conditions in the Mainstem Willamette River.

Total Dissolved Gas

Under Alternative 3A, effects on water quality from TDG in the Mainstem Willamette River would be the same as those described under the NAA. There may be differences in the number of days where the water quality standard for TDG would be met; however, this would not alter the overall adverse effect on water quality from TDG (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 3A, impacts to water quality from turbidity, harmful algal blooms, and mercury in the Mainstem Willamette River would be moderately more adverse than those described under the NAA. This is due to deeper drawdowns in many WVS reservoirs, increasing the likelihood of turbidity, harmful algal blooms, and mercury being passed downstream throughout the Willamette River Basin.

Alternative 3B—Improve Fish Passage through Operations-focused Measures

North Santiam River Subbasin

Water Temperature

Under Alternative 3B, effects on water quality from temperature conditions in the North Santiam River Subbasin would be the same as those described under the NAA. There may be differences in the number of days where water temperature standards would be met; however, this would not alter the overall adverse effect on water quality in this subbasin (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Specifically, under Alternative 3B as compared to the NAA:

- Modeled water temperatures below Detroit and Big Cliff Dams would be within 2°F of the water temperature target more often as compared to the NAA by 2 days per year on average.
- Exceedance of the 64.4°F temperature threshold would remain the same as under the NAA.

Total Dissolved Gas

Under Alternative 3B, there would be a substantial increase in adverse effects to water quality from TDG exceedance of the water quality standard in the North Santiam River Subbasin as compared to the NAA. The increase in TDG exceedance of the water quality standard would be due to an increase in spill operations. There is no structural TDG abatement measure under Alternative 3B.

The passing of water over the spillway would occur in the spring for fish passage at Big Cliff and Detroit Dams. Temperature management would occur in the summer at Detroit Dam along with fall drawdown operations for fish passage.

Specifically, under Alternative 3B as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Detroit Dam by 88 days per year on average.
- There would be an increase in TDG exceedance of the water quality standard below Big Cliff Dam by 78 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 3B would result in adverse effects on water quality from TDG in the North Santiam River Subbasin.

Turbidity

Under Alternative 3B, effects on water quality from turbidity would be substantially more adverse for a few months of the year compared to those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3B would cause an increase in sediment and turbidity levels downstream of Detroit Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations. While some fine-grained sediment that enters Big Cliff Reservoir from Detroit Reservoir may partially settle, most fine-grained sediment would pass through Big Cliff Reservoir and be transported downstream.

Harmful Algal Blooms

Under Alternative 3B, adverse and beneficial effects on water quality from harmful algal blooms would occur. However, total effects on water quality from harmful algal blooms would be moderately more adverse for a few months of the year compared to those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3B would cause an increase in sediment and nutrient loading into Detroit Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Outflow and storage are expected to decrease substantially during summer at Detroit Reservoir under Alternative 3B as compared to NAA operations. These operations would reduce the ability to release deeper reservoir water and, therefore, would avoid releasing surface water that may contain cyanotoxins in Detroit Reservoir when a harmful algal bloom exists. However, the reduced storage in Detroit Reservoir would reduce residence time in the reservoir, thereby decreasing the potential time that harmful algal blooms would be a concern.

Mercury

Under Alternative 3B, effects on water quality from mercury would be moderately more adverse for a few months of the year compared to those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3B would cause an increase in sediment and potential mercury loading into Detroit Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Impacts on water quality from mercury methylation would depend on anoxic conditions and the level of mercury in Detroit and Big Cliff Reservoirs at any given time. Increased shoreline exposure is expected under Alternative 3B operations, which would increase the likelihood of the methylation process if anoxic conditions were to develop in Detroit Reservoir compared to the NAA.

South Santiam River Subbasin

Water Temperature

As under the NAA, effects on water quality from temperature conditions in the South Santiam River Subbasin would continue to be adverse below Green Peter Dam during times of the year when water temperature targets are not met under Alternative 3B. As under the NAA, adverse effects would occur below Foster Dam at certain times of year because of Green Peter Dam fall and spring drawdown operations. The spring drawdown for downstream fish passage would cause warmer downstream temperatures from May through October, resulting in slightly more adverse effects as compared to the NAA.

Specifically, under Alternative 3B as compared to the NAA:

- Modeled water temperatures below Green Peter Dam would be within 2°F of the water temperature target more often as compared to the NAA by 6 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Modeled water temperatures below Foster Dam would be within 2°F of the water temperature target less often as compared to the NAA by 27 days per year on average.
- Modeled water temperatures below Foster Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 45 days per year on average.

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 3B would result in continuation of adverse effects on water quality from temperature conditions in the subbasin.

Total Dissolved Gas

Under Alternative 3B, there would be a moderately more adverse effect to water quality from TDG downstream of Green Peter and Foster Dams in the South Santiam River Subbasin as compared to the NAA because of increased spill operations. There is no structural TDG abatement measure under Alternative 3B.

Specifically, under Alternative 3B as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Green Peter Dam by 50 days per year on average.
- There would be an increase in TDG exceedance of the water quality standard below Foster Dam by 37 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 3B would result in adverse effects on water quality from TDG in the South Santiam River Subbasin.

Turbidity

Under Alternative 3B, effects on water quality from turbidity would be substantially more adverse at Green Peter Reservoir than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3B would cause an increase in sediment and turbidity levels downstream of Green Peter Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations. Most fine-grained sediment would pass through Green Peter Reservoir and be transported downstream, likely resulting in temporary increased turbidity downstream during deeper drawdowns compared to the NAA.

Operations under Alternative 3B would cause an increase in sediment and turbidity levels downstream of Foster Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations. Deeper drawdowns would also increase the potential for conveyance of fine sediment from Green Peter Dam, which is upstream of Foster Reservoir.

Harmful Algal Blooms

Under Alternative 3B, effects on water quality from harmful algal blooms would be moderately more adverse at Green Peter Reservoir than those described under the NAA during the 30-year implementation timeframe as a result of combined adverse and beneficial effects. Operations under Alternative 3B would cause an increase in sediment and nutrient loading into Green Peter Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Unlike NAA operations, operations under Alternative 3B may reduce releases of deeper reservoir water. These operations would avoid releasing surface water that may contain cyanotoxins during dry years in Green Peter Reservoir when a harmful algal bloom exists. These operations would reduce the ability to release deeper reservoir water and, therefore, would avoid releasing surface water that may contain cyanotoxins in Green Peter Reservoir during harmful algal blooms. However, the reduced storage in Green Peter Reservoir would reduce residence time in the reservoir, thereby decreasing the potential time that harmful algal blooms would be a concern.

Under Alternative 3B, effects on water quality from harmful algal blooms in Foster Reservoir would be moderately more adverse than those described under the NAA due to the increased potential for conveyance of nutrient-enriched water and harmful algal blooms from Green Peter Dam, which is upstream of Foster Reservoir.

Mercury

Under Alternative 3B, effects on water quality from mercury would be moderately more adverse at Green Peter Reservoir than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3B would cause an increase in sediment and potential mercury loading into Green Peter Reservoir because of deeper drawdowns year-round, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Impacts on water quality from mercury methylation would depend on anoxic conditions and the level of mercury in Green Peter Reservoir at any given time. Shoreline exposure is expected to increase in both wet and dry years under Alternative 3B operations, which would increase the likelihood of the methylation process if anoxic conditions were to develop in Green Peter Reservoir compared to the NAA.

Under Alternative 3B, effects on water quality from turbidity in Foster Reservoir would be moderately more adverse than those described under the NAA due to increased shoreline exposure and the increased potential for conveyance of mercury from Green Peter Dam upstream of Foster Reservoir.

McKenzie River Subbasin

Water Temperature

Under Alternative 3B, effects on water quality from temperature conditions in the McKenzie River Subbasin would be the same as those described under Alternative 2B. There would be an improvement to water temperature in the McKenzie River Subbasin because downstream conditions would nearly mimic upstream conditions under Alternative 3B operations. Temperature targets would be met less often annually under Alternative 3B and result in more adverse water quality effects as compared to the NAA.

Specifically, under Alternative 3B as compared to the NAA:

- Modeled water temperatures below Cougar Dam would be within 2°F of the temperature target less often as compared to the NAA by 60 days per year on average.
- Exceedance of the 64.4°F temperature threshold would be the same as under the NAA (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Total Dissolved Gas

Under Alternative 3B, effects on water quality from TDG in the McKenzie River Subbasin would be the same as those described under Alternative 2B. This would result in a moderately less adverse effect as compared to the NAA.

Specifically, under Alternative 3B as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Cougar Dam by 31 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 3B would result in adverse effects on water quality regardless of an improvement in meeting TDG targets in the McKenzie River Subbasin as compared to the NAA.

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 3B, effects on water quality from turbidity, harmful algal blooms, and mercury in the McKenzie River Subbasin would be the same as those described under Alternative 2B.

Middle Fork Willamette River Subbasin

Water Temperature

Adverse effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue as under the NAA. However, these effects would trend toward a beneficial effect on water temperature because temperature targets would be met more often under Alternative 3B operations and result in slightly fewer adverse effects below Hills Creek, Lookout Point, and Dexter Dams as compared to the NAA.

Specifically, under Alternative 3B as compared to the NAA:

- Modeled water temperatures below Hills Creek Dam would be within 2°F of the water temperature target more often as compared to the NAA by 34 days per year on average.
- Modeled water temperatures below Hills Creek Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 46 days per year on average.
- Modeled water temperatures below Lookout Point/Dexter Dams would be within 2°F of the water temperature target more often as compared to the NAA by 31 days per year on average. Modeled water temperatures below Lookout Point/Dexter Dams would be below the 64.4°F temperature threshold less often as compared to the NAA by 6 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Effects below Fall Creek Dam would be the same as described under the NAA.

Total Dissolved Gas

Under Alternative 3B, there would be an adverse effect to water quality from TDG in the Middle Fork Willamette River Subbasin, similar to conditions under the NAA. Although operations would spread spill over multiple spillway gates downstream of Lookout Point Dam and Dexter Dam under Alternative 3B, there would be an increase in spill frequency due to drawdown operations for fish passage, which would elevate TDG exceedance of the water quality standard.

There may be differences in the number of days of TDG levels meeting targets as compared to the NAA; however, this would not alter the overall adverse effect on water quality from TDG in the subbasin. Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations under Alternative 3B would result in adverse effects on water quality in the Middle Fork Willamette River Subbasin.

Specifically, under Alternative 3B as compared to the NAA:

- TDG could not be estimated immediately below Lookout Point Dam; however, there would be an increase in TDG exceedance of the water quality standard below Dexter Dam by 42 days per year on average. This would result in a moderately more adverse water quality effect as compared to the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).
- Effects below Hills Creek and Lookout Point Dams would be the same as those described under the NAA.
- Effects below Fall Creek Dam would be the same as those described under the NAA.

There may be differences in the number of days of TDG levels meeting targets; however, this would not alter the overall adverse effect on water quality from TDG in this subbasin (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 3B would result in adverse effects on water quality from TDG in the subbasin as compared to the NAA.

Turbidity

Under Alternative 3B, effects on water quality from turbidity would be substantially more adverse at Hills Creek and Lookout Point than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3B would cause an increase in sediment and turbidity levels downstream of Hills Creek and Lookout Point Reservoirs because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations. While some fine-grained sediment that enters Lookout Point and Dexter Reservoirs from Hills Creek Reservoir may partially settle, most fine-grained sediment would pass through these downstream reservoirs and be transported downstream, likely resulting in increased turbidity downstream during deeper drawdowns compared to NAA operations.

Under Alternative 3B, effects on water quality from turbidity in Fall Creek Reservoir would be the same as those described under the NAA.

Harmful Algal Blooms

Under Alternative 3B, adverse and beneficial effects on water quality from harmful algal blooms would occur. However, total effects on water quality from harmful algal blooms would be moderately more adverse at Hills Creek Reservoir than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3B would cause an increase in sediment and nutrient loading into Hills Creek Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Outflow and storage are expected to decrease substantially during summer at Hills Creek Reservoir under Alternative 3B as compared to NAA operations. These operations would reduce the ability to release deeper reservoir water and, therefore, would avoid releasing surface water that may contain cyanotoxins in Hills Creek Reservoir during harmful algal blooms. However, the reduced storage in Hills Creek Reservoir would reduce residence time in the reservoir, thereby decreasing the potential time that harmful algal blooms would be a concern.

Under Alternative 3B, effects on water quality from harmful algal blooms in Lookout Point Reservoir would be the same as those described under Alternative 1.

Under Alternative 3B, effects on water quality from harmful algal blooms in Fall Creek Reservoir would be the same as those described under the NAA.

Mercury

Under Alternative 3B, effects on water quality from mercury would be moderately more adverse at Hills Creek Reservoir than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 3B would cause an increase in sediment and potential mercury loading into Hills Creek Reservoir because of deeper drawdowns in the spring and summer, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Impacts on water quality from mercury methylation would depend on anoxic conditions and the level of mercury in Hills Creek Reservoir at any given time. Shoreline exposure is expected to increase in both wet and dry years under Alternative 3B operations, which would increase the likelihood of the methylation process if anoxic conditions were to develop in Hills Creek Reservoir compared to the NAA.

Under Alternative 3B, effects on water quality from the mercury methylation process in Lookout Point Reservoir would be the same as those described under Alternative 1.

Under Alternative 3B, effects on water quality from the mercury methylation process in Fall Creek Reservoir would be the same as those described under the NAA.

Coast Fork Willamette River and Long Tom River Subbasins

Water Temperature and Total Dissolved Gas

Under Alternative 3B, effects on water quality from temperature conditions and TDG in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as described under the NAA. There may be differences in the number of days where water temperature standards would be met or in the number of days TDG meets targets; however, this would not alter the overall adverse effect on water quality from temperature conditions and TDG in these subbasins (Table 3.5-10, Table 3.5-11, Table 3.5-12) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 3B, effects on water quality from turbidity, harmful algal blooms, and mercury in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA.

Mainstem Willamette River

Water Temperature

Effects on water quality from temperature conditions in the Mainstem Willamette River would continue to be adverse, similar to the NAA.

Specifically, under Alternative 3B as compared to the NAA:

- Modeled water temperatures on the Mainstem Willamette River at Albany would be below the 64.4°F temperature threshold less often as compared to the NAA by 2 days per year on average.
- Modeled water temperatures on the Mainstem Willamette River at Salem would be below the 64.4°F temperature threshold less often as compared to the NAA by 2 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Chapter 1.6).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 3B would result in continuation of adverse effects on water quality from temperature conditions in this subbasin.

Total Dissolved Gas

Under Alternative 3B, effects on water quality from TDG in the Mainstem Willamette River would be the same as those described under the NAA. TDG is presumed not to be adverse because there are no dam operations on the Mainstem Willamette River.

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 3B, impacts to water quality from turbidity, harmful algal blooms, and mercury in the Mainstem Willamette River would be moderately more adverse than those described under the NAA. This would be due to deeper drawdowns in many WVS reservoirs increasing the likelihood of turbidity, harmful algal blooms, and mercury being passed downstream throughout the Willamette River Basin.

Alternative 4—Improve Fish Passage with Structures-based Approach

North Santiam River Subbasin

Water Temperature

As under the NAA, operations under Alternative 4 would result in adverse effects to water quality during times of year when temperature targets are not met. However, unlike the NAA, a selective withdrawal structure would be operated at Detroit Dam under Alternative 4 resulting in beneficial effects to water quality from improved temperature conditions downstream of Detroit and Big Cliff Dams and substantially fewer adverse effects as compared to the NAA. Temperature targets would be met more often under Alternative 4 as compared to the NAA.

Specifically, under Alternative 4 as compared to the NAA:

- Modeled water temperatures below Detroit and Big Cliff Dams would be within 2°F of the temperature target more often as compared to the NAA by 100 days per year on average (Table3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Exceedance of the 64.4°F temperature threshold would remain the same as under the NAA.

Total Dissolved Gas

As under the NAA, there would be an adverse effect on water quality from TDG under Alternative 4. Operations, including TDG reduction measures and construction of a selective withdrawal structure at Detroit Dam, would result in more beneficial effects to water quality from TDG in the North Santiam River Subbasin and substantially fewer adverse effects as compared to the NAA; however, this would not alter the adverse effect to water quality from TDG.

Specifically, under Alternative 4 as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Detroit Dam by 76 days per year on average.
- There would be a decrease in TDG exceedance of the water quality standard below Big Cliff Dam by 111 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 4, effects on water quality from turbidity, harmful algal blooms, and mercury in the North Santiam River Subbasin would be the same as those described under Alternative 1.

South Santiam River Subbasin

Water Temperature

Under Alternative 4, effects on water quality from temperature conditions in the South Santiam River Subbasin would trend toward a beneficial effect on water temperatures below Green Peter Dam and slightly adverse effects below Foster Dam at certain times of year. Temperature targets would be met slightly more often under Alternative 4 and result in slightly fewer adverse effects as compared to the NAA.

Specifically, under Alternative 4 as compared to the NAA:

- Modeled water temperatures below Green Peter Dam would be within 2°F of temperature targets more often as compared to the NAA by 43 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Modeled water temperatures below Foster Dam would be within 2°F of the temperature targets slightly more often as compared to the NAA by 2 days per year on average.
- Modeled water temperatures below Foster Dam would be below the 64.4°F temperature threshold more often as compared to the NAA by 19 days per year on average.

While adverse effects would continue as under the NAA during the times of year when water temperature targets are not met, Alternative 4 would result in improved water temperatures below Green Peter Dam and a slight difference in water temperatures below Foster Dam, as compared to the NAA.

Total Dissolved Gas

Under Alternative 4, the number of days of TDG exceedance of the water quality standard below and downstream of Foster Dam would have a slightly less adverse effect as compared to the NAA. However, the number of days of TDG exceedance would have a moderately more adverse effect below and downstream of Green Peter Dam as compared to the NAA. This would occur because of use of the spillway in the summer for temperature management instead of a selective withdrawal structure at Green Peter Dam.

However, there would be structural improvements to reduce TDG at Green Peter and Foster Dams under Alternative 4. While there would be a trend toward a beneficial effect in the South

Santiam River Subbasin as compared to the NAA, there would still be an adverse effect to water quality because TDG would not remain below 110 percent year-round in this subbasin.

Specifically, under Alternative 4 as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Green Peter Dam by 117 days per year on average.
- There would be a reduction in TDG exceedance of the water quality standard below Foster Dam by 19 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 4 would result in adverse effects on water quality in the South Santiam River Subbasin regardless of a slight improvement in meeting TDG targets as compared to the NAA.

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 4, effects on water quality from turbidity, harmful algal blooms, and mercury in the South Santiam River Subbasin would be the same as those described under Alternative 1.

McKenzie River Subbasin

Water Temperature

Under Alternative 4, effects on water quality from temperature conditions in the McKenzie River Subbasin would be the same as effects described under the NAA. Operations would result in continued adverse effects on water temperature during times of the year when temperature targets are not met. However, differences in the number of days that temperatures would meet targets would be minimal and would not alter the overall adverse effect on water quality from temperature in this subbasin. Consequently, there would be a slight adverse effect to temperature conditions downstream of Cougar Dam under Alternative 4 operations, similar to the NAA.

Specifically, under Alternative 4 as compared to the NAA:

- Modeled water temperatures below Cougar Dam would be within 2°F of the temperature target less often as compared to the NAA by 17 days per year on average.
- Exceedance of the 64.4°F temperature threshold would be the same as under the NAA (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Total Dissolved Gas

Adverse effects on water quality from TDG when TDG standards are not met would continue under Alternative 4 in the McKenzie River Subbasin as under the NAA. TDG levels would be above 110 percent TDG exceedance of the water quality standard under Alternative 4, but the average number of days per year above 110 percent would be fewer as compared to the NAA. There would be moderately less adverse effect, as compared to the NAA, due to the structural improvement measure to reduce TDG levels.

Specifically, under Alternative 4 as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Cougar Dam by 40 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 1.6, TDG Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 4 would result in adverse effects on water quality in the McKenzie River Subbasin regardless of a slight improvement in meeting TDG targets as compared to the NAA.

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 4, effects on water quality from turbidity, harmful algal blooms, and mercury in the McKenzie River Subbasin would be the same as those described under Alternative 1.

Middle Fork Willamette River Subbasin

Water Temperature

As under the NAA, effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue to have an adverse effect during times of the year when water temperature targets are not met. However, adverse effects from temperature conditions would improve or worsen during certain times of the year as compared to the NAA.

Specifically, under Alternative 4 as compared to the NAA:

- Modeled water temperatures below Hills Creek Dam would be within 2°F of the water temperature target more often as compared to the NAA by 88 days per year on average.
- Modeled water temperatures below Hills Creek Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 28 days per year on average and have a moderately less adverse effect as compared to the NAA.
- Modeled temperatures below Lookout Point/Dexter Dams would be within 2°F of temperature targets slightly less by 2 days per year on average and exceed the 64.4°F temperature threshold more often by 15 days per year on average and have a slightly

adverse effect, the same as described under the NAA (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

- Effects below Fall Creek Dam would be the same as described under the NAA.

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 4 would result in continuation of adverse effects on water quality from temperature conditions in this subbasin.

Total Dissolved Gas

Under Alternative 4, effects on water quality from TDG in the Middle Fork Willamette River Subbasin would be the same as those described under Alternative 1. There may be differences in the number of days of TDG levels meeting targets; however, this would not alter the overall adverse effect on water quality from TDG in this subbasin (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Specifically, under Alternative 4 as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Hills Creek Dam by 1 day per year on average.
- TDG could not be estimated immediately below Lookout Point Dam; however, there would be a decrease in TDG exceedance of the water quality standard below Dexter Dam by 15 days per year on average and have a slightly less adverse effect as compared to the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).
- Effects below Fall Creek Dam would be the same as those described under the NAA.

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 4, effects on water quality from turbidity, harmful algal blooms, and mercury in the Middle Fork Willamette River Subbasin would be the same as those described under Alternative 1.

Coast Fork Willamette River and Long Tom River Subbasins

Water Temperature and Total Dissolved Gas

Under Alternative 4, effects on water quality from temperature conditions and TDG in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as described under the NAA. There may be differences in the number of days where water temperature standards would be met; however, this would not alter the overall adverse effect on water quality from temperature conditions and TDG (Table 3.5-10, Table 3.5-11, Table 3.5-12) (Appendix D, Water

Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 4, effects on water quality from turbidity, harmful algal blooms, and mercury in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA.

Mainstem Willamette River

Water Temperature

Effects on water quality from temperature conditions in the Mainstem Willamette River would continue to be adverse under Alternative 4, similar to the NAA.

Specifically, under Alternative 4 as compared to the NAA:

- Modeled temperatures on the Mainstem Willamette River at Albany would be below the 64.4°F temperature threshold slightly less often as compared to the NAA by 4 days per year on average.
- Modeled temperatures on the Mainstem Willamette River at Salem would be below the 64.4°F temperature threshold slightly less often as compared to the NAA by 5 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 4 would result in continuation of adverse effects on water quality from temperature conditions in this subbasin.

Total Dissolved Gas

Under Alternative 4, effects on water quality from TDG in the Mainstem Willamette River would be the same as described under the NAA. TDG is presumed not to be adverse because there are no dam operations on the Mainstem Willamette River.

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 4, impacts to water quality from turbidity, harmful algal blooms, and mercury in the Mainstem Willamette River would be the same as those described under the NAA.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

North Santiam River Subbasin

Water Temperature

As under the NAA, operations under Alternative 5 would result in adverse effects to water quality during times of year when temperature targets are not met. However, unlike the NAA, a selective withdrawal structure would be operated at Detroit Dam under Alternative 5 resulting in beneficial effects to water quality from improved temperature conditions downstream of Detroit and Big Cliff Dams and substantially fewer adverse effects as compared to the NAA. Temperature targets would be met more often under Alternative 5 as compared to the NAA.

There may be differences in the number of days where water temperature standards would be met; however, this would not alter the overall adverse effect on water quality from temperature conditions in this subbasin (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Specifically, under Alternative 5 as compared to the NAA:

- Modeled water temperatures below Detroit and Big Cliff Dams would be within 2°F of the temperature target more often as compared to the NAA by 99 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Exceedance of the 64.4°F temperature threshold would remain the same as under the NAA.

Total Dissolved Gas

There would be an adverse effect on water quality from TDG under Alternative 5. However, there would be an improvement in water quality from TDG due to a decrease in the average number of days per year above 110 percent TDG exceedance of the water quality standard compared to the NAA. This improvement would result from reduction of spill operations from construction of the selective withdrawal structure at Detroit Dam and substantially fewer adverse effects as compared to the NAA. Operation of the structure would reduce the need for temperature management through operational spill under Alternative 5.

However, there would be no specific measure to reduce TDG levels below Detroit and Big Cliff Dams in the North Santiam Subbasin under Alternative 5. TDG levels would continue to have adverse effects on water quality as under the NAA in these downstream reaches.

Specifically, under Alternative 5 as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Detroit Dam by 77 days per year on average.
- There would be a decrease in TDG exceedance of the water quality standard below Big Cliff Dam by 69 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 5, effects on water quality from turbidity, harmful algal blooms, and mercury in the North Santiam River Subbasin would be the same as those described under Alternative 1.

South Santiam River Subbasin

Water Temperature

Under Alternative 5, adverse effects on water quality from temperature conditions in the South Santiam River Subbasin would continue as under the NAA. Adverse effects would occur under Alternative 5 operations during the times of year when water temperature targets are not met. However, Alternative 5 would result in improved water temperatures below Green Peter Dam due to the use of the regulating outlets to discharge colder water during drawdown operations in the fall and winter to reduce water temperatures, but operations would worsen water temperatures below Foster Dam at certain times of year. Temperature targets would be met slightly more often under Alternative 5 and result in slightly fewer adverse effects as compared to the NAA.

Specifically, under Alternative 5 as compared to the NAA:

- Modeled water temperatures below Green Peter Dam would be within 2°F of the temperature targets more often as compared to the NAA by 80 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Chapter 1.6).
- Modeled water temperatures below Foster Dam would be within 2°F of the temperature targets less often as compared to the NAA by 8 days per year on average. However, modeled water temperatures below Foster Dam would be below 64.4°F temperature threshold more often as compared to the NAA by 7 days per year on average.

Total Dissolved Gas

Under Alternative 5, effects on water quality from TDG in the South Santiam River Subbasin would be the same as those described under Alternative 2B. The increase in TDG exceedance of the water quality standard would occur downstream of Green Peter and Foster Dams. This would be due to an increase in spill operations at Green Peter Dam in the spring (fish passage operation) and summer (temperature management operation). There are no TDG abatement measures proposed under Alternative 5 for the South Santiam River Subbasin. There may be differences in the number of days of TDG levels meeting targets; however, this would not alter the overall adverse effect on water quality from TDG in this subbasin (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Specifically, under Alternative 5 as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Green Peter Dam by 139 days per year on average.
- There would be an increase in TDG exceedance of the water quality standard below Foster Dam by 94 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 5, effects on water quality from turbidity, harmful algal blooms, and mercury in the South Santiam River Subbasin would be the same as those described under Alternative 2B.

McKenzie River Subbasin

Water Temperature

Under Alternative 5, effects on water quality from temperature conditions in the McKenzie River Subbasin would be the same as effects described under Alternative 2B. Operations would result in continued adverse effects on water temperature during times of the year when temperature targets are not met. However, there would be a decrease in adverse temperature conditions downstream of Cougar Dam under Alternative 5 operations.

Unlike NAA operations, Alternative 5 would result in beneficial changes in water temperature conditions downstream of Cougar Dam. There would be an improvement to water temperature in the McKenzie River Subbasin because downstream conditions would nearly mimic upstream conditions under Alternative 5 operations. Temperature targets would be met more often under Alternative 5 and result in substantially fewer adverse effects as compared to the NAA.

Specifically, under Alternative 5 as compared to the NAA:

- Modeled water temperatures below Cougar Dam would be within 2°F of the temperature target less often as compared to the NAA by 61 days per year on average.
- Modeled water temperatures below Cougar Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 6 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Total Dissolved Gas

Similar to the NAA, adverse effects on water quality from TDG would continue under Alternative 5 operations; however, improvements in TDG conditions would be expected. Although there would be no measures implemented to reduce TDG below Cougar Dam under Alternative 5, there would be a decrease in TDG exceedance of the water quality standard and a moderately less adverse effect as compared to the NAA. This would likely result from use of the diversion tunnel at Cougar Dam for a deep drawdown in the spring and fall and limited refill from June 15 until November 15.

Specifically, under Alternative 5 as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Cougar Dam by 42 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 5 would result in adverse effects on water quality in the McKenzie River Subbasin regardless of a slight improvement in meeting TDG targets as compared to the NAA.

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 5, effects on water quality from turbidity, harmful algal blooms, and mercury in the McKenzie River Subbasin would be the same as those described under Alternative 2B.

Middle Fork Willamette River Subbasin

Water Temperature

Effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue to be adverse, similar to the NAA.

Specifically, under Alternative 5 as compared to the NAA:

- Modeled water temperatures below Hills Creek Dam would be within 2°F of the water temperature target less often as compared to the NAA by 14 days per year on average. In addition, modeled water temperatures below Hills Creek would be below the 64.4°F temperature threshold less often as compared to the NAA by 31 days per year on average.
- Modeled water temperatures below Lookout Point/Dexter Dams would be within 2°F of the temperature target more often as compared to the NAA by 6 days per year on average and be below 64.4°F temperature threshold more often as compared to the

NAA by 3 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

- Effects below Fall Creek Dam would be the same as described under the NAA.

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 5 would result in continuation of adverse effects on water quality from temperature conditions in this subbasin.

Total Dissolved Gas

Under Alternative 5, effects on water quality from TDG in the Middle Fork Willamette River Subbasin would be the same as those described under the NAA. There may be differences in the number of days TDG levels meet targets; however, this would not alter the overall adverse effect on water quality from TDG in this subbasin (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Specifically, under Alternative 5 as compared to the NAA:

- There would be a decrease in TDG exceedance of the water quality standard below Hills Creek Dam by 1 days per year on average.
- TDG could not be estimated immediately below Lookout Point Dam; however, TDG exceedance of the water quality standard below Dexter Dam would be the same as under the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).
- Effects below Fall Creek Dam would be the same as those described under the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 5, effects on water quality from turbidity, harmful algal blooms, and mercury in the Middle Fork Willamette River Subbasin would be the same as those described under Alternative 1.

Coast Fork Willamette River and Long Tom River Subbasins

Water Temperature and Total Dissolved Gas

Under Alternative 5, effects on water quality from temperature conditions and TDG in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as described under the NAA. There may be differences in the number of days where water temperature standards would be met or in the number of days TDG meets targets; however, this would not alter the overall adverse effect on water quality from temperature conditions and TDG in these subbasins (Table 3.5-10, Table 3.5-11, Table 3.5-12) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 5, effects on water quality from turbidity, harmful algal blooms, and mercury in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA.

Mainstem Willamette River

Water Temperature

Effects on water quality from temperature conditions in the Mainstem Willamette River would continue to be adverse and nearly the same as effects under the NAA.

Specifically, under Alternative 5 as compared to the NAA:

- Modeled water temperatures on the Mainstem Willamette River at Albany would be below the 64.4°F temperature threshold slightly more often as compared to the NAA by 1 day per year on average.
- Modeled water temperatures on the Mainstem Willamette River at Salem would be below the 64.4°F temperature threshold slightly more often as compared to the NAA by 1 day per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under Alternative 5 would result in continuation of adverse effects on water quality from temperature conditions in this subbasin.

Total Dissolved Gas

Under Alternative 5, effects on water quality from TDG in the Mainstem Willamette River would be the same as described under the NAA. TDG is presumed not to be adverse because there are no dam operations on the Mainstem Willamette River.

Turbidity, Harmful Algal Blooms, and Mercury

Under Alternative 5, impacts to water quality from turbidity, harmful algal blooms, and mercury in the Mainstem Willamette River would be slightly more adverse than those described under the NAA. This is due to deeper drawdowns in many WVS reservoirs, increasing the likelihood of turbidity, harmful algal blooms, and mercury being passed downstream.

3.5.4 Interim Operations under All Action Alternatives Except Alternative 1

The timing and duration of Interim Operations would vary depending on a given alternative. Interim Operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations would be implemented in succession with, and not in addition to, action alternative implementation.

Revisions to modeled Interim Operations from DEIS alternatives analyses to FEIS alternatives analyses did not warrant revisions to water temperature or TDG modeling due to the resulting minor changes to operations. These changes were limited to extreme dry years and are explained further in Appendix D. Therefore, the DEIS analyses were not revised in the FEIS because the expected differences did not warrant analysis modifications.

Operations that focus on deep drawdowns, earlier drawdown, and delayed refills for downstream fish passage would greatly increase erosion and bank stability, which would be a continuation of major, adverse effects to water quality.

3.5.4.1 North Santiam River Subbasin

Water Temperature

An overall continued adverse effect to water quality would occur with implementation of the Interim Operations in the North Santiam River Subbasin. However, there would be a slight improvement to water temperature as compared to the NAA. Temperature targets under the Interim Operations differ from targets modeled for the NAA.

Specifically, under the Interim Operations as compared to the NAA:

- Modeled water temperatures would be within 2°F of targets more often as compared to the NAA below Detroit and Big Cliff Dams by 16 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Exceedance of the 64.4°F temperature threshold would remain the same as under the NAA.

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under the Interim Operations would result in continuation of adverse effects on water quality from temperature conditions in the North Santiam River Subbasin even though the Interim Operations are expected to provide some benefit to water temperature conditions.

Total Dissolved Gas

Under the Interim Operations, there would be a substantial adverse effect to water quality from TDG as compared to the NAA in the North Santiam River Subbasin. This is because there would be a combination of measures implemented that would increase the spill frequency, increasing TDG exceedance of the water quality standard as compared to the NAA.

Specifically, under the Interim Operations as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Detroit Dam by 161 days per year on average and below Big Cliff Dam by 147 days per year on average as compared to the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under the Interim Operations would result in adverse effects on water quality from TDG in the North Santiam River Subbasin.

Turbidity, Harmful Algal Blooms, and Mercury

Under the Interim Operations, effects on water quality in the North Santiam River Subbasin from turbidity, harmful algal blooms, and mercury would be the same as those described under Alternative 1.

3.5.4.2 South Santiam River Subbasin

Water Temperature

Temperature targets under the Interim Operations differ from targets modeled for the NAA. However, effects on water quality from temperature conditions in the South Santiam River Subbasin would be adverse, similar to the NAA.

Specifically, under the Interim Operations as compared to the NAA:

- Modeled water temperatures below Foster Dam would be within 2°F of the water temperature target less often as compared to the NAA by 31 days per year on average; however, temperatures would remain below the 64.4°F temperature threshold by 15 days per year on average more often than under the NAA.

- Modeled water temperatures below Green Peter Dam would be within 2°F of the water temperature target the same as under the NAA (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under the Interim Operations would result in continuation of adverse effects on water quality from temperature conditions in the South Santiam River Subbasin.

Total Dissolved Gas

Under the Interim Operations, there would be a moderately more adverse effect on water quality from TDG as compared to the NAA in the South Santiam River Subbasin. This is because a combination of measures would be implemented that would increase the spill frequency and TDG exceedance of the water quality standard produced by operating Green Peter and Foster Dams.

Specifically, under the Interim Operations as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Green Peter Dam by 67 days per year on average.
- There would be an increase in TDG exceedance of the water quality standard below Foster Dam by 41 days per year on average as compared to the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under the Interim Operations would result in adverse effects on water quality from TDG in the South Santiam River Subbasin.

Turbidity, Harmful Algal Blooms, and Mercury

Under the Interim Operations, effects on water quality from turbidity, harmful algal blooms, and mercury would be the same as those described under Alternative 2A.

3.5.4.3 McKenzie River Subbasin

Water Temperature

Effects on water temperature conditions in the McKenzie River Subbasin would be slightly more adverse under the Interim Operations as compared to the NAA even with operation of the Cougar Dam water temperature control tower.

Specifically, under the Interim Operations as compared to the NAA:

- Modeled water temperatures below Cougar Dam would be within 2°F of the water temperature target less often as compared to the NAA by 36 days per year on average.
- Modeled water temperatures below Cougar Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 24 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under the Interim Operations would result in continuation of adverse effects on water quality in the McKenzie River Subbasin from temperature conditions.

Total Dissolved Gas

Under the Interim Operations, there would be a substantial adverse effect to water quality from TDG exceedance of the water quality standard in the McKenzie River Subbasin as compared to the NAA. This is because a combination of measures would be implemented that would increase frequency of spill through the regulating outlets resulting in elevated TDG levels downstream of Cougar Dam.

Specifically, under the Interim Operations as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Cougar Dam by 77 days per year on average as compared to the NAA (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under the Interim Operations would result in adverse effects on water quality from TDG in the McKenzie River Subbasin.

Turbidity, Harmful Algal Blooms, and Mercury

Under the Interim Operations, effects on water quality from turbidity, harmful algal blooms, and the mercury in the McKenzie River Subbasin would be the same as those described under Alternative 3A.

3.5.4.4 Middle Fork Willamette River Subbasin

Water Temperature

Effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue to be adverse, similar to the NAA.

Specifically, under the Interim Operations as compared to the NAA:

- Modeled water temperatures below Hills Creek Dam would be within 2°F of the water temperature targets more often as compared to the NAA by 7 days per year on average. However, modeled water temperatures below Hills Creek Dam would be below the 64.4°F temperature threshold less often as compared to the NAA by 14 days per year on average.
- Modeled water temperatures below Lookout Point/Dexter Dams would be within 2°F of water temperature targets more often as compared to the NAA by 7 days per year on average. Although, modeled water temperatures below Lookout Point/Dexter Dams would be below the 64.4°F temperature threshold less often as compared to the NAA by 3 days per year on average (Table 3.5-10 and Table 3.5-11) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis).
- Effects below Fall Creek Dam would be the same as described under the NAA.

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under the Interim Operations would result in continuation of adverse effects on water quality in the Middle Fork Willamette River Subbasin from temperature conditions.

Total Dissolved Gas

Under the Interim Operations, there would be a slightly more adverse effect to water quality from TDG as compared to the NAA in the Middle Fork Willamette River Subbasin because a combination of measures would be implemented that would increase spill frequency and TDG levels downstream of the Middle Fork Willamette River dams.

Specifically, under the Interim Operations as compared to the NAA:

- There would be an increase in TDG exceedance of the water quality standard below Dexter Dam by 32 days per year on average.
- There would be an increase in TDG exceedance of the water quality standard below Lookout Point Dam by 15 days per year on average.
- There would be a slight decrease of TDG exceedance of the water quality standard below Hills Creek Dam by 3 days per year on average (Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

- Effects below Fall Creek Dam would be the same as those described under the NAA.

Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations and maintenance under the Interim Operations would result in adverse effects on water quality from TDG in the Middle Fork Willamette River Subbasin.

Turbidity

Under the Interim Operations, effects on water quality from turbidity would be substantially more adverse than those described under the NAA during the 30-year implementation timeframe. Operations under the Interim Operations would cause an increase in sediment and turbidity levels downstream of Lookout Point Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations. While some fine-grained sediment that enters Dexter Reservoir from Lookout Point Reservoir may partially settle, most fine-grained sediment would pass through Dexter Reservoir and be transported downstream, likely resulting in increased turbidity downstream during deeper drawdowns compared to NAA operations.

Harmful Algal Blooms

Under the Interim Operations, effects on water quality from harmful algal blooms would be moderately more adverse than those described under the NAA during the 30-year implementation timeframe as a result of combined adverse and beneficial effects. Operations under the Interim Operations would cause an increase in sediment and nutrient loading into Lookout Point Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Outflow and storage are expected to decrease substantially during summer at Lookout Point Reservoir under the Interim Operations as compared to NAA operations. These operations would reduce the ability to release deeper reservoir water and, therefore, would avoid releasing surface water that may contain cyanotoxins in Lookout Point Reservoir during harmful algal blooms. However, the reduced storage in Lookout Point Reservoir would reduce residence time in the reservoir, thereby decreasing the potential time that harmful algal blooms would be a concern.

Mercury

Under the Interim Operations, effects on water quality from mercury would be moderately more adverse than those described under the NAA during the 30-year implementation timeframe. Operations under the Interim Operations would cause an increase in sediment and potential mercury loading into Lookout Point Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations.

Impacts on water quality from mercury methylation would depend on anoxic conditions and the level of mercury in Lookout Point and Dexter Reservoirs at any given time. Dissolved oxygen monitoring downstream of Lookout Point Dam during deep drawdown operations in fall of 2023 did not result in values below 80 percent saturation. Therefore, any potential increases of anoxic water (or associated mercury methylation) from deep drawdown operations are expected to have low magnitude and be short-lived. Shoreline exposure is expected to increase due to in the Interim Operations, which would increase the likelihood of the methylation process if anoxic conditions were to develop in Lookout Point Reservoir compared to NAA operations.

3.5.4.5 Coast Fork Willamette River and Long Tom River Subbasins

Water Temperature and Total Dissolved Gas

Under the Interim Operations, effects on water quality in the Coast Fork Willamette River and Long Tom River Subbasins from temperature conditions and TDG would be the same as described under the NAA. There may be differences in the number of days where water temperature standards would be met or in the number of days TDG meets targets; however, this would not alter the overall adverse effect on water quality from temperature conditions and TDG in these subbasins (Table 3.5-10, Table 3.5-11, Table 3.5-12) (Appendix D, Water Quality Analysis, Section 1.6, Supporting Data for Water Quality Effects Analysis, Section 2.2, Total Dissolved Gas Results and Effects Analysis).

Turbidity, Harmful Algal Blooms, and Mercury

Under the Interim Operations, effects on water quality from turbidity, harmful algal blooms, and mercury in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA.

3.5.4.6 Mainstem Willamette River

Water Temperature and Total Dissolved Gas

Under the Interim Operations, effects on water quality from temperature conditions and TDG in the Mainstem Willamette River would be the same as described under the NAA. There may be differences in the number of days where water temperature standards would be met; however, this would not alter the overall adverse effect on water quality from temperature conditions. TDG is presumed not to be adverse because there are no dam operations on the Mainstem Willamette River.

Turbidity, Harmful Algal Blooms, and Mercury

Under the Interim Operations, effects on water quality from turbidity, harmful algal blooms, and the mercury in the Mainstem Willamette River would be the same as those described under Alternative 3A.

3.5.5 Climate Change Effects

Water quality parameters such as water temperature and TDG would be influenced by refill timing, storage volume, and outflow at each dam under any of the alternatives. In general, effects from climate change would be indirect in all subbasins and on the Mainstem Willamette River. While temperature management would continue under all alternatives, such management would require modifications to address climate-related flow changes. Specific management modifications, while anticipated under the alternatives, are speculative.

As with modifications to temperature management, specific monitoring requirements and modifications in WVS operations to address increases in turbidity, harmful algal blooms, and mercury are speculative. However, the Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop under any alternative (Appendix N, Implementation and Adaptive Management Plan).

Climate change projections for the 2030s and 2070s under Representative Concentration Pathways (RCP) 8.5 show higher WVS dam inflow between December and March and lower inflow between April and November for the Willamette River Basin (Appendix F2, Supplemental Climate Change Information, Figure 3-5).

Higher winter flows occurring during December and January would not be stored at the WVS dams as the guide curves for the WVS generally begin February 1, which would not likely change during the 30-year implementation timeframe under any alternative. Climate change projections observe less precipitation in the spring and summer (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.5, Changes in Winter Atmospheric Rivers; Appendix F2, Supplemental Climate Change Information, Section 3.1.2, Precipitation and Figure 3-5). Therefore, the reduced spring and summer precipitation would likely lead to decreased release volumes in spring and summer at the WVS dams under any alternative as compared to 2019 conditions (Section 3.5.2, Affected Environment). Consequently, decreased storage would also likely decrease the ability to manage dam releases from different outlets for temperature management, leading to less normative release temperatures during the 30-year implementation timeframe (e.g., cooler in spring-early summer, warmer in fall).

3.5.5.1 No-action Alternative

Specifically, under the NAA there would likely be less flow during the summer from Detroit, Green Peter, Foster, Cougar, Hills Creek, and Lookout Point Dams and the Mainstem Willamette River, which may cause increased downstream water temperatures. This would likely result in adverse water temperature effects depending on site-specific and annual-specific precipitation conditions (Table 3.5-10 and Table 3.5-11).

Turbidity may have slightly adverse effects on water quality during high flow events in winter and spring when reservoirs are at capacity and USACE is unable to store sediment-laden inflows compared to 2019 conditions.

Harmful algal blooms and mercury may have slightly adverse effects on water quality when late summer inflows are lower compared to 2019 conditions. However, similar to water temperature effects, these parameters may be influenced by reservoir storage and time of year resulting from climate change conditions over the 30-year implementation timeframe.

3.5.5.2 Alternative 1—Improve Fish Passage through Storage-focused Measures

Compared to the NAA, Alternative 1 would potentially increase resiliency against climate change impacts on water temperature and TDG (increased water temperature control) below Detroit and Green Peter Dams because of the proposed selective withdrawal structure and TDG abatement measures at each location. Parameters such as turbidity and mercury will likely experience similar effects as those described under the NAA.

Increased releases from the reservoir surface via the proposed selective withdrawal structures at Detroit, Green Peter, and Lookout Point Reservoirs combined with reduced summer flow volumes under Alternative 1 could lead to increased phytoplankton (algae) compared to the NAA (Appendix B, Hydrologic Processes Technical Information).

3.5.5.3 Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Operations and maintenance under Alternative 2A would have the potential for more resiliency against climate change effects on water temperature as compared to the NAA. This would result from measures under Alternative 2A for increased water temperature control below Detroit Dam from the proposed selective withdrawal structure and Green Peter Dam operational temperature control measure. TDG effects immediately below Detroit Dam would likely be more resilient to climate change under Alternative 2A due to the proposed structure (reducing the need for operational temperature control). Impacts on water quality from turbidity, harmful algal blooms, and mercury would likely be similar to those described under the NAA.

3.5.5.4 Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative and Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Measures under Alternative 2B and Alternative 5 would include increased water temperature control below Detroit Dam because of proposed selective withdrawal structures and TDG abatement measures at each location as compared to the NAA. Operations under Alternative 2B and Alternative 5 would potentially increase resiliency against climate change impacts on water temperature and TDG (increased water temperature control) below Detroit Dam because of the proposed selective withdrawal structure and TDG abatement measures at each location. Impacts on water quality from turbidity, harmful algal blooms, and mercury would likely be similar to those described under the NAA.

3.5.5.5 Alternative 3A—Improve Fish Passage through Operations-focused Measures

Compared to the NAA, Alternative 3A would potentially reduce resiliency against climate change impacts on water temperature (decreased water temperature control) below Detroit, Cougar, and Lookout Point Dams, and lower on the Mainstem Willamette River at Salem because of lower storage and outflows at each location. However, operations under Alternative 3A would potentially increase resiliency against climate change impacts on water temperature (more normative water temperature) below Hills Creek, Green Peter, and Foster Dams due to the elevation of summer reservoir levels.

Resiliency against climate change impacts to TDG, turbidity, harmful algal blooms, and mercury would likely decrease as compared to the NAA below Lookout Point, Green Peter, and Detroit Dams due to decreased water storage and increased spill operations (Appendix D, Water Quality Analysis, Chapter 2).

3.5.5.6 Alternative 3B—Improve Fish Passage through Operations-focused Measures

Compared to NAA operations, Alternative 3B would potentially reduce resiliency against climate change impacts on water temperature (decreased water temperature control) below Green Peter Dam and lower on the Mainstem Willamette River at Salem because of lower storage and outflows at each location. However, Alternative 3B would potentially increase resiliency against climate change impacts on water temperature (more normative temperatures) below Lookout Point, Dexter, and Hills Creek Dams due to operational reservoir elevations.

Resiliency against climate change impacts to TDG would likely increase below Cougar Dam and decrease below Lookout Point, Green Peter, and Detroit Dams due to reduced water storage and changes to spill operations. Resiliency against climate change impacts to turbidity, harmful algal blooms, and mercury would likely decrease compared to those described under the NAA.

3.5.5.7 Alternative 4—Improve Fish Passage with Structures-based Approach

Compared to the NAA, Alternative 4 would potentially increase resiliency against climate change impacts on water temperature and TDG (increased water temperature control) below Detroit, Lookout Point, and Hills Creek Dams as a result of the proposed selective withdrawal structure and TDG abatement measures at each location. Parameters such as turbidity and mercury would likely experience similar impacts as those described under the NAA. Increased releases from the reservoir surface via the proposed selective withdrawal structures at Detroit, Lookout Point, and Hills Creek Dams combined with reduced summer flow volumes under Alternative 4 could lead to increased phytoplankton (algae) compared to the NAA (Appendix B, Hydrologic Process Technical Information).

END REVISED TEXT

THE DEIS HAS BEEN MODIFIED TO INCLUDE THE FOLLOWING FIGURES

3.5.6 Summary of Effects

Temperature

No-action Alternative

Downstream Location	Effect
Hills Creek	Moderate Adverse
Dexter	Moderate Adverse
Cougar	Slight Adverse
Foster	Moderate Adverse
Big Cliff	Moderate Adverse
Salem	Slight Adverse

Interim Operations

Downstream Location	Effect
Hills Creek	–
Dexter	–
Cougar	☹
Foster	–
Big Cliff	☺
Salem	–

Action Alternatives

Downstream Location	1	2A	2B	3A	3B	4	5
Hills Creek	–	–	–	☺☺	☺	☺☺	–
Dexter	–	–	–	☺	☺	–	–
Cougar	☺	–	☺☺☺	☹	☺☺☺	--	☺☺☺
Foster	☺	☺	☺	☺	☹	☺	☺
Big Cliff	☺☺☺	☺☺☺	☺☺☺	☹☹	–	☺☺☺	☺☺☺
Salem	–	–	–	☹	–	–	–

Figure 3.5-59. Depiction of Water Quality Parameter Temperature Effects as Compared to the No-action Alternative.

Notes:

Effects would occur immediately below each downstream location.

Interim Operations and Action Alternative effects as compared to No-action Alternative effects = substantially more adverse (☹☹☹), moderately more adverse (☹☹), slightly more adverse (☹), no difference (–), slightly less adverse (☺), moderately less adverse (☺☺), or substantially less adverse (☺☺☺).

Hills Creek and Dexter Dams = Middle Fork Willamette River Subbasin

Cougar Dam = McKenzie River Subbasin

Big Cliff Dam = North Santiam River Subbasin

Foster Dam = South Santiam River Subbasin

Salem = A gage located on the Willamette River

Total Dissolved Gas

No-action Alternative

Downstream Location	Effect
Hills Creek	Slight Adverse
Dexter	Slight Adverse
Cougar	Moderate Adverse
Foster	Slight Adverse
Big Cliff	Moderate Adverse

Interim Operations

Downstream Location	Effect
Hills Creek	☹
Dexter	☹
Cougar	☹☹☹
Foster	☹☹
Big Cliff	☹☹☹

Action Alternatives

Downstream Location	1	2A	2B	3A	3B	4	5
Hills Creek	–	–	–	☺	–	–	–
Dexter	–	–	–	☹☹	☹☹	☺	–
Cougar	☺	–	☺☺	☹	☺☺	☺☺	☺☺
Foster	☺	☹☹☹	☹☹☹	☹☹☹	☹☹	☺	☹☹☹
Big Cliff	☺☺☺	☺☺☺	☺☺☺	☹☹☹	☹☹☹	☺☺☺	☺☺☺

Figure 3.5-60. Depiction of Water Quality Parameter Total Dissolved Gas Effects as Compared to the No-action Alternative.

Notes:

Effects would occur immediately below each downstream location.

Interim Operations and Action Alternative effects as compared to No-action Alternative effects = substantially more adverse (☹☹☹), moderately more adverse (☹☹), slightly more adverse (☹), no difference (–), slightly less adverse (☺), moderately less adverse (☺☺), or substantially less adverse (☺☺☺).

Hills Creek and Dexter Dams = Middle Fork Willamette River Subbasin

Cougar Dam = McKenzie River Subbasin

Big Cliff Dam = North Santiam River Subbasin

Foster Dam = South Santiam River Subbasin

Salem = A gage located on the Willamette River

Turbidity

No-action Alternative

Downstream Location	Effect
Hills Creek	Adverse and Beneficial
Dexter	Adverse and Beneficial
Cougar	Adverse and Beneficial
Foster	Adverse and Beneficial
Big Cliff	Adverse and Beneficial
Salem	Slight Adverse

Interim Operations

Downstream Location	Effect
Hills Creek	–
Dexter	☹☹☹
Cougar	☹
Foster	☹☹☹
Big Cliff	–
Salem	☹☹

Action Alternatives

Downstream Location	1	2A	2B	3A	3B	4	5
Hills Creek	–	–	–	–	☹☹☹	–	–
Dexter	–	–	–	☹☹☹	☹☹☹	–	–
Cougar	–	–	☹☹☹	☹	☹☹☹	–	☹☹☹
Foster	–	☹☹☹	☹☹☹	☹☹☹	☹☹☹	–	☹☹☹
Big Cliff	–	–	–	☹☹☹	☹☹☹	–	–
Salem	–	–	☹	☹☹	☹☹	–	☹

Figure 3.5-61. Depiction of Water Quality Parameter Turbidity Effects as Compared to the No-action Alternative.

Notes:

Effects would occur immediately below each downstream location.

Interim Operations and Action Alternative effects as compared to No-action Alternative effects = substantially more adverse (☹☹☹), moderately more adverse (☹☹), slightly more adverse (☹), no difference (–), slightly less adverse (☺), moderately less adverse (☺☺), or substantially less adverse (☺☺☺).

Hills Creek and Dexter Dams = Middle Fork Willamette River Subbasin

Cougar Dam = McKenzie River Subbasin

Big Cliff Dam = North Santiam River Subbasin

Foster Dam = South Santiam River Subbasin

Salem = A gage located on the Willamette River

Harmful Agal Blooms

No-action Alternative

Downstream Location	Effect
Hills Creek	Slight Adverse
Dexter	Slight Adverse
Cougar	Slight Adverse
Foster	Slight Adverse
Big Cliff	Slight Adverse
Salem	Slight Adverse

Interim Operations

Downstream Location	Effect
Hills Creek	–
Dexter	☹☹
Cougar	☹
Foster	☹☹☹
Big Cliff	–
Salem	☹☹

Action Alternatives

Downstream Location	1	2A	2B	3A	3B	4	5
Hills Creek	☹	☹	☹	☹	☹☹	☹	☹
Dexter	☹	☹	☹	☹☹	☹	☹	☹
Cougar	☹	☹	☹☹	☹☹	☹☹	☹	☹☹
Foster	☹	☹☹	☹☹	☹☹	☹☹	☹	☹☹
Big Cliff	☹	☹	☹	☹☹	☹☹	☹	☹
Salem	–	–	☹	☹☹	☹☹	–	☹

Figure 3.5-62. Depiction of Water Quality Parameter Harmful Algal Bloom Effects as Compared to the No-action Alternative.

Notes:

Effects would occur immediately below each downstream location.

Interim Operations and Action Alternative effects as compared to No-action Alternative effects = substantially more adverse (☹☹☹), moderately more adverse (☹☹), slightly more adverse (☹), no difference (–), slightly less adverse (☺), moderately less adverse (☺☺), or substantially less adverse (☺☺☺).

Hills Creek and Dexter Dams = Middle Fork Willamette River Subbasin

Cougar Dam = McKenzie River Subbasin

Big Cliff Dam = North Santiam River Subbasin

Foster Dam = South Santiam River Subbasin

Salem = A gage located on the Willamette River

Mercury

No-action Alternative

Downstream Location	Effect
Hills Creek	Slight Adverse
Dexter	Slight Adverse
Cougar	Slight Adverse
Foster	Slight Adverse
Big Cliff	Slight Adverse
Salem	Slight Adverse

Interim Operations

Downstream Location	Effect
Hills Creek	--
Dexter	☹☹
Cougar	☹
Foster	☹☹☹
Big Cliff	--
Salem	☹☹

Action Alternatives

Downstream Location	1	2A	2B	3A	3B	4	5
Hills Creek	☹	☹	☹	☹	☹☹	☹	☹
Dexter	☹	☹	☹	☹☹	☹☹	☹	☹
Cougar	☹	☹	☹☹	☹	☹☹	☹	☹☹
Foster	☹	☹☹	☹☹	☹☹	☹☹	☹	☹☹
Big Cliff	☹	☹	☹	☹☹	☹☹	☹	☹
Salem	--	--	☹	☹☹	☹☹	--	☹

Figure 3.5-63. Depiction of Water Quality Parameter Mercury Effects as Compared to the No-action Alternative.

Notes:

Effects would occur immediately below each downstream location.

Interim Operations and Action Alternative effects as compared to No-action Alternative effects = substantially more adverse (☹☹☹), moderately more adverse (☹☹), slightly more adverse (☹), no difference (–), slightly less adverse (☺), moderately less adverse (☺☺), or substantially less adverse (☺☺☺).

Hills Creek and Dexter Dams = Middle Fork Willamette River Subbasin

Cougar Dam = McKenzie River Subbasin

Big Cliff Dam = North Santiam River Subbasin

Foster Dam = South Santiam River Subbasin

Salem = A gage located on the Willamette River

Table 3.5-13. Summary of Effects to Water Quality in the North Santiam River Subbasin as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Detroit and Big Cliff Reservoirs	**Temp –** Moderate adverse effect. **TDG –** Moderate adverse effect. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Substantially less adverse effects. **TDG –** Substantially less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effects. **TDG –** Substantially less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effects. **TDG –** Substantially less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Moderate increase to adverse effects. **TDG –** Substantial increase of adverse effects. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more Adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Substantial increase of adverse effects. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more Adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Substantially less adverse effects. **TDG –** Substantially less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effects. **TDG –** Substantially less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 3.5-14. Summary of Effects to Water Quality in the South Santiam River Subbasin as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Green Peter and Foster Reservoirs	**Temp –** Moderate adverse effect. **TDG –** Slight adverse effect. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Slightly less adverse effect. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Substantially more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Substantially more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Substantially more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Slightly more adverse effects. **TDG –** Moderately more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Slightly less adverse effects downstream of Foster Dam. Moderately more adverse below Green Peter Dam. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Substantially more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 3.5-15. Summary of Effects to Water Quality in the McKenzie River Subbasin as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Cougar and Blue River Reservoirs	**Temp –** Slight adverse effect. **TDG –** Moderate adverse effect. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Slightly less adverse effect. **TDG –** Slightly less adverse effect. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effect. **Mercury –** Slightly more adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effect. **Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effect. TDG **–** Moderately less adverse effect. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more adverse effects. **Mercury –** Moderately more adverse effects.	**Temp –** Slightly more adverse effect. **TDG –** Slightly more adverse effect. **Turbidity –** Slightly more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effect. **TDG –** Moderately less adverse effect. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more adverse effects. **Mercury –** Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Moderately less adverse effect. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effect. **Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effect. **TDG –** Moderately less adverse effect. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more adverse effects. **Mercury –** Moderately more adverse effects.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 3.5-16. Summary of Effects to Water Quality in the Middle Fork Willamette River Subbasin as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hills Creek Reservoir	**Temp –** Moderate adverse effect. **TDG –** Slight adverse effect. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight Adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Same as the No-action Alternative. **TDG** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Moderately less adverse effect. **TDG –** Slightly less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Slightly less adverse effects. **TDG –** Same as the No-action Alternative. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Moderately less adverse effect. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Lookout Point and Dexter Reservoirs	**Temp –** Moderate adverse effect. **TDG –** Slight adverse effect. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –S**imilar to the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp – S**imilar to the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp – S**imilar to the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Slightly less adverse effect. **TDG –** Moderately more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effects. **Mercury –** Moderately more adverse effects.	**Temp –** Slightly less adverse effects. **TDG –** Moderately more adverse effects below Dexter Dam. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Slightly less adverse effect. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.
Fall Creek Reservoir	**Temp –** Moderate Adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight Adverse effect. **Mercury –** Moderate adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HAB –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms, N/A = Not Applicable

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 3.5-17. Summary of Effects to Water Quality in the Coast Fork Willamette River and Long Tom River Subbasins as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Dorena Reservoir	**Temp –** Moderate adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Moderate adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.
Cottage Grove Reservoir	**Temp –** Moderate adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Moderate adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.
Fern Ridge Reservoir	**Temp –** Moderate adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Moderate adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms, N/A = Not Applicable

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 3.5-18. Summary of Effects to Water Quality in the Mainstem Willamette River as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Willamette River at Albany, Oregon	**Temp –** Slight adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Slightly more adverse effects.
Willamette River at Salem, Oregon	**Temp –** Slight to moderate adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –**Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Slightly more adverse effects.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms, N/A = Not Applicable

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.6 VEGETATION

TABLE OF CONTENTS

LIST OF TABLES

3.6 Vegetation

THE VEGETATION SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **DEIS Table 3.6-1 and DEIS Table 3.6-2 have been moved to the end of FEIS Section 3.6.2, Affected Environment, for improved readability. Both tables have been revised to update species listing information.**
- **Information on a reservoir survey program has been added to FEIS Section 3.6.2.2, Vegetation Associated with Reservoirs.**
- **Information on wildfires in 2020 has been added as FEIS Section 3.6.2.3, 2020 Wildfires.**
- **Clarifications have been made regarding Oregon Biodiversity listings and fungi habitat in FEIS Section 3.6.2.4, Special Status Plant and Fungi Species. The statuses of all species have been updated in the FEIS.**
- **Additional information on invasive plants and regulatory requirements for pesticide use has been added to FEIS Section 3.6.2.5, Invasive Plant Species.**
- **A table summarizing effects under each alternative has been added (FEIS Table 3.6-4).**
- **The definitions of short-term and long-term effects criteria have been expanded in FEIS Table 3.6-3. Medium-term effects criteria have been deleted because these effects would not apply under any alternative.**
- **Information on construction and routine and non-routine maintenance and Fern Ridge Dam plant communities has been added to the analyses in FEIS Section 3.6.3.1 and FEIS Section 3.6.3.3, respectively.**
- **Analyses applicable to all alternatives or to all action alternatives have been added to FEIS Section 3.6.3.5, Alternatives Analyses, including new information on wildfire recovery and fine fuels.**
- **Additional analyses on Ecoregion 3b conditions have been provided under each alternative in FEIS Section 3.6.3.5, Alternatives Analyses.**
- **An analysis of fungi species and revisions to the sensitive plant species analysis for accuracy have been provided in FEIS Section 3.6.3.5, Alternatives Analyses.**

Summary of changes from the DEIS, continued:

- **Analyses of impacts related to landslide potential have been revised to reflect analyses in Section 3.4, Soils and Geology. An overview of landslide activity effects has been added as FEIS Section 3.6.3.3, Activation of Landslides.**
- **Definitions of direct and indirect effects were added to FEIS Section 3.6.3.4, Methodology.**
- **Analyses have been revised to accurately reflect alternative implementation in FEIS Section 3.6.3.5, Alternatives Analyses.**
- **Analyses have been reformatted for consistency by topic. Additional comparisons to the No-action Alternative have been added to all action alternative analyses in FEIS Section 3.6.3, Environmental Consequences.**
- **The Near-term Operations Measures analyses have been combined in FEIS Section 3.6.4 Interim Operations under All Alternatives Except Alternative 1. The term "Near-term Interim Operations" has been changed to "Interim Operations" throughout the EIS. Additional information on operations timing has been added.**
- **The climate change analyses have been combined for all alternatives in FEIS Section 3.6.5. Additional information has been provided.**
- **Consistent terminology has been applied and defined as applicable.**
- **Grammatical clarifications have been made.**

3.6.1 Introduction

Vegetation is an important element of ecosystems, providing environmental functions that are valuable to nearby human communities (e.g., improving water quality, providing shade, and controlling erosion of soils) and providing valuable habitat functions for amphibians, reptiles, birds, invertebrates, fish, and mammals. Plants are considered primary producers in the food web, providing the foundation for other organisms, including humans and fish and wildlife species, to survive.

Additional habitat characterizations are provided in Section 3.7, Wetlands, and Section 3.9, Wildlife and Habitat.

3.6.2 Affected Environment

Vegetation in the Willamette River Basin is diverse; vegetation communities are associated with certain habitat types, ranging from alpine meadows and montane forest in the mountains to prairies, oak savannas, and riparian forest on the valley floor. The analysis area for vegetation consists of all Willamette Valley System (WVS) reservoirs up to the maximum pool elevation and associated aquatic, wetland, riparian, and upland vegetative communities (e.g., hillsides), and extends 1 mile beyond maximum pool elevation to characterize the potential occurrence of special status and invasive plant species.

Lists of special status plant and fungi species and noxious plant species present in the analysis area are provided in tables at the end of the Affected Environment descriptions for improved readability (Table 3.6-1 and Table 3.6-2, respectively).

The analysis area also includes the following stream reaches and associated riparian zones:

- Middle Fork Willamette River downstream of Hills Creek Dam to the confluence with the Coast Fork Willamette River
- Coast Fork Willamette River downstream of Cottage Grove Dam to the confluence with the Middle Fork Willamette River
- Row River from downstream of Dorena Dam to the confluence with the Coast Fork Willamette River
- South Fork McKenzie River downstream of Cougar Dam to the confluence with the McKenzie River
- McKenzie River from the South Fork McKenzie River confluence to the confluence with the Willamette River
- Blue River downstream of Blue River Dam to the confluence with the McKenzie River
- Long Tom River downstream of Fern Ridge Dam to the confluence with the Willamette River (includes Coyote Creek from Fern Ridge Dam to the confluence with the Willamette River)
- South Santiam River downstream of Foster Dam to the confluence with the North Santiam River
- North Santiam River downstream to the confluence with the South Santiam River
- Santiam River to the confluence with the Willamette River
- Willamette River mainstem to Willamette Falls

3.6.2.1 Ecoregions

Vegetation in the analysis area is described by applying Environmental Protection Agency (EPA) ecoregions (Thorson et al. 2003). Level III ecoregions are presented below.

Ecoregion 3: Willamette Valley

The Willamette Valley is a wide floodplain valley at about 200 feet to 500 feet in elevation with fertile soils. These soils derive from deposits from the Missoula floods that took place between

20,000 and 15,000 years ago, when the ice dam that formed glacial Lake Missoula at the end of the last ice age burst repeatedly, resulting in flooding that backed up the Willamette River to present day Eugene, Oregon (Wallick et al. 2013) (Section 3.4, Geology and Soils). Historical vegetation in the valley (i.e., pre-European settlement) was a mosaic of gallery forest lining the braided and meandering Willamette River, wet and upland prairie along the floodplains and terraces, and oak savanna in the foothills. Prairies and oak woodlands likely established during a warm climatic period after the ice age and were maintained by indigenous peoples through prescribed fire until the mid-1800s.

The Willamette Valley is densely populated, containing most of Oregon's larger towns and cities surrounded by prime farmland. Consequently, only a remnant of natural vegetation exists today with less than 2 percent of prairie and less than 1 percent of oak savanna remaining (Christy and Alverson 2011). Patches that remain are isolated, threatened by invasive species, and harbor numerous rare and endemic[1] species.

Ecoregion 3b: Willamette River and Tributaries Gallery Forest

The Willamette River and Tributaries Gallery Forest hugs the mainstem and tributaries below about 600 feet in elevation. Most of the vegetation in the analysis area is in this ecoregion. Black cottonwood (*Populus trichocarpa*), Oregon ash (*Fraxinus latifolia*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and Douglas-fir (*Pseudotsuga menziesii*) dominate what remains of the forest, with agricultural fields currently the main vegetation type. The main crops along the Willamette River mainstem include grass for seed as well as fruit and nut trees.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

This ecoregion lies within the historical floodplain of the Willamette River. The deciduous riparian forests that once occupied the region have largely been replaced by agriculture and development. Revetments and reduced flooding following dam construction have diminished the effective floodplain, isolating oxbow lakes and increasing the land area available for farming and towns (Krass et al. 2021). Aquatic vegetation occurs in the Willamette River, tributaries, sloughs, and oxbows.

END REVISED TEXT

Wapato (*Sagittaria latifolia*) is a culturally important species found in this ecoregion with edible tubers harvested by the Kalapuya peoples and others. Wapato is an aquatic plant found in side channels and slower waters of the Willamette River. Several high priority aquatic invasive species threaten water quality and wapato. These include water primrose (*Ludwigia* spp.) and yellow floating heart (*Nymphoides peltata*) (Krass et al. 2021).

This region supports riparian forests comprising Oregon ash, cottonwoods, alder, Douglas-fir, and bigleaf maple. Important vegetation communities that establish on gravel bars within the

[1] Endemic species are those found only in a single geographic location (Wikipedia).

stream channel include native willows (*Salix* spp.) and black cottonwood. Changes to these gravel bars associated with channel migration provide the conditions needed for seedling establishment depending on whether there are channel-forming flows (Wallick et al. 2013). Gravel bars also provide ideal conditions for invasion by noxious weeds, including butterfly bush (*Buddleia davidii)* and purple loosestrife (*Lythrum salicariae*).

Ecoregion 3c: Prairie Terraces

The Prairie Terraces ecoregion occurs on both sides of the Willamette River and once extended from Eugene to Portland, Oregon as a mosaic of wet and upland prairie supporting a diverse community of plants, animals, and insects. Nearly all of this land now consists of farms or cities, including hundreds of crop species and livestock thriving on the rich soil. Remnant prairie patches harbor numerous Endangered Species Act (ESA)-listed plant and animal species (USFWS 2010).

Wet prairies are dominated by tufted hairgrass (*Deschampsia cespitosa*) and support hundreds of other plant species. Sheet flow of water during winter rains occurs at these sites due to an impermeable clay layer formed by ash from the eruption of Mount Mazama, which is now Crater Lake. The recently delisted (86 FR 13200) Bradshaw's desert parsley (*Lomatium bradshawii*) occurs in Willamette Valley and Southwest Washington wet prairies.

Upland prairies were once dominated by short stature native bunch grasses such as California oatgrass (*Danthonia californica*) and Roemer's fescue (*Festuca roemeri*), but these have mostly been replaced with agricultural species including tall fescue (*Schedonorus arundinaceus*), tall oatgrass (*Arrhenatherum elatius*), and creeping bentgrass (*Agrostis stolonifera*).

Upland prairies support several ESA-listed plant species, including the threatened Kincaid's lupine (*Lupinus oreganus*), a host plant for the larva of the endangered Fender's blue butterfly (*Icaricia icarioides fenderi*), the endangered Willamette daisy (*Erigeron decumbens*), which occurs in both wet and upland prairies, and the threatened Nelson's checkermallow (*Sidalcea nelsoniana*) (USFWS 2010).

Ecoregion 3d: Valley Foothills

The Valley Foothills ecoregion occurs around the valley margins and were once dominated by Oregon white oak (*Quercus garryana*) savanna mixed with California black oak (*Quercus kelloggii*) in the south valley and areas including ponderosa pine (*Pinus ponderosa*). Much of this region is now farmed for Christmas trees and wine grapes. Fire suppression has caused the oak savanna to transition to Douglas-fir-dominated forest.

Ecoregion 4a: Western Cascades Lowlands and Valleys

The Western Cascades Lowlands and Valleys ecoregion occurs in the lower elevations of the western slope of the Cascade Mountains from Eugene to Portland, Oregon below about 3,000 feet in elevation. This region is characterized by heavy rainfall and warm soils and supports a lush mixed conifer forest of western hemlock (*Tsuga heterophylla*) and Douglas-fir, with bigleaf maple and alder in riparian areas.

Forest land in this region is a mix of private timber and U.S. Bureau of Land Management (BLM)- and U.S. Forest Service (USFS)-managed lands, with rural communities and farms in the valleys. Special habitats within this region support rare plant species. Some of these include seepy cliffs with Thompson's mistmaiden (*Romanzoffia thompsonii*), riparian forest with tall bugbane (*Cimicifuga elata* var. *elata*), and old growth forest with associated rare lichen and fungi species.

Ecoregion 4b: Western Cascades Montane Highlands

The Western Cascades Montane Highlands ecoregion occurs on the western slope of the Cascades above about 3,000 feet in elevation. This region is characterized by a wet climate with heavy winter snowfall. Forests are primarily managed by the USFS and support a mixed conifer forest of Douglas-fir, western hemlock, noble fir (*Abies procera*), and Pacific silver fir (*Abies amabilis*). Cougar, Blue River, and Hills Creek Reservoirs are at the lower elevation range of this region, but the majority of the analysis area is below 3,000 feet.

3.6.2.2 Vegetation Associated with Reservoirs

USACE manages water levels in the reservoirs by typically maintaining low water in the winter and re-filling reservoirs in spring, holding water over the summer at full pool. These operations result in vegetation communities composed of species suited to higher downstream flows in the fall/winter and lower downstream flows in the spring/summer.

Drawdown zones support areas around the reservoir perimeter where soil saturation is affected by water level fluctuations, creating opportunities for invasive disturbance-tolerant species to rapidly spread and to colonize in new locations. High reservoir water levels in the spring and summer growing season saturate soils and provide benefits to overall plant growth and biomass accumulation for reservoir-adjacent communities.

The hydrologic regime from reservoir operations allows for disturbance-tolerant wetlands to form around many reservoirs despite winter drawdowns (Section 3.7, Wetlands). Wetlands support vegetation communities composed of native and invasive species and provide habitat for wildlife and aquatic species around WVS reservoirs. The ecosystem services provided by these wetlands are limited, however, because species assemblages are dominated by disturbance-tolerant vegetation.

In recent years, around the time the alternatives were analyzed, reservoirs had not been filled because of drought, early drawdowns (required by the 2008 National Marine Fisheries Service (NMFS) Biological Opinion), and summer low water. This reservoir condition has fostered establishment of novel communities of disturbance-tolerant plants in the analysis area.

For example, reed canary grass (*Phalaris arundinacea*) forms extensive monoculture stands covering hundreds of acres, most notably forming a ring around Fern Ridge Reservoir, but also in shallower upstream portions of most reservoir pools. This species appears to expand occupied areas during low water years.

Common species in reservoir waters include:

- reed canary grass
- hardstem bulrush (*Schoenoplectus acutus*)
- broadleaf cattail (*Typha latifolia*)
- both native and introduced milfoils (*Myriophyllum* spp.)
- both native and introduced pondweeds (*Potamogeton* spp.)
- American waterweed (*Elodia canadensis*)
- Brazilian waterweed (*Egeria densa*)
- marsh seedbox (*Ludwigia palustris*)
- common bladderwort (*Utricularia vulgaris)*

Ephemeral drawdown zone and low water year communities often include beggar-ticks (*Bidens* spp.), cudweeds (*Gnaphalium* spp.), smartweeds (*Persicaria* spp.), spikerushes (*Eleocharis* spp.), and flatsedges (*Cyperus* spp.).

Dense beds of aquatic moss (*Fontinalis* sp.) persist. Reservoir margins often support dense thickets of willows, red-osier dogwood (*Cornus stolonifera*), Douglas spirea (*Spirea douglasii*), and black cottonwood. In steeper areas, these species transition immediately to upland vegetation.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

USACE began a reservoir survey program in 2023 to analyze vegetative ecosystem responses to water management. Surveys will document invasive plant growth, species, etc., and will result in recommendations for invasive plant management, such as restoration planning and monitoring, in applicable WVS reservoirs. These recommendations may be incorporated into operational planning during the 30-year implementation timeframe.

3.6.2.3 2020 Wildfires

In September 2020, large catastrophic wildfires altered vegetation and devastated communities in the North Santiam River (Beachie Creek, Lionshead, and P-515 Fires, combined known as the Santiam Fires) and McKenzie River (Holiday Farm Fire) Subbasins. These fires burned hot, killing most trees and altering the landscape and vegetation for years to come. Most burned areas were within Ecoregion 4a and included mainly private timber lands and Federally managed forests. Salvage logging and hazard tree removal operations were in progress when the alternatives were analyzed.

END NEW TEXT

3.6.2.4 Special-status Plant and Fungi Species

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

Table 3.6-1 and Table 3.6-2 have been moved to the end of the Affected Environment Section.

Special-status plant and fungi species have been recorded in the analysis area as defined by the USACE Engineering Regulation (ER) 1130-2-540. However, recent sightings of these species within the analysis area are uncommon, suggesting a trend toward special-status species decline in the analysis area (Table 3.6-1). Although reservoir operations result in vegetation communities composed of species suited to higher downstream flows in the fall/winter and lower downstream flows in the spring/summer, most special-status plant species are not likely affected by this hydrologic regime because they inhabit upland areas (e.g., special-status fungi). A few special status plants exist in this hydrologic environment as described below.

The Oregon Biodiversity Information Center maps rare species locations and ranks species by their rarity and risk of extirpation as documented on its Threatened and Endangered Species of Oregon List. Oregon Conservation Strategy species are those that the Oregon Department of Fish and Wildlife (ODFW) has determined are of the greatest conservation need in Oregon (ODFW 2021e).

- A Listing of “1” means that the species is threatened or endangered throughout its range.
- A Listing of “2” means that the species is threatened, endangered, or extirpated from Oregon, but secure or abundant elsewhere.
- A Listing of “3” means that more information is required before a status can be determined; species may or may not be threatened or endangered.
- A Listing of “4” means the species is of conservation concern but does not meet the criteria to be considered threatened or endangered (ORBIC 2019b).

END REVISED TEXT

A selection of all species of plants and fungi occurring within 1 mile of the analysis area was created using the following data sources with the ArcGIS select-by-location tool: the WVS dam and reservoir boundaries, the Slices Framework 2-year floodplain dataset (Hulse et al. 2002), and Willamette River tributary stream reaches between the 13 dams of the WVS and the Mainstem Willamette River (these lines were selected from the National Hydrography Dataset) (USGS 2021).

The Slices Framework is a spatially explicit system for tracking changes in the Willamette River and its floodplain used for conservation and restoration planning, accessed through the Oregon Explorer Natural Resources Digital Library. Additional occurrences identified on USACE-managed lands were added by USACE botanists.

Special-Status Plant Species

Special-status species surveys in the WVS are typically only conducted for plants that are Federally listed. Many of the plants existing in the analysis area are state listed and, therefore, are not surveyed on a regular basis. Additionally, areas downstream of reservoirs are surveyed less frequently than areas within reservoirs. While most surveys did not document the presence of state-listed species within the analysis area within the last 20 years, the presence or absence of these species is not definitive.

Special-status plant species as defined by USACE Engineering Regulation (ER) 1130-2-540 include:

- U.S. Fish and Wildlife Service listings under the ESA as threatened, endangered, candidate, or Federally listed species of concern
- State of Oregon listings as endangered, threatened, or candidate
- Oregon Biodiversity Information Center as rank 1 or 2
- Oregon Conservation Strategy species

While most special-status species in the analysis area do not rely on the altered hydrologic regime around the dams and reservoirs due to their location in upland habitats, some special-status species do persist under the existing altered hydrologic regimes. However, it is likely that these species are not well adapted to existing operations and are in decline. These include wetland species such as water howellia (*Howellia aquatilis*) and others described below.

Water howellia is an aquatic plant that was listed as threatened under the ESA in 1994 and by the State of Oregon. It is also an Oregon Conservation Strategy species. One current occurrence is in a fen[2] along the Mainstem Willamette River near Canby, Oregon. Several historical collections were also located along the Willamette River.

Habitat for water howellia is restricted to small pools, freshwater wetlands, and old river oxbows that—under naturally occurring, pre-dammed conditions—have an annual cycle of drying in summer and filling with water in winter. Much of the habitat in Oregon was lost due to land conversion, hydrologic changes after dam construction, and river channelization. Because stable populations exist outside of Oregon, water howellia has been Federally delisted as of July 16, 2021 (86 FR 31955).

[2] A fen is a peat-forming wetland that relies on groundwater input and requires thousands of years to develop.

Other special status aquatic species that are able to persist under the existing hydrologic regime include:

- three-colored monkeyflower (*Diplacus tricolor*)
- dotted smartweed *(Persicaria punctata*)
- toothcup (*Rotala ramosior*)
- pale bullrush (*Scirpus pallidus*)
- drooping bullrush (*Scirpus pendulus*)
- humped bladderwort (*Utricularia gibba*)
- dotted watermeal (*Wolffia borealis*)
- Columbia watermeal (*Wolffia columbiana*)
- wheel fruited water-starwort (*Callitriche trochlearis*)
- waterthread pondweed *(Potamogeton diversifolius*)

These species are not state or Federally listed; however, all species listed above are on the Oregon Biodiversity Information Center (ORBIC) Rare, Threatened, and Endangered Species of Oregon List as ORBIC List 2 species. Oregon Biodiversity Information Center List (ORBIC) List 2 contains taxa that are threatened with extirpation or thought to be extirpated from Oregon but are secure elsewhere (ORBIC 2019b).

Wet prairie habitat is less reliant on the current hydrologic regime because precipitation is the primary hydrologic driver in these sites. Keeping water levels low within reservoirs may alter local hydrology, which may change the wet prairie plant community over time. This scenario most likely is currently occurring at Fern Ridge Reservoir, where wet prairie (protected as a Research Natural Area by USACE) is only a few inches above the elevation of the reservoir when it is full. USACE botanists have observed extremely dry conditions at these sites following 2 years of low water during the summer as well as a spring drought in 2021, which is likely placing stress on wet prairie habitat stability at Fern Ridge Reservoir.

Open water habitat for floating, unrooted plants such as dotted watermeal and Columbia watermeal is directly influenced by the existing hydrologic regime. Due to the unique growth form of floating, unrooted plants, they are entirely reliant upon a water medium for survival. If water levels are lowered, these plants either remain floating on the water surface and are relocated or are desiccated on exposed reservoir substrates.

Several special status plant species have been surveyed in the analysis area, including Howell's montia (*Montia howellii*), a state candidate species, and several Oregon Biodiversity Information Center List 2 (ORBIC 2019b) bryophytes, including bending Bruch's moss (*Bruchia flexuosa*) and serrated earth moss (*Ephemera serratum*). In general, reservoir-adjacent areas do not support suitable habitat for special-status fungi, which do not thrive in inundated areas.

A few water-loving special status plants occur in seeps and wet cliffs along the Willamette River and its tributaries. Species include Oregon sullivantia (*Sullivantia oregana*), a Federal and state species of concern, and Thompson's mistmaiden (*Romanzoffia thompsonii*) and Alaskan singlespike sedge (*Carex scirpoidea* ssp. *Stenochlaena*) from the Oregon Biodiversity Information Center List 2 (ORBIC 2019b).

3.6.2.5 Invasive Plant Species

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

Table 3.6-1 and Table 3.6-2 have been moved to the end of the Affected Environment Section.

The analysis area is hospitable to a wide range of invasive plant species due to a mild climate, continued disturbances, and introductions of invasive species that have happened over time. Invasive plants are a major threat to agriculture, native ecosystems, special-status species, and rare species worldwide. As humans travel and engage in commerce, novel species arrive in new locations. Many of these species are not suited to the new locations, but a few are able to flourish and may outcompete native plant species.

> **Native plant species** are those that have evolved and adapted to local environmental conditions.
>
> **Invasive plant species** are those that move aggressively into a habitat and monopolize resources such as sunlight, nutrients, water, and space to the detriment of native plants.
>
> **Noxious plant species** are considered weeds that are harmful to the environment or to animals and are usually classified as noxious because of regulations to control growth.

Reservoir drawdowns have been associated with the loss of organic matter, nutrients, and fine sediments in drawdown zones (Furey et al. 2004). Studies of vegetation succession in reservoirs have shown differences in species assemblages based on substrate[3] texture, distance to forest and successional age, and time since an area was drained. After removal of the Elwha Dam in Washington State, vegetation within fine sediment surfaces were predominantly native species while coarser substrate supported a higher percentage of invasive species (Prach et al. 2019). This could be attributed to moisture content in the soil.

Aquatic invasive plant species are known to establish in drawdown zones. The Willamette Aquatic Invasives Network documented processes and types of flows that may cause aquatic invasive plants to thrive or spread in the analysis area:

[3] Substrate is "the base on which an organism lives." For example, soil is the substrate for seed plants (Merriam Webster Dictionary).

> Scour events during high water can dislodge fragments for further downstream dispersal, flush the area of organic matter, and alter sediment conditions. Conversely, low scour results in increased opportunity for denser plant growth and deeper root establishment that could withstand future high-water events (Krass et al. 2021).

According to Krass et al. (2021), high priority[4] aquatic invasive species in the analysis area include *Ludwigia* species and yellow floating heart. Medium priority aquatic invasive species include yellow flag iris, narrowleaf cattail, purple loosestrife, tree of heaven, knotweeds, and parrot's feather. Widespread aquatic invasive species occurring in the analysis area include reed canary grass, curly leaf pond weed, and Eurasian watermilfoil.

USACE manages weeds using Integrated Pest Management as outlined in USACE ER 1130-2-540, the 2009 USACE Invasive Species Policy (USACE 2009b), and an Integrated Pest Management Plan prepared by USACE for each reservoir. USACE manages invasive species around reservoirs with pesticides (primarily herbicides). These chemicals are applied as spot treatments on a small scale as part of routine maintenance to prevent the establishment of new invasive species, manage/control existing populations, and enhance habitat for native species (Section 3.16, Hazardous Materials).

All USACE pesticide use in the WVS complies with an ESA consultation between the EPA and NMFS and the National Pollutant Discharge Elimination System Pesticide General Permit issued by the Oregon Department of Environmental Quality. No chemicals are used that are listed on the EPA's Restricted Use Products Report.

END REVISED TEXT

Analysis Area Invasive Plants

Invasive plant species listed by Oregon Department of Agriculture are known to occur within 1 mile of the analysis area. The Oregon State Weed Board developed a classification system and includes noxious weeds on lists based on Oregon noxious weed policy (Table 3.6-2). Locations were discovered using a combination of online tools that include the Oregon Department of Agriculture Weed Mapper (ODA 2021b) and the Oregon Flora Project Mapper (OregonFlora 2021). Some species may no longer occur in the analysis area due to successful eradication. Invasive plant species of particular concern are discussed by subbasin in the following section.

3.6.2.6 Subbasin Plant Community Descriptions

North Santiam River Subbasin

The North Santiam River Subbasin, east of Salem, Oregon, is dominated by coniferous forest on steep terrain around Detroit and Big Cliff Reservoirs, and grades to flatter farmland and valley

[4] Priority species are those aquatic and terrestrial weeds identified by Krass et al. (2021) as plants that should be prioritized for survey and treatment within the Willamette River Basin.

floor downstream. The forested lands are in the 4a ecoregion and managed mostly as private timber lands and Federally managed forest. Downstream lands grade into ecoregions 3b, 3c, and 3d.

Much of the watershed was burned in the 193,573-acre Beachy Creek Fire and the western portion of the Lionshead Fire (204,469 acres) in September 2020. Nearly all of the land surrounding Big Cliff Reservoir was burned to the water, and the north side of Detroit Reservoir and the town of Detroit were also burned. The Beachy Creek Fire burned downstream of Big Cliff Dam to the town of Lyons. Details and maps are available on InciWeb (NWCC 2021).

No current locations of special-status plant or fungi species have been found within 1 mile of the Detroit or Big Cliff Reservoirs either by USACE botanists or in the 2019 Oregon Biodiversity Information Center database (ORBIC 2019b). Downstream along the North Santiam River, several wet and upland prairie species occur within 1 mile of the river.

A forest with large trees and old growth structure occurs on USFS-managed lands along the south side of Detroit Reservoir. Seepy cliffs occur at both Big Cliff and Detroit Reservoirs and likely have not been surveyed for plants.

No noxious weeds of particular concern were identified in the North Santiam River Subbasin apart from the usual ubiquitous species (Table 3.6-2).

<u>South Santiam River Subbasin</u>

The South Santiam River Subbasin, east of Albany, Oregon, is

Several special-status species occur on USACE-managed lands around Foster and Green dominated by coniferous forest on steep terrain around Foster and Green Peter Reservoirs and grades to flatter farmland and valley floor downstream. The forested lands are in the 4a ecoregion and managed mostly as private timber lands and Federally managed forest. Downstream lands grade into ecoregions 3b, 3c, and 3d. Peter Reservoirs and downstream. These include tall bugbane, Howell's montia (a state candidate species), and several Oregon Biodiversity Information Center List 2 species (ORBIC 2019b).

A small pond between Foster Reservoir and North River Road near Lewis Creek Park was found to contain three rare aquatic species: humped bladderwort, dotted watermeal, and Columbia watermeal. The pond is separated from Foster Reservoir.

Green Peter Reservoir is mostly surrounded by forest dominated by Douglas-fir. USACE-managed lands support stands of big trees with old growth structure and other special habitats.

Invasive plant species Mediterranean sage (*Salvia aethiopsis*) and meadow hawkweed (*Pilosella cespitosum*), B list weeds, and oblong spurge (*Euphorbia oblongata*), an A list weed, have been found in the South Santiam River Subbasin but not elsewhere in the analysis area (Table 3.6-2).

McKenzie River Subbasin

Blue River and Cougar Reservoirs are in ecoregions 4a and 4b in the western Cascade Mountains. The McKenzie River flows west through forest and small communities, then into the Willamette Valley and the Willamette River near Coburg, Oregon.

In September 2020, much of the McKenzie River Subbasin was burned in the 173,393-acre Holiday Farm Fire. Forested areas and vegetation burned to the river in most places from just downstream of the town of McKenzie Bridge to downstream of Vida, Oregon. Nearly all the land around Blue River Reservoir was burned. Details and maps are available on InciWeb (NWCC 2021).

Several special-status species are found around the reservoirs but are not aquatic species. These are all state candidate and Oregon Biodiversity Information Center List 2 species. Shaddy horkelia *(Horkelia congesta ssp. congesta)*, a Federal species of concern and state candidate, and wayside aster (*Eucephalus vialis)*, a Federal species of concern and state threatened species, occur near the confluence with the Willamette River.

No noxious weeds of particular concern were identified in the North Santiam River Subbasin except the usual ubiquitous species (Table 3.6-2).

The Oregon State Weed Board developed a classification system and includes noxious weeds on lists based on Oregon noxious weed policy.

Middle Fork Willamette River Subbasin

The middle fork of the Willamette River drains a large watershed, and the analysis area includes all previously described ecoregions (3b, 3c, 3d, and 4a). Much of the land around Lookout Point and Hills Creek Reservoirs is managed by the USFS, with USACE-managed land and private timber near Fall Creek and Dexter Reservoirs. The towns of Lowell and Dexter are adjacent to Dexter Reservoir, and small farms, prairies, and woodlands occur downstream. The confluence with the Coast Fork Willamette River occurs near Mt. Pisgah and is in conservation management by local non-profit groups working to restore flows and native vegetation to old gravel mine sites along with restoration in upland areas.

Special-status species Howell's montia (state candidate) is known to occur in multiple locations around the reservoirs, including a large population found growing on the exposed lakebed at the Hardesty Mountain trailhead during a site visit. This tiny, early spring, annual plant is likely found in ideal conditions on the exposed mud, but only a few plants were located on a later visit to the same location by USACE botanists.

Dotted smartweed occurs in a pond downstream of Hills Creek Reservoir. Several upland Oregon Biodiversity Information Center List 2 species and tall bugbane occur around these reservoirs. Special-status species habitats in this watershed include oak balds, sunlit canopy openings in mature and old forests, seepy cliffs, and old growth forest in the 4a ecoregion as well as prairies and woodlands downstream.

Invasive species of concern include Sulphur cinquefoil (*Potentilla recta*) and tree of heaven (*Ailanthus altissima*) at Hills Creek Reservoir, and a report of gorse (*Ulex europaeus*) near Pleasant Hill. Sulphur cinquefoil has been found at Lookout Point and Fall Creek Reservoirs (Table 3.6-2).

Coast Fork Willamette River Subbasin

Cottage Grove and Dorena Reservoirs are located at the transition from ecoregion 3 to ecoregion 4 at the south end of the Willamette Valley within the Coast Fork Willamette River Subbasin. These reservoirs are surrounded by a combination of upland prairie, woodland, and conifer forest; USACE-managed lands are surrounded mostly by private farms and timber lands. Downstream, the rivers are bordered by forests, farms, and the town of Cottage Grove.

Wayside aster, a Federal species of concern and state threatened species, occurs in several locations near both reservoirs in upland areas. Shaggy horkelia, a Federal species of concern and state candidate, occurs near Dorena, above the maximum water surface elevation of the reservoir.

Shaggy horkelia also occurs near the confluence of the Row River and Coast Fork Willamette River. Bradshaw's desert parsley (*Lomatium bradshawii,* ESA-delisted in 2019 and state endangered) occurs nearly 1 mile from the Coast Fork Willamette River in proximity to the confluence of the Coast Fork Willamette River with the Middle Fork Willamette River. Thin-leaved peavine (*Lathyrus holochlorus)*, a Federal species of concern, occurs in four locations in this watershed mostly near water in forested areas. Several other state candidate and Oregon Biodiversity Information Center List 1 species occurring in this subbasin as well (Table 3.6-1).

No noxious weeds of particular concern were identified in the Coast Fork Willamette River Subbasin apart from the usual ubiquitous species (Table 3.6-2).

The Oregon State Weed Board developed a classification system and includes noxious weeds on lists based on Oregon noxious weed policy.

Long Tom River Subbasin

Fern Ridge Reservoir, the only reservoir located west of the Willamette River, is a wide shallow reservoir on the Long Tom River. Prior to dam construction in 1942, the land consisted mostly of farms, prairies, and gallery forest (i.e., formed as a corridor along a river). Current vegetation surrounding Fern Ridge Reservoir is a mix of ecoregions 3b, 3c, and 3d, with some conifer forest of Douglas-fir and ponderosa pine. The Long Tom River below Fern Ridge Dam was channelized by USACE and is lined by a narrow strip of forest or is immediately adjacent to farmland in some locations.

Wet and upland prairies in this subbasin support numerous Federally listed and Oregon Biodiversity Information Center-listed species, and much of these lands are protected as a Research Natural Area by USACE and/or designated critical habitat for Fender's blue butterfly (USFWS 2010). These sites are located above the maximum water level of the reservoir and are managed in accordance with a USFWS Biological Opinion (USFWS 2011). Several Oregon Biodiversity Information Center List 2 aquatic species occur in these wet and upland prairies (Table 3.6-1).

Invasive primrose willow (*Ludwigia spp.*) has been found in the Long Tom River and has mostly been removed. One small patch was discovered and eradicated in Fern Ridge Reservoir, and surveys have not identified more plants. Preventing this species from establishing in Fern Ridge Reservoir is a high priority (Table 3.6-2).

Noxious species parrot's feather (*Myriophyllum aquaticum*), yellow flag iris (*Iris pseudacorus*), South American waterweed (*Egeria densa*), and Eurasian watermilfoil (*Myriophyllum spicatum*) are all common in and around Fern Ridge Reservoir (Table 3.6-2).

Mainstem Willamette River

From the confluence of the Coast Fork Willamette River and Middle Fork Willamette River, the Willamette River flows northward through the wide, relatively flat Willamette Valley through major towns and farms to Portland, Oregon. In many places, narrow strips of gallery forest line the river, while in other locations farms and towns are immediately adjacent to the riverbanks. Parks and conservation areas provide large, forested stretches along with other types of habitats.

Numerous old oxbows and sloughs have been isolated from the river but may connect during high flows. These may be sources of invasive species spread but many also contain special-status species. Wet and upland prairie occur near the river as well.

Water howellia (a Federally delisted and state threatened species) occurs in a fen near Canby, Oregon just west of the Mainstem Willamette River. Other ESA-listed species occur near the Mainstem Willamette River and within the 2-year floodplain, especially in prairies, but with habitat occurring outside of the river channel. Numerous Oregon Biodiversity Information Center List 1 and 2 species occur along the Willamette River, including many aquatic species (Table 3.6-1).

Many invasive plant species occur within this subbasin. These include, but are not limited to, primrose willow, yellow floating heart, milfoils, and loosestrife (Krass et al. 2021) (Table 3.6-2).

THE FOLLOWING TABLE HAS BEEN REVISED FROM THE DEIS

Table 3.6-1. Special-status Plant and Fungi Species Documented in the Analysis Area (2024).

Scientific Name	Common Name	Fed ESA	State ESA[1]	ORBIC List	OCS Species	Subbasin							Habitat
						NS	SS	MK	MF	CF	LT	MW	
Eucephalus vialis	Wayside aster	-	LT	1	yes	-	-	3	1	8	-	-	roadsides, forest edges
Sericocarpus rigidus	White-topped aster	SOC	LT	1	yes	1	-	-	-	-	7	1	wet prairie
Delphinium leucophaeum	White rock larkspur	SOC	LE	1	yes	-	-	-	-	-	-	6	forest edges, meadows, riverbanks
Delphinium pavonaceum	Peacock larkspur	SOC	LE	1	yes	-	-	-	-	-	-	12	wet prairie, woodland, roadsides
Delphinium oreganum	Willamette Valley larkspur	SOC	-	1	-	3	-	-	-	-	3	1	Oak-ash understory, open areas, roadsides
Horkelia congesta ssp. *congesta*	Shaggy horkelia	SOC	-	1	-	-	-	1	-	3	3	3	wet prairie
Sisyrinchium hitchcockii	Hitchcock's blue-eyed grass	SOC	LE	1	-	-	-	-	-	1	1	-	wet and upland prairie
Sullivantia oregana	Oregon sullivantia	SOC	-	1	-	-	-	-	-	-	-	1	wet cliffs
Lathyrus holochlorus	Thin-leaved peavine	SOC	LE	1	-	1	-	-	3	4	4	12	oak-ash understory and margins
Howellia aquatilis	Water howellia	Delisted	LT	1	yes	-	-	-	-	-	-	1	aquatic, Federally delisted
Lupinus oreganus/ Lupinus sulphureus ssp. kincaidii	Kincaid's lupine	LT	LT	1	yes	-	-	-	-	-	8	-	upland prairie
Sidalcea nelsoniana	Nelson's checkermallow	Delisted	LT	1	yes	1	-	-	-	-	-	2	upland prairie
Castilleja levisecta	Golden paintbrush	Delisted	LE	1-ex	yes	-	-	-	-	1	6	1	upland prairie

Scientific Name	Common Name	Fed ESA	State ESA[1]	ORBIC List	OCS Species	Subbasin							Habitat
						NS	SS	MK	MF	CF	LT	MW	
Erigeron decumbens	Willamette Valley daisy	LE	LE	1	yes	3	-	1	-	-	4	-	wet and upland prairie
Lomatium bradshawii	Bradshaw's desert parsley	Delisted	LE	1	yes	1	-	-	-	2	8	6	wet prairie
Cimicifuga elata var. *elata*	Tall bugbane	-	-	3	-	-	2	5	3	1	-	8	moist slopes outside of riparian zones
Montia howellii	Howell's montia	-	C	4	-	-	1	-	9	4	4	10	Moist open places
Sidalcea campestris	Meadow checkermallow	-	C	4	-	2	3	-	-	-	1	12	upland prairie
Hypotrachyna riparia	Lichen	-	-	1	-	-	-	1	-	1	-	-	deciduous shrubs and trees
Navarretia willamettensis	Willamette navarretia	SOC	LE	1	-	-	-	-	-	-	6	1	wet prairie
Romanzoffia thompsonii	Thompson's mistmaiden	-	-	1	-	-	-	3	2	-	-	-	very wet cliffs
Sphaerocarpos hians	Liverwort	-	-	1	-	-	-	-	-	-	-	1	exposed mud - likely around reservoirs though not documented
Blepharostoma arachnoideum	Liverwort	-	-	2	-	-	-	2	-	-	-	-	old growth forests
Bruchia flexuosa	Bending Bruch's moss	-	-	2	-	-	-	-	-	-	3	-	wet prairie, mudflats around reservoirs
Carex retrorsa	Retrorse sedge	-	-	2	-	-	-	-	-	-	-	1	wet places
Carex scirpoidea ssp. stenochlaena	Alaskan single spike sedge	-		2	-	-	-	1	-	-	-	-	wet cliffs
Cicendia quadrangularis	Timwort	-	-	2	-	-	-	1	-	-	4	-	wet prairie and seeps
Danthonia spicata	Poverty oatgrass	-	-	2	-	-	1	-	-	-	-	1	dry, rocky, open

Scientific Name	Common Name	Fed ESA	State ESA[1]	ORBIC List	OCS Species	Subbasin							Habitat
						NS	SS	MK	MF	CF	LT	MW	
Delphinium nuttallii	Nuttall’s larkspur	-	-	2	-	-	-	-	-	1	-	-	meadows
Diplacus tricolor	Three-colored monkeyflower	-	-	2	-	-	-	-	-	-	-	2	wetlands, riparian
Ephemerum crassinervium	Emerald dewdrops	-	-	2	-	-	-	-	-	-	3	-	moist open soil - reservoir edges
Ephemerum serratum	Serrated earth moss	-	-	2	-	-	-	-	-	-	2	-	moist open soil - reservoir edges
Pannaria rubiginella	Shingle lichen	-	-	-	-	1	-	-	-	-	-	-	bark in moist coastal forests
Pellaea andromedifolia	Coffee fern	-	-	2	-	-	-	-	1	-	-	-	dry cliffs
Persicaria punctata	Dotted smartweed	-	-	2	-	-	-	-	1	-	2	-	aquatic
Physcomitrella patens	Spreading-leaved earth moss	-	-	-	-	-	-	-	-	-	-	1	lake margins - exposed soil
Pseudocyphellaria mallota	Lichen	-	-	2	-	-	-	2	-	-	-	-	on bark in young forests with other cyanolichens
Pyrrocoma racemosa var. racemosa	Clustered goldenweed	-	-	2	-	-	-	-	-	-	5	-	wet prairie
Rotala ramosior	Toothcup	-	-	2	-	-	-	-	-	-	1	1	aquatic
Scirpus pallidus	Pale bulrush	-	-	2	-	-	-	-	-	1	-	-	riparian
Scirpus pendulus	Drooping bulrush	-	-	2	-	-	1	-	1	-	-	-	moist areas
Taraxia ovata	Golden eggs	-	-	2	-	-		-	-	-	-	1	open forest understory
Utricularia gibba	Humped bladderwort	-	-	2	-	-	1	-	-	-	1	-	aquatic
Wolffia borealis	Dotted water-meal	-	-	2	-	-	1	-	-	-	-	2	aquatic
Wolffia columbiana	Columbia water-meal	-	-	2	-	-	1	-	-	-	1	4	aquatic
Callitriche trochlearis	Wheel fruited water-starwort	-	-	2	-	-	-	-	-	-	-	1	aquatic
Potamogeton diversifolius	Waterthread pondweed	-	-	2	-	-	-	-	-	-	3	-	aquatic - not in ORBIC yet

Scientific Name	Common Name	Fed ESA	State ESA[1]	ORBIC List	OCS Species	Subbasin							Habitat
						NS	SS	MK	MF	CF	LT	MW	
Helvella elastica	Flexible Helvella	-	-	3	-	-	-	1	1	-	-	-	forests
Sowerbyella rhenana	Stalked orange peel fungus	-	-	3	-	-	1	-	-	-	-	-	mature coniferous forests

Source: ORBIC 2019b

Notes: This table excludes historical and suspected extirpated occurrences. Locations may have been counted in more than one subbasin if near a confluence.

Numbers shown for each subbasin represent number of observed occurrences of each species.

ESA = Endangered Species Act

SOC = Species of Concern, LT = Listed as Threatened, LE = Listed as Endangered, C = Candidate

ORBIC = Oregon Biodiversity Information Center rankings

OCS = Oregon Conservation Strategy Species

NS = North Santiam, SS = South Santiam, MK = McKenzie, MF = Middle Fork, CF = Coast Fork, LT = Long Tom, MW = Mainstem Willamette

THE FOLLOWING TABLE HAS BEEN REVISED FROM THE DEIS

Table 3.6-2. Noxious Weeds Documented in the Analysis Area (2024).

Scientific Name	Common Name	Aquatic?	Oregon State Weed Board Noxious Weed Classification	Location or Regional Presence
Abutilon theophrasti	Velvetleaf	No	B	Long Tom and Mainstem Willamette Rivers
Acroptilon repens	Russian knapweed	No	B, biocontrol	Salem near Santiam, one record
Adonis aestivalis	Pheasant's eye	No	B	Eugene and Corvallis - Historical
Ailanthus altissima	Tree of heaven	No	B	Hills Creek fire camp, Mainstem Willamette River in Eugene and Portland
Alliaria petiolata	Garlic mustard	No	B, T	Benton County and Portland
Ambrosia artemisiifolia	Ragweed	No	B	Eugene to Columbia River
Amorpha fruticosa	Indigo bush	No	B	Portland
Brachypodium sylvaticum	False-brome	No	B	Ubiquitous
Buddleia davidii	Butterfly bush	No	B	Ubiquitous
Butomus umbellatus	Flowering rush	Aquatic	A,T	Arlington
Carduus nutans	Musk thistle	No	B, biocontrol	Oakridge, Molalla River
Carduus pycnocephalus	Italian thistle	No	B	Coast Fork Willamette River, Mainstem Willamette River
Centaurea calcitrapa	Purple star-thistle	No	A, T	Portland
Centaurea diffusa	Diffuse knapweed	No	B, biocontrol	Lane County
Centaurea jacea notho subsp. *pratensis*	Meadow knapweed	No	B	Ubiquitous
Centaurea stoebe ssp. *micranthos*	Spotted knapweed	No	B, T, biocontrol	Cougar and Hills Creek Reservoirs, U.S. Forest Service-managed lands
Centaurea solstitialis	Yellow starthistle	No	B, biocontrol	Lane County
Chondrilla juncea	Rush skeletonweed	No	B, T, biocontrol	Interstate 5 near Lookout Point
Cirsium arvense	Canada thistle	No	B, biocontrol	Ubiquitous
Cirsium vulgare	Bull thistle	No	B, biocontrol	Ubiquitous
Clematis vit-alba	Old man's beard	No	B	Clatsop, Lincoln, Lane, Douglas, Coos, Columbia, Washington, Yamhill, Polk, Benton, Linn, Marion, Clackamas, and Multnomah Counties
Conium maculatum	Poison hemlock	No	B	Ubiquitous
Convolvulus arvense	Field bindweed	No	B, biocontrol	Ubiquitous
Cynoglossum officinale	Houndstongue	No	B	Near Big Cliff and Hills Creek Reservoirs

Scientific Name	Common Name	Aquatic?	Oregon State Weed Board Noxious Weed Classification	Location or Regional Presence
Cyperus esculentus	Yellow nutsedge	No	B	Albany to Confluence
Cytisus scoparius	Scotch broom	No	B, biocontrol	Ubiquitous
Cytisus striatus	Portuguese broom	No	B, T	West Eugene and East of Salem
Daphne laureola	Spurge laurel	No	B	CTG, FOS – Menear's Bend
Echium plantagineum	Paterson's curse	No	A, T	Linn County
Egeria densa	South American waterweed	Aquatic	B	FRN, Mainstem Willamette River
Euphorbia oblongata	Oblong spurge	No	A, T	FOS - Road shoulder between Sunnyside and Lewis Parks, along the Willamette River north of Albany
Galega officinalis	Goatsrue	No	A, T	Portland, OR
Genista monspessulana	French broom	No	B	Lane County
Geranium lucidum	Shining geranium	No	B	Fern Ridge, Dorena, Cottage Grove Reservoirs
Geranium robertianum	Herb robert	No	B	Foster and Green Peter Reservoirs, Portland
Hedera helix	English ivy	No	B	Ubiquitous
Hedera hibernica	Irish ivy	No	B	Ubiquitous: the common ivy in the Pacific Northwest
Heracleum mantegazzianum	Giant hogweed	No	A, T	Oakridge, Eugene, and Portland
Hypericum perforatum	St. John's wort	No	B, biocontrol	Ubiquitous
Impatiens glandulifera	Policeman's helmet	No	B	Portland
Iris pseudacorus	Yellow flag iris	Aquatic	B	Ubiquitous
Lamiastrum galeobdelon	Yellow archangels	No	B	Coast Fork Willamette River, Middle Fork Willamette River, McKenzie River, Fern Ridge Reservoir, Portland
Lathyrus latifolius	Everlasting peavine	No	B	Ubiquitous
Lepidium latifolium	Perennial pepperweed	No	B, T	Portland
Linaria dalmatica	Dalmatian toadflax	No	B, T, biocontrol	Portland
Linaria vulgaris	Yellow toadflax	No	B, biocontrol	Mainstem Willamette River Eugene to Portland
Ludwigia spp.	Primrose willow	Aquatic	B, T	Fern Ridge Reservoir, Long Tom River, Mainstem Willamette River to Portland

Scientific Name	Common Name	Aquatic?	Oregon State Weed Board Noxious Weed Classification	Location or Regional Presence
Lysimachia vulgaris	Garden yellow loosestrife	No	A, T	Willamette River North of Salem
Lythrum salicariae	Purple loosestrife	No	B, biocontrol	Fern Ridge Reservoir, Long Tom River, Mainstem Willamette River, and North and South Santiam Rivers
Myriophyllum aquaticum	Parrot's feather	Aquatic	B	Fern Ridge and Dorena Reservoirs, Mainstem Willamette River
Myriophyllum spicatum	Eurasian watermilfoil	Aquatic	B	Fern Ridge Reservoir and Mainstem Willamette River
Nymphoides peltata	Yellow floatingheart	Aquatic	A, T	Springfield millrace
Onopordum acanthium	Scotch thistle	No	B	Ubiquitous
Orobanche minor	Small broomrape	No	B	Portland
Phragmites australis ssp. *australis*	Common reed	Aquatic	B	Portland
Fallopia japonica (Polygonum)	Japanese knotweed	No	B	establishing
Fallopia sachalinense (Polygonum)	Giant knotweed	No	B	establishing
Fallopia X *'bohemicum'*	Giant knotweed	No	B	Fern Ridge Reservoir, Cottage Grove office, Dorena Dam roadsides
Potentilla recta	Sulphur cinquefoil	No	B	Middle Fork Willamette River and around Portland
Pueraria lobata	Kudzu	No	A, T	Canby and Portland along Willamette River
Ranunculus ficaria	Lesser celandine	No	B	Dorena Reservoir, Middle Fork Willamette River, Mainstem Willamette River, Portland
Rorippa sylvestris	Creeping yellow cress	No	B	Canby and near Fern Ridge Reservoir
Rubus spp.	Introduced blackberries	No	B	Ubiquitous
Sagittaria platyphyla	Delta arrowhead	Aquatic	A, T	Portland
Salvia aethiopsis	Mediterranean sage	No	B, biocontrol	Near Big Cliff and Green Peter Reservoirs
Senecio jacobaea	Tansy ragwort	No	B, T, biocontrol	Ubiquitous
Silybum marianum	Milkthistle	No	B	Jasper-Lowell Road and Mainstem Willamette River
Solanum rostratum	Buffalo bur	No	B	Portland
Spartium junceum	Spanish broom	No	B	Near Dorena Reservoir
Taeniatherum caput-medusae	Medusa-head rye	No	B	Ubiquitous

Scientific Name	Common Name	Aquatic?	Oregon State Weed Board Noxious Weed Classification	Location or Regional Presence
Tribulus terrestris	Puncturevine	No	B, biocontrol	Eugene
Tripidium ravennae	Ravennagrass	No	A, T	Corvallis
Ulex europaeus	Gorse	No	B, T, biocontrol	Powerline near Pleasant Hill
Ventanata dubia	Ventanata grass	No	B	Fern Ridge and Dorena Reservoirs, widespread in Willamette Valley
Xanthium spinosum	Spiny cocklebur	No	B	Eugene to Portland

Source: Oregon State Weed Board 2024

A = A weed of known economic importance that occurs in the state in small infestations to make eradication or containment possible.

B = A weed of economic importance, which is regionally abundant but may have limited distribution in some counties.

T = A designated group of weeds selected from either the A or B list as a focus for prevention and control by the Noxious Weed Control Program.

Biocontrol = Oregon implements biological control as part of its integrated pest management approach to managing noxious weeds.

3.6.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives on vegetation. The discussion includes the methodology used to assess effects and a summary of the anticipated effects. Effects specific to subbasins are incorporated by addressing effects from dam operations.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

3.6.3.1 Construction and Routine and Non-routine Maintenance Activities

Effects to vegetation may occur as part of specific construction activities during alternative implementation. However, information is needed for an informed analysis such as construction location, extent, and activities in relation to existing plant communities in the construction analysis area. Subsequent tiered analyses would detail site-specific construction effects during the implementation phase, and any applicable permits would be obtained at that time (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act). Additional analyses are not provided under each alternative.

Similarly, routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation). Direct, adverse impacts to vegetation from maintenance activities, such as equipment use and human activity, are not expected to occur because maintenance would be conducted on sites developed for dam operations. No new ground disturbance is anticipated with routine maintenance that would adversely impact vegetation or habitat. Major maintenance activities may require site-specific NEPA review prior to initiation at any location in the analysis area. Additional analyses are not provided under each alternative.

3.6.3.2 Fern Ridge Dam and Reservoir Plant Communities

No modifications to operations and maintenance would occur under any alternative at Fern Ridge Dam and Reservoir. Consequently, vegetation conditions and trends would be similar to those described under the Affected Environment. There would be no impact on wet prairie habitat near Fern Ridge Dam and Reservoir under any alternative.

The only Federally listed plant species in the analysis area occur in the Fern Ridge Dam and Reservoir vicinity (Table 3.6-1) (Section 3.6.2.6, Subbasin Plant Community Descriptions, Long Tom River Subbasin). These plant communities would remain protected under Research Natural Area management and indirectly from designated critical habitat for Fender’s blue butterfly.

Effects from climate change over the 30-year implementation timeframe would approximate those for other vegetation communities throughout the analysis area as analyzed below. Existing wet prairie habitat at Fern Ridge Reservoir may continue to be threatened by drought conditions through climate change as observed following 2 years of low water during the summer as well as a spring drought in 2021.

No additional vegetation analysis for the Fern Ridge Dam and Reservoir area is provided under any alternative analysis below.

3.6.3.3 Activation of Landslides

Landslides could be activated by deep fall reservoir drawdowns from inactive and power pool water releases, which may impact reservoir vegetation by burying plant populations in areas of slope failures. Operations under Alternatives 2B, 3A, 3B, and 5 have the potential to induce landslides in the analysis area (Section 3.4.3.1, Geology and Soils, Methodology). Under existing conditions, releases from the inactive and power pools are rare and only occur during times of extreme drought or during special operations, minimizing the potential for landslide activity under existing conditions.

Over the lifetime of WVS operations, a deep drawdown has not initiated a landslide that results in a medium or large earth movement (Section 3.4.3.1, Geology and Soils, Methodology). Cougar Reservoir was drawn down to below elevation 1,510 feet North American Vertical

Datum of 1988 (NAVD88)[5] without incident between December 20, 2012, and January 12, 2013 (USACE 2013b).

Fall Creek Reservoir has been drawn down to the elevation of the original river channel (680 feet NAVD88) annually in the late fall since 2010 without incident (USACE 2016k). Although the WVS does not have a history of catastrophic slope failure during drawdown, the presence of landslides that extend into the reservoir indicates that the potential for future slope failure cannot be eliminated (Section 3.4.3.1, Geology and Soils, Methodology).

END NEW TEXT

3.6.3.4 Methodology

A qualitative analysis was used to assess effects to vegetation. This included assessing information on species presence or absence and suitable habitat as shown in Oregon Biodiversity Information Center data.

Effects of altered flows downstream of reservoirs on vegetation were analyzed using ResSim model outputs (Section 3.2, Hydrologic Processes; Appendix B, Hydrologic Processes Technical Information). Outputs from the ResSim model were used to interpret how flow operations would influence flow stages[6] under any given alternative.

Direct effects to vegetation communities within the WVS analysis area would occur from physical modification of terrain and from operations affecting hydrology, sediment transport, erosion, and slope failure. Indirect effects would include establishment of invasive species from direct effect operations such as lowered reservoir levels, which would increase invasion potential along banks of reservoirs through higher availability of bare disturbed soils.

The environmental effects criteria and a summary of effects are provided in Table 3.6-3 and Table 3.6-4, respectively.

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[5] North American Vertical Datum of 1988 (NAVD 88) consists of an agreed upon leveling network on the North American Continent that is affixed to a single-origin point on the continent and is used to standardize elevation references.

[6] Flow stages are the levels of water in a river measured in relation to a reference elevation.

Table 3.6-3. Vegetation Environmental Effects Criteria.

Degree of Adverse or Beneficial Effect and Extent of Effect	Definition
None/Negligible	Vegetation communities would remain unchanged, and no effects would be observable.
Minor	Effects to vegetation would be observable, although the effects would be small and localized (e.g., signs of erosion or buried plant communities from slope failure, changes in vegetation types, sediment deposits over previously vegetated areas).
Moderate	Effects to vegetation communities would be observable at a regional scale but not be easily measured (e.g., changes to species composition or establishment).
Major	Effects to vegetation would be readily observable and measurable (e.g., obvious changes in vegetated area and species composition) and would have substantial ecological consequences (e.g., dominance of invasive plant species) at a regional level. Long-term adverse effects to vegetation communities would be expected.
Duration	
Short-term	Disturbance to vegetation would occur or re-occur for a short period of time, lasting only as long as a discrete construction project, single event, routine maintenance, or measure implementation in an area. Vegetation communities would not be altered over time or transition to other community types.
Long-term	Disturbance to vegetation would be ongoing or last beyond operation changes or the completion of a discrete construction project, routine maintenance, or measure implementation. An impact would occur or re-occur over a long period of time and up to the 30-year implementation timeframe (i.e., effects that would occur over the 30-year implementation timeframe are considered long-term effects).

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING TABLE IN THE FEIS

Table 3.6-4. Summary of Effects to Vegetation as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Reservoir-adjacent Vegetation	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive - dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.
	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season.	Moderate, adverse effects to vegetation during spring refill on new plant establishment.	Moderate, adverse effects to vegetation during spring refill on new plant establishment.	Moderate, adverse effects to vegetation during spring refill on new plant establishment at all reservoirs, except Cougar Reservoir.	Moderate, adverse effects to vegetation during spring refill on new plant establishment at all reservoirs except Cougar, Lookout Point, and Detroit Reservoirs.	Moderate, adverse effects to vegetation during spring refill on new plant establishment at all reservoirs except Cougar, Hills Creek, and Green Peter Reservoirs.	Moderate, adverse effects to vegetation during spring refill on new plant establishment.	Moderate, adverse effects to vegetation during spring refill on new plant establishment at all reservoirs, except Cougar Reservoir.
	Negligible effects to vegetation from induced landslides compared to the NAA.	Negligible effects to vegetation from induced landslides compared to the NAA.	Minor, adverse effects to vegetation because of increased potential for slope failures at Green Peter Reservoir from fall and spring drawdowns for fish passage.	Moderate, adverse effects to vegetation because of increased potential for slope failures at Cougar and Green Peter Reservoirs from fall and spring drawdowns for fish passage.	Moderate, adverse effects to vegetation because of increased potential for slope failures at Cougar, Lookout Point, and Detroit Reservoirs from fall and spring drawdowns for fish passage.	Moderate, adverse effects to vegetation because of increased potential for slope failures at Cougar, Lookout Point, and Detroit Reservoirs from fall and spring drawdowns for fish passage.	Negligible effects to vegetation from induced landslides compared to the NAA.	Moderate, adverse effects to vegetation because of increased potential for slope failures at Cougar and Green Peter Reservoirs from fall and spring drawdowns for fish passage.
	Negligible effects from potential for reservoirs not to refill.	Negligible effects from potential for reservoirs not to refill.	Minor adverse effects to vegetation if Green Peter Reservoir is unable to refill during the 30-year implementation timeframe.					

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Downstream Stream-adjacent Vegetation	Major, adverse effects to vegetation from limited floodplain connectivity. Negligible effects to vegetation from downstream flow operations.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Minor, beneficial effects to vegetation from higher summer flows. Negligible effects to vegetation from flow differences.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from drawdown-related sediment releases. Minor, beneficial effects to vegetation from higher summer flows. Minor, adverse effects to vegetation from lowered spring flows in dry years.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from drawdown-related sediment releases. Minor, beneficial effects to vegetation from higher summer outflows. Potential for minor, adverse effects to vegetation in dry years from lower spring flows.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from drawdown-related sediment releases. Potential for moderate, adverse effects to vegetation from lowered reservoir elevations in the summer and fall. Minor, beneficial effects to vegetation from spring water releases during dry years.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from drawdown-related sediment releases. Minor, adverse effects to vegetation from lower summer flows.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from flow operations in average years.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from drawdown-related sediment releases. Minor, beneficial effects to vegetation from higher summer flows. Potential for minor, adverse effects to vegetation in dry years from lower spring flows.
Invasive and Noxious Weed Presence	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes.	Major, adverse effects to vegetation from increased potential for invasive establishment compared to NAA from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects to vegetation from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes. Minor, beneficial effects to vegetation from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes. Minor, beneficial effects to vegetation at all reservoirs except, Cougar Reservoir from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes. Minor, beneficial effects to vegetation in all reservoirs, except Cougar, Lookout Point, and Detroit Reservoirs from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes. Minor, beneficial effects to vegetation in all reservoirs, except Hills Creek, Cougar, and Green Peter Reservoirs from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation from increased potential for invasive establishment compared to NAA from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects to vegetation from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes. Minor, beneficial effects to vegetation at all reservoirs except Cougar from spring refills controlling invasive species establishment.
Wildfire Recovery and Fine Fuels	Analysis area forests would continue to recover; no effect on establishment of fine fuels in reservoir or downstream areas from USACE operations.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Special-status Plant Species	Minor, adverse effects to vegetation from frequent reservoir water elevation changes for special-status species.	Moderate, adverse effects to special-status species from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species at all reservoirs, except Cougar Reservoir from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species in all reservoirs, except Lookout Point, Cougar, and Detroit Reservoirs from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species in all reservoirs, except Hills Creek, Cougar, and Green Peter Reservoirs from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species at all reservoirs except ,Cougar Reservoir from spring refill potential to inhibit species establishment.
		Minor, adverse effects to special-status species from frequent reservoir water elevation changes.	Minor, adverse effects to habitat from frequent reservoir water elevation changes.	Minor, adverse effects to special-status species from frequent reservoir water elevation changes.	Minor, adverse effects to special-status species from frequent reservoir water elevation changes.	Minor, adverse effects to special-status species from frequent reservoir water elevation changes.	Minor, adverse effects to special-status species from frequent reservoir water elevation changes.	Minor, adverse effects to special-status species from frequent reservoir water elevation changes.
	Negligible effects to special-status species from landslide activity.	Negligible effects to special-status species from landslide activity.	Minor, adverse effects to special-status species from potential plant community burial from landslide activity because of drawdowns at Green Peter Reservoir.	Minor, adverse effects to special-status species from potential plant community burial from landslide activity because of drawdowns at Green Peter and Cougar Reservoirs.	Minor, adverse effects to special-status species from potential plant community burial from landslide activity because of drawdowns at Green Peter, Lookout Point, Detroit, and Cougar Reservoirs.	Minor, adverse effects to special-status species from potential plant community burial from landslide activity as a result of drawdowns at Green Peter, Lookout Point, Detroit, and Cougar Reservoirs.	Negligible effects to special-status species from landslide activity.	Minor, adverse effects to special-status species from potential plant community burial from landslide activity because of drawdowns at Green Peter and Cougar Reservoirs.
		Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.
	Negligible effect to wapato.	Moderate, adverse effects to special-status plant species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.
Ecoregions	Negligible	Major, beneficial effects from gravel augmentation.	Major, beneficial effects from gravel augmentation	Major, beneficial effects from gravel augmentation.	Major, beneficial effects from gravel augmentation.	Major, beneficial effects from gravel augmentation.	Major, beneficial effects from gravel augmentation.	Major, beneficial effects from gravel augmentation.

[1] The duration of all effects would be long-term.

3.6.3.5 Alternatives Analyses

THE DEIS HAS BEEN MODIFIED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

Fall Creek Reservoir Operations under All Alternatives

Fall reservoir drawdowns at Fall Creek Reservoir may have negligible effects to localized reservoir-adjacent plant communities under all alternatives. This drawdown would result in mobilization of small amounts of sediment material that would likely remain suspended in the water. It is unlikely that sediments would be displaced so that they would bury existing plant communities at the local level over the 30-year implementation timeframe.

Wildfire Recovery and Fine Fuels under All Alternatives

Forested areas affected by the 2020 wildfires would continue to recover because operations and maintenance under any alternative over the 30-year implementation timeframe would not inhibit re-establishment of forests from the existing seedbank or continued natural plant succession of those forests. As forests recover, fine fuels would continue to become available in the analysis area and be subject to management by the BLM and USFS. Operations under any alternative would not affect fine fuel establishment in reservoir or downstream areas beyond existing conditions.

Gravel Augmentation below Dams and Revetment Engineering under All Action Alternatives

Action alternative operations include gravel augmentation that would increase the potential for sediment accumulation along stream margins. Such accumulations may re-engage floodplain habitat such as adjacent wetlands, back water sloughs, and oxbows, which would not occur under the NAA (Section 3.6.2.1, Ecoregions, Ecoregion 3b, Willamette River and Tributaries Gallery Forest). This could be a moderate benefit to plant communities throughout the analysis area depending on the alternative and site-specific designs.

Maintenance under the action alternatives also includes measures for nature-based engineering techniques to maintain or alter existing revetments. Using native plant species as part of the revetment repairs and modifications would benefit native plant communities by increasing the seedbank of native plants for broader distribution within subbasin riparian corridors than under the NAA. These potential benefits would be major and would continue for the 30-year implementation timeframe.

Unlike revetment maintenance under the NAA, these techniques, along with gravel augmentation, may improve connections between vegetation communities along stream margins and wetland and riparian areas further landward. However, site-specific designs, including locations, are necessary to fully assess potential vegetation benefits in the analysis area under any action alternative.

Using native plant species as part of the revetment repairs and modifications would benefit native plant communities by increasing the seedbank of native plants for broader distribution within subbasin riparian corridors than under the NAA. These potential benefits would be major and would continue for the 30-year implementation timeframe.

END NEW TEXT

No-action Alternative

Operations under the NAA would not directly or indirectly impact ecoregion composition or ecology, or special-status fungi (Section 3.6.2.1, Ecoregions). However, the NAA would continue to have minor, adverse impacts to special-status plant species found within the analysis area as described below.

There would not likely be any impacts to special-status fungi in the analysis area under any alternative. Most fungi species identified in the analysis area are found in upland forest habitats, which would not be impacted by operations under any alternative. Further, special-status fungi generally do not thrive in areas inundated with water such as reservoir-adjacent habitats.

Special-status Plant Species and Wapato

Populations of special-status plant species exist outside of the analysis area (Table 3.6-1). Actions taken under any alternative would not impact remnant populations outside of the analysis area. Additionally, seeds produced by these species may persist in the soils (seed bank) within the WVS. Although special-status species may be adversely impacted from alternative implementation, there is the potential for species recovery from the seed bank and remnant populations.

Howell's montia and dotted watermeal are reasonably assumed to have populations within the analysis area that would be directly, adversely impacted by NAA operations[7]. Adverse effects would continue to occur to Howell's montia from reservoir operations that erode and degrade habitat occupied by this species. Dotted watermeal floats on the water surface and would continue to be disturbed, desiccated, or relocated by water level changes associated with dam operations under the NAA. Additionally, reservoir hydrologic regimes under the NAA would continue to favor the establishment of invasive or noxious plants.

Adverse effects to Howell's montia and dotted watermeal would continue to re-occur under the NAA over the 30-year implementation timeframe but would be minor because effects would be localized and there is potential for sensitive species recovery from the seed bank and remnant populations unimpacted by operations. Unimpacted populations of these species outside of affected reservoir areas may continue to thrive and establish, which could allow for reintroduction and re-establishment of these species within the analysis area.

[7] Special-status species included in Table 3.6-1 but not addressed in the analysis do not have enough supporting evidence to determine presence/absence within the analysis area or do not occupy habitat that would be influenced by implementation of any alternative.

Operations under the NAA would not affect the growth or locations of wapato because operations would not alter existing conditions in side channels and slower waters of the Willamette River. Several high priority aquatic invasive species would continue to threaten water quality and wapato. Adverse impacts to this species would remain minor and regional; wapato would be available as a culturally important species to the Kalapuya peoples and others in the analysis area (Section 3.6.2.1, Ecoregions, Ecoregion 3b, Willamette River and Tributaries Gallery Forest). However, aquatic invasive species would continue to threaten water quality and wapato in the side channels and slower waters of the Willamette River under the NAA.

Ecoregions

Specific to Ecoregion 3b, the historical floodplain and revetment influences on vegetation would not be altered under the NAA because operations would not change as compared to existing conditions (Section 3.6.2.1, Ecoregions, Ecoregion 3b, Willamette River and Tributaries Gallery Forest). Aquatic vegetation would continue to establish in the Willamette River and tributaries, sloughs, and oxbows; operations under the NAA would not influence plant populations or locations that would differ from existing conditions.

Reservoir-adjacent Plant Communities

The potential for induced landslides at any reservoir is negligible under NAA operations (Section 3.4, Soils and Geology, Table 3.4-3). Consequently, plant communities would not likely be buried from landslide activity under NAA operations.

Vegetation communities would be subject to the current hydrologic regime of the WVS operations and maintenance, which differs substantially from a natural hydrologic regime. Reservoir elevations would remain at their highest due to the conservation period of operations during the summer from May through September.

Fluctuations in reservoir elevations would continue to result in direct, adverse effects to vegetation adjacent to the reservoir because plant communities would remain subjected to frequent water inundation cycles that prohibit plant community succession, cause disturbance, and depart from the natural hydrologic regime. Consequently, reservoir-adjacent plant communities would continue to be disturbed by reservoir water level fluctuations. Therefore, establishment of less diverse, disturbance-tolerant communities dominated by invasive species would persist in reservoir-adjacent plant communities. This establishment would re-occur over the 30-year implementation timeframe.

This pattern has been observed in Lake Ontario where studies have shown that since regulation of water levels was initiated, reservoir-adjacent plant communities shifted from sedge/grass meadow marsh to wetlands dominated by invasive cattail species (Wilcox et al. 2008). Although plant diversity is negatively affected by reservoir elevation operations, benefits to overall plant growth and biomass accumulation would continue to occur. Higher reservoir water levels, especially during the summer growing season, would provide greater water availability in soils to reservoir-adjacent plant communities, which facilitates plant growth.

Plant Communities Influenced by Downstream Flows

Under the NAA, USACE would continue to manage water levels in the reservoirs by maintaining low water in the winter and re-filling reservoirs in spring, holding water over the summer at full pool. These operations would continue to result in vegetation communities composed of species suited to higher downstream flows in the fall/winter and lower downstream flows in the spring/summer.

Maintenance of revetments would continue to disconnect streams and rivers from the floodplain under the NAA. Direct, major, adverse effects from revetments would occur to stream-adjacent vegetation communities during the 30-year implementation timeframe because riverine wetlands, off-channel areas, backwater sloughs, and oxbows that support diverse plant communities would have limited hydrologic connectivity. These effects would be major and long term over the 30-year implementation timeframe.

Under the NAA, downstream flows would be highest during the fall and winter. As a result, water availability for wetlands downstream of dams would be high. This hydrologic regime is reflective of the natural hydrology in the Willamette Valley. High winter flows would continue to have a negligible effect on native wetland vegetation, which has adapted to wet winters and dry summers.

Riparian vegetation communities established on gravel bars in the Willamette River and tributaries would not be altered under the NAA because operations would not be modified and would not affect channel migration patterns (Section 3.6.2.1, Ecoregions, Ecoregion 3b, Willamette River and Tributaries Gallery Forest). Noxious weeds would continue to establish on gravel bars in the analysis area.

Invasive Plant Communities

Priority aquatic invasive species documented by Krass et al. (2021) would continue to establish in the analysis area because of operations under the NAA during the 30-year implementation timeframe. Invasive species colonize quickly in disturbed environments, such as areas with water fluctuations, which would allow invasive plants to continue to out-compete native plant communities in localized areas around reservoirs.

Invasive species—depending on growth form—would continue to be controlled when reservoirs fill during the summer growing season under the NAA, but the distribution of invasive species around reservoirs would not be entirely disrupted. Consequently, there would be a continual potential for colonization of drawdown zones by invasive species. Summer reservoir storage would also result in more water available in the soil to continue to support noxious plant communities around reservoirs.

Alternative 1—Improve Fish Passage through Storage-focused Measures

As under the NAA, operations under Alternative 1 would not directly or indirectly impact ecoregion composition or ecology, or special-status fungi (Section 3.6.2.1, Ecoregions). However, Alternative 1 has the potential for direct, adverse impacts to special-status plant species found within the analysis area as under the NAA.

Special-status Plant Species and Wapato

Impacts to special-status plant species and wapato under Alternative 1 operations would be similar to those described under the NAA. However, there is a potential for moderate, adverse effects during spring refill under Alternative 1, which may prohibit establishment of special-status plants and wapato during the primary new-growth establishment spring period. As under NAA operations, aquatic invasive species would continue to threaten water quality and wapato in the side channels and slower waters of the Willamette River under Alternative 1.

Additionally, operations under Alternative 1 would include use of the inactive pools at Cottage Grove, Dorena, Fall Creek, and Blue River Reservoirs in the late summer or early fall. Operations could also include use of the power pools during the summer and late fall when needed to support ESA flow requirements. If needed, one or more of all of the WVS power pools could be lowered except for Dexter, Big Cliff, and Foster Reservoirs. Combined, these drawdowns would moderately, adversely impact established special-status plants and wapato localized to these pools as compared to the NAA because these plants have adapted to high water levels and require adequate water supply for growth and survival. Impacts could occur more broadly throughout the analysis area depending on the pool combination for drawdown needs. These actions could re-occur over the 30-year implementation timeframe.

Ecoregions

Impacts to Ecoregion 3b would largely be similar to those described under the NAA. However, unlike the NAA, Alternative 1 operations include gravel augmentation that would increase the potential for re-engagement of floodplain habitat, which would not occur under the NAA (Section 3.6.2.1, Ecoregions, Ecoregion 3b, Willamette River and Tributaries Gallery Forest). Aquatic vegetation would continue to establish in the Willamette River and tributaries, sloughs, and oxbows. Overall, operations under Alternative 1 would have a minor, beneficial effect on plant populations and aquatic habitats within Ecoregion 3b as compared to the NAA.

Reservoir-adjacent Plant Communities

Like operations under the NAA, frequent reservoir fluctuations would result in direct, adverse effects to vegetation adjacent to the reservoir, promoting less diverse, disturbance-tolerant species. Unlike the NAA operations, there is the potential for spring growth to be prohibited during spring refill operations under Alternative 1, which would be a moderate, adverse effect over the 30-year implementation timeframe.

As under NAA operations, there would be a negligible potential for landslide activity that would bury plant communities under Alternative 1 operations (Section 3.4, Soils and Geology, Table 3.4-3).

Plant Communities Influenced by Downstream Flows

Flows and hydrology under Alternative 1 would continue to approximate those under the NAA with slight differences.

There would be an increase of downstream flows from a combination of several reservoirs depending on annual flow requirements under Alternative 1, which would slightly improve hydrologic conditions for the plant communities along the riverbanks. Flow increases would occur in summer; however, flow differences would be minimal compared to the NAA.

Impacts to vegetation communities along the banks of these streams such as those in wetlands and riparian areas are anticipated to have a minor benefit because of greater water availability during the growing season. Also, as under the NAA, floodplain disconnection would continue due to flood reduction operations. This would continue to have major, indirect, adverse effects to stream-adjacent communities as described under the NAA over the 30-year implementation timeframe.

As under the NAA, there would be no effects to riparian vegetation communities established on gravel bars under Alternative 1. Flows would continue to approximate those under the NAA and, therefore, would not affect vegetation communities downstream or on gravel bars. Increased summer and fall flows as needed from a few to several reservoirs would likely have a negligible, beneficial effect on gravel bar vegetation as these communities are adapted to lower flows in the summer months.

Invasive Plant Communities

The potential for invasive species to establish in reservoirs under Alternative 1 would likely be the same as under NAA operations, which would adversely affect reservoir-adjacent plant communities over the 30-year implementation timeframe. However, there may be some benefit to native plant communities from spring refills at some reservoirs that would hinder establishment of invasive, disturbance-tolerant plants that attempt to establish in drawdown zones.

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

As under the NAA, operations under Alternative 2A would not directly or indirectly impact ecoregion composition or ecology, or special-status fungi (Section 3.6.2.1, Ecoregions). As described below, Alternative 2A has the potential for direct, adverse impacts to special-status plant species found within the analysis area as under the NAA.

Special-status Plant Species and Wapato

Adverse impacts to special-status plant species and wapato under Alternative 2A operations would be similar to those described under Alternative 1. However, there is a minor potential for landslide activity at Green Peter Reservoir induced by minimum pool elevations. Landslide activity could bury special-status plant species resulting in minor, adverse effects to vegetation as compared to the NAA.

There is also a potential for moderate, adverse effects during spring refill under Alternative 2A, which may prohibit establishment of special-status plants and wapato during the primary new-growth establishment spring period as compared to the NAA. As under the NAA operations, aquatic invasive species would continue to threaten water quality and wapato found in the side channels and slower waters of the Willamette River under Alternative 2A.

Additionally, operations under Alternative 2A would include use of the inactive pools at Fall Creek and Blue River Reservoirs in the late summer or early fall. Unlike NAA operations, Alternative 2A operations could also include use of the power pools during the summer and late fall when needed to support ESA flow requirements. If needed, one or more of all of the WVS power pools could be lowered at Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit Reservoirs. Combined, these drawdowns would moderately, adversely impact established special-status plants and wapato localized to these pools as compared to the NAA, and possibly more broadly throughout the analysis area depending on the pool combination for drawdown needs. These actions could re-occur over the 30-year implementation timeframe.

Ecoregions

Impacts to ecoregion 3b would be the same as those described under Alternative 1.

Reservoir-adjacent Plant Communities

Effects to reservoir-adjacent plant communities under Alternative 2A would be the same as those described under the NAA. However, a deep fall drawdown at Green Peter Reservoir may result in additional adverse effects to localized vegetation as compared to the NAA because Alternative 2A operations would lower overall reservoir elevations. There is only a minor potential for landslide activity from the deep drawdown to occur at Green Peter Reservoir compared to NAA operations (Section 3.4, Soils and Geology, Table 3.4-3). Consequently, there is negligible to minor potential for landslide activity to bury established plant communities. This effect would only occur seasonally and would be localized to a slide area.

As under the NAA operations, there is the potential for spring growth to be prohibited during spring refill operations under Alternative 2A, which would be a moderate, adverse effect over the 30-year implementation timeframe.

Plant Communities Influenced by Downstream Flows

Unlike NAA operations, sediment releases are anticipated during the first few years of fall drawdown operations under Alternative 2A; however, these sediments would stay in suspension in the water column and would have negligible effects on downstream plant communities. As under the NAA, floodplain disconnection would continue due to flood reduction operations. This would continue to have major, indirect, adverse effects to stream-adjacent communities as described under the NAA over the 30-year implementation timeframe.

Effects to downstream native plant communities would be negligible under Alternative 2A. Landslide activity would not lead to increased sedimentation downstream, and light sediment releases from deep drawdowns would not deposit on vegetation communities along streambanks or gravel bars.

Differences in flows due to operations as compared to the NAA would have a minor benefit to vegetation from higher summer flows, which would provide more water to plant communities in wetlands and riparian areas during the growing season; however, potential adverse effects to vegetation could occur during dry years from lowered spring flows.

Invasive Plant Communities

The potential for invasive species to establish in reservoirs under Alternative 2A would likely be the same as under NAA operations, which would adversely affect reservoir-adjacent plant communities over the 30-year implementation timeframe. However, there may be a minor benefit to native plant communities from spring refills at some reservoirs that would hinder establishment of invasive, disturbance-tolerant plants that attempt to establish in drawdown zones.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

As under the NAA, operations under Alternative 2B would not directly or indirectly impact ecoregion composition or ecology, or special-status fungi (Section 3.6.2.1, Ecoregions). As described below, Alternative 2B has the potential for direct, adverse impacts to special-status plant species and wapato found within the analysis area as under the NAA.

Special-status Plant Species and Wapato

There is only a minor potential for landslide activity from the deep drawdown to occur at Green Peter Reservoir and a moderate potential for landslide activity at Cougar Reservoir under Alternative 2B (Section 3.4, Soils and Geology, Table 3.4-3). Consequently, there is minor to moderate potential for landslide activity to bury established reservoir-adjacent plant communities as compared to NAA operations. This effect would only occur seasonally and would be localized to a slide area.

Adverse impacts to special-status plant species and wapato under Alternative 2B operations would be similar to those described under Alternative 1. However, there is a minor potential for landslide activity at Green Peter Reservoir and a moderate potential for landslide activity at Cougar Reservoir, which could bury special-status plant species resulting in minor, adverse effects. There is a potential for moderate, adverse effects at all reservoirs except Cougar Reservoir during spring refill under Alternative 2B, which may prohibit establishment of special-status plants and wapato during the primary new-growth establishment spring period compared to the NAA.

As under NAA operations, aquatic invasive species would continue to threaten water quality and wapato found in the side channels and slower waters of the Willamette River under Alternative 2B.

Adverse effects from operations under Alternative 2B at Fall Creek and Blue River Reservoirs in the late summer or early fall and drawdowns of power pools would be the same as those described under Alternative 2A.

Ecoregions

Impacts to ecoregion 3b would be the same as those described under Alternative 1.

Reservoir-adjacent Plant Communities

Unlike NAA operations, a deep drawdown at Cougar Reservoir under Alternative 2B may result in additional minor, adverse effects to localized vegetation with increased spread of invasive species from exposed conditions and landslide activity. Drawdowns at Green Peter Reservoir would adversely affect localized vegetation because of disturbances caused by water level fluctuations associated with drawdowns. There is the potential for moderate, adverse effects to vegetation at all reservoirs except Cougar Reservoir during spring refill under Alternative 2B, which may adversely influence new plant establishment.

Plant Communities Influenced by Downstream Flows

As under the NAA, major, adverse effects to floodplain vegetation would occur under Alternative 2B because of flood risk management that does not allow for floodplain connectivity. These adverse effects would occur over the 30-year implementation timeframe.

Direct effects to downstream vegetation as a result of sedimentation from deep reservoir drawdowns in the fall and spring would be similar to effects under Alternative 2A.

Indirect impacts to downstream vegetation in wetlands and riparian areas under Alternative 2B as a result of flow changes would be similar to those under Alternative 2A. Effects would re-occur over the 30-year implementation timeframe.

Invasive Plant Communities

The potential for invasive species to establish in reservoirs under Alternative 2B would likely be the same as under NAA operations, which would adversely affect reservoir-adjacent plant communities over the 30-year implementation timeframe. However, unlike the NAA, there may be a minor benefit in all reservoirs except Cougar Reservoir to native plant communities from spring refills at some reservoirs that would hinder establishment of invasive, disturbance-tolerant plants that attempt to establish in drawdown zones.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

As under the NAA, operations under Alternative 3A would not directly or indirectly impact ecoregion composition or ecology, or special-status fungi (Section 3.6.2.1, Ecoregions). As described below, Alternative 3A has the potential for direct, adverse impacts to special-status plant species found within the analysis area as under the NAA.

Special-status Plant Species and Wapato

There is only a minor potential for landslide activity from the deep drawdown to occur at Green Peter Reservoir and a moderate potential for landslide activity at Cougar, Lookout Point, and Detroit Reservoirs under Alternative 3A (Section 3.4, Soils and Geology, Table 3.4-3). Consequently, there is minor to moderate potential for landslide activity to bury established reservoir-adjacent plant communities as compared to NAA operations. This effect would only occur seasonally and would be localized to a slide area.

Adverse impacts to special-status plant species and wapato under Alternative 3A operations would be similar to those described under Alternative 1; however, there is a minor potential for landslide activity at Green Peter and a moderate potential for landslide activity at Cougar, Lookout Point, and Detroit Reservoirs. Landslide activity could bury special-status plant species resulting in minor, adverse effects as compared to the NAA. There is a potential for moderate, adverse effects during spring refill at all reservoirs except Lookout Point, Cougar, and Detroit Reservoirs under Alternative 3A, which may prohibit establishment of special-status plants and wapato during the primary new-growth establishment spring period.

As under NAA operations, aquatic invasive species would continue to threaten water quality and wapato found in the side channels and slower waters of the Willamette River under Alternative 3A.

Adverse effects from drawdown operations under Alternative 3A would be the same as those described under Alternative 2A.

Ecoregions

Impacts to ecoregion 3b would be the same as those described under Alternative 1.

Reservoir-adjacent Plant Communities

Under Alternative 3A, a deep drawdown at Cougar, Lookout Point, and Detroit Reservoirs may result in additional moderate, adverse effects to localized vegetation as compared to the NAA with increased spread of invasive species from exposed conditions and landslide activity. Drawdowns at Green Peter Reservoir would have a minor, adverse effect on localized vegetation because of disturbances caused by water level fluctuations associated with drawdowns; however, as under the NAA, effects from the spread of invasive species and landslide activity would not occur.

There may be a minor benefit to native plant communities from spring refills at all reservoirs under Alternative 3A except at Lookout Point, Cougar, and Detroit Reservoirs where establishment of invasive, disturbance-tolerant plants that attempt to establish in drawdown zones would be hindered.

Plant Communities Influenced by Downstream Flows

Flow operations under Alternative 3A have the potential for direct, moderately adverse effects to vegetation downstream of reservoirs as compared to the NAA. Under this alternative, spring outflows would be increased during dry years leading to increased flows downstream of reservoirs.

While greater downstream water availability during the spring growing season would provide a minor benefit to vegetation as compared to the NAA, this would result in less water for downstream flow in the summer and early fall. The lower-than-average summer and fall flows expected from the use of inactive and power pools would put extended stress on stream-adjacent plant communities in wetlands and riparian areas. Unlike conditions under NAA operations, this would lead to mortality and shifts in species composition from native plant communities to disturbance-tolerant invasive species. Effects would re-occur over the 30-year implementation timeframe.

As under the NAA, effects to downstream vegetation as a result of sedimentation from deep reservoir drawdowns in the fall and spring would not occur as drawdowns would not mobilize a substantial amount of sediments. Consequently, downstream vegetation would not be subject to burial or sedimentation.

As under the NAA operations, direct, major, adverse effects to floodplain vegetation would occur under Alternative 3A because of flood risk management operations and continued existence of some revetments that would not allow for floodplain connectivity.

Invasive Plant Communities

The potential for invasive species to establish in reservoirs under Alternative 3A would likely be the same as under NAA operations, which would adversely affect reservoir-adjacent plant communities over the 30-year implementation timeframe. However, unlike the NAA, there may be a minor benefit to native plant communities from spring refills at some reservoirs that would hinder establishment of invasive, disturbance-tolerant plants that attempt to establish in drawdown zones. This benefit would not occur at Cougar, Lookout Point, and Detroit Reservoirs.

Alternative 3B—Improve Fish Passage through Operations-focused Measures

Effects to vegetation under Alternative 3B operations would be the same as those described under Alternative 3A; however, an additional deep drawdown at Hills Creek Reservoir may lead to a moderate potential for landslide activity. This potential could lead to additional minor, adverse effects to localized plant communities as compared to the NAA because landslide activity could bury vegetative communities, including those of special-status species and wapato. Under Alternative 3B, spring refill would result in moderate, adverse effects to new plant establishment at all reservoirs except Cougar, Hills Creek, and Green Peter Reservoirs.

Under Alternative 3B, spring refill at all reservoirs except for Hills Creek, Cougar, and Green Peter Reservoirs may lead to moderate, adverse effects to wapato and special-status species compared to NAA operations. Unlike the NAA, reservoir operations could also result in a minor benefit to native plant communities as refills may prevent the establishment of invasive plant species in areas subject to inundation at all reservoirs except Cougar, Hills Creek, and Green Peter Reservoirs. Alternative 3B would also differ from Alternative 3A because use of the power pools during the summer and late fall would not occur at Cougar Reservoir, which would reduce potential adverse impacts to localized special-status plants and wapato similar to the NAA.

Unlike NAA operations, lowered summer downstream flows from reduced reservoir elevations could have a minor, adverse effect on downstream vegetation in wetlands and riparian areas because of less water availability during summer conditions.

Alternative 4—Improve Fish Passage with Structures-based Approach

Effects to vegetation under Alternative 4 operations would be the same as those described under Alternative 1; however, power pool operations during summer and late fall would differ from Alternative 1 operations. Under Alternative 4, the power pool could be used to alter downstream flows at Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit Reservoirs. Increased use of power pools under Alternative 4 would result in greater adverse impacts to localized special-status plant species and wapato compared to the NAA.

Flow operations under Alternative 4 would have negligible effects to downstream wetland and riparian vegetation in an average year, similar to NAA operations.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Effects to vegetation under Alternative 5 operations would be the same as those described under Alternative 2B. However, under Alternative 5, spring refill at all reservoirs except for Cougar Reservoir may lead to moderate, adverse effects to wapato and special-status species because inundation of these plants would prevent establishment and growth. Unlike NAA operations, Cougar Dam operations could also result in a minor benefit to native plant communities as refills may prevent the establishment of plant species in areas subject to inundation.

Higher summer downstream flows under Alternative 5 as compared to NAA operations could lead to a minor benefit to vegetation communities such as those in wetlands and riparian areas in summer. However, unlike the NAA, in dry years, there would be the potential for minor, adverse effects to vegetation and vegetation communities in the spring from lowered spring flows.

3.6.4 Interim Operations under All Action Alternatives Except Alternative 1

The timing and duration of Interim Operations would vary depending on a given alternative. Interim Operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations will be implemented in succession with, and not in addition to, action alternative implementation.

The Interim Operations include deep drawdowns at Green Peter, Cougar, Lookout Point, and Fall Creek Reservoirs along with delayed reservoir refills. Impacts to vegetation communities as a result of drawdowns under these measures would be the same as those resulting from operations at Green Peter Dam under Alternative 2A; specifically, the potential spread of invasive species in the analysis area. Additionally, if reservoirs are unable to refill during the summer months, reservoir-adjacent plant communities may transition to upland type communities due to falling water tables and water surface elevations with implementation of the Interim Operations.

3.6.5 Climate Change Effects under All Alternatives

Climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions over the 30-year implementation timeframe (Climate Impacts Group 2010; RMJOC 2020) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources: Section 3.1 Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

Reservoir levels under all alternatives may fall more frequently and refill would be more difficult than under existing or proposed operations with climate-related conditions and subsequent operational adjustments. Reservoir fluctuations coupled with drought conditions will favor invasive plants suitable to these environments throughout the analysis area and at the local, reservoir-adjacent level.

Adverse effects to vegetation, including special-status plant species and wapato, under all alternatives would increase in degree of intensity because of increased frequency of wildfires destroying available habitat and lower plant survival rates due to drought.

Effects from climate change in the analysis area are likely to decrease plant species diversity (i.e., homogeneity), but this may not result in increased listed species. The criteria for listed species may change over the 30-year implementation timeframe, prompted by climate change effects. Survey efforts may also change. Consequently, it is uncertain how climate change will impact species listings. Regardless, a plant community will persist within the analysis area but would likely change in composition with less species diversity and supported by more drought-tolerant species than under existing conditions.

END REVISED TEXT

US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.7 WETLANDS

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3.7 Wetlands

THE WETLANDS SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **Additional information on revetments has been added to FEIS Section 3.7.1, Introduction.**
- **The description of the analysis area has been revised for clarity and to align with the analyses in FEIS Section 3.7.2, Affected Environment.**
- **Information on invasive species has been added to FEIS Section 3.7.2.1, Willamette Valley Wetlands.**
- **A table summarizing effects under each alternative has been added (FEIS Table 3.7-3).**
- **The definition of short-term and long-term effects criteria has been expanded in FEIS Table 3.7-2. Medium-term effects criteria have been deleted because these effects would not apply under any alternative.**
- **Additional comparisons to the No-action Alternative have been added in FEIS Section 3.7.3, Environmental Consequences.**
- **Analyses of habitat quality and function have been added in FEIS Section 3.7.3, Environmental Consequences.**
- **Information on routine and non-routine maintenance has been added to the analyses in FEIS Section 3.7.3.1, Construction and Routine and Non-routine Maintenance Activities.**
- **Definitions of direct and indirect effects have been added to FEIS Section 3.7.3.2, Methodology.**
- **Several analysis topics have been combined to describe effects under all alternatives in FEIS Section 3.7.3.3, Alternatives Analyses.**
- **The Near-term Operations Measures analyses have been combined in FEIS Section 3.7.4 Interim Operations under All Alternatives Except Alternative 1. The term “Near-term Interim Operations” has been changed to “Interim Operations” throughout the EIS. Additional information on operations timing has been added.**
- **The climate change analyses have been combined for all alternatives in FEIS Section 3.7.5. Additional information has been provided.**

Summary of Changes from the DEIS, continued:

- **Consistent terminology has been applied and defined as applicable.**
- **Grammatical clarifications have been made.**

3.7.1 Introduction

Wetlands and waterways protected under the Federal Clean Water Act (CWA) are called jurisdictional waters and wetlands. Placing or removing material in wetlands or within waterways may require Federal and state permitting.

The CWA assigns responsibility to USACE to regulate discharges of pollutants into waters of the United States, which includes wetlands. The CWA also requires states to develop water quality programs to ensure waters of the United States within the state meet water quality standards. In Oregon, CWA regulatory authority has been granted by the Environmental Protection Agency to the Oregon Department of Environmental Quality (ODEQ) under Section 401 of the CWA. Additionally, the Oregon Department of State Lands has regulatory authority over removal and placement of fill within waters of the State.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

Wetlands are important ecosystems, providing environmental functions that are valuable to nearby human communities (e.g., improving water quality and flood protection) and providing valuable habitat functions for amphibians, reptiles, birds, invertebrates, fish, and mammals. Wetlands are identified by vegetation type (i.e., hydrophytic vegetation), soil type (i.e., hydric soils), and wetland hydrology (e.g., high water table, soil saturation, etc.). Wetlands are typically found in transitional areas between upland areas (e.g., hillsides) and aquatic areas (e.g., reservoirs, streams). Features such as revetments can cause floodplain disconnections, which affect development of wetland habitat. Additionally, these disconnections can promote a transition to upland communities from historical wetland communities.

High quality wetlands provide a variety of ecosystem services, such as water filtration, carbon sequestration, and valuable plant and wildlife habitat. Wetlands with greater plant diversity provide more ecosystem services because they can support more diverse faunal communities through greater habitat variability. Wetlands with low plant diversity also offer ecosystem benefits through biomass accumulation and carbon storage.

Biomass is the total weight of organisms in an area. Vegetative biomass is primarily made up of carbon, which has been gained from atmospheric carbon dioxide. Highly productive wetland systems can accumulate carbon and, therefore, biomass at a rapid rate. Additionally, because of low oxygen conditions in wetland substrates, decomposition of organic matter is slowed. This allows the carbon accumulated by vegetative communities to remain stored in wetland systems. Storage of atmospheric carbon dioxide in these systems can help to mitigate the effects of climate change.

In this section, wetlands are characterized within the context of general habitat classification at the landscape scale. These characterizations describe wetland function and quality in the analysis area. Additional habitat characterizations are provided in Section 3.6, Vegetation (i.e., analysis area plant species and assemblages) and Section 3.9, Wildlife and Habitat.

3.7.2 Affected Environment

The analysis area for wetlands consists of all reservoirs in the Willamette Valley System (WVS) up to the maximum pool elevation (a.k.a., “full pool”) and stream reaches below reservoirs. The analysis area encompasses floodplains, backwater sloughs, oxbow lakes, side channels, and irrigation ditches.

The analysis area was established because (1) the maximum pool elevation is the jurisdictional boundary when assessing in-water impacts to reservoirs in Oregon and (2) wetlands within the WVS may be hydrologically connected to stream flows within WVS stream reaches[1] as well as reservoirs.

END REVISED TEXT

The analysis area includes wetlands adjacent to the following stream reaches:

- Middle Fork Willamette River downstream of Hills Creek Dam to the confluence with the Coast Fork Willamette River
- Coast Fork Willamette River downstream of Cottage Grove Dam to the confluence with the Middle Fork Willamette River
- Row River from downstream of Dorena Dam to the confluence with the Coast Fork Willamette River
- South Fork McKenzie River downstream of Cougar Dam to the confluence with the McKenzie River
- McKenzie River from the South Fork McKenzie River confluence to the confluence with the Willamette River
- Blue River downstream of Blue River Dam to the confluence with the McKenzie River
- Long Tom River downstream of Fern Ridge Dam to the confluence with the Willamette River (includes Coyote Creek from Fern Ridge Dam to the confluence with the Willamette River)

[1] The Ordinary High Water Mark is the jurisdictional boundary for streams and rivers.

- South Santiam River downstream of Foster Dam to the confluence with the North Santiam River
- North Santiam River downstream to the confluence with the South Santiam River
- Santiam River to the confluence with the Willamette River
- Willamette River mainstem to Willamette Falls

3.7.2.1 Willamette Valley Wetlands

Historically, seasonal wetlands were common throughout the Willamette River Basin. Approximately 90 percent of the historical wetlands have been converted to agriculture or other means of development (ODFW 2016).

Wetlands in the analysis area include those located along channels of slow-moving, low-gradient stream reaches downstream of the dams where the floodplain and the channel migration zone broaden.

Backwater sloughs and oxbow lakes are formed when a stream channel migrates across the floodplain over time. This process shifts primary stream flows from previously used channels, now backwater sloughs, and completely isolates other portions, which become oxbow lakes.

These wetlands are part of the riverine and palustrine systems within the analysis area. In these areas, large floodplain wetland complexes sometimes form over time, particularly in lower gradient areas.

Vegetation within a backwater slough includes emergent species as well as woody species such as willows (*Salix* spp.), alder (*Alnus rubra*), Oregon ash (*Fraxinus latifolia*), and black cottonwood (*Populus trichocarpa*). Backwater sloughs and oxbow lakes provide habitat for various fish, reptiles, amphibians, mammals, and birds. Due to the slower movement of water through backwater sloughs, juvenile salmonids use these areas for rearing and refugia during high-water events.

Wetlands have many forms in the analysis area:

- Backwater sloughs (riverine)
- Oxbow lakes (riverine and palustrine)
- Emergent wetlands (palustrine and riverine)
- Seasonal ponds (palustrine)
- Forested wetlands (palustrine)
- Wet prairies (palustrine)

In addition to wetlands located along stream reaches downstream of the dams, wetlands located around or hydrologically connected to the WVS reservoirs, many of which are within the Cascade Mountain foothills, are also included in the analysis area. Reservoirs in the Willamette River Basin provide a hydrological regime that results in wetland formation along the edges of reservoirs despite the lower pool elevations during the winter. This hydrologic regime is opposite of regimes observed in wetlands located around a natural lake.

National Wetland Inventory Wetland Types

- Lacustrine wetlands are lakes, reservoirs, or other waterbodies that are situated in a topographic depression or a dammed river channel and are more than 20 acres.
- Palustrine wetlands include all non-tidal wetlands dominated by trees, shrubs, and persistent emergent vegetation (i.e., plants with their roots underwater but leaves and stems above).
- Riverine wetlands are located within river and stream channels.

The hydrologic regime from reservoir operations allows for disturbance-tolerant wetlands to form around many reservoirs despite winter drawdowns. Emergent wetlands support vegetative communities composed of native and invasive species and provide habitat for wildlife species around WVS reservoirs. The ecosystem services provided by these wetlands are limited, however, because species assemblages are dominated by disturbance-tolerant vegetation. Due to the steep topography of reservoirs found within the Cascade Mountain foothills, the formation of these wetlands is generally limited to lower gradient areas near the upstream end of the reservoirs.

Wetlands in the analysis area are more abundant within lower elevation reservoirs (Cottage Grove, Dorena, and Fern Ridge Reservoirs), within the Willamette Valley in areas adjacent to the Mainstem Willamette River, and in the lower sections of tributaries to the Willamette River. Wetlands in the analysis area are capable of high productivity and will accumulate biomass and store carbon. However, reservoir-adjacent wetlands do not provide optimal wetland function and quality because of low species diversity. Conversely, wetland habitat downstream of dams does support native plant diversity and, therefore, high ecosystem quality and function.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

The analysis area is hospitable to a wide range of invasive plant species due to a mild climate, continued disturbances, and introductions of competing invasive species that have happened over time. Invasive species are non-native species, and their introduction is likely to cause economic or environmental harm.

The spread of invasive species is closely tied to global trade and human movement. As humans travel and engage in commerce, novel species arrive in new locations. Many of these species are not suited to the new locations, but a few are able to flourish and may outcompete native plant species. Introduced invasive species then dominate these ecosystems. Invasive plants are known to establish where soils are bare and where disturbances create bare soil (Zedler 2004). Moreover, the potential for invasion is facilitated by watering/dewatering cycles that prohibit plant community succession and cause disturbance. Consequently, the potential for invasive plant establishment in wetlands is promoted by reservoir drawdowns in the analysis area.

Additionally, scouring events caused by high flow can dislodge invasive propagules (vegetative structures capable of giving rise to a new plant) and introduce them downstream where they may become established in floodplains, backwater sloughs, oxbow lakes, side channels, and irrigation ditches. However, negative effects from lack of scouring can occur as it allows invasive species to establish in the absence of major disturbance (Krass et al. 2021).

Invasive plant species listed by Oregon Department of Agriculture are known to occur within 1 mile of the analysis area. The Oregon State Weed Board developed a classification system and includes noxious weeds on lists based on Oregon noxious weed policy (Section 3.6, Vegetation, Table 3.6-2). Locations were discovered using a combination of online tools, including the Department of Agriculture Weed Mapper (ODA 2021) and the Oregon Flora Project Mapper (OregonFlora 2021). Some species may no longer occur in the analysis area due to successful eradication.

According to Krass et al. (2021), high priority[2] aquatic invasive species in the analysis area include *Ludwigia* species and yellow floating heart. Medium priority aquatic invasive species include yellow flag iris, narrowleaf cattail, purple loosestrife, tree of heaven, knotweeds, and parrots feather. Wide-spread aquatic invasive species occurring in the analysis area include reed canary grass, curly leaf pond weed, and Eurasian watermilfoil.

USACE manages weeds using Integrated Pest Management as outlined in USACE ER 1130-2-540, the 2009 USACE Invasive Species Policy (USACE 2009b), and an Integrated Pest Management Plan prepared by USACE for each reservoir. Invasive species management with pesticides (including herbicides) also requires compliance with the Federal Insecticide, Fungicide, and Rodenticide Act and the Clean Water Act National Pollutant Discharge Elimination System (NPDES) Permit for aquatic applications.

USACE began a reservoir survey program in 2023 to analyze vegetative ecosystem responses to water management. Surveys will document invasive plant growth, species, etc., and will result in recommendations for invasive plant management, such as restoration planning and monitoring, in applicable WVS reservoirs.

National Wetland Inventory

The U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) is a publicly available resource that provides data and mapping on the classification and distribution of wetlands within the U.S. NWI data serves as a planning resource to promote the understanding, conservation, and restoration of wetlands (USFWS 2021). However, NWI data are determined through a desktop analysis and, therefore, these data cannot be used to determine accurate acreage of wetlands within the analysis area.

Within the NWI data, wetlands are classified according to the Cowardin system (Cowardin et al. 1979) into different types based on soil types, hydrologic regime, and vegetation type. The systems of wetland types found within the analysis area include lacustrine, palustrine, and

[2] Priority species are those aquatic and terrestrial weeds identified by Krass et al. (2021) as plants that should be prioritized for survey and treatment within the Willamette River Basin.

riverine. Within the analysis area, palustrine wetlands are located along stream channels. Riverine wetlands are located throughout the analysis area (Table 3.7-1).

Table 3.7-1. National Wetland Inventory Wetland Types in the Analysis Area.

NWI Code	Cowardin Classification	Description
PEM	Palustrine emergent	Non-tidal wetland dominated by emergent, herbaceous vegetation
PSS	Palustrine scrub-shrub	Non-tidal wetland dominated by woody vegetation less than 20 feet tall
PFO	Palustrine forested	Non-tidal wetland dominated by woody vegetation 20 feet tall or taller
PUB	Palustrine unconsolidated bottom	Non-tidal wetland with 25 percent or more cover by particles smaller than stones and with less than 30 percent vegetative cover
PAB	Palustrine aquatic bed	Non-tidal wetland dominated by vegetation that grows on or below the surface of the water
LUB	Lacustrine unconsolidated bottom	Water body in topographic depression or a dammed river channel, 25 percent or more cover by particles smaller than stones, with less than 30 percent vegetative cover
RUB	Riverine unconsolidated bottom	A wetland contained within a channel, 25 percent or more cover by particles smaller than stones, and less than 30 percent vegetative cover
RUS	Riverine unconsolidated shore	A wetland contained within a channel, unconsolidated substrates with less than 75 percent cover of stones, boulders, or bedrock and less than 30 percent vegetative cover

3.7.2.2 Subbasin Wetland Descriptions

North Santiam River Subbasin

According to NWI data, Big Cliff and Detroit Reservoirs[3] are classified as lacustrine unconsolidated bottom (LUB) and include adjacent palustrine emergent (PEM), palustrine scrub-shrub (PSS), and palustrine forested (PFO) wetlands. These adjacent wetlands are found throughout the shoreline where wetland soils, vegetation, and hydrology occur after the construction of the dams and reservoir. Wetlands can also be found in shallow gradient areas at the head of a reservoir and at the confluence of tributaries and a reservoir.

Along the North Santiam River to its confluence with the South Santiam River, riverine unconsolidated bottom (RUB), riverine unconsolidated shore (RUS), palustrine emergent (PEM), palustrine scrub-shrub (PSS), and palustrine forested (PFO) wetlands are located within and

[3] The NWI refers to reservoirs as "lakes," but for EIS consistency, reservoir names have been used.

alongside the stream channel. This includes some side channels, backwater sloughs, and irrigation ditches.

There is a complex of wetlands in the vicinity of Stayton Island in the North Santiam River floodplain that are connected to Wilderness Park and Riverfront Park in Stayton, Oregon. There is a large floodplain wetland in the vicinity of Wiseman Island near the confluence of the North Santiam River with the South Santiam River.

South Santiam River Subbasin

Green Peter Reservoir and Foster Reservoir are classified as LUB, and no adjacent wetlands are shown in the NWI data. However, wetlands not shown in the NWI data (i.e., unmapped wetlands) do occur along reservoir shorelines and in areas that are of shallow gradient near the head of the reservoirs and any confluence of a tributary and reservoir.

Off-channel wetlands that are connected to the South Santiam River but are not hydrologically dependent on Foster Reservoir or the South Santiam River include the former Foster Dam Quarry site, which is connected to the South Santiam River immediately downstream of Foster Dam and a wetland located upstream of Foster Reservoir at Menears Bend.

The South Santiam River downstream of Foster Dam to its confluence with the North Santiam River is classified as RUB and RUS, has PEM, PSS, and PFO wetlands along its edge, and includes side channels, backwater sloughs, and irrigation ditches. Several nearby ponds, which appear to be gravel pits, are classified as palustrine unconsolidated bottom (PUB) along the South Santiam River. Several floodplain wetland complexes are located closer to the confluence of the North and South Santiam Rivers.

McKenzie River Subbasin

Blue River Reservoir and Cougar Reservoir are both classified as LUB and do not show adjacent wetlands in the NWI data. Unmapped wetlands do occur along reservoir shorelines and in areas that are of shallow gradient near the head of the reservoirs and any confluence of a tributary and reservoir.

Downstream of Cougar Dam, the U.S. Forest Service (USFS) conducted a Stage Zero restoration effort along the South Fork McKenzie River that resulted in reconnection with the floodplain, increased habitat complexity, and an increase in off-channel habitat including wetlands (USFS 2018).

The Blue River, South Fork McKenzie River, and McKenzie River are all classified as RUB and RUS and have PEM, PSS, and PFO wetlands along their edges, including side channels, oxbow lakes, backwater sloughs, and irrigation ditches. Within the mainstem of the McKenzie River, Leaburg Dam and Leaburg Canal provide additional wetland areas along their banks. Several floodplain wetland complexes bisected by the McKenzie River are located near Walterville and Springfield, Oregon.

Middle Fork Willamette River Subbasin

Hills Creek, Lookout Point, Dexter, and Fall Creek Reservoirs are all classified as LUB and include a couple of adjacent PEM and PSS wetlands. Unmapped wetlands do occur along reservoir shorelines and in areas that are of shallow gradient near the head of the reservoirs and any confluence of a tributary and reservoir.

Downstream of Hills Creek Dam, the Middle Fork Willamette River to its confluence with the Coast Fork Willamette River is RUB and RSC and includes PEM, PSS, and PFO wetlands along its banks and nearby PUB and palustrine aquatic bed (PAB) wetlands within the floodplain and channel migration zone.

There is a smaller floodplain wetland complex just downstream of Dexter Dam as well as a larger floodplain wetland complex with side channels and islands. Additionally, PEM, PSS, PFO, PUB, PAB, and LUB wetlands are located just upstream and at the confluence of the Middle Fork Willamette River with the Coast Fork Willamette River south of Springfield, Oregon.

Coast Fork Willamette River Subbasin

Dorena Reservoir and Cottage Grove Reservoir are classified as LUB and have large PEM wetlands located at their upstream ends. Unmapped wetlands do occur along reservoir shorelines and in areas that are of shallow gradient near the head of the reservoirs and any confluence of a tributary and reservoir.

Row River downstream of Dorena Dam to its confluence with the Coast Fork Willamette River includes many PEM, PSS, and PFO wetlands, particularly closer to the confluence. The Coast Fork Willamette River appears to lack wetlands in areas where it is highly channelized with a disconnected floodplain through Cottage Grove, Oregon. But just downstream of its confluence with Row River there are several floodplain wetland complexes and many small PEM, PSS, and PFO wetlands in the surrounding area. In addition, there is a large floodplain wetland complex just downstream of Creswell, Oregon with oxbow lakes, backwater sloughs, and side channels.

Long Tom River Subbasin

Fern Ridge Reservoir is classified as a LUB wetland and is surrounded by a large PEM, PSS, and PFO wetland complex, primarily on the south side. The adjacent PEM wetlands are considered wet prairies and include vegetation specific to Willamette Valley wet prairies.

Directly downstream of Fern Ridge Dam, Kirk Pond, Coyote Creek, and the Long Tom River include both backwater sloughs and oxbow lakes. Many of these habitat types were formed by USACE when the Long Tom River channel was modified in the 1940s. This large wetland complex maintains connections with the Long Tom River via culverts and forms a large wetland complex classified as PFO around the historical channel.

Beyond the wetland complex, the Long Tom River (classified as RUB) is highly channelized; very few adjacent wetlands are shown in the NWI data, although there are some nearby PUB/PEM oxbow lakes and irrigation ditches that flow into the Long Tom River. There are a few PEM, PSS, and PFO wetlands closer to the Long Tom River confluence with the Willamette River.

Mainstem Willamette River

There are many types and sizes of wetlands within or along the floodplain of the Willamette River mainstem downstream to Willamette Falls. As within the subbasins, there are several off-channel floodplain features such as oxbow lakes, side channels, irrigation ditches, and backwater sloughs. Many of these features are associated with river meanders and form large floodplain wetland complexes.

Several natural areas are also associated with these wetland floodplain complexes: Blue Ruin Island, Sam Daw's Landing, Bowers Rock State Park, Luckiamute State Natural Area, Minto-Brown Island Park, Beardsley Bar Landing, Willamette Mission State Park, Grand Island, and Molalla River State Park.

Analysis Area Floodplains

Much of the analysis area lies within the historical floodplain of the Willamette River. The deciduous riparian forests that once occupied the region have largely been replaced by agriculture and development. Revetments and reduced flooding following dam construction have diminished the effective floodplain, isolating oxbow lakes and increasing the land area available for farming and towns (Krass et al. 2021). Many floodplain and off-channel wetlands within the subbasin and within the entirety of the analysis area have been disconnected from adjacent streams and rivers through the construction and maintenance of revetments.

3.7.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives on wetlands. The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

3.7.3.1 Construction and Routine and Non-routine Maintenance Activities

Effects to wetlands may occur as part of specific construction activities during alternative implementation and would be the same under any alternative involving construction. There would likely be no or negligible effects on wetlands in the analysis area because construction would be localized and may occur in areas that do not support wetlands. However, subsequent tiered analyses would detail site-specific construction effects during the implementation phase (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act).

During the planning process for any site-specific project, USACE would determine whether wetlands are present on site and, if so, conduct wetland delineations and functional assessments of areas that would be directly or indirectly affected by construction activities. Delineations and functional assessments would be used to determine wetland boundaries and ecological function and value of each wetland potentially affected.

Direct effects from construction could include excavation in wetlands, placing fill in wetlands, impacting wetland vegetation, or altering wetland hydrology. Applicable permits and approvals would be obtained prior to construction implementation. Mitigation may be required if unavoidable impacts to wetlands are identified during this pre-construction assessment process. Additional analyses are not provided under each alternative.

Similarly, routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation).. Direct adverse impacts to wetlands from maintenance activities, such as equipment use and human activity, are not expected to occur because maintenance would be conducted on sites developed for dam operations. No new ground disturbance is anticipated with routine maintenance that would adversely impact wetlands. Major maintenance activities may require site-specific NEPA review prior to initiation at any location in the analysis area. Additional analyses are not provided under each alternative.

END NEW TEXT

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

3.7.3.2 Methodology

The method used to analyze effects to wetlands was qualitative based on potential wetland presence within the analysis area per NWI data and relating that potential presence to effects associated with each alternative.

- Direct effects to wetlands within the WVS analysis area would occur from physical modification of terrain and from operations affecting hydrology, sediment transport, erosion, and slope failure.

- Indirect effects would include establishment of invasive species from direct effect alterations such as fluctuations in reservoir levels. Variation in reservoir water levels would increase the potential for invasive-dominated plant communities to establish along banks of reservoirs because of increases in available bare, disturbed soils, frequent watering/dewatering cycles that prohibit plant community succession, and departure from the natural hydrologic regime.

The environmental effects criteria and a summary of effects are provided in Table 3.7-2 and Table 3.7-3, respectively.

Table 3.7-2. Wetlands Environmental Effects Criteria.

Degree of Adverse or Beneficial Effect and Extent of Effect	Definition
None/Negligible	Wetlands would not be affected, and no effects would be observable.
Minor	Effects to wetlands would be observable, although the effects would be small and localized (e.g., signs of erosion, changes in vegetation types, sediment deposits). WVS-wide effects on wetland quantity would continue to benefit from biomass accumulations.
Moderate	Effects to wetlands would be small at the local level but observable at the WVS-wide scale and not be easily measured (e.g., changes to wetland acreage, magnitude of wetland quality impact throughout the WVS).
Major	Effects to wetlands would be readily observable and measurable (e.g., obvious changes in wetland acreage) and would have substantial ecological consequences (e.g., loss of wetland habitat for special status species) at the WVS level.
Duration	
Short-term	Disturbance to wetlands would occur or re-occur for a short period of time, lasting only as long as a discrete construction project, single event, routine maintenance, or measure implementation in an area. Wetlands would not be altered over time or transition to other habitat types.
Long-term	Disturbance to wetlands would be ongoing or last beyond operation changes or the completion of construction projects, routine maintenance, or measure implementation. An impact would occur or re-occur over a long period of time and up to the 30-year implementation timeframe (i.e., effects that would occur over the 30-year implementation timeframe are considered long-term effects).

Table 3.7-3. Summary of Effects to Wetlands as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Reservoir-adjacent Wetlands	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.
	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season at reservoirs where refill is achieved.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season at reservoirs where refill is achieved.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season at reservoirs where refill is achieved.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season at reservoirs where refill is achieved.
			Negligible effects from potential for reservoir to not refill.	Moderate, adverse effects to wetlands at Cougar Reservoir if reservoir is not refilled.	Moderate, adverse effects to wetlands at Cougar, Lookout Point, and Detroit Reservoirs if unable to refill.	Moderate, adverse effects to wetlands at Cougar, Hills Creek, and Green Peter Reservoirs if unable to refill.	Negligible effects from potential for reservoir to not refill.	Moderate, adverse effects to wetlands at Cougar Reservoir if reservoir is unable to refill.
	Negligible effects to wetlands from the potential for induced landslides.	Negligible effects to wetlands from the potential for induced landslides.	Minor, adverse effects from the potential for induced landslides at Green Peter Reservoir from fall and spring drawdowns.	Moderate, adverse effects from the potential for induced landslides at Green Peter and Cougar Reservoirs from fall and spring drawdowns.	Moderate, adverse effects from the potential for induced landslides at Green Peter, Lookout Point, Detroit, and Cougar Reservoirs from fall and spring drawdowns.	Moderate, adverse effects from the potential for induced landslides at Green Peter, Lookout Point, Detroit, Hills Creek, and Cougar Reservoirs from fall and spring drawdowns.	Negligible effects to wetlands from the potential for induced landslides.	Moderate, adverse effects from the potential for induced landslides at Green Peter and Cougar Reservoirs from fall and spring drawdowns.
Downstream-adjacent Wetlands	Negligible effects from flow operations.	Negligible effects from flow operations.	Minor, beneficial effects from increased summer flows.	Minor, beneficial effects from increased summer flows.	Moderate, adverse effects from lowered reservoir levels in summer and fall preventing flow operations.	Moderate, adverse effects from lowered reservoir levels in summer and fall preventing flow operations.	Negligible effects from flow operations.	Minor, beneficial effects from increased summer flows.
			Minor, adverse effects from lower spring flows.	Minor, adverse effects from lower spring flows in dry years.	Minor benefit to wetlands from spring water releases during dry years.			
	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.
		Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.
			Negligible effects from sediment releases.	Negligible effects from sediment releases.	Negligible effects from sediment releases.	Negligible effects from sediment releases.		Negligible effects from sediment releases.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Invasive and Noxious Weed Presence	Minor, adverse effects in reservoirs from frequent reservoir elevation changes that increases the potential for the establishment of invasive dominated plant communities.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects from spring refills controlling invasive species establishment.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns. Minor beneficial effects from spring refills controlling invasive species establishment. Potential for increased adverse effects because of deep drawdowns at reservoirs.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns Minor, beneficial effects in all reservoirs except Cougar Reservoir from spring refills controlling invasive species establishment. Potential for increased adverse effects because of deep drawdowns at reservoirs.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects in all reservoirs except Cougar, Lookout Point, and Detroit Reservoirs from spring refills controlling invasive species establishment. Potential for increased adverse effects because of deep drawdowns at reservoirs.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects in all reservoirs except Hills Creek, Cougar, and Green Peter Reservoirs from spring refills controlling invasive species establishment. Potential for increased adverse effects because of deep drawdowns at reservoirs.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects from spring refills controlling invasive species establishment.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevations changes and deep drawdowns. Minor, beneficial effects in all reservoirs except Cougar Reservoir from spring refills controlling invasive species establishment. Potential for increased adverse effects because of deep drawdowns at reservoirs.

[1] The duration of all effects would be long term.

3.7.3.3 Alternatives Analyses

Invasive Species under All Alternatives

The existence of invasive plant species throughout the analysis area would continue under all alternatives because fluctuations in reservoir levels would result in disturbed and exposed soils favoring invasive species establishment. Additionally, reservoir-adjacent wetland plant communities would remain subjected to frequent water inundation cycles that prohibit plant community succession, cause disturbance, and depart from the natural hydrologic regime. Consequently, less diverse, disturbance-tolerant communities dominated by invasive species would continue to establish in drawdown zones, replacing or preventing establishment of diverse native wetland vegetation.

The lack of native plant species would adversely impact wetland function and quality. These effects would be direct and long term under any alternative but would be more adverse under the action alternatives where deep drawdown operations would occur.

A potential increase in invasive species establishment is anticipated throughout the analysis area under NAA operations over the 30-year implementation timeframe. Invasive species may be controlled when reservoirs fill during the summer growing season under the NAA, but the distribution of invasive species around reservoirs would not be entirely disrupted. Summer reservoir storage would also result in more water available in the soil to support noxious plant communities around reservoirs.

Consequently, effects to wetland habitat under the NAA would be adverse to a minor degree because NWI mapped and unmapped wetlands would continue to be subject to a hydrologic regime that supports the establishment of invasive species.

Effects to reservoir-adjacent wetland habitat under the action alternatives from invasive plant species establishment would have the potential for greater adverse effects because of deeper drawdown operations as compared to NAA operations. Deep drawdowns would adversely affect wetland communities over the 30-year implementation timeframe because they are associated with the loss of organic matter, nutrients, and fine sediments in drawdown zones (Furey 2004). Studies of vegetation succession in reservoirs has shown differences in species assemblages based on substrate texture, distance to forest and successional age, and time since an area was drained (Section 3.6, Vegetation). For example, after removal of the Elwha Dam in Washington State, vegetation within fine sediment surfaces were predominantly native species while coarser substrate supported a higher percentage of invasive species (Prach et al. 2019). This could be attributed to moisture content in the soil.

Spring refills may provide minor benefits in reservoirs where they occur because they would hinder the establishment of invasive, disturbance-tolerant plants that attempt to establish in drawdown zones.

Under all alternatives, scouring events caused by high flows could continue to occur downstream of dams. These events could dislodge invasive propagules and introduce them downstream where they may become established in floodplains, backwater sloughs, oxbow lakes, side channels, and irrigation ditches throughout the analysis area. However, negative effects from lack of scouring can occur depending on flow regimes. This would allow invasive species to establish in the absence of major disturbance in downstream areas under all alternatives depending on specific site conditions.

Gravel Augmentation Below Dams and Revetment Engineering under All Action Alternatives

Action alternative operations include gravel augmentation that would increase the potential for sediment accumulation along stream margins. Such accumulations may re-engage floodplain habitat such as adjacent wetlands, back water sloughs, and oxbows, which would not occur under the NAA (Section 3.6.2.1, Ecoregions, Ecoregion 3b, Willamette River and Tributaries Gallery Forest). This could be a major benefit to wetlands and riparian areas throughout the analysis area depending on the alternative and site-specific designs.

Maintenance under the action alternatives also includes measures for nature-based engineering techniques to maintain or alter existing revetments. Using native plant species as part of revetment repairs and modifications would benefit native plant communities by increasing the seedbank of native plants for broader distribution within analysis area subbasins as compared to the NAA. These potential benefits would be major and would continue for the 30-year implementation timeframe.

Unlike revetment maintenance under the NAA, these techniques, along with gravel augmentation, may improve connections between wetland vegetative communities along stream margins and wetland and riparian areas further inland. However, site-specific designs, including locations, are necessary to fully assess potential vegetation benefits in the analysis area under any action alternative.

Using native plant species as part of the revetment repairs and modifications would benefit native wetland plant communities by increasing the seedbank of native plants for broader distribution within subbasin riparian corridors as compared to the NAA. These potential benefits would be major and would continue for the 30-year implementation timeframe.

Effects to Floodplain Connectivity under All Alternatives

Under all alternatives, major, adverse effects would occur to downstream wetlands because of floodplain disconnection caused by revetments and flood risk reduction measures in some areas downstream of dams. Disconnected floodplains would continue to prevent establishment of wetland habitat and may promote the transition of wetlands to upland landscape characteristics.

Effects to Wetland Habitat from Landslide Activity under All Alternatives

The potential for landslide activity under any alternative could result in conversion of existing wetlands to areas supporting invasive species if slide debris buries wetlands (Section 3.4, Soils and Geology). Action alternatives with deep drawdown operations may increase the potential for increased slide events and, therefore, wetland disturbance or destruction.

All action alternatives except Alternative 1 and Alternative 4 have a potential to adversely impact wetlands from landslide activity. The greatest potential for landslide activity to adversely affect wetlands would be under Alternative 3B followed by Alternative 3A due to proposed drawdowns in several reservoirs. The degree of effect would depend on slide potential, location, and presence of wetland habitat in a slide pathway.

Effects would be long term as there would be potential for landslide re-occurrence each time a deep drawdown occurs. Landslides could also potentially bury wetland vegetation, resulting in the loss of wetland habitat until new communities could establish.

Table 3.7-4. Potential to Induce Landslide Activity that May Adversely Affect Reservoir-adjacent Wetlands under Alternatives with Deep Drawdown Operations.

Reservoir	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 5
Green Peter	Minor	Minor	Minor	Minor	Minor
Cougar	N/A	Moderate	Moderate	Moderate	Moderate
Lookout Point	N/A	N/A	Moderate	Moderate	N/A
Detroit	N/A	N/A	Moderate	Moderate	N/A
Hills Creek	N/A	N/A	N/A	Moderate	N/A

N/A= not applicable to this alternative.

Note: See Section 3.4, Soils and Geology for supporting information.

No-action Alternative

Reservoir-adjacent Wetlands

Under the No-action Alternative (NAA), NWI mapped and unmapped wetland habitat would be subject to the current hydrologic regime of the WVS operations and maintenance, which differs substantially from a natural hydrologic regime. Frequent water level fluctuations may also prohibit plant establishment and succession, which would increase the potential for invasive species to dominate wetland plant communities.

Reservoir elevations would be highest from May through September under NAA operations. This condition would continue to create and maintain wetlands along the edge of full-pool elevation within the reservoirs at the local level. However, wetland quality and function at the reservoirs and throughout the WVS would remain low from lack of plant diversity and would continue to decline as invasive species continued to establish (Section 3.7.1, Introduction).

Although plant diversity would continue to be negatively affected by reservoir operations, benefits to overall plant growth and biomass accumulation throughout the analysis area would continue to occur under the NAA. Higher reservoir water levels, especially during the summer growing season, would provide water availability in soils to reservoir-adjacent plant communities, facilitating plant growth overall. Additionally, invasive species not well adapted to inundation may be controlled when reservoirs fill during the summer growing season under the NAA, but the distribution of invasive species around reservoirs would not be entirely disrupted. Overall, wetlands would be adversely affected to a minor degree under continuation of the NAA. This effect would continue during the 30-year implementation timeframe.

Wetlands Adjacent to Stream Reaches below Reservoirs

Under NAA operations, downstream flows would be managed in the analysis area so that winter flooding is reduced; flows would be highest during the fall and winter. As a result, water availability for wetlands in floodplains, oxbow lakes, backwater sloughs, side channels, and irrigation ditches downstream of dams would be high. This hydrologic regime is reflective of the natural hydrology in the Willamette Valley, which supports numerous NWI mapped and unmapped wetlands and wetland complexes.

High winter flows would continue to have negligible, adverse effects on wetland vegetation over the 30-year implementation timeframe, and which has adapted to wet winters and dry summers and provides high wetland quality and function. High water availability in the wet season would also continue to facilitate development of hydric soils that are critical to wetland formation.

Alternative 1—Improve Fish Passage through Storage-focused Measures

Reservoir-adjacent Wetlands

Reservoir operations would continue to approximate those under the NAA with slight differences that would not impact wetlands. Consequently, effects on reservoir-adjacent wetland habitat would be the same as under the NAA.

As under the NAA, reservoir operations under Alternative 1 would continue to create and maintain wetlands along the edge of full-pool elevation within the reservoirs. However, wetland quality and function at the reservoirs and throughout the WVS would remain low from lack of plant diversity and the risk of invasive plant colonization. Although plant diversity would continue to be negatively affected by reservoir operations, benefits to overall plant growth and biomass accumulation throughout the analysis area would continue to occur under Alternative 1 as under NAA operations.

Wetlands Adjacent to Stream Reaches below Reservoirs

Operations under Alternative 1 would reduce June through September minimum flows within the analysis area, compared to the NAA, and would decrease flows in the North Santiam and

South Santiam Rivers as well as Fall Creek, which flows into the Middle Fork Willamette River. However, flows and hydrology would continue to approximate those under the NAA. Consequently, hydrologic effects to NWI mapped and unmapped wetlands along these streams would not be affected. There would also be an increase of downstream flows from Dexter and Lookout Point Dams along the Middle Fork Willamette River, which would slightly improve hydrologic conditions for associated wetlands and wetland complexes as compared to the NAA in the short term although benefits to wetlands would be negligible.

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Reservoir-adjacent Wetlands

Effects to reservoir-adjacent wetland habitat under Alternative 2A as a result of reservoir operations would be the same as those described under the NAA. However, a deep fall drawdown at Green Peter Reservoir may result in additional minor, long-term, adverse effects on localized wetland habitat as compared to the NAA from increased risk of invasive species colonization and destruction of wetland habitat, function, and quality. Specifically, the deep fall drawdown is likely to allow invasive and versatile species such as, but not limited to, reed canary grass, yellow flag iris, purple loosestrife, and knotweeds to expand existing populations long term around Green Peter Reservoir as well as downstream through seed or fragment dispersal.

Although plant diversity would continue to be negatively affected by reservoir operations, benefits to overall plant growth and biomass accumulation throughout the analysis area would continue to occur under Alternative 2A as under NAA operations.

These adverse effects would be moderate and last over the course of the 30-year implementation timeframe. Wetland communities would likely re-establish at the new Green Peter Reservoir edge in the long term.

Wetlands Adjacent to Stream Reaches below Reservoirs

Stream flows in downstream areas are anticipated to have minor effects on wetlands over the 30-year implementation timeframe under Alternative 2A as compared to NAA operations. An adverse effect on wetlands would occur as a result of lowered spring flows. Conversely a minor benefit to wetlands may occur from higher summer flows.

Sediment releases are anticipated during the first few years of fall drawdown operations under Alternative 2A; however, releases would be primarily composed of fine sediments that would remain in suspension in the water. These sediments would not deposit in downstream areas and therefore would be a negligible effect on wetland habitat in the short term as compared to the NAA.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Reservoir-adjacent Wetlands

Effects to reservoir-adjacent wetland habitat, function, and quality as a result of reservoir operations under Alternative 2B would be the same as those described under Alternative 1. Minor, direct, long-term adverse effects on wetlands would occur under Alternative 2B as compared to the NAA.

However, if operations under Alternative 2B at Cougar Reservoir are unable to refill the reservoir during the 30-year implementation timeframe, the lowered surface elevations and water table would change the composition of some aquatic and wetland reservoir-adjacent communities to upland communities as compared to the NAA, resulting in moderate, long-term adverse effects to wetlands. Wetland communities would likely re-establish at the new reservoir edges in the long term, benefiting WVS-wide wetlands.

Although plant diversity would continue to be negatively affected by reservoir operations, benefits to overall plant growth and biomass accumulation throughout the analysis area would continue to occur under Alternative 2B as under NAA operations at reservoirs where refill is achieved.

Wetlands Adjacent to Stream Reaches below Reservoirs

Effects on wetlands and wetland complexes associated with stream reaches would be similar to those under Alternative 2A. Higher summer stream flow would provide a minor benefit to wetlands as compared to the NAA. Minor, adverse effects to wetlands from lower spring flows may occur in dry years. Effects on wetlands from sediment releases would be the same as those under Alternative 2A.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

Reservoir-adjacent Wetlands

Effects to reservoir-adjacent wetland habitat, function, and quality as a result of reservoir operations under Alternative 3A would be the same as those described under Alternative 1. Minor, direct, long-term adverse effects on wetlands would occur under Alternative 3A as compared to the NAA.

Operations under Alternative 3A would include spring and fall deep drawdowns at more reservoirs when compared to NAA operations. These additional drawdowns at Cougar, Lookout Point, and Detroit Reservoirs would substantially increase the potential for invasive species to establish in disturbed areas within reservoir beds if operations are unable to refill reservoirs as compared to the NAA over the 30-year implementation timeframe.

Although plant diversity would continue to be negatively affected by reservoir operations, benefits to overall plant growth and biomass accumulation throughout the analysis area would continue to occur under Alternative 3A as under NAA operations at reservoirs where refill is achieved. Operations would result in moderate, long-term adverse effects to wetlands at the local and WVS-wide levels.

Wetlands Adjacent to Stream Reaches below Reservoirs

Unlike NAA operations, Alternative 3A stream flows are anticipated to have a minor, adverse effect on downstream wetlands with the potential for minor, beneficial effects in spring of dry years. The lower-than-average summer and fall flows expected during the 30-year implementation timeframe from the use of inactive and power pools would add extended stress on stream-adjacent wetlands and riparian areas. Effects on wetlands from sediment releases would be the same as those under Alternative 2A.

Alternative 3B—Improve Fish Passage through Operations-focused Measures

Effects to wetlands under Alternative 3B would be the same as those described under Alternative 3A. Operations under Alternative 3B would include spring and fall deep drawdowns at more reservoirs when compared to NAA operations. These additional drawdowns at Cougar, Hills Creek, and Green Peter Reservoirs would substantially increase the potential for invasive species to establish in disturbed areas within reservoir beds if operations are unable to refill reservoirs as compared to the NAA over the 30-year implementation timeframe.

Although plant diversity would continue to be negatively affected by reservoir operations, benefits to overall plant growth and biomass accumulation throughout the analysis area would continue to occur under Alternative 3B as under NAA operations at reservoirs where refill is achieved.

However, unlike the NAA operations, lowered summer downstream flows from reduced reservoir elevations could have a minor, adverse effect on downstream wetlands and riparian areas because of less water availability during summer conditions.

Alternative 4—Improve Fish Passage with Structures-based Approach

Reservoir operations would continue to approximate those under the NAA with slight differences that would not impact wetlands. Consequently, effects on reservoir-adjacent wetland habitat under Alternative 4 would be the same as under the NAA.

Flows and hydrology would continue to approximate those under the NAA. Consequently, hydrologic effects to NWI mapped and unmapped wetlands along these streams would not be affected.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Effects to wetlands under Alternative 5 would be the same as those described under Alternative 2B.

3.7.4 Interim Operations under All Action Alternatives Except Alternative 1

The timing and duration of Interim Operations would vary depending on a given alternative. Interim operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations will be implemented in succession with, and not in addition to, action alternative implementation.

The Interim Operations include deep drawdowns at Green Peter, Cougar, Lookout Point, and Fall Creek Reservoirs along with delayed reservoir refills[4]. Impacts to wetland habitat as a result of drawdowns under these operations would be the same as those resulting from operations at Green Peter Dam under Alternative 2A; specifically, the potential spread of invasive species in the analysis area. Additionally, if reservoirs are unable to refill during the summer months, reservoir-adjacent plant communities and wetland habitat may transition to upland communities due to falling water tables and water surface elevations with implementation of the Interim Operations. This result would depend on the duration of the Interim Operations.

3.7.5 Climate Change under All Alternatives

Climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions over the 30-year implementation timeframe (Climate Impacts Group 2010; RMJOC 2020) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources: Section 3.1 Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

Reservoir levels under all alternatives may fall more frequently and refill would be more difficult than under existing or proposed operations with climate-related conditions and subsequent operational adjustments. Reservoir fluctuations coupled with drought conditions

[4] Implementation of Interim Operations would range from near-term to the full 30-year implementation timeframe. Analyzing effects specific to a given time or timeframe range within the full 30-year implementation timeframe would be speculative because site-specific information was not available when the alternatives were analyzed.

will favor invasive plants suitable to these environments throughout the analysis area and at the local, reservoir-adjacent level.

Specifically, wetland plant communities in the analysis area would likely change in composition with more drought-tolerant vegetation species becoming increasingly predominant throughout the region. As the wetland community changes, invasive plant species are anticipated to establish in areas where native vegetative communities have diminished.

Adverse effects to wetlands under all alternatives will increase in degree of intensity because of increased frequency of wildfires destroying available habitat and lower plant survival rates due to drought. Wetland habitat will persist within the analysis area but would likely change in composition with more drought-tolerant species becoming increasingly predominant throughout the analysis area. Consequently, wetland habitat function and quality are likely to diminish as a result of climate change.

END NEW TEXT

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Willamette Valley
System Operations and Maintenance
Environmental Impact Statement

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.8 FISH AND AQUATIC HABITAT

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3.8 Fish and Aquatic Habitat

THE FISH AND AQUATIC HABITAT SECTION HAS BEEN REVISED IN ITS ENTIRETY FROM THE DEIS

Summary of changes from the DEIS:

- **This section has been reorganized for improved readability. Repeat information was deleted and supporting details moved to Appendix E, Fish and Aquatic Habitat Analyses. All new information is consistent with information and analyses in other EIS sections. Cross-references have been added to locate additional or supporting information, terminology has been defined, and additional photographs inserted.**
- **An overview of the Affected Environment has been added in FEIS Section 3.8.1, Introduction.**
- **Descriptions of fish species and resident and anadromous life history forms have been expanded in FEIS Section 3.8.2.2, Fish Species.**
- **Information and analyses have been added for lamprey, in-reservoir resident fish, and gamefish in FEIS Section 3.8.2.2, Fish Species, and in Section 3.8.3, Environmental Consequences.**
- **Updated information and analyses on bull trout have been included in FEIS Section 3.8.2.2, Fish Species, Bull Trout, and Section 3.8.3.2 Alternatives Analyses.**
- **Information and analyses have been added for the Mainstem Willamette River.**
- **Descriptions of aquatic habitats have been expanded in FEIS Section 3.8.2.4, Aquatic Habitat. Additional information includes aquatic vegetation, large woody debris, habitat connectivity, stream bank modifications, etc. Water quality information has been revised to include additional parameter details.**
- **Definitions have been added for evolutionarily significant units, distinct population segments, and critical habitat in FEIS Section 3.8.2.2, Fish Species.**
- **Information on marine-derived nutrients has been added in various FEIS sections where warranted.**
- **Information on the Willamette Hatchery Mitigation Program in FEIS Section 3.8.2.3 has been revised for accuracy and consistency with information in Chapter 1, Introduction.**

Summary of changes from the DEIS, continued:

- **The analyses methodologies have been revised in FEIS Section 3.8.3.1, Methodology. The approach to evaluate effects to fish and aquatic habitat has been revised and clarified. Metrics and methods have been revised from the DEIS. For example, the DEIS referred to results for three different life cycle models; the FEIS analysis of effects is based on one of these models because the scope of this model is within the 30-year implementation timeframe and the model provides results for the updated metrics used to analyze effects.**
- **DEIS criteria have been revised to address effects qualitatively and descriptively in FEIS Section 3.8.3.1, Methodology. Definitions of direct and indirect effects are clarified.**
- **A summary of adverse and beneficial effects for all alternatives by species has been added to Section 3.8.3.1 Methodology.**
- **Consistent with the Affected Environment format, the Environmental Consequences analyses for all alternatives have been modified in FEIS Section 3.8.3.2, Alternatives Analyses, to include analyses of reservoir habitat, riverine habitat, and dam passage conditions along with construction and maintenance and hatchery mitigation. Effects specific to fish habitat conditions in each subbasin are provided. Habitat descriptions have been revised.**
- **An analysis of chad was deleted because this species does not occur above Willamette Falls and into the analysis area.**
- **The analyses of Near-term Operations Measures have been combined in FEIS Section 3.8.4. The term “Near-term Operations” has been revised to “Interim Operations” throughout the EIS.**
- **The analyses of climate change-related effects have been combined for all alternatives in FEIS Section 3.8.5.**
- **Appendix E, Fish and Aquatic Habitat Analyses, has been revised to include new and updated analyses that support the EIS analyses.**

3.8.1 Introduction

The Willamette River Basin supports a variety of fish species and aquatic habitats. The distribution and abundance of fish species affected by the Willamette Valley System (WVS) are influenced by both biotic and abiotic factors that interact with various life stages. The fish species assessed in this section use a broad range of habitats depending on life stage; therefore, sensitivity to natural and human-induced stressors vary dependent on habitat location, timing, and duration of exposure. Only some stressors are caused by WVS operations and maintenance, depending on when and where those stressors overlap with the species' presence.

3.8.2 Affected Environment

The Affected Environment for fish and fish habitat includes descriptions of the analysis area, species that occur within the analysis area, including listings and gamefish descriptions, the hatchery mitigation program, habitat descriptions, and descriptions of species and habitat in each analysis area subbasin.

3.8.2.1 Analysis Area

The analysis area for fish species and their habitats encompasses the Willamette River Basin. Effects of the WVS on fish and their habitats below Willamette River Falls are negligible. Therefore, the geographic area of potential USACE effects begins immediately upstream of the Willamette Falls Fish Ladder and extends upstream through the Mainstem Willamette River and into the uppermost reaches of its major subbasins. These subbasins are presently, or were historically, accessible to anadromous fish species before construction of the 13 dams. Subbasins in the analysis area include the North Santiam River, South Santiam River, McKenzie River, Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins.

Subbasin descriptions are provided in Section 3.2, Hydrologic Processes, Subsection 3.2.1.5, Hydrologic Processes, Willamette River Basin and Reservoir System. An overview of the analysis area environmental setting (e.g., geography, climate, flow management) is also provided in Section 3.2, Hydrologic Processes.

The fish and aquatic habitat analysis area focuses on where WVS operations and maintenance may affect anadromous or resident fish species and their habitats, including resident species that have fluvial, adfluvial, or non-migratory life history forms. Dam operations and maintenance do not result in measurable effects to any fish species or habitats present downstream of the Willamette Falls Fish Ladder, including anadromous fish species that originate from the Willamette River Basin and migrate to and from the Columbia River estuary and ocean. Effects to anadromous fish species that occur outside of the analysis area of measurable effects (e.g., estuarine and ocean conditions, etc.) are discussed as they contribute to potential alternative effects.

What are the Common Fish Life History Forms?

All fish have some kind of spawning and migration behaviors, often referred to as their "life history strategy." The life history of a fish determines whether it is an anadromous or resident species. If it is a resident, then it can be fluvial, adfluvial, or non-migratory.

Anadromous: As juveniles, fish migrate from freshwater to marine environments and then return to fresh water as adults to spawn. Eggs incubate in gravel and young fish emerge to rear in fresh water as they migrate downstream or prior to migration.

Resident: Also known as non-anadromous. The entire life of the fish is within fresh water, in either streams, rivers, or lakes. Some species migrate to a different freshwater habitat for spawning because of fluvial or adfluvial migration patterns, or they can be 'resident' and do not migrate between spawning and rearing habitats.

Fluvial: These fish live entirely within flowing water and may migrate between larger rivers and smaller tributaries.

Adfluvial: Adults spawn and juveniles rear in freshwater streams but migrate to lakes or reservoirs for feeding as sub-adults or adults, then migrate back to flowing water for spawning.

Native: A native fish species is indigenous to the Willamette River Basin. It has had historical presence and was not introduced into the Basin. Native species can be a resident or an anadromous species.

Reservoirs created by the uppermost dam in each tributary represent the upstream extent that dam operations may directly affect fish habitat (i.e., Green Peter, Detroit, Blue River, Cougar, Hills Creek, Fall Creek, Fern Ridge, Dorena, and Cottage Grove Reservoirs). Fish release sites in upper tributary habitats represent the upstream extent where maintenance operations may directly affect fish habitats.

3.8.2.2 Fish Species

The Willamette River Basin supports diverse populations of fish species. There are 29 native and 30 non-native species that occur in the analysis area, and several have Federal and/or state protected status (Table 3.8-1). Life history descriptions, status, and a general description of species interaction with Willamette River Basin dams are presented for salmon, trout, lamprey, and resident fish. A discussion of gamefish is provided after these descriptions. ESA-listed and state-listed sensitive species are highlighted in the life history descriptions.

Table 3.8-1. Fish Species that Occur in the Willamette River Basin.

Common Name	Scientific Name	Federal Status	State Status	Native or Non-native	Anadromous or Resident
Chinook salmon, spring-run	*Oncorhynchus tshawytscha*	Upper Willamette River ESU Threatened 1999; Critical habitat designated 2005	Sensitive-Critical	Native	Anadromous
Chinook salmon, fall-run		N/A	N/A	Non-native	
Steelhead, winter-run	*Oncorhynchus mykiss*	Upper Willamette River DPS Threatened 1999; Critical habitat designated 2005	Sensitive-Critical	Native	Anadromous
Steelhead, summer-run		N/A	N/A	Non-native	
Coho Salmon	*Oncorhynchus kisutch*	N/A	N/A	Non-native	Anadromous
Kokanee salmon	*Oncorhynchus nerka*	N/A	N/A	Non-native	Resident
Bull trout	*Salvelinus confluentus*	Threatened 1999; Critical habitat designated 2010	Sensitive	Native	Resident
Rainbow trout	*Oncorhynchus mykiss*	N/A	N/A	Native	Resident
Pacific lamprey	*Entosphenus tridentatus*	Species of Concern	Sensitive	Native	Anadromous
Western river lamprey	*Lampetra ayresii*	Species of Concern	Sensitive	Native	Resident
Western brook lamprey	*Lampetra richardsoni*	N/A	Sensitive	Native	Resident
Oregon chub	*Oregonichthys crameri*	Delisted	Sensitive	Native	Resident
Coastal cutthroat trout	*Oncorhynchus clarkia*	Species of Concern	Sensitive	Native	Both
Chiselmouth	*Acrocheilus alutaceus*	N/A	N/A	Native	Resident
Largescale sucker	*Catostomus macrocheilus*	N/A	N/A	Native	Resident
Mountain sucker	*Catostomus platyrhynchus*	N/A	N/A	Native	Resident
Prickly sculpin	*Cottus asper*	N/A	N/A	Native	Resident
Mottled sculpin	*Cottus bairdii*	N/A	N/A	Native	Resident
Paiute sculpin	*Cottus beldingii*	N/A	N/A	Native	Resident
Shorthead sculpin	*Cottus confuses*	N/A	N/A	Native	Resident
Riffle sculpin	*Cottus gulosus*	N/A	N/A	Native	Resident
Reticulate sculpin	*Cottus perplexus*	N/A	N/A	Native	Resident

Common Name	Scientific Name	Federal Status	State Status	Native or Non-native	Anadromous or Resident
Torrent sculpin	*Cottus rhotheus*	N/A	N/A	Native	Resident
Threespine stickleback	*Gasterosteus aculeatus*	N/A	N/A	Native	Resident
Peamouth	*Mylocheilus caurinus*	N/A	N/A	Native	Resident
Sand roller	*Percopsis transmontane*	N/A	N/A	Native	Resident
Mountain whitefish	*Prosopium williamsoni*	N/A	N/A	Native	Resident
Northern pikeminnow	*Ptychocheilus oregonensis*	N/A	N/A	Native	Resident
Longnose dace	*Rhinichthys cataractae*	N/A	N/A	Native	Resident
Leopard dace	*Rhinichthys falcatus*	N/A	N/A	Native	Resident
Speckled dace	*Rhinichthys osculus*	N/A	N/A	Native	Resident
Redside shiner	*Richardsonius balteatus*	N/A	N/A	Native	Resident
Amur goby	*Rhinogobius brunneus*	N/A	N/A	Non-native	Resident
Banded killifish	*Fundulus diaphanous*	N/A	N/A	Non-native	Resident
Pond loach	*Misgurnus anguillicaudatus*	N/A	N/A	Non-native	Resident
Western mosquitofish	*Gambusia affinis*	N/A	N/A	Non-native	Resident
Brook trout	*Salvelinus fontinalis*	N/A	N/A	Non-native	Resident
Brown trout	*Salmo trutta*	N/A	N/A	Non-native	Resident
Smallmouth bass	*Micropterus dolomieu*	N/A	N/A	Non-native	Resident
Largemouth bass	*Micropterus salmoides*	N/A	N/A	Non-native	Resident
Spotted bass	*Micropterus punctulatus*	N/A	N/A	Non-native	Resident
Redear sunfish	*Lepomis microlophus*	N/A	N/A	Non-native	Resident
Green sunfish	*Lepomis cyanellus*	N/A	N/A	Non-native	Resident
Yellow perch	*Perca flavescens*	N/A	N/A	Non-native	Resident
Pumpkinseed	*Lepomis gibbosus*	N/A	N/A	Non-native	Resident
Warmouth	*Lepomis gulosus*	N/A	N/A	Non-native	Resident
Bluegill	*Lepomis macrochirus*	N/A	N/A	Non-native	Resident
White crappie	*Pomoxis annularis*	N/A	N/A	Non-native	Resident

Common Name	Scientific Name	Federal Status	State Status	Native or Non-native	Anadromous or Resident
Black crappie	*Pomoxis nigromaculatus*	N/A	N/A	Non-native	Resident
American shad	*Alosa sapidissima*	N/A	N/A	Non-native	Resident
Black bullhead	*Ameiurus melas*	N/A	N/A	Non-native	Resident
Brown bullhead	*Ameiurus nebulosus*	N/A	N/A	Non-native	Resident
Yellow bullhead	*Ameiurus natalis*	N/A	N/A	Non-native	Resident
White catfish	*Ameiurus catus*	N/A	N/A	Non-native	Resident
Channel catfish	*Ictalurus punctatus*	N/A	N/A	Non-native	Resident
Common carp	*Cyprinus carpio*	N/A	N/A	Non-native	Resident
Grass carp	*Ctenopharyngodon idella*	N/A	N/A	Non-native	Resident
Golden shiner	*Notemigonus crysoleucas*	N/A	N/A	Non-native	Resident
Goldfish	*Carassius auratus*	N/A	N/A	Non-native	Resident
Walleye	*Sander vitreus*	N/A	N/A	Non-native	Resident

Sources: Williams et al. 2022

ESU = evolutionarily significant unit; DPS = distinct population segment; N/A = Not Applicable.

Federally threatened species include the Upper Willamette River (UWR) Chinook salmon (*Oncorhynchus tshawytscha*), UWR steelhead (*O. mykiss*), and bull trout (*Salvelinus confluentus*) distinct population segments (DPSs). State sensitive species include Pacific lamprey (*Enstophenus tridentatus*), western river lamprey (*Lampetra ayresii*), and western brook lamprey (*Lampetra richardsoni*).

Anadromous Fish

Anadromous fishes are those that spawn in fresh water, migrate to the ocean to forage and mature, and return to fresh water to spawn and begin the cycle again. Several anadromous species are present in various locations within the Willamette River Basin analysis area.

Anadromous species, particularly salmonids, are important vectors of energy and nutrients between marine and freshwater ecosystems. For example, anadromous fish carry marine-derived nutrients that fertilize freshwater watersheds when their carcasses decay; these nutrients influence the food web structure in aquatic as well as adjacent terrestrial ecosystems (Gende et al. 2002). Spawning salmon contribute an estimated 5 to 95 percent of the nitrogen and phosphorus in salmon-bearing streams (Gresh et al. 2000). Anadromous fish deliver resources that affect food web productivity and influence a diverse array of plants, fish, and wildlife across vast landscapes (Naiman et al. 2002).

What are Evolutionarily Significant Units and Distinct Population Segments?

ESA-listed fish species may be identified as an evolutionarily significant unit (ESU) or a distinct population segment (DPS). Scientists developed the concepts of ESU and DPS to define a listable population unit according to ESA policy for Pacific salmon (56 FR 58612).

An ESU or DPS is a vertebrate population or group of populations that meet certain criteria of being discrete or isolated from other populations of the species and significant to preservation of the genetic diversity of the species (61 FR 4722). These designations can apply to populations within the species if these conditions occur: (1) they are substantially isolated from other populations of the same species due to physical, physiological, ecological, or behavioral separation; and (2) the population or group represents an important component required to maintain conservation of genetic diversity of the biological species per the ESA regulations (61 FR 4722). Typically, DPS is used for steelhead and inland species and ESU applies to salmon.

Chinook Salmon (Oncorhynchus tshawytscha)

There are two runs[1] of Chinook salmon in the Willamette River Basin named after their peak adult upstream migration timing: fall-run Chinook salmon and spring-run Chinook salmon. Fall-run Chinook salmon are an anadromous gamefish that were introduced into the basin after upstream passage was improved with the construction of fish ladders at the Willamette Falls. Spring-run Chinook salmon are a native species that has been identified by the National Marine Fisheries Service (NMFS) as an evolutionarily significant unit (ESU) in the Willamette River Basin.

Evolutionarily Significant Unit and Critical Habitat

NMFS listed the UWR Chinook salmon ESU as a threatened species under the ESA in 1999 and critical habitat was designated in 2005 (70 FR 37159). This ESU includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River and its tributaries upstream of the Willamette Falls near Oregon City, Oregon. It also includes spring-run Chinook salmon from the following artificial hatchery propagation programs, which are further described in Section 3.8.2.3, Mitigation Hatchery Mitigation Program:

- McKenzie River
- Willamette River
- Clackamas River
- North Santiam River
- South Santiam River
- Molalla River Spring-run Chinook Salmon

Seven independent populations[2] are recognized within this ESU, including North Santiam River, South Santiam River, McKenzie River, Middle Fork Willamette River, Clackamas River, Molalla River, and Calapooia River populations (ODFW and NMFS 2011). The Clackamas River, North Santiam River, McKenzie River, and Middle Fork Willamette River populations are identified as “core populations” and the McKenzie River is considered a “genetic legacy population” (McElhany et al. 2003).

The Coast Fork Willamette River and Long Tom River Subbasins do not have independent populations but do support non-natal[3] UWR Chinook salmon juvenile rearing in lower reaches.

[1] Different runs of salmon refer to distinct populations of the same salmon species that migrate to spawn in fresh water at different times of the year.

[2] McElhany et al. (2000) defines an independent population as “a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and, which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season.”

[3] Non-natal fish rear in streams where they were not born.

What is Critical Habitat for Fish?

Critical habitat is defined by NOAA (2024) as:

- Specific areas within the geographical areas occupied by the species at the time of listing that contain physical or biological features essential to conservation of the species and that may require special management consideration or protections, and
- Specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation.

Critical habitat for this species includes the Columbia River below the Willamette River confluence, the Mainstem Willamette River, and within the Clackamas River, Molalla River, Pudding River, Santiam River, McKenzie River Subbasin, and Middle Fork Willamette River Subbasin (Figure 3.8-1). Reaches upstream of Green Peter and Blue River Dams are not included as critical habitat. The Clackamas River, Molalla River, and Pudding River are not included in the analysis area.

Spawning and Rearing

Spring-run Chinook salmon adult upstream migration may occur from January through October with peak migration occurring from April through August (Table 3.8-2), coinciding with river flows and water temperatures that cue migration. Due to their upstream migration timing, these are referred to as spring-run Chinook salmon.

Spawning occurs from August through November, peaking in September and October (Table 3.8-2) coinciding with optimal water temperatures for this life stage. Incubation of eggs and early fry[4] rearing within the gravel (intragravel development) occurs from August through June of the following year (Table 3.8-2).

[4] Fry are juveniles less than about 60 mm in length.

Figure 3.8-1. Critical Habitat Designated for the Upper Willamette River Chinook Salmon Evolutionarily Significant Unit.

Map Source: http://map.streamnet.org/website/CriticalHabitat/viewer.htm.

Note: Darker lines outlining the stream reaches indicate designated critical habitat.

Table 3.8-2. Life History Timing for Upper Willamette River Chinook Salmon.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Upstream Migration												
Spawning in Tributaries												
Intragravel Development												
Juvenile Rearing												
Juvenile Out-migration												

Source: Adapted from Table 3-4 *in* NMFS 2008

Notes: Columns indicate the month of the calendar year, and the rows indicate the life history stage. Darker shades indicate peak activity for the life stage, lighter shades indicate less pronounced life history stage activity. White cells indicate little or no life stage activity within the Willamette River system.

Rearing of juvenile fry and parr[5] salmon occurs year-round, and downstream migration to the ocean generally occurs from October through May with two peaks, October through December and March through April (Table 3.8-2). According to Whitman et al. 2017:

> Two different phenotypes of Chinook salmon have been identified in Willamette populations based on early migratory behavior; fry that migrate from spawning areas soon after emergence to rear in downstream areas (movers) and fry that rear in spawning areas for 8–16 months after emergence before migrating downstream (stayers) (Schroeder et al. 2016). The primary smolt life histories are those that migrate past Willamette Falls as subyearlings and those that migrate as yearlings (Schroeder et al. 2016). Fry that migrate soon after emergence rely on rearing habitat in the lower tributaries and mainstem Willamette River for much of their growth in freshwater during spring and early summer and migrate as subyearling smolts (Schroeder et al. 2016).
>
> Yearling smolts generally rear in the upper reaches of the spawning tributaries during their first summer, with some migrating downstream in fall and winter to rear and others remaining in spawning reaches until their second spring. Yearling smolts typically migrate in fall and early winter or in early spring (Schroeder et al. 2016). The mainstem Willamette River has been shown to be important rearing habitat for juvenile Chinook salmon at various life stages (Friesen et al. 2007; Teel et al. 2009; Schroeder et al. 2016). The highest densities of juvenile Chinook salmon in habitat along the mainstem Willamette River and lower reaches of the major spawning tributaries were consistently observed in May.

[5] Parr are juveniles larger than about 60 mm that have developed vertical stripes and spots.

Spring-run Chinook salmon emerge from gravel "redds" (i.e., nests), rear in fresh water, then migrate to the ocean a few months to about 1.5 years after emergence. For this reason, medium-size cobble are preferred spawning characteristics because it allows for adequate flow and aeration during incubation.

Most adult spring-run Chinook salmon spend 1 year to 5 years at sea before returning to fresh water to spawn. Spring-run Chinook salmon die after spawning.

Populations

UWR Chinook salmon are one of the most genetically distinct groups of Chinook salmon (Figure 3.8-2) in the Columbia River Basin. Historically, before the placement of a fish ladder at Willamette Falls, passage by returning adult salmonids over Willamette Falls was possible only during the winter and spring high-flow periods (Myers et al. 2003). The early run timing of UWR Chinook salmon relative to other lower Columbia River spring-run Chinook salmon populations is viewed as an adaptation to flow conditions at Willamette Falls. Because the Willamette Valley was not glaciated during the last epoch, the reproductive isolation provided by Willamette Falls was probably uninterrupted for a considerable time and provided the potential for substantial local adaptation relative to other Columbia River populations.

Figure 3.8-2. Adult Chinook Salmon (*Oncorhynchus tshawytscha*).
Source: USFWS 2022

The largest spring-run UWR Chinook salmon populations affected by the WVS were found historically in the North Santiam River and Middle Fork Willamette River Subbasins. Independent populations affected by the WVS also occurred in the South Santiam River and McKenzie River Subbasins. Historically, very few, if any, spring-run Chinook salmon were produced in the Coast Fork Willamette River Subbasin or in the Blue River watershed (located in the McKenzie River Subbasin) where other WVS dams are located.

The count of natural-origin spring-run Chinook salmon returning to the Willamette River Basin at Willamette Falls was about 53,000 in 1946 and 47,000 in 1947 (Mattson 1963). Although annual returns were already in decline due to fishing and land use practices, annual returns continued to diminish as WVS dams were constructed, blocking upstream access to critical spawning and rearing habitat and substantially reducing downstream passage survival for spring-run Chinook salmon and other ESA-listed species in the North and South Santiam River

Subbasins, McKenzie River, and Middle Fork Willamette River Subbasins (Myers et al. 2003; Parkhurst et al. 1950) (Chapter 1, Introduction, Section 1.1, Background).

After 1960, less than 20,000 natural-origin spring-run Chinook salmon adults migrating upstream were counted at Willamette Falls each year (Keefer and Caudill 2010). Natural-origin (unmarked) returns have been lower than 10,000 in more recent years (e.g., NWFSC 2022).

Spawning Habitat

Spawning habitat for UWR Chinook salmon occurs in eastside tributaries to the Mainstem Willamette River. In those tributaries affected by WVS dams, the majority of spawning habitat for UWR Chinook salmon in the North Santiam River, South Santiam River, and McKenzie River Subbasins is present downstream of the WVS dams (Table 3.8-3) whereas in the Middle Fork Willamette River Subbasin a large portion of spawning habitat is present upstream of the WVS dams. This is consistent with estimates of historically available habitat (ODFW and NMFS 2011).

Suitable spawning habitat for UWR Chinook salmon is anticipated to decrease in the future, mostly due to climate change. Under 2080 projected water temperatures, total available spawning habitat is estimated to decrease from the historical average (1993 to 2011) by 26 percent in the North Santiam River, by 80 percent in the South Santiam River, by 24 percent in the McKenzie River, and by 13 percent in the Middle Fork Willamette River (Bond et al. 2017).

Table 3.8-3. Spring-run Chinook Salmon Spawning Habitat (Redd Capacity) Estimates under Historical Average (1993–2011) and Future Projected (2040 and 2080) Water Temperatures.

Basin/Subbasin and Range	Redd Capacity Estimates 1993–2011 avg temp	Redd Capacity Estimates 2040 projected temp	Redd Capacity Estimates 2080 projected temp	Percent of total habitat 1993–2011 avg temp (%)	Percent of total habitat 2040 projected temp (%)	Percent of total habitat 2080 projected temp (%)
North Santiam below Detroit Dam	22,693	19,388	12,712	59	55	45
North Santiam above Detroit Dam	15,602	15,602	15,602	41	45	55
North Santiam River Subbasin Total	38,295	34,990	28,314	100	100	100
South Santiam below Foster Dam	8,787	4,213	2,060	59	69	69
South Santiam above Foster Dam	4,504	1,640	923	30	27	31
South Santiam above Green Peter Dam	1,508	257	0	10	4	0
South Santiam River Subbasin Total	14,799	6,110	2,983	100	100	100
McKenzie below Cougar and Trail Bridge Dams	44,480	39,439	32,698	89	88	86
McKenzie above Cougar Dam	5,423	5,423	5,416	11	12	14
McKenzie River Subbasin Total	49,903	44,862	38,114	100	100	100
Middle Fork Willamette below Fall Creek/Dexter/Lookout Point Dams	8,813	3,801	1,418	8	4	1
Middle Fork Willamette above Fall Creek Dam	3,419	1,220	579	3	1	1
Middle Fork Willamette above Dexter/Lookout Point Dams	72,937	70,649	68,691	65	68	70
Middle Fork Willamette above Hills Creek Dam	27,532	27,525	26,803	24	27	27
Middle Fork Willamette River Subbasin Total	112,701	103,195	97,491	100	100	100

Note: Redd capacity estimates reproduced from Bond et al. 2017.

Population Viability

A recent status review by NMFS (NMFS 2024a) indicates the status of this ESU remains as threatened. The Northwest Fisheries Science Center review of updated information (NWFSC 2022) does not indicate a change in the biological risk category for the UWR Chinook salmon ESU since the time of the last viability assessment (NWFSC 2015). UWR Chinook salmon adult return trends at Willamette Falls and population spawning abundance in key Willamette River subbasins indicate the long-term trend for natural-origin returns was -4 percent over the last 15 years (2004–2019) (Figure 3.8-3).

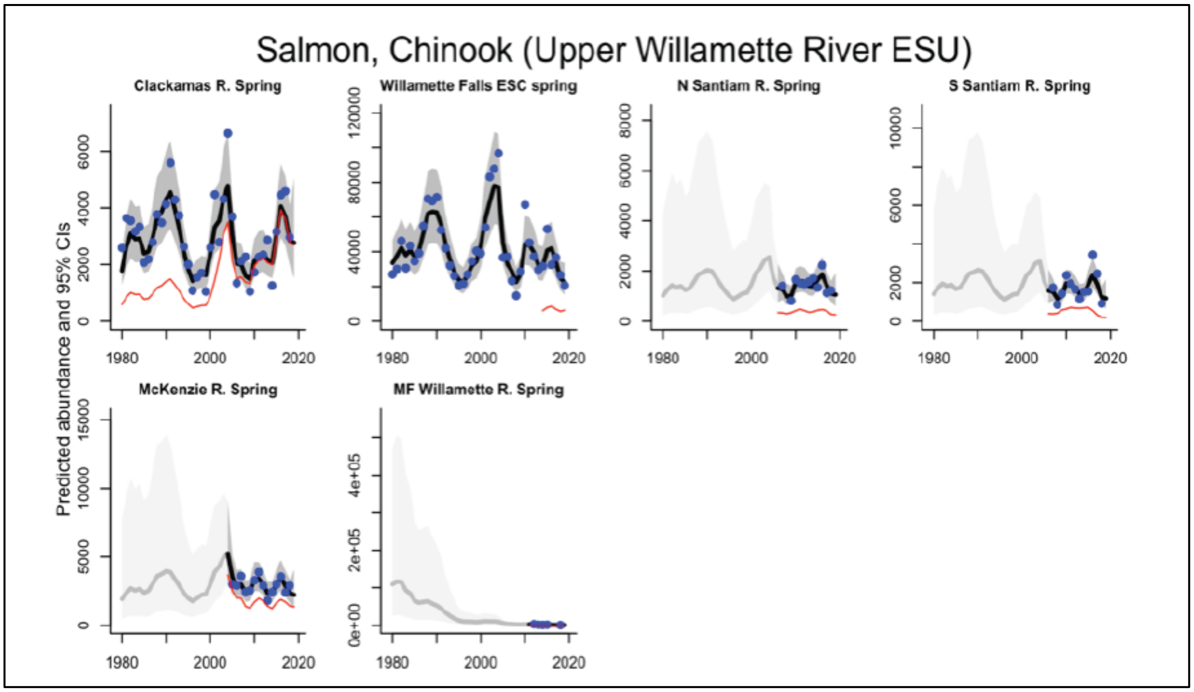

Figure 3.8-3. Upper Willamette River Chinook Salmon Smoothed Trend in Estimated Total and Natural Population Spawning Abundance.

Source: Figure 79 *in* NWFSC 2022

Note: Blue dots show the annual raw spawning abundance estimates. Smoothed trend in estimated totals are depicted by a thick black line, and the natural population spawning abundance is depicted by a thin red line.

The 5-year average abundance geomean for 2015 to 2019 was 6,916 natural-origin adults, a 31 percent decrease from the previous period, and reflects strong influence from warmer-than-normal and less-productive ocean conditions, and warmer- and drier-than-normal freshwater conditions (NWFSC 2022). Returns in more recent years indicate improving abundance (ODFW 2024).

Risk of extinction of UWR Chinook salmon populations is estimated to be very high for most subbasins with the exception of moderate risk in the McKenzie River Subbasin and low risk in the Clackamas River Subbasin (Table 3.8.4).

Table 3.8-4. Risk of Extinction for Upper Willamette River Chinook Salmon by Population.

Population	Extinction Risk Category
Clackamas River	Low
Molalla River	Very High
North Santiam River	Very High
South Santiam River	Very High
Calapooia River	Very High
McKenzie River	Moderate
Middle Fork Willamette River	Very High

Source: Adapted from Table 3-3 *in* ODFW and NMFS 2011

Habitat Limiting Factors

Limiting factors are conditions that adversely affect habitat, thereby limiting the sustainability of salmon populations. Limiting factors vary depending on global location. Limiting factors identified in the UWR Conservation and Recovery Plan for UWR Chinook salmon and UWR steelhead are listed below (ODFW and NMFS 2011). All factors, except for those regarding land use practices and fisheries bycatch, in part or in whole, can be related to effects of WVS operation and maintenance.

- Habitat access from dams; impaired downstream passage of juveniles and steelhead kelts[6] at water control facilities, leading to direct and delayed mortality.
- Habitat access from dams; impaired adult access to holding and spawning habitat due to migration barriers.
- Habitat access; lack of spawning opportunity due to pre-spawning mortality impacts associated with handling stresses at hatchery facilities and altered hydrology/water quality downstream of dams.
- Population traits due to hatchery fish interbreeding with natural-origin fish on the spawning grounds; impaired productivity and diversity.
- Competition due to hatchery programs.
- Food web alterations; impaired growth and survival from changes to estuarine food web.
- Predation by native and non-native species, hatchery summer steelhead, hatchery rainbow trout, birds in the estuary.
- Physical habitat quality degradation due to excessive fine sediments from land use practices.

[6] Kelts are post-spawn steelhead adults that migrate to the ocean.

- Physical habitat quality degradation from flood control/hydropower sources.
- Impaired habitat complexity and diversity.
- Impaired water temperature.
- Impaired water quality downstream of dams from input of toxins.
- Altered hydrology downstream of dams.
- Insufficient stream flows and floodplain storage from land use practices.
- Mortality from targeted fisheries and from bycatch.

Steelhead (Oncorhynchus mykiss)

There are two races of steelhead in the Willamette River Basin: winter-run steelhead and summer-run steelhead. The winter-run steelhead is considered a DPS.

Distinct Population Segment and Critical Habitat

The UWR steelhead DPS was listed as a threatened species under the ESA in 1999 and critical habitat designated in 2005 (70 FR 37159) (Figure 3.8-4). The UWR steelhead DPS includes all naturally spawned populations of winter-run steelhead in the Willamette River and its tributaries upstream of Willamette Falls to the Calapooia River.

This DPS does not include any artificially propagated steelhead stocks that reside within the historical geographic range of the DPS. Hatchery summer-run steelhead occur in the Willamette River Basin but are an out-of-basin stock that are not included as part of the UWR steelhead DPS (71 FR 834). The Summer-run Hatchery Programs are further described under Section 3.8.2.3, Mitigation Hatchery Program.

Designated critical habitat in the analysis area includes the Columbia River below the Willamette River confluence, the Mainstem Willamette River confluence with the Calapooia River, and reaches within the Clackamas River, Tualatin River, Yamhill River, Molalla River, Pudding River, Santiam River, Luckiamute River, and Calapooia River Subbasins. River reaches upstream of Big Cliff Dam, Detroit Dam, and Green Peter Dam are not included as critical habitat.

Figure 3.8-4. Critical Habitat for the Upper Willamette River Steelhead Distinct Population Segment.

Source: NOAA 2022c

Spawning and Rearing

Steelhead life history is different than Chinook salmon life history because juvenile steelhead typically rear in fresh water longer (i.e., 1 to 3 years), and can remain in the ocean up to 6 years compared to Chinook salmon. Furthermore, steelhead may return to the ocean after spawning and then return to fresh water to spawn more than once (although the frequency of repeat spawning is relatively low) (Figure 3.8-5).

Figure 3.8-5. Spawning Steelhead (*Oncorhynchus mykiss*).

Juvenile offspring can mature in fresh water as a resident rainbow trout (resident life history form) or migrate to the ocean to mature as a steelhead and then return to spawn in fresh water (anadromous life history form).

Prior to smolting, juvenile steelhead are indistinguishable from resident rainbow trout. This flexibility for changing between the life history forms of anadromous steelhead and resident rainbow trout allows the species to optimize resources in both freshwater and ocean environments and guard against large-scale environmental impacts (e.g., drought).

Winter-run steelhead adult upstream migration may occur from January through July, with peak upstream migration occurring from March through April coinciding with periods of higher river flows that support migration (Table 3.8-5). Spawning and intragravel development in tributaries occurs from March through August, with peak spawning in April and May coinciding with optimal water temperatures for these life stages (Table 3.8-5).

Table 3.8-5. Life History Timing of Upper Willamette River Steelhead.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upstream Migration												
Spawning in Tributaries												
Intragravel Development												
Juvenile Rearing												
Juvenile Outmigration												

Source: adapted from Table 3-8 *in* NMFS 2008

Notes: Darker shades indicate peak activity for the life stage, lighter shades indicate less pronounced life history stage activity. White cells indicate little or no life stage activity within the Willamette River Basin system.

Juvenile rearing occurs year-round, and outmigration occurs from March through July, with peak downstream migration from March through May coinciding with periods of higher river flows that support migration (Table 3.8-5). Scale analyses indicate they migrate primarily as age-2 smolts (Clemens 2015), and both their freshwater and saltwater residences can be 1 to 4 years (Withler 1966).

In the analysis area, most steelhead adults—about 70 percent— migrate into the Santiam River Subbasin (ODFW and NMFS 2011; Mapes et al. 2017; Jepson et al. 2015). There is a higher proportion of adult migration into the North Santiam River Subbasin compared to the South Santiam River Subbasin, but the migration proportion is about equal in some years (Mapes et al. 2017; Jepson et al. 2015).

The next highest amounts of migrating adult winter-run steelhead were documented in the Middle Fork Willamette River and Molalla River Subbasins (about 9 to 15 percent, respectively), with some of the lowest amounts numbers of migrating adults in the Coast Fork Willamette River and Fall Creek (1 percent) and McKenzie River (1.5 percent) (Jepson et al. 2015). Winter-run steelhead within the McKenzie River and Middle Fork Willamette River Subbasins are not considered part of the DPS.

Spawning Habitat

ODFW and NMFS (2011) estimated a large portion of historical winter-run steelhead habitat occurred in areas downstream of WVS dams in the North Santiam River (56 percent downstream of dams when accounting for habitat lost due to reservoirs) and South Santiam River (85 percent downstream of dams when accounting for habitat lost due to reservoirs) (Table 3.8-6). Several tertiary tributaries in the Santiam River Subbasin—where habitat access, hydrology, and water quality are not affected by WVS dams—are known to be used by winter-run steelhead for spawning and rearing (Mapes et al. 2017).

Table 3.8-6. Upper Willamette River Steelhead Historical Habitat Availability by Subbasin.

Population	Percent of Total IP[1] above WVS Dams (%)	Percent of Total IP Available above WVS Dams with Reservoir Correction[3]
North Santiam River above Big Cliff Dam	48	44
South Santiam River above Foster Dam	18[2]	15

Source: Table 6-6 *in* ODFW and NMFS 2011

Notes: Estimates of percent historically available habitat (intrinsic potential, IP) for Upper Willamette River steelhead above WVS dams by subbasin.

[1] IP (Intrinsic Potential) is defined in ODFW and NMFS 2011 as "the estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, and valley width."

[2] Assumes Foster Dam is not an IP barrier.

[3] Reservoir correction is the amount of habitat upstream of WVS reservoirs (i.e., subtracts the habitat lost due to reservoirs from the Percent of Total IP above WVS Dams reported in table column 2).

Populations

There are four independent UWR steelhead populations, including Molalla River, North Santiam River, South Santiam River, and Calapooia River, defined based on geography, migration rates, genetic attributes, life history patterns, phenotypic characteristics, population dynamics, and environmental and habitat characteristics (McElhany et al. 2000). The North Santiam River and South Santiam River populations were designated as "core" and "genetic legacy" (McElhany et al. 2003) because they are assumed to have been major production areas (USFWS 1948).

There are no hatchery programs supporting this DPS (NMFS 2020). The hatchery summer-run steelhead that are produced and released in the subbasins are from an out-of-basin stock and not considered part of the DPS. Winter-run steelhead in the McKenzie River and Middle Fork Willamette River Subbasins are also not considered part of the DPS.

Population Viability

A recent status review by NMFS (NMFS 2024b) indicates the status of the UWR steelhead DPS remains as threatened. The Northwest Fisheries Science Center's review of updated information (NWFSC 2022) does not indicate a change in the biological risk category for the DPS since the time of the last viability assessment (NWFSC 2015).

The status of all UWR steelhead populations likely remains at moderate to high risk of extinction NMFS (2024b) (NWFSC 2022). However, the UWR steelhead DPS experienced a declining natural population spawning abundance trend from 1980 to 2019 (Figure 3.8-6) (NWFSC 2022).

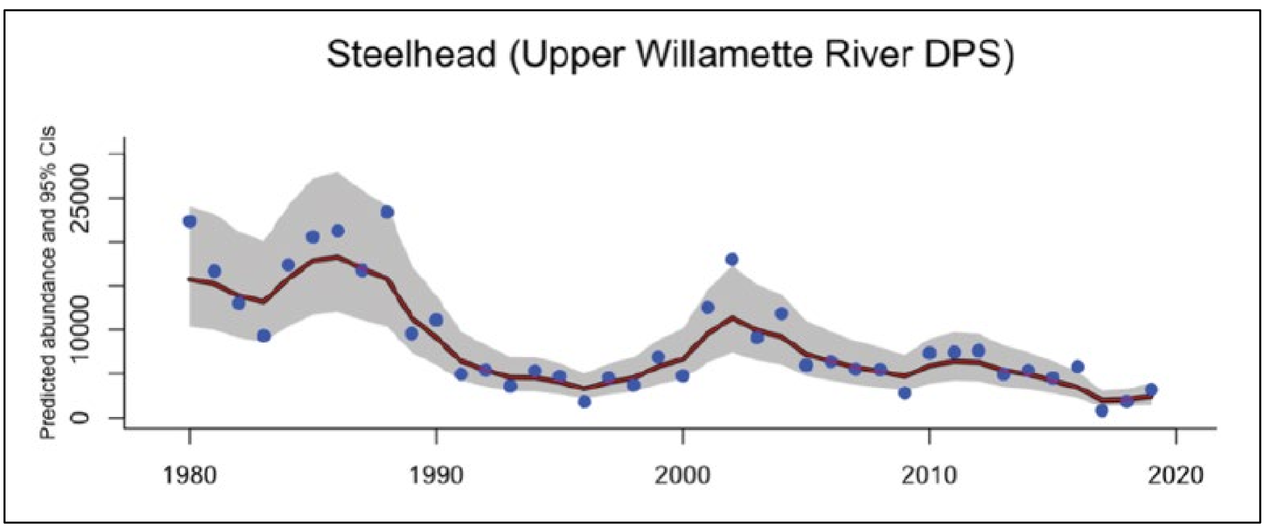

Figure 3.8-6. Upper Willamette River Steelhead Smoothed Trend in Estimated Natural Population Spawning Abundance.

Source: Figure 87 in NWFSC 2022

Note: Blue dots show the annual raw spawning abundance estimates. Abundance estimates include both early- (non-native) and late-winter (native) steelhead. Abundance estimates for Willamette Falls likely includes a much larger proportion of non-native fish than for the independent winter steelhead populations included in the DPS.

Habitat Limiting Factors

Limiting factors for UWR steelhead are the same as those described for Chinook salmon (ODFW and NMFS 2011).

Coho Salmon (Oncorhynchus kisutch)

Coho salmon are a non-native, anadromous gamefish stocked in the Willamette River Basin between 1958 and 1982. Coho in the upper Willamette River started naturally returning in substantial numbers in the early 2000s, years after stocking ended. A self-sustaining run utilizes the lower section of Stout Creek in the North Santiam River Subbasin. In 2023, coho were observed in the McKenzie River when a record-breaking 40,000 coho migrated upstream of Willamette Falls (Urness 2024).

Juvenile coho normally spend one summer and one winter in fresh water, although they may remain for 1 or 2 extra years in the coldest rivers in their range. They migrate to the ocean in the spring, generally 1 year after emergence, as silvery smolts about 4 to 5 inches long. Most adults mature at 3 years of age (ODFW 2024c; USFWS 2024a).

Coho prefer to spawn and rear in small streams. They are also quite flexible in their use of freshwater habitats and can take advantage of swift water tributaries associated with steelhead habitat as well as lower gradient slack waters.

Kokanee (Oncorhynchus nerka)

Kokanee are a non-anadromous, land-locked sockeye salmon. Kokanee are not native to the Willamette River Basin and were first stocked by the Oregon Fish Commission in 1959 (Wetherbee et al. 1965). They are found in Detroit, Big Cliff, Foster, and Green Peter Reservoirs. At the time the alternatives were analyzed, ODFW was stocking kokanee in Detroit Reservoir to support a popular sport fishery.

After being stocked into WVS reservoirs, kokanee have become self-sustaining in some reservoirs. Offspring spawned from kokanee parents may emigrate to the ocean and return as adult sockeye. ODFW avoids risks of disease transference by not transporting returning adult sockeye back upstream of WVS dams.

Kokanee are typically adfluvial, spawning in streams and rearing and foraging in lakes or reservoirs. However, they can also spawn along shorelines of lakes or reservoirs. Sexual maturity usually occurs at age 3. Kokanee in Detroit Reservoir naturally reproduce in the North Santiam River and tributaries, such as the Breitenbush, Tumble, French, and Blowout Creeks, in the fall (Wetherbee et al. 1965). Effects of non-native kokanee on native species have not been documented.

Kokanee compete for zooplankton with other species in Detroit Reservoir whether stocked or naturally spawned. Monthly zooplankton data collected by Kokanee Power of Oregon volunteers in recent years at Detroit Reservoir indicate there is sufficient zooplankton to support a healthy kokanee population. Low food supply reduces the kokanee growth rate. Large rainbow trout have been known to feed on kokanee.

Kokanee are most often found in deeper, colder water. In Detroit Reservoir, they have been found 80 to 100 feet below the surface during the summer months but change their depth depending on water temperature.

Bull Trout (Salvelinus confluentus)

Bull trout is in the family Salmonidae and native to northwestern North America, including in the Willamette River Basin (Figure 3.8-7). USFWS listed all populations of bull trout within the coterminous United States as a threatened species in 1999 (64 FR 58910).

Figure 3.8-7. Bull Trout (*Oncorhynchus kisutch*).

At the time the alternatives were analyzed, bull trout occurred in the Columbia River and Snake River Basins in Washington, Oregon, Montana, Idaho, and Nevada; Puget Sound and Olympic Peninsula watersheds in Washington; the Saint Mary River Basin in Montana; and the Klamath River Basin of south-central Oregon. At the time of their listing, bull trout—although still widely distributed—were estimated to have been extirpated from approximately 60 percent of their historical range (USFWS 2015a).

Distinct Population Segment and Critical Habitat

The USFWS listed all populations of bull trout, as part of a single DPS within the coterminous United States, as a threatened species in 1999 (64 FR 58910). There are six bull trout recovery units identified in the USFWS Recovery Plan for the Coterminous United States Population of Bull Trout (USFWS 2015a). The Coastal Recovery Unit includes the Willamette River Basin (USFWS 2015b). Local populations in the Willamette River Basin include those in the Clackamas, McKenzie, and Middle Fork Willamette River Subbasins (Figure 3.8-8).

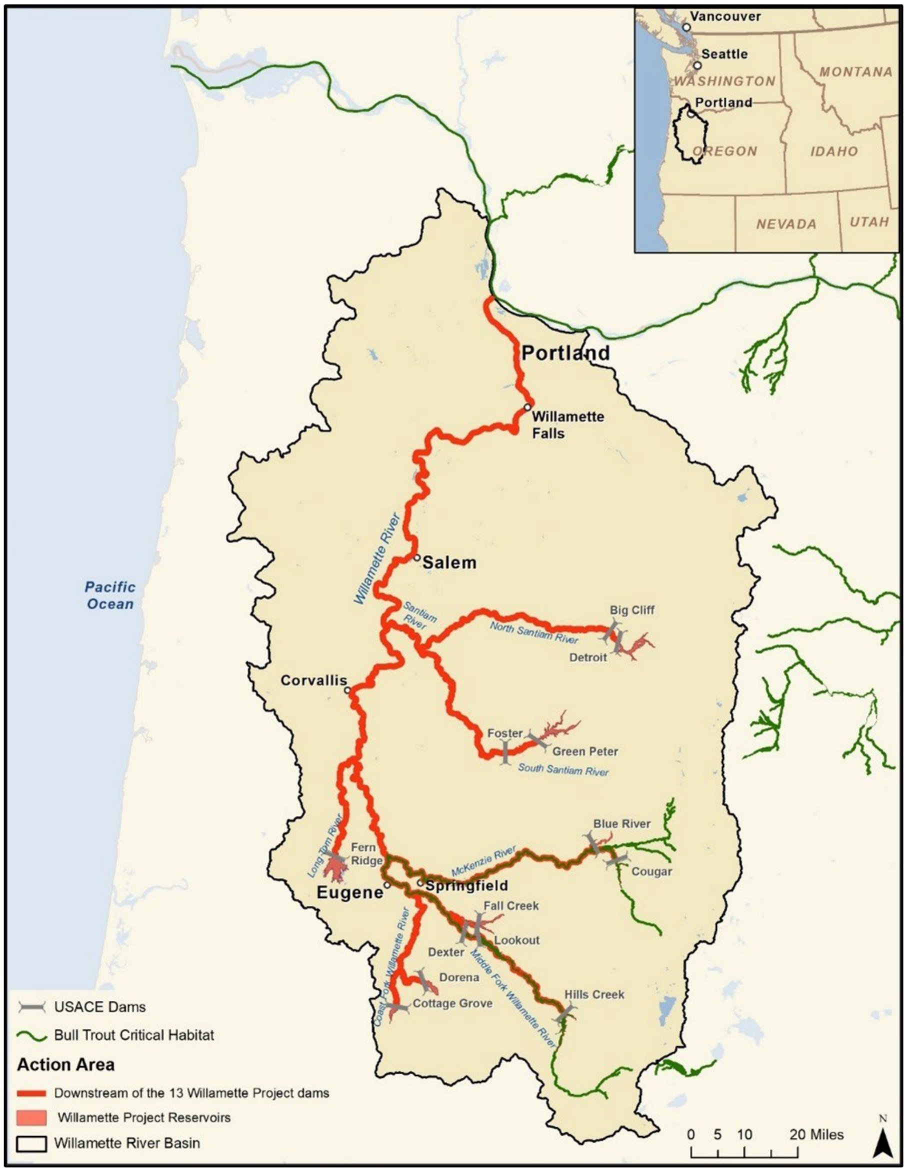

Figure 3.8-8. Willamette River Basin Bull Trout Critical Habitat.

Critical habitat for bull trout was designated by a USFWS final rule on October 26, 2008 (70 FR 56211) and further revised on November 17, 2010 (75 FR 63897). The critical habitat designation includes 32 critical habitat units in six recovery units located throughout the coterminous range of bull trout in Washington, Oregon, Idaho, Montana, and Nevada (Figure 3.8-9).

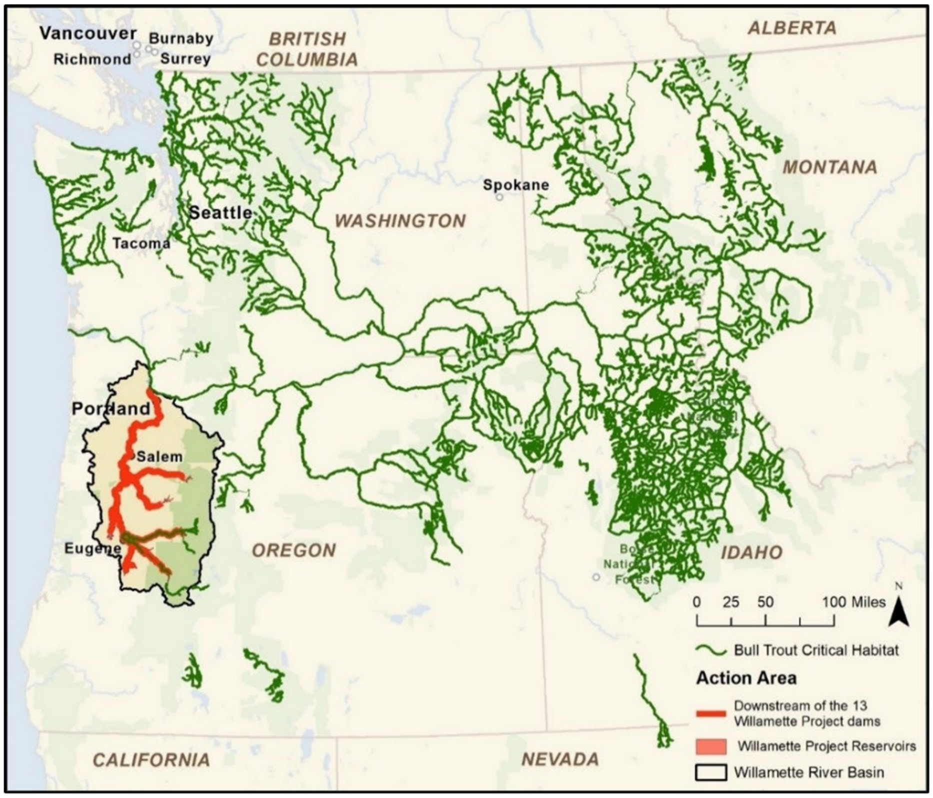

Figure 3.8-9. Bull Trout Critical Habitat Range-wide.

Designated bull trout critical habitat is of two primary use types: (1) spawning and rearing, and (2) foraging, migration, and overwintering habitat. The conservation role of bull trout critical habitat is to support viable core area populations (75 FR 63943). Critical habitat units generally encompass one or more core areas and may include foraging, migrating, and overwintering areas outside of core areas that are important to the survival and recovery of bull trout.

The final rule excludes some critical habitat segments. Critical habitat does not include:

1. Waters adjacent to non-Federal lands covered by legally operative incidental take permits for Habitat Conservation Plans issued under the act in which bull trout is a covered species on or before the publication of the final rule.
2. Waters within or adjacent to tribal lands subject to certain commitments to conserve bull trout or a conservation program that provides aquatic resource protection and restoration through collaborative efforts, and where the tribes indicated that inclusion would impair their relationship with the USFWS.
3. Waters where impacts to national security have been identified (75 FR 63898).

The Principal Biological Factors of bull trout critical habitat, as described by USFWS in the 2010 final revised critical habitat rule (75 FR 63897, 63931) include:

1. Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.
2. Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.
5. Water temperatures ranging from 2°C to 15°C (36°F to 59°F) with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
6. In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.
7. A natural hydrograph, including peak, high, low, and base flows within historical and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
8. Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
9. Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Population Status and Reintroduction

In the analysis area, local bull trout populations occur upstream of Cougar Dam in the McKenzie Subbasin and upstream of Hills Creek Dam in the Middle Fork Willamette Subbasin. There are two additional local populations in the McKenzie River Subbasin not directly affected by WVS dams: (1) Trail Bridge Reservoir local population in the upper McKenzie River above Eugene Water and Electric Board’s Trail Bridge Dam and (2) Fluvial Mainstem McKenzie River local population (USFWS 2008).

Bull trout were last observed in the North Santiam River in 1945 but are expected to be reintroduced above Detroit Dam during the 30-year implementation timeframe (USFWS 2023). Therefore, it was assumed a local bull trout population exists above Detroit Dam in the North Santiam River Subbasin at the time the alternatives were analyzed.

In the South Fork McKenzie River Subbasin above Cougar Dam, the overall trend in redd counts since the 1990s shows an increasing abundance trend, indicating positive population recruitment has been occurring in the analysis area under existing conditions (Figure 3.8-10). Above Hills Creek Dam in the Middle Fork Willamette River Subbasin, the number of redds laid annually has also been increasing since 2013 (Figure 3.8-11), also indicating a positive recruitment trend.

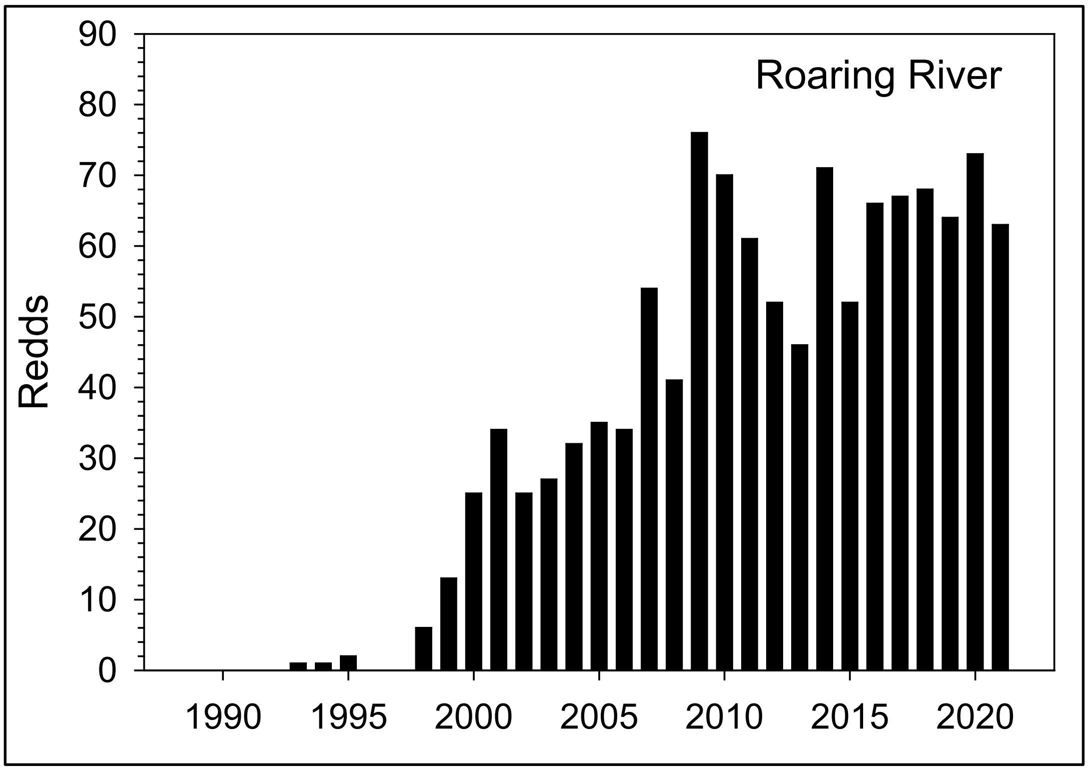

Figure 3.8-10. Annual Redd Counts for Bull Trout in the Roaring River, a Tributary of the South Fork McKenzie River, above Cougar Dam.

Source: Zymonas et al. 2022

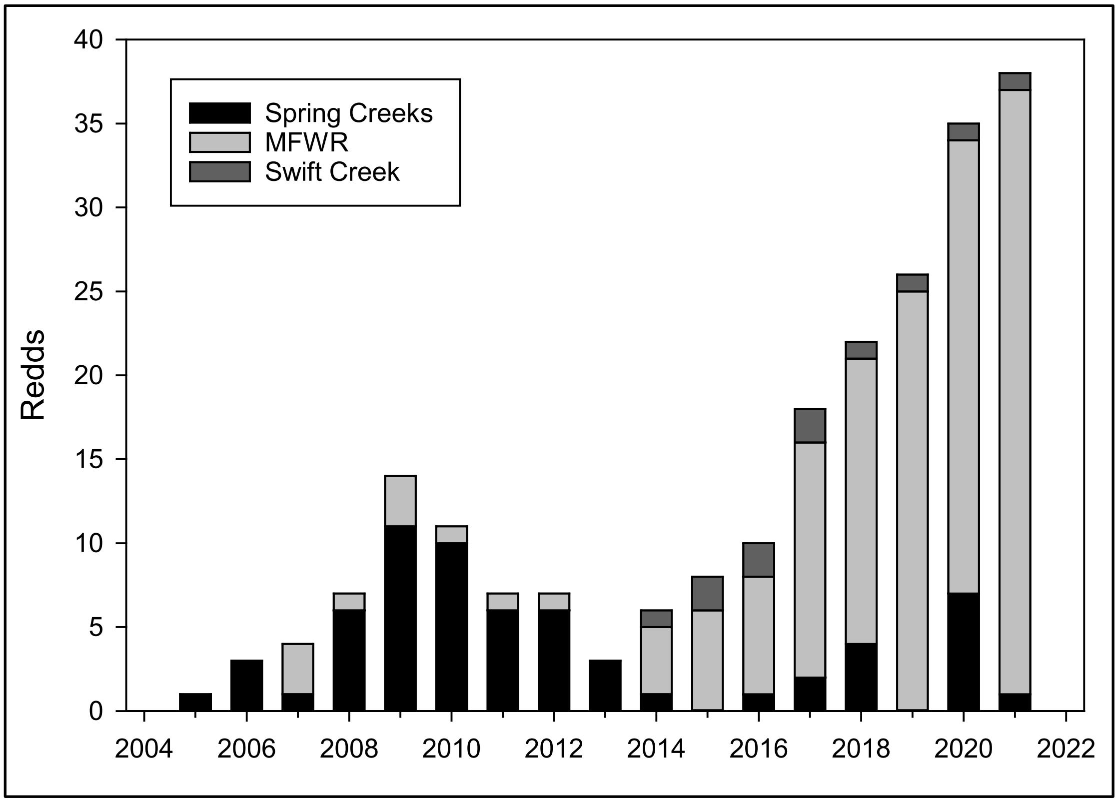

Figure 3.8-11. Annual Redd Counts for Bull Trout in the Middle Fork Willamette River Subbasin, above Hills Creek Dam.

Source: Zymonas et al. 2022

Spawner abundance is expected to maintain due to the habitat available, primarily located in public forest lands upstream of WVS operations. Trends in redd counts further suggest there may be additional habitat capacity available upstream of Cougar and Hills Creek Dams supporting further population growth opportunity.

Life History

Bull trout exhibit both resident and migratory life history strategies, but both forms may be found together and either form may produce offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993). Resident bull trout complete their entire life cycle in the tributary or (nearby) streams in which they spawn and rear. The resident form tends to be smaller than the migratory form at maturity and also produces fewer eggs (Fraley and Shepard 1989a; Goetz et al. 1989).

Migratory bull trout spawn in tributary streams where juvenile fish rear 1 to 4 years before migrating to either a lake (adfluvial form), river (fluvial form) (Fraley and Shepard 1989a; Goetz et al. 1989), or saltwater (anadromous form) to rear as subadults and to live as adults (Cavender 1978; McPhail and Baxter 1996; Bonar, Divens, and Bolding 1997). Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. They are iteroparous (they spawn more than once in a lifetime). Repeat- and alternate-year spawning has been reported, although repeat spawning frequency and post-spawning mortality are not well documented (Fraley and Shepard 1989b; Pratt 1992; Rieman and McIntyre 1996).

Growth rates vary depending upon life history strategy. Resident adults range from 6 to 12 inches total length, and migratory adults commonly reach 24 inches or more (Pratt 1985; Goetz et al. 1989). The largest verified bull trout was a 32-pound specimen caught in Lake Pend Oreille, Idaho in 1949 (Simpson and Wallace 1982).

In regulated streams, many bull trout populations forage in reservoirs and spawn in tributary streams upstream. Growth rates are often higher for fish utilizing reservoirs compared to those remaining in upstream reaches due to the abundance of prey fish. These life history and growth patterns are evident above WVS dams where bull trout occur. Few small-bodied adults occur within these populations (Zymonas et al. 2022), suggesting many access reservoirs to forage, and no entirely or substantially resident populations have been documented in the basin.

Bull trout incubation occurs from late winter to early spring at temperatures between 36°F to 43°F (2°C to 6°C). Fry emerge in the spring (USFWS 2008a) from high elevation, sufficiently cool streams (USFWS 2015a).

Egg-to-hatch success depends on intergravel flow rates and reduced fine sediment (Bowerman, Neilson, and Budy 2014). Alevins may remain in the gravel for a prolonged time (McPhail and Baxter 1996).

After emergence, both migratory and resident forms move downstream to rear in larger rivers or reservoirs. The fully anadromous life history form is less common (Stewart et al. 2007). Juvenile rearing begins in the spring at temperatures typically less than 50°F (10°C) (USFWS 2015a).

Although juveniles prefer cooler water temperatures, juvenile growth and survival is not substantially improved in higher elevation streams (McMahon et al. 2007). Juveniles prefer side channels and edge cover (USFWS 2008). Outmigration from natal reaches occurs over the summer depending on availability of downstream rearing habitat (Fraley and Shepard 1989a). Juvenile bull trout prefer low velocity flow and feed primarily on invertebrates. As juveniles grow larger, they increasingly feed on fish (Stewart et al. 2007).

The iteroparous reproductive strategy[7] of bull trout has important repercussions for management of this species. Bull trout require passage both upstream and downstream, not only for repeat spawning but also for foraging. Therefore, dams or other barriers with upstream fish passage facilities may be a factor in isolating bull trout populations if they do not provide a safe downstream passage route. Additionally, in some core areas, bull trout that migrate to marine waters must pass both upstream and downstream through areas with fisheries. This can increase the likelihood of mortality to bull trout during these spawning and foraging migrations;

[7] Iteroparity is a reproductive strategy where an organism has multiple reproductive cycles over its lifetime.

however, migrations to marine waters have not been reported in Willamette River Basin local bull trout populations.

Population Limiting Factors

Bull trout limiting factors in the Willamette River Basin include limited habitat availability and quality above, in, and downstream of reservoirs. Migration and spawning barriers from dams and altered hydrologic regimes from dam operations adversely affect local bull trout populations. Predation by non-native species in reservoirs, genetic exchange in the upper McKenzie River Subbasin, limited prey, and mortality from sport fishing are also limiting factors (USFWS 2015a; Zymonas et al. 2022).

However, there does not appear to be limiting factors that would reduce current recruitment rates or average spawner abundance from current levels for the local populations affected by WVS dams based on review of available information at the time the alternatives were analyzed. The stability and growth in the bull trout populations above Cougar and Hills Creek Dams are positive indications that mortality from dam passage or effects of reservoir operations are not limiting the ability of these populations to sustain themselves.

Downstream of Cougar, Hills Creek, and Detroit Dams there is limited to no suitable spawning habitat for bull trout (Zymonas et al. 2021). Human disturbances and water temperature increases have decreased habitat value and increased risks for bull trout survival downstream of these dams. Consequently, individuals moving downstream of WVS dams are collected and released above Cougar and Hills Creek Dams to return to their spawning population of origin. This management strategy would be expected to occur in the North Santiam River Subbasin at WVS dams after bull trout are reintroduced.

To help protect bull trout and other native trout and salmon species in the Hills Creek Reservoir and above on the Middle Fork Willamette River, ODFW does not allow the retention of non-adipose fin-clipped salmon or trout. To further reduce risks associated with angling-mortalities, the use of bait in the reaches above Hills Creek Reservoir is prohibited during trout season (Reis et al. 2013).

Improved connectivity to habitat downstream of Cougar, Hills Creek, and Detroit Dams (for the reintroduced local population) could benefit bull trout through:

1. population growth (especially for smaller populations)
2. life history diversity
3. exchange of genetic material
4. access to habitat
5. recolonization

Climate adaptation is another reason habitat connectivity can be important to bull trout survival. Major losses of suitable bull trout habitat throughout their range are predicted from climate change projections (e.g., Isaak et al. 2010; Wenger et al. 2013). Reductions in downstream population boundaries for bull trout driven by climate change has been observed (e.g., LeMoine et al. 2020).

Rainbow Trout (Oncorhynchus mykiss)

Native rainbow trout are river- and lake-dwelling in the Willamette River Basin. Their life history is similar to steelhead; however, they remain in fresh water their entire lives. No abundance estimates were identified for any resident populations at the time the alternatives were analyzed, but they are thought to be common and in moderate abundance.

Trout are the primary gamefish species in Oregon (ODFW 2024a). In addition to sport fishing for native rainbow trout, triploid (sterile) hatchery rainbow trout are released at various locations to provide for sport fishing opportunities.

USACE funds annual basin-wide releases of hatchery produced rainbow trout (Section 3.8.2.3, Willamette Hatchery Mitigation Program) (ODFW and USACE 2021). These hatchery fish come from various facilities (Leaburg, Willamette, Roaring River, Wizard Falls, Marion Forks, and Desert Springs). Stocked rainbow trout can affect native spring-run Chinook salmon and winter-run steelhead through competition, predation, and disease transference (e.g., NMFS 2019d). Fisheries for trout, including those resulting from the release of hatchery rainbow trout, can also result in injury or mortality of ESA-listed fish (e.g., UWR Chinook salmon, UWR steelhead trout, bull trout) and other native fishes.

Cutthroat Trout (Oncorhynchus clarkii)

Cutthroat trout are the most common trout in Oregon (ODFW 2024a). They are a native species and widely distributed throughout the entire Willamette River Basin (ODFW 2005). Although this species may be anadromous, adfluvial, fluvial, or resident, anadromous cutthroat trout have not been documented above Willamette Falls and, therefore, are not presumed to occur in the analysis area.

The Willamette River species management unit (SMU) for non-anadromous cutthroat trout includes all populations inhabiting tributary streams to the Willamette River as well as portions of the Mainstem Willamette River (ODFW 2005). They can be found throughout the Willamette River drainage into the headwaters of most tributaries (Oregon Sea Grant No Date). They are thought to be the dominant trout in most headwater tributaries.

Multiple cutthroat trout age classes are present in most locations where cutthroat trout exist (Hooton 1997). This SMU is considered ‘not at risk’ due to its wide distribution, relatively high abundance, and resilience to events that reduce abundance (ODFW 2005).

Pacific Lamprey (Entosphenus tridentatus)

Pacific lamprey are an anadromous species found in the Willamette River Basin (Figure 3.8-12). They are not an ESA-listed species; however, they are an Oregon Sensitive Species (ODFW 2021e) and a culturally important anadromous fish to Columbia River Basin tribes.

Figure 3.8-12. Pacific Lamprey (*Entosphenus tridentatus*).
Photo by: Heather Monti (USACE Media Images Database)

The Willamette River Basin is considered by ODFW as a single unit for management purposes, but it is generally recognized that distinct subpopulations exist within this unit (ODFW 2020a). The Regional Pacific Lamprey Conservation Initiative considers 18 Regional Management Units for the purpose of implementing conservation actions, among them the Willamette Regional Management Unit (Poirier et al. 2023).

Snake River Pacific lamprey have also been documented at Willamette Falls, but the small number of strays from this out-of-basin population would have little effect, genetic or otherwise, on the Willamette River Basin population (Hess et al. 2022).

Distribution in the Willamette River Basin

In the Willamette River Basin, Pacific lamprey are currently found in the Mainstem Willamette River and in several tributaries downstream of dams (Figure 3.8-13). In addition, they have been reintroduced upstream of Fall Creek Reservoir in the Fall Creek Subbasin. They also may exist in resident form in the Middle Fork Willamette River (Larson et al. 2020).

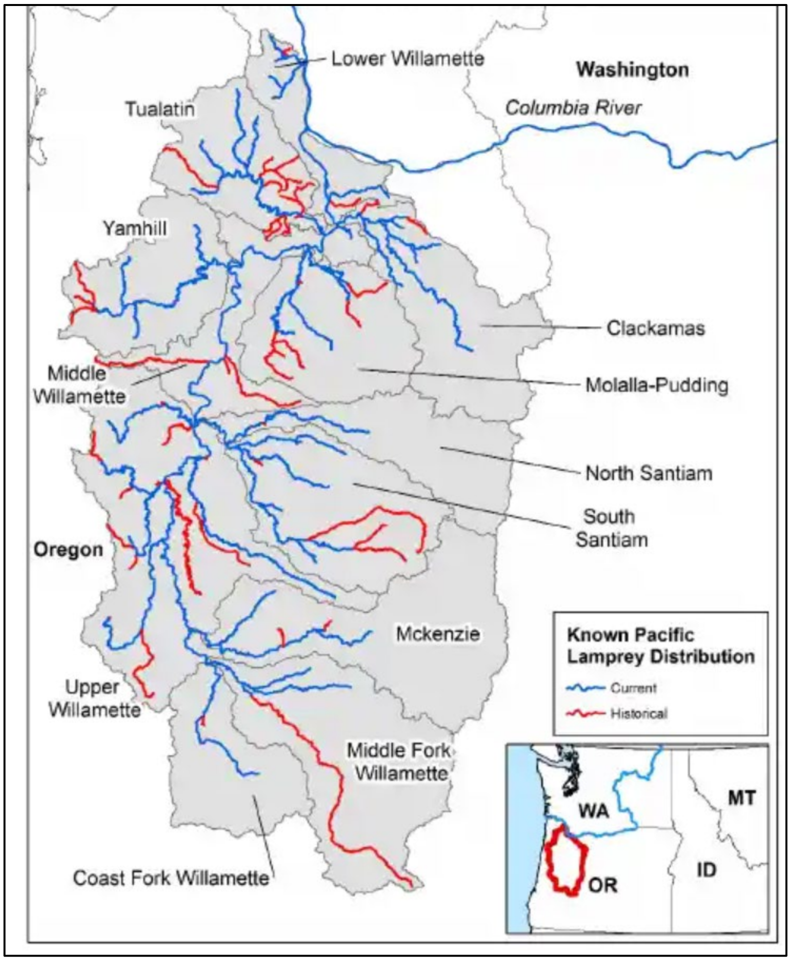

Figure 3.8-13. Current and Historical Distribution of Pacific Lamprey in the Analysis Area.

Source: USFWS 2024b

Note: Map based on known observation data in the Lower Columbia and Willamette Regional Management Unit.

Spawning and Rearing

Pacific lamprey spawn between March and July and die soon after. They spawn in similar habitats to salmon—in gravel-bottomed streams at the upstream end of riffle habitat. After larval lamprey (ammocoetes) hatch in approximately 19 days at 59°F, they drift downstream to burrow into areas with slower water velocity and silt, clay, fine organic matter, and sand (Torgersen and Close 2004).

Ammocoetes rear in streambeds for 2 to 7 years where they mainly filter-feed on algae. Juveniles move downstream to the estuary and ocean between late fall and spring. After 1 to 3 years in marine waters where they are parasitic and feed on other fish, adults stop feeding and migrate upstream to spawning habitat between February and June.

According to Clemens et al. (2023):

> Pacific lamprey require access to high-quality spawning and rearing habitats including depositional areas of relatively slow river flow with sandy and silty sediment into which larvae can burrow and filter feed (Dawson et al. 2015); complex, off-channel habitat for larval rearing (Schultz et al. 2014); large wood for adult holding during spawning migrations (Clemens and Schreck 2021); gravels for adult spawning (Mayfield et al. 2014); and clean, cold (i.e., <20°C) water for all life stages (Clemens 2022).

Habitat Limiting Factors and Conservation Efforts

When WVS dams were constructed, no upstream or downstream passage structures for anadromous lamprey were included. Access to and from upper watershed habitats remains blocked in all subbasins with WVS dams except for Fall Creek Dam.

A ramp/collection box for collection of upstream migrating adult lamprey has been installed at Fall Creek Dam. Adults collected at Fall Creek Dam are released upstream of the Fall Creek Reservoir to support the reintroduction of this species above the dam.

Aside from dam operation passage routes (i.e., spillways, turbines, and regulating outlets), there are no specific facilities for downstream passage of juveniles. Juvenile lamprey have been documented passing downstream of Fall Creek Dam during reservoir drawdown operations through the regulating outlet (Frost 2017). These juveniles were produced by adults collected from Willamette Falls and released upstream of Falls Creek Reservoir for reintroduction (Clemens et al. 2023).

The highest priority threats to Pacific lamprey in the analysis area, in addition to passage limitations, are stream and floodplain degradation, including reservoir creation and operations, water quality, and dam-related flow alterations (Poirier et al. 2023) (Table 3.8-7). Threats from dam operations affect multiple factors critical to lamprey survival, including (e.g., Poirier et al. 2023; Clemens et al. 2023):

- passage
- water quality
- seasonal baseflows and flood flows (timing, magnitude, and duration)
- floodplain dynamics
- habitat (e.g., inundation of habitat, loss of coarse sediment supply)
- species composition (e.g., habitat suitability, predator/prey dynamics)

Table 3.8-7. Summary of Main Threats to the Pacific Lamprey Willamette Management Unit (table continued below).

Watershed	Climate Change		Stream & Floodplain Degradation		Water Quality		Dewatering & Flow Management	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Willamette Sub-Unit								
Middle Fork	4	4	4	4	4	4	4	4
Coast Fork Willamette	4	4	4	4	4	4	4	4
Upper Willamette	4	4	4	4	4	3.5	4	4
McKenzie	4	4	3	2.5	3	3	3	3
North Santiam	4	4	4	4	3	3	4	4
South Santiam	4	4	4	4	4	4	4	4
Middle Willamette	4	4	4	4	3.5	4	4	4
Yamhill	4	4	4	4	4	4	3	3
Molalla-Pudding	4	4	3	3	4	4	4	4
Tualatin	4	4	4	4	4	4	3	3
Clackamas	4	4	3	3	3	3	1	2
Lower Willamette	4	4	4	4	4	4	3	3
Average Scope/Severity	4.0	4.0	3.8	3.7	3.7	3.7	3.4	3.5
Rank	**H**	**H**	**H**	**H**	**H**	**H**	**H**	**H**
Combined Mean	4.0		3.7		3.7		3.5	
Overall Threat Rank	**H**		**H**		**H**		**H**	

Table 3.8-7. Summary of Main Threats to the Pacific Lamprey Willamette Management Unit, Continued.

Watershed	Passage Scope	Passage Severity	Predation Scope	Predation Severity	Lack of Awareness Scope	Lack of Awareness Severity
Willamette Sub-Unit						
Middle Fork	4	4	3	3	3	3
Coast Fork Willamette	4	4	2.5	2.5	3	3
Upper Willamette	2	3	3	3	2	2
McKenzie	3	3	2	2	2	2
North Santiam	4	4	1.5	3	2.5	2.5
South Santiam	4	4	2	4	2.5	2.5
Middle Willamette	3	4	3	3	2.5	2.5
Yamhill	3	3	3	3	2	2
Molalla-Pudding	2.5	2.5	3	3	2	3
Tualatin	3	3	3	3	2.5	2.5
Clackamas	3	2.5	3	U	2	2
Lower Willamette	1.5	2	4	4	2	2
Average Scope/Severity	3.1	3.3	2.8	3.0	2.3	2.4
Rank	**M**	**M**	**M**	**M**	**L**	**L**
Combined Mean	3.2		2.9		2.4	
Overall Threat Rank	**M**		**M**		**L**	

Source: Table 5 *in* Poirier et al. 2023

Notes: Key threats are those that rank moderate or high (2.5 or greater). The Willamette Sub-Unit is defined by Poirier et al. 2023 as part of the larger Lower Columbia/Willamette Regional Management Unit whereas the Pacific Lamprey Conservation Initiative refers to separate Regional Management Units for the Lower Columbia and Willamette Rivers.

Other factors affecting the decline of lamprey are chemical pollution and presence of exotic fish (ODFW 2005). Lamprey are also vulnerable to gas bubble trauma, but the effects are generally sublethal (Liedtke et al. 2023).

Targeted lamprey conservation efforts in the Willamette River Basin have included Fall Creek reintroduction efforts led by the Confederated Tribes of the Grand Ronde. Other conservation efforts have been performed in the greater Columbia River Basin region, including state-led efforts through species conservation statutes and programs and tribal-led restoration, propagation, and translocations as well as Federal actions for habitat and fish passage restoration. Regional lamprey conservation is coordinated through the Pacific Lamprey

Conservation Initiative that is led by the USFWS and includes a large consortium of participants and signatories.

Western River Lamprey (Lampetra ayresii) and Western Brook Lamprey (Lampetra richardsoni)

Western river lamprey and western brook lamprey are found in the Willamette River Basin. Neither has a Federal status but are listed as Oregon Sensitive Species (ODFW 2021e).

Although these species have been regarded as separate from each other, recent genetic analysis indicates they are not genetically distinct (Carim et al. 2023). Instead, Carim et al. (2023) indicates they appear to be members of an interbreeding complex consisting of both anadromous/parasitic (Wester River Lamprey) and resident/non-parasitic (Western Brook Lamprey) ecotypes.

Spawning and Rearing

The resident/non-parasitic life history form spawns in spring through mid-summer in gravel riffles (Pearson Ecological 2024). Incubation occurs for several weeks. Larvae then emerge and move downstream in the river current and into low velocity areas where they burrow into mud or sand. Larvae then feed in these habitats for about 4 years and then transform into adults between August and November. Adults do not eat and remain in the substrate until spring, then spawn before they die.

The anadromous/parasitic life history form is like the resident/non-parasitic life history form for adult spawning and larval rearing phases; however, after transformation to the adult stage, they aggregate immediately upriver from salt water and enter the ocean in late spring (CDFG 2024). Adults then spend approximately 3 to 4 months in salt water where they grow rapidly preying on other fishes, and then they return to fresh water to spawn and die.

Populations

Overall, little is known about abundance and productivity of these species in the Willamette River Basin. Western brook lamprey are likely the second most common and widely distributed lamprey in Oregon after the Pacific lamprey (Kostow 2002, as cited in ODFW 2005). Little data specific to western brook lamprey exists for the lower Columbia/Willamette River population. A small number of brook lamprey have been observed upstream of the North Fork Dam on the Clackamas River (ODFW 2005).

Habitat Limiting Factors

Limiting factors for these species are the same as those described for Pacific lamprey.

Resident Fish

Resident fish are fish that are not anadromous; they spend their entire lives in fresh water. Many resident fish live in one habitat type (e.g., a lake or river) their entire life cycle, while some may migrate between habitat types during different life stages. Migratory resident fish are known as fluvial or adfluvial.

The kinds and numbers of resident fish vary considerably across the Willamette River Basin. Many species interact with each other and their habitats in local fish communities. Some of these species are important for recreational and cultural harvest and are described under gamefish. Approximately 45 percent of the fish species in the Willamette River Basin are non-native (Williams et al. 2022), and the extent of their influence and impacts to native fish assemblages are not well understood.

Oregon Chub (Oregonichthys crameri)

Oregon chub is a resident native species that is found in the Willamette River Basin primarily in off-channel or floodplain habitats with little to no water velocity. It is a small minnow found only in the Willamette River Basin (ODFW 2024b).

USFWS listed Oregon chub as endangered in 1993 and reclassified as threatened in 2010. When listed in 1993, there were only 1,000 known individuals. However, the population grew to over 140,000 fish in at least 80 habitats by the time of delisting in 2015. USFWS officially de-listed Oregon chub on February 17, 2015 (USFWS 2015c).

ODFW has been implementing the Post-Delisting Monitoring Plan for the Oregon chub to track changes in distribution, abundance, habitat conditions, and threats after delisting (USFWS 2014a). Oregon chub were reported at 57 sites in 2023: 13 in the Mainstem Willamette River, 8 in the Santiam River, and 36 in the Middle Fork Willamette River recovery areas (Collver et al. 2024) (Figure 3.8-14). Surveys of 119 sampling sites found Oregon chub at 51 previously occupied sites and 4 new sites, were introduced into 2 new locations, and were not found at 6 previously occupied locations.

Within sites occupied by Oregon chub, non-native fish were captured at 54 percent of locations in the Mainstem Willamette River, 63 percent of locations in the Santiam River, and 33 percent of locations in the Middle Fork Willamette River.

Habitat conditions at sites occupied by Oregon chub were summarized by Collver et al. (2024). There were few differences in habitat conditions noted between sites sampled with and without Oregon chub present. Water temperatures varied widely across sites, and vegetation was present at a majority of occupied locations.

Deep reservoir drawdowns at Green Peter, Lookout Point, Cougar, and Foster Reservoirs, all located above or within known Oregon chub distribution, occurred during 2023; however, Collver et al. (2024) stated the long-term impacts from these deep reservoir drawdowns are not well understood.

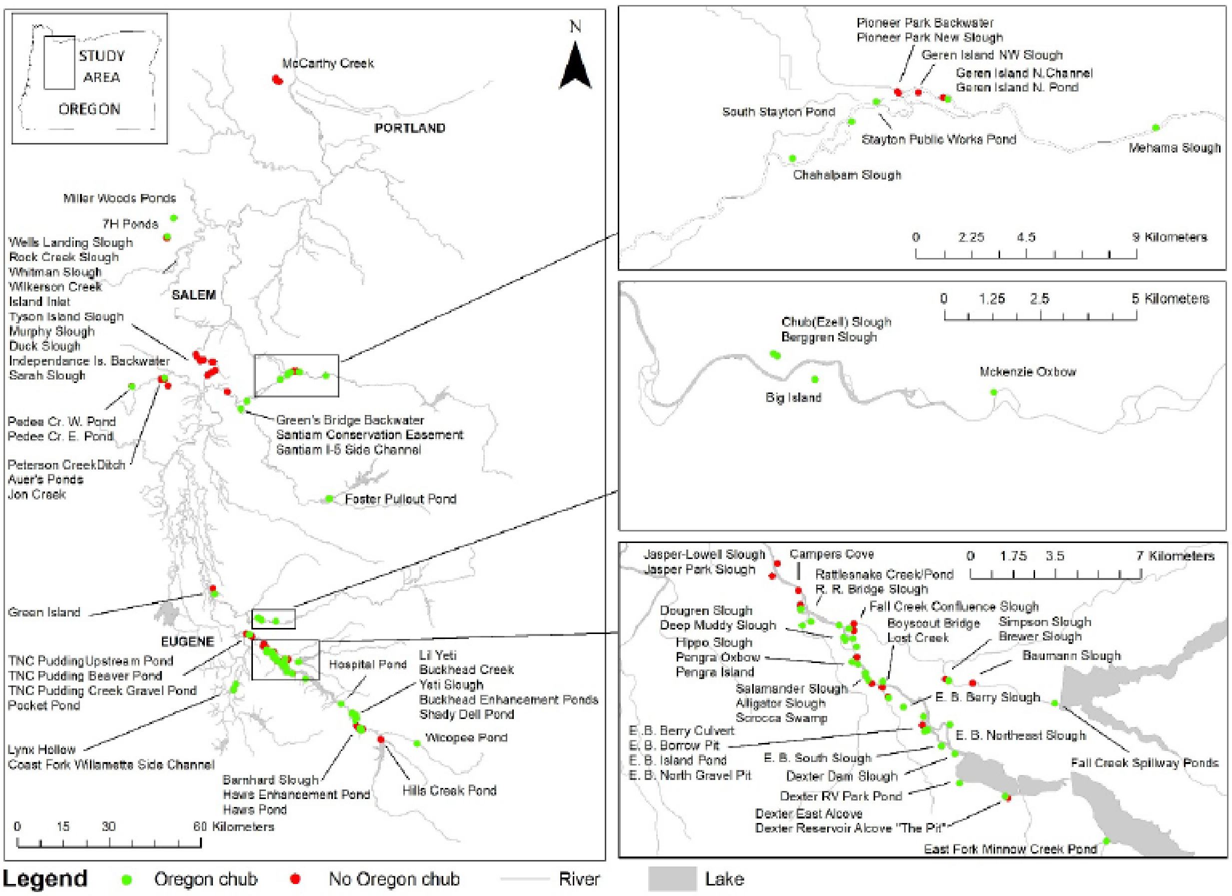

Figure 3.8-14. Oregon Chub Population in the Willamette River Basin in 2023.

Source: Collver et al. 2024

Note: Green circles indicate locations where Oregon chub were detected during sampling. Red circles indicate locations where Oregon chub were not detected during sampling but were observed previously. Overlapping symbols represent multiple locations occurring at or near the same survey location.

Other Resident Fish

Numerous native, resident species occur in the analysis area, including minnows, suckers, sculpins, and dace (Table 3.8-1). The distribution and habitat preferences of native resident fishes often overlap with non-native gamefish (described below), which increases the likelihood of adverse interactions of native resident fishes from competition and predation from non-native fishes.

Gamefish

Gamefish, or sport fish, are species popular for recreational fishing. The category of "gamefish" is defined and regulated under Oregon law. Some gamefish are anadromous species and others are resident species (i.e., non-anadromous).

Anadromous Gamefish

Salmon are the primary anadromous gamefish in the analysis area (described above). Resident/non-anadromous gamefish defined by Oregon regulations and present in the analysis area include trout[8], char, freshwater bass, sunfish, crappie, walleye, and catfish (ORS 496.009).

Resident Gamefish

Many species of warm water, resident fish in the Willamette River Basin were introduced as game species where they thrive primarily because of habitat modification and the creation of slow-moving water, reservoirs, and warm water habitat. Smallmouth bass, largemouth bass, sunfishes, perch, walleye, and catfish are popular species for sport fishing but can compete with or cause predation issues for native fish.

Smallmouth bass and largemouth bass are aggressive, predatory fish that feed on fish as well as amphibians, birds, and small mammals. Invertebrates constitute a large part of smallmouth bass diet, particularly crayfish and other crustaceans (Poe et al. 1991). Juvenile bass begin feeding on fish around 2 years old (Fritts and Pearsons 2006) and have long life spans. Largemouth bass are found throughout the Willamette River Basin (Williams et al. 2014).

Non-native sunfish present in the Willamette River Basin include black and white crappie, bluegill, pumpkinseed, warmouth, redear sunfish, and green sunfish (Murphy et al. 2021). Sunfish occur in streams, lakes, and reservoirs and most can tolerate a wide range of water temperatures (32°F to 90°F) (Beitinger et al. 2000). Black crappie, striped bass, and white crappie prey on juvenile salmon and native resident fish as adults and compete with native fish for invertebrates, zooplankton, and small fish as juveniles (Murphy et al. 2021). Pumpkinseed, warmouth, and bluegill compete with native fish by preying on invertebrates and small prey fish (Gray 2005).

Walleye are generalists living in rivers, natural lakes and reservoirs in both clear and turbid water as well as both shallow and deep water (Bozek et al. 2011). Carp, suckers, and sculpins appear to be more important in walleye diets than juvenile salmon (Zimmerman 1999); however, the walleye population in the Columbia River has been known to consume as many as 2 million juvenile salmon per year (Rieman et al. 1991; Sanderson et al. 2009). Juvenile walleye initially feed on zooplankton and then switch to mainly fish as adults (Caisman 2011).

Catfish live primarily near the bottom of slow-moving lakes and rivers and can tolerate a wide range of water temperatures (32°F to 99°F) (Beitinger et al. 2000). They are predators of native

[8] Bull trout are not a gamefish in the analysis area because of their threatened status under the ESA.

fish and may reduce native fish and invertebrate diversity and abundance (Hughes and Herlihy 2012; Murphy et al. 2021).

Minnows reside in slow-moving lakes and rivers with dense aquatic vegetation. Most can tolerate a wide range of water temperatures (32°F to 100°F) and water conditions, including low oxygen and high turbidity (Beitinger et al. 2000). Minnows feed on zooplankton, macroinvertebrates, and aquatic vegetation (Murphy et al. 2021). Non-native minnows can provide prey items for piscivorous predators, but may also contribute to the decline of native species through competition and predation of eggs.

3.8.2.3 Willamette Hatchery Mitigation Program

The history of the Willamette Hatchery Mitigation Program is described in Chapter 1, Introduction, Section 1.9.2, Willamette Hatchery Mitigation Program. The Hatchery Mitigation Program has changed over time, and adaptive management is applied to modify program management as needed to address potential impacts to ESA-listed species.

USACE funds the operation and maintenance of five hatcheries for mitigation and conservation within the WVS. The USACE Willamette Hatchery Mitigation Program is conducted in the Willamette River Basin above Willamette Falls, primarily in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins (Chapter 1, Introduction, Figure 1.9-1). The hatchery programs within these subbasins include UWR spring Chinook salmon, summer steelhead.

Rainbow trout are produced and released in various locations throughout the Willamette River Basin above Willamette Falls, including within these subbasins. Hatchery Genetic Management Plans (HGMPs) describe these programs in more detail, including where fish are produced and released[9].

Spring-run Chinook Salmon and Summer-run Steelhead Trout Programs

Recently completed Hatchery Genetic Management Plans (HGMPs), prepared jointly by ODFW and USACE for compliance with the ESA, provide the most current definition of hatchery fish production commitments for the USACE Willamette Hatchery Mitigation Program (NMFS 2019a). HGMPs for the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins include "Performance Standards" defining the program goals

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[9] HGMPs are technical documents that thoroughly describe the composition and operation of each individual hatchery program. The primary goal of an HGMP is to describe biologically based artificial propagation management strategies that ensure the conservation and recovery of ESA-listed salmon and steelhead populations. NMFS, who oversees the ESA for salmon and steelhead, uses the information provided by HGMPs to evaluate impacts on salmon and steelhead listed under the Endangered Species Act.

Completed HGMPs may also be used for regional fish production and management planning by Federal, state, and tribal resource managers. HGMPs for hatchery programs in the Willamette River Basin above Willamette Falls can be accessed online at https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/upper-willamette-hatchery-programs.

and "Performance Indicators" for assessing how well the program is meeting those goals (Chapter 1, Figure 1.9-2). Among the goals of these programs is the number of smolts to be produced and released annually (Table 3.8-8; Table 3.8-9).

Table 3.8-8. Hatchery Production Goals (Number of Smolts) for Upper Willamette River Spring Chinook Salmon in Each Subbasin According to the Hatchery Genetics Management Plans.

Subbasin	ESA Conservation Purpose (per HGMP)	Remaining Discretionary USACE Release (per HGMP)	ODFW-funded Release per HGMP	Total Hatchery Release
North Santiam River	630,000	74,000	0	704,000
South Santiam River	350,000	289,000	382,000	1,021,000
McKenzie River	604,750	0	0	604,750
Middle Fork/Mainstem Willamette River	N/A	2,039,000	0	2,039,000

Source: ODFW and USACE 2016d, 2019a, 2019b, 2019c, 2019d, 2021

HGMPs = Hatchery Genetics Management Plans

N/A = Not Applicable

Table 3.8-9. Hatchery Production Goals (Number of Smolts) for Summer-run Steelhead in each Subbasin According to the Hatchery Genetics Management Plans.

Subbasin	Discretionary USACE Release (per HGMP)	ODFW-funded Release per HGMP	Total Hatchery Release
North Santiam River	0	121,000	121,000
South Santiam River	0	121,000	121,000
McKenzie River	0	108,000	108,000
Middle Fork/Mainstem Willamette River	157,000	0	157,000

Source: ODFW and USACE 2018

HGMPs = Hatchery Genetics Management Plans

The spring-run Chinook salmon hatcheries mitigate for habitat lost or for inaccessible habitat from construction and operation of WVS dams by providing adult returns to help meet harvest objectives within the Willamette River Basin and ocean fisheries. As part of the UWR Chinook salmon ESU, spring-run Chinook salmon hatcheries are operated as integrated hatchery programs meant to provide ESA conservation benefits consistent with survival and recovery of the ESU. The Hatchery Science Review Group recommended that an integrated program approach would be an important way to improve the status of UWR Chinook salmon (i.e., where a small proportion of natural-origin fish are taken for the production of hatchery fish in the following year) (HSRG 2009). For the hatchery-origin spring-run Chinook salmon program, integration of natural-origin broodstock into hatchery broodstock has occurred on a limited basis (i.e., proportion of natural-origin broodstock ranged from 0.0 to 0.15 during 2019 to 2021) (Reis 2002). Domestication effects increase when integration of natural-origin broodstock is low, leading to reduced fitness in naturally spawning UWR Chinook salmon populations where the proportion of hatchery-origin spawners is high in the analysis area. Domestication effects and fitness are further discussed in this section below.

The summer-run steelhead program is an isolated harvest program where fish are produced only for harvest purposes. This harvest purpose is to mitigate for habitat lost or inaccessible due to construction and operation of WVS dams. Isolated harvest program hatchery populations are managed to prevent spawning with native populations and use only hatchery fish (i.e., no natural-origin fish) for broodstock.

Hatchery-origin spring-run Chinook salmon are primarily released in spring as yearling smolts, promoting immediate downstream migration to the ocean. A small number are released as subyearlings in the fall, mimicking the life history migration patterns of natural-origin juvenile spring-run Chinook salmon. Hatchery-origin spring-run Chinook salmon are released into the Molalla River, North Santiam River, South Santiam River, McKenzie River, Middle Fork Willamette River, and Coastal Fork Willamette River Subbasins downstream from WVS dams and typically from the hatchery facilities.

Hatchery-origin summer-run steelhead are released in the spring as yearling smolts (promoting immediate downstream migration to the ocean) downstream of WVS dams in the North Santiam River, South Santiam River, McKenzie River, Middle Fork Willamette River, and the Mainstem Willamette River.

Juvenile hatchery-origin spring-run Chinook salmon and summer-run steelhead that are released are generally larger than their natural-origin counterparts because of accelerated growth in hatchery environments. This prepares them for downstream migration to the ocean.

To meet conservation goals listed in the HGMPs for UWR Chinook salmon, hatchery-origin spring-run Chinook salmon are used to supplement natural-origin populations to promote reintroduction efforts above WVS dams (NMFS 2019a) (Table 3.8-10). Outplant goals for spring-run Chinook salmon range from 600 above Cougar Dam on the South Fork McKenzie River to 2,450 above Lookout Point Dam on the Middle Fork Willamette River.

Table 3.8-10. Willamette Valley System Hatchery-origin Chinook Outplant Goals by Subbasin.

Subbasin	HGMP Outplant Goals	Females	Males
McKenzie	600	400	200
Middle Fork	2,450	N/A	N/A
South Santiam	800	N/A	N/A
North Santiam	1,500	750	750

Source: ODFW and USACE 2016d, 2019a, 2019b, 2019c, 2019d, 2021

N/A = Not Applicable

Rainbow Trout Hatchery Program

The hatchery rainbow trout program is also managed as an isolated harvest program. The hatchery rainbow trout program produces triploid (sterile) hatchery fish that helps to ensure hybridization does not occur with native trout populations. Production of triploid hatchery fish is not feasible for the summer-run steelhead program.

The production goal for the hatchery rainbow trout program is 277,000 pounds released basin-wide (ODFW and USACE 2016). Proposed maximum releases of rainbow trout by location are identified in Table 3.8-11.

Table 3.8-11. Proposed Maximum Annual Rainbow Trout Release into the Willamette River Basin[1].

Waterbody	Total Pounds of Trout	Waterbody	Total Pounds of Trout
Alton Baker Canal	15,000	Dorena Reservoir	30,000
Bethany Pond	1,500	Dorman Pond	2,000
Billy Lake	20	EE Wilson Pond	7,300
Blue River above Reservoir	3,000	Fall Creek above Reservoir*	5,000
Blue River Reservoir	8,000	Fall Creek Reservoir*	5,000
Breitenbush River*	6,700	Foster Reservoir*	16,000
Buck Lake	10	Freeway Lake, East	1,800
Canby Pond	800	Green Peter Reservoir*	9,000
Carmen Reservoir*	8,000	Henry Hagg Lake	27,000
Clear Lake	15,000	Hills Creek Reservoir*	30,000
Commonwealth Lake	1,200	Huddleston Pond	4,000
Cottage Grove Reservoir	30,000	Junction City Pond	11,500
Crabtree Lake	20	Lake Eleanor (Indian Prarie) Lake	20
Crabtree Pond	5	Leaburg Lake*	10,000

Waterbody	Total Pounds of Trout	Waterbody	Total Pounds of Trout
Cronemiller Lake	200	McKenzie River above Leaburg Dam*	25,000
Detroit Reservoir*	59,000	McKenzie River below Leaburg Dam*	15,000
Dexter Reservoir*	10,000	Progress Lake	1,300

Source: ODFW 2023

HGMPs = Hatchery Genetics Management Plans

Notes: * indicates hatchery rainbow trout release location with presence of ESA-listed fish.

[1] Proposed maximum annual legal rainbow trout release level into Upper Willamette River Basin, in pounds, for all programs.

Hatchery rainbow trout are released at various sizes within numerous waterbodies both upstream and downstream of dams throughout the Willamette River Basin (Table 12 *in* NMFS 2019a), including Detroit, Foster, Green Peter, Dexter, Cottage Grove, and Dorena Reservoirs (ODFW 2023). Most hatchery rainbow trout are released at catchable size (i.e., about 9 inches or greater). Depending on waterbody, release timing can be year-round or limited to certain periods (e.g., March to July, May to October, etc.).

Effects of Hatchery Programs

NMFS (2019a) determined the benefits and risks to ESA-listed species from operation of the WVS hatchery programs as the following:

1. Hatchery-origin spring-run Chinook salmon integrated programs provide benefits, including increased UWR Chinook salmon spawning abundances, increased marine-derived nutrients, and fishery harvest opportunities. Risks include masking, competition, and predation by hatchery fish on natural-origin UWR Chinook salmon. Integration of natural-origin UWR Chinook salmon into hatcheries increases demographic risk by reducing spawning abundances but provides benefits from reduced genetic domestication effects from hatchery fish.
2. Hatchery-origin summer-run steelhead isolated harvest programs provide benefits to fishery harvest opportunities. Risks include genetic impacts to native UWR steelhead (summer-run steelhead are non-native, out-of-basin fish), predation, and competition, especially from residual smolts.
3. The hatchery rainbow trout program provides benefits to fishery harvest opportunities. Risks include predation, competition, disease transfer, and increased angler exploitation of salmon, steelhead, bull trout, and other native fishes.

Hatchery programs remove fish from a natural environment and displace them into a captive rearing environment. Impacts on natural fish populations (including those that are ESA-listed) from hatchery programs include a reduction in the frequency of natural-origin type genes (i.e., domestication effects), increased risk of pre-spawn mortality, competition, transfer of genetic material, predation, and sport fishing impacts (Christie et al. 2016; Araki et al. 2009; Araki et al.

2008; Weber and Fausch 2003; Wang et al. 2002; Fleming and Petersson 2001; Berejikian 1995; Waples 1991; Reisenbichler and McIntyre 1977).

For example, domestication effects within hatchery programs have been observed over as few as one salmon generation when offspring had at least one hatchery parent (Araki et al. 2008). Also, when hatchery- and natural-origin parents spawn together, genetic material from hatchery fish is transferred to natural fish, and this can lead to reduced fitness in the natural population. Studies have shown that natural-origin-born fish achieve greater fitness than hatchery-origin fish (Araki et al. 2008; Anderson et al. 2013; Milot et al. 2013), including those in the Willamette River Basin (e.g., O'Malley et al. 2014).

The proportion of hatchery-origin spawners (pHOS) is a common metric used to assess genetic effects on natural populations and population viability. For UWR Chinook salmon, targets for pHOS are set for each basin and generally range from 10 percent to 20 percent (ODFW and USACE 2019a, 2019b, 2019c, 2019d, 2021). The proportion of hatchery-origin spawners below dams is currently very high and would not be expected to change in the future even when fish passage at dams is improved, unless decisions are made to reduce hatchery releases.

In some subbasins, dams lower in the watershed can be used to remove adult hatchery fish migrating upstream. Currently, these includes Dexter, Fall Creek, Foster, and Leaburg Dams. Current fish disposition, as directed by the 2008 NMFS biological opinion and the Willamette Fish Operations Plan, direct facility operators at Fall Creek Dam and Foster Dam to only transport unmarked fish to reaches above the dam. However, offspring of hatchery fish that spawn naturally below dams are not marked when they mature and return from the ocean, and some will be inadvertently transported and released above dams. This affects the genetic fitness of above-dam spawners (e.g., Sharpe et al. 2015; O'Malley et al. 2024).

In the McKenzie River Subbasin, a number of actions have occurred to increase the collection of hatchery-origin Chinook salmon and to reduce pHOS. ODFW operates a trap in one of the Leaburg Dam fish ladders and physically removes hatchery-origin Chinook salmon from the ladder. The fish ladder entrance to the hatchery was improved at McKenzie Hatchery to increase attraction of hatchery-origin Chinook salmon by increasing velocities at the entrance. Replumbing of water to the McKenzie Hatchery occurred using Cogswell Creek. This allows incubation and early rearing using a unique water signature from Cogswell Creek with the goal of enhanced juvenile fish imprinting to increase their homing ability when they return from the ocean as adults.

After optimization of various operations at McKenzie Hatchery, pHOS levels decreased substantially. In 2022, pHOS levels were reduced to 3 percent for the reach above Leaburg Dam. Eugene Water and Electric Board, owner and operator of Leaburg Dam, plans to begin on-the-ground decommissioning work of the dam by 2032.

The abundance of hatchery- and natural-origin spawners can indicate the relative amount of marine-derived nutrients delivered to a stream reach from salmon returning from the ocean to spawn. A higher number of salmon or steelhead spawning (as indicated from counts of adults returning to the Willamette River and its tributaries, and more directly from redd and carcass counts) would indicate more nutrients being delivered from spawned carcasses.

Pre-spawn mortality, or adult mortality prior to spawning, in UWR Chinook salmon can be very high (e.g., Bowerman et al. 2018). Annual levels of pre-spawn mortality have been related to the density of adult hatchery-origin Chinook salmon returns, water temperatures, handling and holding protocols, and transport distance above dams, among other factors. Rates of pre-spawn mortality increase with increased adult hatchery returns (Benda et al. 2015; Keefer et al. 2017; Bowerman et al. 2018), which likely reflects negative effects (stress and disease transfer) of high adult returns congregating and holding below or within adult fish facilities, and spawner densities particularly below dams.

Basin-wide pre-spawn mortality is variable depending on annual environmental conditions (particularly water temperatures; Benda et al. 2015), body condition (Keefer et al. 2017), travel time (Caudill et al. 2017), adult fish facility conditions, and management practices. Several of these factors co-occur below WVS dams, and as a result, adult upstream migrants and spawners in these river reaches, or when collected and handled may be more vulnerable to pre-spawn mortality. Effects of dams and adult fish facilities are mitigated through Best Management Practices[10], which can include managing river temperatures and total dissolved gas (TDG) discharged from dams within targets or criteria, reducing spawner densities through frequent transport, decreased holding and handling, and monitoring for disease.

Fisheries for hatchery-origin Chinook salmon also result in direct effects for naturally produced spring-run Chinook salmon. Incidental catch of natural-origin Chinook salmon in sport fisheries for hatchery salmon and steelhead in the Willamette River Basin is not monitored directly and is difficult to estimate. Catches of natural-origin Chinook salmon are self-reported by fishers and, therefore, it is uncertain how many catches are unreported. Increases and decreases in incidental catch rates of natural-origin adults would be expected to relate to the number and proportion of hatchery- and natural-origin returns each year.

Local fisheries for stocked rainbow trout also result in take of ESA-listed juvenile Chinook salmon, bull trout (e.g., Reis, Ziller, and McCormick 2012), and likely juvenile steelhead. Existing fisheries for hatchery-origin Chinook salmon, summer-run steelhead, and rainbow trout increases the likelihood of misidentification and poaching of bull trout, UWR Chinook salmon, and UWR steelhead as well as increasing susceptibility to predation and competition (e.g., USFWS 2008).

Release of hatchery-origin fish affects the ability of existing habitat to support UWR Chinook salmon, steelhead, bull trout, and other native fish species. ODFW and USACE rainbow trout hatchery programs result in spatial overlap with these ESA-listed species in the Willamette River

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[10] Best Management Practices are protocols for the operation of hatchery facilities and hatchery programs to appropriately meet objectives of hatchery programs.

Basin, including within standing water bodies (i.e., WVS reservoirs), resulting in competition and predation (Table 3.8-11).

The 2019 Hatchery Biological Opinion prescribed reducing overlap between rainbow trout and ESA-listed fish where possible (NMFS 2019b); however, this was occurring in several subbasins at the time the alternatives were analyzed. Stocking hatchery trout in WVS reservoirs reduces habitat capacity for UWR juvenile Chinook salmon and UWR steelhead.

The amount of rearing habitat available for native fish in WVS reservoirs is limited by stocked rainbow trout and other non-native fishes. For example, at the time the alternatives were analyzed, there was no available rearing habitat estimated for juvenile Chinook salmon above WVS dams after accounting for annual growth of the resident fish populations in Detroit Reservoir (Bond et al. 2017). Similarly, stocked resident fishes fill most of the estimated rearing capacity in Foster Reservoir, leaving a rearing capacity for only 3,000 subyearling Chinook salmon through the fall. Furthermore, at the time the alternatives were analyzed, adult spring-run Chinook salmon returns have been averaging close to the estimated habitat carrying capacity in recent decades of about 9,000, which may be due to the large numbers of hatchery fish released in the Upper Willamette River Basin (Scheuerell 2019).

Best Management Practices at WVS hatcheries to minimize impacts on ESA-listed fish include adequately screening hatchery intake water supplies to prevent fish loss, ensuring hatcheries are operated in compliance with National Pollutant Discharge Elimination System permits, and outplanting surplus carcasses from the hatchery for nutrient enhancement in the ecosystem where appropriate (IHOT 1995; HSRG 2004; Mobrand et al. 2005).

3.8.2.4 Aquatic Habitat

Features such as water quantity, quality, depth, velocity, cover, substrate, riparian and aquatic vegetation, and prey availability are all important components of aquatic environments that provide habitat for a diverse array of fish species. An overview of these features is described in this section, while location-specific features affected by WVS operations are discussed by basin and individual subbasins under Section 3.8.2.5, Willamette River Basin and Analysis Area Subbasins.

Aquatic habitat can generally be divided into two categories: riverine habitat and reservoir/lake habitat as described below. Each habitat hosts different species or life stages that have adapted to or can tolerate these conditions. Existing habitat conditions of the analysis area, which includes the 13 WVS dams, are also influenced by other non-Federal projects upstream and downstream, which are mentioned where relevant.

Riverine Habitat

Habitat Features

In general, rivers meander across landscapes according to underlying geological and physical features, surrounding terrain, and dominant weather patterns. A natural river ecosystem has a relatively stable pool-to-riffle ratio, which determines how and where the various plants and fish find their supporting habitats in channels and along shorelines. Riffles are key spawning locations with depth, velocity, and substrate[11] influencing spawning areas for salmon, steelhead, and lamprey. Pools support feeding areas for various species and life stages (e.g., juvenile salmon and steelhead, and holding areas for adult salmon and steelhead during upstream migration). Pools and riffles also support different communities of invertebrates, which serve as prey items for fish and help with the important nutrient cycling process of the river ecosystem.

Along riverine shorelines, beaches and sandbars form by deposits of suspended sand in zones of recirculating flow or eddies along the channel margin or by obstacles such as boulders and large logs in the channel that cause slower velocity water where sediment drops out of suspension. Juvenile fish (e.g., Chinook salmon) use areas with gently sloping shorelines that are often associated with beach areas.

Dams that block sediment transport, bank protection structures (i.e., levees, revetments, etc.), riparian vegetation removal, and urbanization and industrialization have altered shorelines of importance to juvenile salmon during their freshwater migration downstream to the ocean. Revetments eliminate localized habitat complexity but can provide some cover for smaller fish in areas where shorelines are severely degraded.

Loss of large woody debris prevented from moving downstream by dams and shoreline aquatic vegetation affected by fluctuating inundation and exposure by dam discharges has reduced total habitat available for juvenile rearing and foraging, cover to hide from predators, and provision of insects and other detritus that flow into mainstem areas for food and cover. Non-native, invasive predatory fish that spawn in rivers include walleye, bass, and channel catfish.

Aquatic Species Habitat Adaptations

Many aquatic species are adapted to the natural hydrologic cycles occurring in the analysis area. In the Pacific Northwest, rivers cycle between periods of high winter flows and low summer flows. High flow events promote biological production and healthy ecosystems, whereas regulated modifications of flows in rivers typically reduce production (Junk, Bayley, and Sparks 1989).

For many species adapted to the patterns of spatial and temporal habitat dynamics, an array of different habitat types is needed for the completion of their life cycle. Quantity and timing of

[11] Substrate is “the base on which an organism lives” (Merriam Webster Dictionary). For example, rocks and gravel are substrate for fish eggs.

flows are important for many migratory fish (e.g., Chinook salmon, steelhead, lamprey, and bull trout), including for juvenile rearing and outmigration, adult upstream migration and holding, access to and preservation of spawning sites, temperature regulation in certain river reaches, and habitat connectivity. In addition, rearing and spawning behaviors of resident species occupying reaches downstream of dams are influenced by quantity and timing of downstream flows.

Stream Flow

Operation of WVS dams has changed historical river flow timing, magnitude, and duration available each year by regulating river flow below the dams and affecting changes in fish behavior, energy use, and survival.

During winter, peak flows are reduced to manage flooding downstream. Reducing peak flows decreases habitat naturally available during high flow events on the river floodplain and limits formation of new habitat through channel-forming processes.

In spring, flows below WVS dams are lower on average than natural flows due to water storage behind reservoirs. During summer and early fall, reservoir storage is then released resulting in increased flows below WVS dams. These storage releases increase flow levels above naturally occurring levels and providing the potential for additional habitat but also result in altered timing and distribution of habitat affecting native species adapted to natural seasonal cycles in annual flow patterns.

Operations include ramping rate[12] thresholds and minimum flow targets to avoid stranding fish due to rapid reduction in river flow or dewatering riverine habitat immediately downstream from dams from excessively low stream flows. However, increasing low seasonal flows also changes the timing and magnitude of seasonal flow succession, the distribution of habitat, and seasonal water temperatures supporting adaptation of native species.

Large variation in flows due to peaking and load-factoring[13] operations of dams further affect habitat conditions. This occurs downstream of Green Peter Dam in the 3.5-mile reach to Foster Reservoir. As a result, this river reach is less biologically productive. For example, when recolonization of aquatic life occurs during higher flows, subsequent reduction in flow can cause widespread stranding and desiccation of insects, small fish, and fish eggs, particularly when recolonization occurs rapidly.

Broadly, USACE has operated dams to a suite of flow objectives to reduce Mainstem Willamette River effects and to provide biological benefits since 2000 and for regulated Willamette River tributaries since 2008. These flow objectives are included in NMFS Biological Opinion 2008

[12] Ramping rates are the speed at which the water discharged from a dam increases or decreases.

[13] Peaking is a short, high demand period for electricity, such as demand for in-home power in the evening. Load factor is a measure of the utilization rate, or efficiency of electrical energy usage.

Reasonable and Prudent Alternative (NMFS 2008). Flow objectives targeted seasonal benefits for ESA-listed species and life history stages.

Due to uncertainty in the benefits of flow objectives implemented since 2000 and 2008, several studies have been completed as directed by NMFS (2008). These studies provide updated information on relationships between flow and habitat availability for each life stage of spring-run Chinook salmon and winter-run steelhead below WVS dams[14]. Studies analyzing adult migration and pre-spawn mortality[15], redds[16], and juveniles[17] provided information on habitat use and preferences. Studies of water quality conditions address the effects and limitations of dam operations on downstream water temperatures and TDG, further informing the effectiveness of existing flow targets[18].

Information collected since 2008 indicates adult UWR Chinook salmon move upstream through the Mainstem Willamette River and into natal tributaries principally in spring as flows decline and water temperatures naturally increase (Keefer et al. 2019). Along with installation of fish ladders at Willamette Falls, augmenting Mainstem Willamette River flows with release of storage water has altered migration patterns for adult UWR Chinook salmon (Myers et al. 2006).

In addition, at the time the alternatives were analyzed, studies indicated water temperatures during adult Chinook salmon migration upstream in the Mainstem Willamette River from April through July demonstrated a negative correlation with mortality (i.e., as water temperatures increase, mortality decreases) (Myers et al. 2022). This correlation is likely because adults increase their migration rate as the river warms, reducing their time in the mainstem. Mortality in the Mainstem Willamette River has been found to be more related to descaling and injuries than to water temperature and discharge (Keefer et al. 2017). There is also evidence that high numbers of hatchery-origin Chinook salmon spawning in the Willamette River Basin may be contributing to a shift in run timing from predominantly spring to additional adult migration up the Mainstem Willamette River later into the summer (Myers et al. 2006; O'Malley et al. 2018).

Adult spring-run Chinook salmon pre-spawn mortality rates, measured after adults have moved upstream of the Mainstem Willamette River into spawning tributaries, has been related to water temperatures and density of adult hatchery-origin Chinook salmon but not with river discharge (Benda et al. 2015; Bowerman et al. 2015, 2018, 2021; Keefer et al. 2015, 2017, 2018b, 2019). Most temperature exposure is accumulated by adult spring-run Chinook salmon within Willamette River tributaries due to the prolonged period spring-run Chinook salmon hold

[14] R2 Resources 2014; River Design Group 2015; White et al. 2022; Hansen et al. 2023

[15] E.g., Benda et al. 2015; Bowerman et al. 2018, 2021; Keefer et al. 2015, 2017, 2018b, 2019

[16] E.g., Sharpe et al. 2017

[17] E.g., Hansen et al. 2023

[18] E.g., Rounds 2010

in natal streams prior to spawning. Similarly, flow augmentation and cool water releases from WVS dams directly affect adult Chinook salmon migration upstream. Those originating from above WVS dams can be delayed by cool water discharged from WVS dams. Migration rates are slower when temperatures are cool, resulting in longer periods adult Chinook salmon hold below WVS dams where they are exposed to higher densities of hatchery-origin adult Chinook salmon and active sport fisheries for salmon and steelhead (both factors that can contribute to pre-spawn mortality rates).

For juvenile Chinook salmon and steelhead, studies indicate they emigrate from the Mainstem Willamette River in spring before water temperatures are stressfully warm (Schroeder et al. 2016; Whitman et al. 2017). Habitat availability is very similar for juvenile Chinook salmon and steelhead at flows near or below the minimum targets prescribed in the 2008 Biological Opinion (NMFS 2008; White et al. 2022). Estimates of smolt survival downstream through the Mainstem Willamette River to Portland, Oregon are very high (Beeman et al. 2014, 2015).

Previously, spring flow targets were in part to address the hypothesis that juvenile steelhead infection and mortality from *Ceratomyxa shasta* (*C. shasta*) would be reduced by supplementing flows to maintain water temperatures below critical thresholds. Recent sampling indicates *C. shasta* spore counts are low in the Willamette River Basin except at Willamette Falls (Chiaramonte 2013). Although smolt survival between WVS dams to Portland was high at the time the alternatives were analyzed, there is uncertainty regarding the potential relationship between WVS dam discharge, Mainstem Willamette River temperatures, and steelhead mortality expressed downstream of Willamette Falls. Analyses of adult Chinook salmon recruitment was not found to relate to flow in the Mainstem Willamette River during the year of juvenile outmigration (Scheuerell 2019).

Field studies of flow-habitat relationships, flow-water quality relationships, and fish habitat preferences have been applied in decision support models to assess how a range of different minimum flow targets affect survival and productivity for Chinook salmon and steelhead (Deweber et al. 2020; Peterson et al. 2022). These models indicate, in part, that there are limited differences on the effects to Chinook salmon and steelhead among different flow targets, likely due to the partial controllability of flows and water quality (and resulting habitat conditions) in the Willamette River Basin. Models further indicate that in dry years, survival would be increased with use of available storage to supplement river flows below dams in late spring and early summer instead of earlier in spring.

There are important trade-offs for Chinook salmon and steelhead life stages when managing Mainstem Willamette River and tributary flows versus when managing flows for different seasons. For example, the extent cool water is released from WVS reservoirs during late spring and summer to supplement Mainstem Willamette River flows positively affects the extent warm water is released in fall. Releasing cooler than ambient temperatures in late spring and early summer can reduce risk of pre-spawn mortality. However, these releases can also slow upstream migration of Chinook salmon, increasing other pre-spawn mortality rate risk factors (e.g., exposure to high densities of hatchery adults and fisheries). Additionally, cool releases early in summer often result in greater volumes of warm water released in fall below WVS dams adversely affecting spring-run Chinook salmon egg incubation timing and survival.

Water Quality

In the decades prior to operation of large dams, Willamette River water quality was very poor due to municipal and industry discharge and run-off (Robbins 2002). These conditions negatively affected habitat conditions and habitat connectivity for both resident and migrating fish. Water quality improved with construction and operation of the WVS, increasing flows in summer that helped to dilute river pollutants and reducing flooding of agricultural and urban areas, thereby reducing polluted runoff from these areas. Reservoirs also trap sediment from upstream flow. However, water quality conditions below reservoirs in the analysis area are not optimal. Operations of dams has continued to modify water quality conditions within reservoirs and downstream as described below.

Temperature

Each fish species and life stage requires a unique range of tolerable and optimum temperatures for survival. Native fish species of the Willamette River Basin are primarily adapted to flowing water with behaviors and distribution to adjust to habitat utilization as seasonal temperatures change. Most prefer water temperatures below about 20°C (68°F). Conversely, some species persist in slightly warmer temperatures in lakes and reaches of larger rivers, depending on their life history and habitat preferences and tolerance. Many introduced (non-native) species tolerate and often thrive in altered temperature regimes resulting from dam operations that can be stressful for native fish.

Water temperatures can be influenced by a variety of factors including:

- inflow
- reservoir surface area
- solar radiation absorption
- water storage
- shading from riparian habitat
- surface air temperatures
- water storage
- water system diversions
- return flows

Fish may move from an unsuitable water temperature into an area with more tolerable water temperatures to maintain control over body temperature. Surface waters in reservoirs can be warmed by the sun and air temperatures, particularly in summer. However, water deeper in reservoirs remains cold.

Choices in operations that are limited by the dam configuration can result in warm or cold water being released or operations that discharge a mix from warm and cold elevations in the reservoir to help meet temperature targets[19] for life cycle stages of ESA-listed fish (Section 3.5, Water Quality, Subsection 3.5.1.3, Water Quality Parameter Overview and Subbasin Conditions, Temperature). For example, at Cougar Dam a selective withdrawal structure is used to meet downstream temperature targets.

Water temperatures downstream of dams can be too cold during the summer for some species when water is discharged from dam outlets at lower elevations that draw from cooler water temperature layers in the reservoirs, particularly in tailwater[20] environments. For example, these conditions are known to impede or delay adult Chinook salmon upstream migration and may limit growth and productivity of other aquatic species. Conversely, cool releases from WVS dams during summer can benefit cold water-dependent species further downstream when streams naturally would become stressfully warm.

Depending on seasonal weather patterns in fall, warmer downstream water temperatures can occur when (1) reservoirs are drawdown in preparation for flood management season, (2) cool water reservoirs are depleted, and/or (3) reservoirs turn-over[21] and become isothermic (mixed). Warmer temperatures discharged from WVS dams are known to affect incubation timing and at times survival of juvenile Chinook salmon (Rounds 2010; ODFW and NMFS 2011).

Warmer water temperatures occurring in late summer and fall from a variety of factors increase the risk of native fish disease and mortality, affect their responses to pollutants, and can affect migratory movements (e.g., Sullivan et al. 2000). Warmer water temperatures increase the foraging rate of predatory fish and help support habitat beneficial to invasive predatory fish. Water temperature is likely the most important physical variable affecting predatory fish consumption rate and growth (Brett 1979).

Total Dissolved Gas

Plunging water over natural features (waterfalls, cascades) or water discharged from dams can cause downstream waters to become supersaturated with dissolved atmospheric gases referred to as supersaturated TDG. TDG results from the entrainment of air bubbles into plunging water.

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[19] The Annual Willamette Basin Water Quality Reports, from 2009 to the time the alternatives were analyzed, details implemented water quality measures describing reservoir temperature targets, temperature TMDLs, TDG, and other water quality (USACE 2011b; USACE 2012b; USACE 2013e; USACE 2014c; USACE 2015m; USACE 2016d; USACE 2017f; USACE 2018c; USACE 2019e; USACE 2020d; USACE 2021f; USACE 2022d).

[20] The tailwater is the river section immediately downstream of a dam.

[21] Reservoir turnover is the seasonal mixing of water layers in a reservoir or lake when the water temperature becomes uniform throughout. This process occurs when the water in the upper layer becomes denser than the water below it. Turnover typically happens in the spring or fall when the water temperature at the top and bottom of a reservoir or lake equalizes.

TDG levels above 110 percent saturation can adversely affect juvenile salmonids through gas bubble trauma with effects similar to underwater diving decompression sickness or “the bends” (Mesa et al. 2000). However, studies indicate TDG levels up to 120 percent may not impact salmonids during less sensitive life stages, depending on depth compensation and other factors (McGrath et al. 2006). Fish residing in shallow or near-surface depths at certain stages of their life cycle are at risk (Maynard 2008):

> Except when stream flow exceeds the ten-year, seven-day average flood, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection may not exceed 110 percent of saturation. However, in hatchery-receiving waters and other waters of less than two feet in depth, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection may not exceed 105 percent of saturation (OAR 340-041-0031).

Dam operators target certain operations intended to reduce adverse impacts and to meet State of Oregon[22] limits of TDG (less than 110 percent) by reducing spill or using certain spill patterns to achieve less gas saturation in water (Figure 3.8-15). The distance downstream of a dam at which normal TDG levels are achieved depends on the TDG level at the point of discharge, river volume, and associated river conditions (depth and presence of cascades and riffles causing turbulence). Spill levels are lowered during some months at some dams and the extent of high TDG waters is, therefore, reduced as well.

[22] Under the State of Oregon Administrative Rule (OAR) 340-041, the Oregon Department of Environmental Quality (ODEQ) implements the Water Quality Standards. Water quality standards in the State of Oregon are listed for pH, bacteria, dissolved oxygen, temperature, TDG, total dissolved solids, turbidity, nuisance phytoplankton, and toxic substances.

Figure 3.8-15. Spill at Detroit Dam.
Unknown photo credit (USACE Media Images Database)

Turbidity

Turbidity is an indicator of the level of suspended particles in water (e.g., fine sand, silt, clay, plankton). Effects of turbidity on fish depend on a number of factors, including body size, eye size, and the trophic position of fish as well as turbidity type, range and ecosystem types while also accounting for evolutionary relationships between species or groups of species (Rodrigues et al. 2024).

Fish take advantage of turbidity to hide from predators, but they also require adequately clear water to locate prey and other forage, and for optimal gill function. It is difficult to define optimal or tolerable turbidity levels for fish. The various native species in the Willamette River Basin maintain turbidity tolerance ranges that vary depending on their life stage, season, their location, and other factors. Generally, it can be assumed that turbidity levels outside of the typical annual range of those present prior to large-scale land use practices would negatively affect native fish species.

Flow regulation and the existence of reservoirs generally reduce turbidity in rivers downstream of WVS dams; however, temporary elevated turbidity levels in both downstream reaches and reservoirs can occur associated with deep drawdowns. During typical flood risk reduction operations, turbid stormwater is held in reservoirs and released at a slower rate than rates of inflow. This prolongs the duration of downstream turbidity while reducing the intensity of downstream turbidity peaks. Reduced turbidity allows visual fish predators, such as the non-native smallmouth bass, to more effectively prey on native fish.

Pollutants

The major pollutants in the Willamette River Basin are released from adjacent landscapes through urban, industrial, and agricultural sources, including use of pesticides, fertilizers, and herbicides (Borgens 2019). Water-based recreation activities also release contaminants into reservoirs (Section 3.16, Hazardous Materials, Subsection 3.16.3.1, Methodology).

Additionally, pollutants are generated from the WVS through construction, demolition, and maintenance (e.g., storage and use of compressed gasses, management of lead-based paint and asbestos-containing materials, and use of other hazardous materials); operations and maintenance of adult fish facilities and hatchery facilities; use of diesel trucks during trap and transport operations; and the operations and maintenance of oil-filled equipment (Section 3.16, Hazardous Materials). Additionally, the proliferation of invasive species around reservoirs has required pesticides (primarily herbicides) to be used throughout the analysis area on an as-needed basis (Section 3.6, Vegetation).

The greatest concern from hazardous material release into the environment in the WVS is due to the operation of oil-filled systems, which are primarily at hydropower-generating facilities (Section 3.16, Hazardous Materials, Subsection 3.16.2.6, Oil Spills and Above-ground Storage Tanks; Subsection 3.16.3.2, Alternatives Analyses, Oil-filled Systems). The environmental effects of oil spills can vary depending on the amount and type spilled and the character of the receiving water body.

Risk of WVS-generated hazardous material reaching water sources is minimized through Best Management Practices (BMPs), compliance with Federal and state regulations, and Occupational Safety and Health Administration and USACE hazard communication and training programs (Section 3.16, Hazardous Materials).

Substrate

The capacity of aquatic habitat to support fish and invertebrate populations in part depends on substrate characteristics as well as depth and velocity of water which in turn influence the size of substrate at the reach scale. Each fish species has adapted to spawn and feed in aquatic habitat with specific substrate types and sizes.

Sedimentation processes have been altered in the Willamette River Basin because of the construction of the WVS dams. Dams block sediments from moving downstream and reduce the quality of substrates available for fish spawning and feeding in these downstream reaches. Reductions in peak flows from the operation of dams and construction of revetments also has affected channel forming processes that redistribute sediment and create habitat within primary river channels and within the larger floodplain. Land use practices, including gravel mining activities within the floodplain, have further impacted sedimentation processes.

Reservoir/Lake-like Habitat

Dam construction causes large-scale changes to habitat types in rivers and streams by creating reservoirs with more lake-like habitat characteristics in portions of watersheds. These changes in habitat types results in differences in fish species distribution, abundance, assemblages, suitability, productivity, and predator/prey relationships than inhabited water systems prior to dam construction. These habitat changes often favor non-native and/or invasive fish species that compete with and prey on native fish species.

Three different habitat zones can be described for most reservoirs impounded by dams (Hjort et al. 1981). The first zone is the forebay area nearest the dam, which is typically lake-like habitat. At the upstream end of the reservoir is a second zone that tends to be shallower than lake-like habitat and has substantial flow velocities. The third zone, between the forebay and the upstream end of the reservoir, is a transition area that changes from riverine to more lake-like in the downstream direction toward the forebay. Each zone can include several habitat sub-types; however, most can be characterized as either nearshore and backwater (including sloughs) or open-water habitats (Hjort et al. 1981; Benda et al. 2015; LaBolle 1984). The extent of these three conceptual zones in WVS reservoirs varies seasonally and daily due to fluctuation in reservoir pool volumes.

Due to shallower water depths, nearshore and backwater areas in reservoirs can provide comparatively warmer temperatures and can include submergent and emergent vegetation depending on the seasonal stability in pool levels. Non-native, resident fish species that spawn in these areas include bass, crappie, bluegill, pumpkinseed, yellow perch, brown and black bullhead, and carp. Many of these species spawn from May through mid-July. Channel catfish and bullhead also spawn in analysis area backwaters. Reservoir nearshore and backwater areas support a high concentration of zooplankton, which attracts small fish species. This in turn allows for large, predatory fish to inhabit a reservoir and to prey on small fish.

Open water is deeper and has less structure than nearshore and backwater areas. Species that spawn in open water include native minnows, suckers, and sandroller. The amount of predation around dams depends on multiple factors, including species and proximity to suitable predator habitat (Petersen 1994; Venditti, Rondorf, and Kraut 2000; McHugh et al. 2012; Evans et al. 2016).

Most native resident fish species in the Willamette River Basin evolved to spawn in flowing waters in tributary streams. Once reservoirs were constructed, some species have since used reservoir habitat to spawn, rear and forage. Other native species continue to spawn in streams and use reservoirs to rear and forage.

Reservoir water surface elevation, water retention time, and dam discharges influence entrainment rates[23] of fish and nutrients through dams. As with riverine drawdown zones described above, biological resources such as plants, invertebrates, and fish life stages within substrates cannot survive periodic shoreline inundation and reservoir draining patterns.

Aquatic Vegetation and Large Woody Debris

Aquatic vegetation in rivers and reservoirs can be important habitat for fish and other aquatic life. Examples of fish habitat provided by aquatic vegetation include aquatic grasses in shallow reservoir areas that provide spawning habitat to species that attach their eggs to vegetation or vegetative cover that predatory fish use to lie in wait for prey. Trees in riparian zones provide shade that reduces water temperatures, are a source of large woody debris that serves as habitat for fish, and deliver organic matter to streams supporting primary and secondary productivity in a river system.

Non-native aquatic vegetation can be detrimental to native fish communities because it can increase water temperatures, provide cover for non-native predators, and can adversely affect flows. Aquatic vegetation (also known as macrophytes) in shallow, slow-moving areas along rivers that is in over-abundance is typically not native (i.e., invasive).

In recent years, around the time the alternatives were analyzed, some reservoirs had not been filled because of drought, early drawdowns, and summer low water (Section 3.6, Vegetation, Subsection 3.6.2.2, Vegetation Associated with Reservoirs). This reservoir condition has fostered establishment of novel communities of disturbance-tolerant plants in the analysis area.

Aquatic invasive plant species are known to establish in drawdown zones and are found in all WVS reservoirs (Section 3.6, Vegetation, Subsection 3.6.2.5, Invasive Plant Species; Section 3.6.2.6, Subbasin Plant Community Descriptions). Drawdown zones support areas around the reservoir perimeter where soil saturation is affected by water level fluctuations, creating opportunities for invasive disturbance-tolerant species to rapidly spread and to colonize in new locations (Section 3.6, Vegetation, Subsection 3.6.2.2, Vegetation Associated with Reservoirs). Invasive vegetation can be detrimental to native fish communities because it can increase water temperatures, provide cover for non-native predators, and can adversely affect flows.

USACE began a reservoir survey program in 2023 to analyze vegetative ecosystem responses to water management (Section 3.6, Vegetation, Subsection 3.6.2.2, Vegetation Associated with Reservoirs). Surveys will document invasive plant growth, species, etc., and will result in recommendations for invasive plant management, such as restoration planning and monitoring, in applicable WVS reservoirs. These recommendations may be incorporated into operational planning during the 30-year implementation timeframe.

[23] Entrainment rates are the metric of unintentional passage of organisms through regulating outlets, turbines, or spillways.

The hydrologic regime from reservoir operations also allows for disturbance-tolerant wetlands to form around many reservoirs despite winter drawdowns (Section 3.7, Wetlands). Wetlands support vegetative communities composed of native and invasive species and provide habitat for aquatic species around WVS reservoirs. The ecosystem services provided by these wetlands are limited, however, because species assemblages are dominated by disturbance-tolerant vegetation.

Large woody debris generally refers to dead trees, branches, limbs, and logs. It provides a variety of environmental and stream function benefits and contributes to habitat complexity. For example, large woody debris can:

- Promote spawning gravel accumulation by stopping gravel from moving downstream.
- Promote pool formation behind material, which provides important juvenile rearing habitat, as well as habitat for all fish during periods of low flows.
- Slow stream speed, which helps with upstream fish movement and energy expenditures of rearing juveniles as they maneuver currents.
- Provide shade that provides cooler water in adjacent areas and can help to lower the temperature of an entire stream.
- Provide refuge from predators.
- Promote bank stability, erosion prevention, and decreases in sediment movement harmful to downstream fish habitat.
- Supply fish food by trapping organic matter and providing habitat for insects and invertebrates (Beechie and Sibley 1997).

Dams prevent large woody debris from distributing downstream. Additionally, flood risk reduction measures (e.g., revetment maintenance) directly removes large woody debris from the analysis area.

Aquatic Habitat Connectivity

Connectivity, or the ability for aquatic species to move between different aquatic habitat areas, is an important part of species survival. Connectivity is necessary for fish to find appropriate habitat conditions, mates for spawning, and food resources as habitat needs change with environmental variability and with species life history. Rivers are also important in connecting various terrestrial and aquatic habitats.

A key aspect of aquatic habitat connectivity is the ability of fish to access the types of habitat that support specific life stages, such as spawning, rearing, migrating, and foraging habitat. This applies to anadromous species that migrate long distances from the ocean into upper tributaries for spawning and rearing, but also applies to resident fish species that migrate between tributaries and reservoir habitats that can become disconnected at lower pool elevations.

Construction and operation of Federal and non-Federal dams in the Willamette River Basin have impacted connectivity by blocking access for upstream migrating fish (Chapter 1, Introduction, Section 1.7.1, Dams and Reservoirs; Section 1.8, Non-U.S. Army Corps of Engineers-managed Dams in the Willamette River Basin). Dams have resulted in survival and passage rate reductions for downstream migrating fish. Downstream, dam operations affect migratory fish corridors by changing stream flow patterns and altering natural water temperature regimes that in many areas can cause delay of migration or form thermal barriers. Loss of connectivity in the analysis area has caused loss and fragmentation of anadromous and resident fish populations.

Floodplain connectivity in the context of aquatic habitat refers to (1) the ability of a river to move water into the adjacent landscape and (2) the ability of aquatic species to access aquatic habitats such as backwater sloughs, ponds, wetlands, and side channels. This connection between the river and its adjacent floodplain areas is important to many fish species to find appropriate habitat for spawning, rearing, and overwintering life stages, and other essential aquatic ecosystem functions.

Many of the WVS dams have blocked access to habitat used by salmon and steelhead for spawning and habitat connectivity to areas above and below dams used by native, resident, stream-dwelling species. Further, some stream habitat used by these species was eliminated where reservoirs were created behind WVS dams. Downstream of dam sites, operation of dams and reservoirs have altered flow regimes by decreasing peak winter flows, reducing access to seasonal floodplain habitat (Rounds, 2010; Graf 2006).

Streambank Modifications

USACE manages and maintains bank protection structures (i.e., revetments, levees, embankments) along the Mainstem Willamette River and the following tributaries: Row, Calapooia, Coast Fork and Middle Fork Willamette, McKenzie, South Santiam, North Santiam, Santiam, Molalla, and Clackamas Rivers and Mill Creek (Chapter 1, Introduction, Section 1.7.2.1, Bank Protection Projects and Regulatory History). Of these structures, a levee reduces flooding, a revetment reduces erosion, and an embankment redirects flow.

Bank protection structures eliminate localized habitat complexity, which is important for native fishes. These structures altered shorelines and connectivity to side channels, oxbows, and other off-channel features of importance to juvenile salmon during rearing and their freshwater migration downstream to the ocean as well as use by other native fishes. However, bank protection structures can provide some cover shelter for smaller fish in areas where shorelines are severely degraded and provide habitat for non-native species.

Bank protection projects were constructed along the Willamette River and its major tributaries (Appendix S, USACE-managed Dams, Reservoirs, and Bank Protection Structures). The projects cleared, sloped, and armored riverbanks; constructed pile and timber bulkheads and drift barriers; and conducted minor channel improvements and maintenance of existing construction. Projects are composed of one or more structures and include additional structures associated with emergency repairs.

At the time the alternatives were analyzed, there were 193 active projects in the Willamette River Bank Protection Program, categorized as either USACE-maintained or non-USACE-maintained.

Revetments typically consist of large stones placed along the riverbank to prevent the bank from eroding further and protect adjacent property. The stone revetments often have accessory structures like drift barriers, which are placed at the mouth of high-water overflow channels to collect debris and to reduce the velocity of flows into the channel. Stone revetments can also include groins, which extend into the channel diagonally or perpendicularly to the riverbank to reduce near bank velocities. Revetments are typically placed on the outside of a river bend where erosion is most likely to occur and sometimes also include the realignment or straightening of the main channel (Figure 3.8-16).

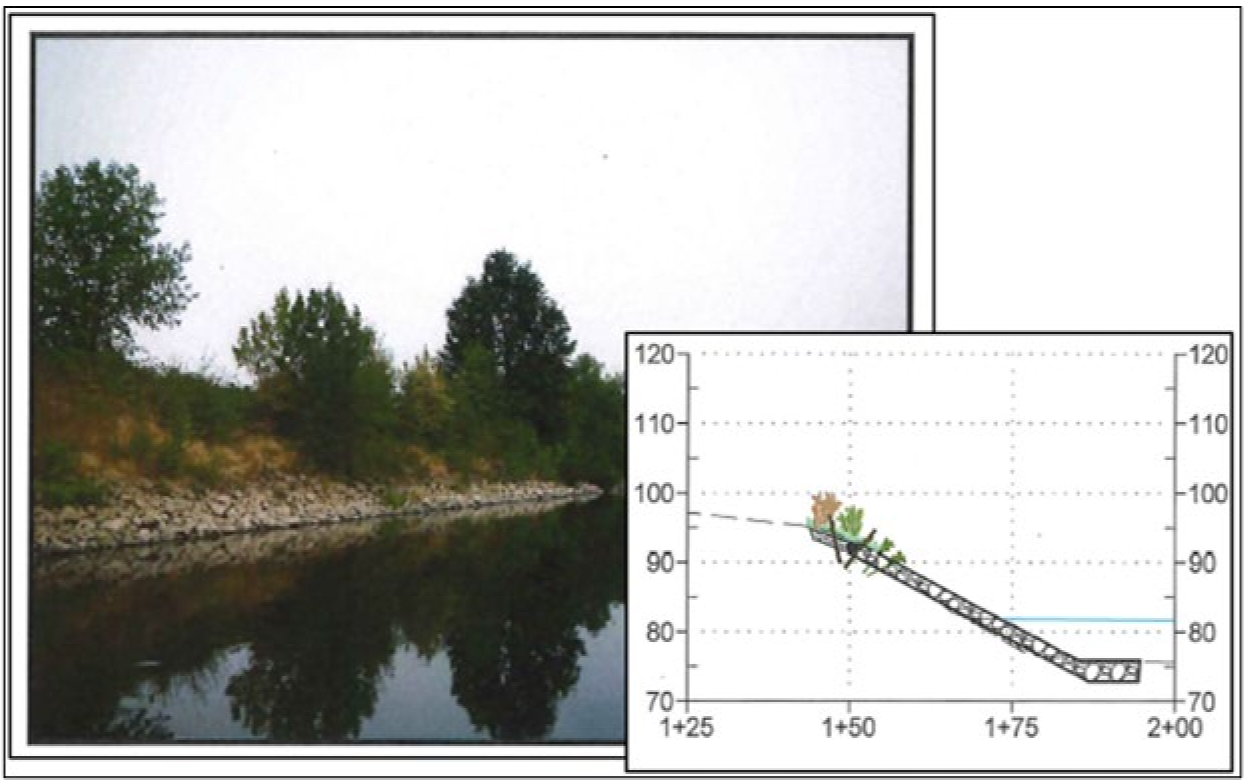

Figure 3.8-16. Example Willamette River Revetment North of Salem, Oregon with Typical Cross Section.

Levees and embankments have also been constructed by USACE in the Willamette River Basin. Levees are designed to protect an area from high flood waters and typically connect to high ground on either side. There will necessarily be a water surface elevation differential inside and outside of the levee.

Embankments increase channel capacity (as along the Long Tom River downstream of Fern Ridge Dam) but can be designed for other purposes. Importantly, neither embankments nor revetments are designed to protect an area from flooding and generally have similar water surface elevations on both sides.

Along with the lower water levels due to flood risk reduction operations, revetments can have the effect of partially restricting previously active floodplain interaction with the main channel where revetments isolate previously connected low areas. Suspended sediments passing into the floodplain over the revetments will then fall out of suspension in the lower energy areas behind the structure and, over the course of years, fill in previously active areas with fine sediment.

Because the revetments constrain lateral movement of the river, the material in the banks is no longer available to be eroded and transported downstream as bed and suspended sediment load. Bed and sediment load are important for creating aquatic habitat. When suspended sediment is high causing high turbidity, it can also negatively impact fish (e.g., impaired respiration, impaired foraging, physical injury leading to disease, etc.).

3.8.2.5 Willamette River Basin and Analysis Area Subbasins

Fish Assistance

Adult Fishway: an in-river ladder that helps fish to maneuver past a barrier such as Willamette Falls.

Adult Fish Facility: a facility located downstream of dams where fish are collected to be transported and released upstream of dams or for hatchery program purposes.

Fish Hatchery: a facility to breed and raise fish for release into streams and lakes.

The Willamette River Basin has undergone substantial man-made alterations and simplification since the 1850s (Krass et al. 2021), including navigation channel maintenance; construction of the Willamette Falls adult fishway in the late 1880s; construction and installation of dams and revetments and other structures for bank protection during the 1950s and 1960s; agricultural, industrial, and urban development; and population growth.

The Willamette Falls adult fishway was constructed to increase upstream anadromous fish migration opportunities at the existing Willamette Falls, which presented a natural passage barrier under seasonally low flows. Construction of this fish ladder allowed for extended timing of upstream annual migrations of some fish species in the Willamette River Basin and provided access to some fish species that were previously unable to migrate upstream into the basin (Bennett 1986).

When WVS dams were constructed, upstream and downstream passage structures for salmonids were included at Fall Creek, Cougar, Green Peter, and Foster Dams; however, these were found ineffective and were abandoned. Several actions have been completed, especially over the 10 to 15 years prior to alternatives analyses, to restore anadromous fish access to habitat upstream of WVS dams.

USACE operates and maintains adult fish facilities located at Foster, Fall Creek, Minto (downstream of Big Cliff), Cougar, and Dexter Dams to help reduce adverse passage effects from WVS dams and to assist with upstream fish migration. In addition to serving hatchery programs, these facilities have been redesigned to accommodate adult salmon and steelhead collection, sorting, outplanting, recycling (summer steelhead), monitoring, and juvenile acclimation of spring-run UWR Chinook salmon (Chapter 1, Introduction, Section 1.9.3, Adult Fish Facilities).

Operation of these facilities allows the collection, transport, and release of adult UWR Chinook salmon and steelhead upstream of WVS dams in these river subbasins to spawn. Although the design and current operations of the facilities at the time the alternatives were analyzed is focused on UWR spring-run Chinook salmon and UWR winter-run steelhead, adult fish facilities are also used to pass any native fish species that are collected during the trap operations, including bull trout and lamprey (Figure 3.8-17). Due to the lack of lamprey trapping infrastructure, lamprey passage is very rare. Use of a surface spillway weir at Foster Dam (Figure 3.8-18), spillway operations at Detroit Dam and Lookout Point Dam, and annual reservoir drawdown to riverbed elevation at Fall Creek Dam have been implemented to improve downstream fish passage (See also Chapter 2, Alternatives, Section 2.8.2.5, Use Spillways to Release Warm Surface Water in Summer (721); Section 2.8.3, Downstream Fish Passage Measures).

Figure 3.8-17. Screw Traps Downstream of Cougar Dam.

Photo by: Tom Conning (USACE Media Images Database)

Note: Water flow turns a large screw in the traps creating hydraulics that keep small fish from escaping.

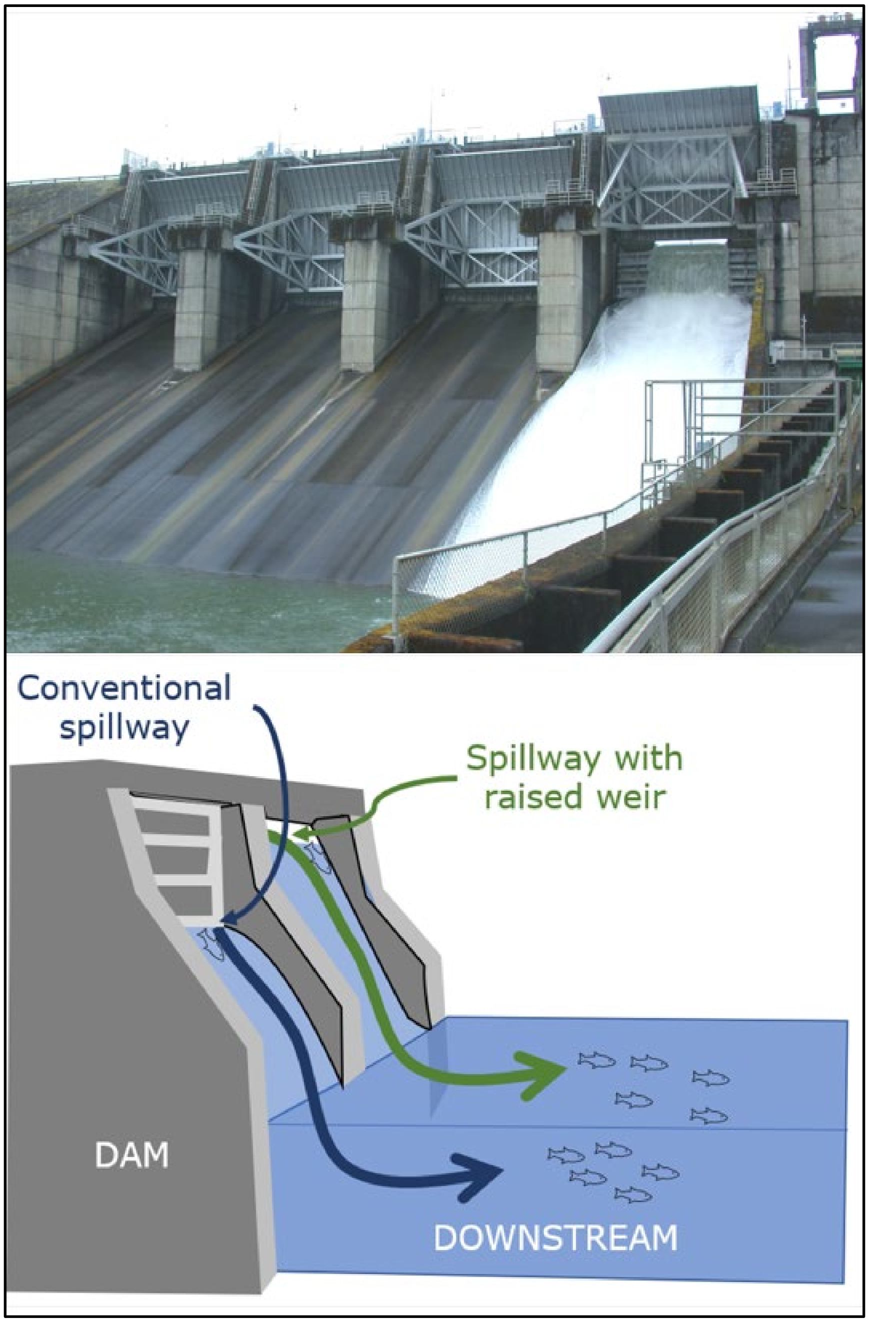

Figure 3.8-18. Foster Dam Fish Weir (top) and General Weir Configuration (bottom).

Additional improvements to downstream fish passage and water temperatures have been implemented at several dams. These improvements have been made by changing dam operations and by constructing adult fish release sites at spawning grounds upstream of reservoirs with road access improvements. Research has been completed to assess fish responses to WVS operations and maintenance.

While it is generally accepted that upstream passage can be accomplished through appropriate infrastructure (i.e., fish ladders) or BMPs (i.e., adult fish facilities), downstream passage effectiveness is less certain. Potential solutions are complicated by large reservoir elevation fluctuations associated with flow management, particularly for flood risk management, and fish passing through dam outlets where mortality is high (e.g., turbines).

Five hatcheries were also constructed in the analysis area under the Willamette Hatchery Mitigation Program (Section 3.8.2.3, Willamette Hatchery Mitigation Program). Descriptions of these hatcheries are provided in the analysis area subbasin descriptions below.

North Santiam River Subbasin

USACE operates Detroit and Big Cliff Dams in the North Santiam River Subbasin. Operations have caused a decrease in the frequency and magnitude of floods, an increase in low flows (Risley et al. 2012), blockage of access for upstream migrating fish, and reduction in the survival and passage rates of downstream migrating fish (ODFW and NMFS 2011). Downstream, three diversion dams also exist that affect fish passage and stream flows to a lesser extent. River channels of the middle and upper river reaches of the subbasin are constrained. The lower reach of the river, near the Willamette River confluence, is mainly composed of a wide, unconstrained floodplain.

Approximately 70 percent of the basin is forested, which has been altered by land use and historical logging (Dykaar and Wigington 2000). Logging practices have affected basin hydrology, reducing large wood within streams and rivers and removing shade, which has increased water temperatures in some locations. Wildfires in 2020 substantially affected riparian zones above and below Detroit and Big Cliff Dams. However, the Santiam River variably provides adequate streamflow for fish and aquatic invertebrates (Wevers et al. 1992; R2 Resources 2014).

The North Santiam River Subbasin supports diverse populations of anadromous and resident fish species and aquatic organisms. These fish species are a mix of native and non-native (i.e., introduced) species. ESA-listed fish species include UWR Chinook salmon and UWR steelhead. ESA-listed bull trout have been extirpated since the mid-1940s; however, USFWS has indicated that bull trout will be reintroduced upstream of Detroit Reservoir during the 30-year implementation timeframe (USFWS 2023). Pacific lamprey and Oregon chub are restricted to the North Santiam River downstream of Big Cliff Dam.

Primary gamefish species targeted for sportfishing in Detroit Reservoir include Chinook salmon, cutthroat trout, rainbow trout, brook trout, largemouth bass, kokanee, and brown bullhead. Large numbers of hatchery salmon and trout are released annually in the subbasin, including into Detroit Reservoir.

Only managed species or those with special status are discussed below due to the lack of data available on other native and non-native species in the subbasin.

Detroit and Big Cliff Dams

Adult hatchery-origin UWR Chinook salmon are outplanted above Detroit Dam. The number of natural-origin adult Chinook salmon released above the dam has been limited due to concerns with existing downstream fish passage conditions. Adult hatchery-origin Chinook salmon are collected at the Minto Adult Fish Facility downstream of Big Cliff Dam and transported by truck to spawn naturally in streams above Detroit Reservoir. To complete their migration to the ocean, juvenile progeny must pass downstream of Detroit Dam using the available spillway, the turbine penstocks, or through regulating outlets. The number of fish passing downstream and fish passage survival through these routes is often low under existing operations (Hansen et al. 2017) (Appendix E, Fish and Aquatic Habitat Analyses).

Hatchery-origin adult returns to Minto Adult Fish Facility have met both broodstock and conservation needs in 60 percent of return years (ODFW and USACE 2016a). The hatchery effects to natural-origin fish in the North Santiam River Subbasin vary with respect to disease transmission, transfer of genetic material, and density-dependent predation and competition (NMFS and ODFW 2011). Pre-spawn mortality of adult UWR Chinook salmon in the North Santiam River Subbasin is relatively low compared to other subbasins (e.g., Keefer et al. 2019).

Active building of Chinook salmon redds occurs both upstream and downstream of USACE dams (Sharpe et al. 2018; Mapes et al. 2017). Passage and survival rates of juvenile Chinook salmon through these routes under existing operations have not resulted in re-establishment of a sustainable population above the Detroit Dam, although female cohort[24] replacement rate[25] greater than 1 above USACE dams has been documented for some cohorts (O'Malley et al. 2015; O'Malley et al. 2023).

Fish assumed to be natural-origin UWR Chinook salmon (because they are unmarked) and UWR steelhead collected at the Minto Adult Fish Facility are generally released below Detroit Dam by ODFW into a 4-mile reach between Minto and Big Cliff Dams. Emergency and contingency operations are in place particularly for dry years, and natural-origin fish were transported above Detroit Dam in 2015. In recent years, natural-origin fish have also been placed above Detroit Reservoir based on pedigree analysis results indicating higher adult returns from spawners above Detroit Dam occur in comparison to those below (O'Malley et al. 2023).

TDG between Minto Dam and Big Cliff Dam exceeds environmental thresholds (greater than 110 percent) during flood control operations. There is concern that spawning fish and incubating eggs are negatively impacted during these periods of supersaturation. USACE manages TDG by releasing water from multiple dam routes (i.e., regulating outlets, turbines, and spillways) and by spreading spill over multiple spill bays when possible.

[24] Cohort refers to a group of fish spawned during a given period, usually within a year.

[25] Cohort replacement rate refers to the number of adults that return to spawn in a given location compared to the number of adults that were transported upstream to produce those fish (Kock et al. 2021).

Willamette River Basin temperatures tend to be too cool in the summer and too warm in the fall when compared to natural non-normative river temperature patterns and effects on native fish (e.g., upstream migration of adult Chinook salmon). To address non-normative temperatures for fish, USACE operates dams to achieve environmental flows (i.e., e-flows) (Chapter 1, Introduction, Section 1.11.2.4, Operational Considerations for Environmental Flows) and uses controlled water releases to manipulate temperature for ESA-listed species downstream of Detroit Dam when reservoir elevation is above spillway crest. This release dampens the downstream effects of non-normative temperatures on fish. These releases are effective during most of the year except during fall drafting, when only warmer surface waters are available for release. This results in winter water temperatures that are warmer than usual, which may disrupt UWR Chinook salmon and UWR steelhead spawning and migration and accelerate egg incubation and emergence timing.

Marion Forks Hatchery and Minto Adult Fish Facility

Marion Forks Hatchery is located along Marion and Horn Creeks about 17 miles east of Detroit, Oregon, along Highway 22. The hatchery is at an elevation of 2,580 feet above sea level. The Marion Forks Hatchery and Minto Adult Fish Facility are managed by ODFW.

Marion Forks Hatchery was constructed in 1951 to compensate for the loss of salmon and steelhead habitat caused by construction of the Detroit and Big Cliff Dams. USACE originally constructed the Minto Adult Fish Facility below Big Cliff Dam to collect adult UWR Chinook salmon as broodstock to supply eggs for the hatchery (Figure 3.8-19). A major reconstruction and updating of the Minto Adult Fish Facility was completed in 2013. Hatchery fish production goals are described in Section 3.8.2.3, Willamette Hatchery Mitigation Program.

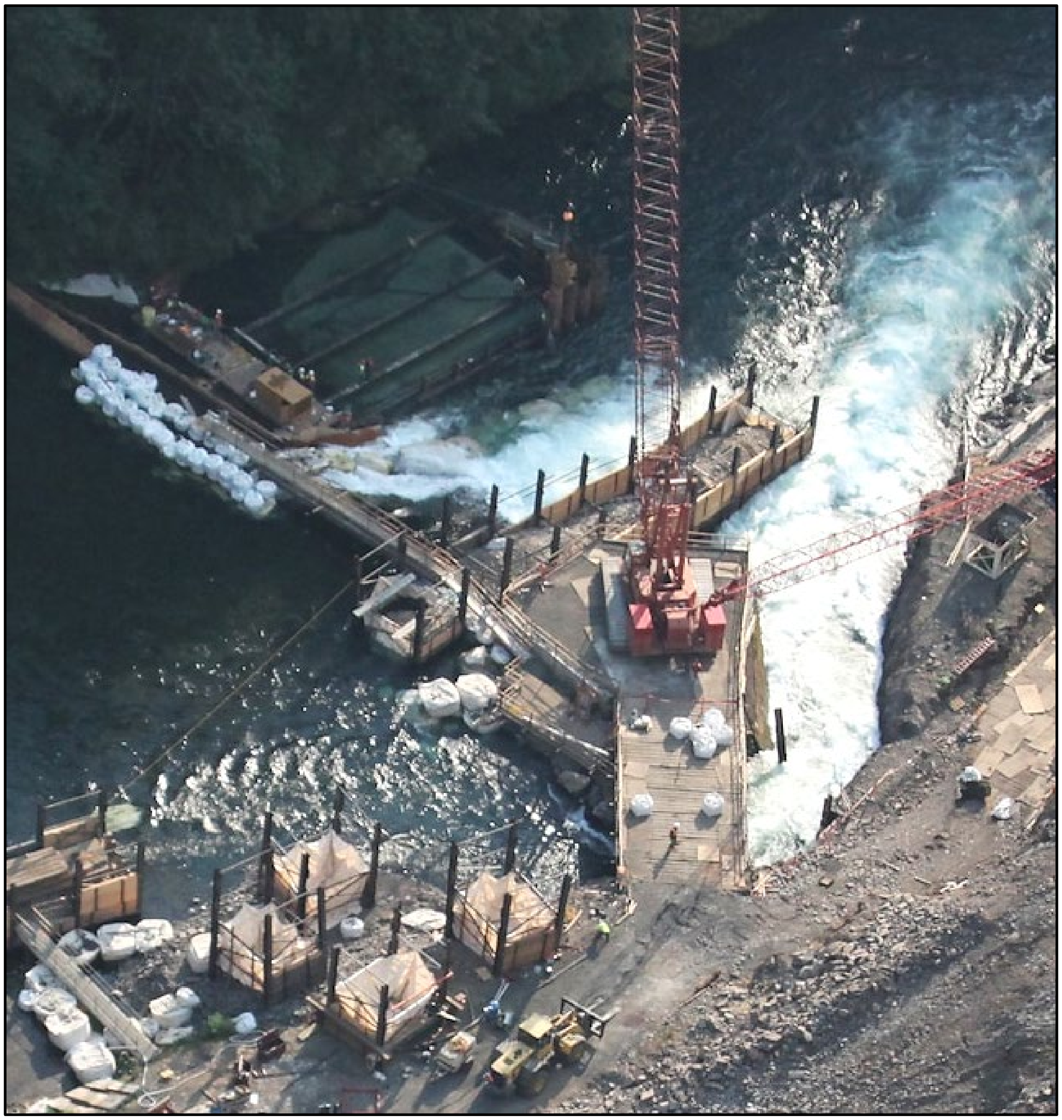

Figure 3.8-19. Minto Adult Fish Facility Construction.
Unknown photo credit (USACE Media Images Database)

South Santiam River Subbasin

USACE operates Green Peter and Foster Dams in the South Santiam River Subbasin. Operations have decreased flood frequency and magnitude, impeded or blocked access for upstream migrating fish, and reduced survival and passage rates of downstream migrating fish (ODFW and NMFS 2011). Located downstream of WVS dams, Lebanon Water Diversion Dam affects fish passage and stream flows to a lesser extent. Additionally, same as the North Santiam River Subbasin, the South Santiam River Subbasin is characterized by historically depleted riparian habitat and effects of forest practices that have reduced large wood in streams and in some locations scoured sediment from riverbeds as a result of splash dams[26].

ESA-listed fish species in the South Santiam River Subbasin include UWR Chinook salmon and UWR steelhead. Pacific lamprey and Oregon chub are restricted to the river area downstream of Foster Dam.

Primary gamefish species targeted for sportfishing in Green Peter and Foster Reservoirs include rainbow trout, largemouth bass, kokanee, black crappie, smallmouth bass, and bluegill. Stocked species in Green Peter Reservoir include rainbow trout and kokanee (although not in recent years based on information available at the time the alternatives were analyzed).

River channels upstream of USACE dams are constrained by narrow mountain valleys, while the lower reach of the South Santiam River is mainly composed of a wide, unconstrained floodplain. Northern pikeminnow (*Ptychocheilus oregonensis*) are a native predator of juvenile salmonids and other fishes (Figure 3.8-20); however, most predation on juvenile salmon is from non-native fish species, namely bass and stocked rainbow trout (ODFW 2014). For example, in spring 2022, a captured hatchery rainbow trout contained 11 radio tags from fish released by Pacific Northwest National Laboratories (Larson et al. 2024). Phytoplankton abundance, primarily blue-green algae and diatoms, generally increases further downstream from the dams (Altman et al. 1997).

Figure 3.8-20. Northern Pikeminnow (*Ptychocheilus oregonensis*).

[26] A splash dam was a temporary wooden dam used to raise the water level in streams to float logs downstream to sawmills.

Approximately 59 percent of the usable spawning habitat for UWR Chinook salmon in the South Santiam River Subbasin is located below Foster Dam, 30 percent is located above Foster Dam, and 10 percent is located above Green Peter Dam (Table 3.8-3). The pHOS below Foster Dam for UWR Chinook salmon is very high and has a high potential to continue unless releases of hatchery-origin Chinook salmon are reduced.

Research on UWR steelhead indicates substantial overlap in geographic locations in the South Santiam River Subbasin and in timing of presence with hatchery-origin summer-run steelhead at the juvenile stage (Harnish et al. 2014). There is also overlap between UWR steelhead and hatchery-origin summer-run steelhead spawners. The transfer of genetic material through interbreeding between hatchery-origin summer-run steelhead and native UWR steelhead in the subbasin and the entire Willamette River Basin is an ongoing impact (Weigel et al. 2019a). The transfer of genetic material associated with non-native steelhead above Foster Dam may also be promoted through the trap and transport program (Weigel et al. 2019b). The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (ODFW and NMFS 2011) indicates that 18 percent of available spawning habitat for steelhead is located above Foster Dam.

A passage program for UWR Chinook salmon and UWR steelhead exists at Foster Dam. Downstream fish passage occurs using a combination of a weir and special spillway operations to support downstream passage of smolts and kelts. Upstream passage occurs using a trap and transport approach from the Foster Adult Fish Facility.

Cold water releases from Foster Dam discouraged returning UWR Chinook salmon adults migrating upstream from entering the ladder at the Foster Adult Fish Facility. As a result, USACE reduced the effects of temperatures on adult collection rates by using temporary actions for spill that also support juvenile passage downstream of Foster Dam. The spillway weir is used to skim warm surface waters thereby encouraging adults to enter the Foster Dam fish ladder. The natural-origin population of UWR Chinook salmon above Foster Dam is not supplemented with placement of hatchery-origin Chinook salmon; however, the population abundance has declined in recent years (NWFSC 2022; O’Malley et al. 2024). There was no transport of UWR Chinook salmon nor UWR steelhead above Green Peter Dam at the time the alternatives were analyzed. Bull trout have been extirpated from the South Santiam River.

Green Peter and Foster Dams

Historically, UWR Chinook salmon and UWR steelhead were transported above Green Peter Dam. A fish ladder and lift were used to transport adults and a high head bypass system was used to pass juveniles downstream of the dam (USACE 1995). These passage systems were abandoned for several reasons (USACE 1995).

The fish ladder used deeper and cooler water from Green Peter Reservoir, resulting in a temperature differential that discouraged adults migrating upstream from entering the fish ladder. Additionally, hydropower-peaking operations at Green Peter Dam resulted in substantial daily alterations in river flows below the dam, which also likely discouraged or impeded upstream passage of adult UWR Chinook salmon and UWR steelhead. Finally, in-reservoir juvenile survival was likely low as a result of high predation rates from resident fish in the reservoir before passage systems were abandoned.

At the time the alternatives were analyzed, UWR Chinook salmon and steelhead were not trapped and transported above Green Peter Dam and, therefore, no returning adults originate from upstream of Green Peter Dam. No juveniles occur in Green Peter Reservoir, with the exception of those occurring as part of a small adfluvial population. If UWR Chinook salmon and UWR steelhead were reintroduced above Green Peter Dam, cold water discharges from Green Peter Dam, hydropower-peaking operations, and predation on juvenile fish within Green Peter Reservoir would continue to adversely affect UWR Chinook salmon and UWR steelhead.

A relict population of adfluvial (i.e., landlocked) spring-run Chinook salmon has been documented to successfully reproduce above Green Peter Dam (Romer and Monzyk 2014). This population is most likely natural origin, originating from previous releases of hatchery juvenile outplants that were landlocked and successfully matured and reproduced.

Trap and transport operations are conducted downstream of Foster Dam at the Foster Adult Fish Facility to transport UWR Chinook salmon and UWR steelhead above Foster Dam and Reservoir. Natural-origin adults (i.e., those not marked with an adipose fin clip) that enter the fish ladder at the Foster adult fish facility are outplanted near the head of Foster Reservoir or into upstream river reaches. Hatchery-origin fish marked with a clipped fin that enter the fish ladder are not outplanted above Foster Dam.

Cold water from hydropower-peaking operations at Green Peter Dam decreases ladder temperatures below Foster Dam and can discourage adults from entering the fish ladder when temperature differences between the ladder and the incoming stream below Foster Dam are too great (Keefer et al. 2018a). Foster Dam fish ladder improvements were being designed at the time the alternatives were analyzed to increase temperatures and for adult collection efficiency.

Juvenile salmon migrating downstream were historically passed through a removable spillway weir but are now passed downstream primarily using a targeted spill operation. USACE redesigned the original spillway weir to improve passage conditions, and although passage rates increased, higher injury rates for juveniles passing downstream occurred from the redesign, particularly for UWR steelhead kelts (Liss et al. 2020). When possible, spill operations at night are also targeted for juvenile Chinook salmon, steelhead, and kelt downstream passage. At the time the alternatives were analyzed, USACE was investigating improvements to the Foster Dam spillway weir design and other structural options to decrease injury rates, particularly for UWR steelhead.

South Santiam Hatchery

South Santiam Hatchery and the Foster Adult Fish Facility are located on the South Santiam River just downstream from Foster Dam, 5 miles east of Sweet Home, Oregon. The hatchery is at an elevation of 500 feet above sea level.

The South Santiam Hatchery began operations in 1968 and is operated for egg incubation and juvenile rearing. In July 2014, the Foster Adult Fish Facility was completed, which housed brood stock and eliminated the need to transport adult salmon. ODFW operates the hatchery and the collection facility for the rearing of spring-run Chinook salmon and summer-run steelhead. Hatchery fish production goals are described in Section 3.8.2.3, Willamette Hatchery Mitigation Program.

McKenzie River Subbasin

Cougar Dam and Blue River Dam are operated by USACE in the McKenzie River Subbasin. Leaburg Dam and other dams in the subbasin are operated by the Eugene Water and Electric Board, located along the Mainstem McKenzie River. Dams downstream from the Cougar and Blue River Dams provide for fish passage.

ESA-listed fish species found in the McKenzie River Subbasin include UWR Chinook salmon and bull trout. State sensitive species include Pacific and western river/western brook lamprey, Oregon chub, coastal cutthroat trout, and rainbow trout.

The McKenzie River Subbasin is heavily stocked with rainbow trout from Leaburg Dam to Blue River Dam. Primary gamefish species targeted for sportfishing in Cougar Reservoir include native cutthroat trout, largemouth bass, smallmouth bass, crappie, walleye, and catfish. Gamefish in Blue River Reservoir include native and hatchery rainbow trout, native cutthroat trout, largemouth bass, back crappie, bluegill, and white crappie.

The McKenzie River Subbasin contains the least degraded habitat among the Willamette River subbasins, and most environmental flow objectives are consistently met (Wallick et al. 2018) (Chapter 2, Alternatives, Section 2.10.2.2, Environmental Flow Operations). This is partially because agricultural and municipal withdrawals are less than in other subbasins (Risley et al. 2010). As a result of dam operations in the subbasin, flood flows and sediment transport have decreased (Risley et al. 2010). Local bull trout populations are located in the McKenzie River Subbasin (Altman et al. 1997; Zymonas et al. 2021).

The WVS in the McKenzie River Subbasin impacts ESA-listed UWR Chinook salmon and bull trout primarily through blocked passage at Cougar Dam (the reach above Blue River Dam did not historically support anadromous salmonids), changes to channel morphology, habitat degradation, predation impacts on juveniles from the summer steelhead and rainbow trout stocking program, and fisheries associated with the release of hatchery fish. The McKenzie River Subbasin UWR Chinook salmon population is a “genetic legacy” population (most genetically intact and a likely source for species recovery) (NMFS and ODFW 2011). A wide range of Chinook salmon juvenile life history migratory strategies have been documented in the McKenzie River Subbasin (i.e., fry, sub-yearling, and yearling outmigrants) (NMFS and ODFW 2011). Approximately 11 percent of the usable spawning habitat in the McKenzie River Subbasin is located above the WVS dams (Bond et al. 2017).

ESA-listed bull trout occur throughout the McKenzie River Subbasin. The 2008 USFWS Biological Opinion documents that the continued operation and maintenance of the WVS would adversely impact bull trout critical habitat through impoundment, habitat fragmentation, and a general decline in water quality (USFWS 2008). However, the bull trout population above Cougar Dam has increased in abundance and remained stable since 2008 following reintroduction (Zymonas et al. 2021).

The recovery plan for bull trout identifies non-anadromous populations of UWR bull trout within the Coastal Recovery Unit (USFWS 2015b). This unit includes populations in the McKenzie River and Middle Fork Willamette River Subbasin. Habitat connectivity for bull trout is restricted by Cougar Dam and is affected by high levels of TDG discharged from the dam (USFWS 2008; Ratliff and Howell 1992). Bull trout require cool temperatures and habitat complexity (Ratliff and Howell 1992).

Cougar Dam

The construction of Cougar Dam blocked access to historical spawning and critical habitat for UWR Chinook salmon and bull trout along the South Fork McKenzie River. Although the dam was built with upstream and downstream fish passage facilities, these were found ineffective and abandoned due to cool water discharge from Cougar Dam blocking upstream migration and collection of adult Chinook salmon for transport upstream to spawn, and poor downstream passage rates and survival for juvenile Chinook salmon migrating downstream through Cougar Dam (Ingram and Korn 1969). Since 2010, upstream migrating UWR Chinook salmon and bull trout have been effectively collected and transported above the dam using an adult fish facility rebuilt in 2010.

A water temperature control tower was constructed at Cougar Dam in 2005 and allows for temperature management of discharged water downstream, supporting effective attraction and collection of adult UWR Chinook salmon.

Unmarked adult UWR Chinook salmon passed above Cougar Dam are supplemented with hatchery-origin Chinook salmon per an HGMP (ODFW and USACE 2016d). Pre-spawn mortality in returning adult Chinook salmon above Cougar Dam is typically low (often less than 10 percent) but is between 30 percent and 40 percent in the lower mainstem McKenzie River below Leaburg Dam.

Downstream migrating fish must pass through existing routes, which include the regulating outlet or turbine penstocks. Unlike bull trout above Cougar Dam, re-establishment of a sustainable population of Chinook salmon has not yet been achieved above the dam in large part due to poor passage and survival rates of juvenile Chinook salmon through existing routes and operations (e.g., Sard et al. 2015; Hansen et al. 2017).

Blue River Dam

There is no fish passage above Blue River Dam, and there were no historical populations of anadromous salmon or steelhead above the dam. At the time the alternatives were analyzed, there was little information on the species that are present in Blue River Reservoir. The reservoir contains stocked rainbow trout.

Blue River Dam operations have impacts on downstream habitats through regulated discharge (Risley et al. 2010). Similar to other WVS operations, controlled releases at Blue River Dam result in non-normative temperatures downstream. With the exception of e-flows, USACE has not conducted operations for temperature control at Blue River Dam.

McKenzie and Leaburg Hatcheries

The McKenzie Hatchery was constructed in 1938 as a State of Oregon hatchery but was expanded by USACE in 1975 to mitigate the effects of USACE dams on UWR Chinook salmon within the McKenzie River Subbasin. The McKenzie Hatchery is managed by ODFW.

Leaburg Hatchery is located on the McKenzie River and was constructed in 1953 by USACE and is managed by ODFW. The hatchery is used to rear rainbow trout, summer-run steelhead, and spring-run Chinook salmon as well as to provide a temporary holding facility for cutthroat and rainbow trout fingerlings for stocking. It is currently being used to support the McKenzie Hatchery.

Hatchery fish production goals are described in Section 3.8.2.3, Willamette Hatchery Mitigation Program. Because of the conservation role of this hatchery program, USACE integrated conservation-oriented genetic protocols so that the McKenzie Hatchery would produce the entire mitigation requirement for spring-run Chinook salmon in the McKenzie River Subbasin.

In 2018, the water supply at McKenzie Hatchery was compromised due to structural integrity issues in Leaburg Canal that supplies the hatchery. To continue fish production, fish have been collected from two locations on the McKenzie River. The primary source of collection is at Leaburg Hatchery. Fish are also collected from a fish sorter located at the top of the left bank ladder, although in lower numbers. Broodstock are held at Leaburg Hatchery and at Foster Adult Fish Facility.

The raceways[27] at Leaburg Hatchery are designed for juvenile fish and are not deep enough for adults. Covers are placed over the raceways to avoid sunburn. Leaburg Hatchery does not physically have the capacity to incubate the number of fish that are required. Early stages of

[27] A hatchery raceway is a channel or series of tanks used in aquaculture to culture fish and other aquatic organisms.

rearing are taking place at McKenzie Hatchery. Once water conditions degrade, fish are moved to Leaburg Hatchery where they are reared until release.

Middle Fork Willamette River Subbasin

The Willamette River originates at the confluence of the Middle Fork Willamette and Coast Fork Willamette Rivers (Altman et al. 1997). Dexter, Lookout Point, Hills Creek, and Fall Creek Dams in the Middle Fork Willamette River Subbasin form a complete barrier to upstream fish passage, requiring adult fish facilities at the base of Dexter and Fall Creek Dams. These facilities are used for collection of hatchery brood and/or transport of adult Chinook salmon upstream of the dams. The older adult fish facility at Dexter Dam does meet NMFS fish passage guidelines, and a new facility was currently being designed and constructed at the time the alternatives were analyzed.

A new adult fish facility was completed at Fall Creek Dam in 2018. Approximately 65 percent of the usable spawning habitat for Chinook salmon in the subbasins is located upstream of Lookout Point Dam, 24 percent is located above Hills Creek Dam, and about 3 percent is located above Fall Creek Dam.

ESA-listed UWR Chinook salmon and bull trout, as well as Oregon chub (delisted in 2015), are present in the Middle Fork Willamette River Subbasin. Pacific lamprey also occur in the subbasin.

Primary gamefish species targeted for sportfishing in Dexter Reservoir include hatchery rainbow trout, small Chinook salmon, largemouth bass, smallmouth bass, brown bullhead, catfish, and white crappie. Crappie, coastal cutthroat trout, bull trout, and rainbow trout are found in Hills Creek Reservoir.

ODFW began transferring excess hatchery-origin adult UWR Chinook salmon above Dexter Dam and Fall Creek Dam in 1993. The NMFS Biological Opinion (2008) included continuation of this program as an experimental aide to UWR Chinook salmon reintroduction above Fall Creek, Lookout Point, and Hills Creek Dams, and bull trout reintroduction above Hills Creek Dam. Since 2009, only unmarked UWR Chinook salmon have been transported above Fall Creek Dam due to operational changes providing for improved downstream passage and leading to a sustainable population above Fall Creek Dam (O'Malley and Bohn 2018). However, adult return numbers have been lower in recent years at the time the alternatives were analyzed. This is in part attributed to high pre-spawn mortality of adults transported and released upstream due to harassment, poaching, and warm water temperatures (Carey et al. 2024). Juvenile offspring of hatchery adult outplants that spawned in streams above WVS reservoirs (or from natural adults released above Fall Creek Dam) migrate into these reservoirs annually (Romer et al. 2013).

The WVS in the Middle Fork Willamette River Subbasin affects ESA-listed UWR Chinook salmon and bull trout and has blocked passage along several reaches. Other impacts include altered hydrology, water temperatures, and habitat degradation through blocked access to spawning grounds due to the presence of dams or by inundation of headwaters from creation of reservoirs.

The accessible reach of the Middle Fork Willamette River Subbasin is lower in elevation than the other three subbasins and typically experiences high water temperatures where returning adult fish hold below dams prior to being collected and transported upstream to spawn. This contributes to high rates of pre-spawn mortality and predation rates in WVS reservoirs, particularly above Lookout Point Dam. Furthermore, habitat degradation downstream of USACE dams may not provide suitable rearing habitat for juvenile Chinook salmon (NMFS 2008).

USACE identified the Middle Fork Willamette River Subbasin as having the greatest uncertainty around establishing a sustainable population of Chinook salmon above Dexter, Lookout Point, and Hills Creek Dams due to high adult pre-spawn mortality, high juvenile mortality in reservoirs, and uncertainty around adequate downstream passage solutions (USACE 2015b).

Due to high temperatures in the lower reaches of the Middle Fork Willamette River, there is no bull trout spawning and incubation habitat downstream of Hills Creek Dam.

Lookout Point and Dexter Dams

Adult Chinook salmon are collected below Dexter Dam at an outdated facility originally built for collection of hatchery broodstock in conditions where temperatures and densities of hatchery-origin fish are high, contributing to high rates of pre-spawn mortality (Bowerman et al. 2018). The NMFS 2008 Biological Opinion reasonable and prudent alternative recommended that the facility below Dexter Dam be updated (NMFS 2008). Design and construction were occurring for this new adult facility at the time the alternatives were analyzed.

The combined length of Lookout Point and Dexter Reservoirs is about 20 linear miles, creating a challenge to downstream fish migrants. Research has estimated high mortality of juvenile UWR Chinook salmon in Lookout Point Reservoir (Kock et al. 2019). This is expected in part to be due to predation (Brandt et al. 2016). At the time the alternatives were analyzed, downstream fish passage conditions at Lookout Point Dam were also poor (Fischer et al. 2019). Several options have been examined to evaluate downstream passage in the Middle Fork Willamette River Subbasin, particularly at Lookout Point Dam.

Hills Creek Dam

Hills Creek Dam blocks access for UWR Chinook salmon to historical salmonid habitat and habitat connectivity for bull trout residing upstream of the dam. Regardless, the reintroduced population of bull trout existing above the dam has grown substantially and steadily over nearly the decade prior to alternatives analyses (Zymonas et al. 2021).

The bull trout population spawns in tributaries to Hills Creek Reservoir and rears and forages in upstream tributaries and within Hills Creek Reservoir. In most years, adult hatchery-origin UWR Chinook salmon are transported by truck above the dam for the purposes of research.

There are no fish passage facilities at Hills Creek Dam. Downstream migrating fish must pass through existing routes including the regulating outlet and turbine penstocks. Rigorous study of passage rates and survival rates for downstream passing fish has not been conducted at Hills Creek Dam, but rates are assumed to be similar to Cougar Dam, based on information reported by Larson (2000) and Keefer et al. (2013).

Fall Creek Dam

Only natural-origin ESA-listed UWR Chinook salmon return to the adult fish facility at Fall Creek Dam. A new Fall Creek Adult Fish Facility was completed in 2018, and downstream passage is achieved by an annual deep drawdown to streambed in late November or early December. This drawdown allows juvenile Chinook salmon and other fish to safely and effectively exit downstream through lower outlets; however, passage timing limits juvenile migration to the fall each year. Successful passage operations have resulted in a sustainable population of UWR Chinook salmon above Fall Creek Dam to be re-established; however, the effective population size of genetic contributors remains small (O'Malley and Bohn 2018) and has demonstrated high pre-spawn mortality (Bowerman et al. 2018; Carey et al. 2024). Due to the small effective population size, survival of juvenile progeny to adulthood is relatively high.

Most juveniles enter Fall Creek Reservoir in February and March after emergence and then rear until the fall reservoir drawdown. After rearing between spring and fall annually, UWR Chinook salmon juveniles achieve an exceptional size in Fall Creek Reservoir. This size at emigration is likely contributing to adult survival rates, as observed in other Chinook salmon populations.

In 2020, adult returns exceeded 800 individuals, well above the historical estimate for this population despite high pre-spawn mortality (WFPOM 2020). Human-related disturbance such as illegal sport fishing may play a role in pre-spawn mortality rates in Fall Creek (Peterson et al. 2022; Carey et al. 2024).

There are no hatchery-origin UWR Chinook salmon transported above Fall Creek Dam. The population is sustained by annual transport of natural-origin adult Chinook salmon upstream.

A ramp/collection box for collection of upstream migrating adult lamprey has been installed at Fall Creek Dam. Adults collected at Fall Creek Dam are released upstream of Fall Creek Reservoir to support reintroduction above the dam.

Juvenile lamprey have been documented passing downstream of Fall Creek Dam during drawdown operations of the regulating outlet (Frost 2017). These juveniles were produced by adults collected from Willamette Falls and released upstream of Falls Creek Reservoir for reintroduction (Clemens et al. 2023). Aside from dam operation passage routes (i.e., spillway and regulating outlets), there are no specific facilities in operation at Fall Creek Dam for downstream passage of juvenile lamprey.

Willamette Hatchery

The Willamette Hatchery is located along Salmon Creek about 2 miles east of Oakridge, Oregon, off Highway 58. The hatchery is at an elevation of 1,217 feet above sea level. The Willamette Hatchery is managed by ODFW.

Hatchery fish production goals are described in Section 3.8.2.3, Willamette Hatchery Mitigation Program. Because of the conservation role of this hatchery program for UWR Chinook salmon, USACE integrated conservation-oriented genetic protocols so that the Willamette Hatchery would produce USACE's entire mitigation requirement for spring-run Chinook salmon in the Middle Fork Willamette River Subbasin.

Adults are collected at Dexter Dam and transported to the adult Chinook salmon holding facility at the Willamette Hatchery until spawning. The holding facility was constructed in a former earthen rearing pond from the original hatchery. Conditions of the ponds are believed to cause stress that contributes to high pre-spawn mortality of adult broodstock collected and held in the ponds prior to spawning.

Coast Fork Willamette River Subbasin

USACE operates Cottage Grove and Dorena Dams and Reservoirs in the Coast Fork Willamette River Subbasin.

Primary gamefish species targeted for sportfishing in Cottage Grove and Dorena Reservoirs include rainbow trout, cutthroat trout, largemouth bass, smallmouth bass, brown bullhead, bluegill, and crappie. Hatchery-origin juvenile Chinook salmon are released into the Coast Fork River below WVS dams supporting a local sport fishery on returning adults.

Long Tom River Subbasin

USACE operates Fern Ridge Dam and Reservoir in the Long Tom River Subbasin. There are three concrete drop structures (Monroe, Stroda, and Cox) downstream of the dam that prevent upstream fish passage and block access to approximately 106 miles of rearing and foraging habitat for migratory native fish between the first drop structure at Monroe and Fern Ridge Dam (Figure 3.8-21).

Although there are no independent UWR Chinook salmon spawning populations in this subbasin, the lower accessible reach below the Monroe drop structure is used by juvenile UWR Chinook salmon for rearing. State-listed sensitive species, including Oregon chub and lamprey, can also be found in this lower accessible reach.

Primary gamefish species targeted for sportfishing in Fern Ridge Reservoir include cutthroat trout, rainbow trout, largemouth bass, black crappie, bluegill, brown bullhead, white crappie, yellow bullhead, warmouth, and carp. Those targeted in the Long Tom River from Fern Ridge Dam downstream to the Willamette River include white crappie, largemouth bass, brown bullhead, bluegill, and warmouth.

Figure 3.8-21. Monroe Drop Structure.
Unknown photo credit (USACE Media Images Database)

3.8.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives on fish and habitat, including effects within each subbasin. The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

3.8.3.1 Methodology

Quantitative and qualitative approaches were used to evaluate effects of alternative implementation on fish species and their aquatic habitat. Effects to bull trout, Pacific lamprey, and resident fish species throughout the analysis area were analyzed using predicted physical habitat metrics, including water flow, reservoir elevation and volume (Section 3.2, Hydrologic Processes), water temperature, and TDG (Section 3.5, Water Quality), and existing literature and expert knowledge from local fish biologists. Appendix E, Fish and Aquatic Habitat, provides additional detail on analysis methodology. The Chinook salmon and steelhead analyses are described separately

Maintenance and construction activities are also addressed qualitatively. Subsequent tiered analyses would detail site-specific construction effects on fish and aquatic habitat during the implementation phase, and any applicable permits or authorizations would be obtained at that time (Chapter 1, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act).

The degree of impact on fish and aquatic habitat is assessed qualitatively and discussed descriptively (e.g., negligible, slight, moderate, substantial[28]). Specified criteria to describe the degree of effect are not provided because criteria based on behavioral fish responses would be speculative (e.g., identifying minor or major effect descriptions that correlate to a behavior response), and data are not available for all parameters or dams. Further, operations-related effects to dam passage and habitat conditions would remain adverse with varying degrees of improvement depending on the alternative; therefore, descriptions of qualitative trends regarding effects are more informative and accurate than attempting to assign established degree criteria to adverse or beneficial effects.

Durations of effects for all analyses are assumed to be long term, occurring during the 30-year implementation timeframe, unless otherwise stated.

Direct effects to fish are those that are directly caused by alternative implementation and include but are not limited to:

- The presence of dams that prevent upstream and downstream passage.
- The presence of bank protection structures that directly impact habitat conditions.
- Effects of hatchery fish production and releases on natural fish abundance.
- Effects of sport fishing on fish abundance.
- Impacts on flow from hydropower-peaking operations.
- Habitat alterations from materials transport below dams.

Indirect effects to fish are those that are caused by alternative implementation but occur from other, direct effects. Examples include:

- The direct effects of operations on water quality that would cause indirect effects on fish from temperature, TDG, and turbidity conditions.
- The direct effects on reservoir and riverine habitat from drawdown operations that would cause indirect effects on competition and predation.
- The direct effects on material transport that would cause indirect effects on aquatic species habitat complexity and food production.
- The direct effects on flow from hydropower-peaking operations would cause indirect effects on fish from stranding risks.

[28] "Negligible" is defined in its common use as "too slight or small in amount to be of importance" (Cambridge Dictionary). "Slight" is defined in its common use as "small of its kind, or in amount" (Merriam-Webster Dictionary). "Moderate" is not used to specify criteria parameters in this analysis. It is defined in its common use as "average in amount, intensity, quality, or degree" (Oxford Languages). "Substantial" is defined in its common use as "considerable in quantity, great [in amount]" (Merriam-Webster Dictionary).

Chinook Salmon and Steelhead

Numerical predictive models were used to assess effects of WVS operations on population performance[29] and viability attributes of UWR Chinook salmon and UWR steelhead under each alternative (passage efficiency and survival rates of downstream migrating juveniles) (Appendix E, Fish and Aquatic Habitat; ICF 2022; McAllister et al. 2022a, 2022b; Myers et al. 2022; Peterson 2022) and in-reservoir and downstream habitat conditions (i.e., reservoir pool volumes and dam discharges[30]). Model components include the life cycle stages of juveniles above and below the dams, and juvenile and sub-adult stages at sea and the returning adults below and above the dams.

The quantitative analysis includes use of independent models described in Appendix E, Fish and Aquatic Habitat Analyses and in separate reports, considering the known advantages and limitations of each model, which is similar to the quantitative and peer reviewed process of Ensemble modeling (Parker 2013). While this approach is broadly applied in many disciplines, it has not yet been used for UWR Chinook salmon or UWR steelhead for the purpose of describing biological benefits and impacts from hydropower system management. Each model covers different assumptions about the hydropower system, which allows the risks and consequences of each assumption to become transparent.

Three fish population models were applied to assess effects on UWR Chinook salmon and UWR steelhead in subbasins where independent populations are present (i.e., North Santiam River and South Santiam River Subbasin for both UWR Chinook salmon and UWR steelhead, and also the McKenzie River and Middle Fork Willamette River Subbasins for UWR Chinook salmon). The fish population models include:

- University of British Columbia Bayesian Integrated Passage Assessment (IPA) (McAllister et al. 2022a)
- NMFS Life Cycle Model (NMFS LCM) (Myers et al. 2022)
- Ecosystem Diagnosis and Treatment (EDT) model (IFC 2022)

The Independent Scientific Advisory Board, an independent technical review body, completed a technical review and determined the models used for the alternatives analyses were technically sound (ISAB 2023).

The IPA and NMFS LCM produce similar performance metrics; however, the NMFS LCM produces simulations of above- and below-dam spawning UWR Chinook salmon and UWR steelhead populations over a 100-year period. The IPA produces simulations of above-dam spawning UWR Chinook salmon and UWR steelhead populations over a 30-year

[29] Fish population performance, or stock assessment, measures the health and abundance of a fish population, helping managers make decisions about fisheries and conservation by evaluating factors like fishing intensity, mortality, growth, and recruitment.

[30] See Appendix B, Hydrologic Processes and Appendix D, Water Quality Analysis.

implementation timeframe, which aligns with the scope of the alternatives analyses. Because of the temporal scale differences in model simulations, the IPA model was applied to the alternatives analyses recognizing the importance of assessing fish passage and habitat above WVS dams for these species in a 30-year timeframe. While other model results are not incorporated into the analyses, they serve to compare and contrast anticipated conditions under various parameters, such as temporal and spatial differences, and were useful to ensure confidence in the alternatives analyses and anticipated outcomes on fish and aquatic habitat.

The EDT model was used to evaluate habitat potential for spring-run Chinook salmon and winter-run steelhead in the Santiam, McKenzie, and Middle Fork Willamette Rivers. EDT provides resolution on habitat traits that give rise to productivity (both reproductive potential and survival) of UWR Chinook salmon and UWR steelhead subbasin populations. These analyses evaluated the habitat potential for both spring-run Chinook salmon (all basins) and winter-run steelhead (North Santiam River and South Santiam River Subbasins only) under the No-action Alternative (NAA) and under each action alternative.

A Below Dam Flow Survival Model was used to assess effects of flow and water quality conditions on Chinook salmon and steelhead survival below WVS dams (Peterson et al. 2022). This model simulated survival of different life stages of UWR Chinook salmon and UWR steelhead populations in the Mainstem Willamette River upstream of Willamette Falls and in the river reaches downstream of dams in main salmon-bearing rivers—North and South Santiam Rivers, McKenzie River, Middle Fork Willamette River, and Fall Creek. Individual decision support models were applied for adult Chinook salmon, juvenile Chinook salmon, returning steelhead adults, and out-migrating steelhead smolt. All models operated on a weekly time step that began on the eighth week of the year and ran through April of the following year. The models are further documented in Peterson et al. (2021).

USACE reviewed the modeling methods applied and selected the most informative data (i.e., metrics) to use as indicators of potential effects of WVS operations over the 30-year implementation timeframe. In combination, metrics were used for comparison purposes[31] to illustrate estimated responses of populations under each of the alternatives.

Metrics

Metrics were used to qualitatively assess effects from operations on in-reservoir and downstream habitat conditions and corresponding effects on fish species. Metrics were also used as components in the IPA model to quantitatively assess effects on UWR Chinook salmon and UWR steelhead. Metrics included:

[31] Quantitative results are not presented with any estimates of uncertainty or statistical precision (e.g., standard error or confidence bounds); therefore, modeled values should not be considered actual numbers and are best suited for relative comparisons of the differences between NAA implementation and action alternatives implementation.

- Water flows downstream of dams and reservoir pool elevations modeled by HEC-ResSim (Appendix B, Hydrologic Processes).
- Water temperatures and TDG downstream of dams modeled by CE-QUAL-W2 (Appendix D, Water Quality Analysis, Supporting Data for Water Quality Effects Analysis, Chapter 1.6). TDG was not included as an input metric in the IPA model.
- Dam passage survival rates of downstream migrating juveniles modeled by the Fish Benefits Workbook (Appendix E, Fish and Aquatic Habitat, Chapter 2, Fish Benefits Workbook Results).

Metrics used to quantitatively assess effects from dam discharge operations on select UWR Chinook salmon and UWR steelhead life stages under dry year conditions[32] included:

- Percent of the spawning period above the 90 percent maximum weighted usable area spawning flow levels, which is an indicator of spawning habitat availability downstream of WVS dams (Appendix E, Fish and Aquatic Habitat). Weighted usable area refers to the wetted area of a stream weighted by its suitability for use by aquatic organisms. Ninety percent of the maximum weighted usable area refers to the flow level providing 90 percent of the maximum weighted useable area estimated for a particular species or life stage in a defined length of stream.
- Chinook salmon redds surviving until swim-up, steelhead age-1, and smolt survival in dry years modeled by the Below Dam Flow Survival Model (Appendix E, Fish and Aquatic Habitat) (Peterson 2022), which is an indicator of spawning and egg incubation success.

Metrics modeled by the IPA used to quantitatively assess effects from operations on viability of above-dam UWR Chinook salmon and UWR steelhead local populations (McAllister et al. 2022a, 2022b; McAllister et al. 2023) included:

- Natural-origin spawner abundance (NOR Sp. Abun.), which is a modeled estimate of the number of natural-origin spawners.
- Recruits per spawner (R/S), which is an indicator of population productivity. It is the ratio of the number of adult progeny produced divided by the number of spawning parents in a given cohort[33].
- Probability of quasi-extinction threshold (p<QET), which is an indicator of extinction risk. It is the probability of falling to a population size threshold at which there is a very high

[32] Spawning habitat availability and incubation success downstream of dams are primarily affected by flow-related management actions, whereas other life stages and habitats can also be affected by factors that cannot be controlled by management actions. Performance in dry years was a focus compared to normal and wet year types because (1) there is less storage available providing flexibility to achieve management objectives compared to normal and wet years, and (2) effects of hot air temperatures on water temperatures can be exacerbated in dry years when flows are lower, increasing effects of flow management on survival.

[33] A cohort is a group of individuals having a statistical factor (such as age or class membership) in common in a demographic study (Webster Dictionary).

and immediate threat of extinction. It is based on predicted spawner abundance and productivity combined.

- Percentage of hatchery-origin spawners (pHOS), which is an indicator of hatchery influence in the natural spawning population. It is the estimated proportion of fish in a spawning population that are of hatchery-origin. No estimated pHOS is reported for UWR steelhead because there are no hatchery winter-run steelhead produced and released in the Willamette River Basin.

Bull Trout

Effects on bull trout were assessed qualitatively because it was not possible to develop and apply numerical predictive models of bull trout abundance, survival, movement and distribution, productivity, or other population attributes for the alternatives analyses with the available information on this species specific to the analysis area. It was assumed bull trout reintroduction upstream of Detroit Dam in the North Santiam River Subbasin occurred at the time the alternatives were analyzed, and reintroduced bull trout responses to WVS operations and maintenance would be similar to existing local bull trout populations above Cougar and Hills Creek Dams. Consequently, effects of WVS operations and maintenance on bull trout local populations were analyzed for the North Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins.

Relationships between habitat metrics and bull trout life history were used to describe expected changes to habitat and effects to individual bull trout upstream and downstream of Detroit, Cougar, and Hills Creek Dams. Quantitative predictions of reservoir and river conditions were reviewed to qualitatively assess effects for bull trout (Appendix E, Fish and Aquatic Habitat, Chapter 3, Bull Trout Assessment).

Pacific Lamprey

Knowledge regarding lamprey species in the analysis area is limited. Although information is limited, Pacific lamprey are the most studied of the lamprey species and were selected as a surrogate to represent the responses for western river lamprey and western brook lamprey. There is less quantitative information on Pacific lamprey than anadromous salmon and steelhead trout species; therefore, no numerical predictive models of lamprey abundance, survival, productivity, or distribution were used for the alternatives analyses. This species was evaluated qualitatively.

For purposes of the Pacific lamprey assessment, it was assumed that adults returning to Fall Creek would continue to be collected and released upstream of Fall Creek Reservoir, and downstream passage at Fall Creek Dam would continue to be provided via drawdown to streambed each fall under all alternatives.

Effects to Pacific lamprey were analyzed using predicted physical habitat metrics, including river flow, reservoir elevation and volume (Section 3.2, Hydrologic Processes), water temperature and TDG (Section 3.5, Water Quality), and existing literature and expert knowledge from local fish biologists. Relationships between these metrics and lamprey life history were used to describe expected changes to habitat and effects to individual lamprey upstream and downstream of WVS dams in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins. Details regarding methods and results of the qualitative Pacific lamprey assessment are included in Appendix E, Fish and Aquatic Habitat.

Resident Fish

Knowledge regarding the many resident fish species in the analysis area is limited. There is less quantitative information on several resident fish species than lamprey, bull trout, and anadromous salmon and steelhead trout; therefore, no numerical predictive models of abundance, survival, productivity, or distribution were used for the analyses. Instead, resident fish species were evaluated qualitatively based on quantitative predictions of reservoir volumes, river flows and water quality, as indicators of habitat availability and passage conditions.

Many resident fish species provide recreational fishing opportunities, particularly in larger WVS reservoirs (i.e., Detroit, Green Peter, Lookout Point, and Hills Creek Reservoirs). Therefore, a focused assessment was completed on key fish species targeted in sport fishing in the larger reservoirs, including kokanee salmon, smallmouth bass, rainbow trout, and crappie.

ODFW stocking practices were then considered because they minimize effects of altered habitats from operations and maintain availability of key gamefish species for sport fishing opportunities (Appendix E, Fish and Aquatic Habitat Analyses).

A summary of effects to fish and aquatic habitat is provide in Table 3.8-27 through Table 3.8-31 in Section 3.8.6, Summary of Effects on Fish and Aquatic Habitat.

3.8.3.2 Alternatives Analyses

WVS operations and maintenance under the NAA would continue to have minor to substantial adverse effects to fish habitat; habitat access; dam passage conditions; breeding, rearing, foraging, migrating, sheltering, overwintering, and genetic exchange opportunities; predation, competition, and disease; and in some cases, genetics. The level of impact would depend on the species, their life history, and location.

Common effects that would occur under all alternatives are presented first. Effects from hatcheries on habitat and from passage conditions across all subbasins are then presented under each alternative.

Analyses of effects specific to each fish species or population under each alternative is provided after these more generalized analyses. The common effects to fish species are not repeated in the species-specific analyses.

Information provided under all alternatives analyses related to flows and water quality can be found in the following EIS sections and appendices:

- Section 3.2, Hydrologic Processes
- Appendix B, Hydrologic Processes Technical Information
- Section 3.5, Water Quality
- Appendix D, Water Quality Technical Information

All action alternatives include a combination of construction of and operations for fish passage improvements, TDG structures, and operational modifications. These actions would result in differences to fish habitats in reservoirs and downstream of dams; habitat access between upper and lower watersheds; dam passage conditions; and susceptibility to predation, competition, and disease when compared to the NAA.

Construction and Routine and Non-routine Maintenance under All Alternatives

Effects on fish and aquatic habitat may occur as part of specific construction activities during action alternative implementation and would be the same under any alternative involving construction. Qualitative effects from construction are analyzed at the programmatic level. Site-specific project details for each construction measure would be determined during a construction implementation phase.

Direct effects from construction of selective withdrawal structures at Detroit, Lookout Point, Green Peter, and Hills Creek Dams and the proposed long-term drawdown at Cougar Dam to construct the outlet works for routine use of the diversion tunnel under all action alternatives may limit temperature management, increase turbidity, and result in TDG exceeding the water quality standard levels. These construction activities would likely have short-term (generally less than 2 years), minor, direct adverse effects on water quality parameters, which may temporarily adversely affect fish in these reservoirs. Indirect effects are uncertain and require site-specific construction details before an assessment of impacts can be made.

Similarly, routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation). Maintenance activities would occur at hatchery program release sites and adult fish release sites upstream of WVS dams in the analysis area.

Dependent on activity and seasonality, maintenance activities would affect a small number of anadromous and resident fish species in localized areas through temporary changes in reservoir pool volumes, dam operations affecting fish passage rates and survival, turbidity and/or water temperatures, or river flows below dams. Additional effects would result from dewatering and associated fish relocations, noise, vibrations, light levels, and human activity.

Maintenance activities would have short-term, minor, adverse effects on anadromous and resident fish species in the analysis area. Major maintenance would require site-specific NEPA review prior to initiation at any location in the analysis area. Additional analyses are not provided under each alternative.

Pollutants under All Alternatives

Major pollutants in the Willamette River Basin would continue to be released under all alternatives during the 30-year implementation timeframe, which can have direct, adverse effects on fish and aquatic habitat. Operations and maintenance of the WVS would also continue to release pollutants. The proliferation of invasive plant species around reservoirs may increase under some alternatives with deep drawdowns, which would continue to require pesticide use (primarily herbicides) throughout the analysis area on an as-needed and possibly on an increased basis (Section 3.6, Vegetation).

The greatest concern from hazardous material release into the environment in the WVS under any alternative would be due to the operation of oil-filled systems, which are primarily at hydropower-generating facilities (Section 3.16, Hazardous Materials, Section 3.16.2.6, Oil Spills and Above-ground Storage Tanks; Section 3.16.3.2, Alternatives Analyses, Oil-filled Systems). The environmental effects of oil spills can vary depending on the amount and type spilled and the character of the receiving water body. Direct, adverse effects on vertebrates can range from minor to major nervous system and reproductive damage to individual birds, mammals, and humans to broader effects such as the decline or loss of key organisms and/or habitats in an ecosystem (EPA 1999; ITOPF No Date).

Risk of WVS-generated hazardous material reaching water sources would be minimized under any alternative during the 30-year implementation timeframe. Risk management would occur through Best Management Practices (BMPs), compliance with Federal and state regulations, and Occupational Safety and Health Administration and USACE hazard communication and training programs (Section 3.16, Hazardous Materials).

Aquatic Vegetation under All Alternatives

Seasonal drawdowns of reservoirs under all alternatives would reduce available open water habitat for fish and other aquatic organisms from the fall until spring and would shift nearshore habitat downward into less vegetated zones. This would result in direct, adverse effects on aquatic vegetation and subsequently on fish dependent on aquatic habitat.

Spawning habitat within reservoirs for fish species that attach their eggs to vegetation may be dewatered, depending on the species' spawning and incubation timing, which could result in substantial, adverse effects to spawning success over the 30-year implementation timeframe. Habitat for predatory fish using vegetative cover to lie in wait for prey would be reduced seasonally when reservoirs are drawn down below the vegetated zone. This would also be an adverse effect to predatory species, but a beneficial effect on some fish prey species or life stages.

Overall, however, seasonal reductions in habitat would continue to support the persistence of fish species in reservoirs similar to existing conditions. At Fall Creek Reservoir, deep drawdowns for fish passage to near the historical streambed result in very little reservoir aquatic habitat available in the fall. Consequently, nearly all reservoir fish move downstream of the dam each fall. This annual reservoir operation adversely affects resident fish that rely on the reservoir for habitat, resulting in loss of habitat during the drawdown and displacement into riverine habitat below the dam during the drawdown. Because non-native fish are not transported back upstream of Fall Creek Dam, the annual drawdown results in few non-native fish species present after Fall Creek Reservoir is refilled each year.

Many resident fish that colonize the reservoir after refill each year would also be adversely affected during fall drawdowns and forced to move downstream of the dam each fall or upstream of the reservoir zone in search of habitat. For fish species residing above Fall Creek Dam or remaining in the exposed stream during the reservoir drawdown, reservoir habitat would become available again in the next conservation season or earlier following increased stream flows in winter and spring. These fish would then utilize the reservoir to rear, forage, or migrate through the reservoir during spring, summer, and fall.

Operations under all alternatives would include frequent water fluctuations prohibiting plant establishment and succession in reservoirs and allowing for the establishment of invasive-dominated plant communities (Section 3.6, Vegetation, Table 3.6-4). Operations such as lowered reservoir levels would increase potential for invasive plant growth along banks of reservoirs through higher availability of bare disturbed soils. This would adversely affect fish by potentially increasing water temperatures, providing cover for warm-water-tolerant predators, and adversely affecting flows.

Invasive plant management, such as restoration planning and monitoring, would occur in applicable WVS reservoirs under all alternatives. Recommendations from a 2023 invasive species survey program may be incorporated into operational planning during the 30-year implementation timeframe. This would result in a system-wide benefit to aquatic habitat.

Dams and the regulation of flows affect aquatic plant species composition, distribution, and growth along rivers downstream of dams. For example, dams reduce the delivery of sediment from upper watersheds important for the establishment and maintenance of aquatic plants. Regulation of river flows also reduces peak flows during storm events, in turn affecting the redistribution of nutrients and the inundation of the floodplain where aquatic plants would occur. In summer, river flows are increased from WVS reservoir water releases. This alters the natural seasonal succession of flows and aquatic plant adaptation. This increases depths in some areas that will not allow some plant species to establish.

Aquatic Habitat Connectivity under All Alternatives

Operation of Federal and non-Federal dams in the Willamette River Basin would continue to adversely affect connectivity and subsequent loss and fragmentation of anadromous and resident fish populations under all alternatives during the 30-year implementation timeframe by blocking access for upstream migrating fish (Chapter 1, Section 1.7.1, Dams and Reservoirs and Section 1.8, Non-U.S. Army Corps of Engineers-managed Dams in the Willamette River Basin). For downstream passage of juvenile anadromous and resident fish, operation of Federal and non-Federal dams in the Willamette River Basin would continue to have direct, adverse effects on survival and passage rate reductions for fish in the analysis area under all alternatives.

Dam operations would also continue to have a direct, adverse effect on migratory fish corridors by affecting stream flow patterns and water temperatures below dams. Temperature effects of dams can cause delay of migration due to cool water releases in summer (e.g., for upstream migrating adult Chinook salmon) and adversely affect survival and growth of fish due to warm water releases in fall under all alternatives (e.g., for incubating eggs in gravel redds). Further downstream in the lower portion of tributaries, and in the Mainstem Willamette River, river temperatures would continue to be adversely affected primarily from other sources of heating (e.g., solar), but beneficially affected from WVS reservoir releases during summer and early fall, over the 30-year implementation timeframe.

In tributaries close to dams, cooler water temperatures released in summer would continue to have a direct, adverse effect on UWR Chinook salmon, UWR steelhead, and other species present below each dam under all alternatives. There would also be continued beneficial effects from cool water released from dams, reducing stress, disease, and mortality in fish caused by seasonally high ambient water temperatures. Further downstream, river flows increased by water released from reservoirs in summer and early fall under all alternatives would decrease peak daily water temperatures and dampen the onset of peak temperatures (Rounds 2010).

Maintaining river flows above natural seasonal low flow levels with release of water from storage in reservoirs would directly benefit fish and other aquatic organisms by maintaining habitat in locations that otherwise would seasonally decrease as flows naturally decrease in spring and summer. Benefits would vary by species and life stage habitat preferences.

The degree of these benefits for native fish species under any alternative is also uncertain because of their evolutionary adaptations in the analysis area. These species have adapted to a hydrologic regime driven by wet winters and dry summers; WVS operations have altered these conditions and would continue to do so under all alternatives during the 30-year implementation timeframe. Additionally, direct benefits to fish and aquatic organisms would result in indirect benefits to wildlife species dependent on fish as a food source, such as osprey, diving ducks, river otters, and eagles, because of increased forage and prey opportunities.

Access to floodplain habitats by aquatic organisms has been reduced in the analysis area from WVS operations resulting in direct, adverse effects on fish species that rely on seasonal access to floodplain habitat. Lack of floodplain connectivity would also continue to be an impediment for salmon and steelhead spawning under all alternatives over the 30-year implementation timeframe. However, gravel augmentation under the action alternatives would create increased opportunities for instream habitat improvements for fish and aquatic species. These improvements would also indirectly or directly benefit other aquatic-dependent species such as American beavers, great blue herons, and frogs depending on species and life stage.

Streambank Modifications under All Alternatives

USACE would continue to manage and maintain bank protection structures (e.g., revetments) along the Mainstem Willamette River and the following tributaries under all alternatives over the 30-year implementation timeframe: Row River, Calapooia River, Coast Fork and Middle Fork Willamette Rivers, McKenzie River, South Santiam River, North Santiam River, Santiam River, Molalla River, Clackamas River, and Mill Creek (Chapter 1, Introduction, Section 1.7.2.1, Bank Protection Projects and Regulatory History). Consequently, these structures would continue to have direct, adverse effects on fish and aquatic habitat by altering shoreline conditions and blocking access to side channels. Under NAA operations, revetments would continue to eliminate localized habitat complexity but would provide some cover for smaller fish and habitat for some fish species that prefer rocky and steeply sloped shorelines. This would result in habitat benefits to these species in areas where shorelines are modified by bank protection structures in the analysis area.

No-action Alternative

Hatchery Mitigation in All Subbasins

All hatchery programs in the Willamette River Basin would continue to be managed according to their applicable HGMPs under NAA operations. This management would be in alignment with the most recent UWR Conservation and Recovery Plan (ODFW and NMFS 2011) and biological opinions (NMFS 2019d, 2024b) to reduce risks to ESA-listed species. Hatchery program facilities would also continue to operate under ODFW National Pollutant Discharge Elimination System permits for waters discharged from these facilities.

For ESA-listed species, there would be mixed direct beneficial and adverse effects from operation of the hatchery programs, depending on the species and hatchery program under NAA operations. Hatchery-origin spring-run Chinook salmon integrated programs would provide benefits to UWR Chinook salmon, including increased spawning abundances and benefits to commercial harvest and sport fishing. This program would also reduce adverse effects from genetic domestication in hatchery fish with integration of natural-origin broodstock.

The continued hatchery summer-run steelhead and rainbow trout programs under NAA operations would provide direct benefits for sport fishing opportunities in the analysis area, but would result in continued adverse effects on UWR Chinook salmon, UWR steelhead, and native rainbow trout as described below.

Additionally, release of hatchery-origin juvenile Chinook salmon and juvenile summer-run steelhead below WVS dams would provide direct, beneficial effects for other larger predatory fish and terrestrial animals as a source of prey for species that feed on smaller fish. The continued upstream release of spring-run Chinook salmon hatchery-origin adults under the NAA would support the reintroduction of spring-run Chinook salmon above WVS dams over the 30-year implementation timeframe (NMFS 2019d). These fish releases, along with progeny of hatchery-origin spawners, would also provide direct, beneficial effects to resident fish species by contributing sources of prey. Indirect benefits would occur through other ecosystem services such as bioturbation[34] of spawning gravels and by release of marine-derived nutrients from carcasses that support food webs, increasing plant, invertebrate, and fish prey sources for resident fish species.

Adverse effects from hatchery programs under NAA operations would include:

- Effects of domestication and genetic introgression from high levels of hatchery-origin fish spawning instream and limited integration of natural-origin spawners into hatchery broodstocks, resulting in reduced life history diversity and reduced fitness in UWR Chinook salmon and UWR steelhead. Overall, UWR Chinook salmon pHOS as averaged across subbasins is predicted to be 0.69. For summer-run steelhead spawning instream above Willamette Falls, the estimated introgressive hybridization is 19 percent to 26 percent of the natural-origin steelhead (Weigel et al. 2019a).
- Reduced natural-origin spawner abundance with the collection and integration of natural-origin UWR Chinook salmon into hatcheries.
- Hatchery summer-run steelhead isolated harvest programs would have adverse genetic effects on native UWR steelhead (summer-run steelhead are non-native, out-of-basin fish).
- Adverse effects on native fish (including UWR Chinook salmon, UWR steelhead, and bull trout) from predation and competition by hatchery fish, disease transfer from hatchery fish to natural-origin fish, and increased sport fishing exploitation created by release of hatchery fish.
- Adverse effects immediately downstream of hatcheries from water discharged from facilities used under each hatchery program.

Where hatchery fish are collected, spawned, reared, or released below WVS dams as part of the hatchery program, hatchery fish production could be adversely impacted by river water quality conditions discharged from dams (temperature and TDG) because these facilities intake water from rivers downstream from WVS dams (see the Riverine Habitat in All Subbasins section under each alternative analysis).

Effects on fish in hatcheries from WVS dam operations in the McKenzie River Subbasin would be negligible because the hatcheries are several miles downstream of Cougar Dam. Water temperatures at these hatchery locations would continue to be more influenced by the

[34] Bioturbation is the process of disturbance and mixing of soil or sediment by organisms.

Mainstem McKenzie River than by dam operations under the NAA. The adult fish facility at Cougar Dam would not be used as part of the hatchery programs under NAA operations.

Reservoir/Lake-like Habitat in All Subbasins

Under NAA operations, reservoir water surface elevations would be maintained at their highest annual levels achievable from May through September (given annual inflows) over the 30-year implementation timeframe. Annually during these months, hydrology retained during spring would directly benefit open water, lake-like, and nearshore habitat within the analysis area when precipitation and inflows are at their lowest in late summer and early fall. When pools reach the maximum conservation elevation the riparian zone would be inundated, providing additional habitat structure for larval and juvenile fish, shoreline spawners, and for resident and migratory species preferring nearshore vegetated habitat.

Annual water temperature stratification within most reservoirs would occur during the conservation season when reservoir levels would be the highest under the NAA over the 30-year implementation timeframe. In years that the maximum conservation pool elevation is achieved, there would be more cool water habitat typically available (although this would vary depending on summer weather patterns). Maximum refill elevations achieved each year would affect water surface area and in turn surface water temperatures. Stratification would provide a diversity of water temperatures at different water depths in most reservoirs in the analysis area. This would be an indirect benefit to fish by supporting warm-water fish species near the surface and colder-water fish species at the middle and bottom elevation layers.

Reservoir water levels in the analysis area would fluctuate substantially each year between the conservation and non-conservation seasons under the NAA over the 30-year implementation timeframe. Water levels may also undergo substantial fluctuations on a daily or seasonal timeframe, affecting the availability of foraging, spawning, rearing, and overwintering habitat opportunities for both resident and migratory species present in the reservoirs during the seasonal drawdown period.

For example, as reservoirs fill during storm events and during the spring conservation refill season, nearshore shallow habitat shifts to higher elevations, requiring fish using nearshore shallow areas for foraging, spawning, rearing, and overwintering habitat to also re-distribute to find similar habitat conditions. This compulsory shift in distribution may expose fish to adverse conditions from competition and predation or the inability to find suitable habitat.

Additionally, the volume of open water increases during times of refill, increasing the area available for fish using open water habitat. This increasing reservoir volume helps provide habitat diversity as reservoir water temperatures stratify in summer and reduces fish densities, which can also reduce competition, predation, and disease transference. The opposite occurs when reservoirs are drawn down after storm events and annually in later summer and fall.

Fluctuations under NAA operations would result in direct adverse and beneficial effects on reservoir/lake-like habitat. Habitat effects would result in indirect adverse and beneficial effects on fish depending on fish species, life stage, annual hydrology (inflows into reservoirs), and season.

These reservoir conditions would indirectly adversely affect juvenile Chinook salmon and steelhead while they reside in reservoirs because of predation and disease risk. However, these fish would also benefit from high growth rates experienced in reservoirs, depending on the annual hydrologic conditions, reservoir operating schedules, and the length of time fish reside in reservoirs.

Under NAA operations, juvenile anadromous fish survival rates while in the ocean would increase because fish would be migrating downstream of dams safely and at larger sizes. This would also increase return rates of adults returning to spawn.

These reservoir conditions would indirectly benefit resident fish species that rely on lake-like habitat. Effects for migratory species, including UWR Chinook salmon and steelhead, would be mixed.

Riverine Habitat in All Subbasins

Indirect, moderate to substantial, adverse effects on fish would occur under NAA operations and maintenance of bank protection structures in the analysis area. These would result from impaired quantity and quality of spawning, incubation, rearing, and migration opportunities available in reaches downstream of dams. Additionally, bank protection structures would continue to locally constrain channel widths and reduce off-channel habitat under the NAA.

Minor to moderate, indirect, beneficial effects would occur from flows increased above naturally seasonal low flows by releases of water from reservoir storage downstream of WVS dams in all subbasins in summer and fall, depending on species, life stage and their habitat preferences, and river channel conditions (e.g., the shape of the channel, and substrate and vegetation composition and distribution).

Flow

Seasonal operations of dams and reservoirs for flood risk management (i.e., decreased peak winter and spring flows) would continue to locally constrain wetted channel widths and seasonal inundation of the floodplain. Conversely, release of water stored in reservoirs downstream of dams would increase stream flows above natural summer and fall base flows. This would reduce peak water temperatures by dampening the effects of ambient thermal loading occurring downstream of WVS dams and in the Mainstem Willamette River. An exception would occur when warmer waters are released from reservoirs in fall during drawdowns (see temperature analysis below).

Habitat conditions for different fish species and life stages would vary depending on local channel conditions and habitat preferences. For example, higher flows in a river reach can increase depths and velocities, which may adversely affect spawning habitat availability but would benefit juvenile migratory fish moving downstream.

Indirect, moderate to substantial, adverse effects on fish would occur in late fall, winter, and early spring from decreased habitat availability due to reduction in peak flows compared to naturally occurring peak flow levels. Indirect, minor to moderate, adverse to beneficial effects on fish would occur from changes in habitat availability due to increased seasonal flows in summer and early fall.

Stranding Risk

Established down-ramping rates would be implemented at each WVS dam under NAA operations to reduce risk of stranding fish. Hydropower-peaking operations at Green Peter Dam would result in indirect, adverse effects on fish and other aquatic life through substantial daily stream flow fluctuations. Consequently, these fluctuations would cause direct, adverse effects on riverine habitat conditions prompting fish to move from the habitat area below Green Peter Dam and increasing the potential for localized stranding in the Middle Santiam River below Green Peter Dam downstream to Foster Reservoir.

Materials Transport

Direct, adverse effects on physical habitat processes downstream of dams in the analysis area would occur under NAA operations. This would result from sediment and large woody debris trapped behind dams and retained in the reservoirs, in combination with reduced winter peak discharges (compared to naturally occurring peak flows) during flood season and the existence of revetments in the analysis area. These effects would be a direct, substantial, adverse effect on habitat complexity. Consequently, simplified habitats would have a substantial, indirect, adverse effect on multiple aquatic species and life stages that rely on complex habitats.

Water Temperature

Indirect effects, and the degree of effects, on fish in the analysis area from adverse or beneficial water temperature conditions would depend on location, season, fish species, and life stage. Water temperature effects from dams vary seasonally. Indirect effects would be beneficial to some fish species or life stages from NAA operational discharges that are cooler than ambient stream temperatures during summer. However, water temperatures would be indirectly adverse on fish species preferring or requiring warmer temperatures in summer or cooler temperatures in fall.

Under NAA operations, water temperatures discharged from WVS dams would continue to have direct, slight to moderate, adverse effects in reaches downstream of dams during fall when warmer water is released. In summer, water discharged from dams would continue to have slight, adverse to moderate, beneficial effects on fish in reaches downstream of dams by releasing cool water and increasing water volumes acting to buffer against solar heating in summer that increases river water temperatures.

Although adverse, exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and on specific dam operations. For example, water temperatures would mostly meet temperature targets in the North Santiam River, South Santiam River, Coast Fork Willamette River, and Long Tom River Subbasins because of dam operations, and downstream of Cougar Dam in the McKenzie River Subbasin because of water temperature control tower operations (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, No-action Alternative).

However, cold water releases from Foster Dam would continue to discourage returning UWR Chinook salmon adults migrating upstream from entering the adult fish facility ladder at the Foster Adult Fish Facility on the South Santiam River and to a lesser extent at the Minto Adult Fish Facility on the North Santiam River in summer. NAA operations would increase summer base flows, dampening the effects of ambient thermal loading occurring downstream of WVS dams in summer and fall benefitting species that prefer cooler than ambient river water temperatures. Effects on fish species preferring warmer summer temperatures or benefitting from habitat conditions at lower flows would be slightly adverse to slightly beneficial because water temperatures would be near or somewhat cooler than the preferred tolerance range.

Hatchery and adult fish facilities intake river water downstream from Big Cliff Dam, Green Peter Dam, and Lookout Point Dam. Water temperatures as taken into these facilities largely reflect water temperatures as discharged from these dams. Downstream of these dams there would continue to be direct, slight to moderate, adverse effects on fish held at or released from these facilities into downstream reaches during fall when warmer water is released from these dams. Conversely, in summer, water discharged from dams would continue to have slight to moderate, beneficial effects for fish held and released from these facilities into reaches downstream by releasing cool water and increasing water volume acting to buffer against solar heating.

There are no WVS dams, hatcheries, or adult fish facilities located on the Mainstem Willamette River; however, water releases downstream of the WVS dams from WVS reservoirs would dampen seasonal water temperature increases on the Willamette River during summer and early fall. Temperature targets are only available for summer extremes for the mainstem. Although water temperature targets would mostly be met on the Mainstem Willamette River under NAA operations (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, No-action Alternative), there would be a direct, slight, adverse effect on water quality from temperature targets not being met in summer under NAA operations, particularly in drier, hot years.

Thermal loading from solar input and local sources results in ambient water temperatures rising above levels preferred by many fish in summer. Consequently, Mainstem Willamette River water temperatures as affected by WVS dam operations would continue to have slight to moderate benefits for fish in spring and early summer due to increased river flows from reservoir releases under the NAA. In summer during peak seasonal temperatures, mainstem river flows would continue to be supplemented by water released from WVS dams. However, increases in seasonal ambient heating would reduce benefits for temperature reductions and, therefore, have slight to moderate effects on fish in the Mainstem Willamette River.

Total Dissolved Gas

Under NAA operations, there would be a direct, slight to moderate, adverse effect on water quality in reaches downstream of dams in all subbasins from TDG during the 30-year implementation timeframe. This is because TDG levels would continue to be above 110 percent maximum saturation in reaches below WVS dams, thereby exceeding water quality standards. This would result from spill operations for flood risk and water temperature management (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, No-action Alternative).

Although a direct, adverse effect on water quality from TDG exceeding the water quality standards would continue under the NAA, exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations. For example, adverse effects may only occur during a few months of a given year based on target achievement in all subbasins.

However, effects on water quality in the Coast Fork Willamette River and Long Tom River Subbasins from TDG below Cottage Grove, Dorena, or Fern Ridge Dams cannot be determined because there are no TDG gages to provide existing data or analyses. Operations under the NAA are expected to continue as under 2019 conditions; therefore, effects on water quality from TDG below these dams would be the same as existing conditions over the 30-year implementation timeframe. This includes limited data demonstrating TDG levels exceeding 110 percent maximum saturation in Dorena Reservoir and in the Row River immediately below Dorena Reservoir. There are no other data on TDG concentrations in areas of the Coast Fork Willamette Subbasin used for listed anadromous salmonids (NMFS 2008) (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, No-action Alternative).

TDG is presumed not to be adverse on the Mainstem Willamette River. This is because exceedance of TDG standards is most affected by dam operations; TDG levels dissipate before reaching the Mainstem Willamette River. Gages are typically located downstream of WVS dams where they are placed to record TDG. There are no dam operations or, to USACE's knowledge, TDG gages on the Mainstem Willamette River. Consequently, there are no data to provide trends in TDG levels related to the Mainstem Willamette River. Although TDG levels and associated effects in the Mainstem Willamette River cannot be determined, TDG under NAA operations are assumed to be the same as existing, non-adverse conditions (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, No-action Alternative).

TDG greater than the 110 percent maximum saturation would result in indirect, adverse effects to fish by causing gas bubble trauma. TDG levels dissipate with distance downstream of each WVS dam. The rate of TDG dissipation depends on specific river conditions below each dam. TDG also varies with daily dam operations, which can result in TDG levels greater than 110 percent for some times of day and below this level at other times. Therefore, effects on fish depend on when and where fish are present below a dam.

The TDG conditions would adversely affect certain fish life stages more than other life stages. There would be no or only minor, adverse effects on eggs below any WVS dam because they would generally not be impacted due to their location in substrate and protective membrane structures. Newly hatched fry would be the most vulnerable fish life stage; adverse effects would range from negligible to moderate corresponding with subbasin locations and seasonal dam operations.

Juveniles migrating through areas with high TDG under NAA operations would experience gas bubble trauma similar to existing conditions (e.g., Romer et al. 2016), which would be a moderate to substantially adverse effect on individuals. Other mobile life stages (i.e., subadults and adults) would be slightly or moderately impacted depending on location, duration in the location, and seasonality during the 30-year implementation timeframe.

Hatcheries and adult fish facilities located below WVS dams are operated to intake water from rivers or reservoirs downstream from Big Cliff Dam, Green Peter Dam, and Lookout Point Dam. TDG levels as discharged from these dams affect waters used in these facilities, although the TDG levels dissipate to some degree before the point of use in these facilities (depending on the amount of degassing that naturally occurs in the river). Under NAA operations, there would be a direct, slight to moderate, adverse effect on fish held in hatcheries and adult fish facilities from TDG in reaches downstream of Big Cliff Dam, Green Peter Dam, and Lookout Point Dam.

Turbidity

Periods of high turbidity can harm fish by causing gill irritation and decreasing visibility for foraging and predatory avoidance. Under the NAA, sediment-related processes are anticipated to occur in all subbasins up to 2019 conditions, resulting in adverse effects on water quality from turbidity. WVS reservoirs can trap sediment from the upstream watershed during high-flow events, which can moderate adverse effects by reducing turbidity downstream of the dams. Reducing turbidity would be a beneficial effect (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, No-action Alternative).

Under the NAA, there would be a deep fall drawdown at Fall Creek Reservoir resulting in temporary elevation of suspended sediment levels discharged from the dam (USGS 2023). Minor, short-term, adverse effects from temporary elevated turbidity may occur under the NAA at this location.

The Willamette River is not listed in the Oregon Department of Environmental Quality 2022 Final Integrated Clean Water Act 303(d) database and does not indicate exceedances of the water quality criteria for turbidity (Section 3.5, Water Quality, Subsection 3.5.2.2, Water Quality Overview and Subbasin Descriptions, Turbidity Conditions in the Mainstem Willamette River). Dam operations under the NAA would not cause measurable adverse effects on water quality from turbidity in the Mainstem Willamette River. There is no indication that water quality criteria for turbidity are exceeded under existing conditions with ongoing WVS operations. Therefore, NAA operations would not alter this water quality condition in the Mainstem

Willamette River (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, No-action Alternative).

Although continuation of both adverse and beneficial effects to turbidity would occur under the NAA during the 30-year implementation timeframe, the degree of effect on water quality would have minor variation across subbasins, depending on geography, climate conditions, and seasonal reservoir operations affecting turbid water conditions in the analysis area (Section 3.5, Water Quality, Subsection 3.5.1.2, Water Quality Parameter Overview and Subbasin Conditions) (Appendix C, River Mechanics and Geomorphology, Chapter 2, Alternative Comparison Summaries).

Under NAA operations, there would be slight to moderate beneficial effects from reduced turbidity below dams on fish, except below Fall creek Dam where there would be a direct, slight to moderate, temporary adverse effect on fish during fall deep drawdowns of the reservoir.

Other Riverine Habitat Conditions in All Subbasins

Resident fish species entrained downstream during fall drawdowns may invade downstream habitats, competing or preying on other fish occupying habitat below dams, including sensitive and ESA-listed species. For example, substantial declines in Oregon chub abundance due to the presence of non-native resident fishes in reaches downstream of dams have been documented (USFWS 2008). Consequently, indirect, substantial, adverse effects to native fish populations may occur under the NAA.

NAA operations would also create localized conditions favoring resident fish, particularly near bank protection structures. For example, smallmouth bass prefer rocky shoreline conditions created by revetments, providing low velocity holding habitat they can use as cover when preying on smaller fish. This would result in indirect, adverse effects on other fish species from competition and predation.

Dam Passage Conditions in All Subbasins

Upstream Passage

Under the NAA, adult migratory fish would not be able to migrate upstream of dams without being trapped and transported. Under all alternatives, Federal and state fish management agencies would continue to determine the species and life stages that are to be transported.

Adult fish facility operations at Minto, Foster, Cougar, Dexter, and Fall Creek would continue to be operated under the NAA, providing passage under existing Federal, state, and tribal programs for UWR Chinook salmon, UWR steelhead, bull trout, lamprey, and other fishes collected at these locations in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins. Additionally, bull trout trapping and capture by hook and line downstream of Hills Creek Dam in the Middle Fork Willamette River Subbasin would also continue under NAA operations.

Some fish that are captured would be transported and released upstream of Detroit, Foster, Cougar, Lookout Point, Hills Creek, and Fall Creek Reservoirs, depending on the fish species and origin (natural or hatchery) as determined based on external marks or tags. In the North Santiam River Subbasin, some adult spring-run Chinook salmon and winter-run steelhead would also be transported and released to the reach between the Minto Adult Fish Facility and Big Cliff Dam under NAA operations.

Fish collected at any facility and released upstream would experience handling- and transportation-associated stress and occasionally injury or mortality. All other WVS dams would continue to completely block upstream fish passage. These direct, adverse effects from upstream passage conditions would be substantial.

Downstream Passage

Under the NAA, existing dam outlets used for water discharge from reservoirs (i.e., regulating outlets, turbines, and spillways) would provide limited downstream fish passage opportunities for migratory fish species. Existing dam discharge outlets would also result in downstream entrainment (unintended passage) of resident fish species residing in reservoir forebays at water depths in the proximity of regulating outlets or turbines or in surface waters near spillways. Injury and mortality rates under NAA operations would vary among fish species and sizes. Larger-sized fish and certain species would be more vulnerable to injury or mortality when passing through dams. This would be due to their body shape and/or swimming abilities (such as crappie and bass), or because of distribution (e.g., kokanee are often found at greater water depths).

Daily and seasonal changes in reservoir levels from dam operations under the NAA would affect fish downstream passage rates and survival at dams in the analysis area. In general, dam passage rates and survival would decrease as water depths over outlets increase. Greater water depths over outlets makes the entrance of outlets harder to find for surface-oriented fish such as salmon and steelhead. This increases the risk of injury and mortality, including pressure-related injuries occurring on fish as they pass through a dam.

The NAA includes operations for downstream fish passage, such as deep fall reservoir drawdowns at Fall Creek Dam; operation of spillways at Detroit, Foster, and Lookout Point Dams; and prioritization of spill though the regulating outlet at Cougar Dam during the fall migration period for Chinook salmon. The range of benefits from operations for downstream passage of fish at all WVS dams would vary widely between dams and be based on the specific conditions at the time fish are present near a dam under NAA operations.

No WVS dam operation would provide optimal downstream fish passage under the NAA; dams would continue to be a direct, adverse effect on fish in the analysis area. Passage and survival conditions would remain substantially adverse to fish survival and abundance.

Operations at WVS dams under the NAA would provide small to moderate reductions in adverse effects on downstream fish passage rate and/or survival, except at Fall Creek Dam. At

Fall Creek Dam, operations would continue to provide benefits for downstream fish passage due to high downstream passage rates and survival each fall when the reservoir is drawn down to streambed. However, the timing of the drawdown would limit passage timing to only the fall, adversely affecting life history diversity for some fish species.

Upper Willamette River Chinook Salmon and Steelhead in All Subbasins

Effects from reservoir habitat, riverine habitat, and fish passage conditions would result in direct, substantial, adverse effects on UWR Chinook salmon and UWR steelhead under the NAA in the analysis area over the 30-year implementation timeframe.

Reservoir/Lake-like Habitat in All Subbasins

UWR Chinook salmon would be released to spawn upstream of several WVS reservoirs under NAA operations, including those in the North Santiam River, South Santiam River (Foster Reservoir only), McKenzie River (Cougar Reservoir only), and Middle Fork Willamette River Subbasins. UWR steelhead would only be released upstream of Foster Reservoir in the South Santiam River Subbasin.

During the 30-year implementation timeframe, offspring from these adults would emigrate downstream and rear in reservoirs within the analysis area between a few days (subyearling/yearling smolts ready to migrate to the ocean) to more than a year (fry and parr not ready to migrate to the ocean) (e.g., Monzyk et al. 2015; Romer et al. 2016). UWR Chinook salmon would primarily enter analysis area reservoirs at the fry stage in spring and inhabit nearshore zones under NAA operations. In early summer, they would transition to the parr stage, move out of the nearshore zone, and become more widely distributed throughout the reservoirs.

Reservoirs and dams would continue to delay downstream migration timing under the NAA due to the difficulty juveniles have finding dam outlets because of water depths. Extended rearing in reservoirs due to delayed migration from dams would result in direct, adverse effects on salmon populations over the 30-year implementation timeframe.

Specifically, reservoir habitat conditions would result in direct, moderate to substantial, adverse effects from exposure to predation and competition for riverine and migratory fish, including UWR Chinook salmon and UWR steelhead. However, predation and competition would be a direct, minor, adverse effect in Fall Creek Reservoir where there would continue to be few resident fish species inhabiting the reservoir because of annual deep fall drawdowns under NAA operations in the Middle Fork Willamette River Subbasin.

Additionally, while inhabiting reservoirs under NAA operations, Chinook salmon may have high rates of infection by parasitic copepods. This would increase mortality and, depending on the number of individuals affected, could be a direct, moderate to substantial, adverse effect on reservoir inhabitation during the 30-year implementation timeframe.

Conversely, reservoir habitat conditions in the conservation season under the NAA over the 30-year implementation timeframe would support rearing conditions for UWR Chinook salmon and UWR steelhead juveniles. The longer rearing periods in reservoirs would result in direct, substantial, beneficial effects on growth due to food availability and adequate temperature conditions. High growth rates would occur as compared to salmon rearing in streams and would be a direct, substantial benefit to salmon populations in the analysis area. Additionally, size at emigration to the ocean positively relates to the abundance of adult salmon and steelhead returning to spawn.

Adverse and beneficial effects of reservoirs on Chinook salmon and steelhead would occur as long as juveniles reside in each reservoir in the analysis area under NAA operations. Juvenile Chinook salmon spend from a few weeks to over a year in reservoirs, with most inhabiting reservoirs for about 6 to 9 months. Juvenile steelhead spend 2 years in fresh water before migrating as smolts to the ocean; their time spent in reservoirs is less understood. The expected range of reservoir inhabitation for juvenile steelhead is between a few months to 2 years.

Chinook salmon fry mortality in reservoirs would be expected to be highest in the spring and would decline over the summer under NAA operations, possibly due to less predation risk as they grow larger. Estimates of juvenile steelhead mortality in reservoirs are not available, but because they would be larger than UWR Chinook salmon while in reservoirs, it would likely be slightly lower than expected for Chinook salmon. In-reservoir juvenile Chinook salmon mortality rates have been estimated to be about 70 percent to 80 percent between spring and fall. Aggregate seasonal mortality rates would result in higher annual Chinook salmon and steelhead mortality rates. These mortality rates would be expected to continue throughout the analysis area under NAA operations during the 30-year implementation timeframe.

Riverine Habitat in All Subbasins

Under the NAA, effects of dam operations would vary by season and location. Generally, dam operations in winter and spring would have direct, substantial, adverse effects on UWR Chinook salmon and UWR steelhead spawning, incubation, rearing, and migration opportunities downstream of dams in the analysis area over the 30-year implementation timeframe. In summer and fall, dam operations would provide beneficial effects due to seasonally increased habitat availability from flow augmentation from reservoir storage during low flow periods.

The level of impact on downstream habitat conditions from revetments and other bank structures that prevent habitat connectivity and complexity is highest in the lower reaches of the tributary rivers and in the Mainstem Willamette River where there are more revetments and bank structures. This would further impact the quality of habitat for incubation, rearing, and migration of UWR Chinook salmon and UWR steelhead under the NAA throughout the analysis area.

Estimates of UWR Chinook salmon spawning habitat availability and spawning and incubation success in reaches downstream of WVS dams under NAA operations are provided below. These estimates are based on modeled flow and water temperature management during dry years over the 30-year implementation timeframe and throughout the analysis area (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 59 percent to 91 percent of the spawning period, which indicates moderate to high spawning habitat availability depending on river reach (Appendix E, Fish and Aquatic Habitat Analyses).
- 2,659 (range 8.3 to 6,945) average number of redds surviving until swim-up (Appendix E, Fish and Aquatic Habitat Analyses), which indicates extremely low to relatively high spawning and incubation success depending on river reach (Middle Fork Willamette River and McKenzie River Subbasins, respectively). This represents an overall moderate average spawning and incubation success in all subbasins combined.

Estimates of UWR steelhead spawning habitat availability and the number of age-1 and smolts in reaches downstream of WVS dams under NAA operations are estimated below. These estimates are based on modeled flow and water temperature management during dry years over the 30-year implementation timeframe and throughout the analysis area (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 99 percent to 100 percent of the spawning period, which indicates high spawning habitat availability in all reaches (Appendix E, Fish and Aquatic Habitat Analyses).
- Average age-1 UWR steelhead abundance was estimated at 209,660 and 137,000, and UWR steelhead smolt survival were estimated at 89.6 and 89.3 in reaches downstream of dams in the North Santiam River and South Santiam River Subbasins, respectively (Appendix E, Fish and Aquatic Habitat Analyses).

Dam Passage Conditions in All Subbasins

Collection and release of adult UWR Chinook salmon and UWR steelhead upstream of reservoirs under the NAA would have a direct, slight adverse effect on UWR Chinook salmon and UWR steelhead in some locations. Collection and release allow for these species to spawn in historical habitats. Offspring of these individuals would then contribute to the natural-origin population.

As a result of this collection and release upstream, UWR Chinook salmon would be provided access to 100 percent of the available spawning habitat in the North Santiam River and Southfork McKenzie River Subbasins, 90 percent in the South Santiam River Subbasin, and 73 percent in the Middle Fork Willamette River Subbasin (Table 3.8-3). Upstream habitat accessibility for UWR steelhead would be provided to 100 percent of the available spawning habitat in the North Santiam River and 82 percent in the South Santiam River Subbasins as compared to NAA operations (Table 3.8-6). Historical habitat covered by the WVS dams and reservoirs is not considered available to salmon or steelhead.

Under NAA operations, UWR Chinook salmon juveniles and UWR steelhead juveniles and kelts (post-spawn steelhead adults) would experience low downstream passage rates and survival because of poor dam passage conditions at most dams, resulting in direct, substantial, adverse effects on downstream migrants passing dams. However, downstream passage survival would be high at Fall Creek Dam for UWR Chinook salmon and moderate to high at Foster Dam for UWR Chinook salmon and UWR steelhead compared to other WVS dams. This would result from a deep drawdown to streambed in late fall at Fall Creek Dam and use of the spillway at Foster Dam for passage under the NAA. Fall Creek Reservoir drawdowns would help support the small population of UWR Chinook salmon upstream of Fall Creek Dam. Consequently, downstream passage at Fall Creek and Foster Dams under the NAA would continue to provide moderate benefits for passage of UWR Chinook salmon in the South Santiam River and Middle Fork Willamette River and to UWR steelhead in the South Santiam River over the 30-year implementation timeframe.

Modeled average downstream passage survival for Chinook salmon would be 57 percent at Foster Dam and 32 percent or less at other dams under NAA operations over the 30-year implementation timeframe (Table 3.8-12) (Appendix E, Fish and Aquatic Habitat Analyses). These estimates are lower than expected due to modeling methodology and when considering available field-based estimates of passage survival (Appendix E, Fish and Aquatic Habitat Analyses).

Table 3.8-12. Average, Minimum, and Maximum Juvenile Upper Willamette River Chinook Salmon and Juvenile Upper Willamette River Steelhead Downstream Dam Passage Survival Estimates under the No-action Alternative.

Species and Dam	Average Survival Estimate (%)	Minimum Survival Estimate (%)	Maximum Survival Estimate (%)
Chinook Salmon			
Cougar	10	9	11
Detroit	28	12	40
Foster	57	53	60
Green Peter	N/A	N/A	N/A
Hills Creek	7	3	12
Lookout Point	32	29	35
Steelhead			
Detroit	28	27	29
Foster	31	28	34

Source: Fish Benefits Workbook model survival estimates from simulated operations for years 1947 to 2019; Appendix E, Fish and Aquatic Habitat Analyses, Chapter 2, Fish Benefits Workbook Results.

Although no modeling was conducted for conditions at Fall Creek Dam, previous field studies showed high survival rates for juvenile UWR Chinook salmon during the drawdown to streambed at this location (see Nesbit et al. 2014). Downstream passage survival for steelhead under the NAA was estimated at an average of 28 percent at Detroit Dam and 31 percent at Foster Dam.

Population Performance in All Subbasins

Life cycle modeling results under the NAA over the 30-year implementation timeframe are discussed separately for each species below. Model results account for dam passage conditions, reservoir and downstream habitat conditions, ocean conditions, and pHOS experienced by above-dam local populations.

The life cycle modeling results indicate population performance of above-dam UWR Chinook salmon and UWR steelhead in all subbasins where they occur would be poor under the NAA. Additionally, there would be a high extinction risk. Consequently, there would be a direct, substantial, adverse effect on above-dam UWR Chinook salmon and UWR steelhead under NAA operations throughout the analysis area over the 30-year implementation timeframe (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a):

- Natural-origin spawner abundance for above-dam UWR Chinook salmon local populations is estimated to be extremely low or low under the NAA in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins (a mean of 963, 25, 82, and 121 adults annually, respectively).
- Initial population productivity in years 6 to 10 is estimated to be above replacement (recruits/spawner greater than 1) for UWR Chinook salmon in the North Santiam River and Middle Fork Willamette River Subbasins and below replacement in the South Santiam River and McKenzie River Subbasins above dams. Productivity is attributed to a high pHOS (88 percent or higher) for all UWR Chinook salmon local populations upstream of dams, except above Foster Dam. Over the 30-year implementation timeframe, all populations would be below replacement levels.
- The probability of each above-dam UWR Chinook salmon local population going below extinction risk abundance levels is estimated to be extremely low in the North Santiam River Subbasin (0 percent) and extremely high in the South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins (greater than 99 percent). In the North Santiam River Subbasin, the extremely low extinction risk is attributed to a high level of outplanting annually (i.e., high pHOS) and does not reflect a naturally sustainable population.
- Natural-origin spawner abundance for UWR steelhead under Alternative 1 is estimated to be extremely low (less than 25 in both subbasin local populations).

- Productivity would be below replacement (recruits/spawner about 0.50) in both local populations.
- The probability of each local population going below extinction risk abundance levels under the NAA in the analysis area is estimated to be extremely high (98 to 100 percent).

Unknown Photo Credit (USACE Media Images Database)

Fishing on Cottage Grove Reservoir.

Table 3.8-13. Summary of Attributes for Upper Willamette River Chinook Salmon in the North Santiam River Subbasin under All Alternatives.

Attribute	Metric	No-action	1	2A	2B	3A	3B	4	5
Abundance	NOR Sp. Abun.	963	12,530	13,083	13,016	7,710	5,923	12,720	13,071
Productivity	R/S	1.06	2.06	2.05	2.07	1.86	1.66	2.05	2.95
Extinction Risk	p<QET	0	0	0	0	0	0	0	0
Hatchery Influence	pHOS	1	0	0	0	0	0	0	0

Source: McAllister et al. 2022a, 2022b; McAllister et al. 2023

Eq. Abun = equilibrium abundance; R/S = recruits per spawner; p<QET = probability less than quasi-extinction threshold; pHOS = proportion of hatchery-origin spawner.

Table 3.8-14. Summary of Attributes for Upper Willamette River Chinook Salmon in the South Santiam River Subbasin under All Alternatives.

Attribute	Metric	No-action	1	2A	2B	3A	3B	4	5
Abundance (Foster)	NOR Sp. Abun.	25	1,046	772	590	433	313	57	544
Abundance (Green Peter)	NOR Sp. Abun.	N/A	1,295	963	728	535	386	N/A	676
Productivity	R/S	0.64	1.56	1.5	1.41	1.32	1.24	0.76	2.28
Extinction Risk	p<QET	0.99	0	0.03	0.10	0.32	0.61	0.96	0.17
Hatchery Influence (Foster)	pHOS	0	0	0	0	0	0	0	0
Hatchery Influence (Green Peter)	pHOS	N/A	0.39	0.43	0.48	0.54	0.61	N/A	0.48

Source: McAllister et al. 2022a, 2022b; McAllister et al. 2023

Eq. Abun = equilibrium abundance, R/S = recruits per spawner, p<QET = probability less than quasi-extinction threshold, pHOS = proportion of hatchery-origin spawner, N/A = Not Applicable.

Table 3.8-15. Summary of Attributes for Upper Willamette River Chinook Salmon in the McKenzie River Subbasin under All Alternatives.

Attribute	Metric	No-action	1	2A	2B	3A	3B	4	5
Abundance	NOR Sp. Abun.	56	44	590	291	108	220	582	296
Productivity	R/S	1.05	1.04	1.35	1.21	1.09	1.16	1.33	1.34
Extinction Risk	p<QET	1	1	0	0.38	1.0	0.74	0	0.02
Hatchery Influence	pHOS	0.88	0.91	0.19	0.48	0.77	0.58	0.20	0.50

Source: McAllister et al. 2022a, 2022b; McAllister et al. 2023

Eq. Abun = equilibrium abundance, R/S = recruits per spawner, p<QET = probability less than quasi-extinction threshold, pHOS = proportion of hatchery-origin spawner, N/A = Not Applicable.

Table 3.8-16. Summary of Attributes for Upper Willamette River Chinook Salmon in the Middle Fork Willamette River Subbasin under All Alternatives.

Attribute	Metric	No-action	1	2A	2B	3A	3B	4	5
Abundance (Lookout Point)	NOR Sp. Abun.	118	182	366	350	95	107	336	330
Abundance (Hills Creek)	NOR Sp. Abun.	N/A	121	N/A	N/A	63	72	224	N/A
Productivity	R/S	1.09	1.15	1.24	1.25	1.08	1.11	1.25	1.49
Extinction Risk	p<QET	1	0.98	0.56	0.56	0.99	0.99	0.65	0.12
Hatchery Influence (Lookout Point)	pHOS	0.89	0.85	0.74	0.75	0.91	0.90	0.75	0.74
Hatchery Influence (Hills Creek)	pHOS	N/A	0.86	N/A	N/A	0.92	0.91	0.78	N/A

Source: McAllister et al. 2022a, 2022b; McAllister et al. 2023

Eq. Abun = equilibrium abundance, R/S = recruits per spawner, p<QET = probability less than quasi-extinction threshold, pHOS = proportion of hatchery-origin spawner, N/A = Not Applicable.

Table 3.8-17. Summary of Attributes for Upper Willamette River Chinook Salmon in the North Santiam River Subbasin under All Alternatives.

Attribute	Metric	No-action	1	2A	2B	3A	3B	4	5
Abundance	NOR Sp. Abun.	22	780	873	873	209	96	818	99
Productivity	R/S	0.53	1.65	1.72	1.72	1.04	0.73	1.68	1.64
Extinction Risk	P<QET	0.98	0.39	0.35	0.35	0.74	0.88	0.37	0.13

Source: McAllister et al. 2022a, 2022b; McAllister et al. 2023

Eq. Abun = equilibrium abundance, R/S = recruits per spawner, p<QET = probability less than quasi-extinction threshold, pHOS = proportion of hatchery-origin spawner.

Table 3.8-18. Summary of Attributes for Upper Willamette River Steelhead in the South Santiam River Subbasin under All Alternatives.

Attribute	Metric	No-action	1	2A	2B	3A	3B	4	5
Abundance (Foster)	NOR Sp. Abun.	9	250	250	250	9	9	159	13
Abundance (Green Peter)	NOR Sp. Abun.	N/A	316	34	32	33	10	N/A	N/A
Productivity (Foster)	R/S	0.51	1.33	1.33	1.33	0.50	0.51	1.14	1.17
Productivity (Green Peter)	R/S	N/A	1.62	0.77	0.76	0.77	0.54	N/A	N/A
Extinction Risk (Foster)	p<QET	1.00	0.72	0.72	0.72	1.00	1.00	0.81	0.98
Extinction Risk (Green Peter)	p<QET	N/A	0.59	0.97	0.98	0.98	1.00	N/A	N/A

Source: McAllister et al. 2022a, 2022b; McAllister et al. 2023

Eq. Abun = equilibrium abundance, R/S = recruits per spawner, p<QET = probability less than quasi-extinction threshold, pHOS = proportion of hatchery-origin spawner, N/A = Not Applicable.

Bull Trout in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Under the NAA, bull trout subadults and adults would use open water habitat in reservoirs for rearing and foraging year-round in the North Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins. Some bull trout adults would temporarily leave reservoirs in late summer and fall to migrate upstream of reservoirs for spawning in tributaries then return downstream to reservoirs for overwintering and to continue foraging. Reservoir conditions would also support fish species that may compete with bull trout.

Conservation operations during the late spring through early fall would have long-term, substantial, beneficial effects on bull trout due to feeding and growth opportunities and suitable temperatures in reservoirs supporting an adfluvial life history.

Reduced open water habitat during fall drawdowns under the NAA would concentrate fish into a smaller space. This may provide slight benefits for foraging to bull trout subadults and adults because they are piscivorous, and slight to moderate adverse effects due to reduced availability of suitable water temperatures. Consequently, closer proximity to prey fish would increase feeding opportunities. Additionally, reduced temperature suitability may increase stress and disease or result in individuals moving up or downstream from the reservoir. Effects on any bull trout moving out the reservoir during fall drawdowns would vary and would depend on its ability to safely locate suitable habitat.

Riverine Habitat in All Subbasins

Under the NAA, bull trout effects from riverine habitat conditions downstream of WVS dams would be limited because most individuals in the local populations reside upstream of dams in the North Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins. Individuals that do move below these dams would be adversely affected by stream flow and water quality in the North Santiam River Subbasin below Detroit and Big Cliff Dams, the McKenzie River Subbasin below Blue River and Cougar Dams, and the Middle Fork Willamette River Subbasin below Hills Creek Dam.

There may be a slight increase in the number of individuals entrained downstream of WVS dams under NAA operations if positive trends in the bull trout population abundance available at the time of this analysis continue over the 30-year implementation timeframe. However, this increase would be limited by habitat carrying capacity[35] constraints.

There is no bull trout spawning and incubation habitat downstream of dams that would be influenced by WVS operations based on information available at the time the alternatives were analyzed. For other bull trout life stages, dam operations under the NAA would have long-term, substantial, adverse effects on bull trout subadult and adult rearing, foraging, and

[35] Carrying capacity is the maximum population that a given area can sustain (Hartvigsen 2001).

overwintering opportunities downstream of Detroit, Cougar, and Hills Creek Dams in the analysis area. However, some beneficial effects would occur under NAA operations due to seasonally increased habitat availability during summer and early fall from increased river flows.

The level of impact on downstream habitat conditions from revetments and other bank structures that prevent habitat connectivity and complexity is more adverse in lower reaches of tributary rivers and the Mainstem Willamette River, further impacting the quality of habitat for rearing, foraging, and overwintering bull trout.

Dam Passage Conditions in All Subbasins

Under the NAA, downstream dam passage conditions would continue to result in direct, adverse effects on bull trout due to low downstream dam passage rates (based on the number of bull trout observed below dams relative to the number of above) and low downstream dam passage survival for fish that do pass downstream through the dam (as assumed from survival rates estimated for Chinook salmon and steelhead trout). This is because bull trout would be entrained or would volitionally pass downstream through dam passage routes in the Middle Fork Willamette River and McKenzie River Subbasins, and North Santiam River Subbasin if reintroduction efforts for above Detroit Dam proceed and are successful.

Local bull trout populations above WVS dams in these subbasins are largely adfluvial, spawning in upstream tributaries and foraging in reservoirs where substantial prey fish are available with adequate habitat and water quality conditions. This reduces the implication- and population-level effects associated with degraded or blocked fish passage at WVS dams. For example, under existing conditions, existing local bull trout populations above WVS dams had grown substantially in abundance at the time the alternatives were analyzed, and recent trends suggest this growth pattern could continue until habitat capacity results in abundance stabilization.

Downstream passage of bull trout at dams is not well studied; actual values were not available when the alternatives were analyzed. Downstream passage rates could be higher than estimated because fish that do not survive passage are often never detected.

Downstream dam passage conditions would result in direct, moderate, adverse effects on bull trout in the analysis area over the 30-year implementation timeframe due to poor passage conditions resulting in low passage survival and habitat connectivity to formerly accessible riverine habitat.

Under the NAA, upstream passage for bull trout at WVS dams would be provided by adult fish passage facilities or by trapping and angling at Hills Creek Dam. For those surviving downstream passage, collection of adults at adult fish facilities and releasing them upstream of reservoirs would provide access to all available bull trout spawning habitat above Detroit Dam in the North Santiam River Subbasin and above Cougar Dam in the McKenzie River Subbasin.

Trapping and angling would continue to provide access for bull trout to available spawning habitat above Hills Creek Dam in the Middle Fork Willamette River Subbasin. This upstream passage of collected adults would be a direct, moderate to substantial benefit to bull trout populations in the analysis area.

Genetic exchange opportunities for local bull trout populations would be extremely low under the NAA in the Middle Fork Willamette River Subbasin due to the distance and presence of multiple dams between the existing local spawning population above Hills Creek Dam and other local populations in other subbasins in the Willamette River Basin (Bohling 2019). This would also be assumed for the reintroduction of a local bull trout population in the North Santiam River Subbasin due to impaired downstream passage at Detroit Dam and the long distance to the nearest local populations in the McKenzie River and Clackamas River Subbasins.

While there would be some limited downstream passage at Cougar Dam under NAA operations, and there are other local populations within the McKenzie River Subbasin, the likelihood for genetic exchange among these local populations is low given there has been only one previous observation of genetic exchange between the South Fork McKenzie River and other local populations in the subbasin (Zymonas et al. 2021). Further, available data indicate there was limited genetic exchange prior to dams being built. Therefore, the continuance of limited opportunities for genetic exchange would be a slight to moderate, indirect, adverse effect of dam passage conditions under the NAA due to increased risks for local population health in the long term.

Pacific Lamprey in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Pacific lamprey would not have access to WVS reservoirs, or tributaries upstream of reservoirs, under NAA operations due to the lack of collection and passage facilities at WVS dams, except above Fall Creek Dam. Therefore, in these locations, direct adverse effects due to lack of access to habitat upstream of dams would be substantial. However, there would be no effects from habitat conditions within any reservoir zone from operations on Pacific lamprey.

In Fall Creek Reservoir, small numbers of fish have been passed from the Fall Creek Adult Fish Facility or translocated above the reservoir from collection at Willamette Falls. At the time the alternatives were analyzed, there was limited information on use of Fall Creek Reservoir by larval and juvenile lamprey. However, it is expected that some lamprey would rear in streams above the reservoir or within the reservoir due to the availability of silt and sand substrates under NAA operations.

Annual drawdowns of Fall Creek Reservoir to streambed under NAA operations would compel larval lamprey to leave rearing areas within reservoir substrate and to migrate downstream or perish due to dewatering of the reservoir. Those migrating downstream would be susceptible to predation or other forms of mortality while seeking rearing habitat. Fall Creek Reservoir drawdowns under NAA operations would be a direct, substantial, adverse effect on larval lamprey.

Riverine Habitat in All Subbasins

Under the NAA, dam operations would have long-term, substantial, adverse effects on Pacific lamprey spawning, incubation, rearing, and migration opportunities in accessible areas downstream of dams in the analysis area. Effects on lamprey would result from reduced winter peak flows and blockage of large woody debris and sediment transport from dam operations. However, some beneficial effects would occur under NAA operations due to seasonally increased habitat availability during summer and early fall due to stored water released from reservoirs.

The level of impact on downstream habitat conditions from bank protection structures that prevent habitat connectivity and complexity would remain more adverse in the lower tributaries where WVS dams are located as well as in the Mainstem Willamette River, further impacting the quality of Pacific lamprey habitat for spawning, incubation, rearing, and migration. Bank protection structures would continue to locally constrain channel widths and reduce off-channel habitat under the NAA. This would contribute to adverse effects on lamprey due to blocked access or degradation of habitat conditions.

Dam Passage Conditions in All Subbasins

There would be long-term, substantial, adverse effects on Pacific lamprey passage conditions under NAA operations. Under the NAA, there would be no Pacific lamprey upstream or downstream passage structures at WVS dams and no passage at drop structures in the Long Tom River, except for Fall Creek Dam. Therefore, habitat access for Pacific lamprey spawning and rearing would be constrained to reaches downstream of WVS dams.

Accessible spawning and rearing habitat would be constrained to about 40 percent of that available in the North Santiam River, South Santiam River, Coast Fork Willamette River, McKenzie River, and Middle Fork Willamette River Subbasins, with the exception of Fall Creek in the Middle Fork Willamette River Subbasin (Appendix E, Fish and Aquatic Habitat Analyses).

Collection and release of adult Pacific lamprey at the Fall Creek Adult Fish Facility would provide for upstream passage. In the absence of data, it is assumed that upstream passage survival would be similar to adult Chinook salmon and steelhead because adult fish facility and collection and transport operations would follow established BMPs. Direct adverse effects to adult lamprey from collection and transport operations would be slight to moderate.

Similarly, in absence of data, it is assumed that downstream passage survival during Fall Creek Reservoir drawdowns would be similar to juvenile Chinook salmon. Therefore, it may be possible to establish a population above Fall Creek Dam under the NAA. If successful, this could increase abundance and spatial distribution of the species.

Larval and juvenile Pacific lamprey migrating downstream of Fall Creek Reservoir would be susceptible to predation or other forms of mortality while seeking rearing habitat. Although downstream passage rates and passage survival for larval and juvenile lamprey were unknown at the time the alternatives were analyzed, some juveniles have been documented passing downstream during the fall, deep streambed drawdowns (Frost 2017). However, downstream passage would only be available in fall, limiting the timing and duration for downstream migration.

Direct, adverse effects to larval and juvenile lamprey during reservoir drawdowns would range from substantially adverse for larval lamprey due to displacement from in-reservoir rearing habitat to slightly adverse for juveniles due to downstream passage during deep reservoir drawdowns during the fall.

Resident Fish in All Subbasins

Reservoir/Lake-like Habitat in All Subbasins

The large-scale alteration of the Willamette River Basin hydrologic system from construction of dams and the resultant changes in flood frequency and intensity has created conditions that support non-native species and predatory fishes (Williams 2014). Local populations of several reservoir resident species (non-native gamefish and native fish) would continue to occur in WVS reservoirs under the NAA, as evidenced by documented presence over multiple years under similar reservoir operations (e.g., Monzyk et al. 2014; Romer et al. 2016). Reservoir operations and resulting reservoir habitat conditions can have beneficial or adverse effects on fish species in reservoirs as discussed below.

Reservoir operations under the NAA are anticipated to have long-term, moderate to substantial, beneficial effects on reservoir resident fish populations that use lake-like habitats in the analysis area (e.g., kokanee, small mouth bass, crappie, etc.) because adequate suitable habitat would be provided over the 30-year implementation timeframe. Reservoirs provide food, a diversity of water temperatures, and a moderate diversity of physical habitat. Riparian vegetation and aquatic macrophytes would be limited and affected by seasonal pool elevation, thereby limiting habitat for some resident species and life stages.

Seasonal refill of reservoirs during the spring conservation season and reservoir drawdown operations during the flood management season under the NAA in the analysis area are anticipated to have both long-term, moderate, adverse and beneficial effects for fish over the 30-year implementation timeframe. Riverine habitat would be reduced wherever dams create more like-lake habitats. These lake-like conditions can improve food availability and water temperature diversity; however, the conditions would also promote competition and predation and adverse impacts from diseases and parasites.

Fish growth rates would be higher in reservoirs compared to streams due to food availability combined with the availability of preferred water temperatures. Biomass and community composition of zooplankton, a prey source of several fish species, would be at peak prey abundance in early summer (Murphy et al. 2020) and available for forage within WVS reservoirs. However, reservoir habitat conditions (e.g., temperatures) would enhance opportunities for parasitic invertebrates, including copepods, to adversely affect salmon and steelhead.

Data on the effects of annual drawdowns on fish species in WVS reservoirs was limited when the alternatives were analyzed. Effects from drawdowns under the NAA would depend on each fish species life history and distribution, diet and food availability, presence of competitors and predators, among other factors. Consequently, mixed adverse and beneficial effects to fish species would occur, depending on species, life stage, and the daily and seasonal habitat conditions resulting from reservoir volume fluctuations.

Some life stages depend on more stable water levels, including incubating eggs and life stages dependent on nearshore vegetation. These life stages would experience slight to substantial adverse effects (e.g., dewatering of eggs or wetland/riparian vegetation) as reservoir pools in the analysis area decline seasonally or periodically fluctuate under the NAA over the 30-year implementation timeframe. Mobile life stages (juveniles, subadults, and adults) would experience shifts in habitat and resource availability as reservoir levels and water quality conditions fluctuate annually, in some cases adverse and in others beneficial.

Fish using open water areas in reservoirs would be expected to adjust their range as habitat conditions (depth, cover, temperatures) change with reservoir volumes and elevations. Open water, piscivorous fish species could experience long-term, beneficial effects in the analysis area under the NAA. This would be due to seasonally increased feeding opportunities under low, winter water surface elevations, which would reduce proximity to prey sources. However, consumption of prey would also be reduced as temperatures decrease during winter months.

At Fall Creek Dam, deep fall reservoir drawdowns would result in almost all fish occupying the reservoir moving downstream of the dam annually under NAA operations. As a result of repeated deep drawdowns since 2011, the fish community in Fall Creek Reservoir changed to one with fewer species, including fewer non-native fish species and fewer large-sized predatory fish. The Fall Creek Reservoir fish community composition at the time the alternatives were analyzed would be expected to be maintained over the 30-year implementation timeframe. This would be a long-term, beneficial effect for migratory species, including UWR Chinook, and a long-term adverse effect for large resident predatory species.

Under the NAA, annual stocking of rainbow trout into Detroit, Green Peter, and Hills Creek Reservoirs and stocking of kokanee salmon into Detroit Reservoir by ODFW would mitigate annual effects of fish harvest in sport fisheries, reservoir fluctuations on in-reservoir habitat, and downstream fish entrainment conditions for stocked species[36]. It is anticipated that the number of gamefish maintained for sport fishing opportunities at the time the alternatives were analyzed would not change under the NAA. This is because in-reservoir habitat conditions and fish entrainment conditions similar to existing conditions would be maintained over the 30-

[36] Stocking may also be resumed in Green Peter Reservoir by ODFW during the 30-year implementation timeframe.

year implementation timeframe under NAA operations. Further, ODFW is anticipated to continue its stocking practices in the analysis area over the 30-year implementation timeframe. This would be a direct benefit to sport fishing opportunities in WVS Reservoirs throughout the analysis area and an indirect benefit to resident fish populations occurring in reservoirs.

Riverine Habitat in All Subbasins

Dam operations would have long-term, substantial, adverse effects on resident fish spawning, incubation, and rearing opportunities in areas downstream of dams in the analysis area over the 30-year implementation timeframe. However, some beneficial effects would occur under NAA operations due to seasonally increased habitat availability during summer and early fall.

The level of impact on downstream habitat conditions from revetments and other bank structures that prevent habitat connectivity and complexity is more adverse in the lower tributaries where WVS dams are located as well as in the Mainstem Willamette River, further impacting the quality of habitat for spawning, incubation, and rearing of resident fish below WVS dams. Conversely, there would be moderate, beneficial effects to resident fish that prefer rocky, steeply sloped shoreline habitat and moderate, adverse effects to resident species that prefer vegetated, gradually sloping shoreline habitat under the NAA.

Dam Passage Conditions in All Subbasins

Under NAA operations, resident fish species in WVS reservoirs would be entrained or pass downstream through existing dam passage routes, depending on the distribution of fish species and life stages relative to water surface elevations, water temperatures, and discharge rates. For example, kokanee, crappie, and bluegill would continue to be entrained at rates similar to existing conditions (Hansen et al. 2017).

Lack of, or degraded, fish passage conditions under NAA operations would generally adversely affect resident fish species. Mortality rates from entrainment would be high for some species due to factors such as their physiology, swimming behavior, and reservoir distribution. For example, kokanee, white crappie, and sunfish are more vulnerable to pressure-related injuries than UWR Chinook salmon and steelhead. Fish that survive passage downstream under the NAA could benefit from additional rearing and foraging habitat but would not be able to breed with their population of origin.

At Fall Creek Dam, annual fall deep reservoir drawdowns would entrain or pass most resident fish downstream, with a few exceptions for those that remain or move upstream of the reservoir zone during drawdowns. Survival rates during passage would be moderate to high, based on available information at the time the alternatives were analyzed.

Downstream entrained resident fish species would likely experience high mortality rates under the NAA due to loss of lake-like habitat availability and density of fish present in riverine habitat downstream. Therefore, a moderate to high, adverse effect on the abundance of resident fish species dependent on lake-like conditions in Cougar Reservoir would occur under the NAA.

Resident fish entrained that survive passage downstream could adversely affect downstream fish populations through competition and predation. The extent and degree of these adverse effects were unknown at the time the alternatives were analyzed.

Current operations at the adult fish facilities are to transport native resident fish collected in the trap. Therefore, these native resident fish populations in the analysis area would benefit from collection and release to support passage upstream of WVS dams under NAA operations. These operations would continue under the NAA over the 30-year implementation timeframe as determined by the state and Federal fish management agencies.

Alternative 1—Improve Fish Passage through Storage-focused Measures

Under Alternative 1, construction and operations of fish passage and water temperature improvement structures would be implemented as well as operational modifications. These measures would cause differences to fish habitats; habitat access between upper and lower watersheds; dam passage conditions; and in the susceptibility of fish to predation, competition, and disease when compared to the NAA.

Common effects analyses from hatcheries on habitat and from passage conditions across all fish species are discussed first, followed by analysis of effects to specific species and for resident fish. Common effects described in this section are not repeated in the species-specific analyses but are assumed to apply to species effects unless stated otherwise.

Hatchery Mitigation in All Subbasins

Under Alternative 1, the Willamette Hatchery Mitigation Program and associated effects would be the same as described under the NAA with the following exceptions:

- The number of hatchery-origin UWR Chinook salmon released upstream of some reservoirs would be reduced.
- There would be a reduction in the adverse impacts on UWR steelhead in the North Santiam River and South Santiam River Subbasins from hatchery summer-run steelhead spawning in streams.
- There would be a reduction in adverse impacts on UWR Chinook salmon from hatchery-origin spring-run Chinook salmon spawners.
- There would be risks to bull trout from the rainbow trout hatchery program.

Reductions in the number of hatchery-origin UWR Chinook salmon released upstream of Detroit Dam in the North Santiam River Subbasin, Green Peter Dam in the South Santiam River Subbasin, and Lookout Point Dam in the Middle Fork Willamette River Subbasin would occur under Alternative 1 as compared to NAA operations. These reductions would occur because of increases in natural-origin UWR Chinook salmon returns largely attributed to improved fish passage conditions under Alternative 1 compared to NAA operations. The increase in natural-origin adult returns and commensurate reductions on hatchery-origin releases above WVS dams would be a long-term, substantial reduction in the adverse effects of hatchery-origin spawners for UWR Chinook salmon under Alternative 1 as compared to the NAA.

Reductions in the number of hatchery-origin Chinook salmon released above dams would vary among subbasins and would occur where natural-origin adult returns have increased, according to the protocols included in each HGMP (ODFW and USACE 2016a, 2016b, 2016c, 2016d). Overall, UWR Chinook salmon pHOS as averaged across subbasins would decrease from 0.69 under the NAA to 0.36 under Alternative 1 operations. This would be a moderate benefit to Chinook salmon populations in the analysis area.

UWR Chinook salmon pHOS would substantially decrease in the North Santiam River Subbasin under Alternative 1. This would reduce associated effects of pHOS in this subbasin in comparison to the NAA. Release of hatchery-origin (and natural-origin) UWR Chinook salmon adults upstream of Green Peter Reservoir would result in an increase in pHOS from 0 under the NAA to 0.19 under Alternative 1 in the South Santiam River Subbasin. Consequently, there would be negligible adverse effects to UWR Chinook salmon in pHOS in these subbasins and in all analysis area subbasins compared to the NAA.

The percent of introgressive hybridization in UWR steelhead in the North Santiam River and South Santiam River Subbasins would decrease as compared to the NAA because of an increase in the abundance of UWR steelhead spawners resulting from improved fish passage at dams in these subbasins under Alternative 1. Improved passage would also increase areas where only natural-origin steelhead are spawned and reared (above dams), reducing competition and predation in these subbasins with hatchery-origin summer-run steelhead (below dams). This would be a direct, moderate benefit to steelhead populations in the analysis area.

Reservoir/Lake-like Habitat in All Subbasins

During the conservation season under Alternative 1, reservoirs within the analysis area would be at higher volumes (with higher pool surface elevations) more often compared to NAA operations due to changes in downstream flow targets in spring (Appendix B, Hydrologic Processes Technical Report). These operations would result in minor habitat benefits for resident fish species that prefer and utilize lake-like habitat provided by reservoirs within the analysis area as compared to the NAA.

Specifically, Alternative 1 operations would increase the amount of foraging, spawning, rearing, and overwintering habitat opportunities for open-water-oriented fish species as compared to NAA operations and would shift nearshore-oriented species habitat higher in elevation. Additionally, the riparian zone would be inundated for more days per year than under the NAA, providing additional habitat structure for larval and juvenile fish, shoreline spawners, and for those species preferring nearshore vegetated habitat. As under the NAA, water temperatures within reservoirs would continue to stratify each summer, and larger pool volumes achieved in some years would increase volumes of cool water within reservoirs and be discharged downstream.

During the non-conservation season, differences in water surface elevations and fluctuations under Alternative 1 compared to the NAA may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations. Drawdown durations would be longer on average across years compared to the NAA due to pools more often achieving maximum conservation elevations. Effects on juvenile UWR Chinook salmon and UWR steelhead rearing in reservoirs from longer drawdowns under Alternative 1 would be slightly beneficial to slightly more adverse for resident fish and migratory species, including UWR Chinook salmon and UWR steelhead compared to the NAA. This would be due to increased duration of higher reservoir volumes and changes in water temperatures. There would be an increased volume of cool water and increased water surface area leading to increased water surface temperatures under Alternative 1 as compared to the NAA.

Riverine Habitat in All Subbasins

Under Alternative 1, operations and management of bank protection structures in the analysis area would have the same effects on fish as described under the NAA. However, flows below dams in all subbasins would be slightly reduced in late spring and early summer and would be increased in summer and fall compared to NAA operations. This would result in a mix of indirect, adverse and beneficial effects to fish, depending on species and life stage, including habitat preferences and channel conditions.

Temperature towers in the North Santiam River Subbasin, South Santiam River Subbasin, and Middle Fork Willamette River Subbasin would increase the number of days temperature targets are met, providing minor to moderate indirect benefits to fish below WVS dams in these subbasins.

Unlike NAA operations, gravel placement below dams would decrease adverse effects of blocked sediment transport from the above-dam watersheds. As a result, effects on fish in riverine habitat below WVS dams from these operations would trend toward less adverse under Alternative 1 as compared to the NAA.

Flow

Under Alternative 1, indirect effects of flow below WVS dams on fish due to operations of dams and reservoirs would be the same as described under the NAA. However, compared to the NAA, flows below dams would be reduced in late spring and early summer and would be increased in summer and fall due to a difference in minimum flow targets. This would result in a mix of indirect, slightly adverse and slightly beneficial effects to fish, depending on species, life stage, habitat preferences, distribution and timing, and channel conditions.

Stranding Risk

Under Alternative 1, established down-ramping rates and hydropower-peaking operations would be similar to those described under the NAA. Therefore, stranding risks to fish below WVS dams would be the same as described under the NAA.

Materials Transport and Habitat Complexity in All Subbasins

Effects on fish habitat complexity and food production from reduced transport of materials below dams under Alternative 1 would be the same as described under the NAA. However, adverse effects of blocked sediment transport from above dams under NAA operations would be reduced by placement of gravel below dams under Alternative 1 operations.

Water Temperature

Adverse effects on water quality from temperature conditions in the North Santiam River, South Santiam River, and McKenzie River Subbasins would continue as under the NAA. However, unlike the NAA, these effects would trend toward a beneficial effect on water temperature because temperature targets would be met more often during an average year under Alternative 1 as compared to the NAA. Targets would be met because of water temperature control towers at Detroit and Green Peter Dams and operation of a warm water supply pipe at the Foster Adult Fish Facility fish ladder (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 1).

Under Alternative 1, effects on water quality from temperature conditions in the Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins and the Mainstem Willamette River would continue to be adverse, similar to effects described under the NAA.

Indirect effects on fish from continued adverse water temperature conditions in the Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins as well as the Mainstem Willamette River would be the same as those described under the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 1).

Total Dissolved Gas

Under Alternative 1, there would be a trend toward more beneficial effects to water quality from TDG impacts in the North Santiam River Subbasin than under the NAA. Operations under Alternative 1 would include structural improvements to reduce TDG and construction of a selective withdrawal structure at Detroit Dam. The selective withdrawal structure would reduce the need to manage water temperature through spill operations. Subsequently, a reduction of spill operations at Detroit Dam under Alternative 1 would also reduce the average number of days annually above 110 percent TDG exceedance of the water quality standard and would result in substantially fewer adverse effects as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 1).

Similarly, beneficial effects from TDG would occur under Alternative 1 in the South Santiam River Subbasin as compared to NAA operations. This is because, although TDG levels would be above 110 percent, the average number of days annually above 110 percent TDG exceedance of the water quality standard below the Santiam River dams would be slightly less adverse as compared to operations under the NAA in the South Santiam River Subbasin (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 1).

There would be moderate, adverse effects on water quality from TDG under Alternative 1 operations in the McKenzie River Subbasin as under NAA operations. However, Alternative 1 operations would result in slightly less adverse effects to TDG conditions below Cougar Dam as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 1).

TDG levels would be above 110 percent under Alternative 1 in the Middle Fork Willamette River Subbasin, but the average number of days above 110 percent TDG exceedance of the water quality standard below Lookout Point and Dexter Dams would be fewer as compared to the NAA. This slight improvement would result from structural improvements to reduce TDG under Alternative 1 (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 1).

Under Alternative 1, effects on water quality from TDG would be the same as those described under the NAA below Hills Creek and Fall Creek Dams. Slight improvements in TDG conditions would occur under Alternative 1 due to structural improvements to reduce TDG exceedance of the water quality standard at Lookout Point and Dexter Dams and construction of a selective withdrawal structure at Lookout Point Dam. The differences in the number of days that TDG levels meet targets would be minimal and would not alter the overall adverse effect on water quality from TDG in the Middle Fork Willamette River Subbasin (Section 3.5, Water Quality, Table 3.5-12) (Appendix D, Water Quality Analysis, Section 2.2, TDG Results and Effects Analysis).

Fewer days of high TDG would have beneficial effects to all fish species present in these subbasins and in hatcheries and adult fish facilities, as compared to the NAA, with substantially fewer adverse effects to fry and juvenile life stages. Indirect, adverse effects to fish from adverse water quality from TDG levels below Hills Creek and Fall Creek Dams in the Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins as well as in the Mainstem Willamette River would be the same as those described under the NAA.

Turbidity

Under Alternative 1, effects on water quality from turbidity would be the same as those described under the NAA in all subbasins and in the Mainstem Willamette River. Subsequent, indirect effects on fish from elevated turbidity would also be the same as described under the NAA.

Other Riverine Habitat Conditions in All Subbasins

Under Alternative 1, direct and indirect adverse effects to resident fish species entrained downstream during fall drawdowns would be the same as described under the NAA. Downstream habitat competition and predation for fish present downstream would continue as under NAA operations. Operations would also continue to create localized conditions favoring fish that prefer rocky, steeply sloped shorelines with limited riparian vegetation, particularly near bank protection structures, as described under the NAA.

Dam Passage Conditions in All Subbasins

Upstream Passage

Under Alternative 1, effects on upstream migrating fish would be the same as described under the NAA at dams with existing upstream passage facilities. However, additional upstream habitat access would be provided with construction of an adult fish facility at Green Peter Dam. This facility would include integrated Pacific lamprey features, upstream passage at drop structures on the Long Tom River, and a warm-water supply pipe constructed at Foster Adult Fish Facility to improve attraction of migrating fish into the fish ladder (particularly adult spring-run Chinook salmon). Operations of these features would reduce adverse impacts for upstream migrating fish, providing access to additional habitat above dams in the South Santiam River Subbasin and Long Tom River Subbasin, which would not occur under NAA operations. Under all alternatives, Federal and state fish management agencies would continue to determine the species and life stages that are to be transported for upstream passage.

Downstream Passage

Under Alternative 1, downstream passage would be provided by floating surface collectors operated in forebays at Detroit Dam, Green Peter Dam, and Lookout Point Dam and by construction of a surface flow outlet at Foster Dam. These floating surface collectors and the surface flow outlet at Foster Dam would be designed to collect surface-oriented fish as they approach these dams. Collected fish would then be transported or passed downstream of the dams. Floating fish collectors are anticipated to decrease downstream entrainment rates of resident fish species or life stages by allowing their collection and release back into the reservoirs.

Consequently, operation of floating surface collectors at Detroit, Green Peter, and Lookout Point Dams and of a surface flow outlet at Foster Dam would allow access to riverine habitat for foraging, migration, overwintering, and genetic exchange opportunities among local populations. Operation of these structures would also reduce direct injury and mortality of fish, increase connectivity between populations of resident fish above and below the dams, and help increase the abundance and genetic fitness of local fish populations compared to NAA operations. Downstream passage structure operations would result in direct, moderate to substantial reductions in adverse effects from dams due to increases in downstream passage rates and survival of migratory fish species under Alternative 1 as compared to NAA operations.

There is uncertainty regarding the realized effectiveness on fish and fish passage conditions at WVS dams although floating surface collector benefits are anticipated based on best available information at the time the alternatives were analyzed (Appendix E, Fish and Aquatic Habitat).

Unlike fish passage under NAA operations, fish collected at floating surface collectors would be passed or transported downstream of Big Cliff Dam, Foster Dam, and Dexter Dam to avoid passage through the re-regulating dams and for fish to avoid locations where harmful TDG conditions most often occur. This would result in higher rates of survival and would increase abundance of migratory fish in the analysis area, which would be a direct, substantial reduction in adverse effects of dams on migratory fish.

Resident fish species collected in downstream fish passage structures could be released back into the reservoir where they were collected, released downstream of dams, or euthanized (e.g., non-native species targeted for removal due to impacts on native fish). The release location for non-migratory, resident fish would be implemented according to state and Federal fish management objectives (e.g., habitat access and sport fishing opportunities). The degree of benefit to resident fish under Alternative 1 as compared to the NAA is unknown because the rate of resident fish collection in surface collectors is unknown, but could range from slight to substantial benefits over the 30-year implementation timeframe.

Effects of dams on downstream fish passage at all other analysis area dams would be the same as described under the NAA.

While these improvements would provide direct benefits to migrating and non-migrating fish in the North Santiam River Subbasin, South Santiam River Subbasin, and Middle Fork Willamette River Subbasin as compared to NAA operations, upstream and downstream passage would remain adverse under Alternative 1.

Upper Willamette River Chinook Salmon and Steelhead

Effects on reservoir habitat, riverine habitat, and fish passage conditions as described below would result in direct, moderate to substantial adverse effects on UWR Chinook salmon and UWR steelhead under Alternative 1 as compared to the NAA.

Reservoir/Lake-like Habitat in All Subbasins

Effects from reservoir operations on UWR Chinook salmon and UWR steelhead under Alternative 1 would be the same as under the NAA. As under the NAA, high volumes of rearing habitat would be supported during the conservation season (spring to fall) for juvenile UWR Chinook salmon and UWR steelhead under Alternative 1 operations. Growth opportunity would continue to be higher for those rearing in reservoirs compared to streams over the 30-year implementation timeframe.

Floating surface collectors operating at Detroit, Green Peter, Foster, and Lookout Point Reservoirs under Alternative 1 would result in reduced reservoir rearing periods as compared to the NAA. Consequently, some individuals would likely pass downstream of reservoirs sooner than under NAA operations.

Reduced time spent rearing in reservoirs would decrease the risk of competition, predation, and disease, which would be an increased benefit to salmon and steelhead compared to NAA reservoir conditions. However, this benefit may be tempered by increased competition and predation on juvenile UWR Chinook salmon and UWR steelhead from increased abundance of resident fish during the 30-year implementation timeframe under Alternative 1. This increase in resident fish would occur from pool elevations operated at maximum conservation levels more often under Alternative 1 than under NAA operations.

Additionally, effects on UWR Chinook salmon and UWR steelhead rearing in reservoirs from longer drawdowns under Alternative 1 would be the same as those under NAA operations.

Riverine Habitat in All Subbasins

Adverse and beneficial effects from dam operations on downstream habitat conditions under Alternative 1 would be similar to those described under the NAA. Downstream habitat improvements and augmented stream flows using reservoir storage under Alternative 1 would moderately increase downstream spawning habitat availability and incubation success, and rearing, foraging, and migrating opportunities for UWR Chinook salmon and UWR steelhead compared to the NAA, providing moderate beneficial effects to these species.

Under Alternative 1, water temperatures would be below stressful levels more often downstream of Detroit and Green Peter Dams compared to the NAA. Combined with either reduced or the same number of days of high TDG, water quality conditions under Alternative 1 would slightly reduce adverse effects on UWR Chinook salmon and UWR steelhead in the North Santiam River and South Santiam River Subbasins.

Under Alternative 1, effects on water quality from temperature conditions in the Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins and the Mainstem Willamette River would continue to be adverse, similar to effects described under the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 1).

The following are estimates of UWR Chinook salmon spawning habitat availability and spawning and incubation success in reaches downstream of dams under Alternative 1, based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area flow levels for 41 percent to 100 percent of the spawning period, depending on the river reach (Appendix E, Fish and Aquatic Habitat Analyses). Estimated amounts include slight increases in the North Santiam River and South Santiam River Subbasins, a slight decrease in the Middle Fork Willamette River Subbasin, and a negligible difference in McKenzie River Subbasin as compared to the NAA.

- 2,762 (range 20 to 7,431) average number of redds surviving until swim-up (Appendix E, Fish and Aquatic Habitat Analyses), which would be a slight decrease of average spawning and incubation success compared to the NAA.

The following are estimates of UWR steelhead spawning habitat availability and the number of age-1 and smolts in reaches downstream of dams under Alternative 1 based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 100 percent of the spawning period in dry years, which would be a negligible increase in spawning habitat available compared to the NAA (Appendix E, Fish and Aquatic Habitat Analyses).
- Average number of age-1 UWR steelhead estimated at 247,473 and 123,346, and steelhead smolts estimated at 87 and 85 in reaches downstream of dams in the North and South Santiam River Subbasins, respectively. These would be increases as compared to the NAA, except for a decrease in steelhead smolts in the North Santiam River Subbasin (Appendix E, Fish and Aquatic Habitat Analyses).

Dam Passage Conditions in All Subbasins

When accounting for habitat above and below dams, upstream dam passage improvements at Foster and Green Peter Dams under Alternative 1 would provide accessibility for UWR Chinook salmon and UWR steelhead spawning to all available habitat upstream of WVS dams in the South Santiam River Subbasin. This would be an increase in habitat access, substantially reducing adverse effects on dam passage conditions for these species compared to the NAA (Table 3.8-3).

Similar to NAA operations, Alternative 1 would also provide upstream passage and access to UWR Chinook salmon spawning habitat at Cougar Dam in the South Fork McKenzie River over the 30-year implementation timeframe. There would also be a slightly reduced adverse effect on upstream dam passage conditions for these species in the Middle Fork Willamette River Subbasin as compared to the NAA under Alternative 1.

Unlike NAA operations, restored upstream passage in the Long Tom River at drop structures under Alternative 1 would provide access to juvenile UWR Chinook salmon, non-natal, rearing habitat. Improvements at the Foster Adult Fish Facility would increase the number of upstream migrating adult UWR Chinook salmon and UWR steelhead collected from the Foster Dam tailrace under Alternative 1.

These improvements would support migration timing that is more consistent with natural run-timing and would reduce UWR Chinook salmon pHOS and summer-run steelhead introgression rates below Foster Dam by improving collection rates of hatchery-origin Chinook salmon and steelhead. The upstream passage and adult fish facility improvements would result in substantial reductions in adverse effects from dam passage conditions to UWR Chinook salmon and UWR steelhead as compared to the NAA.

Alternative 1 modeling indicates downstream dam passage improvements would provide moderate to substantial, beneficial increases in downstream passage rates and survival, habitat access, spatial distribution, and connectivity compared to the NAA. These benefits for UWR Chinook salmon and UWR steelhead would occur in the North Santiam River Subbasin at Detroit Dam and in the South Santiam River Subbasin at Green Peter and Foster Dams (Table 3.8-19) (Appendix E, Fish and Aquatic Habitat Analyses).

Table 3.8-19. Average, Minimum, and Maximum Juvenile Upper Willamette River Chinook Salmon and Juvenile Upper Willamette River Steelhead Downstream Dam Passage Survival Estimates under Alternative 1.

Species and Dam	Average Survival Estimate (%)	Minimum Survival Estimate (%)	Maximum Survival Estimate (%)
Chinook Salmon			
Cougar	8	7	9
Detroit	75	74	75
Foster	66	65	66
Green Peter	71	65	75
Hills Creek	6	2	9
Lookout Point	80	79	80
Steelhead			
Detroit	87	85	88
Foster	75	74	75

Source: Fish Benefits Workbook model survival estimates from simulated operations for years 1947 to 2019; Appendix E, Fish and Aquatic Habitat Analyses, Chapter 2, Fish Benefits Workbook Results.

There would also be substantial beneficial increases in downstream passage rates, survival, and habitat access for UWR Chinook salmon in the Middle Fork Willamette River Subbasin under Alternative 1 over the 30-year implementation timeframe. These benefits would occur at Lookout Point Dam. However, downstream passage rates, survival, and habitat access at Hills Creek Dam would be the same as under the NAA. Effects under Alternative 1 on UWR Chinook salmon would also be similar to those described under the NAA in the McKenzie River Subbasin.

Population Performance in All Subbasins

As under NAA operations, population performance of above-dam UWR Chinook salmon in the McKenzie River and Middle Fork Willamette River Subbasins is estimated to be poor under Alternative 1 with high extinction risk. However, unlike the NAA, population performance is estimated to be good with extremely low extinction risks in the North Santiam River and South Santiam River Subbasins under Alternative 1.

These results reflect moderate performance to substantial extinction risk benefits to UWR Chinook salmon in the North Santiam River and South Santiam River Subbasins in comparison to the NAA, but the same degree of substantial, adverse effect in the McKenzie River and Middle Fork Willamette River Subbasins over the 30-year implementation timeframe (Table 3.8-13 through Table 3.8-18) (Appendix E, Fish and Aquatic Habitat Analyses):

- Natural-origin spawner abundance of above-dam UWR Chinook salmon under Alternative 1 is estimated to be extremely low to low in the McKenzie River and Middle Fork Willamette River Subbasins (44 and 303 adults, respectively), and moderate to high in the South Santiam River and North Santiam River Subbasins (2,241 and 12,530 adults, respectively). These estimates are the same as under the NAA in the McKenzie River Subbasin, a slight increase in the Middle Fork Willamette River Subbasin, and substantial increases in abundance in the South Santiam River and North Santiam River Subbasins compared to the NAA.
- Initial population productivity in years 6 to 10 is estimated to be above replacement (recruits/spawner greater than 1) for most UWR Chinook salmon local populations upstream of WVS dams in the analysis area, except for in the McKenzie River Subbasin. However, estimated productivity is attributed to moderate to very high pHOS (43 and 88 percent, respectively) over the 30-year implementation timeframe and does not reflect naturally sustainable populations in the Middle Fork Willamette River and McKenzie River Subbasins.

  The estimated pHOS is low (0 and 19 percent) under Alternative 1 in the South Santiam River and North Santiam River Subbasins over the 30-year implementation timeframe. The estimated pHOS under Alternative 1 is about the same as the NAA in the McKenzie River and South Santiam River Subbasins, but slightly to substantially less than the NAA in the Middle Fork Willamette River and North Santiam River Subbasins, respectively. Over the 30-year implementation timeframe, populations would be below replacement levels, except above Detroit Dam in the North Santiam River Subbasin.
- The probability of individual UWR Chinook salmon local population upstream of WVS dams in the analysis area going below extinction risk abundance levels is estimated to be extremely low (0) in the North Santiam River and South Santiam River Subbasins and extremely high (greater than 98 percent) in the McKenzie River and Middle Fork Willamette River Subbasins. These estimates represent a substantial improvement (decrease) in extinction risk of UWR Chinook salmon local populations upstream of dams compared to the NAA for the South Santiam River Subbasin, and the same degree of adverse effect as under the NAA in the South Santiam River and North Santiam River Subbasins over the 30-year implementation timeframe.

Under Alternative 1, population performance of above-dam UWR steelhead local populations in the analysis area is estimated to be poor with moderate to high extinction risks, reflecting moderate to substantial adverse effects (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a):

- Natural-origin spawner abundance for above-dam UWR steelhead is estimated to be low in both the North Santiam River and South Santiam River Subbasins (780 and 566 adults, respectively), although these would be substantial increases compared to the NAA.
- Productivity would be above replacement (recruits/spawner greater than 1) in both above-dam UWR steelhead local populations, which represents substantial increases compared to the NAA.
- The probability of each above-dam UWR steelhead local population going below extinction risk abundance levels under the NAA in the analysis area over the 30-year implementation timeframe is estimated to be very high (72 percent) upstream of Foster Dam and moderate upstream of Detroit and Green Peter Dams (39 and 59 percent, respectively), which represent slight to moderate improvement compared to the NAA.

Bull Trout in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Effects on bull trout from drawdowns under Alternative 1 would be similar to those under the NAA. Under Alternative 1, reservoir operations in the analysis area would provide similar to slightly improved foraging habitat due to the increased number of years reservoirs fully refill during the conservation season as under the NAA operations. This would benefit local bull trout populations.

Riverine Habitat in All Subbasins

Adverse and beneficial effects from regulated flow from WVS dams would be similar to those described under the NAA. Downstream habitat improvements[37] under Alternative 1 would slightly to moderately increase downstream rearing, foraging, and overwintering opportunities for bull trout local populations compared to the NAA. However, ambient water temperatures below dams and in the Mainstem Willamette River would continue to limit availability during warmer summer months.

Compared to the NAA, water temperatures below stressful levels for bull trout would occur more often downstream of Detroit Dam under Alternative 1 due to temperature tower operations. Effects on water quality from temperature conditions in the Middle Fork Willamette

[37] Gravel augmentation; maintaining revetments using nature-based engineering or altering revetments for aquatic ecosystem restoration.

River, Coast Fork Willamette River, and Long Tom River Subbasins and in the Mainstem Willamette River would continue to be adverse, similar to effects described under the NAA.

The number of days of high TDG would be reduced or would be the same below Hills Creek and Cougar Dams but reduced below Detroit Dam with operation of a floating surface collector as compared to NAA operations. These conditions would provide slight, beneficial effects on bull trout in the North Santiam River, Middle Fork Willamette River, and McKenzie River Subbasins as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 1).

Dam Passage Conditions in All Subbasins

Under Alternative 1, upstream passage conditions would be the same as described under the NAA. Direct and indirect adverse effects of downstream passage at dams on bull trout in the analysis area would be the same as under the NAA, except at Detroit Dam in the North Santiam River Subbasin.

Downstream passage improvements would be implemented at Detroit Dam under Alternative 1. This would substantially increase survival for bull trout passing downstream and accessing habitat below these dams as compared to the NAA in the North Santiam River Subbasin. Improved downstream passage would also slightly improve opportunities for genetic exchange with other local bull trout populations in the Willamette River Basin. However, improved downstream passage would also increase exposure of bull trout to risks of injury and mortality in sport fisheries downstream of Detroit Dam.

Pacific Lamprey in the Upper Willamette River Basin

Reservoir/Lake-like Conditions in All Subbasins

Effects from reservoir operations under Alternative 1 on Pacific lamprey would be the same as those described under the NAA.

Riverine Habitat in All Subbasins

Downstream habitat improvements under Alternative 1 would slightly decrease adverse effects on spawning habitat availability and associated incubation success and rearing and migrating opportunities for Pacific lamprey compared to the NAA.

Indirect effects of dam operations on Pacific lamprey spawning, rearing, and migration habitat under Alternative 1 would be slightly more adverse in spring due to lower minimum flow targets as compared to NAA operations. Conversely, effects on Pacific lamprey rearing and migration habitat under Alternative 1 would be slightly less adverse in summer and fall in drier years compared to the NAA due to an increase in rearing and migration habitat from increased flow releases under Alternative 1 as compared to NAA operations.

Water temperatures and TDG would be below stressful levels for Pacific lamprey more often downstream of Big Cliff, Cougar, and Dexter Dams under Alternative 1 as compared to NAA operations (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 1). This would slightly reduce adverse effects on Pacific lamprey due to improved rearing and spawning conditions in the North Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins compared to the NAA. Water temperatures would be above stressful levels for lamprey more often downstream of Foster Dam, which would result in slight, adverse effects on Pacific lamprey in the South Santiam River Subbasin.

Dam Passage Conditions in All Subbasins

Effects of dam passage conditions under Alternative 1 in the analysis area over the 30-year implementation timeframe on Pacific lamprey would be the same as under the NAA, except for fish passage improvements at drop structures on the Long Tom River downstream of Fern Ridge Dam under Alternative 1. These fish passage improvements would provide access to additional Pacific lamprey spawning and rearing habitat in the mainstem and tributaries within the Long Tom River Subbasin. Overall, this would be a slight increase in basin-wide spawning and rearing habitat availability and associated production of Pacific lamprey compared to the NAA and, therefore, a slight, beneficial effect over the 30-year implementation timeframe.

Resident Fish in All Subbasins

Reservoir/Lake-like Habitat in All Subbasins

During the conservation season under Alternative 1, reservoirs within the analysis area would be at higher volumes (with higher pool surface elevations) more often compared to the NAA due to changes in downstream flow targets in spring (Appendix B, Hydrologic Processes Technical Report). These operations would result in slight reductions in adverse effects on resident fish populations, particularly those using vegetated reservoir shoreline areas in the analysis area over the 30-year implementation timeframe as compared to the NAA.

Specifically, Alternative 1 operations would increase the amount of foraging, spawning, rearing, and overwintering habitat opportunities for open-water-oriented fish species and would shift nearshore-oriented species higher up on the shoreline. Additionally, the riparian zone would be inundated for more days per year, providing additional habitat structure for larval and juvenile fish, shoreline spawners, and for those species that prefer nearshore vegetated habitat. Water temperatures within reservoirs would continue to stratify each summer, and larger pool volumes achieved in some years would increase volumes of cool water within reservoirs and be discharged downstream.

Effects on stocked gamefish under Alternative 1 would be the same as described under the NAA.

Riverine Habitat in All Subbasins

Under Alternative 1 operations, there would be a slight increase in adverse effects on resident fish species as compared to NAA operations from lower flow releases in spring. Lower flow releases would reduce habitat for rearing, foraging, and spawning for some species and life stages, depending on channel conditions, timing, species, and life stages present.

Beneficial effects to resident fish species would occur under Alternative 1 operations as compared to the NAA during the summer and fall in drier years due to increased flow releases. Increased flow releases would increase habitat for rearing, foraging, and spawning for some species and life stages, depending on channel conditions, timing, species, and life stages present. These releases would occur intermittently during the 30-year implementation timeframe only during dry years.

Additionally, there would be a reduction in TDG under Alternative 1 as compared to NAA operations in the analysis area. Combined, there would be long-term, moderate, beneficial effects on all resident fish species in reaches downstream of all WVS dams under Alternative 1 as compared to NAA operations.

Dam Passage Conditions in All Subbasins

Under Alternative 1, effects to mid- and deep-water-oriented resident fish species and life stages from entrainment downstream through turbine and regulating outlets in the analysis area would be slightly to moderately reduced at Detroit, Green Peter and Lookout Point Dams as compared to NAA operations. This would provide direct, long-term, beneficial effects on resident fish from structural downstream passage improvements at these locations. Effects on resident fish would be the same as described under the NAA at all other WVS dams.

Some surface-oriented reservoir resident fish species would be collected in floating surface collectors in the forebays of Detroit, Green Peter, and Lookout Point Dams under Alternative 1 as compared to NAA operations. While the location of releases would be determined by state and Federal fish managers during the 30-year implementation timeframe, collection and release activities would decrease the numbers of surface-oriented reservoir resident fish species passing downstream over spillways and associated injury and mortality. The extent of these effects over the 30-year implementation timeframe is unknown because species, locations, and timing were unknown at the time the alternatives were analyzed.

As under the NAA, adult fish facilities operated under Alternative 1 would allow passage of resident fish upstream of all WVS dams over the 30-year implementation timeframe. Unlike the NAA operations, passage above Green Peter Dam would be provided to resident fish under Alternative 1. Combined passage improvements over NAA operations would be a substantial benefit to resident fish in the analysis area.

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Under Alternative 2A, construction and operations of fish passage and water temperature improvement structures would be implemented as well as operational modifications. These measures would cause differences to fish habitats; habitat access between upper and lower watersheds; dam passage conditions; and in the susceptibility of fish to predation, competition, and disease when compared to the NAA.

Common effects analyses from hatcheries on habitat and from passage conditions across all fish species are discussed first, followed by analysis of effects specific to each fish species or population. Common effects described in this section are not repeated in the species-specific analyses but are assumed to apply to species effects unless stated otherwise.

Hatchery Mitigation in All Subbasins

The Willamette Hatchery Mitigation Program and associated effects under Alternative 2A would be the same as described under the NAA with the following exceptions:

- Alternative 2A operations would include adjustments to the number of hatchery-origin UWR Chinook salmon released upstream of some reservoirs.
- There would be a reduction in adverse impacts on UWR steelhead in the North Santiam River and South Santiam River Subbasins from hatchery summer-run steelhead spawning in streams.
- There would be a reduction in the adverse impacts on UWR Chinook salmon from hatchery-origin spring-run Chinook salmon spawners.
- There would be risks to bull trout from the rainbow trout hatchery program.

Under Alternative 2A, Chinook salmon (hatchery-origin and natural-origin) adults would be released upstream of Green Peter Dam as compared to the NAA. Average pHOS in all subbasins would decrease from 0.69 under the NAA to 0.29 under Alternative 2A, although there would be some variability between subbasins. This substantial reduction in adverse effects of pHOS would result from improved fish passage conditions, subsequent increases in natural-origin adult Chinook salmon, and commensurate decreases in pHOS in these subbasins as compared to NAA operations.

The percent of introgressive hybridization in UWR steelhead in the North Santiam River and South Santiam River Subbasins would decrease as compared to the NAA because of an increase in the abundance of UWR steelhead spawners resulting from improved fish passage at dams in these subbasins under Alternative 2A operations. Improved passage would also increase areas where only natural-origin steelhead are spawned and reared (above dams), reducing competition and predation in the subbasins with hatchery-origin summer-run steelhead (below dams). This would be a direct, moderate benefit to steelhead populations in the analysis area.

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 2A, effects of reservoir operations on fish would be the same as described under the NAA, except for effects in Green Peter Reservoir. Differences in water surface elevations and fluctuations may occur seasonally at the local level at each reservoir (including Green Peter Reservoir) compared to the NAA, depending on specific annual or seasonal climate conditions and specific dam operations.

A deep fall drawdown at Green Peter Reservoir under Alternative 2A would result in less open water habitat (lower water surface elevation and volume) and increased turbidity in late fall as compared to the NAA. The substantial, adverse effect of reduced reservoir habitat volume would increase competition and predation among species and life stages using open water habitat during fall and winter months, and would reduce water temperature stratification decreasing habitat diversity.

Unlike the NAA, there would be a decrease in abundance of resident reservoir fish species over the 30-year implementation timeframe. Seasonal reductions in open water habitat in Green Peter Reservoir would continue to support persistence of some resident fish species; however, there would be a moderate to substantial, adverse effect on these species. Migratory species, including UWR Chinook salmon and steelhead, would benefit from reduced reservoir pool volumes, including reductions in predation from reduced resident fish abundance, disease risk, and travel times migrating through reservoirs.

Riverine Habitat in All Subbasins

Under Alternative 2A, operations and management of bank protection structures in the analysis area would have similar effects on fish as described under the NAA. However, additional adverse effects would occur from changes in flows and water quality conditions below Green Peter and Foster Dams in the South Santiam River Subbasin. This would be due to a deep, fall drawdown of Green Peter Reservoir.

Conversely, a temperature tower in the North Santiam River Subbasin would increase the number of days temperature targets are met. This would provide minor to moderate, indirect benefits to fish habitat conditions below Big Cliff Dam. A warm water supply pipe at the Foster Adult Fish Facility under Alternative 2A would improve fish collection rates as compared to the NAA.

Unlike NAA operations, gravel placement below dams would decrease adverse effects of blocked sediment transport from the above-dam watersheds. As a result, effects on fish in riverine habitat below WVS dams from these operations would trend toward less adverse under Alternative 2A as compared to the NAA.

Flow

Under Alternative 2A, indirect effects of flow below WVS dams on fish due to operations of dams and reservoirs would be similar to those described under the NAA. However, Alternative 2A operations would shift the release of stored water from the spring to the summer and fall, most prominently in dry years. This would result in increases in flow augmentation from reservoir storage (increases in seasonal base flows) in the summer and fall compared to the NAA. Consequently, there would be a mix of indirect, slightly adverse and slightly beneficial effects to fish, depending on species, life stage, habitat preferences, distribution, timing, and channel conditions compared to the NAA.

Stranding Risk

Under Alternative 2A, established down-ramping rates and hydropower-peaking operations would be similar to those described under the NAA. Therefore, stranding risks to fish below WVS dams would be the same as described under the NAA.

Materials Transport and Habitat Complexity

Effects on habitat complexity and food production from reduced transport of materials below dams under Alternative 2A would be the same as described under the NAA. However, adverse effects of blocked sediment transport from above dams under NAA operations would be reduced by placement of gravel below dams under Alternative 2A operations.

Additionally, partial deep drawdowns of Green Peter Reservoir would increase transport of fine sediments and nutrients, resulting in slight increases in deposition of these materials below Green Peter Dam in the South Santiam River Subbasin. This would be a slight benefit on habitat complexity and food production in this subbasin.

Water Temperature

As under the NAA, operations under Alternative 2A would result in adverse effects to water quality during times of the year when temperature targets are not met in the North Santiam River Subbasin. However, unlike the NAA, a selective withdrawal structure would be operated at Detroit Dam resulting in reduced adverse effects to water quality from improved temperature conditions downstream of Detroit and Big Cliff Dams. Temperature targets would be met more often during an average year under Alternative 2A and result in substantially fewer adverse effects as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

In the South Santiam River Subbasin, operations under Alternative 2A would result in adverse effects to water quality during times of year when temperature targets are not met similar to the NAA. Conversely, moderately beneficial effects from water temperatures in the Foster Adult Fish Facility fish ladder would occur with operation of a warm water supply pipe that would increase the entrance and collection rate of upstream migrating adult Chinook salmon at adult fish facilities below Foster Dam.

Under Alternative 2A, effects on water quality from temperature conditions in the McKenzie River Subbasin would continue to be adverse during times of the year when water temperature targets are not met, similar to effects described under the NAA. A slight increase in adverse temperature conditions downstream of Cougar Dam would occur under Alternative 2A operations. However, differences in the number of days that temperatures would meet targets would be minimal and would not alter the overall adverse effect on water quality from temperature in this subbasin with a slight adverse effect, similar to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

Under Alternative 2A, effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue to be adverse, similar to effects described under the NAA. Slight increases in adverse temperature conditions would occur under Alternative 2A downstream of Hills Creek Dam. However, slight decreases in adverse temperature conditions would occur under Alternative 2A downstream of Dexter Dam. Differences in the number of days that temperatures would meet targets would be minimal and would not alter the overall adverse effect on water quality from temperature in this subbasin (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

Under Alternative 2A, effects on water quality from temperature conditions in the Coast Fork Willamette River Subbasin, Long Tom River Subbasin, and Mainstem Willamette River would continue to be adverse, similar to effects described under the NAA. Effects on fish from continued adverse water temperature conditions in these subbasins would be the same as those described under the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

Under Alternative 2A, indirect effects to fish in river reaches below WVS dams and to fish held in or released below hatcheries or adult fish facilities below WVS dams would be negligible to slightly beneficial as compared to the NAA. This would be because of reduced temperature-related stress in the North Santiam River Subbasin below Detroit and Big Cliff Dams, depending on species and life stage.

Indirect effects to fish in river reaches below WVS dams, and to fish held in or released below hatcheries or adult fish facilities below WVS dams, would be slightly more adverse below Cougar Dam in the McKenzie River Subbasin as compared to the NAA because temperature targets would be met less often under Alternative 2A.

Total Dissolved Gas

Under Alternative 2A, there would be a reduction in adverse effects to water quality in the North Santiam River Subbasin from TDG due to a decrease in the average number of days annually above 110 percent TDG exceedance of the water quality standard compared to the NAA. This improvement would result from reduction of spill operations due to construction of the selective withdrawal structure at Detroit Dam and thereby reducing the need for temperature management through operational spill and resulting in substantially fewer adverse effects as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

Under Alternative 2A, there would be a substantially more adverse effect to water quality from TDG as compared to the NAA in the South Santiam River Subbasin. The increase in TDG exceedance of the water quality standard would be observed downstream of Green Peter and Foster Dams. This would be due to an increase in spill operations at Green Peter Dam in the spring (fish passage operation) and summer (temperature management operation. There would be no TDG abatement measure implemented under Alternative 2A (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

Under Alternative 2A, effects on water quality from TDG in the McKenzie River and Mainstem Willamette River and the Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins would be the same as those described under the NAA. There may be differences in the number of days of TDG levels meeting targets and slight improvements; however, this would not alter overall adverse effects on water quality from TDG (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A). Effects to fish from gas bubble trauma and other TDG-related impacts would be the same as described under the NAA.

Adverse effects to fish from gas bubble trauma and other impacts related to TDG under Alternative 2A would occur in all subbasins as under the NAA. However, indirect, adverse effects to fish from adverse water quality due to TDG levels would be moderately to substantially reduced in the North Santiam River Subbasin compared to the NAA. Conversely, there would be an increase in indirect, adverse effects to fish in the South Santiam River Subbasin from TDG-related impacts under Alternative 2A as compared to NAA operations.

Turbidity

Under Alternative 2A, effects on water quality from turbidity would be the same as described under Alternative 1 in the North Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

In the South Santiam River Subbasin, operations under Alternative 2A would cause an increase in sediment and turbidity levels downstream of Green Peter and Foster Reservoirs because of the deep fall drawdown at Green Peter, increasing the potential for bank erosion and sloughing as compared to NAA operations (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

While some fine-grained sediment that enters Foster Reservoir from Green Peter Reservoir may partially settle, most fine-grained sediment would pass through Foster Reservoir and be transported downstream. This would likely result in temporary increased turbidity during deeper Green Peter Reservoir drawdowns as compared to operations under the NAA. This adverse effect is expected to lessen over time as the exposed banks and channel stabilize (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

Temporary increased sediments downstream of Green Peter Dam from fall deep drawdowns under Alternative 2A would affect prey sources (e.g., bury aquatic invertebrates), fish foraging, and reduce quality of intragravel habitat for fish egg and larval incubation downstream of Green Peter and Foster Dams. However, there could be some longer-term benefits from release of sediments downstream for production of riparian and aquatic plants and insects.

Direct effects to fish from high turbidity in the South Santiam River Subbasin would be minor to substantial during the fall and early winter drawdown period each year. Indirect effects on fish habitat from fine sediment transport and deposition would be minorly beneficial to moderately adverse, depending on species and life stage.

Impacts on water quality and on fish from turbidity in the Mainstem Willamette River would be the same as described under the NAA.

Indirect effects to fish from turbidity would be the same as the NAA, except in the South Santiam. Below Green Peter and Foster Dams, indirect effects to fish would be moderate to substantial during drawdown periods each year as compared to NAA operations. Indirect effects on fish in the South Santiam below dams from fine sediment transport and deposition would be minorly beneficial to moderately adverse, depending on species and life stage.

Other Riverine Habitat Conditions in All Subbasins

Under Alternative 2A, direct and indirect adverse effects on resident fish species entrained downstream during fall drawdowns would be the same as described under the NAA. Downstream habitat competition and predation for fish present downstream would continue as under the NAA.

Partial deep drawdowns of Green Peter Reservoir would increase entrainment of resident fish species below dams in the South Santiam River Subbasin, resulting in increases in competition and predation for fish present in river reaches below dams.

Operations would also continue to create localized conditions favoring fish that prefer rocky, steeply sloped shorelines with limited riparian vegetation, particularly near bank protection structures as described under the NAA.

Dam Passage Conditions in All Subbasins

Upstream Passage

Under Alternative 2A, effects on upstream migrating fish would be the same as described under the NAA at dams with existing upstream passage facilities. However, additional upstream habitat access would be provided with construction of an adult fish facility at Green Peter Dam.

This facility would include integrated Pacific lamprey features, and a warm-water supply pipe constructed at Foster Adult Fish Facility to improve attraction of migrating fish into the fish ladder (particularly adult spring-run Chinook salmon). Operations of these features would reduce adverse impacts for upstream migrating fish, providing access to additional habitat above dams in the South Santiam River Subbasin, which would not occur under NAA operations. Under all alternatives, Federal and state fish management agencies would continue to determine the species and life stages that are to be transported for upstream passage.

Downstream Passage

Downstream dam passage would include a combination of structural modifications and modified operations. New structures would include floating surface collectors at Detroit, Lookout Point, and Cougar Dams and construction of a surface flow outlet at Foster Dam. Benefits of these structures on migratory and resident fish would be the same as described under Alternative 1.

Modified operations as compared to NAA operations would include a deep fall drawdown and spring spills at Green Peter Dam under Alternative 2A. Direct benefits of these operations are expected to improve downstream passage rates and dam passage survival and support life history diversity (with passage during both the spring and fall seasons) of migratory and resident fish. However, the degree of benefit to fish from these operations as compared to the NAA is uncertain because the rate of fish passage under these operations was unknown at the time the alternatives were analyzed. Benefits could range from slight to substantial reductions in adverse effects of dams on downstream fish passage over the 30-year implementation timeframe.

While these improvements would be direct benefits to migrating and resident fish in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins as compared to NAA operations, upstream and downstream passage effects overall would remain adverse under Alternative 2A.

Upper Willamette River Chinook Salmon and Steelhead

Effects on reservoir habitat, riverine habitat, and fish passage conditions would result in direct, moderate to substantial adverse effects on UWR Chinook salmon and UWR steelhead under Alternative 2A as compared to the NAA.

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 2A, effects on UWR Chinook salmon and UWR steelhead from operations-related reservoir habitat conditions would be the same as described under the NAA, except for Green Peter Reservoir. At Green Peter Reservoir, lower water surface elevations and volumes during the deep fall drawdown under Alternative 2A would seasonally concentrate fish into a smaller space compared to NAA conditions. This would slightly increase mortality from higher in-reservoir water temperatures or competition for food, and predation upon juvenile UWR Chinook salmon and UWR steelhead rearing in the reservoir.

Riverine Habitat in All Subbasins

Downstream habitat improvements and augmented streams flows using reservoir storage under Alternative 2A would slightly increase UWR Chinook salmon and steelhead spawning habitat availability and incubation success below dams as well as rearing, foraging, and migrating opportunities compared to the NAA. However, effects on water quality from temperature conditions and TDG in the McKenzie River and the Middle Fork Willamette River Subbasins would be the same as described under the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

Water temperatures would be below stressful levels more often compared to the NAA and would have slight beneficial effects on UWR Chinook salmon and UWR steelhead in the North Santiam River Subbasin downstream of Detroit and Big Cliff Dams, and South Santiam River Subbasin downstream of Green Peter and Foster Dams (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

Conversely, high TDG and increased turbidity and sediments would occur more often downstream of Green Peter and Foster Dams under Alternative 2A compared to the NAA, having slight to moderate increases in adverse effects on UWR Chinook salmon and UWR steelhead in the South Santiam River Subbasin compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2A).

The following are estimates of UWR Chinook salmon spawning habitat availability and spawning and incubation success in reaches downstream of dams under Alternative 2A, based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area flow levels for 30 percent to 100 percent of the spawning period, depending on the river reach (Appendix E, Fish and Aquatic Habitat Analyses). Compared to the NAA, estimated amounts include slight increases in the North Santiam River and South Santiam River Subbasins, a moderate decrease in the Middle Fork Willamette River Subbasin, and negligible differences in the McKenzie River Subbasin.
- 3,071 (range 19 to 7430) average number of redds surviving until swim-up (Appendix E, Fish and Aquatic Habitat Analyses), which would be a slight increase of average spawning and incubation success compared to the NAA.

The following are estimates of UWR steelhead spawning habitat availability and the number of age-1 and smolts in reaches downstream of dams under Alternative 1 based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 99 to 100 percent of the spawning period, the same as the NAA (Appendix E, Fish and Aquatic Habitat Analyses).
- Average number of age-1 UWR steelhead estimated at 240,071 and 141,392, and steelhead smolts estimated at 88 and 86 in reaches downstream of dams in the North and South Santiam River Subbasins, respectively. These levels are increases compared to the NAA, except for a decrease in steelhead smolts in the North Santiam River Subbasin (Appendix E, Fish and Aquatic Habitat Analyses).

Dam Passage Conditions in All Subbasins

Effects of upstream dam passage improvements under Alternative 2A would be the same as described under Alternative 1 with the exception that the benefits of passage would not be realized at drop structures in the Long Tom River.

New structural and operational downstream dam passage improvements would provide moderate to substantial increases in downstream passage rates and survival, habitat access, and genetic exchange opportunities compared to the NAA for UWR Chinook salmon and UWR steelhead. These direct benefits to UWR Chinook salmon would occur in the North Santiam River at Detroit Dam and in the South Santiam River Subbasin at Foster Dam. They would occur in the Middle Fork Willamette River Subbasin at Lookout Point Dam and in the McKenzie River Subbasin at Cougar Dam (Table 3.8-20).

Table 3.8-20. Average, Minimum, and Maximum Juvenile Upper Willamette River Chinook Salmon and Juvenile Upper Willamette River Steelhead Downstream Dam Passage Survival Estimates under Alternative 2A.

Species and Dam	Average Survival Estimate (%)	Minimum Survival Estimate (%)	Maximum Survival Estimate (%)
Chinook Salmon			
Cougar	83	82	84
Detroit	82	81	82
Foster	75	66	79
Green Peter	38	15	53
Hills Creek	N/A	N/A	N/A
Lookout Point	77	77	78

Steelhead			
Detroit	91	89	92
Foster	70	60	75
Green Peter	32	20	39

Source: Fish Benefits Workbook model survival estimates from simulated operations for years 1947 to 2019; Appendix E, Fish and Aquatic Habitat Analyses, Chapter 2, Fish Benefits Workbook Results.

N/A = Not Applicable.

Operational measures for downstream fish passage at Green Peter Dam would moderately increase passage rates and survival for juvenile Chinook salmon migrants in spring and fall as compared to the NAA operations. Under Alternative 2A, the majority of migrants would be subyearlings; fry would be the second most common type of migrants from Green Peter Reservoir.

Population Performance in All Subbasins

Under Alternative 2A, population performance of UWR Chinook salmon above WVS dams in the analysis area is estimated to be fair to good with low to moderate extinction risks. These results represent moderate to substantial reductions in adverse effects compared to the NAA (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a, 2022b; McAllister et al. 2023):

- Natural-origin spawner abundance for upstream of dam local populations under Alternative 2A is estimated to be low in the Middle Fork Willamette River Subbasin (358 adults), moderate in the South Santiam and McKenzie River Subbasins (1,753 and 1,503 adults, respectively), and high in the North Santiam Subbasin (13,083). These estimates represent a substantial increase in the North Santiam River and South Santiam River Subbasins, and a moderate increase in the McKenzie River and Middle Fork Willamette River Subbasins compared to the NAA.
- Initial population productivity in years 6 to 10 is estimated to be above-replacement (recruits/spawner greater than 1) for all four UWR Chinook salmon local populations upstream of dams in the analysis area. Productivity is attributed to a high pHOS (74 percent) in the Middle Fork Willamette River Subbasin. Compared to the NAA, productivity would increase in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette Subbasins. Over the 30-year implementation timeframe, populations would be below replacement levels, except above Detroit Dam in the North Santiam River Subbasin.
- The probability of individual UWR Chinook salmon local populations upstream of WVS dams in the analysis area going below extinction risk abundance levels is estimated to be moderate (0.56 percent) in the Middle Fork Willamette River Subbasin and extremely low (less than 0.03 percent) in the North Santiam River, South Santiam River, and McKenzie River Subbasins. These estimates represent substantial improvement in extinction risk of UWR Chinook salmon compared to the NAA in these subbasins.

Under Alternative 2A, population performance of UWR steelhead above WVS dams in the analysis area is estimated to be poor with high extinction risks, reflecting substantial adverse effects (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a, 2022b; McAllister et al. 2023):

- Natural-origin spawner abundance upstream of Green Peter, Foster, and Detroit Dams for UWR steelhead local populations under Alternative 2A is estimated to be low (284 adults in the South Santiam River Subbasin and 873 adults in the North Santiam River Subbasin), which are substantial increases compared to the NAA.
- Productivity is estimated to be above replacement (recruits/spawner greater than 1) for UWR steelhead local populations upstream of Detroit and Foster Dams, representing an increase compared to the NAA. Like the NAA, productivity is estimated to be below replacement (0.77) for the UWR steelhead local population upstream of Green Peter Dam. Therefore, hatchery supplementation would likely be necessary to maintain steelhead above Green Peter Dam under Alternative 2A.
- The probability of each above-dam UWR steelhead local population going below extinction risk abundance levels is estimated as moderate upstream of Detroit Dam (35 percent) and very high upstream of Foster and Green Peter Dams (72 and 97 percent, respectively). Compared to the NAA, extinction risk would improve substantially above Detroit Dam and modestly above Foster Dam. Extinction risk would be the same as under the NAA above Green Peter Dam.

Bull Trout in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 2A, effects from operations-related reservoir habitat conditions on bull trout would be the same as described under the NAA.

Riverine Habitat in All Subbasins

Adverse and beneficial effects from regulated flow from WVS dams would be similar to those described under the NAA. Effects of downstream habitat improvements under Alternative 2A would be the same as described under Alternative 1.

Compared to the NAA, water temperatures below stressful levels would occur more often downstream of Detroit Dam; however, temperatures would remain similar to the NAA below Cougar and Hills Creek Dams. The number of days of high TDG would be reduced or the same below Cougar and Hills Creek Dams as compared to the NAA. However, the number of days would be reduced below Detroit Dam, which would reduce adverse effects of TDG on bull trout. These conditions would provide slight, beneficial effects on bull trout in the North Santiam River, Middle Fork Willamette River, and McKenzie River Subbasins (Section 3.5.2.1, Water Quality, Methodology Subsection, Table 3.5.10 through Table 3.5.12).

Dam Passage Conditions in All Subbasins

Under Alternative 2A, upstream passage conditions would be the same as described under the NAA. Direct and indirect adverse effects on bull trout from downstream fish passage would be substantially reduced with implementation of floating surface collectors. These structures would provide improved downstream passage conditions at Cougar Dam in the McKenzie River Subbasin and at Detroit Dam in the North Santiam River Subbasin if the reintroduction is implemented and successful above Detroit Dam.

These structures would substantially increase survival for bull trout passing downstream and accessing habitat below these dams as compared to the NAA. Consequently, this increased passage below Detroit and Cougar Dams would improve opportunity for genetic exchange with other local bull trout populations, particularly in the McKenzie River Subbasin due to the proximity with other local populations. However, improved downstream passage would also increase exposure of bull trout to risks of injury and mortality in sport fisheries downstream of these dams, and competition with other resident fish for habitat and food.

Downstream passage conditions at Hills Creek Dam would be the same as described under the NAA. However, structural improvements would provide improved downstream passage conditions at Lookout Point Dam for bull trout that pass downstream of Hills Creek Dam and then move further downstream. Bull trout could also be collected by the floating surface collectors under Alternative 2A at Lookout Point Dam and transported upstream to existing spawning habitat. However, very few bull trout would be expected to move downstream to Lookout Point Dam. Therefore, improved downstream passage at Lookout Point Dam would provide only slightly fewer adverse effects for bull trout dam passage in comparison to the NAA in the Middle Fork Willamette River Subbasin.

Pacific Lamprey in the Upper Willamette River Basin

Reservoir/Lake-like Habitat and Dam Passage Conditions in All Subbasins

Effects of reservoir habitat and dam passage conditions under Alternative 2A on Pacific lamprey would be the same as described under the NAA.

Riverine Habitat in All Subbasins

Under Alternative 2A, adverse effects on Pacific lamprey would occur because of effects on spawning, incubation, and rearing and migration opportunities in downstream habitat. Adverse effects would be similar to those under the NAA or there may be a slight decrease in these effects under Alternative 2A.

Effects would be slightly more adverse as compared to the NAA from changes in flows and water quality conditions below Foster Dam in the South Santiam River Subbasin. This would be due to a deep, fall drawdown of Green Peter Reservoir.

Dam Passage Conditions in All Subbasins

Effects of WVS dam passage conditions under Alternative 2A on Pacific lamprey would be the same as described under the NAA.

Resident Fish in All Subbasins

Reservoir/Lake-like Habitat in All Subbasins

Effects of reservoir operations on resident fish species under Alternative 2A would be the same as described under the NAA, except at Green Peter Reservoir.

Survival for some resident fish species in Green Peter Reservoir would be reduced due to seasonal changes in habitat conditions (e.g., water temperature, turbidity, less vegetative structure) and/or to increased competition and predation as fish are concentrated in a smaller space during fall drawdowns at Green Peter Reservoir as compared to NAA conditions. This would be a moderate to substantial direct, adverse effect on most resident fish species during fall. Conversely, piscivorous fish would benefit from closer proximity to prey fish.

Effects to resident fish in other WVS reservoirs and on stocked gamefish under Alternative 2A would be the same as those described under the NAA.

Riverine Habitat in All Subbasins

Downstream habitat improvements under Alternative 2A would slightly decrease adverse effects on resident fish from spawning habitat availability, incubation, rearing and migrating opportunities, compared to the NAA.

Long-term effects from operations-related downstream habitat conditions on resident fish species would be similar to those described under the NAA. Adverse effects in drier years compared to the NAA would be due to lower flow releases in spring, and beneficial effects would occur in summer and fall due to increased flow releases in drier years.

Reduction in TDG and improved temperature management under Alternative 2A would have long-term, moderate, beneficial effects on all resident fish species in reaches downstream of dams in the North Santiam River Subbasin and Middle Fork Willamette River Subbasin. However, water quality conditions would remain adverse throughout the analysis area, which would continue to be an overall, adverse impact on fish due to exceedance of temperature targets and TDG thresholds.

Dam Passage Conditions in All Subbasins

Effects on resident fish species from structural downstream fish passage improvements under Alternative 2A would be the same as described under Alternative 1, with additional benefits of improved downstream passage at Cougar Dam.

Effects on resident fish species from operational downstream fish passage improvements (spring spill and deep fall drawdown) at Green Peter Dam would be moderately more adverse for some species due to the fall deep drawdowns, resulting in high rates of entrainment of fish through turbines and regulating outlets.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Operations under Alternative 2B would be the same as those described under Alternative 2A. However, unlike NAA operations, downstream fish passage at Cougar Dam would be provided operationally by deep fall and spring drawdowns under Alternative 2B instead of by a floating surface collector.

Common effects analyses from hatcheries on habitat and from passage conditions across all fish species are discussed first, followed by analysis of effects specific to each fish species or population. Common effects described in this section are not repeated in the species-specific analyses but are assumed to apply to species effects unless stated otherwise.

Hatchery Mitigation in All Subbasins

The Willamette Hatchery Mitigation Program and associated effects would be the same under Alternative 2B as described under the NAA with the following exceptions:

- Alternative 2B operations would include adjustments to the number of hatchery-origin UWR Chinook salmon released upstream of some reservoirs.
- There would be a reduction in adverse impacts on UWR steelhead in the North Santiam River and South Santiam River Subbasins from hatchery-origin summer-run steelhead spawning in streams.
- There would be a reduction in adverse impacts on UWR Chinook salmon from hatchery-origin spring-run Chinook salmon spawners.
- There would be risks to bull trout from the rainbow trout hatchery program.

Under Alternative 2B, Chinook salmon (hatchery-origin and natural-origin) adults would be released upstream of Green Peter Dam. Average pHOS in all subbasins would decrease from 0.69 under the NAA to 0.37 under Alternative 2B as compared to the NAA, although there would be some variability between. This moderate to substantial reduction in adverse effects of pHOS would result from improved fish passage conditions, subsequent increases in natural-origin adult Chinook salmon, and commensurate decreases in pHOS in these subbasins as compared to NAA operations.

The percent of introgressive hybridization in UWR steelhead in the North Santiam River and South Santiam River Subbasins would decrease as compared to the NAA because of an increase in the abundance of UWR steelhead spawners resulting from improved fish passage at dams in these subbasins under Alternative 2B operations. Improved passage would also increase areas where only natural-origin steelhead are spawned and reared (above dams), reducing competition and predation in the subbasins with hatchery summer steelhead (below dams). This would be a direct, moderate benefit to steelhead populations in the analysis area.

Conversely, unlike NAA operations, there would be slight to moderate adverse effects on bull trout from the rainbow trout hatchery program under Alternative 2B. Deep reservoir drawdowns in spring and fall under Alternative 2B would increase the number of bull trout moving downstream of Cougar Dam in the McKenzie River Subbasin. This would increase the likelihood of incidental catch, misidentification, and poaching of bull trout where sport fishing for hatchery-released rainbow trout occurs in the analysis area as compared to NAA operations (USFWS 2008).

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 2B, effects of reservoir operations on fish would be the same as described under the NAA except at Green Peter Reservoir and Cougar Reservoir. Differences in water surface elevations and fluctuations may occur at the local level and in the short term at all WVS dams, including Green Peter and Cougar Dams, compared to the NAA, depending on specific annual or seasonal climate conditions and specific dam operations.

Under Alternative 2B, effects of Green Peter Reservoir and Cougar Reservoir operations on fish would decrease the availability of reservoir habitat, resulting in adverse effects for species and life stages dependent on lake-like habitat, and beneficial effects for migratory species that prefer riverine habitat. Deep fall drawdowns at Green Peter Reservoir and Cougar Reservoir under Alternative 2B would result in substantially less open water habitat (lower water surface elevation and volume) and increased turbidity in late fall as compared to the NAA. The substantial, adverse effect of reduced reservoir habitat volume would increase competition and predation during fall and winter months and reduce water temperature stratification, decreasing habitat diversity.

Seasonal reductions in open water habitat would support persistence of some resident fish species; however, at a reduced level of abundance. Overall, there would be a moderate to substantial, adverse effect on resident fish species that are dependent on lake-like habitat.

Migratory species, including UWR Chinook salmon and steelhead, would benefit from reduced reservoir pool volumes, including reductions in predation from reduced resident fish abundance, disease risk, and travel times migrating through reservoirs. However, high growth rates experienced in reservoirs by migratory fish may be reduced, depending on the annual hydrologic conditions, reservoir operating schedule, and the length of time fish reside in reservoirs. Resident species that prefer riverine habitat and are able to find adequate habitat upstream or downstream of dams during the deep drawdowns would also benefit under Alternative 2B.

In the McKenzie River Subbasin, there would be increased riverine habitat connectivity for bull trout in the South Fork McKenzie River, and conversely higher risks for bull trout from the rainbow trout hatchery program under Alternative 2B. Deep reservoir drawdowns in spring and fall would increase the number of bull trout moving downstream of Cougar Dam in the McKenzie River Subbasin. This would allow bull trout residing in Cougar Reservoir to move downstream into riverine habitat in the McKenzie River Subbasin, and would also increase the likelihood of incidental catch, misidentification, and poaching of bull trout where sport fishing for hatchery-released rainbow trout occurs in the analysis area (USFWS 2008).

Riverine Habitat in All Subbasins

Under Alternative 2B, operations and management of bank protection structures in the analysis area would have the same effects on fish as described under the NAA and under Alternative 2A. However, additional adverse effects would occur from changes in flows and water quality conditions below Cougar Dam in the McKenzie River Subbasin.

Unlike NAA operations, gravel placement below dams would decrease adverse effects of blocked sediment transport from the above dam watersheds. As a result, effects on fish in riverine habitat below WVS dams from these operations would trend toward less adverse as compared to the NAA.

Flow

Under Alternative 2B, indirect effects of flow below WVS dams on fish due to operations of dams and reservoirs would be similar to those described under the NAA and Alternative 2A except for flow below Cougar Dam.

Unlike NAA operations, fall and spring deep drawdown operations to the diversion tunnel at Cougar Reservoir for fish passage would draft the reservoir below the power pool most of the time, reducing the volume of reservoir storage water available for downstream flow augmentation. Reduced flows in the summer and fall would adversely impact habitat availability for fish—depending on species, life stage, and river channel conditions—downstream of Cougar Dam in the South Fork McKenzie River in particular. Indirect effects for fish would range from moderately adverse to moderately beneficial, depending on species and life stage.

Stranding Risk

Under Alternative 2B, established down-ramping rates and hydropower-peaking operations would be similar to those described under the NAA. Therefore, stranding risks to fish below WVS dams would be the same as described under the NAA.

Materials Transport and Habitat Complexity

Under Alternative 2B, effects on habitat complexity and food production would be the same as described under the NAA and Alternative 2A. However, adverse effects of blocked sediment transport from above dams under NAA operations would be reduced by placement of gravel below dams under Alternative 2B operations. Additionally, deep drawdowns of Cougar Reservoir would also result in short-term sediment transport and deposition similar to that observed at Fall Creek during deep reservoir drawdowns, with the largest volumes being transported in the first few years of the operations, and then lesser amounts in subsequent years.

Water Temperature

As under the NAA, operations under Alternative 2B would result in adverse effects to water quality during times of year when temperature targets are not met in the North Santiam River Subbasin. However, unlike the NAA, a selective withdrawal structure would be operated at Detroit Dam under Alternative 2B resulting in beneficial effects to water quality from improved temperature conditions downstream of Detroit Dam and Big Cliff Dam. Consequently, substantially fewer adverse effects on water quality would occur in the North Santiam River Subbasin as compared to the NAA. Temperature targets would be met more often during an average year under Alternative 2B as compared to the NAA.

Adverse effects on water quality from temperature conditions in the South Santiam River Subbasin under Alternative 2B would continue as under the NAA. However, these effects would trend toward fewer adverse effects on water temperature in the spring below Green Peter Dam due to use of the spillway for surface spill (fish passage operation) and summer (temperature management operation) under Alternative 2B.

Moderate, beneficial effects from water temperatures in the Foster Adult Fish Facility fish ladder would occur with operation of a warm water supply pipe that would increase the entrance and collection rate of upstream migrating adult Chinook salmon at adult fish facilities below Foster Dam. However, differences in the number of days that temperature targets in the South Santiam River below Foster Dam would be met would be minimal and would not alter the overall adverse effect on water quality from temperature in this subbasin.

Unlike NAA operations, Alternative 2B operations would result in beneficial changes in water temperature conditions downstream of Cougar Dam. There would be an improvement to water temperature in the McKenzie River Subbasin because downstream conditions would nearly mimic upstream conditions under Alternative 2B operations. Temperature targets would be met more often during an average year under Alternative 2B and result in substantially fewer adverse effects as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B). Improvements in water temperature would also result in indirect, minor benefits to fish in the McKenzie River Subbasin.

Under Alternative 2B, effects on water quality from temperature conditions in the Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins and the Mainstem Willamette River would be the same as those described under the NAA. There may be differences in the number of days where water temperature standards would be met or in the number of days TDG meets targets; however, this would not alter the overall adverse effect on water quality from temperature conditions in these subbasins (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B). Indirect effects on fish would be the same as described under the NAA.

Indirect effects on fish in river reaches below WVS dams under Alternative 2B and on fish held in or released below hatcheries or adult fish facilities below WVS dams would be slightly to moderately beneficial compared to the NAA because of reduced temperature-related stress in the North Santiam River Subbasin below Detroit and Big Cliff Dams, depending on species and life stage.

Indirect adverse effects on all fish from temperature-related stress would be similar to those described under Alternative 2A in the South Santiam River Subbasin.

Indirect effects on fish in river reaches below WVS dams and on fish held in or released below hatcheries or adult fish facilities below WVS dams would be slightly more beneficial below Cougar Dam in the McKenzie River Subbasin as compared to the NAA because temperature targets would be met more often under Alternative 2B.

Indirect effects on all fish from continued adverse water temperature conditions in the Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins and the Mainstem Willamette River would be the same as those described under the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B).

Total Dissolved Gas

Under Alternative 2B, effects to water quality from TDG would be the same as under Alternative 2A in the North Santiam River Subbasin and the South Santiam River Subbasin (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B). Consequently, indirect beneficial and adverse effects to fish species would be the same as described under Alternative 2A.

Under Alternative 2B, there would be an adverse effect to water quality from TDG in the McKenzie River Subbasin. However, there would be an improvement to water quality because, although TDG levels would be above 110 percent TDG exceedance of the water quality standard, the average number of days annually above 110 percent would be fewer as compared to the NAA. Improvements in TDG would reduce risks to fish species in the McKenzie River Subbasin.

Under Alternative 2B, effects on water quality from TDG in the Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins and the Mainstem Willamette River would be the same as those described under the NAA. There may be differences in the number of days of TDG levels meeting targets; however, this would not alter overall adverse effects on water quality from TDG (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B).

Indirect adverse effects to fish in the North Santiam River Subbasin under Alternative 2B would be the same as described under Alternative 2A. There would be an increase in indirect, adverse effects to fish in the South Santiam River Subbasin and McKenzie River Subbasin from TDG-related impacts under Alternative 2B as compared to NAA operations.

Indirect effects to fish in the Middle Fork Willamette River Subbasin, Coast Fork Willamette River Subbasin, Long Tom River Subbasin, and the Mainstem Willamette River would be the same as those described under the NAA.

Turbidity

Under Alternative 2B, effects on water quality from turbidity in the North Santiam River Subbasin and Middle Fork Willamette River Subbasin would be same as those described under Alternative 1 (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B). Indirect effects to fish species would be the same as those described under Alternative 1.

Effects on water quality from turbidity in the South Santiam River Subbasin under Alternative 2B would be same as those described under Alternative 2A (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B). Indirect effects on fish species would be the same as those described under Alternative 2A.

Under Alternative 2B, effects on water quality from turbidity would be substantially more adverse at Cougar Reservoir in the McKenzie River Subbasin than those described under the NAA during the 30-year implementation timeframe. Operations under Alternative 2B would cause an increase in sediment and turbidity levels downstream of Cougar Reservoir because of deeper drawdowns to near original streambed elevations, increasing bank erosion and sloughing as compared to NAA operations. Most fine-grained sediment would pass through Cougar Reservoir and be transported downstream, likely resulting in seasonal increased turbidity downstream during deeper drawdowns compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B).

As a result of the deep reservoir drawdowns, sediment discharged below Cougar Dam would increase, resulting in short-term, moderate, adverse effects on all life stages of fish residing downstream from increased turbidity levels as compared to the NAA in the first few years of operations. In the long term, slight, adverse effects would occur in subsequent years due to a reduction in the amount of sediment and turbidity. Indirect effects on fish species from turbidity would also be substantially adverse downstream of Cougar Reservoir in the McKenzie River Subbasin under Alternative 2B.

Effects on water quality from turbidity under Alternative 2B would be the same as described under NAA operations in the Coast Fork Willamette River Subbasin and Long Tom River Subbasin (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B). Indirect effects on fish species would be the same as those described under NAA operations.

Under Alternative 2B, impacts to water quality from turbidity in the Mainstem Willamette River would be slightly more adverse than those described under the NAA. This would be due to deeper drawdowns in many WVS reservoirs, increasing turbidity downstream of these dams. These adverse effects would be re-occurring over the 30-year implementation timeframe during deep drawdown operational periods (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B). Subsequent, indirect, adverse effects on fish species from turbidity-related impacts in the mainstem would be slight to moderate under Alternative 2B.

Indirect effects to fish from high turbidity under Alternative 2B would be minor to substantial during the fall and early winter drawdown period each year as compared to NAA operations. Indirect effects on fish habitat from fine sediment transport and deposition would be minorly beneficial to moderately adverse, depending on species and life stage.

Other Riverine Habitat Conditions in All Subbasins

Under Alternative 2B, direct and indirect adverse effects on resident fish species entrained downstream during fall drawdowns would be the same as those described under the NAA. Downstream habitat competition and predation for fish present downstream would continue as described under the NAA.

Partial deep drawdowns of Green Peter Reservoir and Cougar Reservoir would increase entrainment of resident fish species below dams in the South Santiam River Subbasin and McKenzie River Subbasin, respectively, resulting in increases in competition and predation for fish present in river reaches below these dams. Operations would also continue to create localized conditions favoring fish that prefer rocky, steeply sloped shorelines with limited riparian vegetation, particularly near bank protection structures, as described under the NAA.

Dam Passage Conditions in All Subbasins

Upstream Passage

Under Alternative 2B, effects on upstream migrating fish would be the same as described under the NAA and Alternative 2A.

Downstream Passage

Downstream passage conditions and associated effects on migratory and resident fish species under Alternative 2B would be the same as described under Alternative 2A and Alternative 1, except at Cougar Dam in the McKenzie River Subbasin.

Unlike NAA operations, downstream passage at Cougar Dam under Alternative 2B would be provided operationally with a deep reservoir drawdown in the fall and spring to 25 feet over the diversion tunnel. The improved downstream dam passage through operations at Cougar Dam would result in direct, substantial reductions in adverse effects of dams on downstream fish passage compared to NAA operations.

Effects on resident fish under Alternative 2B would be the same as described under Alternative 2A throughout the analysis area, except in Cougar Reservoir where more fish would be entrained or would migrate downstream in spring and fall when the reservoir is drawn down to 25 feet over the diversion tunnel.

There would be mixed beneficial and adverse effects on non-migratory, resident fish species under Alternative 2B from an increase in downstream passage or entrainment at Cougar Dam compared to the NAA. Entrainment under Alternative 2B would force movement of individual fish from Cougar Reservoir in spring and fall. Indirect effects would occur to fish residing in reaches downstream of Cougar Dam, which would be slightly to moderately adversely affected by increased competition with, or predation by, fish entrained downstream from Cougar Reservoir.

While these improvements would be direct benefits to migrating and resident fish in the North Santiam River Subbasin, South Santiam River Subbasin, McKenzie River Subbasin, and Middle Fork Willamette River Subbasin as compared to NAA operations, upstream and downstream passage would remain adverse under Alternative 2B.

Upper Willamette River Chinook Salmon and Steelhead

Effects from reservoir habitat, riverine habitat, and fish passage conditions would result in direct, moderate to substantial, adverse effects on UWR Chinook salmon and UWR steelhead under Alternative 2B compared to the NAA.

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 2B, effects to UWR Chinook salmon and UWR steelhead in the analysis area would be the same as under Alternative 2A, except for effects on UWR Chinook salmon in the McKenzie River Subbasin. In the McKenzie River Subbasin, there would be a moderate increase in adverse effects on UWR Chinook salmon from reduced in-reservoir rearing and foraging habitat from deep fall and spring drawdowns of Cougar Reservoir. However, there would be slight to moderate, beneficial effects from differences in competition, predation, and potential disease effects due to shifts in rearing locations for juvenile Chinook salmon from within Cougar Reservoir to below Cougar Dam in the McKenzie River Subbasin and Mainstem Willamette River as compared to NAA operations.

The Cougar Reservoir deep drawdowns to 25 feet over the diversion tunnel each spring and fall would substantially reduce the reservoir volume annually with limited opportunity to refill after the spring drawdown. These operations would reduce open water habitat availability and availability of seasonal vegetated nearshore areas resulting in a direct, substantial adverse effect on salmon species.

A large portion of Chinook salmon migrating downstream annually into the small remaining reservoir would proceed to emigrate downstream of Cougar Dam through the diversion tunnel in spring. For those remaining or entering the reservoir after the spring drawdown, competition and predation would increase compared to the NAA, along with food availability, in part due to turbidity and a smaller reservoir volume under Alternative 2B.

Water temperatures would also differ from NAA operations, particularly during summer, due to the decreased volume of water in the reservoir. Temperature differences would depend on the extent the pool refills after the spring drawdown; water temperatures would continue to stratify especially at larger pool volumes. Inflows into the reservoir from surrounding streams would continue to maintain availability of cool water for juvenile Chinook salmon.

Chinook salmon remaining in the reservoir until fall would then emigrate downstream from the reservoir during the fall drawdown. Effects of reservoir rearing would be similar to the NAA.

Riverine Habitat in All Subbasins

Effects on downstream habitat under Alternative 2B would be the same as those described under Alternative 2A except for below Cougar Dam. Alternative 2B operations would result in improved water temperature conditions downstream of Cougar Dam as compared to NAA conditions. Water temperature in the McKenzie River Subbasin would nearly mimic upstream conditions under Alternative 2B operations.

There would also be a slight reduction in adverse effects from high TDG levels resulting from a decrease in regulating outlet spill operations and reduction of TDG exceedances below Cougar Dam under Alternative 2B as compared to the NAA. As a result of the deep reservoir drawdowns, sediment discharged below Cougar Dam would increase, resulting in short-term, moderate, adverse effects on all life stages of UWR Chinook salmon from increased turbidity levels as compared to the NAA in the first few years of operations. In the long term, slight, adverse effects would occur in subsequent years due to reduction in the amount of sediment and turbidity.

The following are estimates of UWR Chinook salmon spawning habitat availability and spawning and incubation success in reaches downstream of dams under Alternative 2B, based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 5 percent to 100 percent of the spawning period, depending on the river reach (Appendix E, Fish and Aquatic Habitat Analyses). Estimated amounts include a substantial decrease in the McKenzie River Subbasin, moderate decrease in the Middle Fork Willamette River Subbasin, and a negligible decrease in the North Santiam River Subbasin as compared to the NAA. There would be no difference in the South Santiam River Subbasin compared to the NAA. The extremely low spawning habitat availability estimated downstream of Cougar Dam would be attributed to the lack of stored water available to supplement downstream flows due to a deep reservoir drawdown in spring.
- 2,936 (range 13 to 7,236) average number of redds surviving until swim-up (Appendix E, Fish and Aquatic Habitat Analyses), which is a slight increase compared to the NAA. The highest number of redds is estimated for the McKenzie River downstream of Cougar Dam and the lowest in the Middle Fork Willamette River downstream of Dexter Dam.

The following are estimates of UWR steelhead spawning habitat availability and the number of age-1 and smolts in reaches downstream of dams under Alternative 2B based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels 100 percent of the spawning period, which would be no difference to a negligible increase compared to the NAA depending on reach (Appendix E, Fish and Aquatic Habitat Analyses).
- Average number of age-1 UWR steelhead estimated at 246,724 and 155,799, and steelhead smolts estimated at 88 and 86 in reaches downstream of WVS dams in the North Santiam River and South Santiam River Subbasins, respectively. These would be increases compared to the NAA except for a slight decrease in steelhead smolts in the North Santiam River Subbasin (Appendix E, Fish and Aquatic Habitat Analyses).

Dam Passage Conditions in All Subbasins

Effects of upstream dam passage improvements and continued operation of existing adult fish facilities under Alternative 2B would be the same as Alternative 1 (Table 3.8-21).

Deep spring and fall drawdowns at Cougar Reservoir would create conditions where downstream passage rates and passage survival for UWR Chinook salmon juveniles would increase compared to the NAA because passage would occur more often through the diversion tunnel where survival is assumed higher than the regulating outlets and turbine routes as under NAA operations.

Table 3.8-21. Average, Minimum, and Maximum Juvenile Upper Willamette River Chinook Salmon and Juvenile Upper Willamette River Steelhead Downstream Dam Passage Survival Estimates under Alternative 2B.

Species and Dam	Average Survival Estimate (%)	Minimum Survival Estimate (%)	Maximum Survival Estimate (%)
Chinook Salmon			
Cougar	42	35	49
Detroit	82	81	82
Foster	65	64	66
Green Peter	41	15	59
Hills Creek	N/A	N/A	N/A
Lookout Point	77	77	78
Steelhead			
Detroit	91	89	92
Foster	75	74	75
Green Peter	32	20	38

Source: Fish Benefits Workbook model survival estimates from simulated operations for years 1947 to 2019; Appendix E, Fish and Aquatic Habitat Analyses, Chapter 2, Fish Benefits Workbook Results.

N/A = Not Applicable.

Population Performance in All Subbasins

Under Alternative 2B, population performance of UWR Chinook salmon above WVS dams is estimated to be fair to good and extinction risk extremely low to moderately high, depending on subbasin (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a, 2022b; McAllister et al. 2023). Effects represent slight to substantial beneficial effects compared to the NAA:

- Natural-origin spawner abundance for upstream-of-dam local populations under Alternative 2B is estimated to be low in the South Fork McKenzie River and Middle Fork Willamette River Subbasins (291 and 350 adults, respectively), moderate in the South Santiam River Subbasin (1,318 adults), and high in the North Santiam River Subbasin (13,016 adults). These estimates represent moderate to substantial increases in spawner abundance in all subbasins compared to the NAA.
- Initial population productivity in years 6 to 10 is estimated to be above replacement (recruits/spawner greater than 1) in all UWR Chinook salmon local populations upstream of WVS dams. These spawner abundance levels represent a substantial increase in the North Santiam River and South Santiam River Subbasins, and a slight increase in the South Fork McKenzie River and Middle Fork Willamette River Subbasins compared to the NAA. In the Middle Fork Willamette River and McKenzie River Subbasins, estimated productivity would be attributed to moderate to very high pHOS (48 to 75 percent, respectively).

  The estimated pHOS above dams under Alternative 2B is extremely low to moderate in the North Santiam River, South Santiam River, and McKenzie River Subbasins (0 percent, 24 percent, and 48 percent, respectively) and high in the Middle Fork Willamette River (75 percent), which represent slight to substantial improvement compared to the NAA. Estimated UWR Chinook salmon smolt to adult returns range from 0.011 to 0.072 upstream of WVS dams, which represent no difference to negligible increases compared to the NAA. Over the 30-year implementation timeframe, populations would be below replacement levels except above Detroit Dam in the North Santiam.
- The probability of individual UWR Chinook salmon upstream of WVS dams in the analysis area going below extinction risk abundance levels is estimated to be extremely low in the North Santiam River and McKenzie River Subbasins (0 percent), and low to moderately high in the South Santiam River and Middle Fork Willamette River Subbasins (10 to 56 percent, respectively). These estimates represent a substantial decrease in extinction risk of UWR Chinook salmon upstream of dams in the South Santiam River and Middle Fork Willamette River Subbasins, and no difference from the NAA in the North Santiam River and McKenzie River Subbasins.

Under Alternative 2B, population performance of UWR steelhead upstream of dams in the analysis area is estimated to be poor to fair with moderate to high extinction risk, depending on subbasin (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a). This would result in no difference or slight beneficial effects compared to the NAA:

- Natural-origin spawner abundance for upstream-of-dam UWR steelhead local populations under Alternative 2B is estimated to be low to moderate in both the North Santiam River and South Santiam River Subbasins (873 and 284 adults, respectively), which would be substantial increases compared to the NAA.
- Productivity is estimated to be above replacement (recruits/spawner greater than 1) for UWR steelhead upstream of Detroit and Foster Dams, representing an increase compared to the NAA. Like the NAA, productivity is estimated to be below replacement (recruits/spawner less than 1) for UWR steelhead upstream of Green Peter Dam. Hatchery supplementation would likely be necessary to maintain this upstream population under Alternative 2B.
- The probability of individual UWR steelhead local populations upstream of WVS dams in the analysis area going below extinction risk abundance levels is estimated to be moderate (35 percent) for the local population upstream of Detroit Dam in the North Santiam River Subbasin and high to very high for the local populations upstream of Foster and Green Peter Dams in the South Santiam River Subbasin (72 and 98 percent, respectively). These estimates represent moderate to substantial improvements for local populations upstream of Foster and Detroit Dams, respectively, as compared to the NAA (there is no local population upstream of Green Peter Dam under the NAA for comparison).

Bull Trout in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Effects on bull trout subadults and adults rearing, foraging, and overwintering in reservoirs under Alternative 2B would be the same as described under the NAA with the exception of effects in Cougar Reservoir.

The amount of rearing, foraging, and overwintering habitat for bull trout in Cougar Reservoir would be substantially reduced under Alternative 2B compared to the NAA. Some individual bull trout would move from reservoirs into upstream tributaries during the deep reservoir drawdowns, and growth opportunity is expected to be lower within the streams of the upper South Fork McKenzie River compared to within Cougar Reservoir due to differences in the amount of available forage and suitable water temperatures.

Deep reservoir drawdowns in spring and fall would also increase the number of bull trout moving downstream of Cougar Dam in the McKenzie River Subbasin. Bull trout moving downstream of Cougar Dam and Reservoir would access additional riverine habitat in the larger McKenzie River Subbasin, where foraging opportunities may not be as beneficial as in the reservoir. However, this would also increase the potential for spawning with other local bull trout populations, providing benefits for genetic exchange.

Bull trout moving downstream would be adversely affected by sport fisheries for trout and other species occurring in the McKenzie River Subbasin below Cougar Dam. An increase in bull trout occupying downstream habitat under Alternative 2B would increase the likelihood of incidental catch, misidentification, and poaching of bull trout where sport fishing for hatchery-released rainbow trout occurs in the analysis area (USFWS 2008). These changes in rearing and foraging opportunity, spawning habitat connectivity, and adverse effects of sport fisheries would result in moderate beneficial to moderate adverse effects for the local bull trout population in the South Fork McKenzie River in the McKenzie River Subbasin due to changes in foraging and seasonal habitat availability.

Riverine Habitat in All Subbasins

Effects on bull trout downstream of dams under Alternative 2B would be the same as described under Alternative 2A, except at Cougar Dam.

Deep reservoir drawdowns of Cougar Reservoir in spring and fall would substantially decrease the availability of reservoir habitat currently used by bull trout above Cougar Dam. Further deep drawdown of Cougar Reservoir would increase the number of bull trout moving below Cougar Dam and accessing additional riverine habitat. Effects would be similar to reservoir/lake-like habitat effects, with added benefits from water temperature effects.

Alternative 2B would result in beneficial changes in water temperature conditions downstream of Cougar Dam. There would be an improvement to water temperature in the McKenzie River Subbasin because downstream conditions would nearly mimic upstream conditions under Alternative 2B operations. Temperature targets would be met more often during an average year under Alternative 2B and result in substantially fewer adverse effects as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B). Improvements in water temperature would also result in indirect, minor benefits to bull trout in the McKenzie River Subbasin.

Dam Passage Conditions in All Subbasins

Under Alternative 2B, direct and indirect adverse effects of upstream passage conditions on bull trout would be the same as described under the NAA. Effects of downstream passage conditions on bull trout would be the same as described under Alternative 2A ,except at Cougar Dam.

Downstream passage at Cougar Dam under Alternative 2B would be provided operationally with a deep reservoir drawdown in the fall and spring to 25 feet over the diversion tunnel. This improved downstream dam passage would result in direct, substantial reductions in adverse effects of dams on downstream bull trout passage compared to NAA operations, increasing the number of bull trout moving safely below Cougar Dam. This increased passage below Cougar Dam would improve opportunities for genetic exchange with other local bull trout populations in the McKenzie River Subbasin. However, improved downstream passage would also increase exposure of bull trout to risks of injury and mortality in sport fisheries and competition with other resident fish residing in the McKenzie River Subbasin downstream of Cougar Dam.

Pacific Lamprey in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Effects of reservoir habitat and dam passage conditions under Alternative 2B on Pacific lamprey would be the same as described under the NAA.

Riverine Habitat in All Subbasins

Downstream habitat improvements under Alternative 2B would slightly decrease adverse effects on spawning habitat availability, and associated incubation success and rearing and migrating opportunities, for Pacific lamprey compared to the NAA.

Under Alternative 2B, effects of dam operations on riverine habitat conditions would be the same as described under the NAA, except below Cougar Dam in the McKenzie River Subbasin. Effects on Pacific lamprey in the McKenzie River Subbasin from differences in flow and water quality conditions below Cougar Dam extend into the McKenzie River.

Reduced flows in the summer and fall would adversely impact habitat availability for lamprey, depending on life stage, and river channel conditions. Conversely, deep reservoir drawdowns would increase sediment transport from above to below Cougar Dam, creating habitat for larval lamprey in the McKenzie River Subbasin in the South Fork McKenzie River and McKenzie River mainstem.

Water temperatures and TDG effects under Alternative 2B would be the same as under the NAA, except below Cougar Dam in the McKenzie River Subbasin. In the McKenzie River Subbasin, direct effects would be slightly less adverse compared to the NAA below Cougar Dam. Flow conditions in the South Fork McKenzie River would be lower in summer and early fall compared to the NAA, which would decrease spawning and incubation habitat availability. Increased sediment discharge rates would adversely affect incubating eggs; however, over the long term, increased sediment discharge rates could increase rearing habitat availability for larval ammocoetes[38].

A deep drawdown of Cougar Reservoir to 25 feet over the diversion tunnel under Alternative 2B would reduce water storage for summer flow supplementation downstream annually and change sediment discharge rates as compared to NAA operations. Pacific lamprey spawning habitat availability below Cougar Dam would be reduced compared to the NAA, resulting in moderate, direct adverse effects to lamprey in the McKenzie River Subbasin.

Sediment releases in the first few years after Cougar Reservoir deep reservoir drawdowns commence under Alternative 2B would slightly to moderately reduce the quality and quantity of Pacific lamprey spawning and rearing habitat in the short term downstream as compared to

[38] Ammocoetes are a larval stage of Pacific lamprey that are filter feeders that draw overlying water into burrows they dig into soft bottom substrates. During the larval stage, they spend most of their time feeding on algae, detritus, and microorganisms (Wikipedia 2025).

NAA operations, particularly within the South Fork McKenzie River below Cougar Dam. In the long term, the levels of sediment would be expected to decline over a few years to natural levels of sediment transport similar to that entering Cougar Reservoir from the upstream watershed. Sediment transported downstream would provide additional habitat over the long term for larval lamprey rearing.

Dam Passage Conditions in All Subbasins

Effects of WVS dam passage conditions under Alternative 2B on Pacific lamprey would be the same as described under the NAA.

Resident Fish in All Subbasins

Reservoir/Lake-like Habitat in All Subbasins

Effects of reservoir operations on resident fish species under Alternative 2B would be the same as the NAA, except for Green Peter Reservoir and Cougar Reservoir.

At Green Peter and Cougar Reservoirs, habitat for spawning, rearing, and foraging for resident reservoir fish species would be reduced due to seasonal changes in habitat availability. Increased competition and predation would result as fish that are concentrated into a smaller space during spring and fall drawdowns at Cougar Reservoir and during fall drawdowns at Green Peter Reservoir as compared to NAA conditions. This would be a moderate, direct, adverse effect on most resident fish species in Green Peter Reservoir, and a substantial direct, adverse effect on resident fish species in Cougar Reservoir. Conversely, piscivorous fish would benefit from closer proximity to prey fish during periods reservoirs are drawdown each year.

Releases of hatchery rainbow trout and kokanee would help maintain sport fishing opportunities where these fish are stocked. However, there were no fish stocked into Cougar Reservoir at the time the alternatives were analyzed. Therefore, effects on stocked gamefish under Alternative 2B would be the same as those described under the NAA.

Riverine Habitat in All Subbasins

Downstream habitat improvements under Alternative 2B would slightly decrease adverse effects on spawning habitat availability, and associated incubation success and rearing and migrating opportunities, for resident fish compared to the NAA.

Long term, effects from operations-related downstream habitat conditions on resident fish species would be similar to the NAA, except below Cougar Dam in the McKenzie River Subbasin. Reductions in water storage availability to augment river flows would reduce riverine habitat availability for some species and life stages below Cougar Dam. Effects from high turbidity would be slightly to moderately more adverse from changes in flows and water quality conditions below Green Peter and Cougar Dams due to the deep reservoir drawdowns as compared to the NAA.

Reduction in TDG and improved temperature management under Alternative 2B would have long-term, moderate, beneficial effects on all resident fish species in reaches downstream of Detroit Dam in the North Santiam River Subbasin and below Lookout Point Dam in the Middle Fork Willamette River Subbasin. However, water quality conditions would remain adverse throughout the analysis area, which would continue to be an overall, adverse impact on fish due to exceedance of temperature targets and TDG thresholds.

Dam Passage Conditions in All Subbasins

Effects on resident fish species under Alternative 2B would be the same as those described under Alternative 2A, except at Cougar Dam where deep drawdowns of Cougar Reservoir to 25 feet over the diversion tunnel would occur in spring and fall.

Annual fall deep reservoir drawdowns to 25 feet over the diversion tunnel at Cougar Dam would entrain or pass a majority of resident fish downstream, with a few exceptions for those that remain in the small reservoir pool or move upstream of the reservoir zone during drawdowns. Survival rates during passage would be moderate, based on available information.

Downstream, entrained resident fish species would likely experience high mortality rates due to loss of lake-like habitat availability and density of fish present in riverine habitat downstream. Therefore, a moderate to high, adverse effect on the abundance of resident fish species dependent on lake-like conditions in Cougar Reservoir would occur under Alternative 2B as compared to the NAA.

As under the NAA, adult fish facilities operated under Alternative 2B would allow passage of resident fish upstream of all WVS dams over the 30-year implementation timeframe.

There were no fish stocked into Cougar Reservoir at the time the alternatives were analyzed. Therefore, effects on stocked gamefish under Alternative 2B would be the same as those described under the NAA.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

Under Alternative 3A, operations would include operational downstream fish passage measures (i.e., spring spills; deep spring and deep fall drawdowns; and deep fall drawdowns and spring spills) at various dams in the analysis area resulting in differences to habitat, habitat access, and foraging opportunities within reservoir zones and downstream of dams, compared to the NAA.

Common effects analyses from hatcheries on habitat and from passage conditions across all fish species are discussed first, followed by analysis of effects specific to each fish species or population. Note that the common effects described in this section are not repeated in the species-specific analyses but are assumed to apply to species effects unless stated otherwise.

Hatchery Mitigation in All Subbasins

Under Alternative 3A, the Willamette Hatchery Mitigation Program and associated effects would be the same as described under the NAA with the following exceptions:

- There would be adjustments to the number of hatchery-origin UWR Chinook salmon released upstream of some reservoirs.
- There would be a reduction in adverse impacts on UWR steelhead in the North Santiam River and South Santiam River Subbasins from hatchery-origin summer-run steelhead spawning in streams.
- There would be a reduction in adverse impacts on UWR Chinook salmon from hatchery-origin spring-run Chinook salmon spawners.
- There would be risks to bull trout from the rainbow trout hatchery program.

Under Alternative 3A, there would be a release of hatchery-origin and natural-origin adults upstream of Green Peter Reservoir as compared to the NAA. Average pHOS in all subbasins would decrease from 0.69 under the NAA to 0.49 under Alternative 3A, although there would be some variability between subbasins. This slight to moderate reduction in adverse effects of pHOS would result from improved fish passage conditions, subsequent increases in natural-origin adult Chinook salmon, and commensurate decreases in pHOS in these subbasins as compared to the NAA.

The percent of introgression in UWR steelhead in the North Santiam River and South Santiam River Subbasins from hatchery-origin summer-run steelhead spawning in streams would negligibly change compared to the NAA due to the similar predicted abundance of adult UWR steelhead. Therefore, effects on UWR steelhead would be the same as under the NAA.

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 3A, effects of reservoir operations on fish would decrease the availability of reservoir habitat, resulting in adverse effects for species dependent on lake-like habitat and beneficial effects for migratory species that prefer riverine habitat.

Deep reservoir drawdowns of Detroit, Green Peter, Hills Creek, Lookout Point, and Fall Creek Reservoirs would seasonally reduce reservoir volumes, resulting in substantially less open water habitat (lower water surface elevation and volume) and seasonally increased turbidity as compared to the NAA. The substantial, adverse effect of reduced reservoir habitat volume would increase competition and predation during fall and winter months and reduce water temperature stratification, thereby decreasing habitat diversity for fish residing in reservoirs during drawdown periods.

Seasonal reductions in open water habitat would support persistence of some resident fish species; however, at a reduced level of abundance. Overall, there would be a moderate to substantial, adverse effect for resident fish species that are dependent on lake-like habitat under Alternative 3A.

Effects on migratory and resident species under Alternative 3A would be the same as those described under Alternative 2B. A drawdown of Cougar Reservoir would occur each spring and fall to near the regulating outlet but would result in negligible effects on reservoir habitat conditions compared to the NAA. This is because habitat conditions from seasonal reservoir volumes would remain similar to NAA conditions.

Riverine Habitat in All Subbasins

Under Alternative 3A, operations and management of bank protection structures in the analysis area would have the same effects on fish as described under the NAA. However, conservation season flows in the Middle Fork Willamette River and North Santiam River Subbasins and in the Mainstem Willamette River would be lower compared to the NAA due to the decrease in availability of storage water to supplement seasonal low flows in summer and early fall.

Unlike NAA operations, gravel placement below dams would decrease adverse effects of blocked sediment transport from the above-dam watersheds. As a result, effects on fish in riverine habitat below WVS dams from these operations would trend toward less adverse under Alternative 3A as compared to the NAA.

Flow

Compared to the NAA, river flows under Alternative 3A would be lower in summer and early fall due to reduced availability of water storage resulting from deep reservoir drawdowns in the North Santiam River Subbasin, Middle Fork Willamette River Subbasin, and Mainstem Willamette River. Consequently, indirect effects on fish would trend toward more adverse compared to the NAA because flows in summer and early fall would be lower, generally reducing habitat availability for fish below WVS Dams when ambient water temperatures are highest.

Effects on fish from reduced river flows in these locations during the conservation season would result in mixed effects, depending on species, life stage, and river channel conditions. Indirect effects on fish would range from moderately adverse to slightly beneficial under Alternative 3A because of habitat availability.

Stranding Risk

Under Alternative 3A, established down-ramping rates and hydropower-peaking operations would be similar to those described under the NAA. Therefore, stranding risks to fish below WVS dams would be the same as described under the NAA.

Materials Transport and Habitat Complexity

Under Alternative 3A, effects on fish habitat and food production would be the same as described under the NAA and Alternative 2A. Partial deep drawdowns of Green Peter Reservoir and Lookout Point Reservoir would increase transport of fine sediments and nutrients, resulting in slight increases in deposition of these materials below dams in the South Santiam River Subbasin and Middle Fork Willamette River Subbasin, respectively. Reservoir drawdowns to regulating outlets at Hills Creek Dam and Cougar Dam would result in the same adverse effects on materials transport and food production as described under the NAA and Alternative 2A.

Water Temperature

Under Alternative 3A, there would be a moderate increase in adverse effects on water quality in the North Santiam River Subbasin because there would be an increase in days when temperature targets would not be met as compared to the NAA. The spring drawdown for downstream fish passage would result in warmer downstream temperatures from May through October, thereby increasing adverse conditions. Adverse conditions would occur downstream of Detroit and Big Cliff Dams in hot, dry years compared to operations under the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

Adverse effects on water quality from temperature conditions under Alternative 3A in the South Santiam River Subbasin would be the same as described under Alternative 2A.

Effects on water quality from temperature conditions in the McKenzie River Subbasin would continue to be adverse during times of the year when water temperature targets are not met, similar to effects described under the NAA. Slightly more adverse effects to water temperature conditions downstream of Cougar Dam would increase under Alternative 3A operations as compared to NAA operations. This increase in adverse effect would occur because temperature targets would be met less often as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

Adverse effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue as under the NAA. However, effects would trend toward a beneficial effect on water temperature because temperature targets would be met more often under Alternative 3A operations and result in moderately less adverse effects below Hills Creek Dam and slightly less adverse effects below Lookout Point and Dexter Dams as compared to the NAA. This would be an improvement on impacts to fish in the Middle Fork Willamette River Subbasin (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

Under Alternative 3A, indirect effects would be slightly less adverse to slightly more adverse depending on fish species, life stage, and habitat preferences from temperature-related stress than under NAA operations. Effects on fish in hatcheries and the adult fish facility would be slightly less adverse compared to the NAA in the Middle Fork Willamette River Subbasin below Lookout Point Dam.

Under Alternative 3A, effects on water quality from temperature conditions would be the same as described under the NAA in the Coast Fork Willamette River Subbasin and Long Tom River Subbasin. There may be differences in the number of days where water quality standards for water temperature would be met; however, this would not alter the overall adverse effect on water quality from temperature conditions (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A). Consequently, indirect effects on fish species would be the same as those described under the NAA.

Effects on water quality from temperature conditions in the Mainstem Willamette River would continue to be adverse during times of the year when water temperature targets are not met under Alternative 3A (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A). Adverse conditions would increase slightly as compared to the NAA, which would result in slightly more indirect, adverse effects on fish species in the Mainstem Willamette River as compared to NAA operations.

Indirect effects to fish in river reaches below WVS dams under Alternative 3A and to fish held in or released below hatcheries or adult fish facilities below WVS dams would moderately increase compared to the NAA in the North Santiam River Subbasin below Detroit and Big Cliff Dams. This is because the deep reservoir drawdown in spring and fall would reduce the availability of water to augment naturally low seasonal flows in summer and early fall, and to provide cooler water than ambient conditions during the warmest time of the year.

Indirect adverse effects on all fish from temperature-related stress would be similar to those described under Alternative 2A in the South Santiam River Subbasin.

Indirect effects to fish from temperature-related stress in the McKenzie River Subbasin and Middle Fork Willamette River Subbasin in river reaches below WVS dams and to fish held in or released below hatcheries or adult fish facilities below WVS dams would be slightly more adverse compared to the NAA.

Indirect effects on all fish from continued adverse water temperature conditions in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

Total Dissolved Gas

Under Alternative 3A, there would be a substantial increase of adverse effects to water quality from TDG exceedance of the water quality standard in the North Santiam River Subbasin as compared to the NAA. The increase in TDG exceedance of the water quality standard would be due to an increase in spill operations (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A). Indirect effects on fish species from TDG-related impacts would also be substantial in this subbasin.

At Detroit Dam, the regulating outlets would be operated for fish passage and temperature management in the spring and fall; the spillway, if available, would be operated for temperature management in the summer. However, as under the NAA, water would continue to be spread over multiple spillway gates, which would reduce TDG exceedance of the water quality standard at Detroit Dam and Big Cliff Dam under Alternative 3A (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

Under Alternative 3A, there would be a substantially more adverse effect to water quality from TDG as compared to the NAA in the South Santiam River Subbasin (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

There would be an increase in adverse effects to water quality from TDG in the McKenzie River Subbasin as compared to the NAA. Slightly more adverse effects would be due to an increase in spill frequency and because no TDG abatement measures would be implemented at Cougar Dam under Alternative 3A as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

Under Alternative 3A, there would be an adverse effect to water quality from TDG in the Middle Fork Willamette River Subbasin similar to the NAA. There would be a slightly less adverse effect downstream of Hills Creek Dam and a moderate, increased adverse effect downstream of Dexter Dam as compared to the NAA. These effects would be due to an increase in spill frequency and TDG abatement measures implemented under Alternative 3A (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

Under Alternative 3A, effects on water quality from TDG in the Coast Fork Willamette River Subbasin, Long Tom River Subbasin, and the Mainstem Willamette River would be the same as those described under the NAA. There may be differences in the number of days where water quality standard for TDG would be met; however, this would not alter the overall adverse effect on water quality from TDG (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

Adverse effects to fish from gas bubble trauma and other impacts related to TDG under Alternative 3A would occur in all subbasins. Indirect, adverse effects to fish in the North Santiam River Subbasin would moderately increase under Alternative 3A compared to the NAA because of use of the regulating outlets during spring and fall reservoir drawdowns.

In the South Santiam River and McKenzie River Subbasins, indirect effects on fish species from TDG-related impacts under Alternative 3A would be the same or similar to those described under Alternative 2B. Indirect effects to fish in the Middle Fork Willamette River Subbasin from TDG would be similar to the NAA below Hills Creek Dam and more adverse below Lookout Point and Dexter Dams compared to the NAA because there would be an increase in the number of days the regulating outlets are used to spill water.

Indirect effects to fish from TDG-related impacts in the Coast Fork Willamette River Subbasin, Long Tom River Subbasin, and the Mainstem Willamette River would be the same as those described under the NAA.

Turbidity

Under Alternative 3A, effects on water quality from turbidity in the North Santiam River, South Santiam River, and Middle Fork Willamette River Subbasins would be substantially more adverse compared to the NAA. Operations under Alternative 3A would cause an increase in sediment and turbidity levels downstream of Detroit, Green Peter, and Lookout Point Reservoirs because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations.

While some fine-grained sediment that enters these reservoirs may partially settle, most fine-grained sediment would pass through dams and result in temporary increased turbidity downstream during deeper drawdowns as compared to NAA operations. Under Alternative 3A, effects on water quality from turbidity would be substantially more adverse at Lookout Point Reservoir than those described under the NAA during the 30-year implementation timeframe.

Operations under Alternative 3A would cause an increase in sediment and turbidity levels downstream of Lookout Point Reservoir because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations. While some fine-grained sediment entering Dexter Reservoir from Lookout Point Reservoir may partially settle, most fine-grained sediment would pass through Dexter Reservoir and result in temporary increased turbidity downstream during deeper Lookout Point Reservoir drawdowns compared to NAA operations.

Indirect effects to fish from high turbidity in the North Santiam River, South Santiam River, and Middle Fork Willamette River Subbasins and the Mainstem Willamette River would be minor to substantial during the drawdown periods each year under Alternative 3A as compared to the NAA. Indirect effects on fish habitat from fine sediment transport and deposition would be minorly beneficial to moderately adverse, depending on species and life stage.

Under Alternative 3A, impacts to water quality from turbidity in the Mainstem Willamette River would be moderately more adverse than those described under the NAA. This is due to deeper drawdowns in many WVS reservoirs increasing the likelihood of turbidity.

Effects on water quality and on fish from turbidity in Hills Creek Reservoir in the Middle Fork Willamette River Subbasin would be the same as those described under the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

Effects on water quality and on fish from turbidity under Alternative 3A in the Coast Fork Willamette River and Long Tom River Subbasins would be same as those described under the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

Other Riverine Habitat Conditions in All Subbasins

Under Alternative 3A, direct and indirect adverse effects of resident fish species entrained downstream during fall drawdowns would be the same as those described under the NAA. Downstream habitat competition and predation for fish present downstream would increase compared to the NAA.

Deep drawdowns of Detroit, Green Peter, Cougar, Lookout Point, and Fall Creek Reservoirs would increase entrainment of resident fish species below dams under Alternative 3A, resulting in increases in competition and predation for fish present in river reaches below these dams. Drawdowns to the regulating outlet at Hills Creek Dam would result in similar downstream effects from resident fish entrainment compared to the NAA.

Operations would also continue to create localized conditions favoring fish that prefer rocky, steeply sloped shorelines with limited riparian vegetation, particularly near bank protection structures, as described under the NAA.

Dam Passage Conditions in All Subbasins

Upstream Passage

Under Alternative 3A, effects on upstream migrating fish would be the same as described under the NAA at dams with existing upstream passage facilities. However, additional upstream habitat access would be provided with construction of an adult fish facility at Green Peter Dam, Blue River Dam, and Hills Creek Dam. These facilities would include integrated Pacific lamprey features. Operations of these features would reduce adverse impacts for upstream migrating fish, providing access to additional habitat above dams in the South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins, which would not occur under NAA operations. Under all alternatives, Federal and state fish management agencies would continue to determine the species and life stages that are to be transported for upstream passage.

Downstream Passage

Under Alternative 3A, downstream passage would be provided by operations at several reservoirs:

- Deep spring and fall drawdowns at Lookout Point and Detroit Reservoirs.
- Modestly deeper spring and fall drawdowns at Cougar Reservoir.
- Spring surface spill and deep fall drawdowns at Fall Creek Reservoir.
- Deep fall drawdowns at Blue River Reservoir.
- Surface spill in spring and moderately deep drawdowns in fall at Hills Creek Reservoir.
- Spring spills at Dexter and Big Cliff Reservoirs.

Effects of downstream passage on migratory and resident fish from continuing deep fall drawdowns at Fall Creek Dam would be the same as described under the NAA.

These operational downstream dam passage improvements would provide direct, slight to moderate benefits to migratory and resident fish by reducing direct injury and mortality of fish, increasing connectivity between populations of resident fish above and below the dams, and helping to increase the abundance and genetic fitness of local fish populations compared to NAA operations.

While these improvements would be direct benefits to migrating and resident fish in the South Santiam River Subbasin, McKenzie River Subbasin, and Middle Fork Willamette River Subbasin as compared to NAA operations, upstream and downstream passage effects overall would remain adverse under Alternative 3A.

Upper Willamette River Chinook Salmon and Steelhead

Effects on reservoir habitat, riverine habitat, and fish passage conditions would result in a range of direct, adverse effects on UWR Chinook salmon and UWR steelhead under Alternative 3A as compared to the NAA.

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 3A, effects of operations-related reservoir habitat conditions on UWR Chinook salmon and UWR steelhead rearing and migration through reservoirs would be the same as those described for drawdown and spill measures under Alternative 2B in the North Santiam River and South Santiam River Subbasins. Effects on UWR Chinook salmon would be similar to those described under the NAA within Cougar Reservoir in the McKenzie River Subbasin, and Hills Creek Reservoir and Lookout Point Reservoir in the Middle Fork Willamette River Subbasin.

Additionally, UWR Chinook salmon and native fish would be transported above Blue River Dam under Alternative 3A. UWR Chinook salmon juveniles would use Blue River Reservoir to rear until a deep reservoir drawdown in the fall results in their passage downstream below the dam. Consequently, effects would be similar to those described at Fall Creek Reservoir under the NAA operations.

Riverine Habitat in All Subbasins

Under Alternative 3A, bank protection structures in the analysis area would continue to have the same effects on downstream fish habitat as under the NAA. Dam operations in winter and spring would have long-term, substantial, adverse effects resulting from reduced peak high flows and blockage of large woody debris and sediment transport. During spring to fall, there would be a decrease in the long-term, adverse effects resulting from augmentation of flows during low flow seasons under Alternative 3A operations.

Deep reservoir drawdowns in spring would decrease the stored water volumes in the North Santiam River and Middle Fork Willamette River Subbasins. Downstream habitat conditions under Alternative 3A would slightly to moderately increase adverse effects on downstream spawning habitat availability; incubation success; and rearing, foraging, and migrating opportunities for UWR Chinook salmon and UWR steelhead local populations as compared to the NAA, depending on the river reach.

Effects of water temperatures discharged from WVS dams under Alternative 3A would be similar to those described under the NAA in the South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins. Effects of water temperatures discharged on riverine habitat would be slightly more adverse in the North Santiam due to changes in the number of days temperature targets are met compared to the NAA. Adverse effects from TDG on fish would increase compared to the NAA due to increases in the number of days above TDG water quality standards (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

The following are estimates of UWR Chinook salmon spawning habitat availability and spawning and incubation success in reaches downstream of dams under Alternative 3A based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 4 percent to 100 percent of the spawning period, depending on the river reach (Appendix E, Fish and Aquatic Habitat Analyses). These percentages represent substantial decreases from the NAA in the Middle Fork Willamette River and McKenzie River Subbasins and no differences or negligible decreases from the NAA in the South Santiam River and North Santiam River Subbasins, respectively. The low percentages in the Middle Fork Willamette River and McKenzie River Subbasins reflect the lack of stored water available to supplement stream flows because of deep reservoir drawdowns in spring.
- 2,744 (range 13 to 7,237) average number of redds surviving until swim-up (Appendix E, Fish and Aquatic Habitat Analyses), which would be a slight increase compared to the NAA. The highest number of redds is estimated for the McKenzie River downstream of Cougar Dam and the lowest in the Middle Fork Willamette River downstream of Dexter Dam.

The following are estimates of UWR steelhead spawning habitat availability and the number of age-1 and smolts in reaches downstream of dams under Alternative 3A based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 100 percent of the spawning period, which would be a negligible increase compared to the NAA (Appendix E, Fish and Aquatic Habitat Analyses).

- Average number of age-1 UWR steelhead estimated at 119,036 and 252,762, and steelhead smolts estimated at 85 and 86 in reaches downstream of WVS dams in the North Santiam River and South Santiam River Subbasins, respectively, which would be decreases compared to the NAA (Appendix E, Fish and Aquatic Habitat Analyses).

Dam Passage Conditions in All Subbasins

Effects to UWR Chinook salmon and UWR steelhead under Alternative 3A would be similar as described under the NAA for upstream passage. However, unlike NAA operations, access to spawning and rearing habitat upstream of Green Peter Dam for both species and upstream of Hills Creek and Blue River Dams for UWR Chinook salmon would also be provided.

Operational dam passage improvements would provide slight to moderate decreases in adverse effects on downstream fish passage due to increases in passage rates and survival under Alternative 3A (Table 3.8-22) (Appendix E, Fish and Aquatic Habitat Analyses). There would also be substantial benefits from habitat access and genetic exchange opportunities under Alternative 3A as compared to the NAA for UWR Chinook salmon and UWR steelhead in the North Santiam River Subbasin at Detroit Dam and in the South Santiam River Subbasin at Green Peter and Foster Dams. These benefits would also occur for UWR Chinook salmon in the Middle Fork Willamette River Subbasin at Lookout Point Dam and in the McKenzie River Subbasin at Cougar Dam.

Spring surface spill occurring at Green Peter, Foster, and Hills Creek Dams would increase the number of fry and yearling life stages passing downstream with a higher survival rate as compared to the NAA. Spring surface spill would occur at Big Cliff and Dexter Dams to aid passage and survival. This would be a moderate benefit to salmon in the analysis area under Alternative 3A as compared to NAA operations.

Unlike NAA operations, deeper reservoir drawdowns in the spring to near the regulating outlets at Detroit Dam and Cougar Dam would also improve salmon survival under Alternative 3A. Additionally, more fry would reach the forebay and pass downstream than under NAA operations due to a shortened reservoir length and depth to regulating outlets.

Table 3.8-22. Average, Minimum, and Maximum Juvenile Upper Willamette River Chinook Salmon and Juvenile Upper Willamette River Steelhead Downstream Dam Passage Survival Estimates under Alternative 3A.

Species and Dam	Average Survival Estimate (%)	Minimum Survival Estimate (%)	Maximum Survival Estimate (%)
Chinook Salmon			
Cougar	27	20	37
Detroit	45	26	57
Foster	57	52	60
Green Peter	40	15	59
Hills Creek	35	12	50
Lookout Point	34	27	38
Steelhead			
Detroit	49	41	53
Foster	31	28	34
Green Peter	32	20	39

Source: Fish Benefits Workbook model survival estimates from simulated operations for years 1947 to 2019; Appendix E, Fish and Aquatic Habitat, Chapter 2, Fish Benefits Workbook Results.

Alternative 3A operations would include deep fall reservoir drawdowns to near regulating outlet elevations at Detroit, Green Peter, Lookout Point, Cougar, and Hills Creek Dams, and to streambed at Blue River and Fall Creek Dams. Under these operations, salmon survival would be higher than under NAA operations in reservoirs where juvenile Chinook salmon use regulating outlets instead of turbines.

Passage timing downstream of Blue River Dam would be constrained under Alternative 3A with a fall-only passage operation similar to NAA operational passage at Fall Creek Dam. This, combined with upstream passage, would provide access to novel habitat that was historically blocked by a waterfall.

Operations at Foster Dam would be the same as the NAA. Consequently, impacts on salmon survival would be the same as under NAA operations.

Population Performance in All Subbasins

Under Alternative 3A, population performance of UWR Chinook salmon upstream of dams in the analysis area is estimated to be poor to good and extinction risk low to high, dependent on subbasin. These results reflect no difference to slight improvements compared to the NAA (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a, 2022b; McAllister et al. 2023):

- Natural-origin spawner abundance for upstream-of-dam local populations under Alternative 3A is estimated to be high in the North Santiam River Subbasin (7,710 adults) and low in the South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins (968, 108, and 158 adults, respectively). These estimates represent a slight increase from the NAA in the Middle Fork Willamette River Subbasin and substantial increases in the North Santiam River, South Santiam River, and McKenzie River Subbasins compared to the NAA.
- Initial population productivity in years 6 to 10 is estimated to be above replacement (recruits/spawner greater than 1) for all UWR Chinook salmon local populations upstream of WVS dams in the analysis area in all four UWR Chinook salmon local populations. In the McKenzie River and Middle Fork Willamette River Subbasins, estimated productivity is attributed to very high pHOS (77 and 91 percent, respectively). The estimated pHOS in upstream-of-dams under Alternative 3A is low to moderate in the North Santiam River (0 percent) and South Santiam River Subbasins (27 percent), representing a substantial decrease and modest increase, respectively compared to the NAA. pHOS in the McKenzie River (77 percent) and Middle Fork Willamette River Subbasins (92 percent) represent a modest decrease and modest increase, respectively, compared to the NAA. Over the 30-year implementation timeframe, populations would be below replacement levels except above Detroit Dam in the North Santiam River Subbasin.
- The probability of individual UWR Chinook salmon local population upstream of WVS dams in the analysis area going below extinction risk abundance levels is estimated to be very low in the North Santiam River Subbasin (0 percent), moderate (32 percent) in the South Santiam River Subbasin, and very high in the McKenzie River and Middle Fork Willamette River Subbasins (96 and 99 percent, respectively). These probabilities represent substantial to slight decreases in extinction risk of UWR Chinook salmon compared to the NAA in the North Santiam River and South Santiam River Subbasins, and no difference from the NAA in the local populations of the Middle Fork Willamette River and McKenzie River Subbasins.

Under Alternative 3A, UWR steelhead population performance is estimated to be poor and risk of extinction high, as under the NAA (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a):

- Natural-origin spawner abundance for upstream-of-dam UWR steelhead local populations under Alternative 3A is estimated to be low to extremely low in the South Santiam River and North Santiam River Subbasins (209 to 44 adults, respectively) under Alternative 2A, which represents a substantial increase in the North Santiam River Subbasin compared to the NAA and no difference upstream of Foster Dam in the South Santiam River Subbasin.

- Productivity is estimated to be above replacement (recruits/spawner greater than 1) for UWR steelhead upstream of Detroit Dam, representing an increase compared to the NAA. Like the NAA, productivity is estimated to be below replacement (less than 1) for the UWR steelhead local populations upstream of Foster and Green Peter Dams. Hatchery supplementation would likely be necessary to maintain UWR steelhead above these dams.
- The probability of UWR steelhead local populations going below extinction risk abundance levels is estimated as very high upstream of Detroit, Foster, and Green Peter Dams (74 percent, 100 percent, and 98 percent, respectively) in both the North Santiam River and South Santiam River Subbasins. The estimated extinction risk under Alternative 3A was about the same as the NAA for the local population upstream of Foster Dam and moderately decreased for the local population upstream of Detroit Dam (there is no local population upstream of Green Peter Dam under the NAA for comparison).

Bull Trout in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 3A, effects of operations-related reservoir habitat conditions on bull trout rearing, foraging, and overwintering in the North Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins would be similar to those described for relevant drawdown and spill measures under Alternative 2B. Deep reservoir drawdowns would affect all three local populations residing above WVS dams in these subbasins.

In-reservoir rearing and foraging habitat and prey fish availability would be reduced compared to the NAA. Decreases in water quality conditions would adversely affect bull trout within reservoirs with seasonal increases in turbidity, affecting respiration and ability to find food, and reduced availability of tolerable water temperatures occurring due to decreased water volumes during drawdown events.

Effects on fish habitat from drawdowns of Cougar Reservoir would be similar to those under NAA operations because the drawdown would occur to only the regulating outlet under Alternative 3A and, therefore, a large reservoir pool would be maintained year-round as available fish habitat.

Riverine Habitat in All Subbasins

Under Alternative 3A, operations and management of bank protection structures in the analysis area would have the same effects on fish as described under the NAA. However, conservation season flows in the Middle Fork Willamette River and North Santiam River Subbasins and in the Mainstem Willamette River, would be lower compared to the NAA due to the decrease in availability of storage water to supplement seasonal low flows in summer and early fall.

Deep reservoir drawdowns of Detroit Reservoir and operation of surface spill at Hills Creek Dam under Alternative 3A would increase the number of bull trout moving below Detroit and Hills Creek Dams in the North Santiam River and Middle Fork Willamette River Subbasins and accessing additional riverine habitat. Some individual bull trout would move from these reservoirs into upstream tributaries during the deep reservoir drawdowns, and growth opportunity is expected to be lower within the streams compared to within reservoirs due to differences in the amount of available forage habitat and suitable water temperatures.

Bull trout moving downstream of these dams would access additional riverine habitat where foraging opportunities may not be as beneficial as in the reservoir. Bull trout moving downstream would be adversely affected by sport fisheries for trout and other species. An increase in bull trout occupying downstream habitat under Alternative 3A would increase the likelihood of incidental catch, misidentification, and poaching of bull trout where sport fishing for hatchery-released rainbow trout occurs in the analysis area (USFWS 2008).

There is no spawning habitat for bull trout below Detroit and Hills Creek Dams; therefore, bull trout moving downstream would be collected and trucked to spawn upstream of these dams. These changes in rearing and foraging opportunity, habitat connectivity, and adverse effects of sport fisheries under Alternative 3A would result in moderate, beneficial to moderate, adverse effects for the bull trout population in the North Santiam River and Middle Fork Willamette River Subbasins due to changes in foraging and seasonal habitat availability.

Bull trout would experience changes in riverine habitat availability under Alternative 3A ranging from beneficial to adverse depending on reach and time of year. Increased water temperatures would occur below WVS dams in the North Santiam River Subbasin and McKenzie River Subbasin as compared to the NAA. TDG-related stress would increase for bull trout below all WVS dams in the North Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins as compared to the NAA. These water quantity and quality impacts would result in slight to moderate, adverse effects on bull trout under Alternative 3A as compared to the NAA.

Dam Passage Conditions in All Subbasins

Under Alternative 3A, direct and indirect adverse effects of upstream passage conditions on bull trout would be the same as described under the NAA, except at Hills Creek Dam. An adult fish facility for bull trout collection would be constructed at Hills Creek Dam, providing substantially improved upstream passage.

Direct and indirect adverse effects of downstream passage conditions on bull trout would be the same as described under the NAA at Cougar and Hills Creek Dams.

Downstream passage at Detroit Dam under Alternative 3A would be provided operationally with a deep reservoir drawdown in the fall and spring. The improved downstream dam passage would result in direct, moderate reductions in adverse effects of dam passage on downstream bull trout compared to NAA operations. These improved passage conditions at Detroit Dam would negligibly to slightly improve opportunities for genetic exchange with other local bull trout populations in the Willamette River Basin. However, unlike NAA operations, improved downstream passage would also increase exposure of bull trout to risks of injury and mortality in sport fisheries.

Pacific Lamprey in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Effects on Pacific lamprey from reservoir operations under Alternative 3A would be the same as those described under the NAA.

Riverine Habitat in All Subbasins

Downstream habitat improvements under Alternative 3A would slightly decrease adverse effects on spawning habitat availability and associated incubation success and rearing and migrating opportunities for Pacific lamprey compared to the NAA.

Compared the NAA, there would be an increase in adverse effects from dam operation on lamprey habitat downstream of Big Cliff Dam in the North Santiam River Subbasin, below Dexter Dam in the Middle Fork Willamette River Subbasin, and the Mainstem Willamette River. Deep reservoir drawdowns in spring would decrease stored water volumes in these reaches, reducing the availability of water to augment summer low flows and habitat for lamprey.

Effects of water temperatures discharged from WVS dams would be similar to the NAA. However, compared to the NAA, effects would be slightly less adverse in the South Santiam River and Middle Fork Willamette River Subbasins and slightly more adverse in the North Santiam River and McKenzie River Subbasins due to changes in the number of days temperature targets are met. Adverse effects from TDG on fish would increase compared to the NAA due to increases in the number of days above TDG thresholds in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins (Section 3.5.2.1, Water Quality, Methodology Subsection, Table 3.5.10 through Table 3.5.12).

Combined spring and fall drawdowns at Detroit, Lookout Point, and Cougar Reservoirs under Alternative 3A would reduce water storage for summer flow supplementation downstream annually, reducing spawning habitat availability in the North Santiam River, Middle Fork Willamette River, and McKenzie River Subbasins compared to the NAA. This would result in slight to moderate, adverse effects on Pacific lamprey under Alternative 3A as compared to the NAA.

Conversely, a deep reservoir drawdown in fall at Green Peter and Hills Creek Reservoirs under Alternative 3A would increase seasonal flows below Foster and Dexter Dams, respectively. This would increase incubation habitat available and associated production in these reaches of the South Santiam River and Middle Fork Willamette River Subbasins compared to the NAA. This would result in slight reduction in adverse effects on Pacific lamprey under Alternative 3A as compared to the NAA.

Effects on lamprey from short-term, increased sediment discharge rates from Detroit, Green Peter, Cougar, Hills Creek, and Lookout Point Dams under Alternative 3A would be the same as described for Green Peter Dam under Alternative 2A.

Dam Passage Conditions in All Subbasins

Effects of dam passage conditions under Alternative 3A on Pacific lamprey would be the same as under the NAA, except at Fall Creek Dam where additional benefits may occur for lamprey. Upstream passage would be the same as under the NAA and would be provided by continued operation of the Fall Creek Adult Fish Facility.

Downstream passage at Fall Creek Dam would also be the same as under NAA operations in the fall with a deep reservoir drawdown to streambed. However, Fall Creek Dam would be operated for surface spill in the spring under Alternative 3A, which would slightly increase the potential for some lamprey to pass downstream as compared to NAA operations.

Resident Fish in All Subbasins

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 3A, two annual deep drawdowns of Detroit, Cougar, and Lookout Point Reservoirs, and fall deep drawdowns at Green Peter, Blue River, Hills Creek, and Fall Creek Reservoirs would reduce open water habitat for rearing, foraging, and spawning habitat for resident fish resulting in substantially direct adverse effects for resident fish.

Releases of hatchery rainbow trout and kokanee would help maintain sport fishing opportunities where these fish are stocked. However, there were no fish stocked into Cougar Reservoir at the time the alternatives were analyzed. Therefore, effects on stocked gamefish under Alternative 3A would be the same as those described under the NAA.

Riverine Habitat in All Subbasins

Downstream habitat improvements under Alternative 3A would slightly decrease adverse effects on spawning habitat availability and associated incubation success and rearing and migrating opportunities for resident fish compared to the NAA.

Compared to the NAA, there would be an increase in adverse effects from dam operations on resident fish habitat downstream of Big Cliff Dam in the North Santiam River Subbasin, below Dexter Dam in the Middle Fork Willamette River Subbasin, and the Mainstem Willamette River. Deep reservoir drawdowns in spring would decrease stored water volumes in these reaches, reducing the availability of water to augment summer low flows and habitat for resident fish.

Effects on resident fish of water temperatures discharged from WVS dams would remain similar to the NAA. However, compared to the NAA, effects would be slightly less adverse in the South Santiam and Middle Fork River Subbasins and slightly more adverse in the North Santiam and McKenzie River Subbasins due to changes in the number of days temperature targets are met.

Adverse effects from TDG on resident fish would increase compared to the NAA due to increases in the number of days above TDG thresholds in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins (Section 3.5.2.1, Water Quality, Methodology Subsection, Table 3.5.10 through Table 3.5.12).

Combined spring and fall drawdowns at Detroit, Lookout Point, and Cougar Reservoirs under Alternative 3A would reduce water storage for summer flow supplementation downstream annually, reducing spawning habitat availability in the North Santiam River, Middle Fork Willamette River, and McKenzie River Subbasins compared to the NAA. This would result in slight to moderate, adverse effects on resident fish under Alternative 3A as compared to the NAA.

Conversely, a deep reservoir drawdown in fall at Green Peter, Blue River, and Hills Creek Reservoirs under Alternative 3A would increase seasonal flows from WVS dams in the South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins. This would increase incubation habitat available in these subbasins and in the Mainstem Willamette River compared to the NAA for some resident fish species and life stages. This would result in a slight reduction in adverse effects on resident fish under Alternative 3A as compared to the NAA.

Effects on resident fish from short-term, increased sediment discharge rates from Detroit, Green Peter, Cougar, Blue River, Hills Creek, and Lookout Point Dams under Alternative 3A would be the same as described for Green Peter Dam under Alternative 2A. Sediment and turbidity levels would be higher in the firsts few years of deep reservoir drawdowns at Blue River Dam and then reduce to lower levels, the same as described for Fall Creek Dam under the NAA.

Unlike NAA operations, indirect, moderate, adverse effects on resident fish in the McKenzie River Subbasin below Blue River Dam would occur in the short term during the first few years of operation from elevated turbidity. In the long term, effects would subside to slight, adverse effects annually for resident fish during deep fall drawdowns of Blue River Dam.

Dam Passage Conditions in All Subbasins

Compared to NAA operations, deeper drawdowns under Alternative 3A would increase passage and entrainment rates of resident fish downstream from reservoirs, with slight to moderate improvements in passage survival. Entrainment rates would be highest at Blue River and Fall Creek Dams with a drawdown to streambed, moderate at Green Peter and Lookout Point Dams, and slightly increased at Cougar and Hills Creek Dams with drawdowns to regulating outlets as compared to NAA operations.

Downstream entrained resident fish species would likely experience high mortality rates due to loss of lake-like habitat availability and density of fish present in riverine habitat downstream. There would be a moderate to substantial adverse effect on the abundance of resident fish species within WVS reservoirs that depend on lake-like conditions compared to the NAA at these reservoirs.

As under the NAA, adult fish facilities operated under Alternative 3A would allow passage of resident fish upstream of all WVS dams over the 30-year implementation timeframe. This includes increased opportunities for upstream fish passage at the proposed new adult fish facility structures for Hills Creek, Green Peter, and Blue River Dams. This would moderately improve conditions for resident fish in the McKenzie River and Middle Fork Willamette River Subbasins.

Alternative 3B—Improve Fish Passage through Operations-focused Measures

Operations under Alternative 3B and associated effects would be the same as described under Alternative 3A. However, spring spill and spring drawdown measures for downstream fish passage would be implemented at different dams under Alternative 3B.

Common effects analyses from hatcheries on habitat and from passage conditions across all fish species are discussed first, followed by analysis of effects specific to each fish species or population. Note the common effects described in this section are not repeated in the species-specific analyses but are assumed to apply to species effects unless stated otherwise.

Hatchery Mitigation in All Subbasins

Under Alternative 3B, the Willamette Hatchery Mitigation Program and associated effects would be the same as described under the NAA with the following exception:

- There would be adjustments to the number of hatchery-origin UWR Chinook salmon released upstream of some reservoirs.
- There would be a reduction in adverse impacts on UWR steelhead in the North Santiam River and South Santiam River Subbasins from hatchery-origin summer-run steelhead spawning in streams.
- There would be a reduction in adverse impacts on UWR Chinook salmon from hatchery-origin spring-run Chinook salmon spawners.
- There would be risks to bull trout from the rainbow trout hatchery program.

Under Alternative 3B, there would be a release of hatchery-origin and natural-origin adults upstream of Green Peter Reservoir as compared to the NAA. Average pHOS in all subbasins would decrease from 0.69 under the NAA to 0.45 under Alternative 3B, although there would be some variability between subbasins. This slight to moderate reduction in adverse effects of pHOS would result from improved fish passage conditions, subsequent increases in natural-origin adult Chinook salmon, and commensurate decreases in pHOS in these subbasins as compared to NAA operations.

The percent of introgression in UWR steelhead in the North Santiam River and South Santiam River Subbasins from hatchery-origin summer-run steelhead spawning in streams would slightly change compared to the NAA due to the slight increase in predicted abundance of adult UWR steelhead. Therefore, effects on UWR steelhead would be the slightly less adverse compared to the NAA.

Conversely, unlike NAA operations, there would be slight to moderate, adverse effects on bull trout from the rainbow trout hatchery program under Alternative 3B. Deep reservoir drawdowns in spring and fall under Alternative 3B would increase the number of bull trout moving downstream of Cougar Dam in the McKenzie River Subbasin. This would increase the likelihood of incidental catch, misidentification, and poaching of bull trout where sport fishing for hatchery-released rainbow trout occurs in the analysis area as compared to NAA operations (USFWS 2008).

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 3B, effects of reservoir operations would be the same on fish would decrease the availability of reservoir habitat in Detroit, Green Peter, Cougar, Blue River, Hills Creek, Lookout Point, and Fall Creek Reservoirs. Effects would be the same as those described under Alternative 3A. Effects on bull trout using Cougar Reservoir from the rainbow trout hatchery program as those described under Alternative 2B.

Riverine Habitat in All Subbasins

Under Alternative 3B, effects of dam operations and bank protection structures on fish would be to the same as described under the NAA and under Alternative 3A. However, there would be differences in flow and water quality effects from deep reservoir drawdowns.

Unlike NAA operations, gravel placement below dams would decrease adverse effects of blocked sediment transport from the above-dam watersheds. As a result, effects on fish in riverine habitat below WVS dams from these operations would trend toward less adverse under Alternative 3B as compared to the NAA.

Flow

Compared to the NAA, river flows under Alternative 3B would be lower in summer and early fall due to reduced availability of water storage resulting from deep reservoir drawdowns in the South Santiam River Subbasin, Middle Fork Willamette River Subbasin, and Mainstem Willamette River. Consequently, indirect effects on fish would trend toward more adverse compared to the NAA. Effects to fish from reduced river flows in these locations during the conservation season would result in mixed effects, depending on species, life stage, and river channel conditions. Indirect effects on fish would range from moderately adverse to slightly beneficial under Alternative 3B.

Stranding Risk

Under Alternative 3B, established down-ramping rates and hydropower-peaking operations would be similar to those described under the NAA. Therefore, stranding risks to fish below WVS dams would be the same as described under the NAA.

Materials Transport and Habitat Complexity

Under Alternative 3B, effects on fish habitat and food production would be the same as described under the NAA and Alternative 3A. However, adverse effects of blocked sediment transport from above dams under NAA operations would be reduced by placement of gravel below dams. Additionally, deep drawdowns of Cougar Reservoir would also result in short-term sediment transport and deposition similar to that observed at Fall Creek during deep reservoir drawdowns, with the largest volumes being transported in the first few years of the operations.

Water Temperature

Under Alternative 3B, effects on water quality from temperature conditions in the North Santiam River Subbasin would be the same as those described under the NAA. There may be differences in the number of days where water temperature standards would be met; however, this would not alter the overall adverse effect on water quality in this subbasin (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Indirect effects to fish in river reaches below WVS dams under Alternative 3B and to fish held in or released below hatcheries or adult fish facilities below WVS dams would be the same as those described under the NAA in the North Santiam River Subbasin.

As under the NAA, effects on water quality from temperature conditions in the South Santiam River Subbasin would continue to be adverse below Green Peter Dam during times of the year when water temperature targets are not met under Alternative 3B. As under the NAA, adverse effects would occur below Foster Dam at certain times of year because of Green Peter Dam fall and spring drawdown operations. The spring drawdown for downstream fish passage would cause warmer downstream temperatures from May through October, resulting in slightly more adverse effects as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Indirect effects to fish in river reaches below WVS dams under Alternative 3B, and to fish held in or released below hatcheries or adult fish facilities below WVS dams, would be slightly to moderately more adverse in the South Santiam River Subbasin compared to the NAA.

Under Alternative 3B, effects on water quality from temperature conditions in the McKenzie River Subbasin would be the same as those described under Alternative 2B (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 2B).

Adverse effects on water quality from temperature conditions in the Middle Fork Willamette River Subbasin would continue as under the NAA. However, unlike the NAA, these effects would trend toward a beneficial effect for fish below dams and for fish held in or released below hatcheries or adult fish facilities below WVS dams from water temperatures because temperature targets would be met more often under Alternative 3B operations and result in slightly less adverse effects below Hills Creek, Lookout Point, and Dexter Dams as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Under Alternative 3B, effects on water quality from temperature conditions in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as described under the NAA. There may be differences in the number of days where water temperature standards would be met or in the number of days TDG meets targets; however, this would not alter the overall adverse effect on water quality from temperature conditions in these subbasins (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B). Consequently, effects on fish under Alternative 3B would be the same as those described under the NAA.

Effects on water quality from temperature conditions in the Mainstem Willamette River would continue to be adverse during times of the year when water temperature targets are not met under Alternative 3B (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B). Adverse conditions would increase slightly as compared to the NAA, which would result in slightly more indirect, adverse effects on fish species in the Mainstem Willamette River as compared to NAA operations.

Total Dissolved Gas

Under Alternative 3B, there would be a substantial increase in adverse effects to water quality from TDG exceedance of the water quality standard in the North Santiam River Subbasin as compared to the NAA. The increase in TDG exceedance of the water quality standard would be due to an increase in spill operations. There is no structural TDG abatement measure under Alternative 3B (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Under Alternative 3B, there would be a moderately more adverse effect to water quality from TDG downstream of Green Peter and Foster Dams in the South Santiam River Subbasin as compared to the NAA because of increased spill operations. There is no structural TDG abatement measure under Alternative 3B (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Under Alternative 3B, effects on water quality from TDG in the McKenzie River Subbasin would be the same as those described under Alternative 2B. This would result in a moderately less adverse effect as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Under Alternative 3B, there would be an adverse effect to water quality from TDG in the Middle Fork Willamette River Subbasin similar to conditions under the NAA. Although operations would spread spill over multiple spillway gates downstream of Lookout Point Dam and Dexter Dam under Alternative 3B, there would be an increase in spill frequency due to drawdown operations for fish passage, which would elevate TDG exceedance of the water quality standard (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

There may be differences in the number of days of TDG levels meeting targets as compared to the NAA; however, this would not alter the overall adverse effect on water quality from TDG in the subbasin. Exceptions may occur at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations, but overall, operations under Alternative 3B would result in adverse effects on water quality in the Middle Fork Willamette River Subbasin (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Under Alternative 3B, effects on water quality from TDG in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as described under the NAA. There may be differences in the number of days where water temperature standards would be met or in the number of days TDG meets targets; however, this would not alter the overall adverse effect on water quality from TDG in these subbasins (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Under Alternative 3B, effects on water quality from TDG in the Mainstem Willamette River would be the same as described under the NAA. TDG is presumed not to be adverse because there are no dam operations on the Mainstem Willamette River (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Adverse effects to fish from gas bubble trauma and other impacts related to TDG under Alternative 3B would occur in all subbasins. Indirect, adverse effects to fish in the North Santiam River Subbasin and South Santiam River Subbasin would be similar to Alternative 3A.

Indirect, adverse effects to fish in the McKenzie River Subbasin from TDG-related impacts would be the same as those described under Alternative 2B. Indirect effects to fish in the Middle Fork Willamette River Subbasin, Coast Fork Willamette River Subbasin, Long Tom River Subbasin, and the Mainstem Willamette River would be similar to those described under the NAA.

Turbidity

Under Alternative 3B, effects on water quality from turbidity would be similar to Alternative 3A; however, the locations and durations would differ. Deeper reservoir drawdowns would occur in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3A).

These operations would cause an increase in sediment movement and turbidity levels downstream of Detroit, Green Peter, Cougar, Blue River, and Lookout Point Reservoirs because of deeper drawdowns, increasing the potential for bank erosion and sloughing as compared to NAA operations. While some fine-grained sediment that enters these reservoirs may partially settle, most fine-grained sediment would pass through dams and result in temporary increased turbidity downstream during deeper drawdowns as compared to NAA operations (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Under Alternative 3B, impacts to water quality from turbidity in the Mainstem Willamette River would be moderately more adverse effects than those described under the NAA. This would be due to deeper drawdowns in many WVS reservoirs, increasing the likelihood of turbidity under Alternative 3B (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Indirect effects to fish from high turbidity would be minor to substantial during the drawdown periods each year as compared to the NAA. Indirect effects on fish habitat from fine sediment transport and deposition would be minorly beneficial to moderately adverse, depending on species and life stage.

Effects on water quality and on fish from turbidity under Alternative 3B in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as those described under the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 3B).

Other Riverine Habitat Conditions in All Subbasins

Under Alternative 3B, direct and indirect adverse effects of resident fish species entrained downstream during fall drawdowns would be the same as described under the NAA. Downstream habitat competition and predation for fish present downstream would increase compared to the NAA.

Deep drawdowns of Detroit, Green Peter, Hills Creek, Lookout Point, and Fall Creek Reservoirs would increase entrainment of resident fish species below these dams, resulting in increases in competition and predation for fish present in river reaches below these dams. Drawdowns to the regulating outlet at Hills Creek Dam would result in similar downstream effects from non-native fish entrainment as described under the NAA.

Operations would also continue to create localized conditions favoring fish that prefer rocky, steeply sloped shorelines with limited riparian vegetation, particularly near bank protection structures as described under the NAA.

Dam Passage Conditions in All Subbasins

Upstream Passage

Under Alternative 3B, effects on upstream migrating fish would be the same as described under Alternative 3A.

Downstream Passage

Unlike the NAA operations, downstream passage would be provided under Alternative 3B from operations at several reservoirs:

- Deep spring and fall drawdowns at Green Peter, Cougar, and Hills Creek Reservoirs.
- Spring spills and fall deep drawdowns at Detroit and Lookout Point Reservoirs.

- Deep fall drawdowns at Fall Creek and Blue River Reservoirs.
- Spring spills at Big Cliff and Dexter Reservoirs.

Effects on migrating and resident fish species from operational downstream dam passage under Alternative 3B would be the same as described under Alternative 3A, with additional direct benefits at Cougar Dam. At Cougar Dam, a deep reservoir drawdown to 25 feet over the diversion tunnel would occur and would provide direct benefits to downstream fish passage and entrainment of resident fish similar to those described at Fall Creek Dam under the NAA.

While these improvements would be direct benefits to migrating and resident fish in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins as compared to NAA operations, upstream and downstream passage would overall remain adverse under Alternative 3B.

Upper Willamette River Chinook Salmon and Steelhead

Effects on reservoir habitat, riverine habitat, and fish passage conditions would result in direct, moderate to substantial adverse effects on UWR Chinook salmon and UWR steelhead under Alternative 3B compared to the NAA.

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 3B, effects of operations-related reservoir habitat conditions on UWR Chinook salmon and UWR steelhead in the North Santiam River and South Santiam River Subbasins, and on UWR Chinook salmon in the McKenzie River and Middle Fork Willamette River Subbasins would be the same as those described for drawdown and spill operations under Alternative 2B. However, effects under Alternative 3B would occur at different dams.

Riverine Habitat in All Subbasins

Under Alternative 3B, bank protection structures in the analysis area would continue to have the same effects on downstream fish habitat as described under the NAA. Effects of dam operations would have similar effects on downstream habitat as described under Alternative 3A, but with effects of deep reservoir drawdowns occurring in different dam locations. Regulated flows would have long-term, substantial, adverse effects on downstream habitat resulting from reduced peak high flows and blockage of large woody debris and sediment transport.

During spring to fall, there would be a decrease in the long-term, beneficial effects resulting from augmentation of flows during low flow seasons under Alternative 3B as compared to NAA operations. Deep spring drawdowns in Hills Creek, Cougar, and Green Peter Reservoirs would decrease the stored water volumes in the Middle Fork Willamette River, McKenzie River, and South Santiam River Subbasins. This would result in moderate, adverse effects on UWR Chinook salmon and UWR steelhead under Alternative 3B as compared to the NAA, depending on channel conditions in each river reach and fish life stage.

The following are estimates of UWR Chinook salmon spawning habitat availability and spawning and incubation success in reaches downstream of dams under Alternative 3B, based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 5 percent to 100 percent of the spawning period, depending on the river reach (Appendix E, Fish and Aquatic Habitat Analyses). Estimated amounts include slight increase in the North Santiam River Subbasin, moderate decreases in the Middle Fork Willamette River and South Santiam River Subbasins, and substantial decreases in the McKenzie River Subbasin compared to the NAA. The lower percentages in the Middle Fork Willamette River, South Santiam River, and McKenzie River Subbasins reflect the lack of stored water available to supplement stream flows because of deep reservoir drawdowns in spring.
- 2,186 (range 9 to 6,935) average number of redds surviving until swim-up (Appendix E, Fish and Aquatic Habitat Analyses), which would be a slight decrease compared to the NAA. The highest number of redds surviving until swim-up is estimated to occur in the McKenzie River downstream of Cougar Dam and the lowest number in the South Santiam River downstream of Foster Dam.

The following are estimates of UWR steelhead spawning habitat availability and the number of age-1 and smolts in reaches downstream of dams under Alternative 3B based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 96 percent to 100 percent of the spawning period, which would be a negligible increase compared to the NAA (Appendix E, Fish and Aquatic Habitat Analyses).
- Average number of age-1 UWR steelhead estimated at 302,134 and 125,391, and steelhead smolts estimated at 89 and 86 in reaches downstream of WVS dams in the North Santiam River and South Santiam River Subbasins, respectively. This includes an increase in age-1 steelhead but no difference in steelhead smolts in the North Santiam River Subbasin and a decrease in age-1 steelhead with a slight increase in steelhead smolts in the South Santiam River Subbasin compared to the NAA (McAllister et al. 2022a).

Dam Passage Conditions in All Subbasins

Effects to upstream UWR Chinook salmon and UWR steelhead under Alternative 3B would be the same as described under Alternative 3A.

Under Alternative 3B, operational dam passage improvements would provide moderate to substantial decreases in direct adverse effects from downstream passage conditions compared to the NAA as well as improved habitat access and genetic exchange opportunities compared to the NAA (Table 3.8-23) (Appendix E, Fish and Aquatic Habitat Analyses). These effects on UWR Chinook salmon and UWR steelhead would occur in the North Santiam River Subbasin at

Detroit Dam and in the South Santiam River Subbasin at Green Peter and Foster Dams. They would also affect UWR Chinook salmon in the Middle Fork Willamette River Subbasin at Lookout Point Dam and in the McKenzie River Subbasin at Cougar Dam and Blue River Dam.

Spring surface spill occurring at Detroit, Lookout Point, Big Cliff, and Dexter Dams would increase the number of subyearling and yearling life stages passing downstream with higher survival rates compared to the NAA. Deeper reservoir drawdowns in the spring to near the regulating outlets at Green Peter and Hills Creek Dams, and to near the diversion tunnel at Cougar Dam would also improve survival; more fry could reach forebays and pass downstream due to a shortened reservoir length and reduced depths to outlets.

In the fall, deep reservoir drawdowns to near regulating outlet elevations at Detroit, Green Peter, Lookout Point, Cougar, and Hills Creek Dams, and to streambed at Blue River and Fall Creek Dams would improve survival compared to NAA operations. Passage timing downstream of Fall Creek Dam would be constrained under Alternative 3B, reducing diversity in migrant life history types as compared to the NAA. Operations at Foster Dam would be the same as under the NAA.

Table 3.8-23. Average, Minimum and Maximum Juvenile UWR Chinook Salmon and Juvenile UWR Steelhead Downstream Dam Passage Survival Estimates under Alternative 3B.

Species and Dam	Average Survival Estimate (%)	Minimum Survival Estimate (%)	Maximum Survival Estimate (%)
Chinook Salmon			
Cougar	37	32	40
Detroit	33	15	43
Foster	58	54	60
Green Peter	26	10	37
Hills Creek	30	15	45
Lookout Point	42	37	47
Steelhead			
Detroit	42	42	42
Foster	32	28	37
Green Peter	26	24	27

Source: Fish Benefits Workbook model survival estimates from simulated operations for years 1947 to 2019; Appendix E, Fish and Aquatic Habitat Analyses, Chapter 2, Fish Benefits Workbook Results.

Population Performance in All Subbasins

Under Alternative 3B, population performance of UWR Chinook salmon upstream of dams in the analysis area is estimated to be good with low extinction risk in the North Santiam River Subbasin and poor with high extinction risk in the South Santiam River, McKenzie River, and

Middle Fork Willamette River Subbasins, providing slight to moderate reductions in adverse effects compared to the NAA (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a):

- Natural-origin spawner abundance above dams under Alternative 3B is estimated to be high in the North Santiam River Subbasin (5,923 adults) and to be moderate to low in the South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins (699, 220, and 179 adults, respectively), representing slight to substantial increases compared to the NAA.
- Initial population productivity in years 6 to 10 is estimated to be above replacement (recruits/spawner greater than 1) in all four UWR Chinook salmon populations affected by the WVS. In the Middle Fork Willamette River and McKenzie River Subbasins, estimated productivity is attributed to moderate to very high pHOS (91 and 58 percent, respectively). The estimated pHOS would be low in the South Santiam River and North Santiam River Subbasins (30 percent and 0 percent, respectively), which represent minor to substantial decreases compared to the NAA. Over the 30-year implementation timeframe, populations would be below replacement levels except above Detroit Dam in the North Santiam River Subbasin.
- The probability of UWR Chinook salmon upstream of WVS dams going below extinction risk abundance levels is estimated as very low in the North Santiam Subbasin (0 percent), moderate in the South Santiam River and McKenzie River Subbasins (61 to 74 percent), and high (99 percent) in the Middle Fork Willamette River Subbasin. These estimated probabilities represent no difference from the NAA in the Middle Fork Willamette River and North Santiam River Subbasins to moderate decreases compared to the NAA in the South Santiam River and McKenzie River Subbasins.

UWR steelhead population performance would generally be poor and extinction risk high, which is no difference from the NAA, as indicated by a combination of the following:

- Natural-origin spawner abundance for UWR steelhead above WVS dams under Alternative 3B is estimated to be extremely low in the South Santiam River and North Santiam River Subbasins (19 to 96 adults, respectively). This represents a substantial increase in the North Santiam River Subbasin compared to the NAA and no difference upstream of Foster Dam in the South Santiam River Subbasin.
- Productivity is estimated to be below replacement (recruits/spawner less than 1) for all UWR steelhead local populations upstream of WVS dams in the analysis area, the same as the NAA.
- The probability of UWR steelhead upstream of WVS dams going below extinction risk abundance levels is estimated to be high upstream of Detroit Dam in the North Santiam River Subbasin (88 percent), which is a slight decrease compared to the NAA, and extremely high upstream of Foster and Green Peter Dams in the South Santiam River Subbasin (100 percent), the same as under the NAA.

Bull Trout in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 3B, effects on bull trout rearing and foraging within WVS reservoirs would vary by subbasin. Effects would be the same at Cougar Reservoir as those described under Alternative 2B. Effects at Hills Creek Reservoir would be the same as the NAA. Effects from fall deep reservoir drawdown operations at Detroit Dam would be the same as described under Alternative 3A.

Riverine Habitat in All Subbasins

Under Alternative 3B, effects on bull trout riverine habitat for rearing and foraging below Detroit, Cougar, and Hills Creek Dams would vary by subbasin. Effects below Cougar Dam would be the same as those described under Alternative 2B. Effects below Detroit and Hills Creek Dams would be the same as those described under the NAA.

Dam Passage Conditions in All Subbasins

Under Alternative 3B, effects of upstream passage conditions on bull trout would be the same as described under the NAA, except at Hills Creek Dam. An adult fish facility for bull trout collection would be constructed at Hills Creek Dam, providing upstream passage. Consequently, this would substantially reduce adverse effects on bull trout due to upstream passage effects from dams as compared to the NAA

Direct and indirect adverse effects of dam passage conditions on bull trout would be similar to those described for bull trout under Alternative 3A at Detroit Dam. Direct and indirect adverse effects of passage conditions at Cougar Dam on bull trout would be the same as described under Alternative 2B. At Hills Creek Dam, direct and indirect adverse effects of dam passage conditions would be similar to those described under the NAA.

Pacific Lamprey in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Effects on Pacific lamprey from reservoir operations under Alternative 3B would be the same as those described under the NAA.

Riverine Habitat in All Subbasins

Downstream habitat improvements under Alternative 3B would slightly decrease adverse effects on spawning habitat availability and associated incubation success and rearing and migrating opportunities for Pacific lamprey compared to the NAA.

Compared to the NAA, there would be an increase in adverse effects from dam operations on lamprey habitat downstream of WVS dams in the South Santiam River, McKenzie River, and

Middle Fork Willamette River Subbasins and the Mainstem Willamette River. Deep reservoir drawdowns in spring would decrease stored water volumes in these reaches, reducing the availability of water to augment summer low flows and habitat for lamprey in these subbasins.

Conversely, a deep reservoir drawdown in fall at Detroit Dam under Alternative 3B would increase seasonal flows downstream in the North Santiam River Subbasin. This would increase incubation habitat available compared to the NAA and result in a slight reduction in adverse effects on Pacific lamprey under Alternative 3B as compared to the NAA.

Effects of water temperatures discharged from WVS dams would be remain similar to the NAA. However, compared to the NAA, temperatures would be slightly more adverse in the South Santiam River Subbasin and slightly less adverse in the North Santiam River Subbasin due to changes in the number of days temperature targets are met. Adverse effects from TDG on fish would increase compared to the NAA due to increases in the number of days above TDG thresholds in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins (Section 3.5.2.1, Water Quality, Methodology Subsection, Table 3.5-10 through Table 3.5-12).

Effects on lamprey from short-term, increased sediment discharge rates from Detroit, Green Peter, Cougar, Hills Creek, and Lookout Point Dams under Alternative 3B would be the same as described for Green Peter Dam under Alternative 2A. Effects from Blue River Dam would be similar to those described for Fall Creek Dam under the NAA.

Dam Passage Conditions in All Subbasins

Effects of dam passage conditions under Alternative 3B on Pacific lamprey would be the same as the NAA.

Resident Fish in All Subbasins

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 3B, two annual deep drawdowns of Green Peter, Cougar, and Hills Creek Reservoirs, and fall deep drawdowns at Detroit, Blue River, Lookout Point, and Fall Creek Reservoirs would reduce open water habitat for rearing, foraging, and spawning habitat for resident fish, resulting in substantial, direct, adverse effects on resident fish. Habitat reductions would be greatest at Fall Creek Reservoir with a drawdown to streambed, high at Cougar Reservoir with drawdowns to 25 feet over the diversion tunnel, moderate at Green Peter and Lookout Point Reservoirs, and slightly increased at Hills Creek Reservoir with drawdowns to the regulating outlet.

Releases of hatchery rainbow trout and kokanee would help maintain sport fishing opportunities where these fish are stocked. However, there were no fish stocked into Cougar Reservoir at the time the alternatives were analyzed. Therefore, effects on stocked gamefish under Alternative 3B would be the same as those described under the NAA.

Riverine Habitat in All Subbasins

Downstream habitat improvements under Alternative 3B would slightly decrease adverse effects on spawning habitat availability and associated incubation success and rearing and migrating opportunities for resident fish compared to the NAA.

Compared to the NAA, there would be an increase in adverse effects from dam operations on resident fish habitat downstream of Cougar Dam in the McKenzie River Subbasin, Foster Dam in the South Santiam River Subbasin, below Dexter Dam in the Middle Fork Willamette River Subbasin, and in the Mainstem Willamette River. Deep reservoir drawdowns in spring would decrease stored water volumes in these reaches, reducing the availability of water to augment summer low flows and habitat for resident fish.

Effects of discharged water temperatures on resident fish from WVS dams would be similar to the NAA. However, effects would be slightly more adverse below WVS dams in the North Santiam River, South Santiam River, and Middle Fork Willamette River Subbasins due to changes in the number of days temperature targets are met. Adverse effects from TDG on resident fish would increase compared to the NAA due to increases in the number of days above TDG thresholds in the North Santiam River, South Santiam River, and Middle Fork Willamette River Subbasins (Section 3.5.2.1, Water Quality, Methodology Subsection, Table 3.5-10 through Table 3.5-12).

Combined spring and fall drawdowns at Cougar Reservoir in the McKenzie River Subbasin, Green Peter Reservoir in the South Santiam River Subbasin, and Hills Creek Reservoir in the Middle Fork Willamette River Subbasin would reduce water storage for summer flow supplementation downstream annually under Alternative 3B. This would reduce spawning habitat availability below WVS dams in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins and in the Mainstem Willamette River compared to the NAA. This would result in slight to moderate, adverse effects on resident fish under Alternative 3B as compared to the NAA.

Conversely, a deep reservoir drawdown in fall at Detroit, Blue River, and Lookout Point Reservoirs under Alternative 3B would increase seasonal flows below WVS dams in the North Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins and in the Mainstem Willamette River. This would increase incubation habitat available in these subbasins below WVS dams as compared to the NAA. This would result in a slight reduction in adverse effects on some resident fish species and life stages under Alternative 3B as compared to the NAA.

Effects on resident fish from short-term, increased sediment discharge rates from Detroit, Green Peter, Cougar, Hills Creek, and Lookout Point Reservoirs under Alternative 3B would be the same as described for Green Peter Reservoir under Alternative 2A. Effects of elevated turbidity on resident fish below Blue River Dam would be the same as described under Alternative 3A.

Dam Passage Conditions in All Subbasins

Under Alternative 3B, twice annual deep drawdowns of Green Peter, Cougar, and Hills Creek Reservoirs and fall deep drawdowns at Detroit, Blue River, Lookout Point, and Fall Creek Reservoirs would increase passage and entrainment rates of resident fish downstream from reservoirs, with slight to moderate improvements in passage survival as compared to the NAA. Entrainment rates would be highest at Blue River and Fall Creek Dams with drawdowns to streambed, high at Cougar dam with drawdowns to 25 feet over the diversion tunnel, moderate at Green Peter and Lookout Point Dams, and slightly increased at Hills Creek Dams with drawdowns to the regulating outlet. There would be a moderate to high adverse effect on the abundance of resident fish species within WVS reservoirs that depend on lake-like conditions compared to the NAA in these reservoirs.

As under the NAA, adult fish facilities operated under Alternative 3B would allow passage of resident fish upstream of all WVS dams over the 30-year implementation timeframe. This includes increased opportunity for upstream fish passage at the adult fish facility structures at Hills Creek, Green Peter, and Blue River Dams. This would moderately improve conditions for resident fish in the South Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins.

Alternative 4—Improve Fish Passage with Structures-based Approach

Alternative 4 operations include construction and operation of fish passage improvements, TDG structures, selective water withdrawal structures, and operational modifications that would cause differences to some fish habitats compared to the NAA. These include habitat access between upper and lower watersheds; dam passage conditions; and susceptibility to predation, competition, and disease.

Common effects analyses from hatcheries on habitat and from passage conditions across all fish species are discussed first, followed by analysis of effects specific to each fish species or population. Note the common effects described in this section are not repeated in the species-specific analyses but are assumed to apply to species effects unless stated otherwise.

Hatchery Mitigation in All Subbasins

Under Alternative 4, the Willamette Hatchery Mitigation Program and associated effects would be the same as described under the NAA with the following exceptions:

- There would be adjustments to the number of hatchery-origin UWR Chinook salmon released upstream of some reservoirs.
- There would be a reduction in adverse impacts on UWR steelhead in the North Santiam River and South Santiam River Subbasins from hatchery-origin summer-run steelhead spawning in streams.

- There would be a reduction in adverse impacts on UWR Chinook salmon from hatchery-origin spring-run Chinook salmon spawners.
- There would be risks to bull trout from the rainbow trout hatchery program.

Average pHOS in all subbasins would decrease from 0.69 under the NAA to 0.24 under Alternative 4, although there would be some variability between subbasins. This substantial reduction in adverse effects of pHOS would result from improved fish passage conditions, subsequent increases in natural-origin adult Chinook salmon, and commensurate decreases in pHOS in these subbasins as compared to NAA operations.

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 4, effects of reservoir operations on fish would be the same as those described under the NAA. Differences in water surface elevations and fluctuations may occur at the local level and in the short term compared to the NAA, depending on specific annual or seasonal climate conditions and specific dam operations. However, overall effects on fish species from water surface elevations resulting from operations would be the same as under NAA operations.

Riverine Habitat in All Subbasins

Under Alternative 4, effects of dam operations and bank protection structures would be similar to those described under the NAA and Alternative 1. However, there would be differences in flow-related habitat effects from minimum flow targets and in water quality in the South Santiam River Subbasin from operations at Green Peter Dam.

Water temperature control towers in the North Santiam River Subbasin and Middle Fork Willamette River Subbasin under Alternative 4 would increase the number of days temperature targets are met, providing minor to moderate, indirect benefits to fish habitat conditions below WVS dams in these subbasins.

Unlike NAA operations, gravel placement below dams would decrease adverse effects of blocked sediment transport from the above dam watersheds. As a result, effects on fish in riverine habitat below WVS dams from these operations would trend toward less adverse under Alternative 4 as compared to the NAA.

Flow

Compared to the NAA, river flows under Alternative 4 would be lower in spring and higher in summer and early fall due to differences in minimum flow targets. Indirect effects of Alternative 4 on fish from flows would be the same as described under Alternative 1 but would vary depending on species and life stage.

Stranding Risk

Under Alternative 4, established down-ramping rates and hydropower-peaking operations would be similar to those described under the NAA. Therefore, stranding risks to fish below WVS dams would be the same as described under the NAA.

Materials Transport and Habitat Complexity

Effects under Alternative 4 on habitat complexity and food production from reduced transport of materials below dams would be the same as described under Alternative 1.

Water Temperature

Under Alternative 4, adverse effects on water quality from temperature conditions in the North Santiam River Subbasin and South Santiam River Subbasin would be the same as described under the NAA. However, these effects would trend toward a beneficial effect on water temperature because temperature targets would be met more often during an average year under Alternative 4 as compared to the NAA due to operation of water temperature control towers at Detroit, Hills Creek, and Lookout Point Dams, use of the spillway and regulating outlets at Green Peter Dam, and operation of a warm-water supply pipe at the Foster Adult Fish Facility fish ladder (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 4). Consequently, indirect effects to fish in river reaches below WVS dams and to fish held in or released below hatcheries or adult fish facilities below WVS dams would be slightly to moderately less adverse compared to the NAA.

Under Alternative 4, effects on water quality from temperature conditions in the South Santiam River Subbasin would trend toward a beneficial effect on water temperatures below Green Peter Dam and slight adverse effects below Foster Dam at certain times of year. Temperature targets would be met slightly more often under Alternative 4 and result in slightly less adverse effects as compared to the NAA (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 4). Conversely, moderately beneficial effects for water temperatures in the Foster Adult Fish Facility fish ladder would occur with operation of a warm-water supply pipe that would increase the entrance and collection rate of upstream migrating adult Chinook salmon at adult fish facilities below these dams.

Indirect effects to fish in river reaches below WVS dams and to fish held in or released below hatcheries or adult fish facilities below WVS dams in the North Santiam River Subbasin and South Santiam River Subbasin would be slightly to moderately beneficial under Alternative 4 as compared to the NAA because of reduced temperature-related stress.

Under Alternative 4, effects on water quality from temperature conditions in the McKenzie River, Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins would be similar to effects described under the NAA. Operations would result in continued adverse effects on water temperature during times of the year when temperature targets are not met (Section 3.5, Water Quality, Subsection 3.5.3.2, Alternatives Analyses, Alternative 4). Indirect effects to fish in river reaches below WVS dams and to fish held in or released below hatcheries or adult fish facilities below WVS dams would be similar to the NAA.

Total Dissolved Gas

As under the NAA, there would be an adverse effect on water quality from TDG under Alternative 4. Operations, including TDG reduction measures and construction of a selective withdrawal structure at Detroit Dam, would result in reduced adverse effects to water quality from TDG impacts in the North Santiam River Subbasin as compared to the NAA.

Under Alternative 4, the number of days of TDG exceedance of the water quality standard below and downstream of Foster Dam in the South Santiam River Subbasin would have a slightly less adverse effect as compared to the NAA. However, the number of days of TDG exceedance would have a moderately more adverse effect below and downstream of Green Peter Dam as compared to the NAA. This would occur because of use of the spillway in the summer for temperature management instead of a selective withdrawal structure at Green Peter Dam. However, there would be structural improvements to reduce TDG at Green Peter and Foster Dams under Alternative 4. While there would be a trend toward a beneficial effect in the South Santiam River Subbasin as compared to the NAA, there would be an adverse effect to water quality because of days when TDG would remain above 110 percent in this subbasin.

Adverse effects on water quality from TDG when TDG standards are not met would continue under Alternative 4 in the McKenzie River Subbasin as under NAA. TDG levels would be above 110 percent TDG exceedance of the water quality standard under Alternative 4, but the average number of days annually above 110 percent would be fewer as compared to the NAA. There would be a moderately less adverse effect as compared to the NAA due to the structural improvement measure to reduce TDG levels.

Under Alternative 4, effects on water quality from TDG in the Middle Fork Willamette River Subbasin would be the same as those described under Alternative 1. There may be differences in the number of days of TDG levels meeting targets; however, this would not alter the overall adverse effect on water quality from TDG in this subbasin.

Under Alternative 4, effects on water quality from TDG in the Coast Fork Willamette River and Long Tom River Subbasins would be the same as described under the NAA. There may be differences in the number of days where water temperature standards would be met; however, this would not alter the overall adverse effect on water quality from TDG.

Under Alternative 4, effects on water quality from TDG in the Mainstem Willamette River would be the same as described under the NAA. TDG is presumed not to be adverse because there are no dam operations on the Mainstem Willamette River.

Adverse effects to fish from gas bubble trauma and other impacts related to TDG under Alternative 4 would occur in all subbasins. Indirect, adverse effects to fish would be similar to those described under Alternative 1 in the North Santiam River, South Santiam River, McKenzie

River, and the Middle Fork Willamette River Subbasins. Indirect effects to fish in the Coast Fork Willamette River Subbasin, Long Tom River Subbasin, and the Mainstem Willamette River would also be similar to those described under the NAA.

Turbidity

Under Alternative 4, effects on water quality from turbidity would be the same as those described under the NAA in all subbasins and in the Mainstem Willamette River. Subsequent, indirect effects on fish would also be the same as described under the NAA.

Other Riverine Habitat Conditions in All Subbasins

Under Alternative 4, direct and indirect adverse effects of resident fish species entrained downstream from reservoirs during fall drawdowns would be the same as those described under the NAA. Downstream habitat competition and predation for fish present downstream would continue as described under the NAA. Operations would also continue to create localized conditions favoring fish that prefer rocky, steeply sloped shorelines with limited riparian vegetation, as described under the NAA.

Dam Passage Conditions in All Subbasins

Upstream Passage

Under Alternative 4, effects on upstream migrating fish would be the same as described under the NAA at dams with existing upstream passage facilities. However, additional upstream habitat access would be provided with construction of an adult fish facility at Hills Creek Dam. This facility would include integrated Pacific lamprey features, upstream passage at drop structures on the Long Tom River, and a warm-water supply pipe constructed at Foster Adult Fish Facility to improve attraction of migrating fish into the fish ladder (particularly adult spring Chinook salmon). Operations of these features would reduce adverse impacts for upstream migrating fish, providing access to additional habitat above dams in the South Santiam River Subbasin, Middle Fork Willamette River Subbasin, and the Long Tom River Subbasin, which would not occur under NAA operations. Under all alternatives, Federal and state fish management agencies would continue to determine the species and life stages that are to be transported for upstream passage.

Downstream Passage

Under Alternative 4, downstream passage would be provided by floating surface collectors operated in forebays at Detroit, Cougar, Hills Creek, and Lookout Point Dams and by construction of a surface flow outlet at Foster Dam. Effects of these new structures would be the same as described under Alternative 1.

There would be no downstream fish passage at Green Peter Dam. Consequently, passage effects would be the same as described under the NAA.

Upper Willamette River Chinook Salmon and Steelhead

Effects from reservoir habitat, riverine habitat, and fish passage conditions would result in direct, moderate to substantial adverse effects on UWR Chinook salmon and UWR steelhead under Alternative 4 as compared to the NAA.

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 4, effects of operations on in-reservoir conditions for fish would be the same as described under the NAA. There would be slight differences in the timing and refill volumes due to operations to meet minimum flow targets under Alternative 4 in comparison to the NAA. However, these Alternative 4 operations are expected to have negligible, adverse effects on in-reservoir habitat conditions as compared to the NAA.

Riverine Habitat in All Subbasins

Under Alternative 4, effects of dam operations and bank protection structures would be similar to those described under the NAA and Alternative 1. However, there would be differences in flow-related habitat effects from minimum flow targets and in water quality in the South Santiam River Subbasin from operations at Green Peter Dam.

The following are estimates of UWR Chinook salmon spawning habitat availability and spawning and incubation success in reaches downstream of dams under Alternative 4, based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 27 percent to 100 percent of the spawning period, depending on the river reach (Appendix E, Fish and Aquatic Habitat Analyses). This represents an increase compared to the NAA. Estimated include a slight increase in the North Santiam River and South Santiam River Subbasins, with a moderate decrease in the Middle Fork Willamette River, and negligible differences in the McKenzie River Subbasin when compared to the NAA.
- 2,938 (range 13 to 7,457) average number of redds surviving until swim-up (Appendix E, Fish and Aquatic Habitat Analyses), which would be a slight increase compared to the NAA.

The following are estimates of UWR steelhead spawning habitat availability and the number of age-1 and smolts in reaches downstream of dams under Alternative 4 based on modeled flow and water temperature management during dry years (Peterson 2022):

- Above the 90 percent maximum weighted usable area spawning flow levels for 100 percent of the spawning period, which would be a negligible difference compared to the NAA (Appendix E, Fish and Aquatic Habitat Analyses).

- Average number of age-1 UWR steelhead estimated at 208,808 and 160,419 and steelhead smolts estimated at 88.1 and 86.8 in reaches downstream of WVS dams in the North Santiam River and South Santiam River Subbasins, respectively, which are slight increases compared to the NAA (Appendix E, Fish and Aquatic Habitat Analyses).

Dam Passage Conditions in All Subbasins

Effects of upstream passage on UWR Chinook salmon and UWR steelhead under Alternative 4 would be the same as described under Alternative 1. However, passage would be provided at Hills Creek Dam and no passage would be provided at Green Peter Dam under Alternative 4, as under the NAA.

Under Alternative 4, downstream dam passage improvements would provide moderate to substantial increases in downstream passage rates and survival (Table 3.8-24) (Appendix E, Fish and Aquatic Habitat Analyses), habitat access, and genetic exchange opportunities compared to the NAA for UWR Chinook salmon and UWR steelhead.

Table 3.8-24. Average, Minimum, and Maximum Juvenile UWR Chinook Salmon and Juvenile UWR Steelhead Downstream Dam Passage Survival Estimates under Alternative 4.

Species and Dam	Average Survival Estimate (%)	Minimum Survival Estimate (%)	Maximum Survival Estimate (%)
Chinook Salmon			
Cougar	81	80	83
Detroit	76	76	77
Foster	65	64	67
Green Peter	N/A	N/A	N/A
Hills Creek	70	65	75
Lookout Point	93	92	94
Steelhead			
Detroit	89	86	90
Foster	67	64	69
Green Peter	N/A	N/A	N/A

Source: Fish Benefits Workbook model survival estimates from simulated operations for years 1947 to 2019; Appendix E, Fish and Aquatic Habitat Analyses, Chapter 2, Fish Benefits Workbook Results.

N/A = Not Applicable.

Population Performance in All Subbasins

Population performance of UWR Chinook salmon upstream of WVS dams in the analysis area would be good with very low extinction risk in the North Santiam River and McKenzie River Subbasins, and performance would be poor with high extinction risk in the South Santiam River and Middle Fork Willamette River Subbasins. These results represent substantial reductions in adverse effects in the North Santiam River and McKenzie River Subbasins, and slight reductions in adverse effects in the South Santiam River and Middle Fork Willamette River Subbasins compared to the NAA (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a, 2022b; McAllister et al. 2023):

- Natural-origin spawner abundance for upstream-of-dam local populations under Alternative 4 is estimated to be very high in the North Santiam River Subbasin (12,720 adults) and low in the South Santiam River, Middle Fork Willamette River, and McKenzie River Subbasins (57,560 and 582 adults, respectively), which represent slight to substantial increases from the NAA.
- Initial population productivity in years 6 to 10 is estimated to be above replacement (recruits/spawner greater than 1) for all four UWR Chinook salmon local populations upstream of WVS dams. In the Middle Fork Willamette River Subbasin, estimated productivity is attributed to very high pHOS (77 percent), which does not reflect naturally sustainable populations and is a moderate decrease compared to the NAA. The estimated pHOS in the McKenzie River Subbasin is low (20 percent) and is extremely low in the South Santiam River and North Santiam River Subbasins (0 percent), which represent substantial decreases compared to the NAA. Over the 30-year implementation timeframe, populations would be below replacement levels except above Detroit Dam in the North Santiam River Subbasin and above Foster and Green Peter Dams in the South Santiam River Subbasins.
- The probability of individual UWR Chinook salmon local populations upstream of WVS dams going below extinction risk abundance levels is estimated to be extremely low in the North Santiam River and McKenzie River Subbasins (0 percent) and extremely high in the Middle Fork Willamette River and South Santiam River Subbasins (65 and 96 percent, respectively). These estimates represent a substantial decrease in extinction risk compared to the NAA in the McKenzie River Subbasin, moderate reduction in the Middle Fork Willamette River Subbasin, and no to negligible differences compared to the NAA in the North Santiam River and South Santiam River Subbasins.

Population performance of UWR steelhead upstream of dams in the analysis area is estimated to be fair with moderate to high extinction risk, which is a slight to substantial decrease in adverse effects compared to the NAA (Table 3.8-13 through Table 3.8-18) (McAllister et al. 2022a, 2022b; McAllister et al. 2023):

- Natural-origin spawner abundance upstream-of-dam UWR steelhead local populations is estimated to be low in the South Santiam River and North Santiam River Subbasins (159 and 818 adults, respectively) under Alternative 4, which represents a substantial increase in both subbasins compared to the NAA.
- Productivity is estimated to be above replacement (recruits/spawner greater than 1) for both UWR steelhead local populations upstream of WVS dams in the analysis area, representing substantial increases compared to the NAA.

- The probability of individual UWR steelhead local populations upstream of WVS dams going below extinction risk abundance levels is estimated to be moderate to high upstream of Detroit and Foster Dams (37 and 81 percent, respectively), which represents moderate to substantial decreases compared to the NAA. As under NAA operations, no local population would be established upstream of Green Peter Dam under Alternative 4.

Bull Trout in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Effects on bull trout reservoir habitat conditions under Alternative 4 would be the same as those described under the NAA.

Riverine Habitat in All Subbasins

Effects on riverine habitat under Alternative 4 would be similar to those described under the NAA. However, improvements in riverine habitat and fish passage under Alternative 4 would have long-term, slight beneficial effects on local bull trout populations.

Dam Passage Conditions in All Subbasins

Under Alternative 4, upstream and downstream passage conditions for bull trout would be the same as described under Alternative 2B.

Pacific Lamprey in the Upper Willamette River Basin

Reservoir/Lake-like Habitat in All Subbasins

Effects from reservoir operations under Alternative 4 on Pacific lamprey would be the same as those described under the NAA.

Riverine Habitat in All Subbasins

Effects from dam operations and habitat improvements downstream of WVS dams on lamprey habitat conditions would be similar to those described under Alternative 1. However, augmentation of summer flows would occur more often under Alternative 4 than under Alternative 1 in spring and summer, resulting in similar effects on Pacific lamprey as described under the NAA.

Resident Fish in All Subbasins

Reservoir/Lake-like Habitat in All Subbasins

Under Alternative 4, effects of operations on habitat conditions within reservoirs used by resident fish species would be the same as those described under the NAA. There would be slight differences in the timing and refill volumes due to modifications to operations to meet minimum flow targets under Alternative 4 operations in comparison the NAA. However, these are expected to have negligible, adverse effects on in-reservoir habitat conditions.

Riverine Habitat in All Subbasins

Downstream habitat improvements under Alternative 4 would slightly decrease adverse effects on spawning habitat availability and associated incubation success and rearing and migrating opportunities for resident fish compared to the NAA.

Adverse effects on resident fish from dam operations would be reduced under Alternative 4 as compared to the NAA. These benefits would be mostly realized in dry years, with improved habitat availability resulting from increases in summer and fall base flows, and improved water temperatures resulting from temperature control structures. Other habitat conditions downstream of dams would be the same as described under the NAA.

Dam Passage Conditions in All Subbasins

Under Alternative 4, effects on resident fish from upstream passage at dams would be the same as described under the NAA at dams with existing upstream passage facilities. However, additional upstream habitat access would be provided with construction of an adult fish facility at Hills Creek Dam, upstream passage at drop structures on the Long Tom River, and a warm-water supply pipe constructed at Foster Adult Fish Facility to improve attraction of fish into the fish ladder. Operations of these features would reduce adverse impacts on resident fish, providing access to additional habitat above dams in the South Santiam River Subbasin, Middle Fork Willamette River Subbasin, and the Long Tom River Subbasin, which would not occur under NAA operations.

Under Alternative 4, downstream passage would be provided by floating surface collectors operated in forebays at Detroit, Cougar, Hills Creek, and Lookout Point Dams and by construction of a surface flow outlet at Foster Dam. Effects of these new structures would be the same as described under Alternative 1.

As under the NAA, there would be no downstream fish passage at Green Peter Dam and passage effects would be the same as described under the NAA.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Under Alternative 5, effects to fish species, including threatened and endangered species, in the analysis area would be the same or similar as those described under Alternative 2B. Effects on habitat availability for fish would vary depending on river reach, species, life stage, and time of year.

3.8.4 Interim Operations under All Action Alternatives Except Alternative 1

The timing and duration of Interim Operations would vary depending on a given alternative. Interim operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations would be implemented in succession with, and not in addition to, action alternative implementation.

3.8.4.1 North Santiam River Subbasin

Interim Operations within the North Santiam River Subbasin include spring fish passage through strategic use of the spillway at Detroit Dam, fall/winter downstream fish passage through the upper regulating outlets with strategic use of the turbines, use of available dam outlets for temperature management, and spreading spill to reduce total dissolved gas at Big Cliff Dam.

Direct and indirect effects on fish and aquatic habitat would be similar to those as described under the NAA. There may be differences at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations; however, effects on fish in this subbasin would remain adverse.

Increased indirect effects would occur under Interim Operations from adverse water quality due to high TDG on fish in the reach below Detroit and Big Cliff Dams in the North Santiam River Subbasin. There may be differences at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations; however, effects on fish in this subbasin would remain adverse. Additionally, downstream fish passage conditions would be slightly less adverse than under the NAA due to increased operation of the regulating outlet and deeper drawdown of Detroit Reservoir under Interim Operations.

3.8.4.2 South Santiam River Subbasin

Interim Operations within the South Santiam Subbasin at Green Peter Dam would be the same as those described under Alternatives 2A, 2B, and 3A for Green Peter Dam and Reservoir operations, with use of the spillway in spring for temperature management and downstream fish passage, and a deep reservoir drawdown to 25 feet over the regulating outlets in fall. These operations provide slight to moderate reductions in adverse effects on fish passage at Green Peter Dam.

Upstream fish passage would be the same as described under the NAA. Therefore, direct and indirect effects on fish and aquatic habitat from operation of Green Peter Dam and Reservoir would be similar to those as described under the NAA and Alternatives 2A, 2B, and 3A.

At Foster Dam, Interim Operations would be similar to those described for Alternative 2A and Alternative 2B regarding effects from dam operations on reservoir and riverine habitat conditions. Specifically, effects of Green Peter Dam operations on downstream Foster Reservoir and Dam operations, and effects of Green Peter Dam operations on downstream flows and water quality. For fish passage conditions, Interim Operations would be the same as those described under the NAA. Therefore, direct and indirect effects on fish and aquatic habitat would be similar to those as described under the NAA, Alternative 2A, and Alternative 2B.

There may be differences at the local level and in the short term, depending on specific annual or seasonal climate conditions and specific dam operations; however, this would not alter the overall adverse effects of fish in this subbasin.

3.8.4.3 Long Tom River Subbasin

There are no local operations proposed under Interim Operations within the Long Tom River Subbasin. Therefore, direct and indirect effects on fish and aquatic habitat would be similar to those as described under the NAA.

3.8.4.4 McKenzie River Subbasin

Interim Operations within the McKenzie River Subbasin include drawdowns at Cougar Reservoir to target below minimum conservation elevation (1,532 feet) during the spring (1,505 feet) and fall (1,520 feet). Interim Operations within the McKenzie River Subbasin at Cougar Reservoir would be similar to those described under Alternative 3A. Therefore, direct and indirect effects on fish and aquatic habitat would be similar to those as described under Alternatives 3A.

3.8.4.5 Middle Fork Willamette River Subbasin

Interim Operations within the Middle Fork Willamette River Subbasin include prioritized use of the regulating outlet for downstream fish passage at Hills Creek Dam in fall, use of the spillway for fish passage at Lookout Point Dam in the spring, deep drawdown for fish passage at Lookout Point Dam in fall, and deep drawdown for fish passage in the fall at Fall Creek Dam. Storage at Hills Creek Dam would be used for refilling Lookout Point Dam in early March. The existing adult facility at Fall Creek Dam in combination with the operational downstream passage from a fall reservoir deep drawdown would support maintaining the re-established UWR Chinook salmon local population above Fall Creek Dam.

Interim Operations within the Middle Fork Willamette River Subbasin would be similar to those described under Alternative 3A. Therefore, direct and indirect effects on fish and aquatic habitat would be similar to those as described under Alternatives 3A.

3.8.4.6 Coast Fork Willamette River Subbasin

There are no local operations proposed under the Interim Operations within the Coast Fork Willamette River Subbasin. Therefore, direct and indirect effects on fish and aquatic habitat would be similar to those as described under the NAA.

3.8.4.7 Mainstem Willamette River

Flows and water temperatures would be similar to the NAA under Interim Operations; however, unlike NAA operations, deep drafting of Green Peter Reservoir in fall would slightly increase Mainstream Willamette River flows below the Santiam River confluence and increase turbidity during the fall. Direct and indirect effects on fish and aquatic habitat would be similar to those as described under the NAA.

3.8.4.8 Effects Common to All Subbasins and the Mainstem Willamette River

Habitat improvements below WVS dams, including gravel placement, would be completed as part of the Interim Operations. The placement of gravel in downstream reaches would increase habitat complexity and subsequently provide an increase in rearing and spawning habitat for fish below analysis area dams. This measure would result in similar effects on fish and aquatic habitat as described under Alternatives 1, 2A, 2B, 3A, 3B, and 4.

3.8.5 Climate Change Effects under All Alternatives

Climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions and independent of the WVS operations and maintenance activities over the 30-year implementation timeframe (Climate Impacts Group 2010; RMJOC 2020) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources: Section 3.1 Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

Overall, climate change is anticipated to result in continuing increases in water temperatures over time as ambient temperatures increase and snowmelt contributes less runoff or earlier runoff within the Willamette River Basin. Low-elevation areas are likely to be more affected. Overall, about one-third of the current cold-water fish habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (USGCRP 2009). The importance of UWR Chinook salmon access to high elevation habitat to reduce effects of climate change is supported by research from Crozier et al. 2019, Myers et al. 2018, and Fitzgerald et al. 2021.

Increased water temperatures and changes in streamflow patterns would decrease the quality of habitat for cold-water-adapted fish species in the analysis area (e.g., salmon, steelhead, bull trout, Pacific lamprey, resident fish, etc.). This is expected to result in adverse effects under warmer water conditions (e.g., increased pre-spawn mortality, accelerated embryo development, premature emergence of fry, increased risk of predation by warm-water tolerant fish species, etc.) and changes in streamflow patterns (e.g., flushing of eggs from redds, flushing of young fish downstream into less suitable habitat, including into estuaries for anadromous fish species before ready for saltwater conditions).

Conversely, warm-water, generally non-native, fish species (including several gamefish species), would benefit from warmer water temperatures; however, changes in streamflow patterns may have similar adverse effects. The seasonality of fish species' life histories would be forced to adapt to the changing climate patterns. This adaptation is anticipated to have a number of adverse effects to species, interactions between species, interactions with their habitats, and likely, overall survival of species that cannot adapt to changing streamflow timing and increasing water temperature. These adverse and beneficial effects, dependent on fish species and life stages, would occur under all alternatives during the 30-year implementation timeframe.

Additionally, anadromous fish are also susceptible to warming ocean conditions. Historically, the abundance of anadromous fish returning to fresh water have generally been higher during cooler ocean periods than during warmer periods (Zabel et al. 2006). Ocean conditions adverse to anadromous fish may be more likely under a warming climate over the 30-year implementation timeframe (Zabel et al. 2006).

Although quantitative modeling was not available at the time the alternatives were analyzed to assess effects to sensitive status species, a qualitative climate change vulnerability assessment framework for UWR Chinook salmon and UWR steelhead prepared by Crozier et al. (2019) was used to score vulnerability of UWR Chinook salmon under each alternative resulting from climate change effects (Appendix E, Fish and Aquatic Habitat Analyses). UWR Chinook salmon scores are considered representative for all cold-water-adapted, sensitive status fish species in the analysis area (e.g., UWR steelhead, bull trout, and Pacific lamprey).

The cumulative vulnerability of UWR Chinook salmon was rated as high to very high among all the alternatives (Table 3.8-25 and Table 3.8-26). These high and very high ratings reflect high vulnerability scores for ocean acidification, seas surface temperature, hydrologic regime, and cumulative life-cycle effects (Crozier et al. 2019), factors largely unaffected by WVS operations under the NAA or any of the action alternatives.

The NAA operations would result in the most vulnerability to climate change attributes adverse to UWR Chinook salmon, with the highest vulnerability score (Table 3.8-25 and Table 3.8-26).

Among the action alternatives, Alternative 2A and Alternative 4 have the lowest cumulative vulnerability scores (10.0), Alternative 2B has the next lowest score (12.0), followed by Alternative 1 (12.8). These alternatives include structural measures for downstream passage and temperature control. These structural measures allow for water storage operations used to augment low river flows in summer, and would permit operational flexibility compared to operational measures for fish passage and water temperatures.

Alternative 2B includes a drawdown of Cougar Reservoir to the diversion tunnel each spring and fall. Although water storage would be impacted by these operations, base flows below Cougar Dam in the Mainstem McKenzie River would remain stable due to natural flow contributions from other streams in the McKenzie River Subbasin and from groundwater inputs. As a result, Chinook salmon habitat access and migration would improve at Cougar Dam under Alternative 2B as compared to the NAA. Additionally, more natural water temperatures below Cougar Dam would occur.

Alternative 3A and Alternative 3B had the highest vulnerability scores (14.9). These scores reflect poor results for summer water deficit below dams, population viability, and hatchery influence attributes when compared to other alternatives. Reservoir drawdowns under Alternative 3A and Alternative 3B would reduce the availability of storage water to augment low flows in summer and water quality below WVS dams. There would be limited improvement in fish passage conditions at WVS dams under these alternatives, which would constrain UWR Chinook salmon population viability.

Table 3.8-25. Attribute Categorization Results for Assessment of Climate Vulnerability of Upper Willamette River Chinook Salmon.

Attribute	No-action[1]	Alternative 1	Alternative 2A	Alternatives 2B/5	Alternative 3A	Alternative 3B	Alternative 4
Exposure Attributes							
Ocean Acidification[1]	Very high	Very high	Very high	Very high	Very high	Very high	Very high
Stream Temperature	Very High	Moderate	Low	Low	Low	Low	Low
Sea Surface Temperature[1]	High	High	High	High	High	High	High
Hydrologic Regime[1]	High	High	High	High	High	High	High
Summer Water Deficit Upstream of Dams[1]	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Summer Water Deficit Downstream of Dams	Moderate	Moderate	Moderate	Moderate	High	High	Moderate
Sensitivity Attributes							
Adult Freshwater Stage	Very High	Moderate	Moderate	Moderate	High	High	Moderate
Cumulative Life-cycle Effects[1]	Very High	Very High	Very High	Very High	Very High	Very High	Very High
Population Viability	Very High	Moderate	Low	Moderate	High	High	Low
Hatchery Influence	Very High	Moderate	Low	Moderate	High	High	Low
Other Stressors	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Adaptive Capacity[1]	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

[1]Results under the NAA and attributes are adopted from Crozier et al. 2019.

Alternative 2B and Alternative 5 are composed of the same measures (only differing in minimum flow targets). Hydrologic modeling showed very little to no differences in resulting reservoir and downstream river flows. Consequently, these two alternatives were treated as equivalent for purposes of this analysis.

Table 3.8-26. Overall Vulnerability Results Based on Conversion of Assessment Categories to Numeric Scores.

Attribute	No-action Alternative[1]	Alternative 1	Alternative 2A	Alternatives 2B/5	Alternative 3A	Alternative 3B	Alternative 4
Exposure Attributes							
Ocean Acidification[1]	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Stream Temperature	4.0	2.0	1.0	1.0	1.0	1.0	1.0
Sea Surface Temperature[1]	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Hydrologic Regime[1]	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Summer Water Deficit Upstream of Dams[1]	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Summer Water Deficit Downstream of Dams	2.0	2.0	2.0	2.0	3.0	3.0	2.0
Exposure Attributes Average Scores	3.0	2.7	2.5	2.5	2.7	2.7	2.5
Sensitivity Attributes							
Adult Freshwater Stage	4.0	2.0	2.0	2.0	3.0	3.0	2.0
Cumulative Life-cycle Effects[1]	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Population Viability	4.0	2.0	1.0	2.0	3.0	3.0	1.0
Hatchery Influence	4.0	2.0	1.0	2.0	3.0	3.0	1.0
Other Stressors	3.0	2.0	2.0	2.0	2.0	2.0	2.0
Sensitivity Attributes Average Scores	**3.8**	**2.4**	**2.0**	**2.4**	**2.8**	2.4	2.4
Adaptive Capacity[1]	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Overall Vulnerability	22.8	12.8	10.0	12.0	16.0	16.0	10.0
	Very High	Very High	High	Very High	Very High	Very High	High

[1]Results from Crozier et al. (2019) are applied under the NAA. Results for attributes marked with footnote 1 are also from Crozier et al. (2019), assuming these attributes would not be changing under each alternative. Results were driven by better (lower) population viability and hatchery influence scores as compared to other alternatives.

Alternative 2B and Alternative 5 are composed of the same measures (only differing in minimum flow targets). Hydrologic modeling showed very little to no differences in resulting reservoir and downstream river flows. Consequently, these two alternatives were treated as equivalent for purposes of this analysis.

3.8.6 Summary of Effects on Fish and Aquatic Habitat

Table 3.8-27. Summary of Fish and Habitat Effects on Upper Willamette River Chinook Salmon as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Mitigation in All Subbasins	Adverse effects from domestication and genetic introgression, increased competition, disease transfer, increased exploitation of native fish, effects on downstream water quality from effluent. Beneficial effects for sport fishing and harvest opportunities, prey sources for other fish, and increased Chinook salmon spawner abundance.	Same as the No-action Alternative, but with reduced number of hatchery Chinook salmon released upstream; reduced proportion of hatchery origin spawners, and increased risks to bull trout from the rainbow trout hatchery program and sport fishing.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Reservoir/Lake-like Habitat	**North Santiam -** Moderate to substantial, adverse effects on juveniles from reservoir operations due to delayed migration, increased predation, and disease. Beneficial effects on juveniles from high growth rates. **South Santiam –** Same as North Santiam, except at Green Peter Reservoir where Chinook salmon would not occur. **McKenzie –** Same as North Santiam, except at Blue River Reservoir where Chinook salmon would not occur. **Middle Fork –** Same as North Santiam, except at Fall Creek Reservoir where adverse effects would be minor due to annual reservoir drawdowns to streambed. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as the No-action Alternative, but reduced adverse effects from Detroit Reservoir due to improved downstream passage reducing duration juveniles are in Detroit Reservoir. **South Santiam –** Same as North Santiam. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative, but reduced adverse effects from Lookout Point Reservoir due to improved downstream passage reducing duration juveniles are in the reservoir. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Foster Reservoir habitat. Increased adverse effects in Green Peter Reservoir during fall drawdowns. **McKenzie –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Cougar Reservoir. **Middle Fork –** Same as Alternative 1. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as 2A. **McKenzie –** Increased adverse effects within Cougar Reservoir during fall drawdowns. **Middle Fork –** Same as Alternative 1. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Moderate reductions in adverse effects from reservoir habitat due to improved downstream passage reducing duration juveniles are in reservoirs. **South Santiam –** Same as the No-action Alternative at Foster Reservoir. Same as Alternative 2A at Green Peter Reservoir. **McKenzie –** Similar to the No-action Alternative. **Middle Fork –** Same as the No-action Alternative at Fall Creek and Hills Creek Reservoirs. Moderate reductions in adverse effects to from Lookout Point Reservoir due to improved downstream reducing duration juveniles are in the reservoir. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Increased adverse effects within Detroit Reservoir during fall drawdowns. **South Santiam –** Same as the No-action Alternative at Foster Reservoir. Moderate reductions in adverse effects from Green Peter Reservoir due to improved downstream passage reducing duration juveniles are in the reservoir. **McKenzie –** Same as Alternative 2B. **Middle Fork –** Same as the No-action Alternative at Fall Creek and Hills Creek Reservoirs. Increased adverse effects within Lookout Point Reservoir during fall drawdowns. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as the No-action Alternative, but improved downstream passage reducing adverse effects from Foster Reservoir. **McKenzie –** Same as Alternative 1. **Middle Fork –** Same as the No-action Alternative, but improved downstream passage reducing adverse effects from Lookout Point and Hills Creek Reservoirs. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Cougar Reservoir. **Middle Fork –** Same as Alternative 3B. **Coast Fork –** N/A **Long Tom –** N/A

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Riverine Habitat	**North Santiam –** Substantial, adverse effects in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Beneficial effects from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons. Adverse effects from TDG below dams. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to the No-action Alternative with slight to moderate improvements during low flow seasons from flow augmentation from minimum flow targets. Moderate increased improvements from temperature management and reduced TDG. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**North Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **South Santiam –** Similar to North Santiam with increased adverse effects on water quality below dams due to Green Peter Reservoir drawdown in fall. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but with slight to moderate reductions in habitat due to lower stream flows in summer, slight increased benefits from water temperatures, and increased adverse effects (moderate in first few years, slight in later years) from turbidity below Cougar Dam. **Middle Fork –** Same as Alternative 2A. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A, but with increased adverse effects on water quality and habitat availability below dams due to Detroit Reservoir drawdown in spring and fall. **South Santiam –** Same as Alternative 2A. **McKenzie –** Similar to the No-action Alternative below Cougar Dam with slight reductions in habitat availability. Increased adverse effects on water quality due to Blue River Reservoir drawdown in fall. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Lookout Point Reservoir drawdown in spring and fall. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A in spring and summer. Increased adverse effects from water quality in fall below dams due to Detroit Reservoir drawdown. **South Santiam –** Increased adverse effects on water quality and habitat availability below dams due to Green Peter Reservoir drawdown in spring and fall. **McKenzie –** Same as Alternative 3B. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Hills Creek Reservoir drawdown in spring and fall and Lookout Point Reservoir drawdown in fall. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**Interim Operations** **North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but reduced adverse effects from reservoir habitat due to improved downstream passage reducing duration juveniles are in Cougar Reservoir. **Middle Fork –** Same as Alternative 3B. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.
Dam Passage Conditions	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor downstream passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as North Santiam from upstream passage effects. Moderate, adverse effects due to poor passage conditions at Foster Dam.	**North Santiam –** Slight, adverse effects from upstream and downstream passage at Detroit and Big Cliff Dams. **South Santiam –** Slight, adverse effects from upstream, and downstream passage at Green Peter Dam. Negligible to slight, adverse effects at Foster Dam. **McKenzie –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream passage at Foster and Green Peter Dams. Slight, adverse effects at Foster Dam from downstream passage. Moderate, adverse effects at Green Peter Dam from downstream passage.	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as Alternative 2A. **McKenzie –** Slight, adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam. **Middle Fork –** Same as Alternative 2A at Dexter and Lookout Point Dams. Same as the No-action Alternative at Fall Creek and Hills Creek Dams.	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above Detroit and Big Cliff Dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as Alternative 2A at Green Peter Dam. Same as the No-action Alternative at Foster Dam.	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as Alternative 2A at Green Peter Dam. Same as the No-action Alternative at Foster Dam.	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream and downstream passage at Foster Dam Same as the No-action Alternative at Green Peter Dam. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A at Fall Creek, Lookout Point, Dexter, and Hills Creek Dams. **Coast Fork –** N/A **Long Tom –** N/A	**Interim Operations** **North Santiam –** Same as Alternative 3A. **South Santiam –** Same as Alternative 3A. **McKenzie –** Same as the No-action Alternative with slight trend toward beneficial effects from downstream passage due to regulating outlet improvements. **Middle Fork –** Same as the No-action Alternative from upstream passage. Same as Alternative 3A from downstream passage.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
	McKenzie - Same as North Santiam from upstream and downstream passage at Cougar Dam. **Middle Fork –** Slight, adverse effects from collection and upstream transport of adults above Dexter and Lookout Point Dams. Moderate, adverse effects above Hills Creek Dam due to transport distance from Dexter Adult Fish Facility. Slight to moderate, adverse effects from upstream and downstream passage at Fall Creek Dam. **Coast Fork –** N/A **Long Tom –** N/A	**Middle Fork –** Slight, adverse effects from upstream and downstream passage at Fall Creek, Dexter, and Lookout Point Dams. Same as the No-action Alternative at Fall Creek and Hills Creek Dams. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**McKenzie –** Slight, adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam. **Middle Fork –**Slight, adverse effects from upstream passage above dams. Slight, adverse effects from downstream passage at Dexter and Lookout Point Dams. Same as the No-action Alternative from downstream passage at Hills Creek and Fall Creek Dams. **Coast Fork –** N/A **Long Tom –** N/A	**Coast Fork –** N/A **Long Tom –** N/A	**McKenzie –** Similar to the No-action Alternative at Cougar Dam, but adverse effects trending toward beneficial. slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Slight, adverse effects from upstream passage above dams. Slight, adverse effects from downstream passage at Fall Creek, Dexter, Lookout Point, and Hills Creek Dams. **Coast Fork –** N/A **Long Tom –** N/A	**McKenzie –** Same as Alternative 2B at Cougar Dam. Slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** N/A **Long Tom –** N/A		**Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.
Population Performance	**North Santiam –** Substantial, adverse effects. **South Santiam –** Moderate to substantial, adverse effects. **McKenzie –** Substantial, adverse effects. **Middle Fork –** Substantial, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Slight, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** Substantial, adverse effects. **Middle Fork –** Moderate to substantial, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Sight, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** Slight, adverse effects. **Middle Fork –** Moderate, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Slight, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** Moderate, adverse effects. **Middle Fork –** Moderate, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Moderate, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** Moderate, adverse effects. **Middle Fork –** Moderate to substantial, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Moderate, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** Moderate, adverse effects. **Middle Fork –** Moderate to substantial, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Slight, adverse effects. **South Santiam –** Moderate to substantial, adverse effects. **McKenzie –** Slight, adverse effects. **Middle Fork –** Moderate, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**Interim Operations** Same as Alternative 3A. **Long-term Operations** Same as Alternative 2B.

N/A = Not Applicable. There are no UWR Chinook salmon populations above dams in these subbasins.

North Santiam = North Fork Santiam River Subbasin, South Santiam = South Fork Santiam River Subbasin, McKenzie = McKenzie River Subbasin, Middle Fork = Middle Fork Willamette River Subbasin, Coast Fork = Coast Fork Willamette River Subbasin, Long Tom = Long Tom River Subbasin

[1] All effects would occur or reoccur over the 30-year implementation timeframe.

Table 3.8-28. Summary of Fish and Habitat Effects on Upper Willamette River Steelhead as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Mitigation in All Subbasins	Adverse effects from domestication and genetic introgression, increased competition, disease transfer, increased exploitation of native fish, effects on downstream water quality from effluent. Beneficial effects for sport fishing and harvest opportunities, prey sources for other fish, and increased steelhead spawner abundance.	Same as the No-action Alternative, but with adverse effects trending toward beneficial due to increased abundance of UWR steelhead.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Reservoir/Lake-like Habitat	**North Santiam -** Moderate to substantial, adverse effects on juveniles from reservoir operations due to delayed migration, increased predation, and disease. Beneficial effects on juveniles from high growth rates. **South Santiam –** Same as North Santiam, except at Green Peter Reservoir where UWR steelhead would not occur. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Detroit Reservoir. **South Santiam –** Same as North Santiam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Foster Reservoir. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as Alternative 2A. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Moderate reductions in adverse effects due to improved downstream passage reducing duration juveniles in reservoirs. **South Santiam –** Same as the No-action Alternative at Foster Reservoir. Same as Alternative 2A at Green Peter Reservoir. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Increased adverse effects within Detroit Reservoir during fall drawdowns. **South Santiam –** Same as the No-action Alternative at Foster Reservoir. Moderate reductions in adverse effects due to improved downstream passage reducing duration juveniles are in Green Peter Reservoir. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as the No-action Alternative, but improved downstream passage reducing adverse effects from Foster Reservoir. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** N/A **Middle Fork –** Same as Alternative 3B. **Coast Fork –** N/A **Long Tom –** N/A

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Riverine Habitat	**North Santiam –** Substantial, adverse effects in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Beneficial effects from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons. Adverse effects from TDG below dams. **South Santiam –** Same as the North Santiam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to the No-action Alternative with slight to moderate benefits during low flow seasons from flow augmentation due to change in minimum flow targets, moderate increased benefits from temperature management, and reduced TDG. **South Santiam –** Same as the North Santiam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. South Santiam – Similar to North Santiam with increased adverse effects on water quality below dams due to Green Peter Reservoir drawdown in fall. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Same as Alternative 2A. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A, but with increased adverse effects on water quality and habitat availability below dams due to Detroit Reservoir drawdown in spring and fall. **South Santiam –** Same as Alternative 2A. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A in spring and summer. Increased adverse effects from water quality in fall below dams due to Detroit Reservoir drawdown. **South Santiam –** Increased adverse effects on water quality and habitat availability below dams due to Green Peter Reservoir drawdown in spring and fall. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**Interim Operations** **North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but reduced adverse effects from reservoir habitat due to improved downstream passage reducing duration juveniles are in Cougar Reservoir. **Middle Fork –** Same as Alternative 3B. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.
Dam Passage Conditions	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor downstream passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Moderate, adverse effects due to poor passage conditions at Foster Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Slight, adverse effects from upstream and downstream passage at Detroit and Big Cliff Dams. **South Santiam –** Slight, adverse effects from upstream and downstream passage at Green Peter Dam. Negligible to slight adverse effects at Foster Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream passage at Foster and Green Peter Dams. Slight, adverse effects at Foster Dam from upstream passage. Moderate, adverse effects from downstream passage at Green Peter Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1 **South Santiam –** Same as Alternative 2A **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above Detroit and Big Cliff Dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as Alternative 2A at Green Peter Dam Same as the No-action Alternative at Foster Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as Alternative 2A at Green Peter Dam. Same as the No-action Alternative at Foster Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream and downstream passage at Foster Dam. Same as the No-action Alternative at Green Peter Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**Interim Operations** **North Santiam –** Same as Alternative 3A. **South Santiam –** Same as Alternative 3A. **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative from upstream passage. Same as Alternative 3A from downstream passage. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Population Performance	**North Santiam –** Substantial, adverse effects. **South Santiam –** Moderate to substantial, adverse effects. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Slight, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as Alternative 1. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as Alternative 1. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Moderate, adverse effects. **South Santiam –** Same as Alternative 1. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Moderate, adverse effects. **South Santiam –** Same as Alternative 1. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as the No-action Alternative. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**Interim Operations** Same as Alternative 3A. **Long-term Operations** Same as Alternative 2B.

N/A = Not Applicable. There are no steelhead populations in these subbasins.

North Santiam = North Fork Santiam River Subbasin, South Santiam = South Fork Santiam River Subbasin, McKenzie = McKenzie River Subbasin, Middle Fork = Middle Fork Willamette River Subbasin, Coast Fork = Coast Fork Willamette River Subbasin, Long Tom = Long Tom River Subbasin

[1] All effects would occur or reoccur over the 30-year implementation timeframe.

Table 3.8-29. Summary of Fish and Habitat Effects on Bull Trout as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Mitigation in All Subbasins	Adverse effects from sport fishing, habitat competition, and effects on downstream water quality from effluent. Beneficial effects from increased forage where hatchery trout releases overlap with bull trout distributions.	Same as the No-action Alternative, but with increased risks to bull trout from the rainbow trout hatchery program and sport fishing below dams due to improved passage conditions at dams in the North Santiam River Subbasin.	Same as the No-action Alternative, but with increased risks to bull trout from the rainbow trout hatchery program and sport fishing below dams due to improved passage conditions at dams in the North Santiam River and McKenzie River Subbasins.	Same as Alternative 2A.	Same as Alternative 1.	Same as Alternative 2A.	Same as the No-action Alternative, but with increased risks to bull trout from the rainbow trout hatchery program and sport fishing below dams due to improved passage conditions at dams in the North Santiam River and McKenzie River, and Middle Fork Willamette River Subbasins.	Same as Alternative 1.
Reservoir/Lake-like Habitat	**North Santiam -** Substantial, beneficial effects due to feeding and growth opportunities in reservoirs. **South Santiam –** N/A **McKenzie –** Substantial, beneficial effects due to feeding and growth opportunities in reservoirs.	**North Santiam –** Same as the No-action Alternative. **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as the No-action Alternative. **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as the No-action Alternative. **South Santiam –** N/A **McKenzie –** Substantial, adverse effects on habitat availability due to spring and fall reservoir drawdowns. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Moderate to substantial, adverse effects on habitat availability due to spring and fall reservoir drawdowns. **South Santiam –** N/A **McKenzie –** Similar to the No-action Alternative.	**North Santiam –** Moderate, adverse effects on habitat availability due to fall reservoir drawdowns. **South Santiam –** N/A **McKenzie –** Same as Alternative 2B. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as the No-action Alternative. **South Santiam –** N/A **McKenzie –** Same as Alternative 1. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 3A. **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** N/A **Long Tom –** N/A

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
	Middle Fork – Substantial, beneficial effects due to feeding and growth opportunities in reservoirs. **Coast Fork –** N/A **Long Tom –** N/A				**Middle Fork –** Moderate, adverse effects on habitat availability due to Hills Creek Reservoir drawdown in fall. **Coast Fork –** N/A **Long Tom –** N/A			
Riverine Habitat	**North Santiam –** Substantial, adverse effects in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Beneficial effects from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons. Adverse effects from TDG below dams. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to the No-action Alternative with slight to moderate benefits during low flow seasons from flow augmentation due to minimum flow targets, moderate increased benefits from temperature management, and reduced TDG. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**North Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **South Santiam –** Similar to North Santiam effects, but increased, adverse effects on water quality below dams due to Green Peter Reservoir drawdown in fall. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but with slight to moderate reductions in habitat due to lower stream flows in summer, slight increased benefits from water temperatures, and increased adverse effects from turbidity below Cougar Dam (moderate in first few years, slight in later years). **Middle Fork –** Same as Alternative 2A. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A, but with increased adverse effects on water quality and habitat availability below dams due to Detroit Reservoir drawdown in spring and fall. **South Santiam –** Same as Alternative 2A. **McKenzie –** Similar to the No-action Alternative below Cougar Dam with slight reductions in habitat availability. Increased adverse effects on water quality due to Blue River Reservoir drawdown in fall. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Lookout Point Reservoir drawdown in spring and fall. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A in spring and summer. Increased adverse effects from water quality in fall below dams due to Detroit Reservoir drawdown. **South Santiam –** Increased adverse effects on water quality and habitat availability below dams due to Green Peter Reservoir drawdown in spring and fall. **McKenzie –** Same as Alternative 3B. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Hills Creek Reservoir drawdown in spring and fall and Lookout Point Reservoir drawdown in fall. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**Interim Operations** **North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Cougar Reservoir. **Middle Fork –** Same as Alternative 3B. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.
Dam Passage Conditions	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** N/A	**North Santiam –** Slight, adverse effects from upstream and downstream passage at Detroit and Big Cliff Dams. **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 1. **South Santiam –** N/A **McKenzie –** Slight, adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam.	**North Santiam –** Same as Alternative 1. **South Santiam –** N/A **McKenzie –** Slight, adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam.	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above Detroit and Big Cliff Dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** N/A	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** N/A **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A at Fall Creek, Lookout Point, Dexter, and Hills Creek Dams. **Coast Fork –** N/A	**Interim Operations** **North Santiam –** Same as Alternative 3A. **South Santiam –** Same as Alternative 3A.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
	McKenzie – Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor passage conditions at Cougar Dam. **Middle Fork –** Slight, adverse effects from collection and upstream transport of adults above Dexter and Lookout Point Dams. Moderate to substantial, adverse effects from upstream passage conditions at Hills Creek Dam due to use of traps and angling for collection. Substantial, adverse effects due to poor downstream passage conditions at Hills Creek Dam. **Coast Fork –** N/A **Long Tom –** N/A	**Middle Fork –** Same as the No-action Alternative at Hills Creek Dam. Slight, adverse effects from upstream and downstream passage at Dexter and Lookout Point Dams. **Coast Fork –** N/A **Long Tom –** N/A	**Middle Fork –** Slight, adverse effects from upstream passage above dams. Same as the No-action Alternative from downstream passage at Hills Creek Dam. Slight, adverse effects from downstream passage at Dexter and Lookout Point Dams. **Coast Fork –** N/A **Long Tom –** N/A	**Middle Fork –** Same as Alternative 2A at Dexter and Lookout Point Dams. Same as the No-action Alternative at Hills Creek Dam. **Coast Fork –** N/A **Long Tom –** N/A	**McKenzie –** Similar to the No-action Alternative at Cougar Dam, but adverse effects trending toward more beneficial. Slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Slight, adverse effects from upstream passage above dams. Slight, adverse effects from downstream passage at Fall Creek, Dexter, Lookout Point, and Hills Creek Dams. **Coast Fork –** N/A **Long Tom –** N/A	**McKenzie –** Same as Alternative 2B at Cougar Dam. Slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** N/A **Long Tom –** N/A	**Long Tom –** N/A	**McKenzie –** Same as the No-action Alternative with slight trend toward beneficial effects from downstream passage due to regulating outlet improvements. **Middle Fork –** Same as the No-action Alternative from upstream passage. Same as Alternative 3A from downstream passage. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.

N/A = Not Applicable. Bull trout populations do not occur in these subbasins.

North Santiam = North Fork Santiam River Subbasin, South Santiam = South Fork Santiam River Subbasin, McKenzie = McKenzie River Subbasin, Middle Fork = Middle Fork Willamette River Subbasin, Coast Fork = Coast Fork Willamette River Subbasin, Long Tom = Long Tom River Subbasin

[1] All effects would occur or reoccur over the 30-year implementation timeframe.

Table 3.8-30. Summary of Fish and Habitat Effects on Pacific Lamprey as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Mitigation in All Subbasins	Slight, adverse effects from predation and effects on downstream water quality from effluent.	Same as the No-action Alternative.	Same as the No-action Alternative.	Same as the No-action Alternative.	Same as the No-action Alternative.	Same as the No-action Alternative.	Same as the No-action Alternative.	Same as the No-action Alternative.
Reservoir/Lake-like Habitat	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Moderate, adverse effects due to Fall Creek Reservoir drawdowns in fall. Lamprey are not above other Middle Fork Willamette River Subbasin dams. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A
Riverine Habitat	**North Santiam –** Substantial, adverse effects in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Beneficial effects from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons. Adverse effects from TDG below dams. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as the North Santiam. **Long Tom –** Same as the North Santiam.	**North Santiam –** Similar to the No-action Alternative with slight to moderate benefits during low flow seasons from flow augmentation due to minimum flow targets. Moderate increased benefits from temperature management and reduced TDG. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Beneficial effects from increased access upstream for spawning and rearing due to removal of drop structures.	**North Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **South Santiam –** Similar to North Santiam with increased adverse effects on water quality below dams due to Green Peter Reservoir drawdown in fall due to turbidity (moderate in first few years, slight in later years). **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but with slight to moderate reductions in habitat due to lower stream flows in summer. Slight increased benefits from water temperatures. Increased adverse effects from turbidity below Cougar Dam (moderate in first few years, slight in later years). **Middle Fork –** Same as Alternative 2A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A, but with increased adverse effects on water quality and habitat availability below dams due to Detroit Reservoir drawdown in spring and fall. **South Santiam –** Same as Alternative 2A. **McKenzie –** Similar to the No-action Alternative below Cougar Dam with slight reductions in habitat availability. Increased adverse effects on water quality due to Blue River Reservoir drawdown in fall. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Lookout Point Reservoir drawdown in spring and fall. **Coast Fork –** N/A	**North Santiam** – Similar to Alternative 2A in spring and summer. Increased adverse effects from water quality in fall below dams due to Detroit Reservoir drawdown. **South Santiam –** Increased adverse effects on water quality and habitat availability below dams due to Green Peter Reservoir drawdown in spring and fall. **McKenzie –** Same as Alternative 2B. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Hills Creek Reservoir drawdown in spring and fall and Lookout Point Reservoir drawdown in fall. **Coast Fork –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach, species, and life stage. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as Alternative 1.	**Interim Operations** **North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as 2b. **Middle Fork –** Same as Alternative 3B **Coast Fork –** N/A **Long Tom –** Same as the No-action Alternative. **Long-term Operations** Same as Alternative 2B.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
					Long Tom – Same as the No-action Alternative.	**Long Tom –** Same as the No-action Alternative.		
Dam Passage Conditions	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Moderate, adverse effects due to Fall Creek Reservoir drawdowns in fall. **Coast Fork –** N/A **Long Tom –** Adverse effects on upstream passage of lamprey at drop structures. Slight, adverse effects on downstream passage of lamprey at drop structures.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased access upstream for spawning and rearing due to removal of drop structures.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Same as the No-action Alternative.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Same as the No-action Alternative.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Same as the No-action Alternative.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Same as the No-action Alternative.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Same as Alternative 1	**Interim Operations** **North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –**Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 1.

N/A = Not Applicable. Lamprey do not occur above dams.

North Santiam = North Fork Santiam River Subbasin, South Santiam = South Fork Santiam River Subbasin, McKenzie = McKenzie River Subbasin, Middle Fork = Middle Fork Willamette River Subbasin, Coast Fork = Coast Fork Willamette River Subbasin, Long Tom = Long Tom River Subbasin

[1] All effects would occur or reoccur over the 30-year implementation timeframe.

Table 3.8-31. Summary of Fish and Habitat Effects on Resident Fish and Gamefish as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Mitigation in All Subbasins	Adverse effects from sport fishing, habitat competition, and effects on downstream water quality from effluent. Beneficial effects from increased forage for some species and life stages.	Same as the No-action Alternative, but with increased risks from the rainbow trout hatchery program and sport fishing below dams due to increased movement of resident fish below dams with improved passage conditions in North Santiam River, South Santiam River, and Middle Fork Willamette River Subbasins.	Same as the No-action Alternative, but with increased risks from the rainbow trout hatchery program and sport fishing below dams due to increased movement of resident fish below dams with improved passage conditions in North Santiam River, South Santiam River, McKenzie, and Middle Fork Willamette River Subbasins.	Same as Alternative 2A.	Same as Alternative 1.	Same as Alternative 2A.	Same as Alternative 2A.	Same as Alternative 1.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Reservoir/Lake-like Habitat	**North Santiam –** Substantial, beneficial effects due to feeding and growth opportunities in reservoirs. **South Santiam –** Same as North Santiam. **McKenzie –** Same as North Santiam. **Middle Fork –** Same as North Santiam. **Coast Fork –** Same as North Santiam. **Long Tom –** Same as North Santiam. **Gamefish in all Subbasins**[2] Adverse effects to sport fishing opportunities moderated by stocking of rainbow trout and kokanee as determined by ODFW.	**North Santiam –** Same as the No-action Alternative. **South Santiam –** Same as the No-action Alternative. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as the No-action Alternative.	**North Santiam –** Same as the No-action Alternative. **South Santiam –** Moderate, adverse effects on habitat availability and entrainment of fish due to Green Peter Reservoir drawdown in fall. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Adverse effects to sport fishing opportunities moderated by stocking of rainbow trout and kokanee as determined by ODFW. However, deep drawdowns at Green Peter Reservoir would reduce stocking benefits.	**North Santiam –** Same as the No-action Alternative. **South Santiam –** Same as Alternative 2A. **McKenzie –** Substantial, adverse effects on habitat availability and entrainment of fish due to Cougar Reservoir spring and fall drawdowns. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as the Alternative 2A. Deep drawdowns at Cougar Reservoir would also reduce stocking benefits.	**North Santiam –** Substantial, adverse effects on habitat availability and entrainment of fish due to spring and fall reservoir drawdowns. **South Santiam –** Same as Alternative 2A. **McKenzie –** Similar to the No-action Alternative. **Middle Fork –** Substantial, adverse effects on habitat availability and entrainment of fish due to Lookout Point Reservoir spring and fall drawdowns. Moderate, adverse effects on habitat availability and entrainment of fish due to Hills Creek Reservoir and Fall Creek Reservoir drawdowns in fall. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as the Alternative 2A. Deep drawdowns at Detroit, Blue River, Lookout Point, and Hills Creek Reservoirs would also reduce stocking benefits.	**North Santiam –** Moderate, adverse effects on habitat availability and entrainment of fish due to fall reservoir drawdowns. **South Santiam –** Substantial, adverse effects on habitat availability and entrainment of fish due Green Peter Reservoir drawdowns in spring and fall. **McKenzie –** Same as Alternative 2B. **Middle Fork –** Substantial, adverse effects on habitat availability and entrainment of fish due to Hills Creek Reservoir spring and fall drawdowns. Moderate, adverse effects on habitat availability and entrainment of fish due to Lookout Point Reservoir and Fall Creek Reservoir drawdowns in fall. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as Alternative 3A. Deep drawdowns at Cougar Reservoir would also reduce stocking benefits.	**North Santiam –** Same as the No-action Alternative. **South Santiam –** Same as the No-action Alternative. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 3A. **South Santiam –** Same as the No-action Alternative. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as the No-action Alternative. Deep drawdowns would also reduce stocking benefits where stocking occurs throughout all subbasins.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Riverine Habitat	**North Santiam –** Substantial, adverse effects in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Beneficial effects from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons. Adverse effects from TDG below dams. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as North Santiam. **Long Tom –** Same as North Santiam.	**North Santiam –** Similar to the No-action Alternative with slight to moderate benefits during low flow seasons from flow augmentation due to minimum flow targets. Moderate increased benefits from temperature management and reduced TDG. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**North Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach, species, and life stage. **South Santiam –** Similar to North Santiam with increased adverse effects on water quality below dams due to Green Peter Reservoir drawdown in fall. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but with slight to moderate reductions in habitat due to lower stream flows in summer. Slight increased benefits from water temperatures. Increased adverse effects from turbidity below Cougar Dam (moderate in first few years, slight in later years). **Middle Fork –** Same as Alternative 2A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A, but with increased adverse effects on habitat available and water quality below dams due to Detroit Reservoir drawdown in spring and fall. **South Santiam –** Same as Alternative 2A. **McKenzie –** Similar to the No-action Alternative below Cougar Dam with slight reductions in habitat availability. Increased adverse effects on water quality due to Blue River Reservoir drawdown in fall. **Middle Fork –** Increased adverse effects water quality and habitat availability due to Lookout Point Reservoir drawdown in spring and fall. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A in spring and summer. Increased adverse effects from water quality in fall below dams due to Detroit Reservoir drawdown. **South Santiam –** Increased adverse effects on water quality and habitat availability below dams due to Green Peter Reservoir drawdown in spring and fall. **McKenzie –** Same as Alternative 3B. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Hills Creek Reservoir drawdown in spring and fall and Lookout Point Reservoir drawdown in fall. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach, species, and life stage. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**Interim Operations** **North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as Alternative 2B. **Middle Fork –** Same as Alternative 3B. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Long-term Operations** Same as Alternative 2B.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Dam Passage Conditions	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor downstream passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as North Santiam. **McKenzie –** Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor passage conditions at Cougar Dam. **Middle Fork –** Slight, adverse effects from collection and upstream transport of adults above Dexter and Lookout Point Dams. Moderate to substantial, adverse effects from upstream passage conditions at Hills Creek Dam due to use of traps and angling for collection. Substantial, adverse effects due to poor passage conditions at Hills Creek Dam. **Coast Fork –** Substantial, adverse due to upstream and downstream passage conditions. **Long Tom –** Substantial, adverse due to upstream and downstream passage conditions.	**North Santiam –** Slight, adverse effects from upstream and downstream passage at Detroit and Big Cliff Dams. **South Santiam –** Slight, adverse effects from upstream, and downstream passage at Green Peter Dam. Negligible to slight, adverse effects at Foster Dam. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative at Hills Creek Dam. Slight, adverse effects from upstream and downstream passage at Dexter and Lookout Point Dams. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream passage at Foster and Green Peter Dams. Slight, adverse effects at Foster Dam from downstream passage. Moderate, adverse effects at Green Peter Dam from downstream passage. **McKenzie –** Slight adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam. **Middle Fork –** Slight, adverse effects from upstream passage above dams. Same as the No-action Alternative from downstream passage at Hills Creek Dam. Slight, adverse effects from downstream passage at Dexter and Lookout Point Dams. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as Alternative 2A. **McKenzie –** Slight, adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam. **Middle Fork –** Same as Alternative 2A at Dexter and Lookout Point Dams. Same as the No-action Alternative at Hills Creek Dam. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam** – Slight, adverse effects from collection and upstream transport of adults above Detroit and Big Cliff Dams. Moderate adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as Alternative 2A at Green Peter Dam. Same as the No-action Alternative at Foster Dam. **McKenzie –** Similar to the No-action Alternative at Cougar Dam, but adverse effects trending toward beneficial. Slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Slight, adverse effects from upstream passage above dams. Slight, adverse effects from downstream passage at Fall Creek, Dexter, Lookout Point, and Hills Creek Dams. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 3A. **South Santiam –** Same as Alternative 2A at Green Peter Dam. Same as the No-action Alternative at Foster Dam **McKenzie –** Same as Alternative 2B at Cougar Dam. Slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream and downstream passage at Foster Dam Same as the No-action Alternative at Green Peter Dam. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A at Fall Creek, Lookout Point, Dexter, and Hills Creek Dams. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**Interim Operations** **North Santiam –** Same as Alternative 3A. **South Santiam –** Same as Alternative 3A. **McKenzie –** Same as the No-action Alternative with slight trend toward beneficial from downstream passage due to regulating outlet improvements. **Middle Fork –** Same as the No-action Alternative from upstream passage. Same as Alternative 3A from downstream passage. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Long-term Operations** Same as Alternative 2B.

North Santiam = North Fork Santiam River Subbasin, South Santiam = South Fork Santiam River Subbasin, McKenzie = McKenzie River Subbasin, Middle Fork = Middle Fork Willamette River Subbasin, Coast Fork = Coast Fork Willamette River Subbasin, Long Tom = Long Tom River Subbasin, ODFW = Oregon Department of Fish and Wildlife

[1] All effects would occur or reoccur over the 30-year implementation timeframe.

[2] Gamefish stocking in all reservoirs is managed by ODFW and may or may not occur throughout all subbasins during the 30-year implementation timeframe.

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.9 WILDLIFE AND HABITAT

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3.9 Wildlife and Habitat

THE WILDLIFE AND HABITAT SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **The mainstem Willamette River to Willamette Falls has been deleted from the analysis area description in FEIS Section 3.9.2, Affected Environment, because flow changes that effect wildlife habitat do not extend all the way to the mainstem.**
- **Species status information has been updated in FEIS Table 3.9-2 for Oregon vesper sparrow, northwestern pond turtle, foothill yellow-legged frog, and Fender's blue butterfly.**
- **Information on northern spotted owls has been added to Section 3.9.2, Affected Environment, and analyses updated in FEIS Section 3.9.3, Environmental Consequences.**
- **Information on the Southern Resident Killer Whale Recovery Plan, revision of critical habitat designation, and the NMFS 2024 Biological Opinion have been added to Section 3.9.2, Affected Environment.**
- **The definition of short-term and medium-term effects criteria have been expanded in FEIS Table 3.9-3.**
- **A table summarizing effects under each alternative has been added (FEIS Table 3.9-4).**
- **Additional comparisons to the No-action Alternative have been added to all analyses in FEIS Section 3.9.3, Environmental Consequences.**
- **Information on routine and non-routine maintenance has been added to the analyses in Section 3.9.3, Environmental Consequences.**
- **Analyses of effects to Southern Resident killer whales, northwestern pond turtles, and northern spotted owls have been updated in Section 3.9.3, Environmental Consequences.**
- **Information on specific alternative measures has been deleted from Section 3.9.3, Environmental Consequences because it is provided in Chapter 2, Alternatives. The analyses incorporate anticipated effects from measure implementation.**
- **The Near-term Operations Measures analyses have been combined for all action alternatives except Alternative 1 in Section 3.9.4. "Near-term Operations Measures" has been changed to "Interim Operations" throughout the EIS. The climate change analyses have been combined for all alternatives in Section 3.9.5.**

3.9.1 Introduction

The Willamette River Basin supports a multitude of aquatic and terrestrial habitat types that sustain rich assemblages of wildlife species. These assemblages include species that live year-round in its waters and associated floodplains, migratory species using seasonal habitat (e.g., breeding, wintering), wildlife movement corridors, and non-breeding/foraging habitats.

For this analysis, aquatic habitats include open water (i.e., reservoir, main channel, secondary channels, backwaters, oxbows, and lakes/ponds) of varying depths. Terrestrial habitats include wetlands, forests, oak savannas, grasslands, and shrublands.

Additional habitat characterizations are provided in Section 3.6, Vegetation, and Section 3.7, Wetlands[1].

3.9.2 Affected Environment

The analysis area for wildlife and their habitat[2] consists of all Willamette Valley System (WVS) reservoirs in the Willamette River Basin up to the maximum pool elevation. Descriptions of wildlife habitat and species within each subbasin is provided below and are current as of the time the alternatives were analyzed.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

The analysis area also includes the following stream reaches and associated riparian zones:

- Middle Fork Willamette River downstream of Hills Creek Dam to the confluence with the Coast Fork Willamette River
- Coast Fork Willamette River downstream of Cottage Grove Dam to the confluence with the Middle Fork Willamette River
- Row River from downstream of Dorena Dam to the confluence with the Coast Fork Willamette River
- South Fork McKenzie River downstream of Cougar Dam to the confluence with the McKenzie River
- McKenzie River from the South Fork McKenzie River confluence to the confluence with the Willamette River
- Blue River downstream of Blue River Dam to the confluence with the McKenzie River

[1] Information on compliance with the Fish and Wildlife Coordination Act is provided in Chapter 7, Relationship to Other Environmental Plans, Policies, and Regulations.

[2] The wildlife and habitat analyses do not include fish. See Section 3.8, Fish.

- Long Tom River downstream of Fern Ridge Dam to the confluence with the Willamette River (includes Coyote Creek from Fern Ridge Dam to the confluence with the Willamette River)
- South Santiam River downstream of Foster Dam to the confluence with the North Santiam River
- North Santiam River downstream to the confluence with the South Santiam River
- Santiam River to the confluence with the Willamette River

END NEW TEXT

Aquatic and wetland habitats offer a diverse range of flows, depths, and temperature regimes for mustelids, amphibians, reptiles, freshwater mussels, migratory birds, resident waterfowl, bats, and macroinvertebrates (Table 3.9-1).

Terrestrial habitats include grasslands, mixed deciduous and conifer riparian forest, mixed upland (e.g., hillside) conifer forest, and oak-savannah habitats. The dynamic and complex vegetation structure produces changes in biomass and other ecosystem functions that affect faunal biodiversity[3].

Freshwater ecosystems support foraging, overwintering, reproduction, metamorphosis, and protection from predators.

Upland ecosystems (e.g., hillsides) support reproductive habitat for nesting and denning, refuge for roosting and overwintering, vertical and horizontal canopy structure for sunning and basking, and a variety of food resources throughout the seasons.

Table 3.9-1. Common Species that may be Present in the Analysis Area.

Taxon	Common Name	Scientific Name	North Santiam	South Santiam	McKenzie	Middle Fork	Coast Fork	Long Tom
Mammals	Roosevelt elk	*Cervus canadensis roosevelti*	x	x	x	x	x	x
Mammals	Black-tailed deer	*Odocoileus hemionus columbianus*	x	x	x	x	x	x
Mammals	Black bear	*Ursus americanus*	x	x	x	x	x	x
Mammals	Cougar	*Puma concolor*	x	x	x	x	x	x
Mammals	Coyote	*Canis latrans*	x	x	x	x	x	x
Mammals	Bobcat	*Lynx rufus*	x	x	x	x	x	x
Mammals	Striped skunk	*Mephitis mephitis*	x	x	x	x	x	x
Mammals	American beaver	*Castor canadensis*	x	x	x	x	x	x

[3] Faunal biodiversity refers to the abundance and variety of wildlife in a geographic area such as the analysis area.

Taxon	Common Name	Scientific Name	North Santiam	South Santiam	McKenzie	Middle Fork	Coast Fork	Long Tom
Mammals	Muskrat	*Ondatra zibethicus*	x	x	x	x	x	x
Mammals	North American river otter	*Lontra canadensis*	x	x	x	x	x	x
Mammals	American mink	*Neovison vison*	x	x	x	x	x	x
Mammals	Short-tailed weasel	*Mustela erminea*	x	x	x	x	x	x
Mammals	Raccoon	*Procyon lotor*	x	x	x	x	x	x
Mammals	Virginia opossum	*Didelphis virginiana*	x	x	x	x	x	x
Mammals	Northern flying squirrel	*Glaucomys sabrinus*	x	x	x	x	x	x
Birds	Bald eagle	*Haliaeetus leucocephalus*	x	x	x	x	x	x
Birds	Osprey	*Pandion haliaetus*	x	x	x	x	x	x
Birds	Great blue heron	*Ardea herodias*	x	x	x	x	x	x
Birds	Mallard	*Anas platyrhynchos*	x	x	x	x	x	x
Birds	Common merganser	*Mergus merganser*	x	x	x	x	x	x
Birds	Wood duck	*Aix sponsa*	x	x	x	x	x	x
Birds	Bufflehead	*Bucephala albeola*	x	x	x	x	x	x
Birds	Ruffed grouse	*Bonasa umbellus*	x	x	x	x	x	x
Birds	Mountain quail	*Oreortyx pictus*	x	x	x	x	x	x
Birds	Band-tailed pigeon	*Patagioenas fasciata*	x	x	x	x	x	x
Birds	Anna’s hummingbird	*Calypte anna*	x	x	x	x	x	x
Birds	American robin	*Turdus migratorius*	x	x	x	x	x	x
Birds	Black-capped chickadee	*Poecile atricapillus*	x	x	x	x	x	x
Birds	Spotted towhee	*Pipilo maculatus*	x	x	x	x	x	x
Reptiles	Common garter snake	*Thamnophis sirtalis*	x	x	x	x	x	x
Reptiles	Western fence lizard	*Sceloporus occidentalis*	x	x	x	x	x	x
Amphibians	Pacific treefrog	*Pseudacris regilla*	x	x	x	x	x	x
Amphibians	Pacific giant salamander	*Dicamptodon tenebrosusis*	x	x	x	x	x	x
Amphibians	Rough-skinned newt	*Taricha granulosa*	x	x	x	x	x	x

Taxon	Common Name	Scientific Name	North Santiam	South Santiam	McKenzie	Middle Fork	Coast Fork	Long Tom
Invertebrates	Pale swallowtail	*Papilio eurymedon*	x	x	x	x	x	x
Invertebrates	White-shouldered bumble bee	*Bombus appositus*	x	x	x	x	x	x

Sources: Oregon Biodiversity Information Center (ORBIC 2019), Oregon Department of Fish and Wildlife Sensitive Species list and Conservation Strategy (ODFW 2021e), USACE and U.S. Fish and Wildlife Service (USFWS) species experts.

Grasslands and oak-savanna habitats provide browsing for native mammals, seeds and insects for grassland birds, roots and fruits for rodents, wildflowers for pollination and nectaring, and open space for invertebrates.

Some species that may be present in the analysis area are Federally or state-listed for protective status or potential protective status (Table 3.9-2). Systematic faunal surveys have not been completed on all USACE-managed lands in the analysis area. A variety of data-deficient species could be present in these areas but are not included in Table 3.9-1 or Table 3.9-2. Additionally, Federally listed Southern Resident killer whales are not present in the analysis area, but some food supply is provided from Upper Willamette River Chinook salmon stock (Section 3.9.2.7, Southern Resident Killer Whales).

3.9.2.1 North Santiam River Subbasin

The North Santiam River Subbasin includes aquatic and terrestrial habitat associated with Detroit Reservoir, Big Cliff Reservoir, and the North Santiam River downstream of Big Cliff Dam to the confluence with the South Santiam River. The subbasin is at an elevation of approximately 1,565 feet National Geodetic Vertical Datum (NGVD) and is within the Cascade Mountain region (Section 3.4, Geology and Soils). Seasonal temperatures affecting species in this subbasin tend to be cooler than in other analysis area subbasins.

Sensitive species such as the inland distribution of Pacific marten (*Pekania pennanti*) and red tree vole (*Arborimus longicaudus*) may acquire food and shelter in the dense canopy of the Cascade Mountains. Riverine and open water habitat provide cold, fresh water for common species such as the American beaver (*Castor canadensis*) and American mink (*Neovison vison*). These species use debris[4] to build shelter and to forage (fish, snakes, crustaceans, amphibians) in and around the Detroit and Big Cliff Reservoirs.

[4] Debris refers to plant material native to an area that support wildlife habitat such as downed trees, in-stream logs, branches, root wads, leaves, and standing dead trees.

Table 3.9-2. Federal and State-listed Sensitive Species that may be Present in the Analysis Area.

Taxon	Common Name	Scientific Name	Federal Status[2]	Critical Habitat	Protective Regulations	State Status[3]	North Santiam	South Santiam	McKenzie	Middle Fork	Coast Fork	Long Tom
Mammals	Gray wolf	*Canis lupus*	LE	Not Designated in Oregon	-	SC	x	-	-	x	-	-
Mammals	Sierra Nevada red fox	*Vulpes vulpes necator*	-	Not Designated	-	S; CS	x	-	x	x	-	-
Mammals	Ringtail	*Bassariscus astutus*	-	Not Designated	-	S; CS	-	-	x	x	-	-
Mammals	Pacific marten (interior)	*Martes caurina (pop. 1)*	-	Not Designated	-	S; CS	x	-	-	x	-	-
Mammals	Fisher	*Pekania pennanti*	-	Not Designated	-	SC; CS	x	x	x	x	-	-
Mammals	American pika	*Ochotona princeps*	-	Not Designated	-	S; CS	x	x	x	x	-	-
Mammals	Red tree vole	*Arborimus longicaudus*	C	Not Designated	-	S; CS	x	x	x	x	x	-
Mammals	Western gray squirrel	*Sciurus griseus*	-	Not Designated	-	S; CS	x	x	x	x	x	x
Mammals	California myotis	*Myotis californicus*	-	Not Designated	-	S; CS	x	x	x	x	x	x
Mammals	Fringed myotis	*Myotis thysanodes*	-	Not Designated	-	S; CS	x	x	x	x	x	x
Mammals	Hoary bat	*Lasiurus cinereus*	-	Not Designated	-	S; CS	x	x	x	x	x	x
Mammals	Little brown bat	*Myotis lucifiugus*	P	Not Designated	-	-	x	x	x	x	x	x
Mammals	Long-legged myotis	*Myotis volans*	-	Not Designated	-	S; CS	x	x	x	x	-	-
Mammals	Silver-haired bat	*Lasionycteris noctivagans*	SOC	Not Designated	-	S	x	x	x	x	x	x
Mammals	Townsend's big-eared bat	*Corynorhinus townsendii*	-	Not Designated	-	SC; CS	x	x	x	x	x	x

Taxon	Common Name	Scientific Name	Federal Status[2]	Critical Habitat	Protective Regulations	State Status[3]	North Santiam	South Santiam	McKenzie	Middle Fork	Coast Fork	Long Tom
Mammals	Southern Resident killer whale†	*Orcinus orca*	LE	Designated	70 FR 69903 69912 86 FR 41668	LE	-	-	-	-	-	-
Birds	Acorn woodpecker	*Melanerpes fornicivorus*	-	Not Designated	-	S; CS	x	-	x	x	x	x
Birds	Black-necked stilt	*Himantopus mexicanus*	-	Not Designated	-	S; CS	-	-	-	-	-	x
Birds	Caspian tern	*Hydroprogne caspia*	-	Not Designated	-	S; CS	-	-	-	-	-	x
Birds	Chipping sparrow	*Spizella passerina*	-	Not Designated	-	S; CS	-	-	-	-	-	x
Birds	Common nighthawk	*Chordeiles minor*	-	Not Designated	-	SC; CS	x	-	-	x	-	x
Birds	Dusky Canada goose	*Branta canadensis occidentalis*	-	Not Designated	-	S; CS	-	-	-	-	-	x
Birds	Grasshopper sparrow	*Ammodramus savannarum perpallidus*	-	Not Designated	-	SC; CS	x	-	-	-	-	x
Birds	Greater sandhill crane	*Antigone canadensis tabida*	-	Not Designated	-	S; CS	x	-	-	-	-	-
Birds	Harlequin duck	*Histrionicus histrionicus*	-	Not Designated	-	S; CS	x	x	x	x	-	-
Birds	Lewis's woodpecker	*Melanerpes lewis*	-	Not Designated	-	SC; CS			x	x	x	x
Birds	Marbled murrelet*	*Brachyramphus marmoratus*	LT	Designated	57 FR 45238 45337; 81 FR 51348 51370	LT; CS	-	-	-	-	-	-
Birds	Mountain quail	*Oreortyx pictus*	-	Not Designated	-	S; CS	x	-	-	x	x	x
Birds	Northern goshawk	*Accipiter gentilis atricaupillus*	-	Not Designated	-	S; CS	x	x	x	x	x	x

Taxon	Common Name	Scientific Name	Federal Status[2]	Critical Habitat	Protective Regulations	State Status[3]	North Santiam	South Santiam	McKenzie	Middle Fork	Coast Fork	Long Tom
Birds	Northern spotted owl	*Strix occidentalis caurina*	LT	Designated	55 FR 26114 26194; 86 FR 62606 62666	LT	x	x	x	x	x	-
Birds	Olive-sided flycatcher	*Contopus cooperi*	-	Not Designated	-	S; CS	x	x	x	x	x	x
Birds	Oregon vesper sparrow	*Pooecetes gramineus affinis*	P	Not Designated	83 FR 30091 30094	-	-	-	-	-	-	x
Birds	Peregrine falcon (American)	*Falco peregrinus anatum*	-	Not Designated	-	S; CS	x	x	x	x	x	x
Birds	Pileated woodpecker	*Dryocopus pileatus*	-	Not Designated	-	S; CS	x	x	x	x	x	x
Birds	Purple martin (Western *subsp.*)	*Progne subis arboricola*	-	Not Designated	-	SC; CS	x	x	x	x	x	x
Birds	Streaked horned lark	*Eremophilia alpestris strigata*	LT	Designated	78 FR 61451 61503; 78 FR 61505 61589	SC; CS	-	-	-	x	x	x
Birds	Western bluebird	*Sialia mexicana*	-	Not Designated	-	S; CS	x	-	-	x	x	x
Birds	Western meadowlark	*Sturnella neglecta*	-	Not Designated	-	SC; CS	x	-	-	-	x	x
Birds	White-breasted nuthatch (Slender-billed)	*Sitta carolinensis aculeata*	-	Not Designated	-	S; CS	x	x	x	x	x	x
Birds	Willow flycatcher	*Empidonax traillii*	-	Not Designated	-	SC; CS	x	-	-	x	x	x
Birds	Yellow-billed cuckoo*	*Coccyzus americanus*	LT	Designated	79 FR 59991 60038; 86 FR 20798 21005	-	-	-	-	-	-	-
Birds	Yellow-breasted chat	*Icteria virens auricollis*	-	Not Designated	-	SC; CS	x	-	-	x	x	x
Reptiles	Northwestern pond turtle	*Actinemys marmorata*	SOC; C	Not Designated	88 FR 68370 68399	SC; CS	x	x	x	x	x	x

Taxon	Common Name	Scientific Name	Federal Status[2]	Critical Habitat	Protective Regulations	State Status[3]	North Santiam	South Santiam	McKenzie	Middle Fork	Coast Fork	Long Tom
Reptiles	Western painted turtle	*Chrysemys picta bellii*	-	Not Designated	-	SC; CS	x	x	x	-	-	-
Reptiles	Western rattlesnake	*Crotalus oreganus*	-	Not Designated	-	SC; CS	-	-	-	x	x	-
Amphibians	Cascade torrent salamander	*Rhyacotriton cascadae*	P	Not Designated	-	S; CS	x	x	x	-	-	-
Amphibians	Cascades frog	*Rana cascadae*	SOC; P	Not Designated	-	S; CS	x	x	x	x	-	-
Amphibians	Clouded salamander	*Aneides ferreus*	-	Not Designated	-	S; CS	x	x	x	x	x	x
Amphibians	Coastal tailed frog	*Ascaphus truei*	-	Not Designated	-	S; CS		x	x	x	-	-
Amphibians	Foothill yellow-legged frog**	*Rana boylii*	SOC	Not Designated	-	SC; CS	x	x	x	-	-	-
Amphibians	Northern red-legged frog	*Rana aurora*	SOC	Not Designated	-	S; CS	x	x	x	x	x	x
Amphibians	Oregon slender salamander	*Batrachoseps wrighti*	SOC	Not Designated	-	S; CS	x	x	x	x	-	-
Amphibians	Western toad	*Anaxyrus boreas*	-	Not Designated	-	S; CS	x	x	x	x	x	-
Invertebrates	California floater mussel	*Anodonta californiensis*	SOC	Not Designated	-	-	x	x	x	x	x	x
Invertebrates	Western ridged mussel	*Gonidea angulata*	P	-	-	CS	x	x	x	x	x	x
Invertebrates	Winged floater freshwater mussel	*Anodonta nuttalliana*	-	Not Designated	-	CS	x	x	x	x	x	x
Invertebrates	Fender's blue butterfly	*Icaricia icarioides fenderi*	LT	Designated	65 FR 3875 3 890; 71 FR 63862 63977; 88 FR 2006 2028	CS	-	-	-	-	-	x
Invertebrates	Monarch butterfly	*Danaus plexippus*	C	Not Designated	85 FR 81813	CS	x	x	x	x	x	x

Taxon	Common Name	Scientific Name	Federal Status[2]	Critical Habitat	Protective Regulations	State Status[3]	North Santiam	South Santiam	McKenzie	Middle Fork	Coast Fork	Long Tom
Invertebrates	Taylor's checkerspot butterfly*	*Euphydryas editha taylori*	LE	Designated	76 FR 66370 66439; 78 FR 61505 61589	CS	-	-	-	-	-	-
Invertebrates	Suckley cuckoo bumble bee**	*Bombus suckleyi*	P	Not Designated	-	-	-	-	-	-	-	-
Invertebrates	Western bumble bee	*Bombus occidentalis*	P	Not Designated	-	CS	x	x	x	x	-	-

*Occurs in the Willamette River Basin, but presence data are lacking for the subbasins.

**Could be present in the Willamette River Basin, but systematic surveys are lacking for the subbasins.

† Species located outside of Willamette River Basin, but prey are found within the Basin.

[1] ORBIC, 2019; Oregon Department of Fish and Wildlife Oregon Sensitive Species List and Conservation Strategy

[2] LE = Listed Endangered; LT = Listed Threatened; SOC = Species of Concern; P = Petitioned for listing; C = Candidate for listing

[3] LT = Listed Threatened; S = Sensitive; SC = Sensitive Critical; CS = Conservation Strategy

3.9.2.2 South Santiam River Subbasin

The South Santiam River Subbasin includes Green Peter and Foster Dams and Reservoirs. It is located within the western slope of the Cascade Mountains. Agricultural lands are interspersed along the South Santiam River northwest to Jefferson, Oregon.

Foster Dam and Reservoir are bordered to the south and west by the Sweet Home, Oregon urban area. Highway 20 borders the south portion of the reservoir. Green Peter Dam and Reservoir are located in a rural area 11 miles northeast of Sweet Home.

Aquatic habitat includes open water and wetlands associated with Green Peter and Foster Reservoirs and the Middle Santiam and South Santiam Rivers. Predominant terrestrial habitat near Green Peter and Foster Dams consists of old growth, mixed coniferous forest, and a mixed deciduous and conifer riparian forest. Complex, thick forest structure and canopy cover provides an abundance of biomass and moist areas ideal for rough-skinned newts (*Taricha granulosa*) and secretive forest birds.

Common avian species include bald eagles (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), mallards (*Anas platyrhynchos*), common mergansers (*Mergus merganser)*, and buffleheads (*Bucephala albeola*). These species use the reservoirs for forage and refuge.

The northwestern pond turtle (*Actinemys marmorata*) is a candidate for listing as Federally threatened under the Endangered Species Act (ESA) and was a state sensitive-critical species at the time the alternatives were analyzed. This species is present at Sunnyside Park adjacent to Foster Reservoir (Table 3.9-2). Past sightings of northwestern pond turtles have been reported in other locations in and around Foster Reservoir, although no pond turtles have been observed at Green Peter Reservoir.

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Additionally, Northern red-legged frogs (*Rana aurora)* are found at the Foster Reservoir quarry and elsewhere around the reservoir. Foothill yellow-legged frog has been present historically near Foster Reservoir; however, at the time the alternatives were analyzed, no recent surveys had been conducted for this species. Consequently, the status of this species around Foster and Green Peter Reservoirs is unknown. Foothill yellow-legged frogs have been observed near the Santiam River and in satellite ponds managed by both USACE and Linn County Parks.

END REVISED TEXT

Photo by Jason Mrachina (USACE Media Images Database)
Bald eagle (*Haliaeetus leucocephalus*).

3.9.2.3 McKenzie River Subbasin

The McKenzie River Subbasin includes Cougar and Blue River Dams and Reservoirs. Like the North Santiam River Subbasin, these dams are higher in elevation (1,558 feet and 1,350 feet NGVD, respectively) than most WVS dams and, therefore, the McKenzie River Subbasin may include a different suite of species than those associated with habitat surrounding lower elevation dams in the analysis area. This Western Cascades ecoregion is predominantly composed of western hemlock (*Tsuga heterophylla*), western redcedar (*thuja plicata*), and Douglas-fir (*Pseudotsuga menziesii*) forests.

Common game species such as Roosevelt elk (*Cervus canadensis roosevelti*), black-tailed deer, black bear (*Ursus americanus*), and cougar (*Puma concolor*) inhabit the region. Upland game birds include sooty grouse (*Dendragapus fuliginosus*), ruffed grouse (*Bonasa umbellus*), mountain quail (*Oreortyx pictus*), and band-tailed pigeon (*Patagioenas fasciata*). Furbearers include American beaver, raccoon (*Procyon lotor*) and, less commonly, North American river otter (*Lontra canadensis*), bobcat (*Lynx rufus*), and mink. Resident waterfowl such as mallards, common mergansers, and wood ducks (*Aix sponsa*) inhabit the river, reservoir, and riparian areas of the subbasin.

Non-game wildlife commonly observed in this ecoregion include small mammals (chipmunks, squirrels, rabbits, and mice), bald eagles, osprey, and pacific treefrogs (*Pseudacris regilla*). Sensitive species include Harlequin ducks (*Histrionicus histrionicus),* Oregon slender salamanders (*Batrachoseps wrighti*), and the Townsend's big-eared bat (C*orynorhinus* *townsendii*). Bats forage along the reservoir and tributaries during warmer months and use tree cavities, bark, leaf litter, and artificial structures for roosting.

3.9.2.4 Middle Fork Willamette River Subbasin

The Middle Fork Willamette River Subbasin includes Hills Creek, Lookout Point, Dexter, and Fall Creek Dams and Reservoirs. This subbasin is located within the western slope of the Cascade Mountains.

Most urban development in the subbasin is limited to the towns of Lowell and Oakridge, Oregon. Lowell is adjacent to Dexter Reservoir and within 10 miles of Fall Creek and Lookout Point Reservoirs. Oakridge and West Fir are near Hills Creek Dam.

Hills Creek Dam is higher in elevation (1,545 feet NGVD) and closer to the Cascade Mountains than the other three dams; therefore, a unique suite of species, such as Northern red-legged frogs and the Harlequin ducks, occur at Hills Creek Reservoir.

Upland habitats found within this subbasin include grasslands, riparian and mixed conifer forest, and a limited amount of oak savanna habitat. Vegetative heterogeneity and varying elevations near these dams provide habitat complexity that supports unique breeding, denning, roosting, basking, and foraging environments for a variety of wildlife species.

Common avian species observed at these reservoirs include bald eagles, osprey, bufflehead, Western grebes (*Aechmophorus occidentalis*), tree swallows (*Tachycineta bicolor*), and spotted towhees (*Pipilo maculatus*). Amphibians that are well-represented at Fall Creek Reservoir and surrounding areas include rough-skinned newts and Oregon ensatinas (*Ensatina eschscholtzii oregonensis*), along with more unique salamanders such as the Dunn's (*Plethodon dunni*) and long-toed salamanders (*Ambystoma macrodactylum*). Moist soil and forested understory provide ideal habitat for salamander species around Fall Creek, Hills Creek, and Lookout Point Reservoirs.

Northwestern pond turtles occur in or near each of these four reservoirs and are typically found in protected reservoir coves or tributaries containing basking structures (logs or rocks). Other sensitive species present at these reservoirs include clouded salamanders (*Aneides ferreus*) and western bluebirds (*Sialia mexicana*).

Populations of waterfowl, both resident and migratory, use the reservoirs for foraging and refuge. Predators such as bobcats (*Lynx rufus*) and coyotes (*Canis latrans*) are also found around the reservoirs.

3.9.2.5 Coast Fork Willamette River Subbasin

The Coast Fork Willamette River Subbasin includes Cottage Grove and Dorena Dams and Reservoirs. The forests within the subbasin are dominated by Douglas-fir with some remnant oak forests.

The town of Cottage Grove, Oregon lies within 7 miles of both reservoirs and is the most developed urban area near the reservoirs. Private properties also line the perimeter of these reservoirs. The Coast Fork Willamette River riparian corridor consists of agricultural fields with limited forested habitat up to the confluence with the Middle Fork Willamette River near Eugene, Oregon.

Upland habitats near these reservoirs include grasslands, riparian forest, mixed conifer forest, agricultural lands, and oak savanna. More specifically, mixed deciduous and conifer riparian forests make up most of the habitat at Dorena and Cottage Grove Reservoirs.

Common avian species observed at these reservoirs include bald eagles, osprey, and hooded mergansers (*Lophodytes cucullatus*). Amphibians include long-toed salamanders, rough-skinned newts, and Oregon ensatinas.

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Historical reports indicate northwestern pond turtles occupied the river adjacent to Schwarz Park and were also observed in the southern portions of both Dorena and Cottage Grove Reservoirs (Adamus 2003; ORBIC 2024; USACE unpublished data). Stationary and roving visual encounter surveys conducted by USACE biologists in 2023 produced negative occupancy data within Dorena and Cottage Grove Reservoirs, although pond turtles were present in ponds adjacent to Dorena Reservoir at the time the alternatives were analyzed (USACE unpublished data). A small population of western purple martins (*Progne subis arboricola*) is supported by artificial nest boxes at Dorena and Cottage Grove Reservoirs.

Photo by Lorelle Sherman (USACE Media Images Database)
Purple martin (*Progne subis arboricola*).

3.9.2.6 Long Tom River Subbasin

The Long Tom River Subbasin includes Fern Ridge Dam and Reservoir and the Long Tom River upstream of its confluence with the Willamette River. Adjacent land use along the Long Tom River is predominantly agriculture, with grass seed propagation the dominant crop. Remnant native oak riparian forest areas dot the landscape along the unmodified portion of the Long Tom River channel south of Monroe, Oregon.

Adjacent land use around Fern Ridge Reservoir includes a mix of residential and agricultural. It is located within a few miles of the Euguene, Oregon metropolitan area and is bordered to the south by Highway 126. Habitat types within Fern Ridge Reservoir include upland Willamette Valley prairie, Willamette Valley wet-prairie, oak woodland, riparian forest remnants, emergent vegetation, and open water. Constructed wetland cells at the southeastern end of Fern Ridge Reservoir are managed for winter waterfowl use by the Oregon Department of Fish and Wildlife (ODFW).

Common species include voles, chipmunks, bats, and rabbits. Roosevelt elk and black-tailed deer are also seen along the reservoir shores. Resident and migratory waterfowl use the reservoir for both breeding and wintering. Various shorebirds forage in the exposed lakebed during the winter reservoir drawdowns. A variety of secretive marsh birds use the emergent lake vegetation for breeding.

Fern Ridge Reservoir and surrounding wetlands are renowned for the abundance and diversity of avian species. Occasional migrant raptors like snowy owls (*Bubo scandiacus*) and migrating winter shorebirds such as dunlin (*Calidris alpina*) and black-bellied plovers (*Pluvialis squatarola*) can be observed.

Unique and sensitive species found in and around Fern Ridge Reservoir and the Long Tom River channel include northwestern pond turtles, grasshopper sparrows (*Ammodramus savannarum*), western purple martins, Fender’s blue butterflies (*Icaricia icarioides fender*), and streaked horned larks (*Eremophila alpestris strigata*). Northwestern pond turtles are seen throughout the reservoir and are concentrated in Kirk Pond and Park, directly north of the dam. Non-native red-eared sliders are also present at Fern Ridge and compete with the native pond turtle for resources. An active red-eared slider removal program was ongoing at Fern Ridge Reservoir at the time the alternatives were analyzed.

END REVISED TEXT

Grasshopper sparrows and Fender’s blue butterflies inhabit the remanent native upland prairie that surrounds the reservoir. Every spring and summer, migratory western purple martins take advantage of artificial nest boxes that surround Fern Ridge Reservoir. This population is thought to be the largest population of inland nesting purple martins in Oregon.

Photo by Lorelle Sherman (USACE Media Images Database)

A purple martin (*Progne subis arboricola*) peeks its head out of a nest box at Fern Ridge Dam and Reservoir, west of Eugene, Oregon. Normally, the birds find cavities in dead trees or snags to nest in, but nest boxes are an acceptable alternative.

A small breeding assemblage of streaked horned larks are found at the southern end of the reservoir, south of Highway 126. Periodic reports of streaked horned lark calls have been reported near Fern Ridge Reservoir, just north of the highway. Streaked horned larks require large expanses of open ground with sparse vegetation and vernal pools for breeding and foraging, which is provided in the Fern Ridge Reservoir area.

3.9.2.7 Federal Threatened and Endangered Species

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Southern Resident Killer Whales

Southern Resident killer whales (*Orcinus orca*), listed under the Federal Endangered Species Act (ESA) as endangered, do not occur within the analysis area; however, a small portion of their prey base may be affected by the alternatives.

A recovery plan for this species was prepared by the National Marine Fisheries Service in 2008. Primary limiting factors for this species include (1) quantity and quality of prey, (2) high levels of organochlorine contaminants and increasing levels of emerging contaminants such as flame retardant, (3) sound and disturbance from vessel traffic, and (4) oil spills (NMFS 2008a).

The 2006 final rule designating critical habitat identified three habitat features essential to the conservation of the distinct population segment: (1) Water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging (71 FR 69054). However, in 2021, NMFS determined the primary "essential feature" for Southern Residents in the northern Oregon inshore areas to be prey (86 FR 41668).

Killer whales (*Orcinus orca*) are found in waters throughout the North Pacific. Along the west coast of North America, resident, transient, and offshore ecotypes have overlapping distributions, and multiple stocks are recognized within that broader classification scheme (NMFS 2008). According to the most recent stock assessment at the time the alternatives were analyzed (NOAA 2023), the West Coast Transient stock included animals that range from California to southern Alaska and is genetically distinct from other transient populations in the region (i.e., Gulf of Alaska, Aleutian Islands, and Bering Sea transients and AT1 transients). As of December 2022, there are a total of 74 individuals within the Southern Resident killer whale distinct population segment (NOAA 2023).

The Southern Resident killer whale distinct population segment was listed as endangered under the ESA in 2005 (70 FR 69903) and was listed at the time the alternatives were analyzed due to: 1) scarcity of prey, 2) high levels of contaminants from pollution, and 3) disturbance from vessels and noise impacts[5]. Critical habitat for Southern Resident killer whale occurs in inland waters of Washington State; there is no designated critical habitat in the EIS alternatives analysis area[6]. The distinct population segment consists of three pods (J, K, and L), which inhabit coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (70 FR 69903, updated in 79 FR 20802).

Southern Resident killer whales have been observed near the mouth of the Columbia River, likely to feed on adult salmon migrating back into the river. The presence of Southern Resident killer whales may be driven by seasonal abundance of prey items, coinciding with adult Chinook salmon in-migration (84 FR 49214). Salmon compose approximately 98 percent of the Southern Resident killer whale diet. Of this amount, Chinook salmon account for approximately 79 percent (Carretta et al. 2020). Southern Residents spend about 50 to 67 percent of their time foraging (NMFS 2008a).

Salmon from the Upper Willamette River are available to Southern Resident killer whales as they occupy the same geographic space and are in offshore areas at the same time. Over the last 40 years, the diet of Southern Resident killer whales has shifted from salmonids from the

[5] NMFS removed the endangered listing exclusion for captive animals and confirmed that delisting the Southern Resident killer whale distinct population segment was not warranted in 2013.

[6] Although Southern Resident killer whales are not in the EIS alternatives analysis area, this species was addressed in the 2023 Biological Assessment.

Salish Sea to those originating in the Columbia Basin (including the Upper Willamette River) (Couture et al. 2022). However, the Upper Willamette River Chinook salmon stock does not make up the majority of Southern Resident killer whale prey, which are stocks from the Puget Sound (Couture et al. 2022; Hanson et al. 2021).

Northern Spotted Owl

Northern spotted owls, listed under the Federal ESA as threatened, may occupy old growth forest habitats surrounding reservoirs and streams on the western slope of the Cascade Mountains. Habitat destruction and competition from predatory bird species such as the barred owl (*Strix varia*) have contributed to the threatened listing of northern spotted owls.

USACE had not conducted past or current surveys at the time the alternatives were analyzed for northern spotted owls on USACE-managed land. USFWS Northern Spotted Owl Nesting/Roosting Forest Maps and Trend Viewer habitat modeling indicates that all USACE-managed dams within the analysis area have potential nesting and roosting forest nearby (USFWS 2024). The U.S. Bureau of Land Management Northern Spotted Owl Sites Publication Point Hub displays northern spotted owl sightings near Cottage Grove, Dorena, Dexter, Lookout Point, Fall Creek, Foster, and Green Peter Dams (BLM 2024)[7].

END REVISED TEXT

Streaked Horned Lark

Streaked horned larks (*Eremophilia alpestris* strigata), listed under the Federal ESA as threatened, occur in the Middle Fork Willamette River, Coast Fork Willamette River, and Long Tom River Subbasins. A small breeding assemblage of streaked horned larks are found at the southern end of Fern Ridge Reservoir. ODFW, in cooperation with the Long Tom Watershed Council, was conducting habitat restoration at Coyote Creek South and Coyote Creek Northeast at the time the alternatives were analyzed (Phase 1 through Phase 3) (Altman 2023). Streaked horned larks require large expanses of open ground with sparse vegetation and vernal pools for breeding and foraging.

Northwestern Pond Turtle

Northwestern pond turtles (*Actinemys marmorata*) were a candidate for listing as Federally threatened under the Endangered Species Act (ESA) and a state sensitive-critical species at the time the alternatives were analyzed. This species is present at Sunnyside Park at Foster Reservoir (Table 3.9-2). Past sightings of northwestern pond turtles have been reported in other locations in Foster Reservoir, although no pond turtles have been observed at Green Peter Reservoir.

[7] At the time the alternatives were analyzed, U.S. Bureau of Land Management Northern Spotted Owl Sites Publication Point Hub data were last updated April 3, 2024.

Northwestern pond turtles also occur in areas in or around Hills Creek, Lookout Point, Dexter, and Fall Creek Dams and Reservoirs and are typically found in protected reservoir coves or tributaries containing basking structures (logs or rocks).

Additionally, northwestern pond turtles are present throughout Fern Ridge Reservoir and are concentrated in East Kirk Pond/Park, directly north of the dam. ODFW manages Fern Ridge Wildlife Area and East Kirk Park; however, USACE biologists actively survey for pond turtles and remove non-native red-eared sliders from the area. The Fern Ridge Wildlife Area covers approximately half of the reservoir and consists of wetlands, wet prairie, oak and mixed woodlands, upland prairie, and freshwater aquatic habitats. East Kirk Park is one of 11 management units within the Fern Ridge Wildlife Area; the eastern two-thirds of the area is designated for wildlife.

This species has also historically and currently been observed in ponds below Dorena Dam. Past reports indicate northwestern pond turtles have occupied the river adjacent to Schwarz Park and were also observed in the southern portions of both Dorena and Cottage Grove Reservoirs (Adamus 2003; ORBIC 2024).

3.9.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives on wildlife and habitat. The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

3.9.3.1 Methodology

The method used to assess direct effects to wildlife, birds, and associated habitat was a qualitative analysis based on species presence or absence or suitable habitat present in the analysis area as shown in ORBIC, USFWS, and ODFW conservation strategy data as well as direct coordination with USFWS species experts.

Potential effects to wildlife and associated habitats within the analysis area are also the result of indirect effects related to hydrology, water quality, and fish passage measures proposed under each alternative.

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Construction effects are addressed qualitatively. Subsequent tiered analyses would detail site-specific construction effects during the implementation phase, and any applicable permits would be obtained at that time (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act).

Similarly, routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation).

END NEW TEXT

The environmental effects criteria and a summary of effects are provided in Table 3.9-3 and Table 3.9-4, respectively.

Table 3.9-3. Wildlife and Habitat Environmental Effects Criteria.

Degree of Adverse or Beneficial Effect and Extent of Effect	Definition
None/negligible	Species and/or habitat would not be affected, and no effects would be detectable (e.g., noise disturbance, physical harm, etc.).
Minor	Effects to the species and/or habitat would be detectable; however, effects would be only to a small number of individuals and would be localized (e.g., vacated habitats, evidence of a lethal effect to individuals, improvement of habitat function).
Moderate	Effects to the species and/or habitat would be measurable and include effects at the population and subbasin scale (e.g., lethal wildlife effects, loss or creation of suitable habitat, loss of prey base).
Major	Effects to species and/or habitat would be measurable and would have substantial ecological consequences at the population scale for multiple subbasins within the analysis area (e.g., lethal wildlife effects, loss or creation of habitat for special status species, adverse or beneficial effects to designated critical habitat). Long-term population effects would be anticipated.
Duration	
Short-term	Effect to species and/or habitat would be short in duration lasting only as long as a discrete construction project, single event, routine maintenance, or measure implementation (e.g., construction noise).
Long-term	Effect to species and/or habitat would be ongoing or lasts beyond operation changes, completion of construction projects, routine maintenance, or measure implementation. An impact would occur or re-occur over a long period of time and up to the 30-year implementation timeframe (i.e., effects that would occur over the 30-year implementation timeframe are considered long-term effects).

Table 3.9-4. Summary of Effects to Wildlife and Habitat as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Construction	Minor, adverse	Minor, adverse	Minor, adverse	Minor, adverse	Minor, adverse	Minor, adverse	Minor, adverse	Minor, adverse
Summer Water Surface Elevations	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species.	Moderate, beneficial due to sustained water source , supports the presence of aquatic prey species. Minor, adverse effects to northwestern pond turtle as nests may be inundated by high surface elevations.	Moderate, beneficial due to a sustained water source, supports the presence of aquatic prey species.	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species.	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species.	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species.	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species. Minor adverse effect to northwestern pond turtle as nests may be inundated by high surface elevations.	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species.
Winter Water Surface Elevations	Minor, adverse from increased distance from sheltering/foraging habitats to the water's edge requiring some species to travel longer distances for water.	Minor, adverse from increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water.	Moderate, adverse due to the additional deep drawdown at Green Peter and increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water. Moderate, adverse from dramatic changes in reservoir elevations over the year causing wetting/drying cycles for reservoir-adjacent habitats.	Moderate, adverse due to additional deep drawdown at Cougar and from increased distance from sheltering/ foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water.	Moderate, adverse due to additional deep drawdown at multiple reservoirs and increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water, which would have lasting generational impacts on wildlife populations.	Moderate, adverse due to the additional deep drawdown at multiple reservoirs and increased distance from sheltering/ foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water, which would have lasting generational impacts on wildlife populations.	Minor, adverse from increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water.	Moderate, adverse due to the additional deep drawdown at Green Peter and increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water. Moderate, adverse from dramatic changes in reservoir elevations over the year causing wetting/drying cycles for reservoir-adjacent habitats.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Downstream Habitat	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, beneficial to riparian wildlife habitat from increased summer flows. No gravel augmentation or revetment improvements, so no benefits. No effect to northwestern pond turtle downstream habitat from gravel augmentation. No effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, beneficial due to maintained instream flows. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse effects to northwestern pond turtle downstream habitat from gravel augmentation. No effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, channel alteration, and migration limitations. Minor, adverse from spring drawdown and associated high flows/sediment releases dislodging amphibian egg masses and burying mussel beds and aquatic invertebrates. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. Minor, beneficial effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, channel alteration, and migration limitations. Minor, adverse from spring drawdown and associated high flows/sediment releases dislodging amphibian egg masses and burying mussel beds and aquatic invertebrates Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. Minor, beneficial effects to prey and foraging availability from fish passage measures	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, benefits from increased flows downstream. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. No effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations and revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, benefits from increased flows downstream. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. No effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, beneficial due to maintained instream flows. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. No effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, adverse from spring drawdown and associated high flows and sediment releases dislodging amphibian egg masses and burying mussel beds and aquatic invertebrates. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. Minor, beneficial effects to prey and foraging availability from fish passage measures.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
ESA Threatened and Endangered Species	Negligible, adverse effects to Southern Resident killer whales from adverse effects to prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Minor benefits to northwestern pond turtles in summer with high water levels. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Minor benefits to northwestern pond turtles in summer with high water levels. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Minor benefits to northwestern pond turtles in summer with high water levels. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Minor benefits to northwestern pond turtles in summer with high water levels. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from multiple deep drawdowns resulting in lowered winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Spring deep drawdowns may negatively affect turtles by increasing the return distance to aquatic habitat. Minor, adverse effects from early drawdowns may reduce habitat availability and increase resource competition. Turtles that overwinter in reservoir bed may have to move to follow the drawdown resulting in greater energy expenditures. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from multiple deep drawdowns resulting in lowered winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Spring deep drawdowns may negatively affect turtles by increasing the return distance to aquatic habitat. Minor, adverse effects from early drawdowns may reduce habitat availability and increase resource competition. Turtles that overwinter in reservoir bed may have to move to follow the drawdown resulting in greater energy expenditures. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Minor benefits to northwestern pond turtles in summer with high water levels. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. No effect to northern spotted owl or streaked horned lark.

[1] The extent of all effects would be long term.

3.9.3.2 Alternatives Analysis

No-action Alternative

Under the No-action Alternative (NAA), existing operations and maintenance would not change. While no major construction is contemplated under the NAA, routine and non-routine maintenance would continue over the 30-year implementation timeframe. Direct, minor, adverse effects to wildlife from maintenance activities, such as noise and human activity, would be localized, minor, and short term. Additionally, such activities are common in all dam areas in the analysis area, suggesting wildlife in these areas may be adjusted to such short-term disturbances.

Summer Water Surface Elevations

Under the NAA, operations would continue to maintain water surface elevations at the highest level within reservoirs from May through September over the 30-year implementation timeframe. This would be a beneficial effect on wildlife and habitat in the analysis area. Hydrology would be retained that helps sustain water availability for a variety of mammals and birds and that supports the presence of aquatic prey species available to various predatory wildlife.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

Available open water aquatic habitat during the summer months under the NAA would continue to benefit a range of species, including amphibians such as the northern red-legged frog, reptiles such as the northwestern pond turtle, wading birds, aquatic diving birds, waterfowl, and furbearers such as the American beaver.

END REVISED TEXT

Additionally, amphibians would benefit from operations that maintain water levels in late winter through spring under the NAA when egg masses require inundation to keep the eggs from drying out.

Wetland fringe habitat maintained by reservoir operations under the NAA would continue to support wildlife species by retaining foraging, breeding, rearing, nesting, and sheltering habitat in these subbasin locations. High water surface elevations during the summer would also continue to provide easy access to water for a variety of upland wildlife species such as black-tailed deer, raccoons, voles, and Pacific martens (*Martes caurina*).

Winter Water Surface Elevations

Under NAA operations, adverse effects would occur to wildlife requiring access to the water's edge for foraging because of winter low pool elevations and especially with the deep drawdown conditions at Fall Creek Reservoir. Adverse effects would occur to wildlife unable to access lowered reservoir elevations when additional energy is expended in winter months to find other sources of water and locations for foraging. Under these low reservoir elevation conditions, wildlife would travel farther to access water and aquatic foraging habitat. This travel would require wildlife to traverse mudflats, posing physical limitations to larger species, such as ungulates, to access water.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

The deep drawdown at Fall Creek Reservoir would reduce the aquatic environment for northwestern pond turtles and require them to travel farther to their terrestrial overwintering sites or force them into a smaller aquatic environment where they would compete with other turtles for space and resources. Deep drawdowns may also be detrimental to amphibians who rely on reservoir tributaries for resources and to complete their life cycle.

END NEW TEXT

Downstream Habitat

Downstream flows would be managed during flood events by dam operations and through the existence of revetments under the NAA for the 30-year implementation timeframe. Control of these flows and reduction of flood events would create adverse effects on wildlife by preventing flood inundation of these habitat types within the Willamette River Basin, resulting in disconnection of the floodplain. This would result in habitat fragmentation and overall habitat reduction of downstream wetland and riparian corridor habitat important to numerous species in the analysis area. Further, habitat fragmentation resulting from floodplain disconnection would reduce foraging and sheltering habitat. Migration corridors would also be fragmented with this disconnection, reducing the potential for individual movement that could create genetic islands that reduce overall wildlife biodiversity.

Additionally, habitat would be fragmented by revetment management. Combined with limited fish passage under the NAA, there would continue to be adverse effects to fish-eating birds and mammals in the analysis area.

Flow operations to meet the 2008 NMFS Biological Opinion targets and use of the inactive or power pool at Green Peter Reservoir would support flows that maintain downstream aquatic and riparian habitat when precipitation is reduced during the summer months. The contribution of these flows to streamside habitats would be a minor benefit to wildlife in the analysis area under the NAA.

Endangered Species Act Threatened and Endangered Species

Southern Resident Killer Whale

The primary essential feature for Southern Residents in the northern Oregon inshore areas is prey (86 FR 41668). Salmon are an important part of the prey base for Southern Resident killer whales, particularly Chinook salmon, which are present in the EIS alternatives analysis area.

Implementation of the NAA would adversely affect some Upper Willamette River salmon species because of habitat fragmentation and limited fish passage. Consequently, Southern Resident killer whales may be adversely affected by continued declines in these salmon species as an available food source. However, USACE funds the operation and maintenance of five hatcheries for mitigation and conservation within the WVS, which would continue to produce salmon as Southern Resident prey. Additionally, Upper Willamette River salmon species are not the primary prey base for Southern Resident killer whales, so adverse effects would likely be negligible over the 30-year implementation timeframe (NMFS 2024).

Contaminants can adversely affect fish that are prey for Southern Residents. Mercury is known to be a legacy contaminant in the Willamette River Basin and can accumulate in fish tissue (Section 3.18, Hazardous, Radioactive, and Toxic Waste). However, mercury contamination has not been identified as a specific limiting factor on Southern Residents (NMFS 2008). Consistent with the NMFS 2024 Biological Opinion, there would be no adverse effect on Southern Residents from water quality conditions in the analysis area under any alternative (NMFS 2024) (See also Section 4.5, Water Quality, cumulative effects).

Northern Spotted Owl

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

As of April 2024, sightings of northern spotted owls were recorded near Cottage Grove, Dorena, Dexter, Lookout Point, Fall Creek, Foster, and Green Peter Dams by the U.S. Bureau of Land Management (BLM 2024). Although nesting and roosting habitat likely exists in forested areas surrounding the WVS dams and reservoirs, there would be no direct, beneficial or adverse effects on northern spotted owls under NAA operations because changes in reservoir elevations or downstream instream flows would not impact habitat necessary for this species.

Disturbance could occur from noise if owls are in the vicinity of a construction area, but these effects would be short-term and temporary, lasting only while construction was ongoing. Temporary disturbances would not likely permanently displace owls present in the vicinity of any dam. Any activities on USACE-managed lands that have the potential to impact northern spotted owls would be reviewed through an ESA Section 7 consultation with USFWS.

END REVISED TEXT

Streaked Horned Lark

There would be no direct, beneficial or adverse effects on streaked horned larks under the NAA because changes in reservoir elevations or downstream instream flows would not impact habitat necessary for this species.

Northwestern Pond Turtle

Over the 30-year implementation timeframe, continued implementation of the NAA is anticipated to provide minor benefits to northwestern pond turtle populations during the summer season in the Long Tom River Subbasin, Middle Fork and Coast Fork Willamette River Subbasins, and the North Santiam River Subbasin (if present). These benefits would result from water levels that support the semi-aquatic life cycle of turtles by maintaining aquatic habitat for basking and foraging.

Conversely, winter operations would reduce reservoir water surface elevations that would moderately adversely affect northwestern pond turtles. Reduced water levels would result in increased distances turtles would need to travel from their aquatic environment to terrestrial overwintering sites under NAA operations.

Alternative 1—Improve Fish Passage through Storage-focused Measures

Operations under Alternative 1 would include minor changes to habitat, habitat access, and foraging opportunities when compared to the NAA. Adverse effects from construction and routine and non-routine maintenance would be the same as described under the NAA.

Summer Water Surface Elevations

Compared to the NAA, Alternative 1 operations would marginally increase habitat availability by maximizing refill volumes of conservation pools. Subsequently, wetland fringe habitat that supports foraging, breeding, rearing, nesting, and sheltering habitat would be increased. This would result in beneficial effects to a wide variety of species by providing foraging opportunities and water availability. However, northwestern pond turtle nests could be inundated if water surface elevations rise over the summer.

Winter Water Surface Elevations

Reservoir drawdowns for flood operations would have the same effects on analysis area wildlife as the NAA operations.

Downstream Habitats

Flow modification under Alternative 1, including increased use of power pools and inactive pools, would increase the potential to maintain instream flows later in the summer. This increase would be localized and beneficial as compared to the NAA; however, water levels in downstream reaches would not be measurably affected.

Maintained instream flows would improve conditions for fish and other aquatic organisms under Alternative 1, resulting in increased foraging opportunities for wildlife species dependent on fish as a food source such as osprey, diving ducks, river otters, and eagles. Gravel augmentation that would create increased opportunities for habitat instream improvements would also benefit American beavers, great blue herons, and frogs. Depending on where gravel is placed and the amount, it may be detrimental to northwestern pond turtles by filling in deep pools and off-channel habitats they often use. However, this increase would be localized, and water levels in downstream reaches would be similar to those under NAA operations.

Downstream flows would be managed during flood events and through the existence of revetments under Alternative 1 operations. As under the NAA, adverse effects to wildlife would result from these operations by disconnecting the floodplain and by limiting the size of available downstream wetland and riparian corridor habitat important to numerous species in the analysis area.

Endangered Species Act Threatened and Endangered Species

Overall, implementation of Alternative 1 would result in effects to threatened and endangered wildlife as described under the NAA. However, there would be increases in adult UWR Chinook salmon abundance under all action alternatives, including Alternative 1, which would benefit Southern Resident killer whales. There is some uncertainty on the range of this benefit since UWR Chinook salmon comprise only a small percentage of Southern Resident killer whale prey. As under the NAA, the hatchery mitigation program would continue to provide salmon available as prey to Southern Residents under all action alternatives.

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Deep drawdowns at Fall Creek would continue under Alternative 2A operations. Additionally, deep drawdown operations at Green Peter Reservoir would occur that would cause changes to habitat, habitat access, and foraging opportunities when compared to NAA operations. Adverse effects from construction and routine and non-routine maintenance would be the same as described under the NAA.

Summer Water Surface Elevations

Under Alternative 2A operations, effects from summer water surface elevations would be the same as described under the NAA.

Winter Water Surface Elevations

Seasonal drawdowns would cause wildlife to seek alternative water sources during the drawdown time periods. However, drawdowns would not occur during the predominant breeding season (spring), which would reduce the potential overall adverse effect on wildlife in the analysis area.

The deeper drawdown at Green Peter would adversely affect wildlife species' access to the water during the drawdown within the South Santiam River Subbasin. Species such as black-tailed deer, elk, raccoons, ermine, and coyotes would need to travel farther to get to the water's edge and in some areas may need to cross steep unvegetated slopes. Additionally, the seasonal drawdown may cause wildlife attempting to access the water's edge to locate alternative water sources in the vicinity of the reservoirs during the drawdown time periods.

In addition, the increased frequency and deeper drawdowns, when compared to the NAA, would increase adverse effects to wildlife species that build lodges, burrows, or dens along the water's edge such as beavers, muskrats, and otters. The dramatic changes in reservoir surface levels throughout the year would flood these habitat structures at certain times of year and leave them exposed and dry at other times. This would cause animals to build multiple habitat structures throughout the year in these locations.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

The fall drawdown would result in loss of aquatic habitat, particularly in tributaries, for amphibians that have a two-part complex lifecycle that includes aquatic and terrestrial phases. Species, such as the Pacific giant salamander, would be adversely affected.

Downstream Habitat

The downstream impacts of reservoir drawdown could include the burying of freshwater mussel beds and aquatic invertebrates. Movement of non-native fish from the reservoirs to off-channel habitats could lead to increased predation of native fish, amphibians, and turtle hatchlings in the South Santiam River Subbasin.

Additionally, the reduction of peak flows would cause changes in the floodplain forest. The lack of sediment moving downstream coupled with lateral channel migration would continue to minimize substrate in downstream habitat and create channel downcutting/avulsion. This would cause adverse habitat conditions for native fish, amphibians, and turtles under Alternative 2A.

As under NAA operations, flood management from revetments and flood operations would continue to fragment riparian and wetland habitat and reduce overall habitat availability. However, improvements to fish passage and survival under Alternative 2A may improve prey availability and foraging opportunities for fish-dependent wildlife as compared to the NAA, resulting in minor, direct, beneficial effects to downstream habitat.

Endangered Species Act Threatened and Endangered Species

Effects to northern spotted owls and streaked horned larks would be the same as described under the NAA. Effects to Southern Resident killer whales would be the same as described under Alternative 1.

Northwestern Pond Turtle

In contrast to the NAA, under Alternative 2A operations, overwintering northwestern pond turtles would need to travel longer terrestrial distances to suitable habitat, or if they are overwintering in reservoirs, turtles would need to adjust their locations as the reservoirs draw down.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Alternative 2B operations include drawdown operations at Fall Creek and Cougar Reservoirs that would result in changes to habitat, habitat access, and foraging opportunities when compared to NAA operations. Adverse effects from construction and routine and non-routine maintenance would be the same as described under the NAA.

Summer Water Surface Elevations

Under Alternative 2B operations, effects from summer water surface elevations would be the same as described under the NAA.

Winter Water Surface Elevations

Operations under Alternative 2B would result in adverse effects to wildlife in the analysis area because of deep drawdowns at Fall Creek and Cougar Reservoirs. Effects to wildlife from access to water and inundation of habitat structures such as dens and burrows, would be the same as those described under Alternative 2A.

Unlike the NAA, there would be a loss of wetland habitat adjacent to these reservoirs under Alternative 2B during spring and fall drawdowns.

Downstream Habitats

Under Alternative 2B, adverse effects to downstream habitats would be the same as those described under Alternative 2A in the McKenzie River Subbasin. The spring drawdown would create higher flows that dislodge amphibian egg masses and larvae downstream and bury mussels and aquatic invertebrates. Furthermore, higher flows in spring could result in inundation of turtle nesting areas resulting in hatchling/egg mortality. Similarly, the increased downstream flows due to the fall drawdown could result in northwestern pond turtle nest mortality if flows are high enough and turtles lay nests adjacent to the riverbed.

As under NAA operations, flood management from revetments and flood operations would continue to fragment habitat, impede migration, and reduce overall habitat availability under Alternative 2B. However, improvements to fish passage and survival under Alternative 2B may improve prey availability and foraging opportunities for fish-dependent wildlife as compared to the NAA, resulting in minor, direct, beneficial effects to downstream habitat.

Endangered Species Act Threatened and Endangered Species

Effects of the Alternative 2B drawdowns to threatened and endangered species would be the same as those described under Alternative 2A operations because there would be no measurable distinction in effects resulting from operational differences between these alternatives.

<u>Alternative 3A—Improve Fish Passage through Operations-focused Measures</u>

Operations under Alternative 3A would include drawdowns at multiple reservoirs resulting in changes to habitat, habitat access, and foraging opportunities when compared to the NAA.

Adverse effects from construction and routine and non-routine maintenance would be the same as described under the NAA.

Summer Water Surface Elevations

Under Alternative 3A, effects from water surface elevations during the conservation season would be the same as described under the NAA.

Winter Water Surface Elevations

Operations under Alternative 3A would result in adverse effects on wildlife in the analysis area because of the increased number of deep drawdowns as compared to NAA operations. Adverse effects would be long-term because of the potential generational impact that operations would have on wildlife populations throughout the analysis area during the 30-year implementation timeframe. Requirements such as increased energy expenditure to access water and foraging areas would be multiplied as compared to the NAA because of the increased number of reservoirs where these adverse conditions would occur.

Endangered Species Act Threatened and Endangered Species

Effects to northern spotted owls and streaked horned larks would be the same as described under the NAA. Effects to Southern Resident killer whales would be the same as described under Alternative 1.

Northwestern Pond Turtles

Northwestern pond turtles would experience increased adverse effects, as compared to the NAA, because during the fall deep drawdown, they would expend more energy traveling farther from their aquatic environment to terrestrial overwintering sites.

Multiple deep drawdown operations under Alternative 3A would have increased adverse effects, when compared to NAA operations, to turtle movements in the fall and potentially the spring. More time traveling over land may result in additional energy expenditures and increased potential for predation.

Early drawdowns (starting during the summer and continuing into the fall) under Alternative 3A, would force turtles into a smaller aquatic area as water surface elevations recede. This recession may increase intraspecific competition for resources (e.g., food, basking structures, suitable habitat). For those turtles that overwinter in the reservoir bed, turtles may follow the reservoir drawdown and move periodically to avoid predation, which would result in greater energetic expenditures.

Downstream Habitats

While there would be some minor improvements compared to the NAA for downstream riparian and wetland habitats, adverse effects would continue due to limits in overall habitat connectivity from flood management and revetments under Alternative 3A.

Alternative 3B—Improve Fish Passage through Operations-focused Measures

Under Alternative 3B, effects to northern spotted owls and streaked horned larks would be the same as described under the NAA. Effects to Southern Resident killer whales would be the same as described under Alternative 1. Effects to northwestern pond turtles would be the same as described under Alternative 3A.

Alternative 4—Improve Fish Passage with Structures-based Approach

Under Alternative 4 operations, effects to wildlife, including threatened and endangered species, in the analysis area would be the same as those described under Alternative 1.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Under Alternative 5 operations, effects to wildlife, including threatened and endangered species, in the analysis area would be the same as those described under Alternative 2A.

3.9.4 Interim Operations under All Action Alternatives Except Alternative 1

The timing and duration of Interim Operations would vary depending on a given alternative. Interim operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Overall effects on wildlife in the analysis area would be the same under implementation of Interim Operations as under the NAA because drawdown operations would be similar to the NAA operations.

As under the NAA, drawdown impacts from the Interim Operations on wildlife, including threatened and endangered species, in the analysis area may reduce access to reservoir surface waters and impact nests, dens, and other habitation structures. Downstream effects on wildlife in the analysis area are not anticipated to be substantial because of the limited measurable contribution that these operations would have on instream flow elevations. Further, the Interim Operations would not impact revetments or change downstream habitat connectivity.

Decline in water quality due to increased transport of fine sediments during extreme drawdowns at Lookout Point and Green Peter Reservoirs may have localized, adverse effects on wildlife downstream from these reservoirs. However, impacts are anticipated to be short-term during the drawdown periods and are anticipated to eventually minimize once reservoir bed sediments stabilize.

3.9.5 Climate Change Effects under All Alternatives

Climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions and independent of the WVS operations and maintenance activities over the 30-year implementation timeframe (Hamlet 2010; RMJOC 2020) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources, Section 3.1, Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

Overall, climate change conditions would likely decrease available habitat for species in the analysis area, resulting in adverse effects to amphibians, reptiles, and those terrestrial species that rely on water bodies for foraging such as birds and bats. These adverse effects would occur under all alternatives during the 30-year implementation timeframe.

Effects from climate change including, but not limited to, increased water temperatures in the Willamette River and more frequent and intense wildfires in the Willamette River Basin have negatively impacted wildlife habitat within the analysis area at the time the alternatives were analyzed (Halofsky et al. 2020; Talke et al. 2023). Changes to habitat in the analysis area from increased wildfires, drought, and low summer flows, for example, will likely increase stress on wildlife species to find suitable habitat. For example, amphibian breeding success will be adversely affected, reptile foraging will be altered, and raptor prey base will be diminished.

Additionally, climate change is anticipated to continue to increase water temperature over time as ambient temperatures increase and snowmelt contributes less runoff or earlier runoff within the Basin. Such temperature increases will adversely affect wildlife prey species, such as fish, important to fish-eating species such as Southern Resident killer whales and raptors (Pörtner and Peck 2010).

Increased water temperatures would also cause a greater frequency of algal blooms[8], which can introduce toxins both to prey species (e.g., fish) as well as species higher up the food chain that ingest these toxins (Section 3.5.4, Water Quality, Climate Change under All Alternatives).

[8] USACE contracted Portland State University to produce a CE-QUAL-W2 model utilizing physical parameters and potential algae bloom response within Dexter Reservoir (Cervarich et al. 2020). Analyses included scenarios for climate change and structural changes (i.e., power intake, Lowell Covered Bridge, and the curtain weir at the bridge). Results showed the simulated algae bloom was eliminated with structural changes and intensified with climate change scenarios (Cervarich et al. 2020).

The seasonality of wildlife species' life histories[9] will be forced to adapt to the changing climate patterns (e.g., birds, reptiles, insects, etc.), which is anticipated to have a number of adverse effects to species, interactions between species, interactions with their habitats, and likely, overall survival of species that cannot adapt to changing conditions such as air and water temperature increases or loss of suitable habitat.

END REVISED TEXT

Photo by Wes Messinger (USACE Media Images Database)
Fender's blue butterfly (*Icaricia icarioides fender*).

[9] The life history of an organism is its pattern of survival and reproduction along with the traits that directly affect survival and the timing or amount of reproduction (Oxford Bibliographies 2013).

US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.10 AIR QUALITY AND GREENHOUSE GAS EMISSIONS

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Photo by Mike Pomeroy (USACE Media Images Database)

Detroit Dam during 2020 Santiam Fires.

3.10 Air Quality and Greenhouse Gas Emissions

THIS SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **Additional information has been added regarding greenhouse gas emissions, including information on the socioeconomic effects of greenhouse gas emissions under each alternative. The DEIS section title has been changed.**
- **DEIS effects analyses to air quality from fugitive dust and pollutants during drawdowns have been deleted because, after further analysis, there would be no potential for a significant impact from this activity under any alternative.**
- **The DEIS effects analyses from Near-term Operation Measures have been deleted because the potential effects would be the same as the direct and indirect effects analyzed under all alternatives. Additionally, details regarding power generation under Interim Operations are analyzed in Section 3.12, Power Generation and Transmission (note that the term "Near-term Operations" has been changed to "Interim Operations" throughout the EIS).**
- **Additional information on climate change and its relationship to wildfires and air quality effects has been added (FEIS Section 3.10.4.1, No-action Alternative, Climate Change).**
- **Additional information on the Implementation and Adaptive Management Plan has been added to the action alternatives climate change analyses (FEIS Section 3.10.4.1, No-action Alternative, Climate Change; Section 3.10.4.2, All Action Alternatives, Climate Change).**

3.10.1 Introduction

Air quality is the measure of the atmospheric concentration of defined pollutants in a specific area. Air quality is affected by pollutant emission sources as well as the movement of pollutants in the air via wind and other weather patterns. An air pollutant is any substance in the air that can cause harm to humans or the environment. Pollutants may be natural or human-made and may take the form of solid particles, liquid droplets, or gases (UCAR 2025).

Natural sources of air pollution include smoke from wildfires, dust, and wind erosion. Human-made sources of air pollution include emissions from vehicles, dust from unpaved roads or construction sites, facilities, smoke from coal-burning power plants, toxic gases from industry, and smoke from prescribed fires (UCAR 2025).

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

Greenhouse gases trap heat in the Earth's atmosphere, contributing to planet warming and shifting climate patterns. Some greenhouse gases occur naturally in the atmosphere, such as water vapor, carbon dioxide, methane, and nitrous oxides[1], although human activities (such as the burning of fossil fuels for energy) increase their abundance. Other greenhouse gases, such as fluorocarbons, are synthetic. Greenhouse gases are often measured in terms of their relative global warming potential, which is a common unit of measure that allows comparisons of the potential climate change impacts of different greenhouse gases[2].

In the United States, most emissions of human-caused greenhouse gases are from carbon dioxide, which comes primarily from burning fossil fuels—coal, natural gas, and petroleum—for energy use (EIA 2023a). Economic growth (with short-term fluctuations in growth rate) and weather patterns that affect heating and cooling needs are the main factors that drive the amount of energy consumed (EIA 2023a). Human-caused methane comes from landfills, coal mines, agriculture, and oil and natural gas operations, whereas nitrous oxides come from using nitrogen fertilizers and burning fossil fuels and certain industrial and waste management processes (EIA 2023a).

END NEW TEXT

[1] Nitrous oxides refers to the gas nitrous oxide (NO2). Nitrogen oxide(s) is a broad category that encompasses several gases including nitric oxide (NO) and nitrogen dioxide (NO2).

[2] Global warming potential (GWP) is a measure of the radiative forcing of a greenhouse gas relative to carbon dioxide (IPCC 2014). Radiative forcing properties of greenhouse gases are due to absorption and reflection of infrared radiation back to the Earth's surface. The GWP was developed to allow comparisons of the global warming impacts of different gases and is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time (100 years is the standard used for GWPs), relative to the emissions of 1 ton of carbon dioxide (EPA No Date-a). The larger the GWP, the more that a given gas warms the Earth compared to carbon dioxide over the time period (EPA No Date-a).

Carbon dioxide, by definition, has a GWP of 1 regardless of the time period used because it is the gas being used as the reference (EPA No Date-a). The global warming potential of methane ranges from 27 to 30 times that of carbon dioxide over 100 years, and nitrous oxide is 273 times that of carbon dioxide over 100 years (EPA No Date-a). Some fluorinated gases' greenhouse gas potential is in the thousands. The range in greenhouse gas potential relates to uncertainty regarding climate carbon feedback, which is the effect that changing climate has on the carbon lifecycle (EPA No Date-a). As described by their relative greenhouse gas potentials, greenhouse gases vary in their radiative intensity. Some greenhouse gases persist longer in the atmosphere than others and some have more of a radiative effect (EPA No Date-a).

3.10.2 Affected Environment

Operation and maintenance of the Willamette Valley System (WVS) would primarily affect air quality by air emissions generated from diesel trucks during fish trucking operations and diesel-powered generator use at dam locations (Section 3.10.2.1, Air Emissions from U.S. Army Corps of Engineers Operations and Maintenance Activities). Air quality would also be affected by construction or maintenance activities, including operation of vehicles, machinery, and other heavy equipment. Greenhouse gases would also be affected by these activities as well as by power generation. Federal and state regulations addressing air quality in the WVS are described in Section 3.10.2.2, Federal and State Regulations.

The analysis area for air quality is Lane, Linn, and Marion Counties, Oregon. Within these counties, USACE operates and maintains 13 dams and reservoirs, 5 adult fish facilities, 5 fish hatcheries, and trap-and-haul fish trucking operations that transport fish above and below existing reservoirs (Figure 1.1-1). The Affected Environment and analysis area for greenhouse gas emissions is extended to include the State of Oregon because greenhouse gases become free to move within the atmosphere once they are emitted and can travel far away from their sources.

3.10.2.1 Air Emissions from U.S. Army Corps of Engineers Operations and Maintenance Activities

Air Emissions from U.S. Army Corps of Engineers Operations and Maintenance Activities

This section addresses USACE operations and maintenance activities that generate air emissions within the WVS and describes those emissions, specifically diesel emissions.

Sources of Air Emissions

Operations, maintenance, and vehicles generate air emissions throughout the analysis area. The two primary sources of air emissions within the WVS within Lane, Linn, and Marion Counties are diesel generators used at various dams and fish trucking operations using light- and medium-duty diesel trucks.

Dam and hatchery operations and maintenance activities require emergency diesel generators to supply electricity to heat and cool buildings and to power equipment and machinery. Emergency diesel-powered generators located at all dams and hatcheries are individually operated less than 50 hours per year. Fish trucking operations utilize light- and medium-duty trucks to transport fish and generate air emissions from diesel-powered internal combustion truck engines.

Overall, fish trucking accounts for nearly 92,000 miles worth of diesel fuel emissions per year, while 22 diesel-powered generators account for additional diesel air emissions (Table 3.10-1).

Table 3.10-1. USACE Air Emission Sources in the Analysis Area including Facilities and Related Activities.

Dam and Reservoir	Adult Fish Facilities	Hatcheries	Fish Trucking Trap-and-Haul Routes	Fish Trucking Mileage Per Year	Number of Emergency Diesel Generators
Lane County					
Cougar	Cougar Adult Fish Facility	None	30-mile round trip	8,294	2
Dexter	Dexter Adult Fish Facility	None	30-, 70-, 80-, and 100-mile round trips	23,040	1
Hills Creek	None	Willamette Fish Hatchery	None	7,680	2
Fall Creek	Fall Creek Adult Fish Facility	None	18-mile round trip	4,608	2
Blue River	None	Leaburg Hatchery[1]; McKenzie Hatchery[2]	None	4,352	2
Lookout Point	None	None	None	20,915	2
Dorena	None	None	None	None	1
Cottage Grove	None	None	None	None	1
Fern Ridge	None	None	None	None	1
Linn County					
Foster	Foster Dam Adult Fish Facility	South Santiam Fish Hatchery	40- and 50-mile round trips	4,480	2
Green Peter	None	Marion Forks Hatchery[3]	None	2,560	2
Marion County					
Big Cliff	Minto Adult Fish Facility	None	40- and 60-mile round trips	12,416	2
Detroit	None	None	None	3,635	2
TOTAL				**91,980**	**22**

[1] Leaburg Hatchery is approximately 19 miles from Blue River Dam.

[2] McKenzie Hatchery is approximately 20 miles from Blue River Dam.

[3] Marion Forks Hatchery is approximately 60 miles from Green Peter Dam. This is the closest dam to the hatchery facility within Linn County.

Diesel Air Emissions

Diesel is the dominant fuel used by the commercial transportation sector because it offers fuel economy, power, and durability. In the United States, approximately 80 percent of all freight is moved by diesel engines, while most non-road equipment used in the construction, agriculture, marine, and locomotive sectors is powered by diesel (ODEQ No Date-f).

Diesel engines emit large amounts of nitrogen oxides[3], particulate matter (in particular $PM_{2.5}$), carbon, and other toxic air pollutants (ODEQ No Date-f). Diesel particulate matter is linked to several serious health problems, including aggravating asthma, heart and lung disease, cancer, and premature mortality (ODEQ No Date-f). In 2012, diesel exhaust was classified as a known carcinogen to humans based on sufficient evidence that exposure to diesel engine exhaust is associated with increased lung cancer risk (ODEQ No Date-f).

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

Diesel exhaust also has environmental significance as a global warming greenhouse gas contributor due to carbon dioxide and black carbon particulate. In 2021, diesel fuel consumption in the United States' transportation sector resulted in the emission of about 472 million metric tons of carbon dioxide (EIA 2022). This amount was equal to about 26 percent of total United States' transportation-sector carbon dioxide emissions and equal to about 10 percent of total United States' energy-related carbon dioxide emissions in 2021 (EIA 2022).

END NEW TEXT

Black carbon represents about 70 percent of the particulate emitted by a diesel engine. Black carbon only lasts in the atmosphere for a few weeks to months but is second only to carbon dioxide as a potent climate change driver. Diesel engines are the largest source of black carbon in North America (ODEQ No Date-f).

Over half of all diesel particulate emissions in Oregon are from on-road vehicles, such as trucks, buses, and other traffic; 30 percent of diesel particulate matter is generated from non-road vehicles, such as construction equipment; and 14 percent is generated by trains, ships, and generators (Figure 3.10-1) (ODEQ No Date-j). USACE operations and maintenance within the WVS would contribute to all categories of diesel particulate emissions under any alternative.

[3] Nitrous oxides refers to the gas nitrous oxide (NO2). Nitrogen oxide(s) is a broad category that encompasses several gases including nitric oxide (NO) and nitrogen dioxide (NO2).

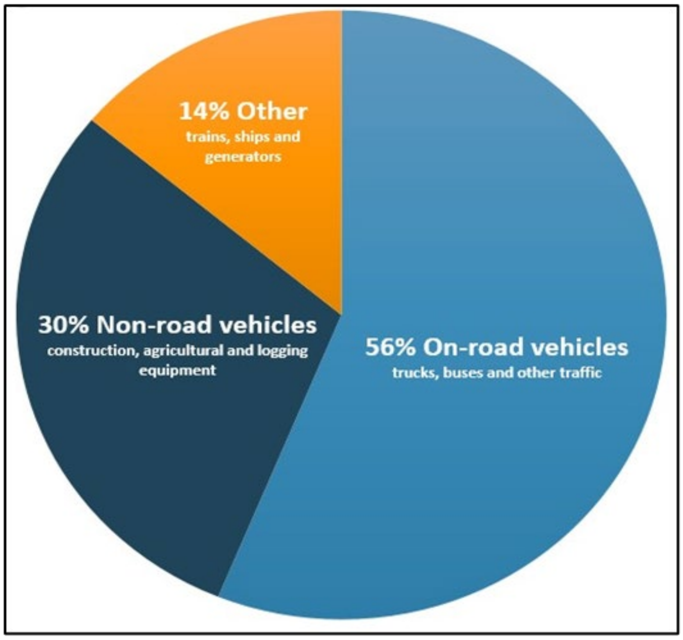

Figure 3.10-1. Oregon Statewide Diesel Particulate Matter Emissions.

Source: ODEQ No Date-j

Construction Activities and Fugitive Emissions

Construction activities such as bulldozing, hauling, and construction vehicle travel rely on diesel equipment to provide necessary operational power. Environmental Protection Agency (EPA) regulations apply to new engines while older diesel engines are not regulated by EPA and can remain in operation for 30 years or more. EPA offers funding, as appropriated annually by Congress, for programs and projects that reduce emissions from existing diesel engines.

For example, EPA's *Clean Air Construction* is a program designed to promote the reduction of diesel emissions from construction equipment and vehicles. The program provides funding opportunities for clean diesel projects and information on strategies for reducing emissions from older engines, including idle-reduction practices, retrofitting engines, opting for cleaner fuels, properly maintaining equipment, and replacing vehicles or engines with models that save money and fuel while reducing emissions (EPA 2021a; EPA 2024d).

Secondary sources of air emissions include construction activities and fugitive dust. The use of construction vehicles and equipment, such as bulldozers, cranes, and other heavy equipment, results in tailpipe emissions to the air from internal combustion diesel engines.

Fugitive dust is a type of particulate matter that becomes airborne by wind or other similar forces (EPA 2021b). Fugitive dust generation can occur from construction activities or from driving on unpaved roads.

Oregon Administrative Rules (OAR) 340-208-0210 specify requirements for fugitive dust emissions:

> No person may cause or permit any materials to be handled or transported; any building or road to be used, constructed, altered, repaired, or demolished; or any equipment to be operated – without taking reasonable precautions to prevent particulate matter from becoming airborne. Precautions may include but are not limited to using water or chemicals for dust control during demolition or construction of buildings or structures, the grading of roads, or the clearing of lands; covering open bodied trucks transporting materials likely to become airborne; and full or partial enclosure of material stockpiles to prevent particulate matter from becoming airborne.

If fugitive particulate emissions escape the containment source, the Oregon Department of Environmental Quality may order the owner or operator to abate the emissions, including the development of a Fugitive Emission Control Plan (OregonLaws 2021).

THE DEIS HAS BEEN MODIFIED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

Additional Sources of Emissions Reported as National and State Inventory Data

The EPA publishes the National Emissions Inventory every 3 years to catalog air pollutant and greenhouse gas emissions by source, county, state, and pollutant type, which includes the analysis area (Table 3.10-2). Emission levels of carbon monoxide, nitrogen dioxides, sulfur dioxide, and PM10 have been trending downward at most locations across Oregon over the last 10 years (ODEQ 2021f). In addition to human-caused sources, some of the largest sources of air emissions come from natural occurrences. Wildfires, for example, are a major cause of air pollutants and greenhouse gases in Oregon, contributing to 80 percent of the total PM2.5, 59 percent of total carbon monoxide, and 84 percent of total methane reported in 2020 (EPA No Date-b). Wildfires are also increasing, and seasonal patterns of carbon dioxide and other pollutants emitted by wildfires have been increasing in August and decreasing in other months (Buchholz et al. 2022).

Table 3.10-2. Summary of 2020 Emissions Reported in the Three Analysis Area Counties and State of Oregon.

Emission Type	Analysis Area Counties (tons)[c]	State of Oregon (tons)[c]
Criteria Air Pollutants		
Ammonia	57,690	169,078
Carbon Monoxide	3,243,226	7,666,078
Nitrogen Oxides	37,679	123,229
PM2.5 Primary (Filterable + Condensable)	418,857	1,268,340

Emission Type	Analysis Area Counties (tons)[c]	State of Oregon (tons)[c]
PM10 Primary (Filterable + Condensable)	283,239	708,913
Sulfur Dioxide	21,111	53,830
Volatile Organic Compounds	837,560	2,341,936
Hazardous Air Pollutants		
114 Types (analysis area counties)/132 Types (Oregon)[a]	89,681,217	32,715,700
Greenhouse Gases		
Carbon Dioxide	32,715,700	89,681,217
Methane[b]	4,334,099	10,913,476
Nitrous Oxides[b]	3,823	104,332

Source: EPA No Date-b

[a] Includes mercury compounds that constitute 0.033 tons in the analysis area counties and 0.202 tons in Oregon.

[b] Amounts provided in carbon dioxide equivalents (CO_2e).

[c] Amounts depicted for both the Analysis Area Counties (Lane, Linn, and Marion Counties) and the State of Oregon reflect data combined from two separate spreadsheets (County Level Data and Facility Level Data) obtained from the National Emissions Inventory (NEI): 2020 NEI Date Retrieval Tool. County Level Data contains on-road mobile, nonroad mobile, and nonpoint emissions information and Facility Level Data contains point source emission information. The NEI tool is available online at: https://awsedap.epa.gov/public/single/?appid=20230c40-026d-494e-903f-3f112761a208&sheet=5d3fdda7-14bc-4284-a9bb-cfd856b9348d&opt=ctxmenu,currsel.

Oregon Greenhouse Gas Emissions

States often create greenhouse gas emission inventories to set emission reduction goals, establish baselines, and catalog emission levels by sector and over time. Oregon, through its Department of Environmental Quality, uses a consumption, sector-based inventory to report greenhouse gas emissions. This inventory includes carbon dioxide and other greenhouse gases (e.g., methane, etc.) that are then converted to a carbon dioxide equivalent (CO2e) for comparison by sector.

Total 2021 greenhouse gas emissions in Oregon were 61 million metric tons CO2e, which is equivalent to about 13.6 million gasoline-powered passenger vehicles driven for 1 year. This is about 13 percent lower than 2000 levels (70 million metric tons CO2e), or approximately 2 million fewer vehicles driven for 1 year (ODEQ No Date-b).

Similar to past years, transportation (35 percent) and electricity use (29 percent) together accounted for most emissions in 2021 (ODEQ No Date-b). Since 2000, transportation emissions have remained constant in Oregon at or around 23 million metric tons CO2e with largest contributors being on-road gasoline motor and diesel fuel vehicles (ODOE 2022), while electricity use emissions have fluctuated but declined to about 18 million metric tons CO2e from a high of about 23 million metric tons CO2e (ODEQ No Date-b).

At the national level, the primary source of greenhouse gas emissions is fossil fuel combustion for electricity generation and transportation (EPA No Date-d). However, due to the prevalence of hydropower in the Pacific Northwest, greenhouse gas emissions from electric power generation in Oregon are relatively low compared to the rest of the nation.

Power Generation in Oregon and the Pacific Northwest Region

Historically, hydropower and fossil fuel-fired resources (coal and natural gas) have been relied upon heavily in Oregon to meet power demands. A recent 2020 closure of the last coal-fired plant in Oregon eliminated about *2 million tons* of greenhouse gas emissions annually emitted from the plant (OPB 2020), leaving hydropower and natural gas as the current predominant resources used to meet power demands.

Eight of the 13 WVS dams are managed for hydropower generation (Chapter 1, Introduction, Section 1.7.1, Dams and Reservoirs), which contribute to the power generation resource mix in Oregon and the Pacific Northwest region. The primary source of greenhouse gas emissions from WVS operations and maintenance activities is not from hydropower generation itself, but from conditions (typically water year-related) that limit the ability to generate hydropower and that result in an increase in the amount of greenhouse gas-emitting natural gas generation used to meet power needs. Hydropower maintenance activities would also contribute a negligible amount of greenhouse gas emissions through use of vehicles and equipment.

Emissions from electric power generation in the Pacific Northwest, including Oregon, tends to fluctuate with the level of hydropower generation. For example, in years of poor water conditions emission rates are higher because the use of fossil fuel-fired resources increases to make up for the decrease in hydropower generation, which then increases emissions from fossil fuel-fired powerplants (Herrera-Estrade et al. 2018). Conversely, increases in hydropower generation would be expected to displace power that must be purchased from suppliers connected to the regional electric system (grid). To the extent that the displaced power would have been generated by fossil fuel-fired powerplants, emissions of pollutants from these plants would decrease.

END NEW TEXT

3.10.2.2 Federal and State Regulations

Federal Ambient Air Quality Standards

Under the Clean Air Act, EPA establishes National Ambient Air Quality Standards (40 CFR Part 50) for six principal pollutants that can be harmful to public health and the environment (Chapter 7, Compliance with Environmental Laws, Regulations, and Executive and Secretarial

Orders). These six principal pollutants include particulate matter[4] (PM), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and lead (Pb).

The Clean Air Act (CAA) identifies two types of National Ambient Air Quality Standards:

1. Primary standards that provide public health protection and that safeguard the health of sensitive populations such as people with asthma, children, and the elderly.
2. Secondary standards that provide public welfare protection against decreased visibility and damage to animals, crops, vegetation, and buildings (EPA 2021c).

Short-term National Ambient Air Quality Standards have been established for pollutants that contribute to acute health effects (i.e., 1-, 8-, and 24-hour periods). In contrast, long-term National Ambient Air Quality Standards have been established for pollutants contributing to chronic health effects (i.e., an annual period) (Table 3.10-3).

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING TABLE IN THE FEIS

Table 3.10-3. National Ambient Air Quality Standards.

Pollutant		Primary/Secondary	Averaging Time	Level	Exceedance Limit
Carbon Monoxide (CO)		Primary	8 hours	9 ppm	Not to be exceeded more than once per year.
			1 hour	35 ppm	
Lead (Pb)		Primary and Secondary	Rolling 3-month average	0.15 µg/m$^{3(1)}$	Not to be exceeded.
Nitrogen Dioxides (NO_2)		Primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years.
		Primary and Secondary	1 year	53 ppb$^{(2)}$	Annual mean.
Ozone (O_3)		Primary and Secondary	8 hours	0.070 ppm$^{(3)}$	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years.
Particle Matter (PM)	$PM_{2.5}$	Primary	1 year	9.0 µg/m^3	Annual mean, averaged over 3 years.
		Secondary	1 year	15.0 µg/m^3	Annual mean, averaged over 3 years.
		Primary and Secondary	24 hours	35 µg/m^3	98th percentile, averaged over 3 years.
	PM_{10}	Primary and Secondary	24 hours	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years.

[4] PM is measured in two size categories: (1) less than or equal to 10 microns in diameter (PM_{10}) and (2) less than or equal to 2.5 microns in diameter ($PM_{2.5}$).

Pollutant	Primary/Secondary	Averaging Time	Level	Exceedance Limit
Sulfur Dioxides (SO_2)	Primary	1 hour	75 ppb[(4)]	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years.
	Secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year.

Source: EPA 2024a

Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air (μg/m^3).

[1] Previous standards (1.5 μg/m^3 as a calendar quarter average) remain in effect in areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards. Previous standards also apply to implementation plans to attain or maintain the current (2008) standards not submitted and approved by 2024.

[2] The annual NO_2 standard is 0.053 ppm. Shown here in ppb for comparison to the 1-hour standard level.

[3] Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards were not revoked and remain in effect for designated areas as of 2024. Additionally, some areas may have certain continuing implementation obligations under the prior revoked 1-hour (1979) and 8-hour (1997) O_3 standards.

[4] The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (a) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards and (b) any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting requirements of a State Implementation Plan fall under the previous SO_2 standards (40 CFR 50.4(3)). A State Implementation Plan call is an EPA action requiring a state to resubmit all or part of its Plan to demonstrate attainment of the required National Ambient Air Quality Standards.

Federal regulations designate areas with pollution levels below the National Ambient Air Quality Standards as attainment areas, and areas with pollution levels above, and in violation of, the standards as nonattainment areas. For nonattainment areas, states must develop a State Implementation Plan that details the path to attainment and maintenance of the standards. An Implementation Plan must also contain control measures for emissions that cross state lines (EPA 2021d).

If an area was in nonattainment but now attains the standard with an approved implementation Plan, it is designated a maintenance area. All states in the Pacific Northwest, including Oregon, have EPA-approved State Implementation Plans. The Oregon Plan helps to attain and maintain air quality in the WVS within Lane, Linn, and Marion Counties, Oregon (40 CFR Subpart MM).

State Ambient Air Quality Standards

Each state can adopt standards stricter than those established under the Federal program. The State of Oregon's air quality laws are codified in the Oregon Revised Statutes, Chapter 468A, and its corresponding regulations are in the OAR, Chapter 340. The Oregon Department of Environmental Quality operates the ambient monitoring network for the entire state except for Lane County, which is operated by the Lane Regional Air Protection Agency.

The ambient monitoring network is a system of monitors to measure air quality, which provides a long-term assessment of the quantities and types of certain air pollutants in the surrounding outdoor air (EPA 2023a). EPA retains oversight of Oregon air quality compliance with regular audits of state air quality. Tribal lands are sovereign and do not fall under Oregon Department of Environmental Quality or Lane Regional Air Protection Agency jurisdictions, although several tribes operate their own monitoring networks (EPA 2008).

The ambient air quality standards for the State of Oregon are listed in OAR 340-202-0050 through 340-202-0130. These state standards are an established concentration, exposure time, and frequency of occurrence of an air contaminant or multiple contaminants in the ambient air that must not be exceeded (Table 3.10-4). These standards are included in the Oregon State Implementation Plan that the Oregon Environmental Quality Commission adopted under OAR 340-200-0040 (Oregon Secretary of State 2022).

Table 3.10-4. Oregon Ambient Air Quality Standards.

Pollutant		Averaging Time	Level	Exceedance Limit
Carbon Monoxide (CO)		Same as National Ambient Air Quality Standards		
Lead (Pb)		Rolling 3-month average	0.15 µg/m³	Not to be exceeded over a 3-year period.
Nitrogen Dioxide (NO_2)		Same as National Ambient Air Quality Standards (Table 3.10-3)		
Ozone (O_3)		8 hours	0.070 ppm	Annual fourth-highest daily maximum 8-hour concentration.
Particle Matter (PM)	$PM_{2.5}$	Same as National Ambient Air Quality Standards (Table 3.10-3)		
	PM_{10}	Same as National Ambient Air Quality Standards (Table 3.10-3)		
Sulfur Dioxide (SO_2)		1 hour	0.075 ppm	99th percentile of 1-hour daily maximum concentration, averaged over 3 years.
		3 hours	0.50 ppm	Not to be exceeded more than once per year.
		24 hours	0.10 ppm	Not to be exceeded more than once per year.
		1 year	0.02 ppm	Annual mean.
Particle Fallout		1 month	10 g/m²	In industrial areas.
		1 month	5 g/m²	In residential and commercial areas; in industrial areas if visual observations show the presence of wood waste/soot and the volatile fraction of the sample is > 70%.
		1 month	3.5 g/m²	In residential and commercial areas if visual observations show the presence of wood waste/soot and the volatile fraction of the sample is > 70%.

Source: Oregon Secretary of State 2022

> = greater than

% = percent

Units of measure for the standards are parts per million (ppm) by volume, micrograms per cubic meter of air (µg/m³), and grams per square meter of air (g/m²).

Attainment Status in Lane, Linn, and Marion Counties

Lane, Linn, and Marion Counties generally meet the National Ambient Air Quality Standards, which translates to relatively good air quality throughout the area (ODEQ No Date-g; ODEQ No Date-i). Two of the three counties contain maintenance areas; however, none of the USACE dam or reservoir locations are within confirmed nonattainment or maintenance areas (Figure 3.10-2).

1. Lane County[5] meets all National Ambient Air Quality Standards but contains one maintenance area in the Greater Eugene-Springfield Area for PM_{10}. This maintenance area is located 4 miles from Fern Ridge Dam and 4 miles from Dexter and Fall Creek Dams.
2. Linn County meets all National Ambient Air Quality Standards.
3. Marion County meets all National Ambient Air Quality Standards but contains one maintenance area in the Greater Salem-Kaiser Area for carbon monoxide. This maintenance area is located 34 miles from Big Cliff Dam.

Federal Action Conformity with the Clean Air Act

Section 176(c)(1) of the CAA requires Federal agencies to conform to State Implementation Plans for achieving and maintaining the National Ambient Air Quality Standards for criteria pollutants, which include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. Conformity requires that Federal actions must not contribute to new violations of standards for ambient air quality, increase the frequency or severity of existing violations, or delay timely attainment of standards in a given area. This applies to emissions of criteria air pollutants that would occur in locations designated as nonattainment or maintenance areas for the emitted pollutants (DOE 2000). There are two conformity phases:

1. The first phase of the general conformity requirements is the conformity review process, which evaluates whether the conformity regulations would apply to an action.
2. If the conformity regulations would apply, then the next phase is the conformity determination, which demonstrates how an action would conform with the applicable implementation plan (DOE 2000).

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[5] Lane County contained one nonattainment area in Oakridge, Oregon for $PM_{2.5}$ and PM_{10} in 2020. The Oregon Department of Environmental Quality and the Lane Regional Air Protection Agency petitioned EPA to concur that the 2020 data for $PM_{2.5}$ and PM_{10} from September 11, 2020 to September 16, 2020 should be declared an exceptional event due to multiple county wildfires and, therefore, be excluded from the 2020 dataset for National Ambient Air Quality Standards compliance. EPA concurred with this request and redesignated the area an attainment area in August 2022 (87 FR 51262).

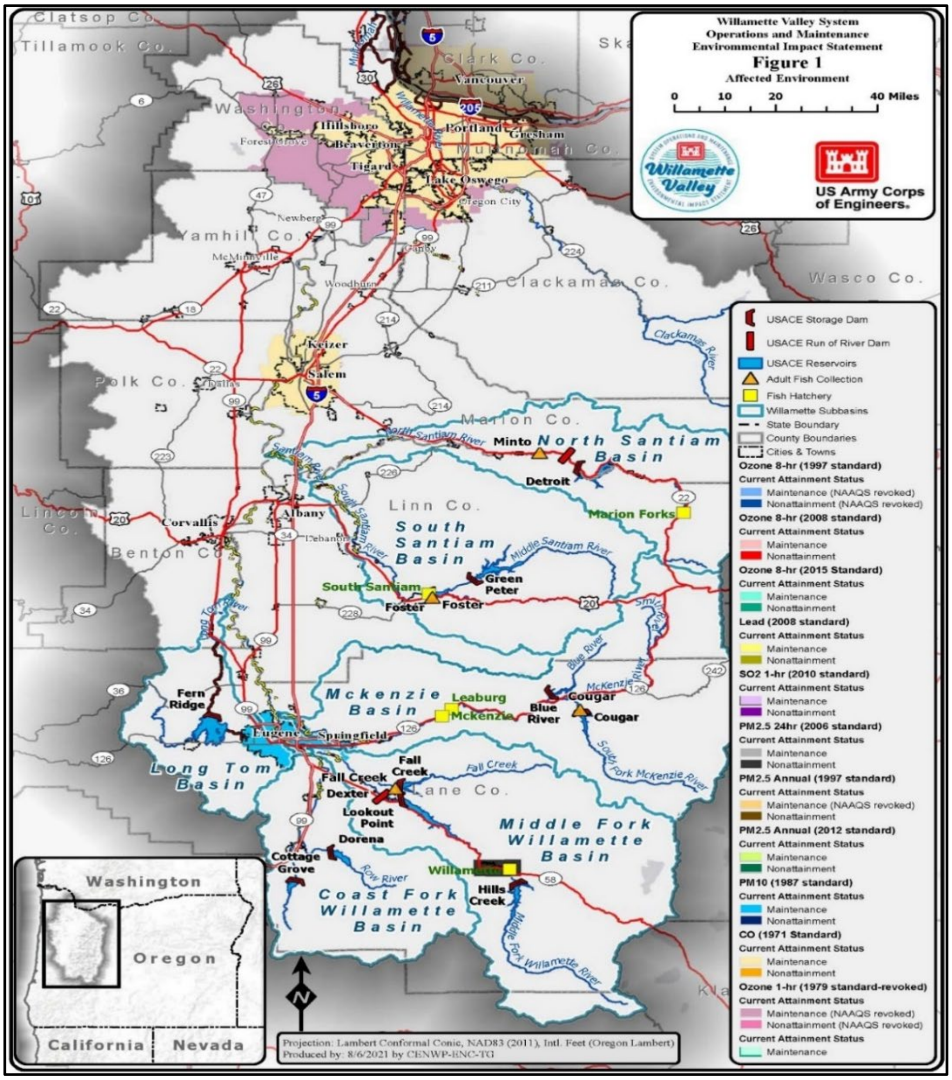

Figure 3.10-2. Attainment, Nonattainment, and Maintenance Areas in the Willamette Valley System within Linn, Lane, and Marion Counties.

While the three counties contain two maintenance areas, operations and maintenance by USACE would not occur within any of these areas under any alternative. A general conformity analysis is, therefore, not required and is not included in the environmental consequences analyses below.

Oregon Diesel Reduction Programs

To reduce diesel emissions in Oregon, including the analysis area, the Oregon Department of Environmental Quality provides grants and programs to incentivize businesses, state and local governments, and equipment owners to replace older and more polluting diesel engines with new, cleaner technologies and exhaust control retrofits (ODEQ No Date-e). The Diesel Emissions Mitigation Fund is a program that provides funding to public, private, and tribal diesel equipment owners to replace their current diesel vehicles or equipment with equivalent, cleaner burning engines or power sources (ODEQ No Date-e).

The 2019 Oregon Legislature addressed concerns regarding substantial pollution from older on-road diesel engines by passing House Bill (HB) 2007 to reduce diesel emissions across the state. Among other directives, HB 2007 requires the Oregon Department of Environmental Quality to establish retrofit technologies for diesel engines that power certain on-road vehicles and the process for issuing a certificate of compliance.

The two vehicle weight classifications categorized in HB 2007 include medium-duty vehicles, such as certain box trucks and flatbed or service trucks, and heavy-duty vehicles, such as tractor-trailer trucks (ODEQ No Date-c). In addition, the Oregon Governor signed a Memorandum of Understanding in 2020 that committed Oregon to work toward the goal of 100 percent of all new medium- and heavy-duty vehicles sales to be zero emissions by 2050 (ODEQ No Date-h).

Point Source Permits

Major stationary sources of air emissions are defined under the CAA as facilities that emit or have the potential to emit 10 tons of any one toxic air pollutant or 25 tons of more than one toxic air pollutant per year (EPA 2021d). USACE facilities do not include major sources of air emissions in Linn, Lane, or Marion Counties, and no new major sources would occur under any alternative. Therefore, permit requirements for major sources are not included in the environmental consequences analyses below.

The Oregon Department of Environmental Quality and the Lane Regional Air Protection Agency establish permit rules and air quality limits based on the size and type of the emission source and the type of pollutant emitted. Facilities, operations, processes, and activities that emit air pollution above certain levels are required to carry air quality permits. These permits specify pollutant limits and record-keeping requirements. Records must be submitted to the Oregon Department of Environmental Quality to document compliance (ODEQ No Date-d).

Types of air contaminant discharge permits can vary based on the source category, size of the facility, and types of emissions discharged (ODEQ No Date-a). Air Contaminant Discharge Permits are primarily used to regulate minor sources of air contaminant emissions but are also required for any new major source or major modification at a major source. There are five different levels of Air Contaminant Discharge permits for varying levels of complexity.

A General Air Contaminant Discharge Permit authorizes the operation of electrical power generators rated at 500 kilowatts or greater and is issued for a period of up to 10 years. Device and Equipment Form Series 200, AQ 213 ‘Electric Power Generators’ provides the application form that must include information for each generator used, including the size of the generator, type of fuel used, and projected maximum number of hours to be operated in 1 year.

Construction-related Air Contaminant Discharge Permits include requirements for the construction or modification of stationary sources or air pollution control equipment at sources that are required to obtain a Standard Air Contaminant Discharge Permit or Oregon Title V Operating Permit. None of the construction activities under any alternative would result in modification or construction of a stationary source of air emission so this type of permit would not be required. Therefore, neither permit is included in the environmental consequences analyses below.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

Greenhouse Gas Emissions Regulations and Management

Consistent with Executive Order 13990, Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis, the Council on Environmental Quality has issued interim *National Environmental Policy Act Guidance on Consideration of Greenhouse Gas Emissions and Climate Change* (88 FR 1196). The Council provides guidance for agencies to quantify projected greenhouse gas emissions or reductions resulting from proposed actions and requires disclosure and context for emissions resulting from proposals. Such disclosure and context are to include the use of the best available social cost of greenhouse gas emission (SC-GHG) estimates that translate potential climate impacts into the more accessible metric of dollars.

The EPA regulates certain greenhouse gas emission sources, including light-duty passenger cars and trucks, commercial trucks, buses, aircraft, Federal fleets, and non-road engines such as generators[6] (EPA No Date-c). The National Highway Traffic Safety Administration's Corporate Average Fuel Economy standards regulate how far light-duty vehicles (passenger cars and small trucks) and medium- and heavy-duty trucks and engines must travel on a gallon of fuel (i.e., fuel efficiency) (NHTSA No Date). EPA released its proposed rule for new greenhouse gas emission standards for fossil fuel-fired power plants (e.g., natural gas) on May 8, 2023 (88 FR 33240) and extended the comment period to August 8, 2023 (88 FR 39390). There are no Federal regulations specifically focused on greenhouse gas emissions associated with hydroelectric-based power generation.

Greenhouse gas emissions are managed at state and local levels under emission reductions targets and sector-specific plans and policies. Targets for reducing greenhouse gas emissions have been set by the State of Oregon and local governments through regulatory, legislative, and public action. Despite relatively small emission profiles compared to national averages, considerable emission reductions are targeted by 2050 relative to 1990. Oregon State is a member of the United States Climate Alliance, a bipartisan coalition of 23 governors (as of March 2019) committed to reducing greenhouse gas emissions consistent with the goals of the

[6] 40 CFR Part 89 Control of Emissions of Air Pollution from Nonroad Diesel Engines as published in the Federal Register, Vol. 69, No. 124, pages 38957–39273 on June 29, 2004 or 40 CFR Part 90 Control of Emissions from Nonroad Large Spark-Ignition Engines, and Recreational Engines (Marine and Land-Based) as published in the Federal Register, Vol. 67, No. 217, pages 68241–68447 on November 8, 2002.

Paris Agreement[7]. The Oregon Clean Energy and Coal Transition Act (2016) mandates the elimination of the cost of coal resources in retail rates of investor-owned utilities by 2030 (ORS 757.518) (Section 3.12, Hydropower and Transmission).

In 2007, the Oregon legislature set a state target of reducing greenhouse gas emissions to 10 percent below 1990 levels by 2020 and 75 percent below 1990 levels by 2050 (House Bill 3543). In March 2020, the Governor signed an Executive Order directing state agencies to take actions to reduce and regulate greenhouse gas emissions (Executive Order 20-04). The order increases the emission reduction target to at least 80 percent below 1990 levels by 2050 and directs the Department of Environmental Quality to create a greenhouse gases Cap and Reduce Program among multiple other decarbonization policies across various sectors and agencies. Although the state missed its 2020 greenhouse gas emission reduction target by 13 percent, actions have since been identified and implemented to track the greenhouse gas emission reduction goal of 45 percent below 1990 levels (OGWC 2023). Deep reductions in greenhouse gas emissions are also mandated by Oregon's clean energy standard (HB 2021).

3.10.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives to air quality and greenhouse gas emissions. The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

3.10.3.1 Methodology

The primary sources of air emissions from the WVS are construction, fish trucking operations, and emergency generator usage (Table 3.10-1). The primary source of greenhouse gas emissions from WVS operations and maintenance activities is power generation-related, with some greenhouse gas emissions from construction, fish trucking operations, and emergency generator usage.

Air quality effects were assessed qualitatively for construction activities and quantitatively for changes in total fish trucking mileage and total generator operations. Alternatives were assessed to determine how each would potentially affect air quality and if any alternative would potentially cause a change in air quality that would exceed any Federal or state air quality standard over the 30-year implementation timeframe.

Greenhouse gas emissions effects were assessed quantitatively for changes in total fish trucking mileage, total generator operations, and hydropower generation (power generation-related) to determine how each alternative would potentially affect greenhouse gas emissions. Additionally, effects on the social costs of the associated changes in greenhouse gas emissions were quantified to ascertain the socioeconomic implications related to greenhouse gas

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[7] The Paris Agreement, developed in 2015 and entered into force in 2016, is an international agreement within the United Nations Framework Convention on Climate Change to increase investment to both combat climate change and adapt to its effects.

emissions (Section 3.21, Socioeconomics, combines this information with other effects on socioeconomics).

Subsequent NEPA analyses would assess detailed site-specific effects on air and greenhouse gas emissions from any construction and major non-routine maintenance (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation) (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act).

Construction-related Analyses

Construction activities included under the alternatives would be secondary sources of air emissions. In the absence of site-specific design details regarding individual projects, a qualitative approach was implemented to analyze construction activity effects. This assessment included the anticipated types of equipment that would be used and the duration and area of construction activities.

A qualitative approach was also implemented to assess effects from fugitive dust. This assessment included the location and duration of construction under each alternative.

Fish Trucking and Emergency Generator Analyses

Air quality and greenhouse gas emissions from fish trucking and emergency generators were estimated quantitatively using the USACE (2023a) Net Emissions Analysis Tool (NEAT) model as detailed in Appendix U, Air Quality and Greenhouse Gas Emission Analysis.

Power Generation-related Greenhouse Gas Emissions Analysis

Hydropower generation itself produces very little greenhouse gas emissions; therefore, a marginal emissions analyses was performed. This approach is commonly used to assess greenhouse gas emissions related to a power generation system consisting of individual hydropower facilities (WPTO No Date). It involves calculating the marginal increase in greenhouse gas emissions across the system for given changes in electricity demand. For purposes of this analysis, it was assumed that an increase in average annual hydropower generation (aMW) would result in a commensurate decrease in natural gas generation, whereas a decrease in hydropower would result in a commensurate increase in natural gas generation.

Decreases or increases in natural gas generation would result in corresponding decreases or increases in carbon emissions and associated social cost of carbon (SC-CO2). According to Holland et al. (2022), “marginal emission rates, in contrast to average emissions (i.e., carbon intensity), are critical for the evaluation of electricity-shifting climate policies in the United States.” Therefore, because electricity-sector greenhouse gas emissions are a focus of evolving regulatory and policy initiatives in Oregon and the Pacific Northwest, the alternatives analysis quantifies effects on carbon dioxide emissions using a range of marginal carbon dioxide emission rates[8].

The analysis focused on carbon dioxide emissions because these are the primary source of greenhouse emissions from power generation, accounting for over 80 percent of energy-related carbon emissions (CBO 2022). Quantifying only carbon dioxide emissions may understate total greenhouse emissions, which was considered when assessing the intensity of greenhouse gas emission effects of the alternatives.

Analysis of Greenhouse Gas Emissions on Socioeconomic Factors

The socioeconomic effect from greenhouse gas emissions can be assessed as the monetary value of climate-related damage. Greenhouse gas emissions influence a variety of socioeconomic outcomes related to climate change, including agricultural productivity, human health, flood risk, and infrastructure and fishery damages. The value of reducing levels of greenhouse gases in the atmosphere is the avoided damages that would be generated by a unit of greenhouse gas if it were present. Economists express this value in monetary terms representing society's willingness to pay to avoid climate-related impacts associated with an additional unit of a greenhouse gas in the atmosphere. This value is defined as the "social cost" of greenhouse gases. The more common term, "social cost of carbon (SC-CO_2)," generally pertains to carbon dioxide emissions. The SC-CO_2 is used in this analysis.

SC-CO_2 was calculated using the most recent United States Interagency Working Group on the Social Cost of Greenhouse Gases' (IWG 2021) year-specific SC-CO_2 values. These values were multiplied by the estimated amount of average annual carbon dioxide for (1) fish trucking and emergency generators combined and for (2) power generation-related emissions, which were then assigned monetized values for these activities. The estimated monetized value reflects the social costs of the incremental changes in carbon dioxide emissions associated with (1) increases in miles driven during fish trucking and increased numbers of emergency generators used and (2) increases or decreases in carbon-emitting natural gas generation as a result of increases or decreases in hydropower generation over the 30-year implementation timeframe.

Appendix U, Air Quality and Greenhouse Gas Emissions Analysis, includes the SC-CO_2 calculated for each of the alternatives. As suggested by the IWG (2021), a range of results was generated using different discount rates to account for the considerable uncertainty involved with SC-CO_2 analysis. For purposes of this effects analysis, the 3 percent average discount rate results are used for comparison among alternatives to represent the estimated present value and annualized value of changes in greenhouse gas emissions for each action alternative as

[8] *Average emissions* describe the carbon intensity of the grid in a defined area based on the predominant generation sources (i.e., the aggregated emissions from all hydroelectric, gas, solar, and wind power plants that supply power to an area) (Holland et al. 2020; Sustainable Campus 2022), whereas the marginal emissions rate is the rate at which emissions change due to adjustments in electrical load in a specific timeframe (i.e., when customers increase or decrease electricity use, certain power plants adjust to match that increase or decrease) (Sustainable Campus 2022; Corradi 2019).

compared with the No-action Alternative. Actual SC-CO_2 could be lower or substantially higher with potential differences in SC-CO_2 reflected by estimates identified in Appendix U, Air Quality and Greenhouse Gas Emission Analysis, using a 5 percent average discount rate and a 3 percent High Impact (95th) discount rate.

While the emissions sources described in the analyses are located in Lane, Linn, and Marion Counties, the estimated SC-CO_2 values reflect global effects (i.e., either benefits of avoided climate-related damages due to reduced carbon dioxide emissions or adverse effects of climate-related damages due to increased carbon dioxide emissions) associated with WVS operations and maintenance.

Environmental Effects Criteria and Summary of Effects

The environmental effects criteria for air quality are provided in Table 3.10-5. Greenhouse gas emissions do not have established Federal or state thresholds. For purposes of this analysis, the degree of impact from greenhouse gas emissions are assessed qualitatively and discussed descriptively (as slight, moderate, or substantial effects[9]). Specified criteria to describe the degree of effect are not provided because criteria based on emissions would be speculative (e.g., assigning a minor, moderate, or major effect to emission levels comparable to the air quality criteria). Descriptions of emission trends are more informative and accurate than attempting to assign established degree criteria to adverse or beneficial effects. Generally, however, substantial effects from greenhouse gas emissions are considered as greater than 25,000 metric tons of CO2 per year, consistent with the EPA Greenhouse Gas Reporting Program threshold (EPA 2023a) (it would be unsupportable to assign criteria to thresholds below this amount).

Table 3.10-5. Air Quality Emission Environmental Effects Criteria.

Degree of Adverse or Beneficial Effect	Air Quality Emission Definitions
None/Negligible	Emissions would be nondetectable and indistinguishable from ambient air quality conditions.
Minor	Emissions would not exceed 50 percent of a Federal or state standard.
Moderate	Emissions would exceed 50 percent of a Federal or state standard.
Major	Emissions would exceed a Federal or state standard.
Duration	
Short-term	Effect lasts for the duration of a small construction project and is continuous for less than 2 years.
Medium-term	Effect lasts for the duration of large construction projects and is continuous for a period of 2 to 5 years.

[9] "Moderate" is not used as a specified criteria in the greenhouse gas analysis. It is defined in its common use as "average in amount, intensity, quality, or degree" (Oxford Languages).

Degree of Adverse or Beneficial Effect	Air Quality Emission Definitions
Long-term	Effects are permanent or last continuously beyond operation changes or the completion of all construction projects; the effects recur at regular intervals (i.e., fish trucking operations that occur weekly or monthly); or the alteration occurs intermittently.
Extent	
Small	Effects would be confined to the dam or reservoir location.
Medium	Effects would be confined to a single county.
Large	Effects would extend to multiple counties or throughout the entire Willamette River Basin, state, or beyond.

END NEW TEXT

A summary of effects on air quality and on greenhouse gas emissions based on results of the qualitative and quantitative analysis methods described above are provided in Table 3.10-6 and Table 3.10-7, respectively.

Table 3.10-6. Summary of Effects on Air Quality and Compliance with Federal and State Regulations as Compared to the No-action Alternative.

Degree of Adverse or Beneficial Effect and Extent	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Short-term Duration								
Degree	• None	• Minor adverse.	• None	• None	• None	• None	• Minor adverse.	• None
Extent	• None	• Small (Fern Ridge Dam)	• None	• None	• None	• None	• Small (Fern Ridge Dam)	• None
Medium-term Duration								
Degree	• Minor adverse	• Minor adverse.	• Minor adverse.	• Minor adverse.	• Minor adverse.	• Minor adverse.	• Minor adverse.	• Minor adverse.
Extent	• Small	• Small (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam).	• Small (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam).	• Small (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam).	• Small (Blue River Dam, Green Peter Dam, Hills Creek Dam).	• Small (Blue River Dam, Green Peter Dam, Hills Creek Dam).	• Small (Detroit Dam, Lookout Point Dam, Hills Creek Dam, Foster Dam, Cougar Dam).	• Small (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam).
Long-term Duration (Permanent, Intermittent, and/or Recurring)								
Degree	• Negligible adverse. • Minor adverse for climate change effects.	• Minor adverse; minor beneficial. • Minor adverse for climate change effects.	• Minor adverse. • Minor adverse for climate change effects.	• Minor adverse. • Minor adverse for climate change effects.	• Minor adverse. • Minor adverse for climate change effects.	• Minor adverse. • Minor adverse for climate change effects.	• Minor adverse; minor beneficial. • Minor adverse for climate change effects.	• Minor adverse. • Minor adverse for climate change effects.
Extent	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Small (Fern Ridge Dam) • Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Small (Fern Ridge Dam) • Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING TABLE IN THE FEIS

Table 3.10-7. Summary of Effects on Greenhouse Gas Emissions as Compared to the No-action Alternative.

Degree of Adverse or Beneficial Effect and Extent	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
	Short-term Duration							
Degree	• Negligible adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.
Extent	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)
	Medium-term Duration							
Degree	• Slightly adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.
Extent	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)
	Long-term Duration (Permanent, Intermittent, and/or Recurring)							
Degree	• Moderate to substantial adverse. • Moderate to substantial adverse for climate change effects.	• Slight to moderate beneficial. • Moderate to substantial adverse for climate change effects.	• Slight to moderate adverse. • Moderate to substantial adverse for climate change effects.	• Slight to moderate adverse. • Moderate to substantial adverse for climate change effects.	• Moderate to substantial adverse. • Moderate to substantial adverse for climate change effects.	• Moderate to substantial adverse. • Moderate to substantial adverse for climate change effects.	• Slightly beneficial. • Moderate to substantial adverse for climate change effects.	• Slight to moderate adverse. • Moderate to substantial adverse for climate change effects.
Extent	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)

3.10.4 Alternatives Analyses

3.10.4.1 No-action Alternative

Under the No-action Alternative (NAA), the existing operations and maintenance of the WVS would continue. This would include adult fish facility and hatchery activities such as fish trucking operations to outplant fish using light- and medium-duty diesel trucks. Emergency diesel-powered generators would also be used at dams and hatcheries.

All ongoing, scheduled, and routine maintenance actions for the USACE-managed infrastructure in the Willamette River Basin and all USACE-managed structural features, including those recently constructed or that were reasonably foreseeable in 2019, would occur under the NAA (Chapter 2, Alternatives, Section 2.10.3, No-action Alternative).

Fish Trucking Operations and Emergency Generator Activities

The continued operation of adult fish facilities and trucking operations would occur at Dexter, Cougar, Foster, and Fall Creek Dams, and the Minto Fish Collection Facility, which could require use of emergency generators. Hatchery activities would continue to occur at Willamette Fish Hatchery near Hills Creek, Leaburg and McKenzie Hatcheries near Blue River, South Santiam Fish Hatchery near Foster, and Marion Forks Hatchery near Green Peter, which could also require use of emergency generators. Maintenance of existing and new fish release sites would occur at Detroit, Green Peter, Foster, Cougar, Lookout Point, Fall Creek, Hills Creek, and Big Cliff Dams. Under the NAA, there are an estimated 92,000 annual vehicle miles traveled for fish trucking operations associated with operations and maintenance by USACE, and there are about 22 emergency generators at dam and reservoir locations throughout the WVS (Table 3.10-1).

Air emissions from fish trucking operations or emergency diesel generator usage would not cause air quality in the analysis area to exceed 50 percent of a Federal or state standard under the NAA (Table 3.10-8). Further, USACE-generated emissions would not result in designation of an existing attainment area to a nonattainment area within the analysis area under the NAA. USACE would comply with all necessary Federal and state air emissions regulations under the NAA.

The degree of adverse effects from these activities would be negligible in the long term because these activities would not change the total fish trucking mileage or the number of generators from current levels and, therefore, would not cause a change in air emissions different from emissions under existing conditions. The extent of effects would be large because the hatcheries, adult fish facilities, and release sites for outplanted fish are located in various counties across the Willamette River Basin. The location of these activities would not change under the NAA over the 30-year implementation timeframe.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING TABLE IN THE FEIS

Table 3.10-8. Estimates of Fish Trucking and Emergency Generator Air Quality Pollutants and Greenhouse Gas Emissions.

Pollutant	Yearly (metric tons)	30-Year Implementation Timeframe (metric tons)
No-action Alternative Air Quality Pollutant Emissions		
Reactive Organic Gases aka Volatile Organic Compounds (ROG/VOC)	0.10	3.14
Carbon Monoxide (CO)	0.65	19.52
Sulfur Oxides (SOx)	0.51	15.15
Nitrous Oxides (NOx)	0.29	8.57
Particulate Matter - 2.5 micron ($PM_{2.5}$)	0.02	0.69
Particulate Matter - 10 micron (PM_{10})	0.03	0.81
No-action Alternative Greenhouse Gas Emissions		
Carbon Dioxide (CO_2)	332.51	9,975.45
Methane (CH_4)	0.01	0.22
Nitrous Oxides (N_2O)	0.29	8.57
Alternatives 1, 2A, 2B, 4, 5 Air Quality Pollutant Emissions		
Reactive Organic Gases aka Volatile Organic Compounds (ROG/VOC)	0.14	4.12
Carbon Monoxide (CO)	0.86	25.74
Sulfur Oxides (SOx)	0.55	16.55
Nitrous Oxides (NOx)	0.46	13.94
Particulate Matter - 2.5 micron ($PM_{2.5}$)	0.03	0.91
Particulate Matter - 10 micron (PM_{10})	0.04	1.07
Alternatives 1, 2A, 2B, 4, 5 Greenhouse Gas Emissions		
Carbon Dioxide (CO_2)	427.47	12,823.97
Methane (CH_4)	0.01	0.27
Nitrous Oxides (N_2O)	0.46	13.94
Alternative 3A and Alternative 3B Air Quality Pollutant Emissions		
Reactive Organic Gases aka Volatile Organic Compounds (ROG/VOC)	0.15	4.60
Carbon Monoxide (CO)	0.96	28.69
Sulfur Oxides (SOx)	0.64	19.30
Nitrous Oxides (NOx)	0.50	14.88

Pollutant	Yearly (metric tons)	30-Year Implementation Timeframe (metric tons)
Particulate Matter - 2.5 micron ($PM_{2.5}$)	0.03	1.01
Particulate Matter - 10 micron (PM_{10})	0.04	1.19
Alternative 3A and Alternative 3B Greenhouse Gas Emissions		
Carbon Dioxide (CO_2)	479.15	14,374.53
Methane (CH_4)	0.01	0.31
Nitrous Oxides (N_2O)	0.50	14.88

Construction Activities and Fugitive Dust

Under the NAA, operation, maintenance, repair, replacement, and rehabilitation would continue during the 30-year implementation timeframe, including within and around the dams and powerhouses, adult fish facilities, and hatcheries. However, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation).

Major maintenance projects that take power lines off-line would likely reduce air emissions and could have beneficial effects to air quality. Alternatively, construction vehicles and equipment used during major rehabilitation or restoration projects would likely generate additional air emissions and adversely affect air quality.

Construction vehicles and equipment, such as bulldozers, cranes, and other heavy equipment, would be required to complete ongoing and planned construction projects during the 30-year implementation timeframe under the NAA. The effects to air quality would include the combustion of diesel fuel to power construction vehicles and machinery. During combustion, diesel engines emit large amounts of nitrogen oxides, particulate matter (in particular $PM_{2.5}$), carbon, and other toxic air pollutants. While the nature and scale of construction projects would vary, the effects to local and regional air quality would be expected to be minimal. The degree of adverse effects would be negligible to minor because air emissions would not cause air quality in the analysis area to exceed 50 percent of a Federal or state standard.

The duration of an effect cannot be assessed without project-specific information; however, generally, a medium-term effect to air quality would be experienced for construction activities that require 2 to 5 years to complete. The extent of medium-term effects would be small because construction activities typically result in localized air pollution emissions and would be confined to the construction location.

The degree of adverse effects from fugitive dust related to construction activities under the NAA would be negligible because USACE would continue to comply with all Oregon Department of Environmental Quality management requirements for fugitive emissions. This compliance would continue to minimize or eliminate the potential for adverse air quality effects from fugitive dust, and air quality would be expected to remain at current conditions.

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Greenhouse Gas Emissions

Existing operations and maintenance activities would not contribute substantial amounts of greenhouse gas emissions into the analysis area (Table 3.10-8). These routine operations and maintenance activities would continue under the NAA for the 30-year implementation timeframe. Increases in construction activities and in diesel emissions from trucks and generators would not occur under the NAA and therefore would not increase greenhouse gas emissions.

Overall, a reduction in greenhouse gas emissions in Oregon is anticipated over the 30-year implementation timeframe relative to current levels due to state initiatives toward decarbonization. State-wide changes in fuel sourcing over time under the NAA are most likely to favor low-carbon resources, such as hydropower, solar, and wind as well as demand-response measures.

END NEW TEXT

Climate Change

Climate change would potentially affect air quality within the Willamette River Basin in Linn, Lane, and Marion Counties under the NAA. More intense and frequent wildfires are anticipated over the 30-year implementation timeframe as compared to current conditions (Fleishman 2023) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.8, Summary of Projected Trends in Climate; Appendix F2, Supplemental Climate Change Information, Section 3.1.5, Wildfire Danger). Ambient air temperature changes, such as the projected 2°F to 5°F increase by 2070 in the region’s annual temperature, could make wildfires more common due to drier conditions from higher evapotranspiration rates (USGCRP 2017; RMJOC 2018).

Wildfires in and around the analysis area would affect emissions in the surrounding area and beyond by releasing air pollutants (e.g., particulate matter, carbon monoxide, etc.), aerosols (black carbon and brown carbon), and greenhouse gases (e.g., carbon dioxide, etc.) into the air (NASA 2021; UCR 2023) and by contributing to the production of ozone, a greenhouse gas (NOAA 2022a; Farmiloe 2023). Wildfire-emitted greenhouse gases and inputs to ozone production would continue to contribute to climate change under the NAA, while particulate matter and ozone could create smog that blocks sunlight and could be harmful to human health (C2ES No Date; NASA 2015, 2017; NOAA 2022a).

Climate change increases the risk of natural disasters over the 30-year implementation timeframe. The number and degree of wildfires in and surrounding the analysis area can substantially adversely affect air quality. Consequently, annual wildfire events would amplify adverse effects to air quality and greenhouse gas emission in the analysis area for short durations while fires are occurring. Increased greenhouse gas emissions associated with an increase in wildfires could be a major adverse effect by making it more difficult to achieve state greenhouse gas reduction targets.

During wildfire events, there could potentially be an air quality change that would temporarily exceed 50 percent of a Federal or state standard; however, the combined effect with WVS operations and maintenance activities would not be a contributing factor to such exceedances. Air quality and greenhouse gas emissions would return to normal ambient levels in the analysis area after fires are controlled. Climate change would amplify the effects to air quality under the NAA to minor adverse effects. However, increases in regional wildfires would result in moderate to major adverse effects that would be temporary but intermittent or reoccurring.

Effects from climate change on air quality in the analysis area would be long term because climate change continues to evolve. Effects would also be large in extent depending on the size of wildfires and the distance pollutants would travel, along with the widespread effects air pollutants such as carbon dioxide, particulate matter, and ozone have on greenhouse gases in the atmosphere.

Public land management agencies would continue to implement fire management strategies such as prescribed burns and burn bans throughout the analysis area. USACE operations and maintenance activities would likely continue to negligibly contribute to adverse air quality effects. USACE would comply with all necessary Federal and state air emissions regulations under the NAA, which would minimize or prevent the potential for long-term effects from USACE activities. Further, the Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop during the 30-year implementation timeframe (Appendix N, Implementation and Adaptive Management Plan).

3.10.4.2 All Action Alternatives

Fish Trucking Operations and Emergency Generator Activities

Measures under the action alternatives would increase the number of fish collected at each dam and increase the need for transportation to release sites, thereby increasing fish trucking mileage and associated air and greenhouse gas emissions as compared to the NAA. New facilities and structures at each dam would also require additional emergency diesel generators to supply power, contributing slight to moderate increases in associated pollutant and greenhouse gas emissions.

The increases in total fish trucking mileage and number of generators would vary by action alternative because each alternative contains a different combination of measures and dam locations that would affect these totals. As under the NAA, it is not likely that air emissions from total fish trucking mileage and emergency diesel generators would cause air quality in the analysis area to exceed 50 percent of a Federal or state standard under any action alternative.

Under the NAA, there would be an estimated 92,000 annual vehicle miles traveled for fish trucking operations (Table 3.10-1). Under any action alternative, fish trucking mileage would only increase by about 576 miles to 1,216 miles annually, which would be an increase of approximately 1 percent as compared to existing conditions.

Additionally, there would be 22 emergency diesel generators associated with operations under the NAA (Table 3.10-1). Each action alternative would add between 7 and 10 new generators.

The degree of adverse effects to air quality would be the same or negligible to minor under any action alternative as compared to the NAA because the additional air emissions from diesel truck and generator use would not create a change to air quality that would exceed 50 percent of a Federal or state standard and would likely be undetectable across the three-county analysis area (Table 3.10-8). As under the NAA, there would be a long-term, recurring effect on air quality and to greenhouse gas emissions because fish trucking operations would be recurring within the 30-year implementation timeframe.

Greenhouse gas emissions would remain in compliance with state regulations. However, the degree of adverse effects to greenhouse gas emissions under the action alternatives would be slight to moderate because gases may travel far from the analysis area and remain in the atmosphere for extended periods.

As under the NAA, the extent of effects would be large because the release sites for trucked fish would potentially be located throughout the entire Willamette River Basin. The extent of effects to greenhouse gas emissions would also be large because greenhouse gases can travel far from their source.

Beneficial effects to potential air and greenhouse gas emissions resulting from reduced or no fish trucking activities once structural fish passage measures have been completed would be minor and long-term under an applicable action alternative. The extent of the beneficial effects on air quality would be localized to a given dam but would have extended greenhouse gas emission benefits outside of the analysis area. These beneficial effects would not occur under the NAA.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

Under the action alternatives, there would be minor increased climate-related damages from changes in fish trucking and emergency generators as compared to the NAA. Social costs from climate-related damages under these alternatives would range from an increase of $137,725 under Alternatives 1, 2A, 2B, 4, 5 to an increase of $196,236 under Alternative 3A and Alternative 3B over the 30-year implementation timeframe (Appendix U, Air Quality and Greenhouse Gas Emissions Analysis). Increased costs reflect the global increase in climate-related damages that would be associated with estimated increases in greenhouse gas emissions under these action alternatives as compared to those under the NAA.

END NEW TEXT

Construction Activities and Fugitive Dust

Unlike the NAA, structural measures under the action alternatives with the potential to impact air quality include construction of water temperature control towers, adult fish facilities, downstream fish passage, restoring upstream and downstream passage at drop structures, and deeper fall and spring reservoir drawdowns. Construction vehicles and equipment, such as bulldozers, cranes, and other heavy equipment, would be required to implement these construction projects.

Effects to air quality under the action alternatives would include the combustion of diesel fuel to power construction vehicles and machinery. During combustion, diesel engines emit large amounts of nitrogen oxides, particulate matter (in particular $PM_{2.5}$), carbon, and other toxic air pollutants. USACE would comply with all necessary Federal and state air emissions and greenhouse gas regulations under all alternatives, which would minimize or eliminate the potential for adverse effects to air quality and greenhouse gases in the analysis area as well as adverse effects from greenhouse gases beyond the analysis area. Further, as under the NAA, USACE-generated emissions would not result in the designation of an existing attainment area to a nonattainment area within the analysis area under any action alternative.

Effects to local and regional air quality would be expected to be minimal from construction projects under the action alternatives as compared to the NAA. The degree of adverse effects to air quality would be negligible to minor because air emissions from construction activities would not cause air quality in the analysis area to exceed 50 percent of a Federal or state standard under any action alternative as compared to the NAA.

Short-term effects would only occur under Alternative 1 and Alternative 4 from implementation of Measure 639. Restoring upstream and downstream passage at drop structures would take less than 2 years within annual work periods to complete. Therefore, construction activities would have a minor, adverse, and short-term effect on air quality.

There would be a medium-term adverse effect to air quality and greenhouse gas emissions as compared to the NAA because action alternative construction activities would require 2 to 5 years within annual work periods to complete. The extent of adverse effects on air quality would be small because construction activities typically result in localized air pollution emissions and would be confined to the dam or reservoir location. However, the extent of effects to greenhouse gas emissions would be large because greenhouse gases may travel far from the analysis area.

The degree of adverse effects on air quality from fugitive dust related to construction activities under the action alternatives would be the same as the NAA because USACE would comply with all Oregon Department of Environmental Quality management requirements for fugitive emissions. This compliance would minimize or eliminate the potential for adverse air quality effects from fugitive dust. There would be no effects from fugitive dust on greenhouse gas emissions.

Power Generation-related Greenhouse Gas Emissions

The action alternatives would affect the amount of hydropower generation produced by the WVS over the 30-year implementation timeframe due to operational and structural measures related to fish passage and water quality. This, in turn, would affect the fuel mix (i.e., relative contribution of power generation from fossil fuels, hydropower, and other renewables) and thus affect Oregon and regional electricity-sector greenhouse gas emissions. All adverse or beneficial effects would be long term. The extent of effects to greenhouse gas emissions would also be large because greenhouse gases may travel far from the analysis area.

Under Alternative 1 and Alternative 4, there would be slight to moderate beneficial effects on greenhouse gas emissions. A slight increase in average annual hydropower generation (1 to 4 aMW) would occur under these two alternatives as compared to the NAA, which would slightly reduce annual average natural gas generation and associated greenhouse gas emissions over the 30-year implementation timeframe.

Decreases of greenhouse gas emissions under Alternative 1 and Alternative 4 would be commensurate with increases in hydropower generation as compared to the NAA. Under Alternatives 1 and 4, estimated decreases range from 3.6 to 58.2 thousand metric tons of annual average carbon dioxide emissions as compared to the NAA over the 30-year implementation timeframe (Appendix U, Air Quality and Greenhouse Gas Emissions Analysis). Beneficial effects would result from more hydropower generation and less use of natural gas under the action alternatives compared to the NAA.

Under Alternatives 2A, 2B, 3A, 3B, and 5, there would be slight to substantial adverse effects on greenhouse gases. Slight to large decreases in annual average hydropower generation would occur under Alternatives 2A, 2B, 3A, 3B, and 5 as compared to the NAA (4 to 87 aMW), which would increase the annual average natural gas generation and associated greenhouse gas emissions over the 30-year implementation timeframe (Appendix U, Air Quality and Greenhouse Gas Emissions Analysis).

Increases of greenhouse gas emissions under Alternatives 2A, 2B, 3A, 3B, and 5 would be commensurate with decreases in hydropower generation as compared to the NAA. Under Alternatives 2A, 2B, 3A, 3B, and 5, estimated increases range from 14.5 to 632.6 thousand metric tons of annual average carbon dioxide emissions as compared to the NAA over the 30-year implementation timeframe. Adverse effects on greenhouse gas emissions would result from an increase in natural gas generation under these alternatives as compared to the NAA. However, if the region were able to replace the reduction in hydropower generation with zero-carbon resources instead of natural gas, adverse effects could be reduced commensurate with the amount of natural gas that would be displaced.

Unlike the NAA, there would be a slight, beneficial financial effect under Alternative 1 and Alternative 4. Reduced emissions benefits would range from a decrease of $9 million under Alternative 4 to a decrease of $68 million under Alternative 1 (assuming a 3 percent discount rate, in accordance with best practices) (Appendix U, Air Quality and Greenhouse Gas Emissions Analysis). Benefits would be attributed to the global reduction in climate-related damages associated with the estimated reductions in greenhouse emissions under these two alternatives, which would not occur under the NAA.

Under Alternatives 2A, 2B, 3A, 3B, and 5, there would be moderate to substantial increased climate-related damages from changes in power generation as compared to the NAA. Social costs from climate-related damages under these alternatives would range from an increase of $34 million under Alternative 2A to an increase of $739 million under Alternative 3A (Appendix U, Air Quality and Greenhouse Gas Emissions Analysis). Increased costs reflect the global increase in climate-related damages that would be associated with estimated increases in greenhouse gas emissions under Alternatives 2A, 2B, 3A, 3B, and 5 as compared to those under the NAA.

Climate Change

Effects on air quality and greenhouse gas emissions from the action alternatives in combination with climate change would be similar to those described under the NAA. Climate change conditions would occur regardless of the alternative implemented, including increased frequency and magnitude of wildfires in the analysis area and region. However, construction, fish trucking operations, and emergency generator use would be increased under the action alternatives. Further, increased natural gas emissions could occur under those alternatives where hydroelectric power decreases during the 30-year implementation timeframe (i.e., Alternatives 2A, 2B, 3A, 3B, and 5). In combination, effects from these activities to air quality and greenhouse gas emissions could increase in magnitude in the analysis area as compared to the NAA.

While there could be an increase from moderate to major effects under the action alternatives, this would depend on the magnitude, extent, and duration of air pollutant and greenhouse gas emissions occurring from USACE activities in the analysis area at the time of a climate change-generated event, such as wildfires. The degree of effect on greenhouse gas emissions from decreased hydroelectric power generation would also depend on whether the region is able to replace the reduction with zero-carbon resources instead of with natural gas.

As under the NAA, USACE would comply with all necessary Federal and state air and greenhouse gas emissions regulations under any alternative, which would minimize or prevent the potential for long-term effects. Further, the Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

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Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.11 SOCIOECONOMICS

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3.11 Socioeconomics

THE SOCIOECONOMICS SECTION HAS BEEN REVISED IN ITS ENTIRETY FROM THE DEIS

Summary of changes from the DEIS:

- **An introduction has been provided to define the scope of review, which is modified from the DEIS (FEIS Section 3.11.1, Introduction).**
- **Related to the revised scope of review, information on the economic relationship with communities has been added as FEIS Section 3.11.1.2.**
- **DEIS non-use and existence value information has been deleted because it is subjective information. Specifically, qualitative assessments of measures on ESA-listed species have been deleted because the effect to society from fish impacts is subjective and more appropriately analyzed as impacts to fish species, fish habitat, and recreational fishing in FEIS Section 3.8, Fish and Aquatic Habitat, and Section 3.14, Recreation Resources, as effects on water-based recreation, including sport fishing.**
- **DEIS quality of life information has been deleted because this parameter was not defined in the DEIS.**
- **Population growth and age data have been deleted from the Affected Environment description because operations under any alternative would not directly or indirectly affect population size. Population information is discussed as it pertains to analysis area information, such as the sizes of Metropolitan Statistical Areas. Population information is primarily applicable to the cumulative effects analysis, and has been moved to FEIS Section 4.11, Socioeconomics.**
- **Labor force, population, and housing statistics in Polk County have been added to tables in FEIS Section 3.11.2, Affected Environment.**
- **The analysis area description has been revised to highlight communities and to clarify the analysis area parameters in FEIS Section 3.11.2.1, Analysis Area. The analyses have been revised to incorporate analysis area information in FEIS Section 3.11.3.2, Alternatives Analyses.**
- **The relevance of statistical parameters has been added in FEIS Section 3.11.2.3, Analysis Area Housing.**
- **The effects criteria have been revised to apply a qualitative and descriptive approach to the analyses in FEIS Section 3.11.3, Environmental Consequences. Direct and indirect effects criteria have been added.**

Summary of changes from the DEIS, continued:

- **The analyses have been modified to compare degree of effect between each alternative and the degree of effect under the No-action Alternative rather than demonstrating a degree of change, which may minimize actual effect outcomes (e.g., a degree of change could be negligible, but the degree of effect remains substantially adverse when compared to the No-action Alternative) (FEIS Section 3.11.3.1, Methodology, Qualitative Analysis).**
- **Direct and indirect effects have been identified under each alternative in FEIS Section 3.11.3.2, Alternatives Analyses.**
- **The FEIS does not include the quantitative effects of Federal construction spending at each reservoir because the estimations for regional economic activity are provided in Appendix I, Socioeconomics Analysis. This information was not repeated. Capital costs are analyzed qualitatively based on the scale of spending under each alternative in FEIS Section 3.11.3.2, Alternatives Analysis, Employment, Labor, and Earnings under All Alternatives, Employment Industry Growth and Federal Spending. This analysis is supported by the updated FEIS Appendix I, Socioeconomics Analysis, and Appendix M, Costs.**
- **Analyses of communities with environmental justice concerns are not addressed because Executive Orders related to environmental justice were rescinded in January 2025. An analysis of the economic relationship with analysis area communities has been added as FEIS Section 3.11.3.3. This analysis incorporates consistent analyses from other resources in the EIS.**
- **The Near-term Operations Measures analyses have been combined in FEIS Section 3.14.4, Interim Operations under All Alternatives Except Alternative 1. The term “Near-term Interim Operations” has been changed to “Interim Operations” throughout the EIS. Additional information on operations timing has been added.**
- **The climate change analyses have been combined for all alternatives in FEIS Section 3.11.5. Additional information has been provided to incorporate community effects.**
- **Consistent terminology has been applied and terms defined.**

THE DEIS HAS BEEN MODIFIED TO REVISE ALL INFORMATION IN THE FEIS

3.11.1 Introduction

The socioeconomic analysis addresses how economic conditions under each alternative would affect communities in the analysis area. Communities are described by geographic location and primary economic relationship to jobs, recreation revenue, etc. generated by the Willamette Valley System (WVS).

3.11.1.1 Economics

Operations and maintenance are described as dam functions for all other resource analyses in the EIS. However, operations and maintenance are defined as economic conditions for the socioeconomics analysis of potential effects. Economics related to operations and maintenance of the WVS are specified as employment from construction and maintenance projects, the cost of hydroelectric power generation and water treatment, and recreation-related visitor revenue. Analysis area economics would be impacted by various measures under each alternative. Factors related to regional economics include labor and earnings (including unemployment), industry job opportunities in addition to those created by operations and maintenance of the WVS, hydropower generation, recreation opportunities, and climate change.

Population in the analysis area is not expected to change as a result of any alternative implementation. Direct or indirect effects on population are not anticipated and, therefore, not analyzed. However, population is addressed in the cumulative effects analysis (Section 4.11, Socioeconomics).

Economic activity is described as both impacts and contributions to an economy from construction-related activities to alternative implementation. This activity is measured as economic output from sales, annual average of jobs available monthly, income earned, and value added[1]. Local, state, and national estimates of existing economic activities are summarized below to describe existing economic conditions related to any alternative implementation.

Metropolitan Statistical Areas (MSAs) were identified to document existing conditions for primary communities in the analysis area (Section 3.11.2.1, Analysis Area).

3.11.1.2 Economic Relationship with Communities

The relevance of economic conditions pertains to the economic influence on analysis area communities over the 30-year implementation timeframe under any alternative. Community effects are important in assessing the social aspect of the human environment. These effects are realized from economic conditions but also from the relationship of economic conditions

[1] Value added is an estimate of gross regional product. It is a combination of employee compensation, business owner income, industry profits, and indirect business taxes.

with other community impacts such as water quality, drinking water quality, greenhouse gas emissions, hydropower transmission, water supply, and recreation opportunities.

The socioeconomics section synthesizes EIS resource analyses relevant to analysis area communities in addition to economic conditions from alternative implementation (i.e., “socioeconomic” effects). Resource analyses related to socioeconomic conditions include the following:

- Section 3.5, Water Quality—provides an analysis of potential impacts on water temperature, total dissolved gas, turbidity, harmful algal blooms, and mercury. This analysis is relevant to the socioeconomic effects because water quality conditions can impact communities by impacting public safety and visitation.
- Section 3.10, Air Quality and Greenhouse Gas Emissions—provides an analysis of the socioeconomic effect from greenhouse gas emissions assessed as the monetary value of climate-related damage. This analysis is relevant to the socioeconomic effects because it includes an analysis of the social costs to society from increases in greenhouse gas emissions. These social costs are applicable to analysis area communities. However, air quality is not anticipated to be noticeably affected under any alternative; therefore, this information is not addressed as a community impact.
- Section 3.12, Hydropower and Transmission—provides an analysis of the cost of producing hydropower generation and the economic viability of hydropower generation. Hydropower and transmission are relevant to socioeconomic effects because the economic viability of hydropower has the potential to impact ratepayers. Additionally, hydropower reliability directly affects communities in the analysis area.
- Section 3.13, Water Supply—provides analyses of effects on municipal, industrial, and agricultural water supply. This analysis is relevant to socioeconomic effects because water supply can affect local communities.
- Section 3.14, Recreation Resources—provides an analysis of recreation opportunities. Recreation effects are relevant to socioeconomic effects for several reasons. Recreation opportunities in the analysis area provide community revenue. Additionally, these opportunities are linked to community identity and community stability.
- Section 3.19, Drinking Water—provides an analysis of effects on analysis area populations from drinking water impacts. Drinking water information is important to the socioeconomics analysis because it is related to community health.

3.11.2 Affected Environment

3.11.2.1 Analysis Area

The socioeconomics analysis area encompasses the Willamette River Basin, which includes the WVS. County and multi-county areas are also included in this analysis area and represent local conditions as described below. MSAs were defined to capture WVS dams and reservoirs or industry activities associated with analysis area metropolitan communities.

3.11.2.2 Analysis Area Communities

The analysis area to assess existing socioeconomic conditions and potential effects is the Salem, Albany, and Eugene, Oregon Metropolitan Statistical Areas (MSAs). MSAs are defined in the USACE Regional Economic System (RECONS) model as Core-based Statistical Areas (CBSAs). CBSAs are based on population and labor force commuting patterns.

The metropolitan areas for this EIS analysis are Salem, Eugene, and Albany, Oregon. Metropolitan areas contain at least 50,000 people and include numerous cities, towns, and unincorporated communities. Additionally, counties surrounding the CBSAs are included in the MSA/CBSA analysis area. Populations within the corresponding counties for the MSAs include Lane, Linn, Benton, Marion, and Polk Counties (Figure 3.11-1). Counties were included in the analysis area because direct and indirect effects from alternative implementation would occur in these MSA locations. Counties outside of the analysis area are not anticipated to experience measurable adverse or beneficial effects from alternative implementation and, therefore, were not included in the analysis area. Each relevant factor affecting existing economic conditions in the analysis area is described below.

Several small communities with economic and social associations with WVS operations are also in the analysis area but are not considered metropolitan areas. An example of this community relationship with the WVS is the City of Detroit located within Marion County and the Salem MSA. Detroit Reservoir operations are integrally tied to the City of Detroit. All-season recreation is a large part of the community identity and includes the Detroit Oregon Rocks scavenger hunts and annual traditions of summer fireworks on the reservoir and the spring fishing derby.

Another example of this community relationship is the City of Oakridge located within Lane County and the Eugene MSA. The City of Oakridge economy is supported by recreation and tourism, which can be adversely affected by power generation loss. Additionally, the City is reliant on emergency power transmission from the WVS hydroelectric dam capability to operate isolated from the rest of the power system (Section 3.12, Power Generation and Transmission).

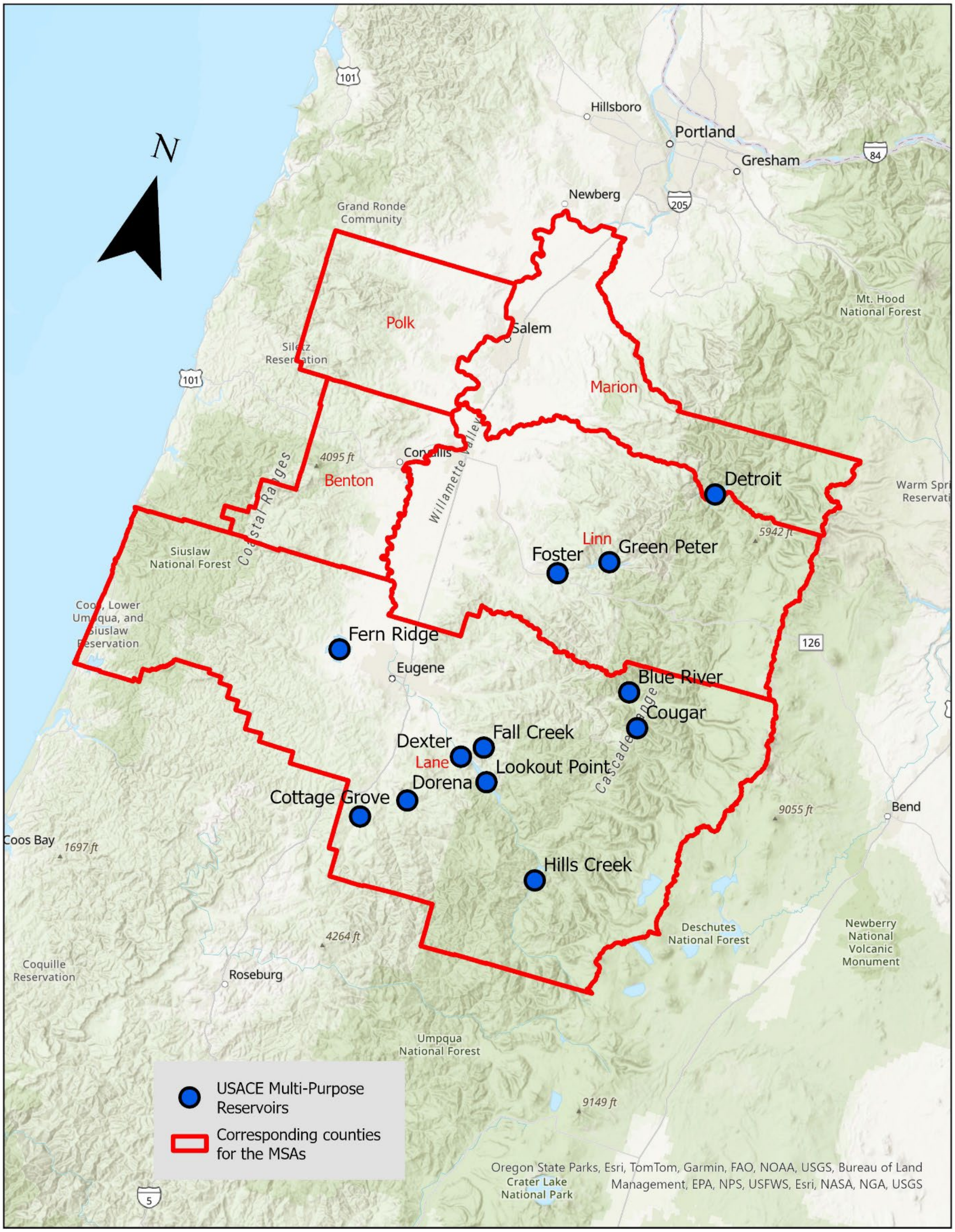


Figure 3.11-1. Willamette Valley System Reservoirs and Corresponding Metropolitan Statistical Areas Counties.

3.11.2.3 Analysis Area Housing

> **What's a Housing Unit?**
>
> A house, an apartment, a mobile home or trailer, a group of rooms, or a single room occupied as separate living quarters, or if vacant, intended for occupancy as separate living quarters.

Housing in the analysis area is described because it supports project workers or has relevance to existing housing occupancy and burden on availability. At the time the alternatives were analyzed, there were approximately 100 residential units in the nearby vicinity of Fern Ridge, Cottage Grove, and Dexter Dams (Google Earth 2020). Blue River, Dorena, Fall Creek, Foster, Lookout Point, and Hills Creek Dams include at least 100 residential units within 1 mile of the dams and reservoirs (Google Earth 2020). No other substantial residential areas are within 1 mile of other WVS dams and reservoirs.

Both occupied and vacant housing units are included in the total housing unit inventory for each MSA (Table 3.11-1). A housing unit is classified as occupied if it is the usual place of residence of a person or group of people; conversely, a housing unit is classified as vacant if it is not the usual place of residence of a person or group of people. Vacancy rates ranged from 4.2 percent to 5.6 percent in the analysis area in 2022.

Table 3.11-1. Housing Characteristics in the Metropolitan Statistical Areas, 2022.

Location	Total Housing Units	Occupied Housing Units	Vacancy Rate (%)
Lane County	166,750	158,621	4.9
Linn County	52,145	49,944	4.2
Benton County	40,092	37,853	5.6
Marion County	129,065	123,460	4.3
Polk County	33,916	32,222	5
State of Oregon	1,818,599	1,680,800	7.6

Source: USCB 2022c

3.11.2.4 Analysis Area Recreation

The WVS supports numerous recreation opportunities (Section 3.14, Recreation). These opportunities generate revenue for local communities and the state and support the labor force in the analysis area.

For some communities in the immediate vicinity of the WVS reservoirs, the recreation season has a substantial impact on community identity as well as individual livelihood. Local governments, community organizations, USACE, and other agencies managing recreation resources in the analysis area work year-round to support recreation opportunities so that visitors can utilize these areas during the recreation season.

3.11.2.5 Analysis Area Labor

The labor force in the analysis area is described as the sum of those employed and unemployed. Unemployment is defined as those who do not have a job, have actively looked for work in the prior 4 weeks, and are currently available for work (BLS 2015). Labor has increased and unemployment has decreased in the analysis area between 2010 and 2019. As of 2024, the labor force increased in the analysis area in the years following the coronavirus pandemic, with fluctuations. Additionally, as of 2024, the labor force increased over pre-pandemic labor in Lane County.

Overall, the labor force in the analysis area has been increasing since 2010, although not as large in most MSAs as the overall labor force growth rate in the State of Oregon (Table 3.11-2). The Lane County MSA has historically supported the lowest labor force growth rate, which is also lower than the overall State of Oregon labor force growth rate. Conversely, the Polk County MSA has the largest labor force growth rate for the period 2010 to 2023, which reflects a growth rate larger than the state rate for the same period.

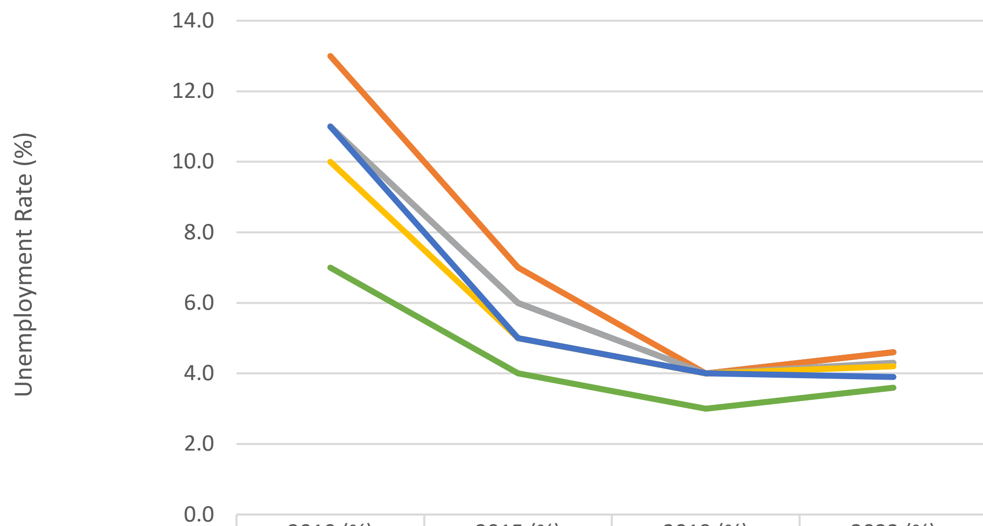
Table 3.11-2. Metropolitan Statistical Area Labor Force, 2010 to 2023.

MSA County and State of Oregon	2010	2015	2019	Growth Rate of Labor Force (2010-2019)	2021	2022	2023	Growth Rate of Labor Force (2019-2023)
Lane County	177,650	170,048	181,844	2.4	182,572	183,397	181,141	-0.39
Linn County	56,877	54,058	59,386	4.4	60,734	61,677	60,545	1.95
Benton County	43,834	43,662	46,553	6.2	47,620	49,114	49,345	6.00
Marion County	151,234	148,376	158,741	5.0	167,391	170,317	169,991	7.09
Polk County	36,523	36,607	40,014	9.6	41,967	42,727	42,696	6.70
State of Oregon	1,957,286	1,940,921	2,083,094	6.4	2,144,461	2,159,953	2,162,127	3.79

Source: BLS 2023

Notes: (1) Numbers may not add to total due to rounding. (2) The 2020 census data collection was substantially disrupted, which heavily impacted the reliability of population and housing data during the coronavirus pandemic period. Consequently, the 2020 labor force data were not included in the table. Data that are included are considered representative of expected trends.

The unemployment rate is calculated based on the number of unemployed persons divided by the labor force. Unemployment rates have decreased in all MSA counties, reflecting the same trend in the State of Oregon during the 2010 to 2019 period (5.3 percent to 6.7 percent decrease statewide) (Figure 3.11-2). The greatest decrease in MSA unemployment from 2010 to 2015 was in Linn County. During the coronavirus pandemic period from 2019 to 2022, the greatest decrease in MSA unemployment was in Lane and Linn Counties, occurring at a similar rate when compared to overall employment rates in Oregon during this period.



	2010 (%)	2015 (%)	2019 (%)	2022 (%)
Lane County	11.0	6.0	4.0	4.6
Linn County	13.0	7.0	4.0	4.6
Benton County	7.0	4.0	3.0	3.6
Marion County	11.0	6.0	4.0	4.3
Polk County	10.0	5.0	4.0	4.2
Oregon	11.0	5.0	4.0	3.9

Figure 3.11-2. Metropolitan Statistical Area Unemployment Rates, 2010 to 2022.
Source: BLS 2023

3.11.2.6 Employment by Industry

Employment industries, earnings, and personal income in the analysis area have relevance to local workers specific to employment opportunities and to burden on employment availability. Various industries support the MSA labor force in the analysis area (Table 3.11-3). Employment industries are listed in groups below, with a description of the service provided or product produced. Various employment industries may be grouped and called a sector for a common characteristic (for example: the private sector).

In 2019, the largest employment industries in Lane and Polk Counties were education services and health care and social assistance. The government was the largest employer in Marion County. Most people were employed in manufacturing in Linn County (OED 2019a, 2019b, 2019c). However, there were fluctuations in the labor force in the years following the coronavirus pandemic.

As of 2023, the three largest employment industries in the analysis area were trade, transportation, and utilities; health care and social assistance; and government (Table 3.11-3). Lane County employment industries were equally distributed among these categories. Government has become the highest employment industry in Polk County since 2019. The largest employment industries, including Trade, Transportation, and Utilities, in Linn and Polk Counties remained the same in 2023 as in 2019.

Table 3.11-3. Metropolitan Statistical Area Employment by Industry, 2023.

Industry Description	Lane County Employed	Linn County Employed	Benton County Employed	Marion County Employed	Polk County Employed
Natural Resources and Mining	2,483	2,650	1,029	10,465	1,685
Construction	7,924	3,156	1,311	12,037	1,214
Manufacturing	14,640	8,214	2,883	10,045	1,837
Trade, Transportation, and Utilities	29,325	10,821	4,608	27,184	2,548
Information	1,924	328	696	1,549	105
Finance and Insurance	4,254	735	710	4,160	298
Real Estate, Rentals, and Leasing	2,592	438	434	1,968	217
Professional and Business Services	17,454	3,365	4,544	15,541	1,367
Educational Services	1,949	562	361	2,870	192
Health Care and Social Assistance	26,700	6,781	6,492	25,679	3,992
Arts, Entertainment, and Recreation	2,014	494	534	1,489	241
Accommodation and Food Services	15,108	3,372	3,788	12,152	2,110
Other Services	5,274	1,378	1,456	5,070	696
Government	25,306	6,537	9,827	37,646	5,124
Total Employees	**156,947**	**48,831**	**38,673**	**167,855**	**21,626**

Source: OED 2023

3.11.2.7 Earnings

Earnings are described as per capita personal income, total industry income, and compensation by industry.

- Personal income is the personal income for county residents divided by the total county population.

- Compensation data represent income from the county of work location and are typically reported on a per job basis. Compensation data indicate the wages and salaries for work done in a particular place (e.g., a county), but if the worker does not live in the county where the work occurred then a sizeable portion would be spent elsewhere. These expenditures would not remain in or flow back into that county's economy. Total compensation includes wages and salaries as well as employer contribution for employee retirement funds, social security, health insurance, and life insurance.

3.11.2.8 Per Capita Personal Income

Per capita personal income is the income received from all sources. It is the sum of net earnings by place of residence, property income, and the average amount of money earned per person from jobs or other income sources (i.e., personal current transfer receipts or government social benefits) (BEA 2016). This includes earnings from work and interest and dividends received as well as government social benefits such as social security disbursement. It is measured before the deduction of personal income taxes and other personal taxes and is reported in current dollars.

The per capita personal income increased in the analysis area MSAs from 2010 to 2019 by approximately 2.7 percent, which was below the personal income increase for the state (Table 3.11-4). Polk County experienced the highest average change in personal income between 2019 and 2022.

There were fluctuations in the labor force in the years following the coronavirus pandemic (Figure 3.11-2). From 2019 to 2022, the per capita personal income increased from 4.5 percent to 8 percent statewide.

Table 3.11-4. Metropolitan Statistical Area Per Capita Personal Income, 2010 to 2022.

MSA County and State of Oregon	2010 ($)	2015 ($)	2019 ($)	2022 ($)	Average Annual Percent Change (2010–2022)
Lane County	23,869	24,960	29,705	36,776	13.5
Linn County	22,165	21,706	27,345	32,501	11.6
Benton County	26,177	27,888	33,817	39,940	13.1
Marion County	21,915	22,490	27,338	33,545	13.2
Polk County	24,345	23,967	29,440	38,920	14.9
Oregon	26,171	27,684	33,763	41,805	14.9

Source: USCB 2010a, 2015a, 2019a, 2022a

Note: All dollar estimates are in current dollars (not adjusted for inflation).

3.11.2.9 Total Industry Income and Compensation by Industry

Total industry compensation includes private sector and government employment. Data in this category are used to demonstrate the relative sizes of market-related economic activity, or business activity, performed in a county (Table 3.11-5).

Income in the MSA analysis area is generated through employment in numerous industries; however, some of the income may be earned by those living outside of an MSA county. Regardless, employee compensation by industry measures economic activity generated in an MSA county, regardless of where the employee resides.

Table 3.11-5. Metropolitan Statistical Area Total Industry Compensation, 2023.

Industry Description	Lane County Compensation ($000)	Linn County Compensation ($000)	Benton County Compensation ($000)	Marion County Compensation ($000)	Polk County Compensation ($000)
Natural Resources and Mining	132,287	134,020	55,754	437,739	76,265
Construction	525,585	216,850	86,293	836,138	76,169
Manufacturing	917,527	591,254	267,890	588,561	93,204
Trade, Transportation, and Utilities	1,376,393	514,930	195,937	1,334,434	116,262
Information	181,132	25,456	77,439	140,828	7,137
Finance and Insurance	358,919	44,286	60,806	372,214	20,002
Real Estate, Rentals, and Leasing	126,505	18,974	19,154	104,860	10,596
Professional and Business Services	1,124,303	212,359	348,320	891,445	74,895
Educational Services	75,747	25,024	13,083	129,809	6,398
Health Care and Social Assistance	1,668,806	352,503	459,809	1,622,523	180,371
Arts, Entertainment, and Recreation	47,260	10,876	10,579	42,203	5,053
Accommodation and Food Services	378,110	78,842	92,513	306,670	47,876
Other Services	206,331	50,104	65,101	205,694	24,756
Government	1,721,185	399,240	758,296	2,987,795	329,297
Total Compensation of Employees	**8,840,089**	**2,674,718**	**2,510,973**	**10,000,914**	**1,068,282**

Source: OED 2023

Note: Numbers may not add to total due to rounding.

3.11.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives related to socioeconomics. The analyses address effects on MSA communities from operations, maintenance, construction, management, rehabilitation, and the alteration of reservoir outflows and water levels under the No-action Alternative (NAA) and the action alternatives[2].

The discussion includes the methodology used to assess effects and a summary of the anticipated effects. Additional detail supporting the action alternatives analyses specific to capital costs associated with construction are in Appendix I, Socioeconomics Analysis, and Appendix K, Recreation Analysis, respectively.

Direct effects would occur from:

- Revenue opportunities within MSA communities.
- Employment earnings opportunities within MSA communities.
- Costs to MSA communities.

Indirect effects would occur if:

- An MSA community is adversely impacted by a change in reservoir operations resulting in an employment industry shift to a different county associated with one or more other reservoirs in the analysis areas (i.e., displaced visitor use from one reservoir to another for recreation opportunities). The direct, adverse effect on the recreation socioeconomic factor in one county would, in turn, be an indirect, beneficial, or adverse effect to another county related to employment in the recreation industry.
- Managing agencies and organizations are required to adjust to visitor shifts resulting from alterations in water-based recreation opportunities, requiring staffing and financial resources to manage impacts. Impacts could include closure- and safety-related management, unauthorized dispersed recreation management, and possible financial burdens, including lost revenue or increases in revenue at the local level, among other unknown effects.
- The direct effect of drawdown operations on water quality results in indirect, increased water treatment costs or lack of potable water from turbidity increases in MSA communities.

[2] The extent of effects analyzed under each alternative is the largest extent that would occur, even if the most severe adverse effect or the least beneficial effect would be localized.

3.11.3.1 Methodology

Potential effects to socioeconomics were evaluated both quantitatively and qualitatively for the MSAs and corresponding Lane, Linn, Benton, Polk, and Marion Counties. With some exceptions, counties and communities are not specified in the analyses; however, reservoir analyses can be correlated with MSA descriptions (Figure 3.11-1).

<u>**Quantitative Analysis**</u>

Federal spending would occur under all alternatives over the 30-year implementation timeframe to continue WVS operations and maintenance activities. However, costs specific to operation and maintenance attributed to MSAs under the NAA are not available but were estimated. While regional economic benefits from operations and maintenance would occur under all alternatives, NAA estimated benefits are unknown and, therefore, a comparison of the action alternatives to NAA benefits was not practicable. Consequently, the analysis addresses only the effects from Federal spending for construction costs.

> **What are Costs Associated with Dams and Reservoirs?**
>
> **Operations and maintenance** costs associated with operations and maintenance of dams and include numerous activities such as monitoring, updating, safety protocol adjustments, and daily operations. These costs are not included in the analyses because it is not practical to attribute these costs with specific MSAs; data would be misleading.
>
> **Capital costs** for purposes of the analyses are the costs required for construction activities under the alternatives, specifically mobilization, construction, and demobilization. These costs are not included in the No-action Alternative analysis because construction is not proposed.
>
> **Federal spending** is allocation of Federal dollars for construction costs (i.e., Federal dollars used for capital costs).

The quantitative analyses address capital costs of construction under the action alternatives. Construction is not anticipated under the NAA; therefore, no quantitative data are provided. Capital cost analyses incorporate December 2024 costs of construction. These data were updated in the FEIS alternatives analyses from the DEIS information. Additional analyses will be conducted in future NEPA assessments prior to construction implementation.

Average annual monetary benefits attributable to recreation alone were also prepared using hydrographic inputs and USACE NED modeling methods (Appendix K, Recreation Analysis). Monetary recreation benefit differences among alternatives were then used as inputs into the RECONS[3] model to estimate regional differences in employment, earnings, and total economic value that would result from differences in recreational visitation as compared to conditions under the NAA. Results of RECONS modeling were based on expected differences in visitation

[3] RECONS is a proprietary USACE input-output modeling methodology that allows for the estimation of changes in economic contributions from a given investment.

(Appendix K, Recreation Analysis, Chapter 5, Recreation Effects on Regional Economic Development).

Differences in visitation among alternatives due to alterations in recreation values from alternative implementation would have direct and induced economic effects reflected in model results. The direct and indirect effects of recreation opportunities and visitation are analyzed in Section 3.14, Recreation Resources.

RECONS was also applied to model construction spending economic activity under the action alternatives. Changes in monetary benefits were then assessed as the degree of effect relative to the degree of effect on monetary conditions under the NAA.

RECONS output summaries are presented by activity type and were aggregated to the nearest MSA (Appendix I, Socioeconomics Analysis). For example, Green Peter and Foster Reservoirs are located along the same fork of the South Santiam River and are, therefore, within the Albany MSA.

Recreation-related revenue and employment earnings analyses under each alternative incorporate water-based and land-based visitation during the peak recreation season of May 15 to September 15 and outside of this season where applicable (Section 3.14, Recreation). Recreation-related revenue and employment earnings modeling does not separate outcomes by peak and non-peak recreation seasons; RECONS results capture all possible recreation-related employment earnings at any time.

Further, under all alternatives, land-based recreation opportunities around reservoirs would remain available (Section 3.14, Recreation); however, effects specific to land-based recreation employment cannot be quantitatively separated from water-based recreation employment. It is assumed that land-based recreation employment at any reservoir is predicated on water-based recreation employment under any alternative.

Effects analyses in Section 3.14, Recreation, may differ from socioeconomic effects analyses. Recreation analyses focus on recreation opportunities during the peak recreation season at each reservoir, and are therefore assessed as being available or not available under each alternative. Socioeconomic analyses focus on localized economic and community effects based on economic modeled outcomes that incorporate several modeled inputs as describe above and in Appendix K, Recreation Analysis. Therefore, RECONS modeling may or may not result in the same effects outcome as effects on recreation opportunities described in Section 3.14, Recreation.

Visitation data help describe direct and indirect economic effects such as visitor/trip spending. At the time the alternatives were analyzed, both water-based and land-based recreation visitation in the WVS was highest at Fern Ridge and Foster Reservoirs (Section 3.14, Recreation).

These visitation estimates reflect fiscal year 2022 (October 1 to September 30). However, recreation-related economic effects are known to be greatest in communities surrounding Detroit Reservoir when compared to the other WVS reservoirs[4].

Visitation data available for USACE-, county-, and state-managed facilities and estimates for visitation to U.S. Forest Service-managed facilities are obtained from different sources. Estimated visitation at the WVS reservoirs at the time the alternatives were analyzed did not fully reflect the 30-year implementation timeframe because visitation return rates following the 2020 wildfires were not available.

Visitation data alone cannot be used to estimate revenue and are only one input into the RECONS model that estimated community (i.e., local) revenue under each alternative. Additional model inputs are described in Appendix K, Recreation Analysis.

Qualitative Analysis and Effects Criteria

Results of RECONS modeling were based on expected differences in visitation (Appendix K, Recreation Analysis, Chapter 5, Recreation Effects on Regional Economic Development). However, while useful information, the degree of difference among alternatives from visitation does not provide a comprehensive analysis of effects as compared to the NAA and can be misleading. For example, a minor decrease in visitation under an alternative inaccurately results in a minor degree of adverse effect; a minor decrease does not necessarily equate to a minor, adverse effect when compared to NAA conditions where visitation may be high. In this case, the degree of effect from alternative implementation would continue to be a benefit on recreation-related employment, but with a minor decrease in that benefit.

Consequently, the adverse or beneficial degree of impact to socioeconomic factors is assessed qualitatively and discussed descriptively as compared to NAA conditions (e.g., negligible, slight[5], moderate, substantial). Specified criteria to describe the degree of effect are not provided because criteria cannot be reliably linked to model results based on degrees of change in visitation, as described above (e.g., a minor degree of change is not a reliable criterion to establish degree of effect when compared to NAA conditions).

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[4] Detroit Reservoir has traditionally experienced the highest recreation use in the WVS. However, the 2020 North Santiam River Subbasin wildfires resulted in substantial adverse effects on recreation opportunities at this reservoir (see Section 3.6, Vegetation, Section 3.6.2.3, 2020 Wildfires). Opportunity impacts included lack of potable water, the damage or full destruction of recreation sites, and substantial aesthetic damage. Potable water was restored in 2021, but the area was still recovering when the alternatives were analyzed, which is reflected in the 2022 visitor data. Consequently, the 2022 visitor data are not likely reflective of anticipated trends over the 30-year implementation timeframe.

[5] "Negligible" is defined as no measurable effect. "Slight" is defined in its common use as "small of its kind, or in amount" (Merriam-Webster Dictionary). "Moderate" is not used as a specified criteria in this analysis. It is defined in its common use as "average in amount, intensity, quality, or degree" (Oxford Languages). "Substantial" is defined in its common use as "considerable in quantity, great [in amount]" (Merriam-Webster Dictionary).

This qualitative analysis was applied to analyses of community effects. The analysis area population could experience direct, indirect, or induced economic effects from employment and wages from construction, operation, and maintenance under any alternative. Consequently, effects to labor income, economic activity, or annual employment and, therefore, to housing from construction expenditures would potentially impact MSA communities. Construction expenditure effects were modeled and are analyzed quantitatively and qualitatively (Appendix I, Socioeconomics Analysis).

Economic Relationship with Communities

The qualitative analysis also estimates effects to the analysis area communities if impacts from greenhouse gas emissions; hydropower generation, transmission reliability, and economic viability; water quality treatment costs; and water supply would result in increased indirect costs and/or would result in impacts to communities under each alternative when combined with other community effects (e.g., employment, housing, climate change conditions, etc.).

Socioeconomic effects were estimated by incorporating analyses of these other community impacts and comparing outcomes to the NAA. These analyses are summarized below, but each resource analysis applied unique methodology and criteria to determine anticipated degrees of effect on the human environment, which can be reviewed in each resource section (e.g., qualitatively describing water supply effects rather than assigning defined criteria). The criteria used for the socioeconomics analyses was not imposed on each resource analysis. Degrees of effect described under each resource were, therefore, assumed to correlate to similar degrees of effect analyzed for impacts on MSA communities.

Estimates were also made by applying relevant case studies, expert knowledge of common revenue or cost flows, and professional judgement concerning impacts typically associated with construction at dams and reservoirs to modeled results. Qualitative effects were also assessed by applying assessment factors in USACE Engineering Regulation 1105-2-103 (USACE 2023b) and the Institute for Water Resources Handbook on Applying "Other Social Effects" in USACE Water Resources Planning (Dunning and Durden 2009). These factors included basic social statistics, social vulnerability and resiliency indicators, social connectedness, economic vitality, leisure and recreation, participation, and health and safety, which were combined to derive an assessment of community effects in the analysis area.

The duration of all effects to MSA communities and counties would be occurring or reoccurring over the 30-year implementation timeframe.

The socioeconomics effects criteria for extent and a summary of effects are provided in Table 3.11-6 and Table 3.11-7, respectively.

Table 3.11-6. Extent Criteria for Socioeconomics Effects.

Extent	Definition
Local	Effects would be confined to the dam/reservoir and communities within these vicinities. This includes the MSAs and smaller communities.
Regional	Effects are perceived in communities throughout the MSA counties, multiple counties, or the entire Willamette River Basin.
Statewide	Effects are perceived in communities throughout the entire state.

Table 3.11-7. Summary of Socioeconomic Effects on Metropolitan Statistical Area Communities as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Arts, Entertainment, and Recreation Industry Employment	Negligible, direct, beneficial effect to any employment industry. Employment opportunities would not be a substantial contributor to MSA industry employment rates at the local, regional, or statewide levels.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Housing	None	None	None	None	None	None	None	None
Labor Force and Unemployment	Minor, beneficial effects	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Art, Entertainment, and Recreation Industry	No measurable adverse or beneficial effect	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Federal Spending for Construction	No benefit	Second most beneficial	Third most beneficial	Fourth most beneficial	Fifth most beneficial	Sixth most beneficial	Most beneficial	Fourth most beneficial
Federal Spending for Operations and Maintenance	Slight, beneficial	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Recreation-related Revenue and Employment Earnings at the Local, Reservoir Level	Substantial, beneficial	Same as NAA with slight increases in benefits, except a slight decrease in benefits to Eugene MSA communities localized to Lookout Point Reservoir in late summer.	Same as NAA with slight increases in benefits, except a slight decrease in benefits to Salem MSA communities localized to Green Peter Reservoir in late summer.	Same as NAA, except a substantial adverse effect to Eugene MSA communities localized to Cougar Reservoir.	Substantial, adverse effect to Salem and Eugene MSA communities localized to Detroit, Cougar, and Lookout Point Reservoirs.	Substantial, adverse effect to Eugene MSA communities localized to Cougar, Green Peter, and Hills Creek Reservoirs. Substantial, adverse effects to communities localized to Detroit, Blue River, and Lookout Point Reservoirs in late summer, depending on the amount of precipitation during the summer and timing of drawdown initiation at each reservoir.	Same as NAA with negligible decreases in benefits to Salem MSA communities localized to Detroit Reservoir and slight decreases in benefits to Albany MSA communities localized to Green Peter Reservoir.	Same as NAA with negligible decreases in benefits to Albany MSA communities localized to Green Peter Reservoir and slight decreases in benefits to Salem MSA communities localized to Detroit Reservoir.
Economic Relationship with Communities	Beneficial	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative with slightly fewer benefits.	Substantial, adverse	Substantial, adverse	Same as No-action Alternative.	Same as No-action Alternative with slightly fewer benefits.

[1] All effects would occur or reoccur over the 30-year implementation timeframe (i.e., long term).

3.11.3.2 Alternatives Analyses

Industry Employment under All Alternatives

The most relevant employment industries related to any alternative implementation are the government and art, entertainment, and recreation industries. The latter is not a substantial employment industry in the MSA counties, but is an important industry for labor and earnings, and would remain important under any alternative.

Routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation). Consequently, it is unknown if these activities would result in increased, temporary or long-term employment opportunities to MSA communities under a given alternative. Direct economic effects from routine and non-routine maintenance would be assessed under site-specific NEPA reviews.

While operations and maintenance under any alternative would result in temporary or long-term employment opportunities, there would be a negligible, direct, beneficial effect to any employment industry resulting from operations at the 13 WVS dams during the 30-year implementation timeframe under any alternative. Types of jobs within employment industries such as recreation, and local employer management priorities, are likely to shift with changing visitor use at WVS reservoirs (Section 3.14, Recreation). However, employment opportunities at WVS dams alone would not be a substantial contributor to MSA industry employment rates at the local, regional, or statewide levels.

Housing Characteristics under All Alternatives

Housing characteristics in the analysis area MSA communities are not expected to change under any alternative over the 30-year implementation timeframe. There would be no measurable direct or indirect impact on total available housing units; however, implementation of the action alternatives would result in a negligible, direct, adverse impact on vacancy rates temporarily if construction workers require short-term relocation.

Regardless of temporary housing needs, there are housing units within 10 miles of WVS dam operations that are anticipated to adequately support housing needs for any temporary increase in WVS workers in the analysis area. There would be no long-term, adverse effects on occupancy (or vacancy) rates to any community under any alternative.

Employment, Labor, and Earnings under All Alternatives

Labor Force and Unemployment Effects

Labor force increases and unemployment decreases in the analysis area are anticipated to continue under any alternative over the 30-year implementation timeframe. For analysis purposes, it is assumed there would be long-term, minor, beneficial effects on labor and employment under any alternative from employment to operate and maintain the dams based on trends at the time the alternatives were analyzed.

However, unforeseen economic events could occur that cannot be accurately assessed in relation to local, regional, and statewide labor forces and unemployment over 30 years (e.g., recessions). Regardless, operations and maintenance under any alternative would not result in substantial direct or indirect effects on the labor force or unemployment experienced in any MSA county under any economic condition. This is because of limited employment opportunities at WVS dams in comparison to overall employment opportunities in any MSA county, including temporary construction-related labor.

Employment Industry Effects

Earnings are described as per capita personal income, total industry income, and compensation by industry. Both contracted and government employment in the MSAs would be necessary under the action alternatives for continued operations and maintenance work or to support construction activities. Contracted and government employment would also continue under the NAA over the 30-year implementation timeframe although no construction projects are identified under this alternative. However, any direct or indirect effects on the government employment industry in each MSA would be minor and long term because of the limited impact on MSA employment overall. These effects would be primarily localized, but could have minor, regional benefits.

The Arts, Entertainment, and Recreation employment industry is the industry category with potential effects from alternative implementation. Recreation employment is only one of many employment sectors in this industry category.

While WVS operations under each alternative would affect recreation employment at the local level (see Recreation-related Revenue and Employment Earnings under All Alternatives below), there would be no measurable adverse or beneficial effect at the industry level under any alternative. This is because the Arts, Entertainment, and Recreation industry category supports only a small percentage of total employment in the MSA counties (1 to 1.5 percent across all counties) (Table 3.11-3).

Employment Industry Growth and Federal Spending

Under any alternative, industry labor and earnings resulting from business activity in the MSA communities are expected to continue growing at the rate when the alternatives were analyzed over the 30-year implementation timeframe independent of WVS operations and maintenance. This growth trend reflects the relative sizes of market-related economic activity performed in each MSA. This would be a long-term, beneficial effect on MSA communities as well as regionally.

No Federal spending for construction costs is included under the NAA. Under the action alternatives, Federal spending for construction costs in the MSAs would result in both direct and indirect, beneficial impacts. Economic activity, impacts, and contributions to the local, regional, and statewide[6] economies because of Federal spending are measured as economic output from sales, annual average jobs available monthly, income earned, and value added.

Consequently, local, regional, and statewide estimates of economic activity, direct and indirect impacts, and contributions from construction-related Federal spending would be greatest under Alternative 4, followed by Alternatives 1, 2A, 2B/5, 3B, and 3A as generating the least economic benefit. However, these benefits would be a minor contribution to total economic benefits in the MSAs (Appendix I, Socioeconomics Analysis).

As under the NAA, it is anticipated that economic activity resulting from Federal spending for operations and maintenance under all action alternatives would be a continued long-term, slight, beneficial economic effect in the MSAs resulting from this separate category of Federal spending.

While regional economic benefits from operations and maintenance would occur under all alternatives including the NAA, NAA-estimated benefits are unknown. Therefore, a quantitative comparison of the action alternatives to NAA benefits was not practicable. NAA benefits would include primarily construction and project management benefits in addition to government employee compensation.

Recreation-related Revenue and Employment Earnings under All Alternatives

Recreation opportunities support visitor spending related to land-based and water-based recreation activities in the analysis area MSAs (i.e., visitation-induced economic activity). Recreation opportunities also support employment for recreation site management and private local businesses. For analysis purposes, it is assumed direct and indirect economic effects would occur during the May 15 to September 15 peak recreation season in the analysis area. Some effects during the fall, non-peak recreation season could occur, which are identfied as applicable.

All direct economic effects on MSA communities from recreation opportunities would be primarily localized because of localized reservoir drawdown operations. Indirect economic effects would also be localized to the communities that benefit from displaced recreation opportunities due to drawdowns. There would be no measurable effect to the recreation employment industry long term under any alternative.

Most effects would result in continued benefits on recreation-related revenue and employment under the alternatives with negligible increases or decreases in these benefits at the local level. Substantial, adverse economic effects would occur at some local levels under Alternative 3A and Alternative 3B and during dry years in late summer under some alternatives. These effects would be localized to some reservoirs and surrounding communities depending on alternative

[6] It is possible that construction resources would be needed from sources outside of the state. This assumption is included in Appendix I, Socioeconomics Analysis, but national benefits are not analyzed here. The area for this analysis is the MSA communities, which would primarily be directly or indirectly affected.

implementation as described below (Table 3.11-8). Analyses under each alternative are supported by information in Section 3.14, Recreation; Appendix I, Socioeconomic Analysis; and Appendix K, Recreation Analysis.

Economic activity is described as both impacts and contributions to an economy from construction related to alternative implementation. This activity is measured as economic output from sales, annual average of jobs available monthly, income earned, and value added[7]. RECONS represents interdependencies between Federal spending and output.

Because of the scale of each alternative and associated measures, and the cost associated with each alternative, alternatives that appear similar in terms of implementation can potentially produce substantial, disparate RECONS model outputs and effects on MSAs. This outcome is pertinent to disparities between Alternative 2B and Alternative 5. Although these alternatives have similar measures, there are distinctions as compared to the NAA. Consequently, these distinctions resulted in different MSA recreation-related revenue and employment outputs between the two alternatives.

[7] Value added is an estimate of gross regional product. It is a combination of employee compensation, business owner income, industry profits, and indirect business taxes.

Table 3.11-8. Local Reservoir-induced Visitation and Direct Economic Activity for All Metropolitan Statistical Areas Combined under Each Alternative as Compared to the No-action Alternative (2023 Price Level)[1].

Alternative[1]	No-action	1	2A	2B	3A	3B	4	5
Output[2]	$342,309,548	+$5,135,975	+$3,117,036	+$3,037	-$14,641,302	-$18,197,015	+$1,685,630	-$2,539,633
Jobs[3]	2,730.5	+40.5	+24	-0.6	-116.2	-156.9	+12.5	-20.3
Labor Income[4]	$129,233,206	+$1,926,566	+1,156,531	-$7,750	-$5,466,372	-$7,086,551	+$621,299	-$959,312
Value Added[5]	$197,811,013	+$2,974,218	+1,829,070	+$14,591	-$8,450,154	-$10,261,567	+$994,953	-$1,467,916

Note: Results described represent the model "local" area. "Local" is a term defined by the RECONS model as the MSAs; it is not synonymous with the use of "local" throughout this analysis. "Local" as applied to the analyses refers to the communities in which reservoir-induced visitation and direct economic activity would occur (e.g., person-to-business monetary transactions that occur because of the existence of the reservoir). Economic effects at the local, community level could be more beneficial or adverse than those realized in an entire MSA.

[1] Values in each category under each action alternative represent amounts in addition to (+) or less than (-) amounts under the No-action Alternative.

[2] Output can be measured either by total value of purchases by intermediate and final consumers or by intermediate outlays plus value added. It is also known as gross revenues or sales.

[3] Jobs are presented in full-time (40 hours per week) equivalent jobs supported.

[4] Labor income represents all forms of employment earnings. In IMPLAN's regional economic model, it is the sum of employee compensation and proprietor income.

[5] Value added consists of employee compensation, proprietary income, other property type income, and indirect business taxes. Value added is an estimate of the gross regional or state product.

Summary tables of the degree of adverse or beneficial effect on recreation-related revenue and employment earnings are located at the end of each alternative analysis.

No-action Alternative

Revenue and employment earnings in MSA communities from recreation visitation during the peak May 15 to September 15 analysis area recreation season would continue to be a direct, substantial, beneficial effect under NAA operations because both would continue to be positive contributions to MSA communities (Table 3.11-9).

It is assumed that visitation interest by reservoir would remain the same as under existing conditions over the 30-year implementation timeframe (i.e., those reservoirs with high visitor use for water-based opportunities such as Fern Ridge and Foster Reservoirs would continue to be of high interest to visitors in the Eugene, Veneta, and Sweet Home, Oregon areas). Further, it is anticipated that population increases would likely directly increase visitation to analysis area reservoirs for land-based and water-based recreation opportunities.

Revenue and employment earnings would likely increase under NAA operations over the 30-year implementation timeframe as the analysis area population increases. Some communities would benefit to greater degrees than others depending on proximity to reservoirs. For example, economic benefits from reservoir recreation would likely be less in Salem, Oregon than in Detroit, Oregon, which is localized at Detroit Reservoir.

It is also assumed that visitation at Detroit Reservoir would increase during the 30-year implementation timeframe from visitation at the time the alternatives were analyzed due to population increases in the analysis area and improvements in post-2020 wildfire conditions (Section 3.11.3.1, Methodology).

Exceptions to these increased employment benefits would occur during years of low precipitation, which would require use of reservoirs for Congressionally authorized purposes other than recreation. Depending on the timing of drawdowns, late season operations could be an adverse effect on water-based recreation opportunities when prohibited at reservoirs where water-based recreation activities are the primary recreation activities supported by operations.

Although direct, adverse effects, or a decrease in beneficial effects, to recreation in years with low precipitation cannot be accurately assessed, it is assumed these operations would adversely affect water-based recreation opportunities by limiting use of boat ramps during the peak recreation season under the NAA. This could be a direct, substantial, adverse effect on recreation-related revenue and employment if persistent over an entire recreation season or reoccurring over the 30-year implementation timeframe and affecting several high visitor-use reservoirs under NAA operations, including Foster, Hills Creek, Fern Ridge, Cottage Grove, or Dorena Dams and local communities.

During dry-year conditions, there would be no measurable direct or indirect adverse effect to the MSA recreation-related revenue or employment long term under any alternative if the effects are intermittent and do not impact all analysis area reservoir recreation opportunities during the same recreation season. Water-based recreation opportunities may be available at some reservoir locations, which would be an indirect benefit to these MSA communities from displaced visitors and possible increases in employment opportunities at the local level.

Employers within MSA communities may require adjustments in management priorities related to recreation opportunities over the 30-year implementation timeframe under any alternative resulting from implementation or climate change-related effects (Section 3.11.5, Climate Change under All Alternatives). Management priorities could shift to land-based recreation opportunities or to increased use at other reservoirs during deep drawdown closures. This would likely require additional employee services at nearby reservoirs and safety/security management costs around reservoir access under some alternatives, including Alternative 3A and Alternative 3B.

Water-based closures could result in lost or increased recreation management revenue at some locations. However, indirect effects from the need for additional management resources, including employment or lost or increased revenue over a 30-year timeframe, are unknown.

Table 3.11-9. Degree of Adverse or Beneficial Effect on Recreation-related Revenue and Employment Earnings under the No-action Alternative[1].

Reservoir	Degree of Effect	MSA CBSA	MSA County
Detroit	Substantial, beneficial	Salem	Marion
Foster	Substantial, beneficial	Albany	Linn
Green Peter	Substantial, beneficial	Albany	Linn
Cougar	Substantial, beneficial	Eugene	Lane
Blue River	Substantial, beneficial	Eugene	Lane
Lookout Point	Substantial, beneficial	Eugene	Lane
Hills Creek	Substantial, beneficial	Eugene	Lane
Dexter	Substantial, beneficial	Eugene	Lane
Fall Creek	Substantial, beneficial	Eugene	Lane
Dorena	Substantial, beneficial	Eugene	Lane
Cottage Grove	Substantial, beneficial	Eugene	Lane
Fern Ridge	Substantial, beneficial	Eugene	Lane

Note: Does not represent degrees of effect anticipated during wet years within or outside of the peak recreation season.

[1] All effects would be long term.

Alternative 1—Improve Fish Passage through Storage-focused Measures

Operations under Alternative 1 would not include deep drawdowns or other operations that would substantially alter recreation opportunities during the peak recreation season[8] and, therefore, would not measurably impact reservoir-related recreation revenue and employment

[8] The peak recreation season in the analysis area is May 15 to September 15.

opportunities in MSA communities near Foster, Hills Creek, Fern Ridge, Cottage Grove, or Dorena Dams, as compared to NAA operations.

Specifically, under Alternative 1 there would be slightly higher reservoir levels from earlier refills and higher levels remaining later in the year at several reservoirs (e.g., boat ramp availability extended in dry years under Alternative 1 flow operations). These operations would include Foster Dam near Eugene, Springfield, and Sweet Home, Oregon; Hills Creek Dam near Oakridge, Oregon; Fern Ridge Dam near Eugene and Veneta, Oregon; and Cottage Grove and Dorena Dams near Cottage Grove, Oregon. All other reservoir operations would provide continued recreation opportunities, revenue, and employment earnings benefits as under NAA operations with slight increases.

Operations under Alternative 1 would, therefore, provide for recreation opportunities at WVS reservoirs similar to or improved over those under the NAA. Direct, slight, increased beneficial effects from revenue and employment earnings would occur at local communities from Alternative 1 recreation opportunities (Table 3.11-8). However, the overall degree of effect in the analysis area is unknown because there are no data to identify recreation employment in communities specific to WVS reservoir operations. Additionally, some communities would benefit to greater degrees than others depending on proximity to reservoirs.

As under the NAA, reservoir operations under Alternative 1 would result in direct, beneficial effects on recreation-related revenue and employment earnings at nearly all WVS reservoir locations over the 30-year implementation timeframe (Table 3.11-10). These benefits would occur in nearly all MSA communities because local reservoir-induced visitation and direct economic activity would result in increases over NAA conditions. The degree of effect would vary depending on localized recreation opportunities.

However, per RECONS, there would be a slight decrease in these benefits on recreation-related revenue and employment earnings at Lookout Point Reservoir under Alternative 1 operations. However, this slight decrease would not minimize the continued benefits on recreation-related revenue and recreation employment in earnings under Alternative 1 in the Eugene MSA over the 30-year implementation timeframe.

Adverse revenue and employment effects from loss of recreation opportunities during dry years over the 30-year implementation timeframe cannot be assessed for specific reservoirs or communities. However, impacts are anticipated to be slight and medium-term, occurring during the May 15 to September 15 peak recreation season, because of the slight improvement in the flow regime under Alternative 1 as compared to the NAA.

Table 3.11-10. Degree of Adverse or Beneficial Effect on Recreation-related Revenue and Employment Earnings under Alternative 1 as Compared to the No-action Alternative[1].

Reservoir	Degree of Effect	MSA CBSA	MSA County
Detroit	Same as NAA with slight increased benefits	Salem	Marion
Foster	Same as NAA with slight increased benefits	Albany	Linn
Green Peter	Same as NAA with slight increased benefits	Albany	Linn
Cougar	Same as NAA with slight increased benefits	Eugene	Lane
Blue River	Same as NAA with slight increased benefits	Eugene	Lane
Lookout Point	Same as NAA but with slight decrease in benefits	Eugene	Lane
Hills Creek	Same as NAA with slight increased benefits	Eugene	Lane
Dexter	Same as NAA	Eugene	Lane
Fall Creek	Same as NAA with slight increased benefits	Eugene	Lane
Dorena	Same as NAA with slight increased benefits	Eugene	Lane
Cottage Grove	Same as NAA with slight increased benefits	Eugene	Lane
Fern Ridge	Same as NAA	Eugene	Lane

MSA = Metropolitan Statistical Area; CBSA = Core-based Statistical Area

Note: Does not represent degrees of effect anticipated during wet years within or outside of the peak recreation season.

[1] All effects would be long term.

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Reservoir operations under Alternative 2A would result in direct, beneficial effects on recreation-related revenue and employment earnings at nearly all WVS reservoir locations similar to NAA benefits over the 30-year implementation timeframe (Table 3.11-11). Per RECONS, these benefits would occur in nearly all MSA communities because local reservoir-induced visitation and direct economic activity would result in increases over NAA conditions. The degree of effect would vary depending on localized recreation opportunities.

However, there would be a slight, decrease in beneficial effects on recreation opportunities at Green Peter Reservoir under Alternative 2A during the later portion of the peak recreation season in late summer. Consequently, there would be a corresponding slight decrease in recreation-related revenue and recreation employment in earnings under Alternative 2A in the

Salem MSA over the 30-year implementation timeframe. However, this decrease would not alter continued beneficial revenue and employment effects in this MSA.

It is not anticipated that the Green Peter Reservoir drawdown would impact economic conditions in the communities of Sweet Home or Lebanon, Oregon because the slight decrease in revenue and employment earnings would affect only recreation-related employment beyond the peak recreation season and would not impact local employment. The degree of effect is unknown because there are no data to identify recreation employment in these communities specific to WVS reservoir operations. Additionally, some communities would benefit to greater degrees than others depending on proximity to reservoirs.

Impacts on recreation employment during dry years under Alternative 2A would be the same as those described under NAA operations.

Table 3.11-11. Degree of Adverse or Beneficial Effect on Recreation-related Revenue and Employment Earnings under Alternative 2A as Compared to the No-action Alternative[1].

Reservoir	Degree of Effect	MSA CBSA	MSA County
Detroit	Same as NAA with slight increased benefits	Salem	Marion
Foster	Same as NAA with slight increased benefits	Albany	Linn
Green Peter	Same as NAA but with slight decrease in benefits	Albany	Linn
Cougar	Same as NAA with slight increased benefits	Eugene	Lane
Blue River	Same as NAA with slight increased benefits	Eugene	Lane
Lookout Point	Same as NAA with slight increased benefits	Eugene	Lane
Hills Creek	Same as NAA with slight increased benefits	Eugene	Lane
Dexter	Same as NAA	Eugene	Lane
Fall Creek	Same as NAA with slight increased benefits	Eugene	Lane
Dorena	Same as NAA with slight increased benefits	Eugene	Lane
Cottage Grove	Same as NAA with slight increased benefits	Eugene	Lane
Fern Ridge	Same as NAA	Eugene	Lane

MSA = Metropolitan Statistical Area; CBSA = Core-based Statistical Area

Note: Does not represent degrees of effect anticipated during wet years within or outside of the peak recreation season.

[1] All effects would be long term.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Reservoir operations under Alternative 2B would result in direct, beneficial effects on recreation-related revenue and employment earnings at nearly all WVS reservoir locations compared to NAA benefits over the 30-year implementation timeframe with the exception of Cougar Reservoir (Table 3.11-12). A deep fall drawdown at Cougar Reservoir under Alternative 2B would result in substantial, adverse effects on recreation opportunities, revenue, and employment at the local level.

Water-based recreation at Cougar Reservoir would be prohibited during the peak recreation season. Consequently, there would be no demand for recreation-related services or employment to support these local services in the Eugene MSA. A corresponding substantial, adverse, localized effect on recreation-related employment earnings would occur under Alternative 2B in the Eugene MSA. However, compared to other reservoirs in the analysis area, Cougar Reservoir supports low visitation numbers, especially for water-based recreation (Section 3.14, Recreation).

Employment effects under Alternative 2B from the Cougar Reservoir drawdown are anticipated to be long term and could result in indirect, beneficial effects to other MSA communities from increases in employment to address displaced visitation and/or adverse financial effects from closure-related management requirements. However, as under the NAA, displacement effects and management priority adjustments cannot be accurately assessed.

Adverse effects on recreation opportunities from Green Peter Reservoir drawdowns in the later portion of the peak recreation season in late summer under Alternative 2B would be the same as described under Alternative 2A.

Impacts on recreation employment during dry years under Alternative 2B would be the same as those described under NAA operations.

Table 3.11-12. Degree of Adverse or Beneficial Effect on Recreation-related Revenue and Employment Earnings under Alternative 2B as Compared to the No-action Alternative[1].

Reservoir	Degree of Effect	MSA CBSA	MSA County
Detroit	Same as NAA	Salem	Marion
Foster	Same as NAA with slight increased benefits	Albany	Linn
Green Peter	Same as NAA with slight decrease in benefits	Albany	Linn
Cougar	Substantial, adverse effects	Eugene	Lane
Blue River	Same as NAA with slight increased benefits	Eugene	Lane
Lookout Point	Same as NAA	Eugene	Lane

Reservoir	Degree of Effect	MSA CBSA	MSA County
Hills Creek	Same as NAA with slight increased benefits	Eugene	Lane
Dexter	Same as NAA	Eugene	Lane
Fall Creek	Same as NAA with slight increased benefits	Eugene	Lane
Dorena	Same as NAA with slight increased benefits	Eugene	Lane
Cottage Grove	Same as NAA with slight increased benefits	Eugene	Lane
Fern Ridge	Same as NAA	Eugene	Lane

MSA = Metropolitan Statistical Area; CBSA = Core-based Statistical Area

Note: Does not represent degrees of effect anticipated during wet years within or outside of the peak recreation season.

[1] All effects would be long term.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

Of the action alternatives, Alternative 3A and Alternative 3B would have the greatest adverse impact on MSA communities as compared to NAA operations because of localized deep drawdowns during the peak recreation season over the 30-year implementation timeframe. Reservoir operations under Alternative 3A would result in direct, adverse effects on recreation-related opportunities and revenue and employment earnings to several MSA communities localized to WVS reservoirs (Table 3.11-13). There would be a substantial decrease in revenue and employment earnings attributed to recreation under Alternative 3A as compared to NAA benefits over the 30-year implementation timeframe (Table 3.11-8).

Compared to NAA operations, deep drawdowns under Alternative 3A would be a direct, substantial, adverse impact to recreation employment in MSA communities localized to reservoirs. Water-based recreation at Detroit, Cougar, and Lookout Point Reservoirs would be prohibited during the peak recreation season. Consequently, there would be no demand for recreation-related services or employment to support these services in the Salem and Eugene MSAs, including any reservoir-related employment from Oakridge, Oregon. The overall degree of effect in the analysis area is unknown because there are no data to identify recreation employment in communities specific to WVS reservoir operations. Additionally, some communities would benefit to greater degrees than others depending on proximity to reservoirs.

Direct, substantial, adverse effects on recreation-related revenue and employment earnings would occur to the community of Detroit, Oregon and its surrounding communities under Alternative 3A because water-based recreation opportunities would be prohibited during the entire peak recreation season. These effects would occur annually during the 30-year implementation timeframe and would likely be permanent.

Hills Creek Reservoir drawdowns would result in a direct, substantial, adverse impact in some years[9] to only recreation opportunities during the later portion of the peak recreation season in late summer under Alternative 3A. This would be a negligible to slight localized effect to the Eugene MSA and to Oakridge, Oregon because the decrease in employment revenue would affect only recreation-related employment beyond the peak recreation season and would not impact local employment.

Employment effects under Alternative 3A from the deep, peak season drawdown are anticipated to be long term and could result in indirect, beneficial effects to other MSA communities from increases in employment to address displaced visitation and/or adverse financial effects from closure-related management requirements. However, as under the NAA, displacement effects and management priority adjustments cannot be accurately assessed.

There would be no measurable effect on MSA recreation-related revenue or employment resulting from the late summer drawdown at Green Peter and Blue River Reservoirs under Alternative 3A.

Impacts on recreation employment during dry years under Alternative 3A would be the same as those described under NAA operations.

Table 3.11-13. Degree of Adverse or Beneficial Effect on Recreation-related Revenue and Employment Earnings under Alternative 3A as Compared to the No-action Alternative[1].

Reservoir	Degree of Effect	MSA CBSA	MSA County
Detroit	Substantial, adverse effects	Salem	Marion
Foster	Same as NAA	Albany	Linn
Green Peter	Same as NAA with slight decreased benefits	Albany	Linn
Cougar	Substantial, adverse effects	Eugene	Lane
Blue River	Same as NAA	Eugene	Lane
Lookout Point	Substantial, adverse effects	Eugene	Lane
Hills Creek	Substantial, adverse effect in some years in late summer Same as NAA in other years	Eugene	Lane
Dexter	Same as NAA	Eugene	Lane
Fall Creek	Same as NAA	Eugene	Lane
Dorena	Same as NAA with slight increased benefits	Eugene	Lane

[9]Effects during some years are dependent on Res-Sim rule curves and could include dry years (Appendix J, Water Supply Analysis).

Reservoir	Degree of Effect	MSA CBSA	MSA County
Cottage Grove	Same as NAA	Eugene	Lane
Fern Ridge	Same as NAA	Eugene	Lane

MSA = Metropolitan Statistical Area; CBSA = Core-based Statistical Area

Note: Does not represent degrees of effect anticipated during wet years within or outside of the peak recreation season.

[1] All effects would be long term.

Alternative 3B—Improve Fish Passage through Operations-focused Measures

Alternative 3B operations would result in the most substantial decrease in localized recreation opportunities and, therefore, in recreation-related revenue and employment earnings among all alternatives as compared to NAA operational benefits over the 30-year implementation timeframe (Table 3.11-8). Reservoir operations under Alternative 3B would result in direct, adverse effects on recreation-related revenue and employment earnings to several MSA communities localized to WVS reservoirs, including Sweet Home and Oakridge, Oregon (Table 3.11-14). This is because operations would prohibit water-based recreation during the peak recreation season at Green Peter, Cougar, and Hills Creek Reservoirs affecting communities in and surrounding the Eugene MSA. Water-based recreation would also likely be prohibited in the fall at Hills Creek Reservoir.

Compared to NAA operations, deep drawdowns under Alternative 3B would be a direct, substantial, adverse impact to recreation employment in MSA communities localized to reservoirs. Water-based recreation at Green Peter, Cougar, and Hills Creek Reservoirs would be prohibited during the peak recreation season. Consequently, there would be no demand for recreation-related services or employment to support these services in associated MSAs. The overall degree of effect in the analysis area is unknown because there are no data to identify recreation employment in communities specific to WVS reservoir operations. Additionally, some communities would benefit to greater degrees than others depending on proximity to reservoirs.

Deep fall drawdowns at Detroit, Blue River, and Lookout Point Reservoirs under Alternative 3B could have direct, substantial adverse effects to visitors during the later portion of the peak recreation season in late summer depending on the amount of precipitation during the summer and timing of drawdown initiation at each reservoir. Drawdowns at Lookout Point Reservoir could adversely affect employment in Oakridge, Oregon, particularly if combined with drawdowns at Hills Creek Reservoir during the peak recreation season. However, adverse effects on employment revenue would affect only recreation-related employment and would not impact annual employment.

Employment effects under Alternative 3B from the deep, peak season and fall drawdowns are anticipated to be long term and could result in indirect, beneficial effects to other MSA communities from increases in employment to address displaced visitation and/or adverse financial effects from closure-related management requirements. However, as under the NAA, displacement effects and management priority adjustments cannot be accurately assessed.

Impacts on recreation employment during dry years under Alternative 3B would be the same as those described under NAA operations.

Table 3.11-14. Degree of Adverse or Beneficial Effect on Recreation-related Revenue and Employment Earnings under Alternative 3B as Compared to the No-action Alternative[1].

Reservoir	Degree of Effect	MSA CBSA	MSA County
Detroit	Substantial, adverse effect in some years in late summer	Salem	Marion
Foster	Same as NAA with slight decreased benefits	Albany	Linn
Green Peter	Substantial, adverse effect	Albany	Linn
Cougar	Substantial, adverse effect	Eugene	Lane
Blue River	Substantial, adverse effect in some years in late summer	Eugene	Lane
Lookout Point	Substantial, adverse effect in some years in late summer	Eugene	Lane
Hills Creek	Substantial, adverse effect	Eugene	Lane
Dexter	Same as NAA	Eugene	Lane
Fall Creek	Same as NAA	Eugene	Lane
Dorena	Same as NAA with slight increased benefits	Eugene	Lane
Cottage Grove	Same as NAA with slight increased benefits	Eugene	Lane
Fern Ridge	Same as NAA	Eugene	Lane

MSA = Metropolitan Statistical Area; CBSA = Core-based Statistical Area

Note: Does not represent degrees of effect anticipated during wet years within or outside of the peak recreation season.

[1] All effects would be long term.

Alternative 4—Improve Fish Passage with Structures-based Approach

As under the NAA, reservoir operations under Alternative 4 would result in direct, beneficial effects on recreation-related revenue and employment earnings at nearly all WVS reservoir locations over the 30-year implementation timeframe (Table 3.11-8). These benefits would occur in nearly all MSA communities because local reservoir-induced visitation and direct economic activity would result in increases over NAA conditions. The degree of effect would vary depending on localized recreation opportunities (Table 3.11-15).

However, per RECONS, there would be negligible decreases at Detroit Reservoir and slight decreases at Green Peter Reservoir in recreation employment benefits under Alternative 4 operations. However, these negligible and slight decreases would not minimize the continued benefits to recreation-related revenue and recreation employment earnings under Alternative 1 in the Salem and Albany MSAs, respectively, over the 30-year implementation timeframe. The overall degree of effect in the analysis area is unknown because there are no data to identify recreation employment in communities specific to WVS reservoir operations. Additionally, some communities would benefit to greater degrees than others depending on proximity to reservoirs.

Table 3.11-15. Degree of Adverse or Beneficial Effect on Recreation-related Revenue and Employment Earnings under Alternative 4 as Compared to the No-action Alternative[1].

Reservoir	Degree of Effect	MSA CBSA	MSA County
Detroit	Same as NAA with negligible decreases in benefits	Salem	Marion
Foster	Same as NAA	Albany	Linn
Green Peter	Same as NAA with slight decreases in benefits	Albany	Linn
Cougar	Same as NAA	Eugene	Lane
Blue River	Same as NAA	Eugene	Lane
Lookout Point	Same as NAA	Eugene	Lane
Hills Creek	Same as NAA	Eugene	Lane
Dexter	Same as NAA	Eugene	Lane
Fall Creek	Same as NAA	Eugene	Lane
Dorena	Same as NAA	Eugene	Lane
Cottage Grove	Same as NAA	Eugene	Lane
Fern Ridge	Same as NAA	Eugene	Lane

MSA = Metropolitan Statistical Area; CBSA = Core-based Statistical Area

Note: Does not represent degrees of effect anticipated during wet years within or outside of the peak recreation season.

[1] All effects would be long term.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Operations under Alternative 5 would be similar to those under Alternative 2B with continued benefits to recreation opportunities and related employment and earnings during the 30-year implementation timeframe. As under Alternative 2B, a deep fall drawdown at Cougar Reservoir under Alternative 5 would result in substantial, adverse effects on recreation opportunities, revenue, and employment at the local level (Table 3.11-16).

Additionally, there would be negligible, adverse effects at Green Peter Reservoir and slight, adverse effects at Detroit Reservoir on recreation opportunities under Alternative 5 as compared to NAA operations, but not during the peak recreation season. Consequently, there would be a corresponding decrease in recreation-related revenue and employment earnings under Alternative 5 during the later part of the peak recreation season in late summer. This would result in negligible and slight decreases in benefits in the Albany and Salem MSAs, respectively, over the 30-year implementation timeframe.

As under all alternatives, the overall degree of effect in the analysis area is unknown because there are no data to identify recreation employment in communities specific to WVS reservoir operations. Additionally, some communities would benefit to greater degrees than others depending on proximity to reservoirs.

Impacts on recreation employment during dry years under Alternative 5 would be the same as those described under NAA operations.

Table 3.11-16. Degree of Adverse or Beneficial Effect on Recreation-related Revenue and Employment Earnings under Alternative 5 as Compared to the No-action Alternative[1].

Reservoir	Degree of Effect	MSA CBSA	MSA County
Detroit	Same as NAA with slight decreased benefits	Salem	Marion
Foster	Same as NAA	Albany	Linn
Green Peter	Same as NAA with negligible decreased benefits	Albany	Linn
Cougar	Substantial, adverse effects	Eugene	Lane
Blue River	Same as NAA with slight increased benefits	Eugene	Lane
Lookout Point	Same as NAA with slight increased benefits	Eugene	Lane
Hills Creek	Same as NAA with slight increased benefits	Eugene	Lane
Dexter	Same as NAA	Eugene	Lane
Fall Creek	Same as NAA with slight increased benefits	Eugene	Lane
Dorena	Same as NAA with slight increased benefits	Eugene	Lane
Cottage Grove	Same as NAA with slight increased benefits	Eugene	Lane
Fern Ridge	Same as NAA	Eugene	Lane

MSA = Metropolitan Statistical Area; CBSA = Core-based Statistical Area

Note: Does not represent degrees of effect anticipated during wet years within or outside of the peak recreation season.

[1] All effects would be long term.

3.11.3.3 Economic Relationship with Communities under All Alternatives

Greenhouse Gas Emissions Community Costs

Greenhouse gas emissions would affect MSA community health and socioeconomic conditions under all alternatives to varying degrees during the 30-year implementation timeframe. These emissions would be generated from several nearby sources unrelated to WVS operations but would include WVS fish trucking, emergency generator use, and power generation (Appendix U, Air Quality and Greenhouse Gas Emissions Analysis).

Community and socioeconomic impacts of greenhouse gas emissions are analyzed as the social cost of carbon (Section 3.10, Air Quality and Greenhouse Gas Emissions; Appendix U, Air Quality and Greenhouse Gas Emissions Analysis). The social cost of carbon represents society's willingness to pay to avoid climate-related impacts associated with an additional unit of a greenhouse gas in the atmosphere. Adverse changes in the long term to community health, flood risk, agricultural productivity, and other socioeconomic outcomes are more likely the higher the estimates of social costs when compared to the NAA.

Compared to the NAA, implementation of Alternative 3A and Alternative 3B would result in the most substantial social costs to MSA communities (Appendix U, Air Quality and Greenhouse Gas Emissions Analysis). Compared to NAA operations, operations under these two alternatives would require a greater distance for fish trucking to fish release sites, a greater number of generators possibly used in emergencies, and the greatest power generation-related carbon dioxide emissions.

Hydropower Generation, Transmission Reliability, and Economic Viability

Hydropower Generation and Transmission Reliability

Power reliability can adversely impact communities through increased economic costs and disruptions of essential services and residential and commercial power needs. Eight of the WVS dams produce power. Regional power system reliability is reflected by loss of load probability, which is the probability that the region's expected supply of power would not be available to meet demand for electricity. Overall reliability/predictability from the eight WVS power-generating dams has a minimal contribution to the regional power system and, therefore, to MSA communities.

The MSAs are located within the Bonneville Power Administration (BPA) service area. BPA sells firm[10] power at wholesale under long-term contracts to 136 power customers within a 300,000 square mile service area in the Pacific Northwest.

The BPA transmission system connects and moves power generated from WVS dams and non-Federal dams; nuclear, natural gas, and coal-fired power plants; and solar and wind generation

[10] Firm power is defined as power or power-producing capacity intended to be available at all times during the period covered by a guaranteed commitment to deliver, even under adverse conditions (EIA 2023).

projects to loads throughout the Pacific Northwest and beyond. BPA's transmission system contains multiple "paths" or routes over which power flowing from one point to another is monitored and managed. Consequently, operations under any alternative would not result in socioeconomic impacts on communities to any measurable degree because power would continue to be provided to MSA communities from regional sources over the 30-year implementation timeframe.

This power reliability would continue to be a benefit to MSA communities given the severe weather and wildfire-related events that occurred in 2020 (Section 3.9, Vegetation; Appendix F1, Qualitative Assessment of Climate Change Impacts; Appendix F2, Supplemental Climate Change Information). At the time the alternatives were analyzed, regional climate projections indicated increased winter storm event frequency and duration (Fleishman 2023).

A power transmission delay related to outages from severe weather, wildfire events, or emergency situations could result in direct, adverse impacts to these localized communities. Although impacts would be temporary, they could be major and adverse from multi-day outages impacting medical care facilities, communication systems, and other essential public health and safety services.

For example, in February of 2019, a severe winter storm caused an outage on the Hills Creek Dam to Lookout Point Dam 115kV line, which isolated the community of Oakridge, Oregon between February 24 and March 5, 2019. Hills Creek Dam generation was critical to providing this community with electric power while the line was repaired. It is expected that under current circumstances, Hills Creek Dam power generation would be needed most years to provide service to Oakridge outage in the event of a transmission outage.

Wildfire could have similar or greater impacts on power and transmission to Willamette Valley communities. For example, although temporary, impacts on power transmission could continue for long periods until power is restored. It is assumed these conditions would continue under all alternatives.

Under all alternatives, there is a 1-in-15-year likelihood of power shortages in the analysis area. Under Alternative 1, Alternative 2A, and Alternative 4, power generated at Hills Creek Dam would continue to be operated islanded (isolated) as needed to provide power to Oakridge, Oregon. Similarly, Cougar Dam would continue to be able to operate islanded[11] as needed to provide power to the Blue River, Oregon community in the event of system outages due primarily to severe weather events and wildfire during the 30-year implementation timeframe. This would be a continued, substantial benefit to these MSA communities.

Similarly, power could be provided to Oakridge from Hills Creek Dam operations under Alternative 2B. However, power could not be provided to the community of Blue River during

[11] Islanded power generation means that USACE operations can generate power while isolated from the main system to provide power to local communities.

power outages because Cougar Dam could not be operated as an isolated power supply, which would be a substantial, adverse effect on this community.

Operations under Alternative 3A and Alternative 3B would have the most substantial, adverse effects on the communities of Oakridge and Blue River because Hills Creek and Cougar Dam operations could not continue to be operated islanded during power outages.

Economic Viability

Regional power supply and marketing directly impacts the wholesale power customers who receive generated power that serves residential, commercial, and industrial retail customers in the region and within the MSAs. The economic viability of power generation is dependent on the ability to meet contractual (20-year contracts) obligation in addition to new resource acquisition/replacement power and new transmission infrastructure construction to offset lost capability.

Power generation from the WVS operations would be economically viable under NAA operations because the benefits of power would outweigh the costs of production. The cost of power generation under the NAA at the time the alternatives were analyzed was marginal relative to average market prices and to other generation resources but is among the highest costs in the FCRPS. Power generation costs from WVS dams are anticipated to increase over the 30-year implementation timeframe under the NAA, which could result in increased power costs to MSA communities .

However, power generation would not be economically viable under any action alternative over the 30-year implementation timeframe (Appendix G, Power Generation and Transmission), primarily due to the cost of alternative implementation. These impacts would result from market prices of competing resources or changes in power generation. Generation would need to be replaced from more distant sources under some alternatives. There would be enough power generation in the hydropower/transmission analysis area to replace power under all alternatives. However, replacement would adversely affect existing congested transmission systems in the analysis area. It is possible that these impacts could lead to increased power costs to MSA communities .

<u>Water Quality Treatment Costs</u>

While WVS operations store water for municipal and industrial uses, USACE is not authorized to provide drinking water for consumer use. Similarly, while water quality is an authorized purpose, USACE is not responsible for the quality of water that is then used for drinking water. Drinking water quality is the responsibility of municipalities that own and operate public water systems. At the time the alternatives were analyzed, the injunction deep drawdown operations at Green Peter Dam mobilized large amounts of sediment at Green Peter Dam. The drawdown was halted over concerns by communities in Linn County, Oregon that the sediment would overwhelm the surrounding cities' drinking water systems (USACE 2024b).

Water quality would be adversely affected by the liberation of previously stored sediments caused by construction activities or by deep reservoir drawdowns over the 30-year implementation timeframe. These effects would be basin-wide.

Construction and deep drawdowns could cause an increase in the amounts of turbidity and harmful algal blooms discharged downstream into drinking water sources. These conditions would result in indirect, adverse, temporary treatment costs of additional chemicals; testing; facility maintenance, repairs, and/or equipment replacement; and administrative costs.

Adverse effects on MSA communities could also include temporary loss of drinking water access and the requirement to supplement potable water. The degree of effect would depend on the severity of water quality impact and the duration of the impact, but would likely range from moderate to substantial, and would be temporary.

Turbidity

Sediment-related processes would occur in all subbasins under all alternatives, resulting in adverse water quality from turbidity. The degree of effect on water quality depends on geography, climate conditions, and seasonal reservoir operations affecting turbid water conditions in the analysis area. However, continued benefits in water quality from turbidity would occur because WVS reservoirs can trap sediment from the upstream watershed during high-flow events (Section 3.5, Water Quality, Section 3.5.2.2, Alternatives Analyses, No-action Alternative, Turbidity).

Under the NAA, there would be a deep fall drawdown at Fall Creek Reservoir resulting in temporary elevation of suspended sediment levels discharged from the dam (USGS 2023). Slight, short-term, adverse effects from temporary elevated turbidity could occur under the NAA at this location over the 30-year implementation timeframe.

Turbidity would become more adverse under all action alternatives as compared to the NAA with the exception of Alternative 1 and Alternative 4 (Section 3.5, Water Quality, Table 3.5-59 through Table 3.5-63). Increased adverse conditions would vary depending on alternative and location downstream of a given dam. Adverse conditions would range from slightly more adverse than under NAA operations as measured at the Salem gage under Alternative 2B and Alternative 5 to substantially more adverse below Hills Creek, Dexter, Cougar, Foster, and Big Cliff Dams under Alternative 3B.

Harmful Algal Blooms

Under the NAA, operations at dams with deep outlets would continue to avoid releasing surface water that could contain cyanotoxins when conditions allow, having a beneficial effect on downstream water quality. However, due to the potential for harmful algal blooms to occur at some reservoirs in some years and under various conditions, a slight adverse effect from harmful algal blooms is expected under the NAA over the 30-year implementation timeframe

(Section 3.5, Water Quality, Section 3.5.2.2, Alternatives Analyses, No-action Alternative, Harmful Algal Blooms).

Harmful algal bloom impacts on water quality would become slightly more adverse to moderately more adverse under all action alternatives (Section 3.5, Water Quality, Table 3.5-59 through Table 3.5-63).

Turbidity and Harmful Algal Bloom Effects on Drinking Water and Facility Operations

All adverse water quality resulting from USACE operations and maintenance under any alternative would be addressed by water treatment and would remain compliant with Federal and state regulations for safe drinking water.

Specifically, water sourced from downstream of the WVS reservoirs would continue to be treated by a combination of filtration, aeration, and disinfection at a public water treatment facility before it is distributed within the analysis area under any alternative over the 30-year implementation timeframe.

Operations would not affect existing available water volumes from in-river locations downstream of any WVS reservoir with the exception of Alternative 3A and Alternative 3B. Flow augmentation would not occur in dry years under these alternatives.

Elevated turbidity and harmful algal blooms and subsequent treatment requirements could include increased costs of additional chemicals; testing; facility maintenance, repairs, and/or equipment replacement; and administrative costs. Adverse effects on MSA communities could also include temporary loss of drinking water access and the requirement to supplement potable water.

Substantially more adverse turbidity under Alternative 3B could have a correlated substantial, adverse effect on MSA communities if increased water treatment costs and alternate potable water supply are required. Increases in harmful algal blooms under any alternative, in combination with slight increases in turbidity under Alternative 2B and Alternative 5, could also result in temporary adverse conditions to MSA communities if additional treatment costs are needed. Socioeconomic costs to MSA communities would be indirect and temporary under any alternative.

Water Availability in Dry Years

Delivery of water stored in the WVS reservoirs for agricultural irrigation and municipal and industrial uses may be ceased or curtailed in dry years, limiting availability for drinking water. This would be an adverse effect to drinking water supply under all alternatives and would impact several communities in the analysis area but to varying degrees depending on alternative operations.

The impact to drinking water users from dry-year water supply management cannot be accurately assessed. However, it is anticipated that dry water-year effects would not be continuous over the full 30-year implementation timeframe, but dry water years could be reoccurring depending on annual climate conditions.

<u>**Water Supply**</u>

Groundwater Supply and Use

There would not likely be any direct effect on groundwater supply or indirect effect on MSA water supply users in the analysis area from operations under any alternative during the 30-year implementation timeframe.

Operations under all alternatives include a deep drawdown at Fall Creek Reservoir in addition to other deep drawdowns depending on alternative implementation. Drawdown operations would occur annually. However, USACE has not identified any groundwater wells that are hydrologically connected to WVS reservoirs. Consequently, drawdown operations would not likely result in any direct, adverse effects to water supply or indirect, adverse effects to water users in the MSA communities reliant on groundwater wells during the 30-year implementation timeframe. There would be no effect on groundwater supply-related costs from WVS operations under any alternative to MSA communities.

Water Availability in Dry Years

Per the Willamette Basin Review Feasibility Study Biological Opinion (NMFS 2019b), delivery of water stored in the WVS reservoirs for municipal and industrial and agricultural uses may be ceased or curtailed in dry years, indirectly limiting availability for water uses. This would be a direct, adverse effect to water supply under all alternatives but to varying degrees depending on alternative operations.

The indirect impact to water users in the MSA communities in terms of costs from dry-year water supply management cannot be accurately assessed. However, it is anticipated that dry water-year effects would not be continuous over the full 30-year implementation timeframe, but dry water years could be reoccurring depending on annual climate conditions.

No-action Alternative

There would be a direct, substantial, beneficial effect on water supply under the NAA during most times of the year. NAA operations would result in stored water exceeding the volume of stored water needed to satisfy forecasted demands for consumptive uses during the 30-year implementation timeframe.

Operations under the NAA would result in an indirect, beneficial effect from the release of stored water from the WVS reservoirs and withdrawal from downstream reaches for MSA community municipal and industrial purposes to satisfy new water storage agreements and for agricultural irrigation during the 30-year implementation timeframe. There would be no indirect effect on water supply management costs to MSA communities under the NAA.

Similarly, beneficial water supply effects from river flow would occur under NAA operations. However, not all water uses would be satisfied in all years and in all months under the NAA due to hydrologic conditions not subject to USACE operations and maintenance, such as dry years where river flows are low, thereby adversely affecting water supply and associated costs to MSA communities reliant on river flow.

Alternative 1, Alternative 2A, and Alternative 4

As under the NAA, there would be a direct, substantial, beneficial effect on water supply under Alternative 1, Alternative 2A, and Alternative 4 during most times of the year. However, operations under these alternatives would provide more stored water systemwide than under the NAA, which would be an increased benefit to MSA communities.

Direct, beneficial effects on water supply and indirect, beneficial effects on MSA water users from flows in the analysis area under these alternatives would be the same as under NAA operations during the 30-year implementation timeframe with no indirect effect on water supply management costs.

Alternative 2B and Alternative 5

As under the NAA, there would be a direct, beneficial effect on water supply and an indirect, beneficial effect on MSA water users under Alternative 2B and Alternative 5. However, the benefit to MSA communities under these alternative operations would be slightly less beneficial than under NAA operations because, although stored water would be available for nearly all the forecasted consumptive use demands, it would not be enough to meet all the demands. This could result in indirect, water supply management costs to MSA communities.

As under NAA operations, effects on water supply under Alternative 2B and Alternative 5 would be directly beneficial because flows in river reaches downstream of the dams would remain above flow targets in all but dry years during the 30-year implementation timeframe. This would also result in an indirect, beneficial effect on MSA water users as under the NAA with no indirect effect on water supply management costs.

Alternative 3A and Alternative 3B

Compared to the NAA, Alternative 3A and Alternative 3B would result in a direct, substantial, adverse effect on water supply because the combined operations under each alternative would adversely affect system-wide conservation storage during the 30-year implementation timeframe. Reduced storage as compared to the NAA would result in no water available for municipal and industrial or agricultural irrigation MSA water users during the 30-year implementation timeframe, and would be an indirect, substantial, adverse effect on these MSA community users. Indirect water supply management costs would likely be a substantial, adverse effect on MSA communities.

Direct effects on river flow supply and indirect effects to MSA water users under Alternative 3A and Alternative 3B would be the same as described under the NAA except at Detroit Reservoir under Alternative 3A and at Green Peter Reservoir under Alternative 3B. Spring drawdowns at these reservoirs would eliminate the ability to store water to augment naturally low flows in the summer as compared to the NAA during the 30-year implementation timeframe. This would be an indirect, adverse effect to MSA water users dependent on flows below Detroit Dam under Alternative 3A and below Green Peter Dam under Alternative 3B, including the community of Sweet Home. Similarly, there would be indirect, adverse effects on these MSA communities for water supply management.

Recreation Opportunities and Community Identity

Communities in the MSAs, such as Detroit, Sweet Home, Blue River, Veneta, Elmira, Cottage Grove, and Oakridge, would continue to support annual visitors to WVS reservoirs and, conversely, visitors would continue to support local communities throughout the 30-year implementation timeframe under any alternative. This socioeconomic relationship would continue to be sustained by a connection to the reservoir and surrounding upland landscape and to recreation opportunities.

Further, recreation opportunities around the WVS reservoirs that form this relationship would continue to be a key component of community identity that contributes to social connectedness, which is not easily understood but a relevant socioeconomic factor. Economic conditions are commonly linked to community identities in the analysis area such as the important influence that the logging industry has had on communities such as Sweet Home, Cottage Grove, Oakridge, Veneta, and Elmira.

Communities in the MSAs have been historically impacted by an influx of workers for dam construction, changes to the timber industry, and more recently by wildfires. However, the effects of these employment industry adjustments specific to a community connection to the landscape and community identity cannot be known with certainty but it is likely that shifts in economic industry have had an adverse effect on community identity in the long term.

Recreation opportunities would continue to be available at all reservoirs under most alternatives, which would be a positive contribution to community economies and identities. However, there would be substantial, adverse effects on these opportunities under Alternative 3A at Detroit, Cougar, and Lookout Point Reservoirs and at Green Peter, Cougar, and Hills Creek Reservoirs under Alternative 3B. This would result in similar adverse effects on community economies and identities each recreation season over the 30-year implementation timeframe. Land-based opportunities would be available at all reservoirs under all alternatives but would likely be of low visitor interest if water-based opportunities are not available.

Summary of the Economic Relationship with Communities under All Alternatives

Adverse Socioeconomic Effects

Adverse socioeconomic effects to MSA communities would be most substantial under Alternative 3A and Alternative 3B because of the social costs of carbon, hydropower-related effects, water management and treatment costs, and loss of water-based recreation opportunities.

- Implementation of Alternative 3A and Alternative 3B would result in the most substantial social costs of carbon to MSA communities from greenhouse gas emissions (Appendix U, Air Quality and Greenhouse Gas Emissions Analysis).
- Operations under Alternative 3A and Alternative 3B would have the most substantial, hydropower-related adverse effects on the communities of Oakridge and Blue River, Oregon because Hills Creek Dam and Cougar Dam operations could not continue to be island operated during power outages.
- Available water volumes from in-river locations downstream of any WVS reservoir would be most adversely affected under Alternative 3A and Alternative 3B because flow augmentation would not occur in dry years under these alternatives.
- Alternative 3A and Alternative 3B would result in a direct, substantial, adverse effect on water supply because operations under each alternative would adversely affect system-wide conservation storage during the 30-year implementation timeframe. Reduced storage as compared to the NAA would result in no water available for municipal and industrial or agricultural irrigation MSA water users during the 30-year implementation timeframe, and would be an indirect, substantial, adverse effect on these MSA community users. Indirect water supply management costs would likely be a substantial, adverse effect on MSA communities.
- Substantial, adverse turbidity conditions under Alternative 3B could have a correlated substantial, adverse effect on MSA communities, including but not limited to the communities of Sweet Home and Oakridge, Oregon if increased water treatment costs and alternate potable water supply are required.
- There would be substantial, adverse effects on water-based recreation opportunities under Alternative 3A at Detroit, Cougar, and Lookout Point Reservoirs and at Cougar, Green Peter, and Hills Creek Reservoirs under Alternative 3B. This would result in similar adverse effects on community economies and identities each recreation season over the 30-year implementation timeframe. Land-based opportunities would be available at all reservoirs under all alternatives but would likely be of low visitor interest if water-based opportunities are not available.

In addition to adverse socioeconomic effects under Alternative 3A and Alternative 3B, adverse socioeconomic effects to MSA communities would occur under all action alternatives related to economic, operational, and climate conditions.

- Power generation costs from WVS dams are anticipated to increase over the 30-year implementation timeframe, which could result in increased power costs to MSA communities .
- Power generation would not be economically viable under any action alternative over the 30-year implementation timeframe (Appendix G, Power Generation and Transmission), primarily due to the cost of alternative implementation. It is possible that these impacts could lead to increased power costs to MSA communities .
- Elevated turbidity and harmful algal blooms under any alternative and subsequent treatment requirements could include increased costs of additional chemicals; testing; facility maintenance, repairs, and/or equipment replacement; and administrative costs. Adverse effects on MSA communities could also include temporary loss of drinking water access and the requirement to supplement potable water.
- Delivery of water stored in the WVS reservoirs for agricultural irrigation and municipal and industrial uses may be ceased or curtailed in dry years, limiting availability for drinking water. This would be an adverse effect to drinking water supply under all alternatives and would impact several communities in the analysis area but to varying degrees depending on alternative operations.

Beneficial Socioeconomic Effects

The greatest socioeconomic beneficial effects to analysis area communities would occur under the NAA, Alternative 1, Alternative 2A, and Alternative 4 from hydropower generation, water management and treatment costs, and recreation opportunities. Effects on water supply under these alternatives would be directly beneficial because flows in river reaches downstream of the dams would remain above flow targets in all but dry years during the 30-year implementation timeframe. This would also result in an indirect, beneficial effect on MSA water users as under the NAA with no indirect effect on water supply management costs.

Overall beneficial socioeconomic effects would also occur under Alternative 2B and Alternative 5 but to a lesser degree. Although stored water would be available for nearly all the forecasted consumptive use demands under Alternative 2B and Alternative 5, it would not be enough to meet all the demands. This could result in indirect, water supply management costs to MSA communities.

Beneficial effects would occur to all communities under all alternatives related to power reliability and recreation opportunities.

- Overall reliability/predictability from the eight WVS power-generating dams has a minimal contribution to the regional power system and, therefore, to MSA communities. Consequently, operations under any alternative would not result in socioeconomic impacts on communities to any measurable degree because power would continue to be provided to MSA communities from regional sources over the 30-year implementation timeframe.

- Water-based and/or land-based recreation opportunities would continue to be available at all reservoirs under most alternatives, which would be a positive contribution to community economies and identities. Loss of water-based recreation opportunities due to deep drawdowns under some alternatives would not preclude opportunities at other reservoirs in the analysis area.

3.11.4 Interim Operations under All Action Alternatives Except Alternative 1

The timing and duration of Interim Operations would vary depending on a given alternative. Interim operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations would be implemented in succession with, and not in addition to, action alternative implementation.

It is anticipated that Interim Operations at Green Peter Dam during dry years would lead to adverse impacts on recreation opportunities outside of the peak recreation season. Adverse effects would occur by prohibiting water-based recreation at Green Peter Reservoir in late fall in dry years when less water is available to meet the Congressionally authorized recreation purpose. However, no socioeconomic effects are anticipated to MSA communities given that effects would be limited to non-peak season recreation use and only in dry years. Additionally, there would be no measurable effect on socioeconomics region-wide because lack of recreation opportunities at Green Peter Reservoir under these conditions would not likely result in measurable displaced recreation at other reservoirs, would not prevent late fall recreation use throughout the WVS, and would, therefore, not measurably affect any MSA community reliant on recreation revenue either beneficially or adversely.

Based on consideration of the alternatives analyses, impacts on community economics and on this relationship to MSA communities would approximate those described as direct and indirect effects resulting from implementation of the NAA and the action alternatives.

3.11.5 Climate Change under All Alternatives

Climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions over the 30-year implementation timeframe (Climate Impacts Group 2010; RMJOC 2020) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources, Section 3.1 Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

3.11.5.1 Air Quality and Greenhouse Gas Emissions

Effects on MSA communities from air quality and greenhouse gas emissions could increase in magnitude in the analysis area under any action alternative as compared to the NAA. For example, operational activities including construction, fish trucking operations, and emergency generator use would be increased under the action alternatives. Further, increased natural gas emissions could occur under those alternatives where hydroelectric power decreases during the 30-year implementation timeframe (i.e., Alternatives 2A, 2B, 3A, 3B, and 5). These conditions would increase the social costs of carbon to all MSA communities during the 30-year implementation timeframe.

While there could be an increase from moderate to major effects under the action alternatives, this would depend on the magnitude, extent, and duration of air pollutant and greenhouse gas emissions occurring from USACE activities in the analysis area at the time of a climate change-generated event, such as wildfires. The degree of effect on greenhouse gas emissions on MSA communities from decreased hydroelectric power generation would also depend on whether regional reduction is replaced with zero-carbon resources instead of with natural gas.

3.11.5.2 Hydropower and Transmission Reliability

Because the WVS will likely experience increasing winter (December through March) flow volumes due to climate change generally, it is possible that operations could be able to capture some additional flow, which could produce incremental increases in power generation during the winter. However, higher projected air temperatures are likely to result in decreased loads. Increases in power generation that may occur in the winter months would incrementally decrease stress on existing congested transmission paths (i.e., South of Allston and Cross Cascades South).

Lower snowpack may reduce spring and summer flows as well as potentially impact refill ability. This could lead to reduced ability to generate power in the spring and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested transmission paths (i.e., South of Allston and Cross Cascades South). These adverse effects would be experienced by all MSA communities.

Decreasing summer and fall inflows may lead to more rapid drawdown in the fall to meet downstream minimum flow targets during the 30-year implementation timeframe. Reduced reservoir levels associated with decreased refill ability, combined with anticipated increases in the likelihood of extreme weather- or wildfire-related events, would increase the risks that Cougar Dam would be unable to provide power to the community of Blue River during a transmission outage between Blue River and Thurston substations. Similarly, these conditions would increase the risks that Hills Creek Dam would be unable to provide power to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point Dam substation, which would be a major, adverse effect on this community.

3.11.5.3 Water Quality and Drinking Water

Climate change would exacerbate direct, adverse effects to stored water supply and subsequently to drinking water users as compared to the NAA under Alternative 3A and Alternative 3B. Operations in reservoirs that have a spring drawdown for fish passage would not likely refill as seasonal drier hydrologic conditions would start earlier under climate change conditions, resulting in even less rainfall to refill the reservoirs than under the NAA.

Adverse climate change effects to river flow water supply under Alternative 3A and Alternative 3B operations would be worse than under the NAA. River flow in the summer would likely decrease due to climate change because of lower snowpack, which sustains summer baseflows. Consequently, this would adversely affect drinking water users because there may not be adequate water in the rivers to satisfy existing water rights, which would be a major, adverse effect on some or all MSA communities depending on specific climate-related conditions and locations.

Climate change effects are anticipated to slightly or moderately worsen turbidity and harmful algal bloom water quality conditions under all alternatives (Section 3.5, Water Quality, Section 3.5.4, Climate Change). Under most alternatives, turbidity could have slight adverse effects on water quality during high flow events in winter and spring when reservoirs are at capacity and USACE is unable to store sediment-laden inflows compared to 2019 conditions. However, reservoirs trap sediment from high upstream flows, which would be a continued direct benefit to water quality conditions and an indirect benefit to drinking water users in all MSA communities over the 30-year implementation timeframe.

Harmful algal blooms could also have slightly adverse effects on water quality under most alternatives when late summer inflows are lower compared to 2019 conditions. However, harmful algal blooms could be influenced by reservoir storage and time of year resulting from climate change conditions over the 30-year implementation timeframe.

Turbidity and harmful algal bloom effects would be more adverse under Alternative 3A and Alternative 3B because of decreased water storage and an increase in spill operations.

However, it is anticipated that municipal water systems would continue to adjust to water quality and adverse conditions over the 30-year implementation timeframe per Federal and state laws. Specifically, water sourced from downstream of the WVS reservoirs would continue to be treated by a combination of filtration, aeration, and disinfection at a public water treatment facility before it is distributed within the analysis area under any alternative over the 30-year implementation timeframe.

Under all alternatives, elevated turbidity and harmful algal blooms and subsequent treatment requirements could include temporary increased costs to MSA communities of additional chemicals; testing; and facility maintenance, repairs, and/or equipment replacement. Adverse effects on MSA communities could also include temporary loss of drinking water access and the requirement to supplement potable water. These costs and requirements could occur more often than under existing conditions under any alternative implementation as a result of continued climate change-related water quality conditions.

3.11.5.4 Water Supply

Increased climate variability in the spring months, drier hotter summers, and lower summer baseflow are the most impactful climate change factors affecting conservation season water supply operations. Consequently, water supply from water stored in analysis area reservoirs and groundwater wells and from river flow, could be adversely affected in the long term under any alternative. Additionally, decreased summer baseflows would adversely affect water users in all MSA communities under any alternative as there may not be adequate water in the rivers to satisfy existing water rights.

Increased demands for water supply from climate conditions would likely increase the costs of water supply management for MSA communities. For example, demand for additional water supply available for agricultural use is forecasted through the year 2050 as a result of a drier, hotter climate in the analysis area (OWRD 2015).

3.11.5.5 Recreation Opportunities

Reservoir levels under all alternatives could fall more frequently and refill would be more difficult than under existing or proposed operations with climate-related conditions and subsequent operational adjustments.

Reservoir fluctuations coupled with drought conditions could result in less reservoir-related water-based and land-based recreation opportunities at several reservoirs in the analysis area. Land-based recreation opportunities could also be displaced or eliminated from increased wildfire frequency depending on fire locations. Consequently, while recreation-related employment and revenue would not likely be adversely affected in the short term, over time, economic conditions could worsen as climate-related conditions worsen under all alternatives.

Worsening recreation-related economic conditions at the local level over the 30-year implementation timeframe would also adversely affect community identity attributed to recreation opportunities at the WVS reservoirs. However, recreation opportunities and the recreation employment industry would not likely be fully eliminated throughout the analysis area over the 30-year implementation timeframe as a result of climate change-induced recreation impacts.

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.12 POWER GENERATION AND TRANSMISSION

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3.12 Power Generation and Transmission

THIS SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **The criteria for assessing degrees of effect have been modified in FEIS Section 3.12.3.1, Methodology, Effects Criteria. Degrees of effect have been modified in the analyses and in Table 3.12-5, Summary of Effects to Power Generation and Transmission.**
- **Additional information on greenhouse gas emissions regulations and on Step 2 of the analysis process have been added to FEIS Section 3.12.3.1, Methodology, Analysis Process.**
- **Information to clarify power generation replacement and replacement resources has been added to Step 3 of the analysis process in FEIS Section 3.12.3.1, Methodology, Analysis Process.**
- **Information to describe effects assumptions for Net Present Value and Levelized Cost of Generation has been added to Step 4b of the analysis process in FEIS Section 3.12.3.1, Methodology, Analysis Process.**
- **Information on routine and non-routine maintenance has been added to Step 4b of the analysis process in FEIS Section 3.12.3.1, Methodology, Analysis Process.**
- **Analyses have been reformatted to consistently present information for comparisons among alternatives in FEIS Section 3.12.3.2, Alternatives Analyses.**
- **The analyses have been modified to compare degree of effect between each alternative and the degree of effect under the No-action Alternative rather than demonstrating a degree of change, which may minimize actual effect outcomes (e.g., a degree of change could be negligible, but the degree of effect remains substantially adverse when compared to the No-action Alternative) (FEIS Section 3.12.3.2, Environmental Consequences). The criteria discussion reflects this modification (FEIS Section 3.12.3.1, Methodology, Effects Criteria).**
- **Clarifications regarding summaries of effects as compared to the No-action Alternative have been made in the analyses and in the summary tables under each alternative analysis (FEIS Section 3.12.3.2).**
- **Information on various analysis timeframes/study periods has been added in Section 3.12.3.2, Alternatives Analyses.**

Summary of changes from the DEIS, continued:

- **Additional information on the number of homes that would be powered under each alternative during the 30-year implementation timeframe has been added to Section 3.12.3.2, Alternatives Analyses.**
- **Analyses have been added to each alternative to include the 1-in-15-year likelihood of a loss of load event or events in FEIS Section 3.12.3.2, Alternatives Analyses.**
- **Contributions to the regional power system have been added to each alternative analysis in FEIS Section 3.12.3.2, Alternatives Analyses.**
- **Effects to economic viability have been clarified under each alternative analysis in FEIS Section 3.12.3.2, Alternatives Analyses.**
- **Effects from construction activities have been added to the analyses where applicable in FEIS Section 3.12.3.2, Alternatives Analyses.**
- **Information on wildfire events has been updated for accuracy in FEIS Section 3.12.3.2, Alternatives Analyses, No-action Alternative, Transmission. Subsequent alternative analyses are compared to this information.**
- **The term “Near-term Operations” has been changed to “Interim Operations” throughout the EIS. Additional information has been added to the alternatives analyses in FEIS Section 3.12.3.2 and to FEIS Section 3.12.4, Interim Operations under All Action Alternatives Except Alternative 1, to further clarify anticipated effects under Interim Operations.**
- **An Interim Operations timeline has been added as Figure 3.12-13.**
- **A summary of power and transmission effects under Interim Operations has been provided in FEIS Table 3.12-25.**
- **The climate change analysis has been combined for all alternatives in FEIS Section 3.12.5, Climate Change under All Alternatives. Additional information regarding expected Willamette River Basin conditions has been added.**
- **Cost information has been updated and was current as of February 2025.**
- **Consistent terminology has been applied and defined as applicable.**
- **Grammatical clarifications have been made.**

3.12.1 Introduction

According to the U.S. Department of Energy,

> Hydropower is one of the oldest and largest sources of renewable energy, which uses the natural flow of moving water to generate electricity. Hydropower currently accounts for 28.7 percent of the total United States renewable electricity generation and about 6.2 percent of the total United States electricity generation.
>
> While most people might associate the energy source with Hoover Dam – a huge facility harnessing the power of an entire river behind its wall – hydropower facilities come in all sizes. Some may be very large, but they can be tiny, too, taking advantage of water flows in municipal water facilities or irrigation ditches. They can also be “dam-less,” with diversions or run-of-river facilities that channel part of a stream through a powerhouse before the water rejoins the main river (DOE 2024).

The Willamette River Basin contains several Federal and non-Federal hydroelectric facilities used to generate electrical energy for local and regional consumption as well as high-voltage transmission lines and other facilities that move this energy from the generating facilities to regional loads (Chapter 1, Introduction, Section 1.7, U.S. Army Corps of Engineers-managed Dams, Reservoirs, and Bank Protection Structures in the Willamette Valley System; Section 1.8, Non-U.S. Army Corps of Engineers-managed Dams and Structures in the Willamette River Basin).

The Flood Control Acts of 1948, 1950, and 1954 modified the Flood Control Act of 1938 to provide for the installation of hydroelectric power-generating facilities at eight USACE multipurpose dams throughout the Willamette Basin: Detroit, Green Peter, Lookout Point, Cougar, Hills Creek, Big Cliff, Foster, and Dexter Dams (Chapter 1, Introduction, Section 1.1, Background). These are a subset of the Federal Columbia River Power System (FCRPS) hydroelectric projects[1]. Each of these USACE-managed dams are operated in compliance with Congressionally authorized purposes that include hydropower generation among other purposes (Chapter 1, Introduction, Section 1.10, Congressionally Authorized Purposes).

3.12.1.1 Power Generation and the Bonneville Power Administration

USACE establishes parameters for dam operations to meet its statutory requirements, and power generation operations are subsequently scheduled within these parameters. The Cougar, Hills Creek, Big Cliff, Foster, and Dexter Dams are operated to run a flat generation schedule each day based on water available, and the generation schedule is determined solely by USACE. The Bonneville Power Administration (BPA) is provided an opportunity to optimize the daily

[1] “Projects” as used to describe hydroelectric generation are generally large and include several facilities such as dams, impoundments, diversions, and pumped storage (DOE 2024).

Bonneville Power Administration Customers
Municipalities
Public Utility Districts
Power Cooperatives
Federal Agencies
Investor-owned Utilities
One Direct Service Industry Customer

timing of power generation at Detroit, Green Peter, and Lookout Point Dams after USACE determines its Congressionally authorized requirement needs for other dam and reservoir purposes, such as flood risk management, fish and wildlife, and water quality operations and identifies how many hours of generation would be available within a day as well as any operational constraints (e.g., cannot be more than 10 continuous hours without generation).

BPA is a Federal power marketing administration designated by statute to sell power and transmission services throughout the Pacific Northwest region. BPA sells electric power generated by FCRPS projects, operated and maintained by other Federal agencies (i.e., USACE or Bureau of Reclamation), to its regional firm power[2] customers (wholesale power customers) across the Pacific Northwest. These wholesale power customers in turn serve residential, commercial, and industrial retail customers (i.e., "end users"). Market prices for energy are typically locally determined by the regional energy market in which they are purchased based on a number of factors including availability of power, local fuel costs, and regulations. BPA's proportionally large share of generating resources in the northwest are very influential on market prices for the region.

BPA also operates and maintains about 15,000 circuit miles of the high-voltage transmission system within the Pacific Northwest region (BPA 2024). This system integrates and transmits electric power within the Pacific Northwest region and interconnects with external transmission systems throughout the western United States and parts of Canada and Mexico. Separate from its power sales, BPA sells transmission services (for the delivery of electricity from generating resources to end users) and associated ancillary services (for maintaining transmission system reliability) to regional firm power customers, independent power producers, and power marketers.

3.12.1.2 Non-Federal Hydropower Generation

Non-Federal hydropower generation projects in the Willamette Valley upstream or downstream of the Willamette Valley System (WVS) are mainly licensed by the Federal Energy Regulatory Commission (Table 3.12-1). The Eugene Water and Electric Board owns and operates two run-of-river hydroelectric projects on the McKenzie River: Carmen-Smith and Leaburg-Walterville (Table 3.12-1). However, the Board is in the process of decommissioning the Leaburg-Waterville project with removal estimated to begin in 2033.

[2] Firm power is defined as power or power-producing capacity intended to be available at all times during the period covered by a guaranteed commitment to deliver, even under adverse conditions (EIA 2023c).

Table 3.12-1. Willamette Valley Non-Federal Hydropower Project Details.

Project	Owner	Federal Energy Regulatory Commission License No.	River Basin	Megawatts	Energy Gains in aMW[1, 2]	Headwater Benefit Payment[1]
Carmen-Smith	Eugene Water and Electric Board	2242	McKenzie	92.00	NA[3]	NA[3]
Leaburg-Walterville	Eugene Water and Electric Board	2496	McKenzie	23.90	0.84	$8,400
Dorena Lake Dam	Dorena Hydro, LLC	11945	Row	7.50	NA[3]	NA[3]
Geren Island	Santiam Water Control District	Exempt	North Santiam	0.19	NA[3]	NA[3]
Willamette Falls	Portland General	2233	Willamette	16.00	2.94	$26,600

Source: FERC 2024

aMW = average megawatts

[1] Annual amount averaged over a 5-year period (2017-2021).

[2] The aMW for energy gains does not represent an increase in average annual generation. Instead, it is a weighted average to account for differences in critical period generation and average energy with their respective values multiplied by 1 and 2.

[3] Energy gains and headwater benefit payments do not apply to projects that are upstream of Federal storage projects or are not functionally downstream of Federal projects (i.e., Carmen-Smith Project and Dorena Lake Dam, respectively) or are Federal Energy Regulatory Commission-exempt (Geren Island).

The Carmen-Smith project is located a few miles downstream from the headwaters of the McKenzie River at Clear Lake; its operation is independent of other generation projects in the Willamette Valley[3]. Downstream of USACE-managed Cougar and Blue River Dams, the Eugene Water and Electric Board diverts McKenzie River flows to the Walterville Power Canal for hydropower generation at the Walterville generation facility, and then returns these flows to the river.

The Santiam Water Control District operates a small hydropower project at its Geren Island facilities (185 kilowatt) in the Santiam River downstream of Detroit Dam and is in the process of licensing additional generation capacity. In 2013, private developers built a 7.5 MW powerhouse that uses discharges from Dorena Dam. Portland General Electric operates a 15 MW facility at Willamette Falls.

[3] The Carmen-Smith Hydroelectric Project is a network of three dams and reservoirs and two power-generating plants (Northwest Public Power Association 2017).

Under section 10(f) of the Federal Power Act, non-Federal hydropower projects downstream of Federal storage reservoirs are required to pay a portion of the storage costs of the upstream Federal projects for the use of improved stream flows that increase project generation (referred to as “energy gains”). The payments for these energy gains are known as headwater benefit payments. In the Willamette Valley, this applies to Leaburg-Walterville and Willamette Falls. Both Portland General Electric and Eugene Water and Electric Board make annual payments (Table 3.12-1).

Unknown Photo Credit (USACE Media Images Database)

Hydropower Generators.

3.12.2 Affected Environment

The hydropower generation analysis area is broader than the Willamette River Basin because it includes regional power supply and marketing. Power-generating capacity within the analysis area includes the Western Interconnection, the Pacific Northwest, all of BPA’s marketable resources, and WVS dams. The Affected Environment for these areas includes descriptions of area energy- and power-generating capacities and trends.

The analysis areas for power and transmission resources are different from each other because of the nature of their services and products. Both the power and transmission Affected Environments encompass the BPA service area (Figure 3.12-1). BPA’s service area is defined by the Northwest Power Act as the Pacific Northwest, which includes Oregon, Washington, Idaho, the portion of Montana west of the Continental Divide, and the portions of Nevada, Utah, northern California, and Wyoming within the Columbia River drainage basin.[4] However, because BPA regularly markets its surplus power both within and outside the Pacific Northwest, the power analysis area includes power markets within the larger Western Interconnection area (Figure 3.12-2).

The Western Electric Coordinating Council is a non-profit corporation that ensures bulk power system reliability and security in the Western Interconnection. Additionally, it is responsible for compliance monitoring, enforcement, reliability planning, and reliability assessments.

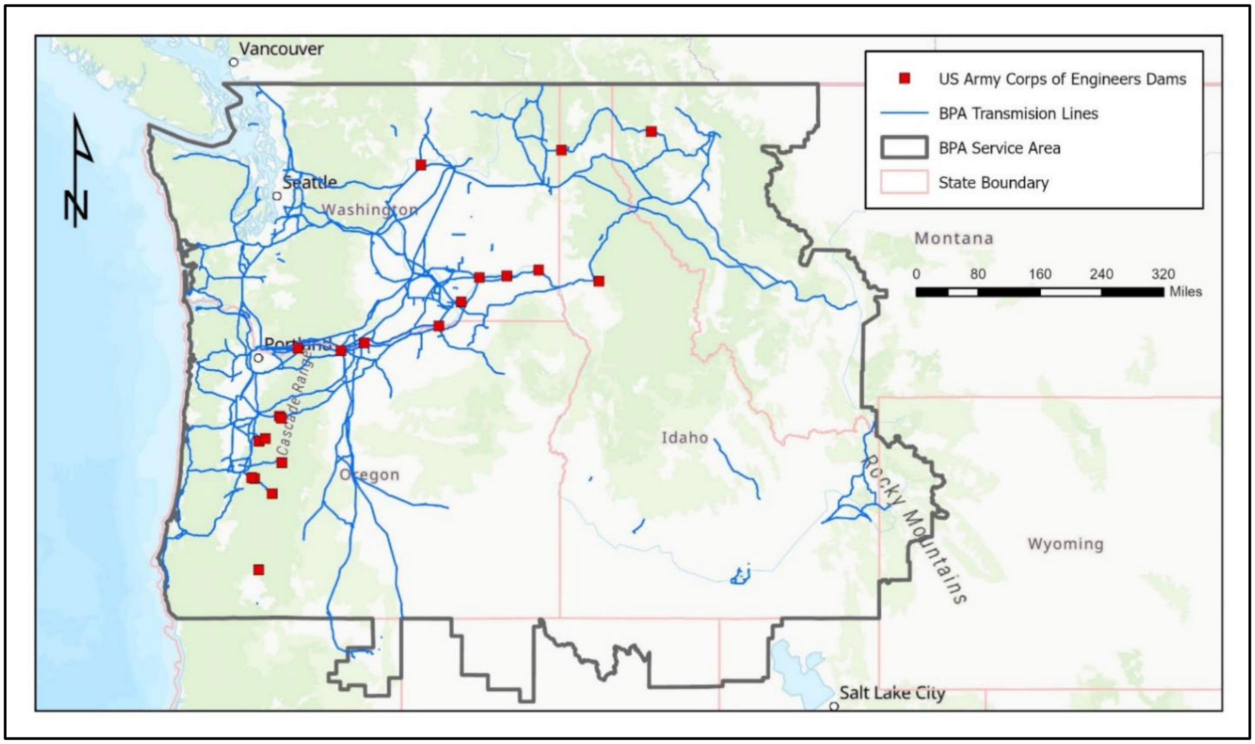

Figure 3.12-1. Transmission Analysis Area within the Bonneville Power Administration Service Area.

Figure prepared by BPA 2024

Note: Red squares denote USACE dams. Blue lines indicate BPA transmission lines. The gray outline is the BPA service area.

[4] 16 U.S.C. § 839a(14) (2018)

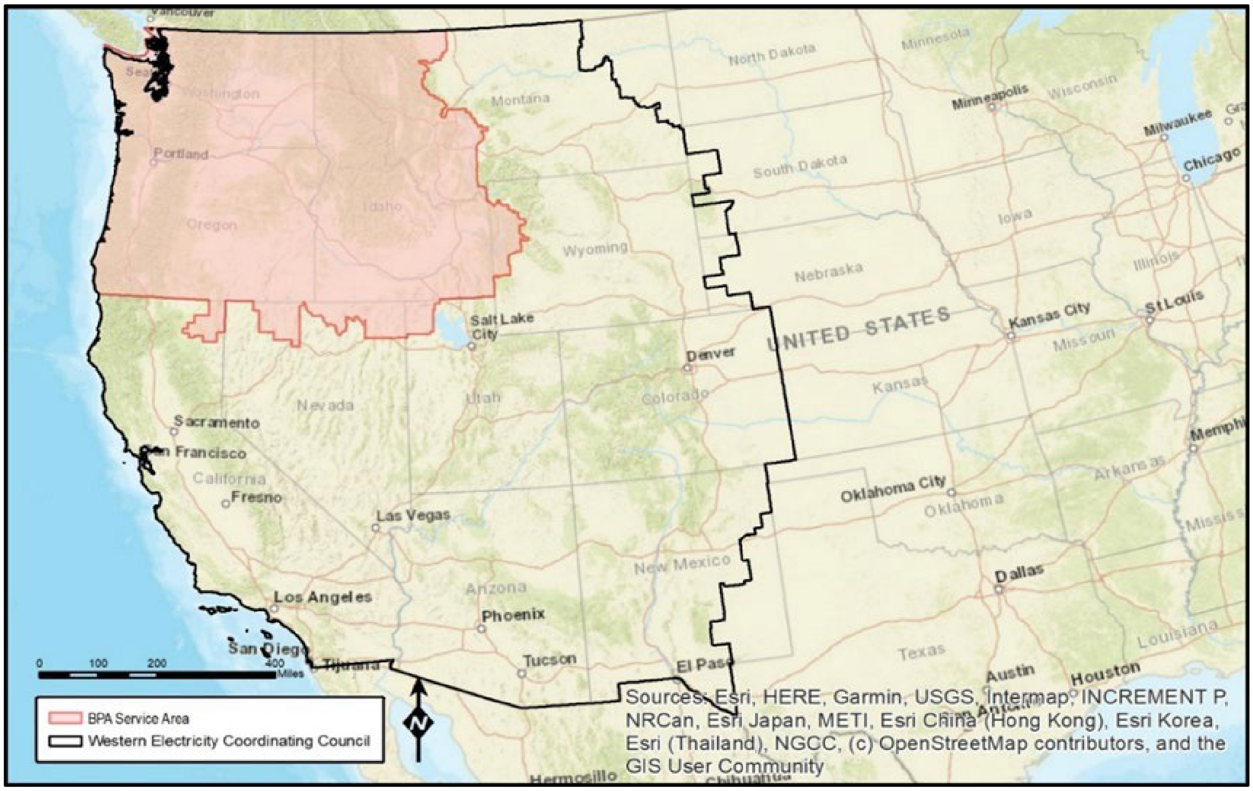

Figure 3.12-2. Power Analysis Area within the United States Portion of the Western Interconnection and the Bonneville Power Administration Service Area.

Figure prepared by BPA 2024. Source information is available from BPA.

Note: The red shaded area identifies the BPA service area; the black outline delineates the area managed by the Western Electric Coordinating Council.

3.12.2.1 Federal Power

BPA sells firm power at wholesale under long-term contracts to 136 power customers within a 300,000-square-mile service area in the Pacific Northwest. The BPA service area is geographically located within the boundary of the Western Interconnection power system. The Western Interconnection is one of four substantial North American power systems and includes power generation and transmission facilities across 14 states, 2 Canadian provinces, and parts of Mexico (WECC 2018). BPA imports power and exports surplus power (i.e., power not needed to meet BPA's firm power commitments) beyond the Pacific Northwest but within the Western Interconnection.

Capacity is distinct from energy. Capacity is defined as the maximum potential output of a generation unit that can be physically produced at any given instant and is commonly expressed in megawatts (MW). Generators often do not operate at full capacity, and output can vary according to a variety of factors such as lower demand, market conditions, and variability in water availability. In this context, energy is defined as the amount of electric power generated at a project or power plant over a period of time and is expressed in megawatt-hours (MWh) or average megawatts (aMW).

What is an Average Megawatt?

An aMW is a unit of energy representing 1 MW of electric power capacity generated continuously over a year.

One aMW is equal to 8,760 MWh.

The analysis area consists of the power-generating capacity within the Western Interconnection, the Pacific Northwest, all of BPA's marketable resources, and WVS dams (Table 3.12-2). For each of these areas, the values summarized in Table 3.12-2 are not additive—the smaller areas are a subset of the larger areas (i.e., the Pacific Northwest is a subset of the Western Interconnection, BPA's marketable resources are a subset of the Pacific Northwest, and the WVS dams are a subset of BPA's marketable resources).

Table 3.12-2. Analysis Area Power Generation Capacity in Megawatts (Current as of 2023).

Type	Western Interconnection	Pacific Northwest Region	BPA[1]	Willamette Valley System
Hydropower	75,200	34,650	22,441[2]	469
Wind	36,600	10,710	248	0
Natural Gas	104,700	9,450	0	0
Coal	22,000	5,040	0	0
Solar	34,700	1,260	0	0
Nuclear	8,300	1,260	1,144	0
Battery	9,800	0	0	0
Geothermal	3,800	61	0	0
Other	4,400	569	0	0
Total Capacity	299,500	**63,000**	**23,833**	**469**

Source: BPA 2019a, WECC 2023, NW Power and Conservation Council 2021

Note: The estimates across geographic regions are not additive; the Pacific Northwest is geographically within the Western Interconnection. The WVS capacity is for the eight WVS projects with hydropower facilities that would be affected by the alternatives, which are a subset of the BPA resources.

[1] This column (BPA) represents the generation capacity of all of BPA's marketable resources.

[2] This statistic (BPA hydropower) represents the total capacity of the FCRPS hydropower system, inclusive of the WVS dams, from a total of 196 hydropower-generating units.

In addition, power-generating projects typically operate below full capacity primarily because of the variation in available resources (e.g., water, wind, solar, etc.), demand for electric supply, and constraints on project operation to achieve non-power objectives as well as for any applicable Ancillary Services (e.g., Incremental Capacity, Decremental Capacity, synchronous condensing, etc.).

Power-generating Areas

Western Interconnection Resources

The diverse mix of generation resources, referred to as a "resource mix," in the Western Interconnection constitutes roughly 20 percent of all national power generation including approximately 40 percent of all national hydropower capacity and 35 percent of all wind and solar capacity. Given the geographic, climatic, and consumer diversity across the Western Interconnection (e.g., urban and rural, residential, commercial, and industrial electricity end users), demand for and generation of power varies greatly.

Coordination across the Western Interconnection allows for planning across this diverse power system to ensure cost-effective and reliable power. There were 92,353 aMW generated across the Western Interconnection in 2023 (WECC 2023).

Pacific Northwest Regional Resources

The Pacific Northwest regional resources are a component of the Western Interconnection resources (Table 3.12-2). Power generation has fluctuated in the Pacific Northwest year-to-year between 2006 and 2019 (NW Power and Conservation Council 2021[5]) (Figure 3.12-3). Wind energy production has been increasing during this period.

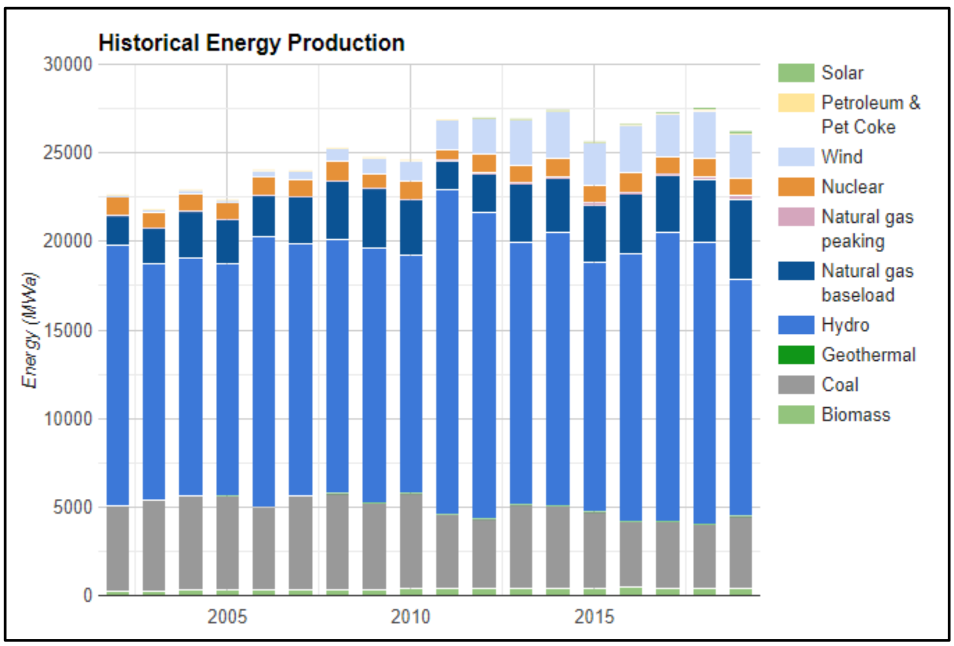

Figure 3.12-3. Breakdown of Annual Generation in the Pacific Northwest by Type from 2002 to 2019.

Source: NW Power and Conservation Council 2021

[5] The next power plan will be initiated by the Northwest Power and Conservation Council in 2025 with completion anticipated in 2027.

The region is experiencing rapid growth in new renewable energy generation, primarily wind and solar energy. This renewable energy is largely developed by independent power producers.

Bonneville Power Administration Marketable Resources

BPA does not own generating resources but markets power from a combination of Federal resources (31 FCRPS dams), certain non-Federal generating resources (e.g., wind, hydropower, nuclear, etc.) whose output BPA has acquired under contracts, and other contract purchases, as needed (Table 3.12-2).

Willamette Valley System Dams

The eight WVS dams that generate hydropower are a subset of the 31-project FCRPS. Each of these dams has one or more generation units with a specific capacity to produce power. The nameplate capacity (i.e., the maximum potential for energy output) for each WVS dam ranges from 21 MW to 138 MW (Table 3.12-3).

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Table 3.12-3. Willamette Valley System Power Generation Characteristics.

Dam	Number of Units	Capacity (MW)	Historical Average Modeled Generation[1] (aMW)	2024 Average Modeled Generation with Interim Operations Implementation (aMW)
Big Cliff	1	21	11	10.6
Detroit	2	115	37	27.5
Dexter	1	17	10	8.2
Foster	2	23	11	7.8
Green Peter	2	92	28	18.4
Hills Creek	2	34	18	18.1
Lookout Point	3	138	41	17.7
Cougar	2	29	16	11.5
Total	**15**	**469**	**171**	**119.7**

Capacity Source: BPA 2019b

aMW = average megawatts

Note: Historical average power generation is representative of a 73-year timeframe between 1936 to 2008. This was the most current available data representing average values (and power generation variation) over a period of record at the time the alternatives were analyzed. 2023 values were available; however, they were not used in the analysis because they did not represent average power generation values over prior years.

[1] Represents modeled data under the No-action Alternative.

The total combined nameplate capacity of these dams is 469 MW. This represents about 2 percent of the 22,616 MW nameplate capacity of the FCRPS. Historical average generation at these eight dams combined is 171.4 aMW, as modeled under the No-action Alternative (NAA) (Section 3.12.3.2, Alternatives Analyses), which constitutes less than 2 percent of the total energy of the FCRPS. Average generation is reduced to a modeled estimate of 119.7 aMW due to implementation of the Interim Operations at the time the alternatives were analyzed.

END REVISED TEXT

3.12.2.2 Pacific Northwest Regional Power Supply and Reliability

"Power system reliability" refers to the ability of the power supply to meet the demand, and demand for power is typically referred to as "load." The flexibility and capacity of a hydropower system is critical to ensuring power system reliability. Power system reliability is measured and discussed in terms of "loss of load probability" (LOLP) of a region's power supply. When the power supply is unable to meet demand, customers could experience blackouts for brief or extended periods of time. LOLP reflects the probability that the region's expected supply of power would not be able to meet the region's demand for electricity.

What is "LOLP?"

Power system reliability is reflected by loss of load probability. LOLP describes the probability that the region's expected supply of power would not be able to meet the regions' demand for electricity.

The Northwest Power and Conservation Council sets the metric (e.g., LOLP) and target for reliability for the Pacific Northwest. Created by the Northwest Power Act in 1980, the Council develops both a regional power plan and the Columbia River Basin Fish and Wildlife Program, which collectively "ensure, with public participation, an affordable and reliable energy system while enhancing fish and wildlife in the Columbia River Basin."[6] The current target for LOLP set by the Council in 2011 is 5 percent. This means the power supply should have sufficient resources (both capacity and energy) to limit the likelihood of a shortfall to no more than 5 percent during a future year.

Conditions such as cold weather events in winter and heat waves in summer are factored into the LOLP. To measure adequacy, LOLP is calculated by dividing the number of model simulations with shortfalls by the total number of model simulations studied. For the power supply to be deemed adequately reliable, that fraction must be less than 1/20, equating to an LOLP of 5 percent or less.

Electricity production at the WVS dams is influenced both by the turbine capacity and the amount of water available for generation. The amount of water available at each dam varies from year to year, season to season, day to day, and even hour to hour because it is based on

[6] See Northwest Power and Conservation Council, https://www.nwcouncil.org/about/mission-and-strategy. The Council uses the term "standard," but because this is not an enforceable standard, USACE refers to this as a "target."

variation in flows and operational constraints. USACE provides daily operational guidance to BPA for scheduling power generation for a specific number of hours each day. Hydropower generated at the eight generating dams has minimal ability to respond to load shifts. Consequently, the ability to manage the timing of water flow through the WVS dams for power purposes is limited to daily operations. Given this, WVS-generated power has minimal contribution to the overall reliability of the regional system.

3.12.2.3 Multipurpose System and Economical Power Supply

As a multipurpose system, the FCRPS produces both power and non-power benefits for the Pacific Northwest, and facilities are owned and operated by either USACE or U.S. Bureau of Reclamation (BOR). USACE and BOR operate and maintain their respective FCRPS facilities with a combination of BPA direct funding and Federal appropriations. BPA solely funds activities related to power generation and jointly funds activities that support the shared purposes of the facilities.

The FCRPS consists of 196 power-generating units with a total capacity of 22,441 MW, making it the largest hydropower system in the United States (EIA 2014) (Section 3.12.1, Introduction). For decades, it has been an engine of economic prosperity. It provides low-cost, carbon-free electricity, flood risk mitigation, irrigation, navigation, water quality, municipal and industrial water supply, and recreational opportunities throughout the region.

Effective management of FCRPS facilities requires balancing the many uses of these shared resources as efficiently as possible. A joint agency asset management strategy is used to make decisions that maximize the value of the FCRPS while meeting each agency’s various obligations. This means identifying optimal investment timing to mitigate safety, environmental, and financial risks; tailoring maintenance programs to the level of service necessary to meet obligations; and efficiently planning and operating the power system.

In the WVS, using revenues from its electric power rates, BPA pays USACE for its share of operation and maintenance and capital repayment costs based on the power allocation of each dam as determined by Congressionally authorized purposes. The FCRPS dams in the WVS have historically been operated, and continue to be operated, at a higher cost relative to other FCRPS hydroelectric facilities (Table 3.12-4).

THE FOLLOWING TABLE HAS BEEN REVISED IN THE FEIS

Table 3.12-4. Five-year Average Cost of Power Metrics (Cost of Generation and Fully Loaded Cost) at Average Water Conditions.

Strategic Class	Cost of Generation[1] ($/MWh)	Fully Loaded Cost[2] ($/MWh)
Mainstem Columbia River	8.13	18.71
Lower Snake River	18.30	30.18
Headwater	14.26	25.11
Area Support[3]	23.52	33.91
Area Support - Willamette Valley[3]	24.75	36.00
Local Support[4]	35.55	47.53
FCRPS Hydropower Projects	10.49	21.24

Source: BPA, USACE, and Reclamation 2024 Strategic Asset Management Plan

[1] Cost of Generation represents the BPA direct funded costs associated with producing power at a plant. Includes operations, maintenance, administrative, and capital-related costs (interest expense).

[2] Fully Loaded Cost includes the Cost of Generation plus allocations for all remaining Power Services costs attributable to the FCRPS (including fish and wildlife program, residential exchange, and other overhead). Most of these costs are system-wide costs that would still be incurred and reapportioned across other Strategic Classes if the power purpose for any individual dam were eliminated.

[3] Area Support facilities primarily provide voltage support, flood risk mitigation, irrigation, and recreation to a specific region, such as the Willamette Valley, but not the broader Columbia River Basin as a whole. This category includes Willamette Valley power projects, Albeni Falls, Lost Creek, and Palisades.

[4] Local Support facilities primarily provide voltage support, flood risk mitigation, irrigation, and recreation local to a dam, but not the broader Columbia River Basin as a whole. All facilities in the Local Support category are operated and maintained by the BOR.

3.12.2.4 Transmission

BPA's transmission system connects and moves power generated from Federal and non-Federal dams; nuclear, natural gas, and coal-fired power plants; and solar and wind generation projects to loads throughout the Pacific Northwest and beyond. Over 260 BPA substations collect power, control its flow, and deliver electricity to BPA customers. BPA's transmission system contains multiple "paths," or routes over which power flowing from one point to another is monitored and managed[7] (Figure 3.12-4).

[7] See glossary for additional definitions of transmission paths and interties.

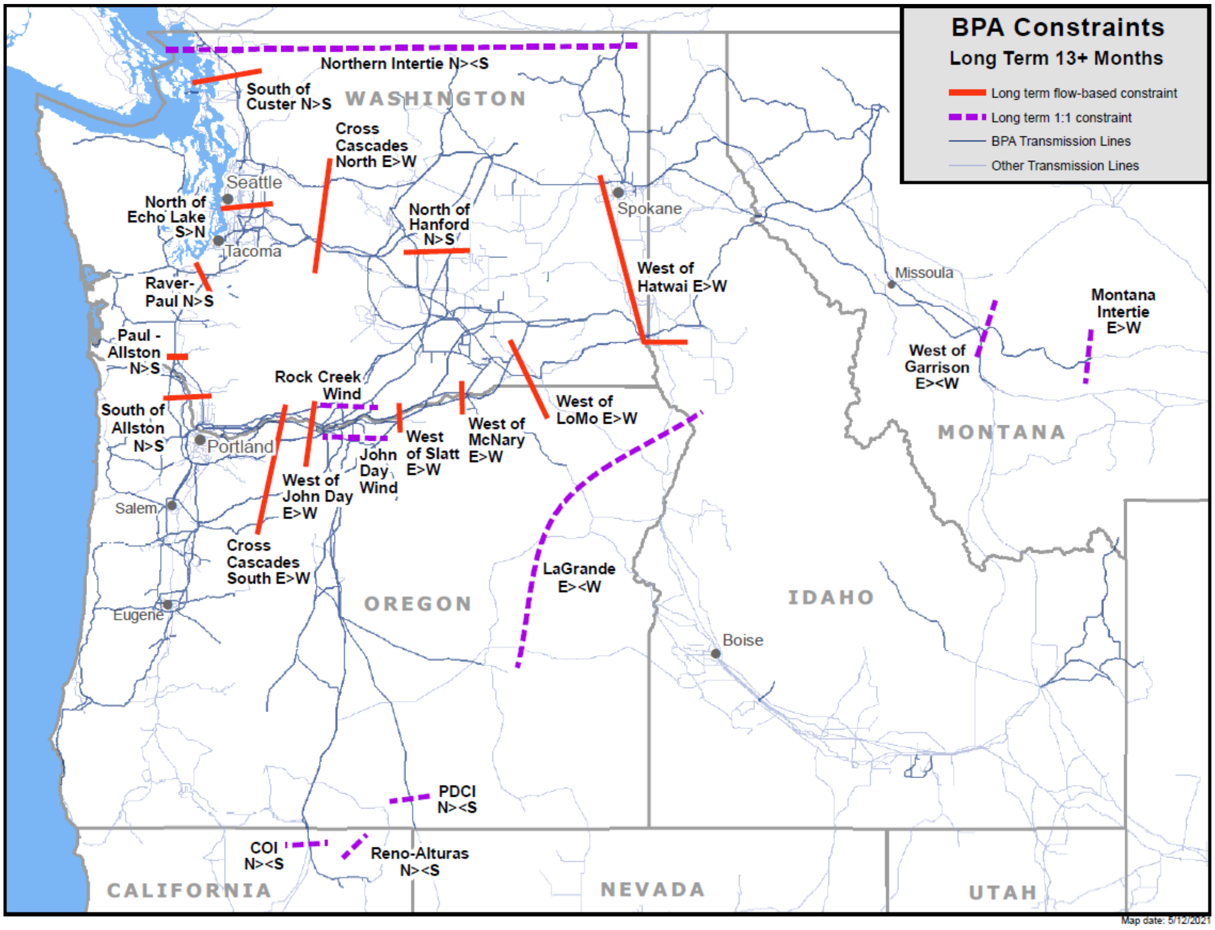

Figure 3.12-4. Northwest Transmission Paths.

Source: BPA 2021

Note: Blue lines represent BPA transmission lines, light gray-blue lines represent non-BPA transmission lines, and red and dashed purple lines denote defined paths and interties (locations where power flows are monitored and analyzed).

Bonneville Power Administration Transmission Flows and Load Areas

BPA's portion of the bulk electric power system is planned, designed, maintained, and operated to interconnect Federal and non-Federal generation to the substantial load centers in both the Pacific Northwest and externally to the substantial load centers in the Western Interconnect region.

The transmission lines that are primarily used for serving loads in the Willamette Valley run approximately from The Dalles, Oregon to substations between Portland and Salem (the "Cross Cascades South" corridor), and then south along the Interstate 5 corridor. This corridor is considered congested,[8] especially in the winter months when loads tend to be highest. There is a notable transmission path that connects thermal generation in the Longview, Washington

[8] Congestion occurs on electric transmission systems when flows of electricity across a portion of the system are restricted or constrained below desired levels (DOE 2014).

area with other generators as far north as Olympia, Washington to Portland, Oregon called "South of Allston," which is also considered congested. A southern transmission path to the Klamath Falls area ties into the Pacific Alternating Current Intertie helps with congestion but has limited capacity to serve load in the Willamette Valley.

Changes in generation at the WVS dams tend to incrementally impact the congested paths of South of Allston and Cross Cascades South; power from generators east of the Cascades is then expected to balance any changes. Seasonal conditions further affect these transmission path capacities because resulting temperature differences change the line ratings of all transmission paths. Changes in generation patterns due to spring runoff and availability of wind and solar impact transmission path flows across the entire network, including paths that serve the Willamette Valley.

Localized Transmission Reliability

Willamette Valley Wildfires

In 2020, wildfires burned through the Thurston to Holden Creek 115kV transmission line, causing a multi-day outage. However, USACE operations at Cougar Dam generated power while isolated ("islanded") from the main system to provide power to the community of Blue River, Oregon.

Some Willamette Valley generators influence local power and transmission reliability in nearby communities. For example, in February of 2019, a severe winter storm caused an outage on the Hills Creek to Lookout Point 115kV line, which isolated the community of Oakridge between February 24 and March 5, 2019. Hills Creek Dam generation was critical to providing this community with electric power while the line was repaired. It is expected that under current circumstances, Hills Creek Dam power generation would be needed most years to provide service to Oakridge in the event of a transmission outage.

3.12.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives on power generation, power system reliability, power flows across the transmission system, and economic viability of WVS power generation. The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

3.12.3.1 Methodology

This analysis assesses changes to power generation that would result from alternative implementation and addresses potential impacts on BPA's ability to ensure an adequate and reliable supply of power contributed by USACE-managed dam operations to meet its firm power obligations under long-term contracts. The analysis considers whether implementation of any alternative would require BPA or other regional entities (i.e., wholesale customers who might be receiving less power from BPA under an alternative) to acquire power from new resources (e.g., new or existing generating plants, wind, solar, etc.[9]) and/or to construct new transmission infrastructure to replace lost capability from USACE-managed dam operations. The analysis methodology concluded that, while power may need to be acquired from other sources, newly constructed replacement sources are not required under any alternative.

If USACE operations under a given alternative would result in lost power generation, and if BPA or other regional entities propose to acquire newly sourced power, BPA would do so consistent with its applicable statutes (such as the Northwest Power Act and Transmission System Act) and would complete additional site-specific planning, analysis, and compliance with environmental laws, including the National Environmental Policy Act. Acquiring additional power and compliance with laws and regulations to accomplish such acquisitions would not be a USACE responsibility.

The future of power generation and transmission across the Pacific Northwest is subject to uncertainty, even under the NAA, due to evolving policy (e.g., emissions reductions targets), environmental factors (e.g., climate change), and technological growth. To evaluate potential effects of the action alternatives in comparison to implementation of the NAA, the power generation and transmission analyses require common assumptions regarding these evolving conditions. These common assumptions, as identified throughout the methodology and results discussion, form the “base case” for the analyses.

A summary of effects on power and transmission resources is provided in Table 3.12-5. The effects criteria and analysis process are provided below the table.

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[9] In the context of power acquired from new resources, “existing” refers to currently operating generating plants or renewables (e.g., wind, solar, etc.) located outside of the Pacific Northwest region.

Table 3.12-5. Summary of Effects to Regional Power System Generation and Transmission as Compared to the No-action Alternative.

Effect Category	No-action Alternative	Alternative 1	Alternative 2	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5	Interim Operations
Regional Power System Reliability Impacts	Long-term, slight, beneficial.	Same as No-action Alternative, but more beneficial from slight, additional power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but less beneficial from substantially less power generation.	Same as No-action Alternative, but less beneficial from substantially less power generation.	Same as No-action Alternative, but more beneficial from slightly more power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but medium term and less beneficial from less power generation and shorter term.
Willamette Valley System Dam Generation Impacts	Long-term, substantial, beneficial.	Same as No-action Alternative, but more beneficial from slightly more additional power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but less beneficial from a 50 percent power generation decrease.	Same as No-action Alternative, but less beneficial from a 50 percent power generation decrease.	Same as No-action Alternative with negligible changes to power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but less beneficial from moderately less power generation. Interim Operations implementation would be shorter than an alternative implementation but may extend for nearly the full 30-year implementation timeframe.

Effect Category	No-action Alternative	Alternative 1	Alternative 2	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5	Interim Operations
Transmission System Impacts	Long-term, slight, adverse. Power generated at Hills Creek and Cougar Dams would continue to be able to operate islanded (isolated) as needed and to provide power to the Oakridge and Blue River communities during outage, respectively.	Long-term, slight, adverse. Islanding during power outages would be the same as the No-action Alternative.	Long-term, moderate, adverse. Islanding during power outages would be the same as the No-action Alternative.	Long-term, moderate, adverse. Islanding during power outages from Hills Creek Dam would be the same as the No-action Alternative. Deep fall and spring drawdowns at Cougar Reservoir would likely compromise the ability to provide power to the community of Blue River, which would be a substantial, adverse effect to the community.	Long-term, moderate, adverse. Substantial, adverse community effects because operations at Hills Creek and Cougar Dams would not be able to continue to operate islanded (isolated).	Long-term, moderate, adverse. Substantial, adverse community effects because operations at Hills Creek and Cougar Dams would not be able to continue to operate islanded (isolated).	Long-term, slight, adverse. Islanding during power outages would be the same as the No-action Alternative.	Long-term, moderate, adverse. Islanding during power outages from Hills Creek Dam would be the same as the No-action Alternative. Deep fall and spring drawdowns at Cougar Reservoir and limited ability to manage Cougar Dam for power generation would likely compromise the ability to provide power to the community of Blue River, which would be a substantial adverse effect to the community.	Medium-term, moderate, adverse. Islanding during power outages from Hills Creek Dam would be the same as the No-action Alternative. Deep fall and spring drawdowns at Cougar Reservoir would likely compromise the ability to provide power to the community of Blue River, which would be a substantial, adverse effect to the community.
Economic Viability of Power Generation Impacts	Long-term, slight, beneficial.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Medium-term, substantial, adverse.

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Effects Criteria

The degree of impact to hydropower generation and transmission is assessed qualitatively and discussed descriptively (e.g., slight[10], moderate, substantial). Specified criteria to describe the degree of effect are not provided because criteria would be speculative (e.g., what type of impact or combinations of impacts constitute the definition of a slight or substantial effect).

The power and transmission analysis characterizes effects as adverse or beneficial (or no effect, where relevant). The degree of an adverse or beneficial effect is described by considering the interrelationship of the following:

- Context of the impact is the geographic scope of the effect, or the size of the population affected. Because of the interconnected nature of the Pacific Northwest electricity system, operations at one or more WVS dam under any alternative may affect power and transmission more broadly across the Pacific Northwest.
- Intensity is the relative degree of the effect. The intensity of the power and transmission effects refers to the degree of power generation, transmission flows, Net Present Value (NPV)[11], and Levelized Cost of Generation (LCOG) and how that effect is compared to NAA operations.
- How an effect persists over time is also factored into the degree of effect. An effect may be moderate in the short term (e.g., limited to a construction period) but have negligible or no effect over the long term (e.g., beyond the construction period and within the 30-year implementation timeframe). The power and transmission analyses consider the effects of the alternatives over a 30-year implementation timeframe[12].

END REVISED TEXT

[10] Slight" is defined in its common use as "small of its kind, or in amount" (Meriam Webster Dictionary). "Moderate" is not used as a specified criteria in this analysis. It is defined in its common use as "average in amount, intensity, quality, or degree" (Oxford Languages). "Substantial" is defined in its common use as "considerable in quantity, great [in amount]" (Meriam Webster Dictionary).

[11] NPV was calculated by BPA, which did not use USACE methodologies to evaluate economic impacts.

[12] The BPA standard power generation economic analysis timeframe is 50 years. For consistency with other analyses in the EIS, a 30-year timeframe was used instead. For transmission analysis, the Western Electric Coordinating Council produces power flow models for the Western Interconnect power system for different planning horizons; a 10-year case is the furthest case produced.

Analysis Process

Potential effects under each alternative were assessed by applying a four-step approach as defined in the following process (Figure 3-12.5) (Appendix G, Power Generation and Transmission Analysis).

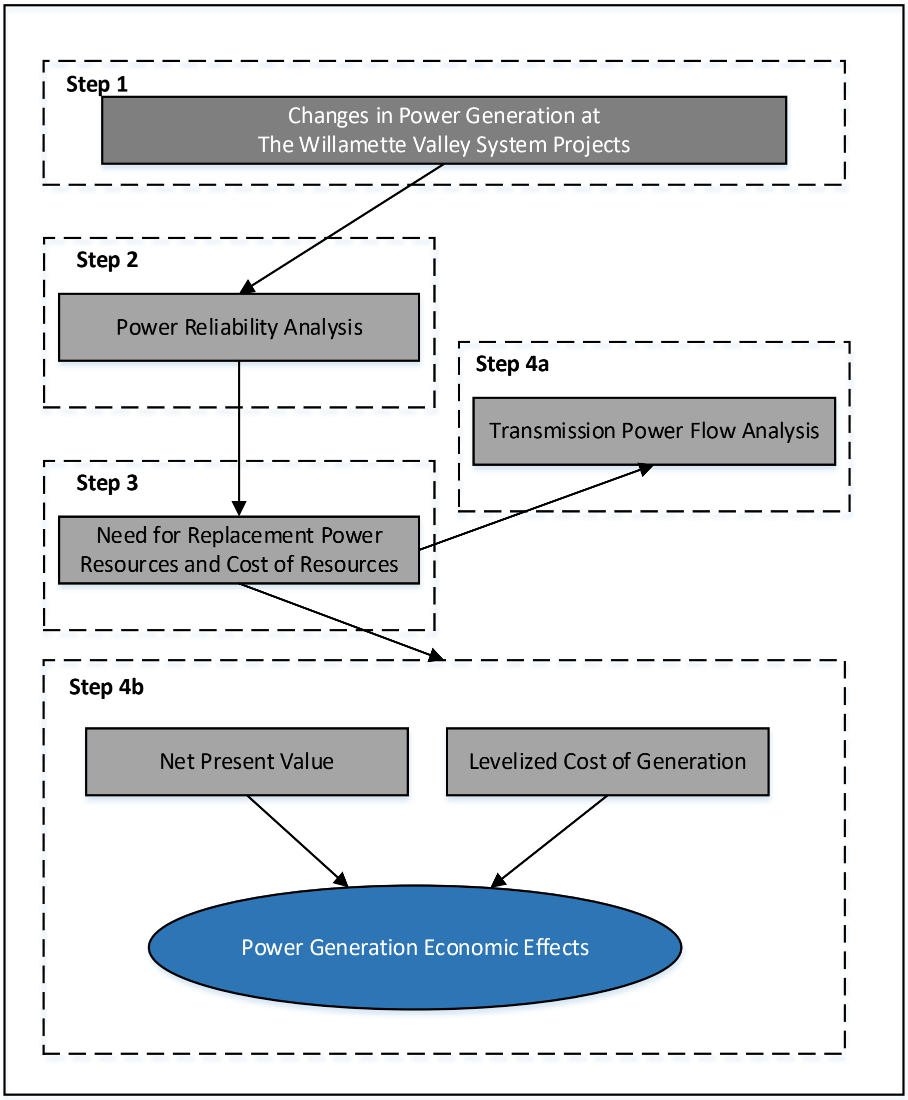

Figure 3.12-5. Analytical Approach for Evaluating Power and Transmission Effects.

Note: Additional power and transmission analyses occur within each of the step boxes depicted.

Step 1—Assess Hydropower Generation under Each Alternative

Under Step 1 of the analysis, the effects of the alternatives on hydropower generation were assessed based on average historical water conditions and for critical water conditions that were extrapolated to the 30-year implementation timeframe.[13] The BPA hydropower simulation model (HYDSIM) calculates power generation and analyzes that output in 73 different flow years (Water Years 1935 to 1936 through 2007 to 2008) at each of the eight WVS dams. First, the power generated under the NAA was calculated. Then the generation under each of the action alternative operations was calculated to determine whether additional changes to, or investments in, the system may be required to maintain BPA's ability to supply adequate and reliable power (both energy and capacity) to its firm power customers under 20-year contracts.

Step 2—Regional Power Capacity and De-carbonization Policies

Step 2 of the analysis considered whether the region has enough power capacity and energy to meet consumer demand over the 30-year implementation timeframe (i.e., load). This allowed evaluation of the extent to which the alternatives, including the NAA, would result in the need for BPA or other regional entities to acquire power from other resources (e.g., new or existing generating plants) and to construct new transmission infrastructure to replace the lost capability under a given alternative at USACE-managed dams.

Synthesizing HYDSIM hydropower generation outputs with Northwest Power and Conservation Council load-and-resource forecasts and power-import assumptions, the Generation Evaluation System (GENESYS) model simulates regional power generation and demand to determine power system reliability (i.e., LOLP). This is representative of the NAA (Table 3.12-6). If operations under an alternative would reduce power system reliability relative to the NAA, then the analysis continued to Step 3; otherwise, it progressed directly to Step 4a (transmission analysis) and Step 4b (NPV and LCOG analyses).

Table 3.12-6. Coal Plants Included/Excluded under the No-action Alternative Genesys Study and Generation Capacities.

Coal Plant	State	MW
Included		
Centralia 2	WA	670
Colstrip 3	MT	518
Colstrip 4	MT	681
Hardin	MT	119
Jim Bridger 1	WY	530
Jim Bridger 2	WY	530
Jim Bridger 3	WY	530

[13] The "critical water year" or "critical water conditions" represent the historical water year (in this case, 1937) when the capability of the hydropower system produces the least amount of dependable generation to serve the least amount of load while considering power and non-power operating constraints. In June 2022, BPA updated its long-term hydropower planning. BPA now uses the last-30-year subset of the most recent (1989 to 2018) flows and takes a statistical approach to establish firm generation. This methodology will first be used in the BP-24 rate case.

Coal Plant	State	MW
Jim Bridger 4	WY	530
Montana 1	MT	4
North Valmy 2	NV	134
Total Included		**4,246**
Excluded (assumed retired prior to 2022)		
Centralia 1	WA	670
Boardman	OR	570
Valmy 1	NV	127
Colstrips 1 and 2	MT	308
Total Excluded		**1,675**

WA = Washington, MT = Montana, WY = Wyoming, NV = Nevada, OR = Oregon

The LOLP estimate relies on an assumption about the resources available to serve regional loads over time. The basis for that assumption is the Northwest Power and Conservation Council's resource adequacy dataset developed in 2017. While the LOLP estimate accounts for the planned coal plant closures known in 2017, the estimate also assumes coal plant generating capacity (4,246 MW) would continue to serve primarily regional investor-owned utility loads.

Energy economics and state and local de-carbonization policies are changing the generation portfolio in the region and across the Western Interconnection that will accelerate coal plant retirements post-2025. Since 2017, the year of the base-case assumptions for this EIS analysis, additional and accelerated coal plant retirements have been announced and more are being contemplated, mainly impacting the region's investor-owned utilities, which use these resources to serve their retail loads.

THE DEIS HAS BEEN MODIFIED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

Greenhouse gas emissions are managed at state and local levels under emission reductions targets and sector-specific plans and policies. Targets for reducing greenhouse gas emissions have been set by the State of Oregon and local governments through regulatory, legislative, and public action. Despite relatively small emission profiles compared to national averages, considerable emission reductions are targeted by 2050 relative to 1990 (Section 3.10, Air Quality and Greenhouse Gas Emissions). Oregon State is a member of the United States Climate Alliance, a bipartisan coalition of 23 governors (as of March 2019) committed to reducing greenhouse gas emissions consistent with the goals of the Paris Agreement.[14]

[14] The Paris Agreement, developed in 2015 and entered into force in 2016, is an international agreement within the United Nations Framework Convention on Climate Change to increase investment to both combat climate change and adapt to its effects.

The Oregon Clean Energy and Coal Transition Act (2016) mandates the elimination of the cost of coal resources in retail rates of investor-owned utilities by 2030 (ORS 757.518). In Washington State, the Clean Energy Transformation Act (2019) mandates the elimination of coal-generated electricity by all Washington utilities by December 31, 2025 (RCW 19.405). Additionally, deep reductions in greenhouse gas emissions are being mandated by recently enacted legislation, including Oregon's clean energy standard (HB 2021), Washington's Clean Energy Transformation Act, and Washington's Climate Commitment Act (RCW 70A.65.260).

There was focus in Oregon and Washington on transitioning to carbon-free resources at the time the alternatives were analyzed. Oregon's clean energy standard requires the state's largest investor-owned utilities and energy service suppliers to provide 100 percent carbon-free electricity by 2040. Washington's clean Energy Transformation Act requires retail utilities in the state to use 100 percent carbon-free electricity by 2045.

At the time the alternatives were analyzed, the loss of dispatchable coal generation was having an impact on regional resource adequacy. The Northwest Power and Conservation Council 8th Power Plan addressed regional reliability in the period from 2022 to 2029 that included additional coal plant retirements. Depending on the scenario, regional energy needs to meet the Council adequacy standard range from 0 aMW to 2,857 aMW. Regional utilities, including BPA, began working together to address the issue at the time the alternatives were analyzed.

Step—Identification of Potential Replacement Resources

Step 3 would identify potential replacement resources and associated costs if Step 2 identified a potential need for power from new resources in the region or to build transmission infrastructure to meet load resulting from alternative implementation. While generation would need to be replaced under some alternatives, this need would not require a replacement resource, which is defined as a new power plant. There is enough power generation in the analysis area to replace power under all alternatives. Therefore, a replacement resource was not identified for any of the alternatives.

END NEW TEXT

Step 4a—Assessment of Effects on Transmission Reliability

Under Step 4a, transmission incremental power flow on BPA network flow paths was estimated under the NAA first, and then under each of the action alternatives during multiple seasons as a result of generation output changes at USACE-managed dams with hydropower facilities (Detroit, Big Cliff, Cougar, Green Peter, Foster, Hills Creek, Lookout Point, and Dexter Dams). The BPA transmission system analysis relies on power flow models to assess changes to the flow of electricity on the transmission system under each alternative.

Because the transmission system is planned to reliably operate during times of peak loading, performance (and the need to reinforce the system to maintain reliable transmission operation) was analyzed during seasonal peak loading times within the region. Replacement resource assumptions (including quantities and general locations) developed under Step 3 were incorporated into the power flow models. However, no replacement resources were deemed necessary in the analysis.

Results of the generation and power flow models were used, along with individual WVS transmission grid connections (single or more than one transmission line) and susceptibility of those connections to adverse weather/wildfire conditions, to qualitatively assess potential effects on local transmission reliability as compared to effects under the NAA.

Step 4b—Estimating Power Costs

Under Step 4b of the analysis, USACE considered the NPV[15] and LCOG resulting from the increased costs of providing power associated with the inclusion of any new capital investments under the NAA and each of the action alternatives. The NPV analysis compares the expected revenue produced by each WVS operation with hydropower facilities against their expected costs over the 30-year implementation timeframe (in U.S. dollars/MWh). A positive NPV indicates that power generation benefits outweigh the cost while a negative NPV indicates that the costs of power production outweigh the benefits. The NPV provides a relative measure of cost-competitiveness when compared to other generating resources or market purchases. Market price forecasts used in this analysis have a real levelized price over the 30-year implementation timeframe of $32.14/MWh as a point of comparison to impacts in the Willamette Valley.

THE DEIS HAS BEEN MODIFIED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

The primary effect on NPV and LCOG would be costs associated with implementing the alternative (e.g., construction costs for downstream fish passage structures) rather than generation losses associated with changes in hydropower generation as compared to NAA operations.

END NEW TEXT

THE DEIS HAS BEEN MODIFIED TO REVISE THE ANALYSES IN THE FEIS

Effects from construction under the alternatives are not analyzed (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act). USACE would determine to what extent power and transmission may be impacted at any WVS dam during the planning phase of any construction or maintenance project.

Routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation). Effects from routine and non-routine

[15] NPV was calculated by BPA, which did not use USACE methodologies to evaluate economic impacts.

maintenance under the alternatives are incorporated into the analyses. Impacts on power generation and transmission from construction and routine and non-routine maintenance under any alternative and at any location would be temporary.

3.12.3.2 Alternatives Analyses

No-action Alternative

The NAA analysis projects generation and reliability of the regional power system over the 30-year implementation timeframe. It accounts for planned maintenance at WVS dams in future years, load and resource forecasts, and planned retirements of coal power plants as of 2017[16] (i.e., base case assumptions).

Power Generation

Under the NAA, average annual generation from the combined WVS operations over a 73-year period of record (Water Years 1936 through 2008) is estimated at 171 aMW and for the 1937 critical water year is 150 aMW. This would power approximately 136,116 homes during the 30-year implementation timeframe[17] (Table 3.12-7).

Table 3.12-7. Willamette Valley System 73-year Average Generation (aMW) (Water Years 1936 through 2008) and Critical Water Year (1937) under the No-action Alternative.

Month[1]	No-action Alternative Average Monthly Generation	No-action Alternative Critical Water Year Average Generation
October	134	119
November	230	156
December	231	80
January	235	47
February	147	67
March	143	121
April I	177	188
April II	182	227
May	222	356
June	162	264

[16] See Table 3.12-6 for coal retirement base-case assumptions under the NAA. At the time the alternatives were analyzed, it was assumed that all coal power plants would be retired during the 30-year implementation timeframe (i.e., all coal use in the analysis area phased out); therefore, 2017 information remains the best available and relevant information for alternatives analyses.

[17] According to the Northwest Power and Conservation Council, 1 aMW can power about 796 Northwest homes for a year.

July	106	111
August I	114	115
August II	118	124
September	151	155
Annual Average[2]	**171**	**150**

Source: HYDSIM modeling results

aMW = average megawatts

[1] HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves. Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

[2] The Annual Average is a weighted average to account for the different number of days in the 14 periods.

Operations under the NAA would result in long-term, slight, beneficial effects to the regional power system because of its continued power generation over the 30-year implementation timeframe.

Operations under the NAA would result in long-term, substantial, beneficial effects specific to WVS dam generation with total estimated annual generation of 171 aMW on average and total estimated critical water year generation of 150 aMW.

Based on load forecasts, some coal plant retirements, and changes in power generation, the NAA would result in an LOLP of 6.5 percent, which would continue through the 30-year implementation timeframe if there were no further change. Operations under the NAA would exceed the current Northwest Power and Conservation Council LOLP target of 5 percent, but would be within the reasonable historical range of the Council target.[18] A 6.5 percent LOLP is roughly equivalent to a 1-in-15-year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions) over the 30-year implementation timeframe.

There would be no acquisition of power from newly constructed replacement resources under the NAA.

[18] Note that LOLP is a probabilistic estimate and does not indicate magnitude or scale of potential power system outages and it is also not linear in effects; however, it is a useful metric of overall power system reliability and stability. Furthermore, the Northwest Power and Conservation Council target is not an enforceable standard. See Northwest Power and Conservation Council, https://www.nwcouncil.org/sites/default/files/2011_14_1.pdf Page 4, "The adequacy standard adopted by the Council does not mandate compliance or imply any enforcement mechanisms. It does not apply to individual utilities because each utility faces different circumstances. It is intended to be an early warning should aggregate regional resource development fall short, for whatever reason."

Transmission

The existing congested paths of Cross Cascades South and South of Allston would remain congested under NAA operations with capacity either slightly unsubscribed or oversubscribed during the 30-year implementation timeframe (Appendix G, Power and Transmission Analysis).

Operations under the NAA would result in long-term, slight, adverse effects to the regional transmission system because of its small contribution to congestion. Conversely, long-term, substantial, beneficial effects to the local Willamette Valley transmission system would occur under the NAA because power generated at Hills Creek and Cougar Dams would continue to be able to operate islanded (isolated) as needed and to provide power to the Oakridge and Blue River communities, respectively, in the event of system outages due primarily to severe weather events and wildfire during the 30-year implementation timeframe.

At the time the alternatives were analyzed, severe winter weather events had caused annual power outages in the analysis area. Regional climate projections indicate increased winter storm event frequency and durations (Fleishman 2023). Consequently, there is an expected increase in annual power outages in the analysis area over the 30-year implementation timeframe under all alternatives.

Wildfire could have similar or greater impacts on power and transmission to Willamette Valley communities. For example, although temporary, impacts on power transmission could continue for long periods until power is restored. It is assumed these conditions would continue under all alternatives.

Economic Viability of Power Generation

Power generation from WVS sources would be economically viable under NAA operations because the benefits of power would outweigh the costs of production. The 3-year (2018 to 2020) average cost of generation at the WVS dams under expected generation would be $25.28/MWh (Table 3.12-8). This cost of generation was marginal when the alternatives were analyzed relative to average market prices and to other generation resources and is among the highest costs in the FCRPS. Over the 30-year implementation timeframe, the median LCOG for the combined WVS generation is estimated to rise to $30.03/MWh under the NAA and the median NPV would be about $356 million[19] (Appendix G, Power and Transmission Analysis).

[19] The BPA share of basin-wide costs (e.g., research, monitoring, and evaluation) were not included in this analysis. With inclusion of those costs, the NPV would be incrementally lower and the levelized costs of generation would be incrementally higher.

Table 3.12-8. Summary of Effects to Power and Transmission under the No-action Alternative[1].

Metrics	No-action Alternative
WVS Operations 73-year Average Generation (aMW)	171
WVS Operations Critical Water year (1937) Average Generation (aMW)	150
Loss of Load Probability (LOLP)	6.5%[2]
Transmission Flow Paths[3] Cross Cascades South	W 6475.5 SP 4100.5 SU 5862.9
South of Allston	W 1183.0 SP 4100.5 SU 5862.9
Transmission Reliability	Slightly Congested
NPV (median)	$356 Million
LCOG ($/MWh)	$30.03

% = percent

aMW = average megawatts

[1] The Bonneville Power Administration share of basin-wide costs (e.g., research, monitoring, evaluation) were not included in this analysis. With inclusion of those costs, the NPV would be incrementally lower, and the levelized costs of generation would be incrementally higher. However, for calculations of the LCOG and NPV, a 30-year study period was used because this is the implementation timeframe for any alternative implementation. Typically, hydropower analysis considers a 50-year study period; however, this timeframe demonstrates more extreme outcomes under each alternative than would be the case in a 50-year analysis because costs occur upfront and are not distributed across as many years for benefits purposes.

[2] Though greater than the Northwest Power and Conservation Council standard of 5 percent, LOLP is within the reasonable historical range of the Council target.

[3] The amount of loading (in MW) on the congested paths of Cross Cascades South and South of Allston are depicted during three seasonal cases (W = Winter Peak; SP = Spring Off-peak; SU = Summer Peak).

Operations under the NAA would result in long-term, slight, continued beneficial effects on regional power system economic viability because, the median NPV under this alternative would be positive, and would be a relatively small contribution to the regional power system. Operations under the NAA would have slight, beneficial effects on WVS dam economic viability due to the larger contribution of the WVS to the local power system, but NAA operations would result in a marginally viable LCOG.

Alternative 1—Improve Fish Passage through Storage-focused Measures

Power Generation

Power generation from the WVS operations would increase from 171 aMW under the NAA, on average over all water years, to 179 aMW under Alternative 1 operations during the 30-year implementation timeframe (Table 3.12-9) (Figure 3.12-6). This represents an increase of 8 aMW, which would be a 4.7 percent increase in average annual generation. This would power approximately 142,484 homes during the 30-year implementation timeframe, an increase of 6,368 homes powered over NAA operations.

The difference in critical water year generation from 150 aMW under NAA operations to 160 aMW under Alternative 1 operations represents a 10 aMW (or 6.7 percent) increase (Appendix G, Power and Transmission Analysis).

Table 3.12-9. Willamette Valley System 73-year Average Generation (aMW) (Water Years 1936 through 2008) and Critical Water Year (1937) under Alternative 1.

Month[1]	No-action Alternative Average Generation	Alternative 1 Average Generation	Average Generation Difference	No-action Alternative Critical Water Year Generation	Alternative 1 Critical Water Year Generation	Critical Water Year Generation Difference
Oct	134	173	39	119	127	8
Nov	230	276	46	156	208	52
Dec	231	227	-4	80	71	-9
Jan	235	230	-5	47	41	-6
Feb	147	146	-1	67	57	-10
Mar	143	132	-11	121	114	-7
Apr I	177	150	-27	188	185	-3
Apr II	182	153	-29	227	251	24
May	222	213	-9	356	361	5
Jun	162	183	21	264	314	50
Jul	106	136	30	111	131	20
Aug I	114	134	20	115	132	17
Aug II	118	135	17	124	134	10
Sep	151	142	-9	155	143	-12
Annual Average[2]	**171**	**179**	**8**	**150**	**160**	**10**

Source: HYDSIM modeling results

aMW = average megawatts

[1] HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

[2] The Annual Average is a weighted average to account for the different number of days in the 14 periods.

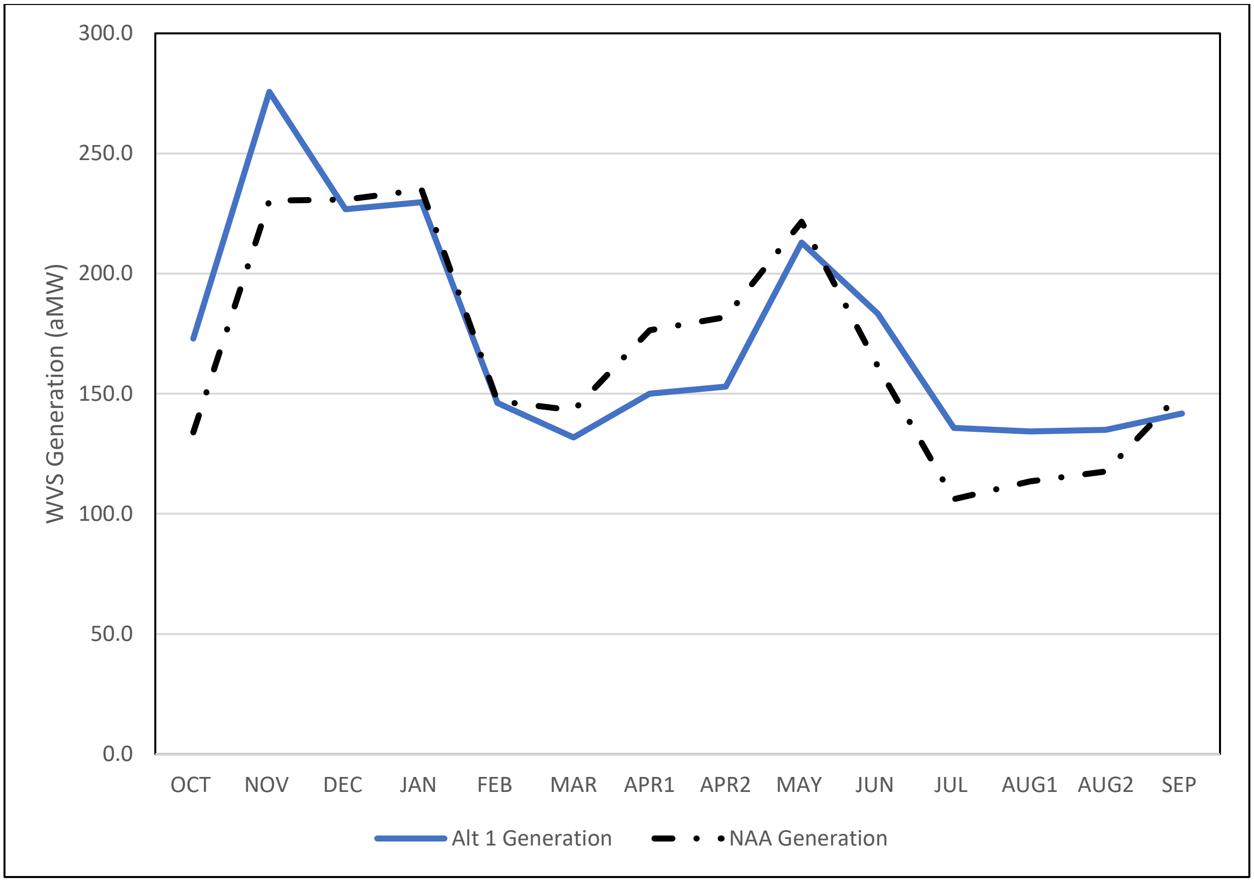

Figure 3.12-6. Monthly Average Generation (aMW) under Alternative 1 and the No-action Alternative.

Operations under Alternative 1 would result in a small increase in aMW generation when compared to the NAA, resulting in continuation of long-term, slight, beneficial effects to the regional power system. As under the NAA, contribution to the regional power system under Alternative 1 would be slight as a fraction of the total power generated in the system but would remain a beneficial contributor to power supply.

Also, as under the NAA, long-term, substantial, beneficial effects to WVS dam generation would continue to occur under Alternative 1 because operations would increase generation slightly over the 30-year implementation timeframe by an estimated 5 percent.

Alternative 1 would result in an LOLP of 6.4 percent. This represents 0.1 percentage points lower than the LOLP generated under the NAA due to the slight increase in total hydropower generation under Alternative 1. No newly constructed replacement resources would be needed to return the LOLP to the NAA level because this difference of 0.1 percent is within the +/-1 range of the accuracy of the model as well as an improvement to the current risk; LOLP is within the reasonable historical range of the Northwest Power and Conservation Council target.

A 6.4 percent LOLP under Alternative 1 is roughly equivalent to a 1-in-15-year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions) over the 30-year implementation timeframe, which is the same likelihood of an event(s) under NAA operations.

As under the NAA, there would be no acquisition of power from newly constructed replacement resources under Alternative 1.

Transmission

As under NAA operations, congested paths of Cross Cascades South and South of Allston would be congested with small (less than 10MW) increases to loading expected (Appendix G, Power and Transmission Analysis). Local impacts on the Willamette Valley transmission system under Alternative 1 would be the same as those described under the NAA.

Construction projects at Cougar Dam under Alternative 1 are not anticipated to impact local transmission services to Blue River, provided generation is not affected. Any effects on generation would be temporary and assessed prior to construction.

Impacts on power and transmission to Willamette Valley communities during severe weather- or wildfire-related events would be the same as described under the NAA operations.

Economic Viability of Power Generation

Unlike operations under the NAA, power generation from the combined WVS operations under Alternative 1 would not be economically viable (Appendix G, Power and Transmission Analysis). Over the 30-year implementation timeframe, power operations are estimated to have a median NPV of -$1.4 billion (Table 3.12-10). This would be a $1.76 billion, or 494 percent, reduction in NPV compared to the NAA median NPV. Across the 630630 analysis iterations that varied energy prices and water conditions, no iterations resulted in a positive NPV for the combined WVS operations under Alternative 1.

Table 3.12-10. Summary of Effects to Power and Transmission under Alternative 1[1].

Metrics	No-action Alternative	Alternative 1	Alternative 1 Compared to the No-action Alternative
WVS Operations 73-year Average Generation (aMW)	171	179	+8
WVS Operations Critical Water year (1937) Average Generation (aMW)	150	160	+10
Loss of Load Probability (LOLP)	6.5%	6.4%	-0.1
Transmission Flow Paths[2] Cross Cascades South	W 6475.5 SP 4100.5 SU 5862.9	W 6478.7 SP 4105.7 SU 5836.6	W +3.2 SP +5.2 SU -26.3

Metrics	No-action Alternative	Alternative 1	Alternative 1 Compared to the No-action Alternative
South of Allston	W 1183.0 SP 732.1 SU 2525.1	W 1184.2 SP 733.9 SU 2521.9	W +1.2 SP +1.8 SU -3.2
Transmission Reliability	Slightly Congested[4]	Same as NAA	Same as NAA
NPV (median)	$356 Million	-$1.4 billion	-$1.76 Billion
LCOG ($/MWh)	$30.03	$78.66	+$48.63

% = percent

aMW = average megawatts

Note: The estimated LOLP effect and resulting transmission and economic viability effects rely on the best available information regarding planned coal plant retirements as of 2017.

[1] The BPA share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the NPV would be incrementally lower, and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50 percent contingency. For other structural projects of similar size and complexity, the conceptual design cost estimates increased by 137 percent to 215 percent upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the NPV and increases in the levelized costs of generation. However, for calculations of the LCOG and NPV, a 30-year study period was used because this is the implementation timeframe for any alternative implementation. Typically, hydropower analyses consider a 50-year study period; however, this timeframe demonstrates more extreme outcomes under each alternative than would be the case in a 50-year analysis because costs occur up front and are not distributed across as many years for benefits purposes.

[2] The amount of loading (in MW) on the congested paths of Cross Cascades South and South of Allston are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

The median LCOG for the combined WVS operations is estimated to rise from $30.03/MWh under the NAA to $78.66/MWh under Alternative 1, which is a $48.63, or 162 percent, increase. This substantial increase would result in an LCOG higher than expected market prices.

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Power Generation

Power generation from operations under Alternative 2A would decrease from 171 aMW under NAA operations, on average over all water years, to 167 aMW under Alternative 2A during the 30-year implementation timeframe (Table 3.12-11). This represents a decrease of 4 aMW, which is a 2.3 percent decrease in annual average generation as compared to the NAA (Appendix G, Power and Transmission Analysis). This would power approximately 132,932 homes during the 30-year implementation timeframe, a decrease of 3,184 homes powered compared to NAA operations.

Table 3.12-11. Willamette Valley System 73-year Average Generation (aMW) (Water Years 1936 through 2008) and Critical Water Year (1937) under Alternative 2A.

Month[1]	No-action Alternative Average Generation	Alternative 2A Average Generation	Average Generation Difference	No-action Alternative Critical Water Year Generation	Alternative 2A Critical Water Year Generation	Critical Water Year Generation Difference
Oct	134	172	38	119	136	17
Nov	230	217	-13	156	163	7
Dec	231	178	-53	80	64	-16
Jan	235	205	-30	47	39	-8
Feb	147	140	-7	67	57	-10
Mar	143	131	-12	121	78	-43
Apr I	177	151	-26	188	182	-6
Apr II	182	146	-36	227	227	0
May	222	201	-21	356	330	-26
Jun	162	189	27	264	291	27
Jul	106	126	20	111	136	25
Aug I	114	128	14	115	122	7
Aug II	118	130	12	124	129	5
Sep	151	166	15	155	177	22
Annual Average[2]	**171**	**167**	**-4**	**150**	**150**	**0**

Source: HYDSIM modeling results

[1] HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

[2] The Annual Average is a weighted average to account for the different number of days in the 14 periods.

There would be no difference in average annual generation between operations under the NAA and Alternative 2A during a critical water year.

Interim Operations would be implemented until construction of various action alternative measures are complete. Interim operations could occur for a long term while the alternative is being implemented. During the Interim Operations, generation would be reduced when compared to generation under the NAA or generation under Alternative 2A (Figure 3.12-7). Power generation would continue to be reduced until structural measures proposed are fully implemented to 120 aMW, a decrease of 30 percent.

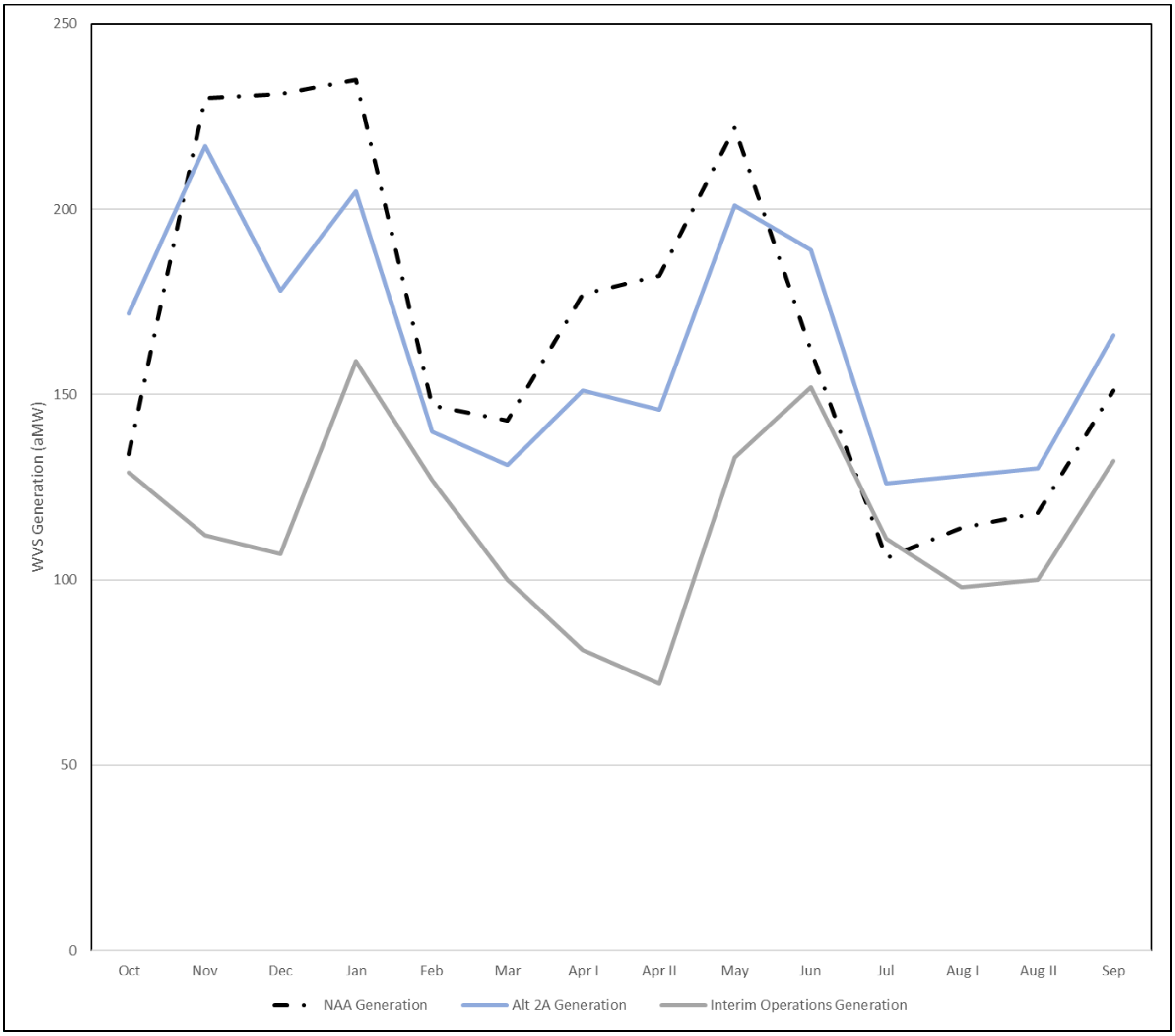

Figure 3.12-7. Monthly Average Generation (aMW) under the No-action Alternative, Alternative 2A, and Interim Operations.

Note: Depicts generation under both Interim Operations and Alternative 2A as compared to the NAA because actual generation during the 30-year implementation timeframe is likely to vary between those two points.

Operations under Alternative 2A would result in a slight decrease in aMW generation when compared to the beneficial NAA operations. As under the NAA, Alternative 2A operations would result in long-term, slight, beneficial effects to the regional power system because operations would contribute to the overall generation capacity over the 30-year implementation timeframe. However, Alternative 2A benefits would be slightly smaller than those under the NAA.

As compared to the NAA, Alternative 2A would continue to provide long-term, substantial, beneficial effects specifically to WVS dam generation as power would continue to be generated under this alternative over the 30-year implementation timeframe. However, there would be a slight decrease in generation relative to the NAA of 2 percent. Additionally, under Alternative 2A, there would be some period of Interim Operations that would further decrease average annual generation moderately by 30 percent.

Due to the minimal decrease in total hydropower generation under Alternative 2A, the LOLP would be 6.5 percent, which is the same as the NAA LOLP. As under the NAA, no newly constructed replacement resources would be necessary under Alternative 2A.

A 6.5 percent LOLP under Alternative 2A is roughly equivalent to a 1-in-15-year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions) over the 30-year implementation timeframe, which is the same likelihood of an event(s) under NAA operations. No replacement resources would be needed to return the LOLP to the NAA level because this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the Northwest Power and Conservation Council target.

Transmission

Power generation under Alternative 2A would result in moderate adverse effects to the Willamette Valley transmission system compared to the NAA because generation would need to be replaced from more distant sources over the 30-year timeframe. The congested path of Cross Cascades South would increase by 18.4MW in the Winter Peak case (Appendix G, Power and Transmission Analysis). Additionally, the congested paths of Cross Cascades South and South of Allston would increase by 61.3MW and 11.8MW in the Spring Off-peak case, respectively.

Local impacts on Willamette Valley communities under Alternative 2A would be the same as described under the NAA. Impacts related to islanding at Hills Creek and Cougar Dams due to severe weather- and wildfire-related events would be the same as described under the NAA.

Economic Viability of Power Generation

Unlike power generation under the NAA, generation from the combined WVS operations under Alternative 2A would not be economically viable (Appendix G, Power and Transmission Analysis). Over the 30-year implementation timeframe, power operations are estimated to have a median NPV of -$891 million under Alternative 2A (Table 3.12-12). This would be a $1.25 billion, or 350 percent, reduction in NPV compared to the NAA NPV. Across the 630 analysis iterations that varied energy prices and water conditions, no iterations resulted in a positive NPV.

Table 3.12-12. Summary of Effects to Power and Transmission under Alternative 2A.

Metrics	No-action Alternative	Alternative 2A	Alternative 2A Compared to the No-action Alternative
WVS Operations 73-year Average Generation (aMW)	171	120 - 167	-51 to -4
WVS Operations Critical Water year (1937) Average Generation (aMW)	150	108 - 150	-42 to 0
Loss of Load Probability (LOLP)	6.5%	6.5%	0
Transmission Flow Paths[1] Cross Cascades South	W 6475.5 SP 4100.5 SU 5862.9	W 6493.9 SP 4161.8 SU 5853.5	W +18.4 SP +61.3 SU -9.4
South of Allston	W 1183.0 SP 732.1 SU 2525.1	W 1189.9 SP 743.9 SU 2521.9	W +6.9 SP +11.8 SU -9.0
Transmission Reliability	Slightly Congested	Same as NAA	Same as NAA
NPV (median)	$356Million	-$891 million	-$1.25 billion
LCOG ($/MWh)	$30.03	$65.74	+$35.71

% = percent

aMW = average megawatts

Note: The estimated LOLP effect and resulting transmission and economic viability effects rely on the best available information regarding planned coal plant retirements as of 2017.

[1] The amount of loading (in MW) on the congested paths of Cross Cascades South and South of Allston are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

The median LCOG for the combined WVS operations is estimated to rise from $30.03/MWh under the NAA to $65.74/MWh under Alternative 2A, which is a $35.71, or 119 percent, increase as compared to the NAA. This substantial increase would result in an LCOG higher than expected market prices. These impacts are primarily due to the cost of alternative implementation rather than a change in generation.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Power Generation

Power generation from the WVS operations would decrease from 171 aMW under the NAA, on average over all water years, to 153 aMW under Alternative 2B (Table 3.12-13). This represents a decrease of 18 aMW, which would be a 10.5 percent decrease in annual average generation over the 30-year implementation timeframe (Appendix G, Power and Transmission Analysis).

This would power approximately 121,788 homes during the 30-year implementation timeframe, a decrease of 14,328 homes powered as compared to NAA operations.

Table 3.12-13. Willamette Valley System 73-year Average Generation (aMW) (Water Years 1936 through 2008) and Critical Water Year (1937) under Alternative 2B.

Month[1]	No-action Alternative Average Generation	Alternative 2B Average Generation	Average Generation Difference	No-action Alternative Critical Water Year Generation	Alternative 2B Critical Water Year Generation	Critical Water Year Generation Difference
Oct	134	147	13	119	113	17
Nov	230	189	-41	156	126	7
Dec	231	164	-67	80	66	-16
Jan	235	199	-36	47	33	-8
Feb	147	141	-6	67	50	-10
Mar	143	121	-22	121	67	-43
Apr I	177	138	-39	188	163	-6
Apr II	182	132	-50	227	184	0
May	222	183	-39	356	306	-26
Jun	162	169	7	264	272	27
Jul	106	115	9	111	123	25
Aug I	114	119	5	115	123	7
Aug II	118	121	3	124	127	5
Sep	151	157	6	155	179	22
Annual Average[2]	**171**	**153**	**-18**	**150**	**136**	**-14**

Source: HYDSIM modeling results

[1] HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

[2] The Annual Average is a weighted average to account for the different number of days in the 14 periods.

The difference in critical water year generation from 150 aMW under the NAA to 136 aMW under Alternative 2B represents a 14 aMW (or 9.3 percent) decrease.

Interim Operations would be implemented until construction of various action alternative measures are complete. Interim operations could occur for a long term while the alternative is being implemented. During the Interim Operations, generation would be reduced when compared to generation under the NAA or generation under Alternative 2B (Figure 3.12-8). Power generation would continue to be reduced until structural measures proposed are fully implemented to an annual average of 120 aMW, a decrease of 30 percent.

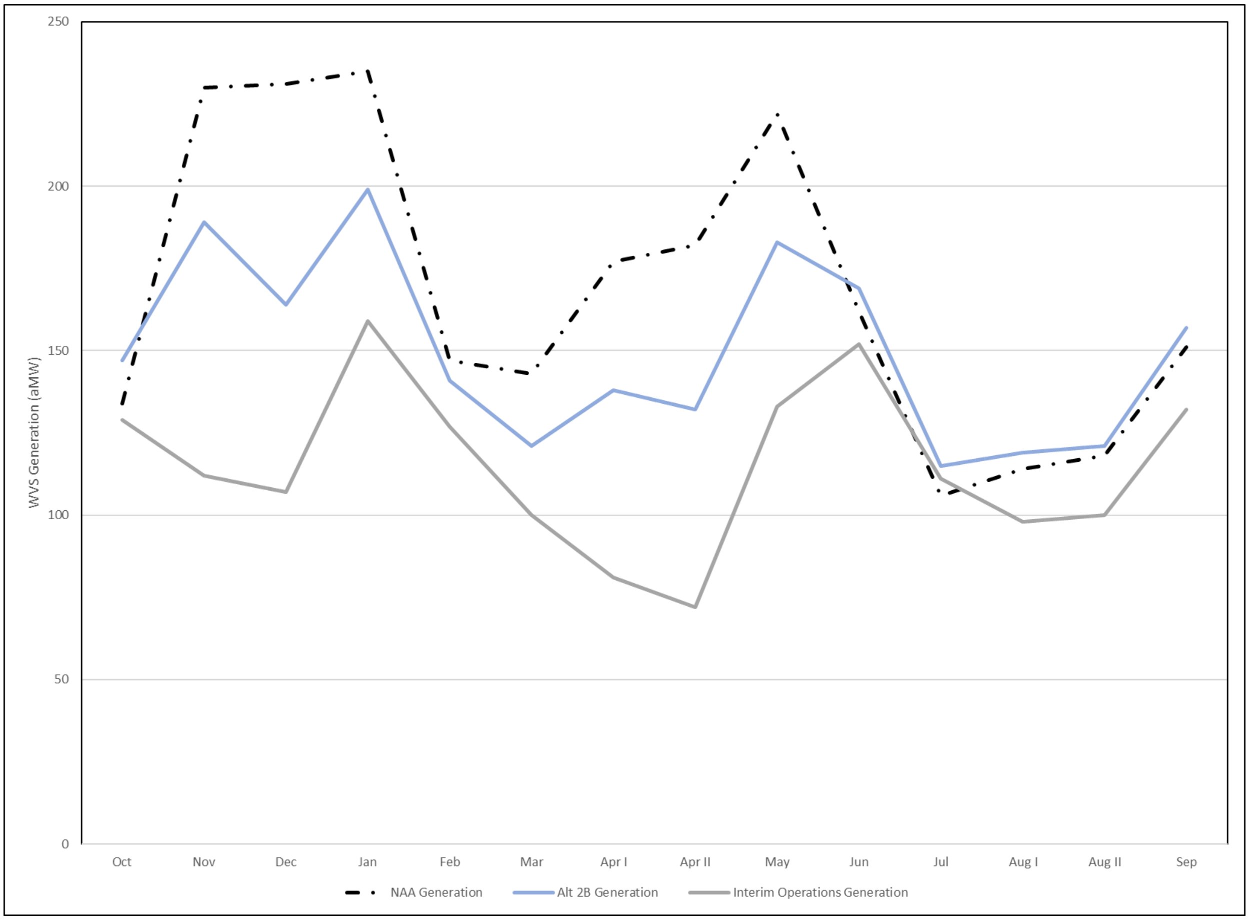

Figure 3.12-8. Monthly Average Generation (aMW) under the No-action Alternative, Alternative 2B, and Interim Operations.

Note: Depicts generation under both Interim Operations and Alternative 2B as compared to the NAA because actual generation during the 30-year implementation timeframe is likely to vary between those two points.

Operations under Alternative 2B would result in a slight decrease in aMW generation when compared to the NAA operations. This would result in negligible effects to the regional power system over the 30-year implementation timeframe and would continue to provide long-term, slight, beneficial effects as under the NAA.

As compared to the NAA, Alternative 2B would continue to provide long-term, substantial, beneficial effects specifically to WVS dam generation as power would continue to be generated under this alternative over the 30-year implementation timeframe. However, there would be a slight decrease in generation relative to the NAA of 10.5 percent. Additionally, under Alternative 2B, there would be some period of Interim Operations that would further decrease average annual generation moderately by 30 percent.

Due to the slight decrease in total hydropower generation under Alternative 2B, the LOLP would be 6.6 percent, or 0.1 percentage points, greater than the LOLP under NAA operations. No newly constructed replacement resources would be needed to return the LOLP to the NAA level because this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the Northwest Power and Conservation Council target.

A 6.6 percent LOLP under Alternative 2B is roughly equivalent to a 1-in-15-year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions) over the 30-year implementation timeframe, which is the same likelihood of an event(s) under NAA operations.

Transmission

Power generation under Alternative 2B would result in moderate adverse effects to the Willamette Valley transmission system compared to the NAA because generation would need to be replaced from more distant sources. The congested path of Cross Cascades South and South of Allston would increase by 21.9MW and 8.3MW in the Winter Peak case, respectively, and by 25.1MW and 5.1MW in the Spring Off-peak case, respectively (Appendix G, Power and Transmission Analysis).

Local impacts on Willamette Valley communities under Alternative 2B would be the same as under the NAA regarding power generation at Hills Creek Dam. Hills Creek Dam operations would continue to be able to operate islanded (isolated) from the rest of the power system. As under the NAA, this would provide power to the community of Oakridge during temporary power system outages primarily due to severe weather- or wildfire-related events.

However, deep fall and spring drawdowns at Cougar Reservoir under Alternative 2B would likely compromise the ability to provide power to the community of Blue River in the event of a wildfire or severe weather event causing a temporary transmission outage between Blue River and Thurston substations. This would be a substantial, adverse effect to the community of Blue River.

Economic Viability of Power Generation

Unlike power generation under the NAA, generation from the combined WVS operations under Alternative 2B would not be economically viable (Appendix G, Power and Transmission Analysis). Over the 30-year implementation timeframe, power operations are estimated to have a median NPV of -$970 million under Alternative 2B (Table 3.12-14). This is a -$91.33 billion, or 373 percent, reduction in NPV compared to the NAA. Across the 630 analysis iterations that varied energy prices and water conditions, no iterations resulted in a positive NPV.

Table 3.12-14. Summary of Effects to Power and Transmission under Alternative 2B.

Metrics	No-action Alternative	Alternative 2B	Alternative 2B Compared to the No-action Alternative
WVS Operations 73-year Average Generation (aMW)	171	120 - 153	-51 to -18
WVS Operations Critical Water year (1937) Average Generation (aMW)	150	108 - 136	-42 to -12
Loss of Load Probability (LOLP)	6.5%	6.6%	+0.1
Transmission Flow Paths[1] Cross Cascades South	W 6475.5 SP 4100.5 SU 5862.9	W 6497.4 SP 4125.6 SU 5858.6	W +21.9 SP +25.1 SU -4.3
South of Allston	W 1183.0 SP 732.1 SU 2525.1	W 1191.3 SP 737.2 SU 2523.8	W +8.3 SP +5.1 SU -1.3
Transmission Reliability	Slightly Congested	Regionally: Same/similar to NAA Locally: unable to operate islanded at Cougar Dam during deep fall and spring drawdowns under certain conditions	Same as the NAA regionally; compromised ability to meet local transmission services for the Blue River community during weather- or wildfire-related temporary outages
NPV (median)	$356 Million	-$970 million	-$1.33 billion
LCOG ($/MWh)	$30.03	$70.70	+$40.67

% = percent

aMW = average megawatts

MWh = megawatt hour

Note: The estimated LOLP effect and resulting transmission and economic viability effects rely on the best available information regarding planned coal plant retirements as of 2017.

[1] The amount of loading (in MW) on the congested paths of Cross Cascades South and South of Allston are depicted during three seasonal cases (W = Winter Peak; SP = Spring Off-peak; SU = Summer Peak).

The median LCOG for the combined WVS operations is estimated to rise from $30.03/MWh under the NAA to $70.70/MWh under Alternative 2B, which is a $40.67, or 135 percent, increase. This substantial increase would result in an LCOG higher than expected market prices.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

Power Generation

Power generation from WVS operations would decrease from 171 aMW under the NAA, on average over all water years, to 84 aMW under Alternative 3A over the 30-year implementation timeframe (Table 3.12-15). This represents a decrease of 87 aMW, which is a 50.9 percent decrease in average annual generation. This would power approximately 66,864 homes during the 30-year implementation timeframe, a decrease of 69,252 homes powered as compared to NAA operations.

Table 3.12-15. Willamette Valley System 73-year Average Generation (aMW) (Water Years 1936 through 2008) and Critical Water Year (1937) under Alternative 3A.

Month[1]	No-action Alternative Average Generation	Alternative 3A Average Generation	Average Generation Difference	No-action Alternative Critical Water Year Generation	Alternative 3A Critical Water Year Generation	Critical Water Year Generation Difference
Oct	134	51	-83	119	36	-83
Nov	230	48	-182	156	12	-144
Dec	231	83	-148	80	22	-58
Jan	235	175	-60	47	21	-26
Feb	147	164	17	67	38	-29
Mar	143	115	-28	121	56	-65
Apr I	177	96	-81	188	125	-63
Apr II	182	71	-111	227	138	-89
May	222	45	-177	356	67	-289
Jun	162	43	-119	264	67	-197
Jul	106	53	-53	111	80	-31
Aug I	114	58	-56	115	69	-46
Aug II	118	66	-52	124	66	-58
Sep	151	92	-59	155	125	-30
Annual Average[2]	**171**	**84**	**-87**	**150**	**60**	**-90**

Source: HYDSIM modeling results

aMW = average megawatts

[1] HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

[2] The Annual Average is a weighted average to account for the different number of days in the 14 periods.

The change in critical water year generation from 150 aMW under the NAA to 60 aMW under Alternative 3A represents a 90 aMW (or 60 percent) decrease (Appendix G, Power and Transmission Analysis).

Interim Operations would be implemented at some dams until structural modifications to fully implement an operational measure are complete. Interim operations could occur for a long term while the alternative is being implemented. During the Interim Operations, generation would be reduced when compared to generation under the NAA to an annual average of 120 aMW. However, generation under fully implemented Alternative 3A (Figure 3.12-9) would be lower than under Interim Operations, a decrease of 30 percent.

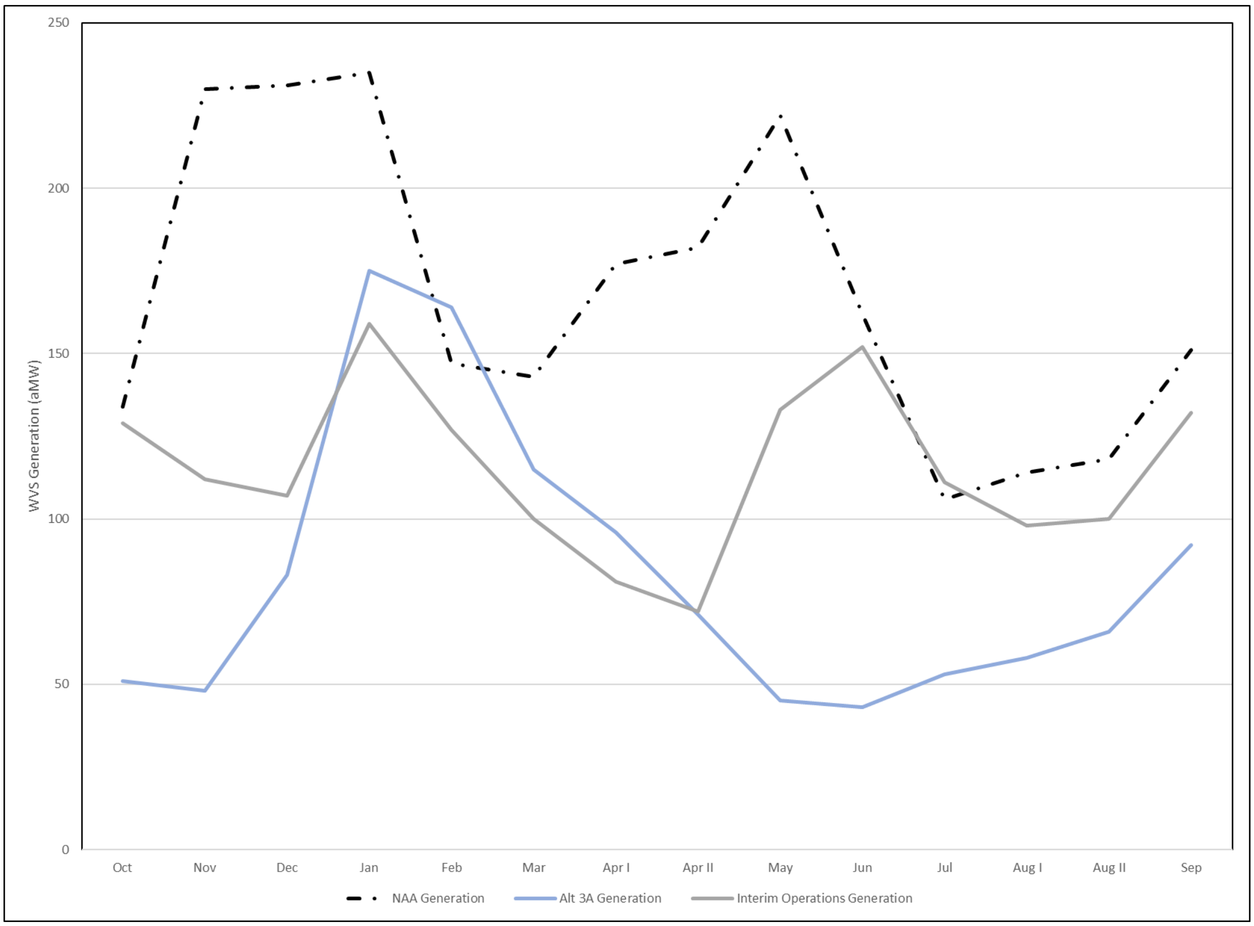

Figure 3.12-9. Monthly Average Generation (average megawatt) under the No-action Alternative, Alternative 3A, and Interim Operations.

Note: Depicts generation under both Interim Operations and Alternative 3A as compared to the NAA because actual generation during the 30-year implementation timeframe is likely to vary between those two points.

Alternative 3A operations would result in a decrease in aMW generation when compared to NAA operations; however, this would result in negligible impacts to the regional power system because of the minimal contribution from WVS dams to the regional power system. Regardless of the decrease in aMW generation, Alternative 3A operations would continue to result in long-term, slight, beneficial effects overall because of the minimal contribution combined with the ability to continue providing power over the 30-year implementation timeframe.

As compared to the NAA, Alternative 3A would continue to provide long-term, substantial, beneficial effects specifically to WVS dam generation as power would continue to be generated under this alternative over the 30-year implementation timeframe. There would be a decrease in generation relative to the NAA of 50 percent, but Alternative 3A operations would continue to provide a substantial benefit to WVS dam power generation. Additionally, under Alternative 3A, there would be some period of Interim Operations that would decrease average annual generation moderately by 30 percent relative to NAA.

Due to the decrease in total hydropower generation under Alternative 3A, the LOLP would be 7 percent, or 0.5 percentage points, greater than the LOLP under the NAA. No newly constructed replacement resources would be needed to return the LOLP to the NAA level because this difference of 0.5 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the Northwest Power and Conservation Council target.

A 7 percent LOLP under Alternative 3A is roughly equivalent to a 1-in-15-year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions) over the 30-year implementation timeframe, which is the same likelihood of an event(s) under NAA operations.

Transmission

Power generation under Alternative 3A would result in moderate adverse effects to the Willamette Valley transmission system because generation would need to be replaced from more distant sources over the 30-year implementation timeframe. The congested path of Cross Cascades South and South of Allston would increase by 37.2MW and 13.6MW in the Winter Peak case, respectively. Additionally, the congested paths of Cross Cascades South and South of Allston would increase by 113.7 MW and 22.3 MW in the Spring Off-peak case, respectively. The Cross Cascades South path would increase by 28.3 MW in the Summer Peak case under Alternative 3A (Appendix G, Power and Transmission Analysis).

Local impacts on the Willamette Valley communities under Alternative 3A would be substantially adverse as compared to the NAA operations because operations at Hills Creek and Cougar Dams would not be able to continue to operate islanded (isolated). Deep fall and spring drawdowns at Hills Creek Reservoir may compromise the ability to provide power to the Oakridge community during transmission system outages. There is little redundancy (additional transmission availability) for Oakridge, and the loss of the Hills Creek–Lookout Point 115kV transmission line would cause a loss of power to Oakridge if Hills Creek Dam generation is not available.

Unlike operations under the NAA, deep fall and spring drawdowns of the Cougar Reservoir would likely compromise the ability of Cougar Dam to provide power to the community of Blue River during severe weather- or wildfire-related events. These conditions would cause temporary transmission outages between Blue River and Thurston substations. This would be a substantial, adverse effect to the community of Blue River.

Economic Viability of Power Generation

Unlike power generation under the NAA, generation from the combined WVS operations under Alternative 3A would not be economically viable (Appendix G, Power and Transmission Analysis). Over the 30-year implementation timeframe, power operations are estimated to have a median NPV of -$789 million under Alternative 3A (Table 3.12-16). This would be an -$1.15 billion, or 322 percent, reduction in NPV compared to the NAA. Across the 630 analysis iterations that varied energy prices and water conditions, no iterations resulted in a positive NPV.

The median LCOG for the combined WVS operations is estimated to rise from $30.03/MWh under the NAA to $91.48/MWh under Alternative 3A, which would be a $61.45, or 205 percent, increase. This substantial increase would result in an LCOG higher than expected market prices.

Table 3.12-16. Summary of Effects to Power and Transmission under Alternative 3A.

Metrics	No-action Alternative	Alternative 3A	Alternative 3A Compared to the No-action Alternative
WVS Operations 73-year Average Generation (aMW)	171	84 – 120	-87 to -51
WVS Operations Critical Water year (1937) Average Generation (aMW)	150	60 – 108	-90 to -42
Loss of Load Probability (LOLP)	6.5%	7.0%	0.5[1]
Transmission Flow Paths[1] Cross Cascades South	W 6475.5 SP 4100.5 SU 5862.9	W 6512.7 SP 4214.2 SU 5891.2	W +37.2 SP +113.7 SU +28.3
South of Allston	W 1183.0 SP 732.1 SU 2525.1	W 1196.6 SP 754.4 SU 2535.4	W +13.6 SP +22.3 SU +10.3
Transmission Reliability	Slightly Congested	Regionally: Same/similar to NAA Locally: unable to operate islanded at Hills Creek and Cougar Dams during deep fall and spring drawdowns under certain conditions	Same as the NAA regionally; compromised ability to meet local transmission services to the Oakridge and Blue River communities during weather- or wildfire-related temporary outages

Metrics	No-action Alternative	Alternative 3A	Alternative 3A Compared to the No-action Alternative
NPV (median)	$356 Million	-$789 million	-$1.15 billion
LCOG ($/MWh)	$30.03	$9148	+$61.45

% = percent

aMW = average megawatts

Note: The estimated LOLP effect and resulting transmission and economic viability effects rely on the best available information regarding planned coal plant retirements as of 2017.

[1] The amount of loading (in MW) on the congested paths of Cross Cascades South and South of Allston are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

Alternative 3B—Improve Fish Passage through Operations-focused Measures

Power Generation

Power generation from the WVS operations would decrease from 171 aMW under the NAA, on average over all water years, to 93 aMW under Alternative 3B (Table 3.12-17). This represents a decrease of 79 aMW, which would be a 45.6 percent decrease in average annual generation over the 30-year implementation timeframe (Appendix G, Power and Transmission Analysis). This would power approximately 74,028 homes during the 30-year implementation timeframe, a decrease of 62,088 homes powered as compared to the NAA.

Table 3.12-17. Willamette Valley System 73-year Average Generation (aMW) (Water Years 1936 through 2008) and Critical Water Year (1937) under Alternative 3B.

Month[1]	No-action Alternative Average Generation	Alternative 3B Average Generation	Average Generation Difference	No-action Alternative Critical Water Year Generation	Alternative 3B Critical Water Year Generation	No-action Alternative Average Generation Difference
Oct	134	57	-77	119	45	-74
Nov	230	43	-187	156	14	-142
Dec	231	72	-159	80	17	-63
Jan	235	167	-68	47	15	-32
Feb	147	185	38	67	30	-37
Mar	143	132	-11	121	69	-52
Apr I	177	118	-59	188	106	-82
Apr II	182	82	-100	227	103	-124
May	222	68	-154	356	105	-251
Jun	162	55	-106	264	84	-180
Jul	106	62	-44	111	88	-23

Month[1]	No-action Alternative Average Generation	Alternative 3B Average Generation	Average Generation Difference	No-action Alternative Critical Water Year Generation	Alternative 3B Critical Water Year Generation	No-action Alternative Average Generation Difference
Aug I	114	60	-54	115	76	-39
Aug II	118	75	-43	124	91	-33
Sep	151	112	-39	155	152	-3
Annual Average[2]	**171**	**93**	**-79**	**150**	**67**	**-83**

Source: HYDSIM modeling results

aMW = average megawatts

[1] HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

[2] The Annual Average is a weighted average to account for the different number of days in the 14 periods.

The change in critical water year generation from 150 aMW under the NAA to 67 aMW under Alternative 3B represents an 83 aMW (or 55.3 percent) decrease.

Interim Operations would be implemented at some dams until structural modifications to fully implement an operational measure are complete. Interim operations could occur for a long term while the alternative is being implemented. During the Interim Operations, generation would be decreased when compared to generation under the NAA and an estimated annual average of 120 aMW. However, generation under fully implemented Alternative 3B would be lower than under Interim Operations (Figure 3.12-10).

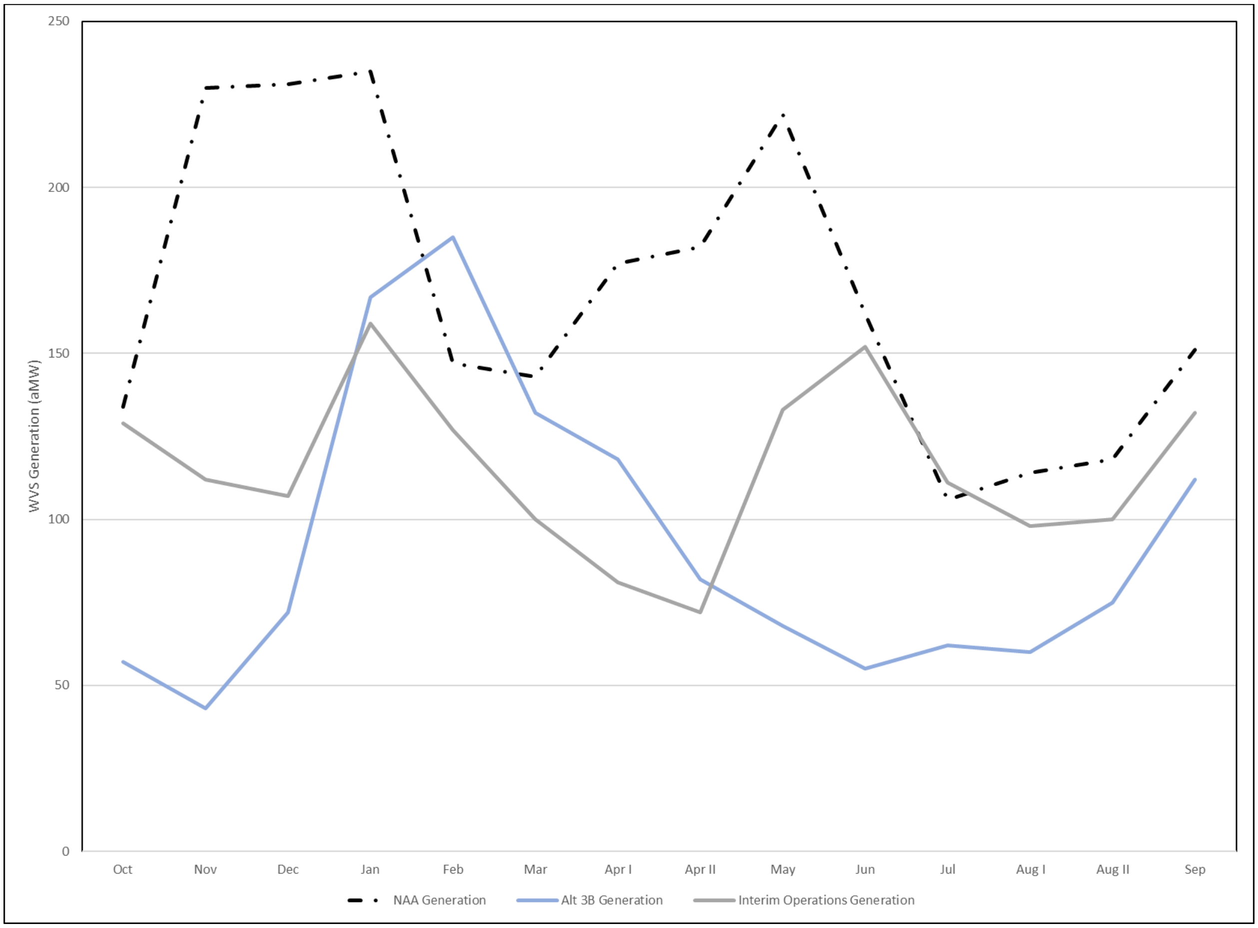

Figure 3.12-10. Monthly Average Generation (aMW) under the No-action Alternative, Alternative 3B, and Interim Operations.

Note: Depicts generation under both Interim Operations and Alternative 3B as compared to the NAA because actual generation during the 30-year implementation timeframe is likely to vary between those two points.

Alternative 3B operations would result in a decrease in aMW generation when compared to NAA operations; however, this would result in negligible impacts to the regional power system because of the minimal contribution from WVS dams to the regional power system. Regardless of the decrease in aMW generation, Alternative 3B operations would continue to result in long-term, slight, beneficial effects overall because of the minimal contribution combined with the ability to continue providing power over the 30-year implementation timeframe.

Although there would be a decrease in generation of 45.6 percent relative to NAA operations, Alternative 3A would continue to provide long-term, substantial, beneficial effects specific to WVS dam power generation. Additionally, under Alternative 3B, there would be some period of Interim Operations that would decrease average annual generation moderately by 30 percent relative to NAA.

Due to the decrease in total hydropower generation under Alternative 3B over the 30-year implementation timeframe, the LOLP would be 7 percent, or 0.5 percentage points, greater than the LOLP under the NAA operations. No newly constructed replacement resources would be needed to return the LOLP to the NAA level because this difference of 0.5 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the Northwest Power and Conservation Council target.

A 7 percent LOLP under Alternative 3B is roughly equivalent to a 1-in-15-year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions) over the 30-year implementation timeframe, which is the same likelihood of an event(s) under NAA operations.

Transmission

Power generation under Alternative 3B would result in moderate adverse effects to the Willamette Valley transmission system compared to the NAA because generation would need to be replaced from more distant sources over the 30-year implementation timeframe. The congested path of Cross Cascades South and South of Allston would increase by 41.4MW and 15.2MW in the Winter Peak case, respectively. Additionally, the congested paths of Cross Cascades South and South of Allston would increase by 94.8MW and 18.7MW in the Spring Off-peak case, respectively. The Cross Cascades South path would increase by 25.6MW in the Summer Peak case under Alternative 3B.

Unlike operations under the NAA, deep fall and spring drawdowns of Cougar Reservoir would likely compromise the ability of Cougar Dam and Hills Creek to provide power to the communities of Blue River and Oakridge, respectively, during severe weather- or wildfire-related events. This would be a substantial adverse effect to these communities.

Economic Viability of Power Generation

Unlike operations under the NAA, power generation from the combined WVS operations under Alternative 3B would not be economically viable. Over the 30-year implementation timeframe, power operations are estimated to have a median NPV of -$771 million under Alternative 3B (Table 3.12-18) (Appendix G, Power and Transmission Analysis). This would be an -$1.13 billion or 317 percent, reduction in NPV compared to the NAA. Across the 630 analysis iterations that varied energy prices and water conditions, no iterations resulted in a positive NPV.

Table 3.12-18. Summary of Effects to Power and Transmission under Alternative 3B.

Metrics	No-action Alternative	Alternative 3B	Alternative 3B Compared to the No-action Alternative
WVS Operations 73-year Average Generation (aMW)	171	93 – 120	-79 to -51
WVS Operations Critical Water year (1937) Average Generation (aMW)	150	67 – 108	-83 to -42

Metrics	No-action Alternative	Alternative 3B	Alternative 3B Compared to the No-action Alternative
Loss of Load Probability (LOLP)	6.5%	7.0%	+0.5
Transmission Flow Paths[1] Cross Cascades South	W 6475.5 SP 4100.5 SU 5862.9	W 6516.9 SP 4195.3 SU 5888.5	W +41.4 SP +94.8 SU +25.6
South of Allston	W 1183.0 SP 732.1 SU 2525.1	W 1198.2 SP 750.8 SU 2534	W +15.2 SP +18.7 SU +8.9
Transmission Reliability	Slightly Congested[4]	Regionally: Same/similar to NAA Locally: unable to operate islanded at Hills Creek and Cougar Dams during deep fall and spring drawdowns under certain conditions	Same as the NAA regionally; compromised ability to meet local transmission services to the Oakridge and Blue River communities during weather- or wildfire-related temporary outages
NPV (median)	$356 Million	-$771 million	-$1.13 billion
LCOG ($/MWh)	$30.03	$83.84	+$53.81

% = percent

aMW = average megawatts

Note: The estimated LOLP effect and resulting transmission and economic viability effects rely on the best available information regarding planned coal plant retirements as of 2017.

[1] The amount of loading (in MW) on the congested paths of Cross Cascades South and South of Allston are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

The median LCOG for the combined WVS operations is estimated to rise from $30.03/MWh under the NAA to $83.84/MWh under Alternative 3B, which would be a $53.81, or 179 percent, increase. This substantial increase would result in an LCOG higher than expected market prices.

<u>Alternative 4—Improve Fish Passage with Structures-based Approach</u>

Power Generation

Power generation from the WVS operations would increase from 171 aMW under the NAA, on average over all water years, to 172 aMW under Alternative 4 over the 30-year implementation timeframe (Table 3.12-19). This represents an increase of 1 aMW, which would be a 0.6 percent increase in average annual generation (Appendix G, Power and Transmission Analysis). This would power approximately 136,912 homes during the 30-year implementation timeframe, an increase of 796 homes powered as compared to NAA operations.

Table 3.12-19. Willamette Valley System 73-year Average Generation (aMW) (Water Years 1936 through 2008) and Critical Water Year (1937) under Alternative 4.

Month[1]	No-action Alternative Average Generation	Alternative 4 Average Generation	Average Generation Difference	No-action Alternative Critical Water Year Generation	Alternative 4 Critical Water Year Generation	Critical Water Year Generation Difference
Oct	134	160	26	119	129	10
Nov	230	250	20	156	174	18
Dec	231	223	-8	80	59	-21
Jan	235	228	-7	47	36	-11
Feb	147	147	0	67	59	-8
Mar	143	132	-11	121	115	-6
Apr I	177	151	-26	188	176	-12
Apr II	182	145	-37	227	227	0
May	222	199	-22	356	325	-31
Jun	162	189	27	264	285	21
Jul	106	126	19	111	134	23
Aug I	114	128	15	115	123	8
Aug II	118	130	13	124	126	2
Sep	151	137	-14	155	137	-18
Annual Average[2]	**171**	**172**	**1**	**150**	**148**	**-2**

Source: HYDSIM modeling results

aMW = average megawatts

[1] HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

[2] The Annual Average is a weighted average to account for the different number of days in the 14 periods.

The change in critical water year generation from 150 aMW under the NAA to 148 aMW under Alternative 4 represents a 2 aMW (or 1.3 percent) decrease. As under the NAA operations, these values represent a slight contribution to the regional power system and minimal difference in the substantial contribution to power generated by the WVS dams.

Interim Operations would be implemented until construction of various action alternative measures are complete. Interim operations could occur for a long term while the alternative is being implemented. During the Interim Operations, generation would be reduced when compared to generation under the NAA or generation under Alternative 4 (Figure 3.12-11). Power generation would continue to be reduced until structural measures proposed are fully implemented to an estimated annual average of 120 aMW, a decrease of 30 percent.

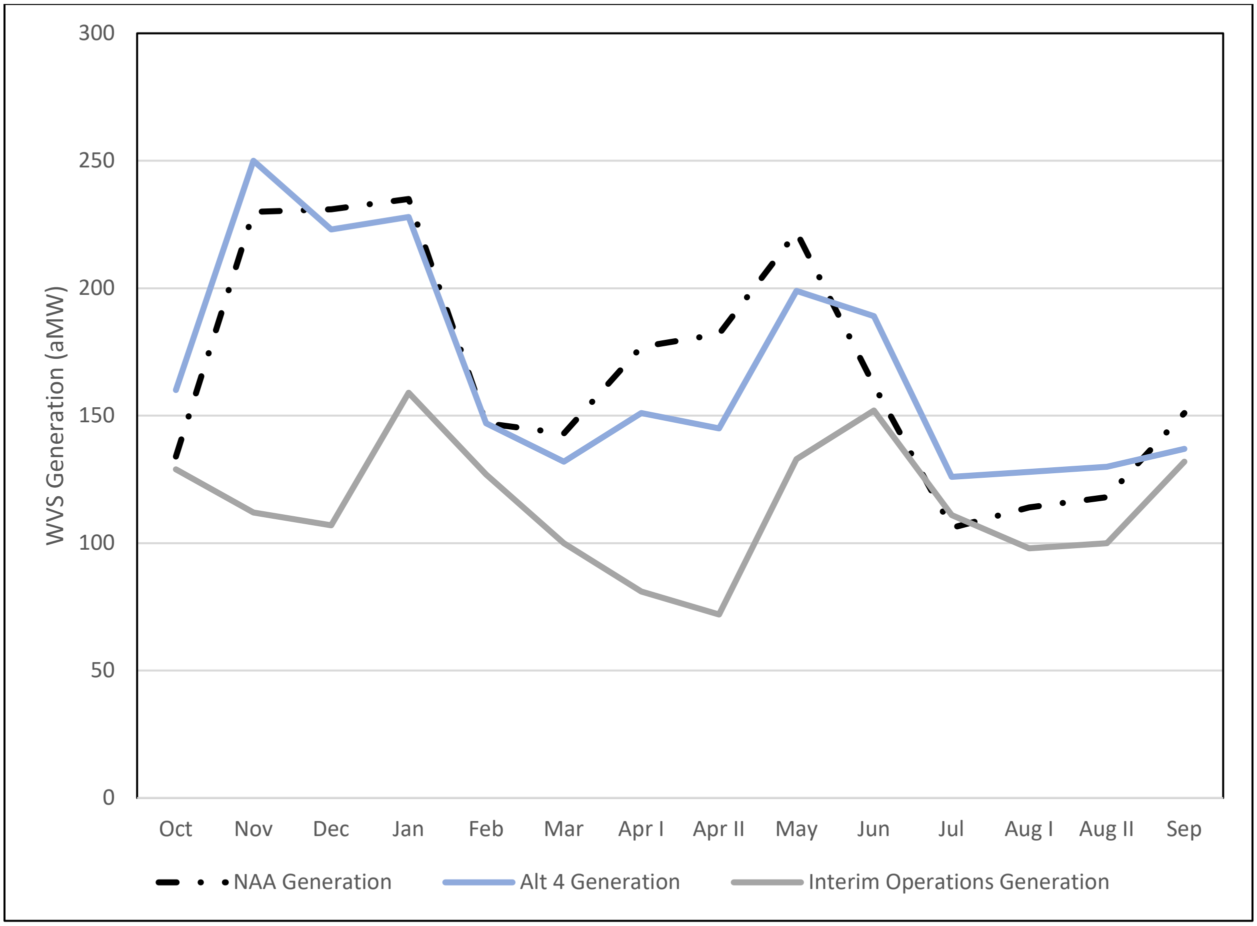

Figure 3.12-11. Monthly Average Generation (aMW) under the No-action Alternative, Alternative 4, and Interim Operations.

Note: Depicts generation under both Interim Operations and Alternative 4 as compared to the NAA because actual generation during the 30-year implementation timeframe is likely to vary between those two points.

Operations under Alternative 4 would result in a small increase in aMW generation when compared to the NAA, resulting in the same long-term, slight, beneficial effects to the regional power system. As under the NAA, contribution to the regional power system under Alternative 4 would be slight as a fraction of the total power generated in the system but would remain a beneficial contributor to power supply.

As under the NAA operations, long-term, substantial, beneficial effects to WVS dam generation would continue to occur under Alternative 4 because operations would increase generation slightly over the 30-year implementation timeframe by an estimated 0.6 percent.

Due to the minimal decrease in total hydropower generation under Alternative 4, the LOLP would be 6.5 percent, which is the same as the LOLP under the NAA. No newly constructed replacement resources would be needed to return the LOLP to the NAA level because there would be no difference in LOLP.

A 6.5 percent LOLP under Alternative 4 is roughly equivalent to a 1-in-15-year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions) over the 30-year implementation timeframe, which is the same likelihood of an event(s) under NAA operations.

Transmission

As under the NAA, the paths of Cross Cascades South and South of Allston would be congested with small (less than 10MW) increases to loading expected (with the exception of a slightly greater increase of 15MW on the Cross Cascades South path in the Spring Off-peak case) (Appendix G, Power and Transmission Analysis). This would be a long-term, slight, adverse effect on the Willamette Valley transmission system under Alternative 4.

Local impacts related to severe weather- or wildfire-related events would be the same as described under the NAA.

Economic Viability of Power Generation

Unlike operations under the NAA, power generation from the combined WVS operations under Alternative 4 would not be economically viable. Over the 30-year implementation period, power operations are estimated to have a median NPV of -$1.26 billion under Alternative 4 (Table 3.12-20) (Appendix G, Power and Transmission Analysis). This would be a $1.61 billion, or 453 percent, reduction in NPV compared to the NAA. Across the 630 analysis iterations that varied energy prices and water conditions, no iterations resulted in a positive NPV.

Table 3.12-20. Summary of Effects to Power and Transmission under Alternative 4.

Metrics	No-action Alternative	Alternative 4	Alternative 4 Compared to the No-action Alternative
WVS Operations 73-year Average Generation (aMW)	171	120 – 172	-51 to +1
WVS Operations Critical Water year (1937) Average Generation (aMW)	150	108 – 148	-42 to -2
Loss of Load Probability (LOLP)	6.5%	6.5%	0
Transmission Flow Paths[1] Cross Cascades South	W 6475.5 SP 4100.5 SU 5862.9	W 6479.7 SP 4115.5 SU 5853.5	W +4.2 SP +15 SU -9.4
South of Allston	W 1183.0 SP 732.1 SU 2525.1	W 1184.5 SP 735.3 SU 2522.4	W +1.5 SP +3.2 SU -2.7
Transmission Reliability	Slightly Congested	Same as NAA	Same as NAA

Metrics	No-action Alternative	Alternative 4	Alternative 4 Compared to the No-action Alternative
NPV (median)	$356 Million	-$1.26 Billion	-$1.61 Billion
LCOG ($/MWh)	$30.03	$76.34	+$46.31

% = percent

aMW = average megawatts

$/MWh = megawatt hour

Note: The estimated LOLP effect and resulting transmission and economic viability effects rely on the best available information regarding planned coal plant retirements as of 2017.

[1] The amount of loading (in MW) on the congested paths of Cross Cascades South and South of Allston are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak). The congested paths of Cross Cascades South and South of Allston remain congested. Generation at Hills Creek and Cougar Dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River during power system outages due to, especially, weather events or wildfires.

The median LCOG for the combined WVS operations is estimated to rise from $30.03/MWh under the NAA to $76.34/MWh under Alternative 4, which would be a $46.31, or 154 percent, increase. This substantial increase would result in an LCOG higher than expected market prices.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Operations under Alternative 5 would not differ substantially from operations under Alternative 2B. The following effects can be distinguished from Alternative 2B in comparison to the NAA.

Power Generation

Power generation from the WVS operations would decrease from 171 aMW under the NAA, on average over all water years, to 152.4 aMW under Alternative 5 (Table 3.12-21). This represents a decrease of 18.6 aMW, which would be a 10.8 percent decrease in annual average generation over the 30-year implementation timeframe. This would power approximately 121,788 homes during the 30-year implementation timeframe, a decrease of 14,328 homes powered as compared to NAA operations.

Table 3.12-21. Willamette Valley System 73-year Average Generation (aMW) (Water Years 1936 through 2008) and Critical Water Year (1937) under Alternative 5.

Month[1]	No-action Alternative Average Generation	Alternative 5 Average Generation	Average Generation Difference	No-action Alternative Critical Water Year Generation	Alternative 5 Critical Water Year Generation	Critical Water Year Generation Difference
Oct	134	149.5	15.5	119	151	32
Nov	230	180.8	-49.2	156	107	-49
Dec	231	161.5	-69.5	80	38	-42
Jan	235	197.2	-37.8	47	27	-20
Feb	147	142	-5	67	47	-20
Mar	143	119.7	-23.3	121	67	-54
Apr I	177	143.2	-33.8	188	158	-30
Apr II	182	135.8	-46.2	227	183	-44
May	222	184.2	-37.8	356	303	-53
Jun	162	169.3	7.3	264	272	8
Jul	106	114.1	8.1	111	125	14
Aug I	114	118.7	4.7	115	116	1
Aug II	118	120.9	2.9	124	126	2
Sep	151	157.3	6.3	155	173	18
Annual Average[2]	**171**	**152.4**	**-18.6**	**150**	**133**	**-17**

Source: HYDSIM modeling results

[1] HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

[2] The Annual Average is a weighted average to account for the different number of days in the 14 periods.

The change in critical water year generation from 150 aMW under the NAA to 134 aMW under Alternative 5 represents a 17 aMW (or 11.3 percent) decrease.

Interim Operations would be implemented until construction of various action alternative measures are complete. Interim operations could occur for a long term while the alternative in being implemented. During the Interim Operations, generation would be reduced when compared to generation under the NAA or to generation under Alternative 5 (Figure 3.12-12). Power generation would continue to be reduced until structural measures proposed are fully implemented to an estimate of 120 aMW.

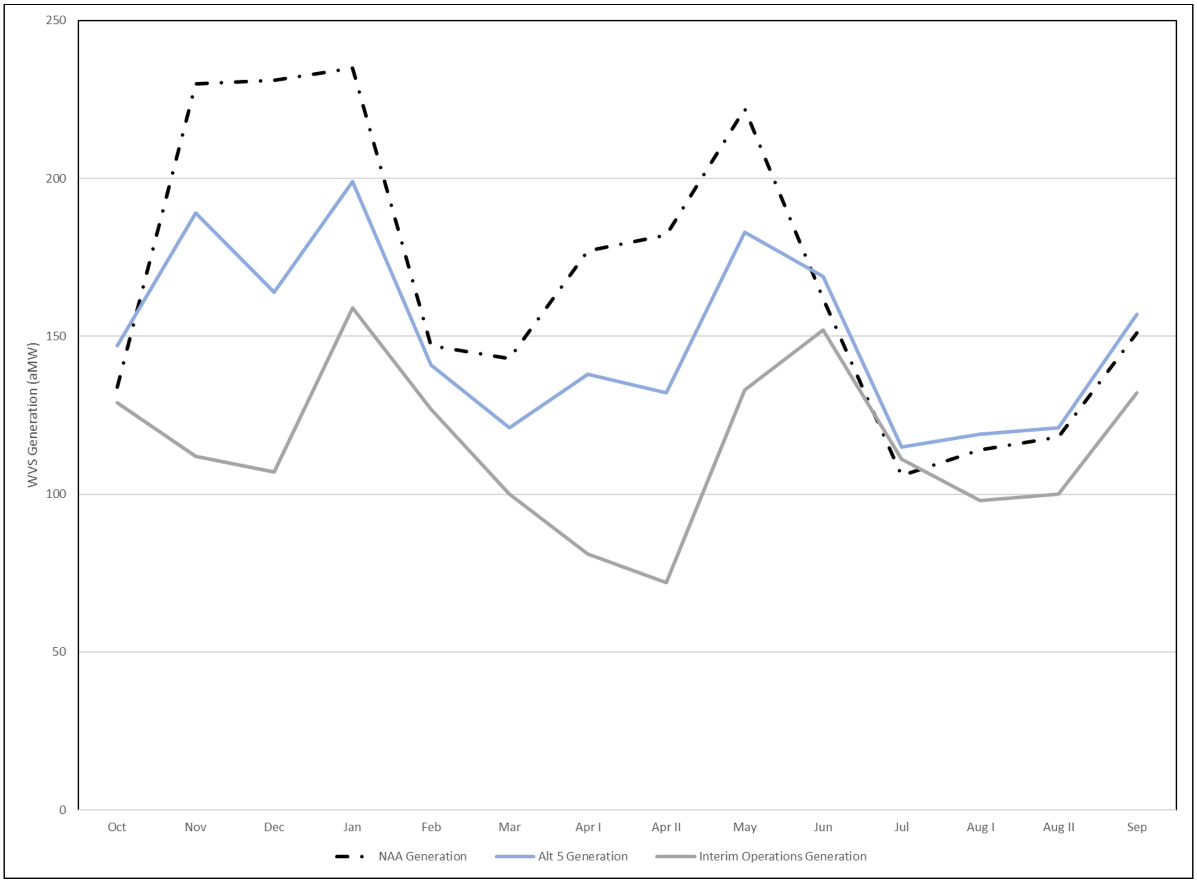

Figure 3.12-12. Monthly Average Generation (aMW) under the No-action Alternative, Alternative 5, and Interim Operations.

Note: Depicts generation under both Interim Operations and Alternative 5 as compared to the NAA because actual generation during the 30-year implementation timeframe is likely to vary between those two points.

Operations under Alternative 5 would result in a slight decrease in aMW generation when compared to the NAA operations, resulting in negligible effects to the regional power system over the 30-year implementation timeframe and continuing to provide long-term slight beneficial effects as under the NAA.

As compared to the NAA, Alternative 2B would continue to provide long-term, substantial, beneficial effects specifically to WVS dam generation as power would continue to be generated under this alternative over the 30-year implementation timeframe. However, there would be a slight decrease in generation relative to the NAA of 10.9 percent. Additionally, under Alternative 2B, there would be some period of Interim Operations that would further decrease average annual generation moderately by 30 percent.

Due to the slight decrease in total hydropower generation under Alternative 5, the LOLP would be 6.6 percent, or 0.1 percentage points, greater than the LOLP under the NAA. No replacement resources would be needed to return the LOLP to the NAA level because this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the Northwest Power and Conservation Council target.

A 6.6 percent LOLP under Alternative 5 is roughly equivalent to a 1-in-15-year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions) over the 30-year implementation timeframe, which is the same likelihood of an event(s) under NAA operations.

Transmission

Power generation under Alternative 5 would result in moderate adverse effects to the Willamette Valley transmission system compared to the NAA because generation would need to be replaced from more distant sources over the 30-year timeframe.

Alternative 5 operations would result in long-term, moderate, adverse effects to the regional transmission system because of increased contributions to congestion as compared to NAA operations. Moderate, beneficial, effects to the local Willamette Valley transmission system would occur because power generated at Hills Creek Dam would continue to operate islanded (isolated) and to provide power to the Oakridge community.

However, unlike operations under the NAA, operations at Cougar Dam may not be able to provide power to the Blue River community in the event of system outages from severe weather and wildfire events under Alternative 5. This temporary limitation would be due to deep fall and spring drawdowns combined with the generally limited ability for USACE to operate Cougar Dam for hydropower under Alternative 5. This would result in a substantial adverse effect to the community of Blue River.

Economic Viability of Power Generation

Unlike operations under the NAA, power generation from the combined WVS operations under Alternative 5 would not be economically viable. Over the 30-year implementation timeframe, power operations are estimated to have a median NPV of -$986 million under Alternative 5 (Table 3.12-22) (Appendix G, Power and Transmission Analysis). This would be an -$1.34 billion, or 377 percent, reduction in NPV compared to the NAA. Across the 630 analysis iterations that varied energy prices and water conditions, no iterations resulted in a positive NPV.

The median LCOG for the combined WVS operations is estimated to rise from $30.03/MWh under the NAA to $71.22/MWh under Alternative 5, which would be a $41.19, or 137 percent, increase and a substantial adverse effect on power and transmission. This substantial increase would result in an LCOG higher than expected market prices.

The primary driver for impacts to NPV and LCOG is the cost associated with implementing the alternative rather than only changes to generation.

Table 3.12-22. Summary of Power and Transmission Effects under Alternative 5.

Metrics	No-action Alternative	Alternative 5	Alternative 5 Compared to the No-action Alternative
WVS Operations 73-year Average Generation (aMW)	171	120 - 153	-51 to -18.6
WVS Operations Critical Water year (1937) Average Generation (aMW)	150	108 - 133	-42 to -17
Loss of Load Probability (LOLP)	6.5%	6.6%	+0.1
Transmission Flow Paths[1] Cross Cascades South	W 6475.5 SP 4100.5 SU 5862.9	W 6497.4 SP 4125.6 SU 5858.6	W +21.9 SP +25.1 SU -4.3
South of Allston	W 1183.0 SP 732.1 SU 2525.1	W 1191.3 SP 737.2 SU 2523.8	W +8.3 SP +5.1 SU -1.3
Transmission Reliability	Slightly Congested	Regionally: Same/similar to NAA Locally: unable to operate islanded at Cougar Dam during deep fall and spring drawdowns under certain conditions	Same as the NAA; compromised ability to meet local transmission services for the Blue River community during weather- or wildfire-related temporary outages
NPV (median)	$356 Million	-$986 million	-$1.34 billion
LCOG ($/MWh)	$30.03	$71.22	+$41.19

% = percent

aMW = average megawatts

Note: The estimated LOLP effect and resulting transmission and economic viability effects rely on the best available information regarding planned coal plant retirements as of 2017.

[1] The amount of loading (in MW) on the congested paths of Cross Cascades South and South of Allston are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

3.12.4 Interim Operations under All Action Alternatives Except Alternative 1

The alternatives analyses describe anticipated power generation under Interim Operations. This section provides additional information on power generation, transmission, and economic viability under Interim Operations.

The timing and duration of Interim Operations would vary depending on a given alternative. Interim operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations will be implemented in succession with, and not in addition to, action alternative implementation.

3.12.4.1 Power Generation

Interim Operations would be implemented until construction of various action alternative measures are complete (Figure 3.12-13) (Appendix G, Power and Transmission Analysis). Generation would be reduced during Interim Operations under any applicable alternative when compared to generation under the NAA (Table 3.12-23). Regardless, there would continue to be substantial benefits from WVS power generation although with moderately less power generated.

THE DEIS HAS BEEN MODIFIED TO INCLUDE THE FOLLOWING FIGURE IN THE FEIS

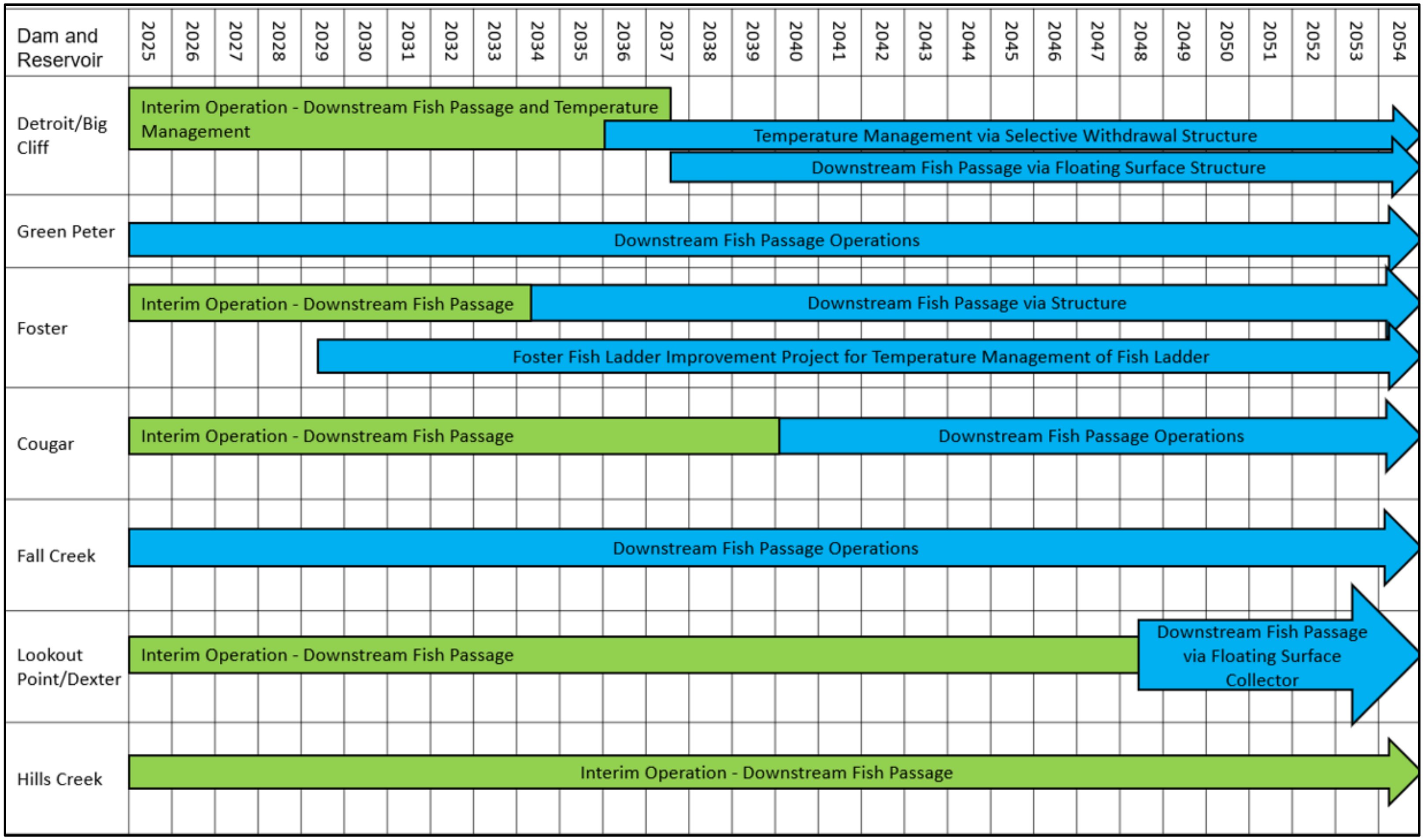

Figure 3.12-13. Example Implementation Timeline Illustrating Interim Operations Correlation with Long-term Measures for Downstream Fish Passage and Temperature Management.

Notes:

This figure is a representation, and dates do not reflect exact transition timeframes. The figure is intended to illustrate that Interim Operations (green) would be in place until a long-term measure (blue) is online. The blue arrows depict activities into the future; green bands indicate when the Interim Operation ends because the long-term activity is being implemented. The green band in the Detroit Dam and Reservoir category overlaps with the blue arrow for temperature management because a lag would occur between selective withdrawal structure construction and operation and floating screen structure construction and operation.

Table 3.12-23. Summary of Hydropower Generation from Willamette Valley System Dams under All Alternatives Post-Interim Operations.

Alternative	Average Annual Hydropower Generation (aMW)	Percent Increase or Decrease from the No-action Alternative (%)
NAA	171	Not Applicable
Alternative 1	179	+4.7
Alternative 2A	167	-2.3
Alternative 2B[1]	153	-10.6
Alternative 3A[2]	84	-47.9
Alternative 3B[2]	93	-45.8
Alternative 4	172	+0.6
Alternative 5	152	-10.8

% = percent

aMW = average megawatts

[1] Reflects monthly reductions from November through May counterbalanced by increases in power from June through October.

[2] Reflects operational changes resulting in reservoir elevations frequently below the power pool, thereby precluding hydropower generation for extended periods.

As demonstrated under the alternatives analyses, power generation would continue to be reduced until structural measures proposed under a given action alternative are fully implemented, at which time, power generation would increase under Alternatives 2A, 2B, 4, and 5 (Table 3.12-24) (Figure 3.12-14). However, generation would decrease further under Alternatives 3A and Alternative 3B.

Table 3.12-24. Willamette Valley System 73-year Average Generation (aMW) (Water Years 1936 through 2008) and Critical Water Year (1937) during Interim Operations.

Month[1]	No-action Alternative Average Generation	Interim Average Generation	Average Generation Difference	No-action Alternative Critical Water Year Generation	Interim Critical Water Year Generation	Critical Water Year Generation Difference
Oct	134	129	-5	119	108	-11
Nov	230	112	-118	156	74	-82
Dec	231	107	-124	80	35	-45
Jan	235	159	-76	47	20	-27
Feb	147	127	-20	67	27	-40
Mar	143	100	-43	121	78	-43
Apr I	177	81	-96	188	106	-82
Apr II	182	72	-110	227	87	-140
May	222	133	-89	356	211	-145

Month[1]	No-action Alternative Average Generation	Interim Average Generation	Average Generation Difference	No-action Alternative Critical Water Year Generation	Interim Critical Water Year Generation	Critical Water Year Generation Difference
Jun	162	152	-10	264	250	-14
Jul	106	111	5	111	131	20
Aug I	114	98	-16	115	107	-8
Aug II	118	100	-18	124	102	-22
Sep	151	132	-19	155	159	4
Annual Average[2]	**171**	**120**	**-52**	**150**	**108**	**-42**

Source: HYDSIM modeling results

aMW = average megawatts

[1] HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

[2] The Annual Average is a weighted average to account for the different number of days in the 14 periods.

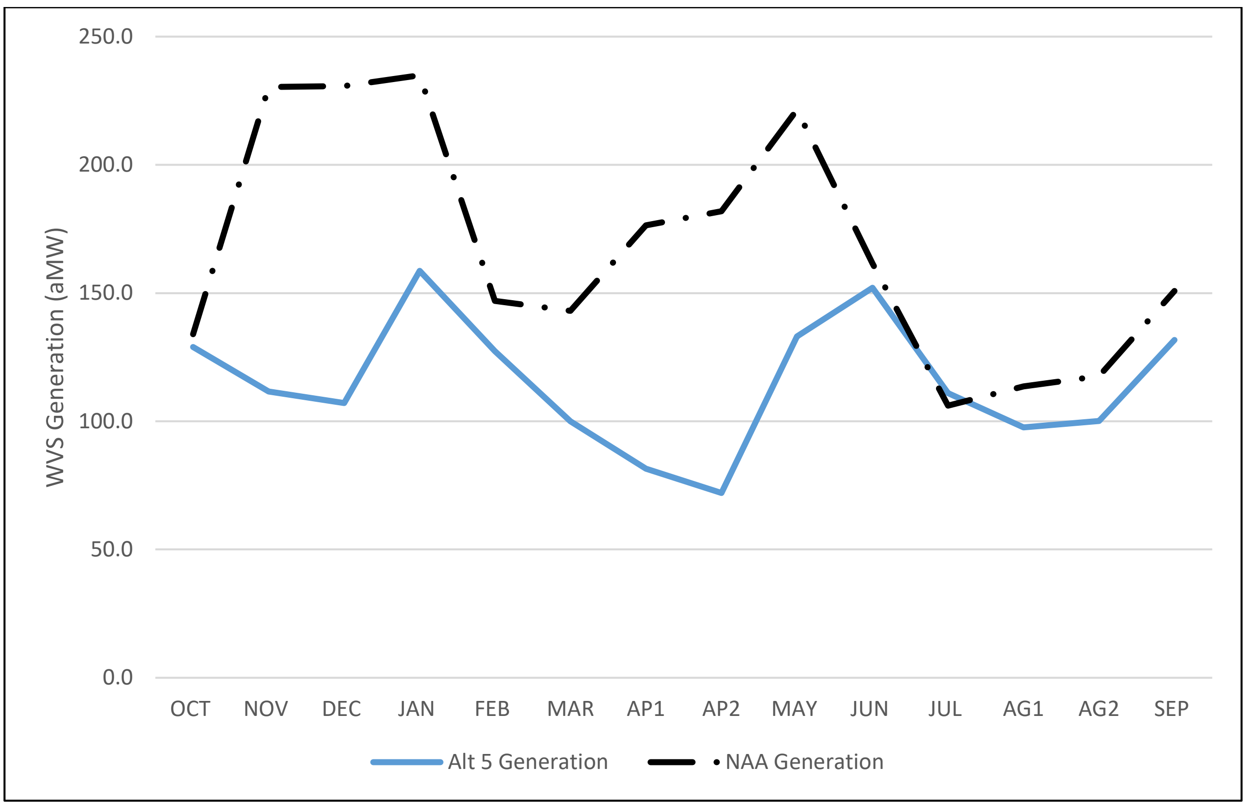

Figure 3.12-14. Monthly Average Generation (aMW) under Interim Operations and the No-action Alternative.

Generation from WVS operations would decrease from 171 aMW under the NAA, on average over all water years, to 120 aMW under Interim Operations. This would power approximately 41,392 homes compared to the NAA (however, power supply to homes during Interim Operations would be temporary until an alternative is fully implemented. Refer to each action alternative analysis). This represents a decrease of approximately 52 aMW, which would be a 30.1 percent decrease in average annual generation. The change in critical water year generation from 150 aMW under the NAA to 108 aMW under Interim Operations represents a 42 aMW (or 28 percent) decrease.

Interim Operations would result in a medium-term, moderate decrease in aMW generation when compared to the NAA operations. This would cause a negligible effect to the regional power system over the 30-year implementation timeframe. Long-term, slight, beneficial effects would be continued under the Interim Operations. As under the NAA, contributions to the regional power system would be slight as a fraction of the total power generated in the system but would remain a beneficial contributor to power supply.

As under NAA operations, there would be beneficial effects on WVS dam power generation under the Interim Operations; however, effects would be less beneficial from moderately less power generation and in a shorter term as compared to NAA operations. This is because aMW generation would continue during Interim Operations although there would be a 30 percent decrease in average annual power generation.

Due to the decrease in total hydropower generation under Interim Operations, the LOLP would be 6.8 percent, or 0.3 percentage points, greater than the LOLP under the NAA. As under the NAA, no replacement resources would be necessary under Interim Operations.

A 6.8 percent LOLP under Interim Operations is roughly equivalent to a 1-in-15-year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions) over the 30-year implementation timeframe, which is the same likelihood of an event(s) under NAA operations.

3.12.4.2 Transmission

Power generation during Interim Operations would result in adverse effects on Willamette Valley power transmission compared to the NAA because generation would need to be replaced from more distant sources (Figure 3.12-14). As under the NAA, impacts to the paths of Cross Cascades South and South of Allston would be adversely congested, but there would be substantial increases to loading expected under the Interim Operations, especially in the Spring Off-peak case (up to 60MW). This would result in moderate, adverse effects on the Willamette Valley transmission system. However, effects under the Interim Operations would be shorter term than under the NAA.

Deep fall and spring drawdowns would compromise USACE abilities to operate Cougar Dam as temporarily islanded (isolated) to serve the Blue River community under severe weather- or wildfire-related outage conditions. This would be a substantial adverse effect on the community of Blue River.

3.12.4.3 Economic Viability of Power Generation

Unlike the NAA operations, power generation from the combined WVS operations would not be economically viable during Interim Operations. Costs of structural implementation are considered in the NPV under each alternative analysis. While the decrease in NPV under the Interim Operations and under a fully implemented alternative are not cumulative, it is recognized that the adverse effect to NPV is likely represented between NPV during the Interim Operations and NPV from implementation of a given action alternative (except Alternative 1).

Over the 30-year implementation timeframe, power operations are estimated to have a median NPV of -$213 million during Interim Operations (Table 3.12-25) (Appendix G, Power and Transmission Analysis). This is a -$569 million, or 160 percent, reduction in NPV compared to NAA operations. Across the 630 analysis iterations that varied energy prices and water conditions, only 8.6 percent resulted in a positive NPV.

THE DEIS HAS BEEN MODIFIED TO INCLUDE THE FOLLOWING TABLE IN THE FEIS

Table 3.12-25. Summary of Power and Transmission Effects under Interim Operations.

Metrics	No-action Alternative	Interim Operations	Interim Operations Compared to the No-action Alternative
WVS Operations 73-year Average Generation (aMW)	171	120	-52
WVS Operations Critical Water year (1937) Average Generation (aMW)	150	108	-42
Loss of Load Probability (LOLP)	6.5%	6.8%	+0.3[1]
Transmission Flow Paths[2] Cross Cascades South	W 6475.5 SP 4100.5 SU 5862.9	W 6522.5 SP 4160.3 SU 5872.9	W +47.0 SP +59.8 SU +10
South of Allston	W 1183.0 SP 732.1 SU 2525.1	W 1200 SP 743.5 SU 2528.7	W +17 SP +11.4 SU +3.6

Metrics	No-action Alternative	Interim Operations	Interim Operations Compared to the No-action Alternative
Transmission Reliability	Slightly Congested	Regionally: Same/similar to NAA Locally: unable to operate islanded at Cougar Dam during deep fall and spring drawdowns under certain conditions	Same as the NAA; compromised ability to meet local transmission services for the Blue River community during weather- or wildfire-related temporary outages
NPV (median)	$356 Million	-$213 million	-$569 million
LCOG ($/MWh)	$30.03	$48.95	+$18.92

% = percent

aMW = average megawatts

Note: The estimated LOLP effect and resulting transmission and economic viability effects rely on the best available information regarding planned coal plant retirements as of 2017.

[1] No replacement resources would be needed to return the LOLP to the NAA level because this difference of 0.3 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the Northwest Power and Conservation Council target.

[2] The amount of loading (in MW) on the congested paths of Cross Cascades South and South of Allston are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

The median LCOG for the combined WVS operations is estimated to rise from $30.03/MWh under the NAA to $48.95/MWh during Interim Operations, which would be an $18.92, or 63 percent, increase. This substantial increase would Result in an LCOG higher than expected market prices.

3.12.5 Climate Change under All Alternatives

Climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions over the 30-year implementation timeframe (Climate Impacts Group 2010; RMJOC 2020) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources: Section 3.1 Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

Because the WVS will likely experience increasing winter (December through March) flow volumes due to climate change generally, it is possible that operations may be able to capture some additional flow, which could produce incremental increases in power generation during the winter. However, higher projected air temperatures are likely to result in decreased loads. Increases in power generation that may occur in the winter months would incrementally decrease stress on existing congested transmission paths (i.e., South of Allston and Cross Cascades South).

END REVISED TEXT

Lower snowpack may reduce springtime and summertime flows as well as potentially impact refill ability. This could lead to reduced ability to generate power in the spring and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested transmission paths (i.e., South of Allston and Cross Cascades South).

Decreasing summer and fall inflows may lead to more rapid drawdown in the fall to meet downstream minimum flow targets. Reduced reservoir levels associated with decreased refill ability, combined with anticipated increases in the likelihood of extreme weather- or wildfire-related events, would increase the risks that Cougar Dam would be unable to provide power to the community of Blue River during a transmission outage between Blue River and Thurston substations. Similarly, these conditions would increase the risks that Hills Creek Dam would be unable to provide power to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point substation.

Photo by Ernie Henry (USACE Media Images Database)

Substation at Sunset.

US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.13 WATER SUPPLY

TABLE OF CONTENTS

LIST OF TABLES

3.13 Water Supply

THE WATER SUPPLY SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **The introduction has been updated to clarify the scope of the water supply analysis and to correlate this analysis with the water quality and water supply analyses (Section 3.13.1, Introduction).**
- **The Affected Environment section has been revised to align the existing conditions description with correlated analyses (FEIS Section 3.13.2, Affected Environment). DEIS information on water supply system operations has been deleted because USACE operations do not affect analysis area municipal and industrial water systems.**
- **Information on water rights has been clarified in FEIS Section 3.13.2.3, River Flow Use in the Willamette River Basin.**
- **Table 3.13-1 has been revised to illustrate the number of water rights issued and to delete information on permitted water volume for consistency with the scope of the analysis in this section.**
- **FEIS Section 3.13.2.5, Uses of Stored Water, has been added to clarify Congressionally authorized purposes, USACE water storage operations, and water supply demand.**
- **Information on groundwater supply existing conditions and related analyses have been revised in FEIS Section 3.13.2.6, Groundwater, and FEIS Section 3.13.3.2, Alternatives Analyses, Groundwater Supply and Use under All Alternatives.**
- **Information on the scope of direct and indirect effects has been added to FEIS Section 3.13.3, Environmental Consequences.**
- **Information on construction-related and routine and non-routine maintenance effects have been added to FEIS Section 3.13.3.2, Alternatives Analyses.**
- **The effects criteria have been revised to apply a qualitative and descriptive approach to the analyses in FEIS Section 3.13.3.1, Methodology. Direct and indirect effects criteria have been added.**
- **The analyses have been revised in their entirety from the DEIS. The effects analysis criteria and effects summary tables have been revised to reflect the revised FEIS scope of review focused on water supply and water users related to supply sources (FEIS Table 3.13-3 and Table 3.13-4, respectively). Additional comparisons to the No-action Alternative have been added to all analyses in FEIS Section 3.13.3.2, Alternatives Analyses.**

Summary of changes from the DEIS, continued:

- **Tables illustrating reservoir stored water amounts met in 80 percent of water years has been added to the alternatives analyses in FEIS Section 3.13.3.2.**
- **The analyses of Near-term Operations Measures have been combined in FEIS Section 3.13.4. The term "Near-term Operations" has been revised to "Interim Operations" throughout the EIS.**
- **The analyses of climate change-related effects have been combined for all alternatives in FEIS Section 3.13.5.**
- **Consistent terminology has been applied and defined as applicable.**

3.13.1 Introduction

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

Water is critical for the sustenance and continued growth of the Willamette Valley, where more than 70 percent of the Oregon population resides. The Oregon Water Resources Department (OWRD) is responsible for managing water in the state and issues water rights to withdraw from Oregon waterways, including groundwater wells. Water rights are used for consumptive uses, instream purposes, or to store water for future use.

Water users in the Willamette River Basin rely on river flow, groundwater wells, and stored water released from reservoirs to satisfy state-issued water rights for many types of uses. The two main consumptive uses of water from Basin rivers are municipal and industrial water supply and agricultural irrigation. This section focuses on the relationship between WVS operations and water supply from river flow, stored water, and groundwater as permitted for municipal and industrial uses and agricultural irrigation. Indirect effects from operations on water users are also addressed.

An overview of water rights is provided; however, the analysis does not address effects to water rights. Analyses of drinking water are provided in Section 3.19, Drinking Water.

3.13.2 Affected Environment

The analysis area is the Willamette River Basin where the 13 WVS dams and reservoirs are located. The analysis area includes tributaries to the Willamette River in several subbasins. Subbasins analyzed include North Santiam River, South Santiam River, McKenzie River, Middle Fork Willamette River, Coast Fork Willamette River, Long Tom River, and the Mainstem Willamette River Subbasins. USACE operations do not affect water supply in other subbasins.

3.13.2.1 Municipal and Industrial Water Supply

Municipal and industrial water needs are not limited to domestic drinking water, but include water used for other domestic functions, landscape management, and industrial uses such as manufacturing and processing. The Willamette River and its tributaries, along with groundwater, are the major sources of water for municipal and industrial needs in the analysis area. As the population increases throughout the Willamette River Basin, municipal and industrial needs will increase, putting pressure on existing water supplies.

3.13.2.2 Agricultural Irrigation

The expansion of agricultural irrigation in the Willamette River Basin was slow until the 1940s, when irrigated acres increased during the post-World War II decades, from 27,000 irrigated acres in 1940 to approximately 194,000 irrigated acres in 1964 (OWRB 1967). Irrigated acreage increased to about 300,000 acres by 2007 and was 276,000 acres in 2017 (USDA 2019). Unlike in other basins in Oregon, there are limited irrigation districts in the Willamette River Basin, with most irrigation diversions installed by individual users (USACE 2019a).

3.13.2.3 River Flow Use in the Willamette River Basin

This section details municipal and industrial water supply and agricultural irrigation uses in the analysis area by examining the number of water rights issued and volumes permitted for these purposes directly from the river.

Oregon operates under the doctrine of prior appropriation—priority use of water is established by the date of the water right. As such, the right to use water is not attached to land ownership adjacent to a waterbody.

Water rights encompass the source of the water, typically documented by the stream name for river flow water rights (surface water) or reservoir for water rights that use water stored in and subsequently released from a reservoir (stored water), or groundwater.

Water rights can also be issued for the purpose of storing water for later use. When the stored water is released, or discharged, from a reservoir, that water is considered stored flow. A water right to use or withdraw stored water from a stream is called a secondary water right, and the source of the water is the reservoir, not the stream itself (OWRD 2024a).

END REVISED TEXT

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Water rights change over the course of a year. Currently, municipal and industrial water needs (specifically large population centers) rely heavily on the flow from the Willamette River and its tributaries. Many points of diversion are located along the Willamette River (Table 3.13-1). Diversions are the locations where water is withdrawn from the river for municipal, industrial, irrigation, or other consumptive use on each tributary that contains a WVS dam and reservoir, along with the Mainstem Willamette River.

Table 3.13-1. Summary of Water Permitted for Use on June 1 for Water Rights in Select Tributaries to the Willamette River*.

Tributary to the Willamette River	Municipal Surface Water Diversions[1] (cfs)	Industrial Surface Water Diversions (cfs)	Irrigation Surface Water Diversions (cfs)	Other Surface Water Diversions (cfs)
Coast Fork Willamette River	8.3	4.4	38.1	53.1
Row River	7.0	0.0	4.0	11.0
Middle Fork Willamette River	85.0	80.8	7.1	173.0
Fall Creek	0.0	0.0	3.6	4.0
McKenzie River	340.0	69.7	96.0	217.5
Long Tom River	0.8	1.0	252.3	0.0
North Santiam River	271.8	402.3	343.9	1,262.4
South Santiam River	80.1	5.5	44.0	5.4
Santiam River	3.1	0.0	8.2	0.0
Willamette River	817.8	608.1	425.4	248.8

cfs = cubic feet per second

* June 1 is generally considered the beginning of the peak water use season, which coincides with the dry season in the Willamette Valley.

[1] Data were provided by OWRD as the best-known data available as of December 2023 (OWRD 2024b).

For users with river flow water rights, water availability during dry years is determined by OWRD for the Willamette River Basin. Water use restrictions can vary between subbasins because restrictions depend on local hydrology and quantity of water rights.

END NEW TEXT

3.13.2.4 Subbasin Descriptions

North and South Santiam River Subbasins

The Santiam River Basin, comprising the North and South Rivers (i.e., subbasins) and the relatively short reach of the Santiam River, is an important area for agricultural use within the analysis area. The North and South Santiam River Subbasins combined are second only to the Mainstem Willamette River for both municipal and industrial use and agricultural irrigation water use in the analysis area.

Large irrigation districts, including the Santiam Water Control District, which provides water to irrigation customers and numerous municipal entities, are some of the largest users of water in the combined subbasins. Irrigators in the two subbasins use stored water released from Detroit and Green Peter Dams.

The City of Salem uses water withdrawn from the North Santiam River at Geren Island, near the town of Stayton, as its primary source for drinking water and for industrial use. The drinking water treatment plant on Geren Island requires a minimum flow in the river of 750 cubic feet/second (cfs) to be operational.

McKenzie River Subbasin

The McKenzie River Subbasin has the second highest number of municipal and industrial water supply and agricultural irrigation diversions of the subbasins in the analysis area, but only one-third and one-quarter, respectively, of the number of combined diversions on the Mainstem Willamette River.

Middle Fork Willamette River Subbasin

This subbasin has a moderate level of demand for agricultural irrigation water and a small level of demand for municipal and industrial water supply. Fall Creek does not have any municipal and industrial diversions, but there are withdrawals from Fall Creek for agricultural irrigation.

Coast Fork Willamette River Subbasin

This is a small subbasin with relatively small levels of consumptive use for municipal and industrial water supply and agricultural irrigation compared to the other subbasins and the Mainstem Willamette River.

Long Tom River Subbasin

The Long Tom River Subbasin has a very small number of withdrawals for municipal and industrial water supply, but has a very high number of agricultural irrigation diversions relative to the size of the river. Land use in this subbasin supports substantial agricultural use.

Mainstem Willamette River

The majority of water withdrawals in the analysis area occurs from the mainstem of the Willamette River, from just south of Eugene, Oregon north to the confluence with the Columbia River. The highest level of use occurs below Salem, Oregon in the Portland metropolitan area, which supports the majority of the analysis area population.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

3.13.2.5 Uses of Stored Water

USACE operations store and release water in the WVS for multiple Congressionally authorized purposes, including irrigation use to those who have a contract for stored water with the U.S. Bureau of Reclamation (BOR) (i.e., water service contracts) (Chapter 1, Introduction, Section 1.10, Congressionally Authorized Purposes). Currently, USACE operates releases and subsequent downstream flows in the analysis area under the 2008 National Marine Fisheries Service (NMFS) Biological Opinion (NMFS 2008) (Chapter 1, Introduction, Section 1.3.3, Willamette Valley System Endangered Species Act and National Environmental Policy Act History since 2008).

Agricultural irrigation is a Congressionally authorized purpose for the WVS; irrigation was thought to be the largest future use of WVS stored water when the dams were authorized. However, agricultural irrigation water demand in the Willamette Valley has not grown at the rate projected in the authorizing documents. Water use and conservation practices employed by the agricultural community have also changed since the WVS was authorized (Chapter 1, Introduction, Section 1.1, Background).

Conservation storage is the space in the reservoir between the maximum conservation pool elevation and the minimum conservation/flood pool elevation that is used to store water. USACE provides this storage through its WVS operations. Additionally, USACE operates to release water stored in the conservation storage space (i.e., stored water) for downstream flow management.

WVS conservation storage totals approximately 1,590,000 acre-feet. As of September 2024, of this total, only 84,349 acre-feet of stored water (less than 5 percent of the WVS conservation storage volume) was contracted through BOR for irrigation use on 45,715 acres in the analysis area. Typically, at the current low level of use for BOR-administered agricultural irrigation water service contracts, it is not necessary for USACE to increase releases above minimum flows as required by the 2008 NMFS Biological Opinion to meet irrigation water service contract requirements in effect at the time the alternatives were analyzed[1].

The Willamette Basin Review Feasibility Study (USACE 2019a) included a detailed analysis for future demands of water for agricultural irrigation, using multiple methods to calculate future demands (Chapter 1, Introduction, Section 1.3.3, Willamette Valley System Endangered Species Act and National Environmental Policy Act History since 2008). The study area for irrigation demands was a 4-mile boundary on either side of the Willamette River and tributaries where WVS reservoirs are located. The study area was selected because it is not cost effective to transport water longer than the 4-mile distance.

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[1] There were no signed agreements for conservation storage use from any of the WVS reservoirs for municipal and industrial water supply at the time the alternatives were analyzed. However, the Eugene Water and Electric Board had requested an agreement for 437 acre-feet.

An assumption was made that future demands would need to be met with stored water from the WVS because most waterways in the Willamette River Basin have limited availability for river flow water rights. A total of 327,650 acre-feet was reallocated to the specific use of agricultural irrigation in the Water Resources Development Act of 2020 (WRDA) (USACE 2019a) based on the forecasted demand[2] for stored water for agricultural irrigation use to the year 2070.

At the time the alternatives were analyzed, population growth created a demand for water that exceeded existing supplies for many municipal and industrial systems throughout the Willamette River Basin. This need was one of the factors that led to the Willamette Basin Review Feasibility Study (USACE 2019a), which resulted in a total of 159,750 acre-feet of conservation storage reallocated to the purpose of municipal and industrial water supply.

Demands for water stored in the WVS to supply municipal and industrial and agricultural irrigation water are spread across all subbasins (USACE 2019a). However, the greatest demand is on the Mainstem Willamette River (Table 3.13-2).

Table 3.13-2. Estimated New Municipal and Industrial and Irrigation Demands (Annual) for Stored Water by the Year 2050 (i.e., Forecasted Demands).

River Reach	Waterway	Municipal and Industrial Demand for Stored Water (acre-feet)	Agricultural Irrigation Demand for Stored Water (acre-feet)
1	Willamette River, downstream of Santiam River confluence	65,358	69,483
2	Santiam River	387	3,666
3	North Santiam River	1,490	5,124
4	South Santiam River	552	5,963
5	Willamette River, between the Santiam and Long Tom River confluences	2,018	6,433
6	Long Tom River	1	6,389
7	Willamette River, between the Long Tom and McKenzie River confluences	808	3,870
8	McKenzie River	1,867	2,740
9	Willamette River, between McKenzie and Coast Fork/Middle Fork River confluences	795	29
10	Middle Fork Willamette River, below the Fall Creek confluence	7	1,127
11	Middle Fork Willamette River	1	4,819
12	Fall Creek	0	84

[2] The Willamette Basin Review Feasibility Study period was 50 years (USACE 2019a).

River Reach	Waterway	Municipal and Industrial Demand for Stored Water (acre-feet)	Agricultural Irrigation Demand for Stored Water (acre-feet)
13	Coast Fork, below confluence with Row River	0	730
14	Row River	6	52
15	Coast Fork, above confluence with Row River	0	11
Total		**73,920**	**110,520**

The Willamette Basin Review Feasibility Study Biological Opinion includes a Reasonable and Prudent Alternative (RPA) (NMFS 2019b) (Chapter 1, Introduction, Section 1.3.3, Willamette Valley System Endangered Species Act and National Environmental Policy Act History since 2008). RPA Measure 2 includes a cap of 11,000 acre-feet on municipal and industrial use. Further, there can be no water supply agreements between USACE and suppliers in the Santiam Basin (i.e., North and South Santiam River Subbasins) until NMFS issues its written agreement to USACE that instream water rights are in place and provide sufficient protection to flows intended to benefit fish.

Water availability for users with a right to use stored water from the WVS reservoirs is based on how much water USACE stored in the WVS reservoirs. Further, availability is subject to minimum streamflows as required by the 2008 NMFS Biological Opinion and the Willamette Basin Review Feasibility Study Biological Opinion (NMFS 2019b).

3.13.2.6 Groundwater

Groundwater is another source of water used for municipal and industrial water supply and agricultural irrigation purposes in the analysis area. However, USACE has not identified any groundwater wells that are hydrologically connected to WVS reservoirs. There was no documented impact on groundwater wells in areas adjacent to WVS reservoirs during the 2024 deep drawdown operations.

Groundwater wells that are hydrologically connected to rivers downstream of USACE reservoirs benefit from augmented streamflows, especially during dry years, which helps to maintain the water table at levels accessible by groundwater wells. There was no documented impact on groundwater wells in areas downstream of WVS reservoirs during the 2024 deep drawdown operations.

3.13.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives on water supply. The discussion includes the methodology used to assess effects and a summary of the anticipated effects. The analysis area for effects on water supply encompasses the subbasins in the Willamette River Basin and the Mainstem Willamette River.

Direct effects include effects on water supply, which would occur from WVS operations, hydrologic conditions during dry years, and variations in river flow.

Indirect effects include effects on water users from direct water supply effects. Water user effects are indirect because the allocation of water supply is not a Congressionally authorized purpose for the WVS.

3.13.3.1 Methodology

The alternatives analyses include the assumption that NMFS will provide written agreement to lift the cap on municipal and industrial water user agreements during the 30-year implementation timeframe. Consequently, modeling assumed 73,920 acre-feet of water would be used to meet municipal and industrial demands by 2050.

While the Willamette Basin Review Feasibility Study (USACE 2019a) evaluated effects from the full agricultural irrigation allocation volume of 327,650 acre-feet, the 2008 NMFS Biological Opinion did not address the existing cap on BOR agricultural irrigation water service contracts of 95,000 acre-feet. After coordination with BOR at the time the alternatives were analyzed, USACE assumed agricultural irrigation contracts under the No-action Alternative (NAA) would remain the same (84,349 acre-feet). Further, the NAA assumes BOR would not initiate ESA consultations to lift the 95,000 acre-feet cap.

It is reasonable to assume that demand for water service contracts for agricultural irrigation will increase within the next 30 years and that, for the purposes of this analysis, BOR will initiate consultation with NMFS to issue contracts in excess of 95,000 acre-feet under all action alternatives. The total agricultural irrigation uses of stored water considered in this analysis is 255,385 acre-feet, which consists of the 2050 level of irrigation water service contracts forecasted in the Willamette Basin Review Feasibility Study (USACE 2019a).

ResSim-modeled flow data were applied to the water supply analyses under each alternative to qualitatively evaluate physical effects to water supply by looking at differences in river flow levels and conservation storage refill between the NAA and action alternatives. The ResSim model incorporated the forecasted demands in Table 3.13-2 as best available data for future water use.

Analyses under all of the alternatives, including the NAA, include the forecasted demands for municipal and industrial water use (Table 3.13-2). However, only the action alternatives include the forecasted demands for agricultural irrigation use (Table 3.13-2). Data used to support the alternatives analyses are provided in Appendix J, Water Supply Analysis. Additionally, alternative analyses rely on the hydrologic results and effects described in Section 3.2, Hydrologic Processes.

Stored Water

USACE assessed the volume of water that would be stored by June 1 with an 80 percent likelihood of this storage being met or exceeded. This assessment was conducted to evaluate effects to storage allocations and use of stored water for consumptive use[3]. June 1 was selected because this is the date when consumptive uses of water increase for both municipal and industrial water supply and agricultural irrigation. The 80 percent metric was used because OWRD uses an 80 percent metric for determining availability when processing water rights applications (OAR 690-502-0040 (1) General Provisions).

The Willamette Basin Review Feasibility Study Biological Opinion (NMFS 2019b) RPA Measure 3 and Measure 4 require USACE to determine, on an annual basis, the amount of water that will be available to satisfy municipal and industrial storage agreements and irrigation water service contracts. This water supply availability determination will be made annually throughout the 30-year implementation timeframe based on actual stored water volumes. This stored water would be released to meet municipal and industrial water supply and agricultural irrigation uses and instream flows to support fish and wildlife.

In dry years when system-wide stored water (amount of water stored in the conservation pools of the WVS reservoirs) is low, water may not be available to meet all water demands for stored water. The analyses in Section 3.13.3.2, Alternatives Analyses, compare the June 1 modeled volume to the fish and wildlife allocation of 1,102,600 acre-feet. Volumes less than or equal to the fish and wildlife allocation were considered an adverse effect because of the RPA requirements; volumes greater than this allocation were considered a beneficial effect. However, reductions in the amount of stored water available for consumptive uses were not included in the ResSim modeling due to modeling limitations. Consequently, the alternatives analyses do not quantify available stored water to each of the three purposes: municipal and industrial, agricultural irrigation, or fish and wildlife uses.

The water supply alternatives analyses assume municipal and industrial and agricultural irrigation users have agreements and water rights to use the level of demand forecasted to be needed in the year 2050 and developed through the Willamette Basin Review Feasibility Study (USACE 2019a).

Under all alternatives, the amount available to satisfy municipal and industrial storage agreements and agricultural irrigation water service contracts would be determined on an annual basis based on actual stored water volumes across the system.

[3] Dexter and Big Cliff Dams are re-regulation dams and do not have conservation storage; therefore, these two reservoirs are not considered in the stored water analysis methodology or in the total volume of stored water. Re-regulation dams are downstream of power-peaking dams and regulate the fluctuating flow from the power dams to maintain a consistent flow in the river.

River Flow

The analyses address differences in river flow among alternatives to demonstrate potential effects on water supply from USACE operations. Assessing effects to individual river flow water rights or a group of water rights (e.g., municipal and industrial or agricultural irrigation rights), is beyond the scope of this programmatic analysis. Additionally, water rights administration is not under USACE purview; therefore, the analyses are not specific to effects on municipal and industrial water supply and agricultural irrigation water rights users.

The level of flow downstream of dams at control points on tributaries affected by USACE operations and on the Mainstem Willamette River was analyzed under each alternative to determine an expected level of impact to irrigation and municipal and industrial water users reliant on the flow of the river. It was assumed that adverse effects to water supply for municipal and industrial uses or agricultural irrigation would occur if flow was not maintained above the 2008 NMFS Biological Opinion minimum flow targets.

Groundwater

Effects to groundwater sources were not assessed on individual wells. Water supply from groundwater sources was assessed qualitatively based on effects to reservoir and river levels and known information on hydrologic connections.

Construction and Routine and Non-routine Maintenance

Construction and routine and non-routine maintenance effects are addressed qualitatively because site-specific NEPA analyses would be needed to assess actual effects that would occur during the 30-year implementation timeframe. Construction would not occur under the NAA.

Routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities. (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation).

Effects Criteria

Effects criteria are defined as either beneficial or adverse. The degree of impact on water supply is assessed qualitatively and discussed descriptively[4]. Degrees of effect, such as slight and substantial, are provided for analyses of stored water because modeled results demonstrate amounts of stored water across alternatives for degree of effect comparison. This degree of effect is based on forecasted demands.

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[4] "Slight" is defined in its common use as "small of its kind, or in amount" (Merriam Webster Dictionary). "Moderate" is defined in its common use as "average in amount, intensity, quality, or degree" (Oxford Languages). "Substantial" is defined in its common use as "considerable in quantity, great [in amount]" (Merriam Webster Dictionary).

Conversely, qualified degrees of effect are not described for water supply reliant on river flows. Modeled results demonstrate flow in the river that was then compared to the 2008 NMFS Biological Opinion minimum flow requirements and described as either beneficial or adverse to water supply. Degrees of beneficial or adverse effects were not described because administration of water rights is the purview of the State of Oregon and is based on available water on a real-time basis and not on preset flow volumes or rates. Further, water would continue to be supplied under any alternative with varying degrees of adversity or improvement depending on the alternative. Therefore, descriptions of these effects are more informative and accurate than attempting to assign degrees of adverse or beneficial effects.

Overall, operations and maintenance under any of the alternatives could result in the described effects on water supply during the 30-year implementation timeframe. However, exceptions may occur at the local level and in the short term depending on specific annual or seasonal climate conditions and on specific dam operations.

The environmental effects criteria and a summary of effects are provided in Table 3.13-3 and Table 3.13-4, respectively.

Table 3.13-3. Effects Criteria for Water Supply and on Water Dependent on Stored Water River Flows.

Degree of Effect	Criteria For Stored Water	Criteria For River Flow Water
Beneficial	Based on the period of record, there would be an 80 percent likelihood that water in the reservoirs system-wide is more than 1,102,600 acre-feet by June 1.	Based on the period of record, there would be an 80 percent likelihood that flows at control points are at or above the target minimum.
Adverse	Based on the period of record, there would be an 80 percent likelihood that water in the reservoirs system-wide is less than 1,102,600 acre-feet by June 1.	Based on the period of record, there would be an 80 percent likelihood that flows at control points are below the target minimum.

[1] Although the model results indicate an increase or decrease to June 1 in stored water volumes, the actual effects to specific stored water users are unknown because the annual management process in dry years has not been established as required by the Willamette Basin Review Feasibility Study Biological Opinion (NMFS 2019b) RPA.

Table 3.13-4. Summary of Effects on Water Supply and to Water Users Dependent on Stored Water and River Flows as Compared to the No-action Alternative[1,2].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5	Interim Operations
System-wide Stored Water[1]	Substantially beneficial except during dry years or when reductions are needed to meet flow targets.	Substantially beneficial except during dry years or when reductions are needed to meet flow targets.	Substantially beneficial except during dry years or when reductions are needed to meet flow targets.	Moderately beneficial except during dry years or when reductions are needed to meet flow targets.	Substantially adverse	Substantially adverse	Substantially beneficial except during dry years or when reductions are needed to meet flow targets.	Moderately beneficial except during dry years or when reductions are needed to meet flow targets.	Slightly beneficial except during dry years or when reductions are needed to meet flow targets.
North Santiam River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Adverse	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
South Santiam River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Adverse	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
Santiam River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
Long Tom River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
McKenzie River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
Middle Fork Willamette River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
Coast Fork Willamette River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
Mainstem Willamette River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.

[1] Although model results indicate an increase or decrease to June 1 in stored water volumes, the actual effects to specific stored water users are unknown because the annual management process in dry years has not been established as required by the Willamette Basin Review Feasibility Study Biological Opinion (NMFS 2019b) RPA.

[2] Effect summaries include both direct effects on water supply and indirect effects on water users.

3.13.3.2 Alternatives Analyses

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

Construction and Routine and Non-routine Maintenance Activities under All Alternatives

Effects on water supply may occur as part of specific construction activities during alternative implementation and would be the same under any alternative involving construction. Effects may result from temporary drawdowns of reservoirs during the conservation season. However, subsequent tiered analyses would detail site-specific construction effects during the implementation phase (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act). Additional analyses are not provided under each alternative.

Similarly, routine and non-routine maintenance would occur under all alternatives during the 30-year implementation timeframe (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation). There would not likely be direct adverse impacts on water supply from routine maintenance activities because most would occur on dam structures and not require activities that would affect reservoir storage.

Non-routine, major maintenance activities may temporarily adversely affect water supply from construction. Major maintenance would require site-specific NEPA review prior to initiation at any location in the analysis area. Additional analyses are not provided under each alternative.

Groundwater Supply and Use under All Alternatives

There would not likely be any direct effect on groundwater supply or indirect effect on water supply users in the analysis area from operations under any alternative during the 30-year implementation timeframe.

System operations that result in greatly reduced summer flows downstream of a dam or deep drawdowns of the reservoirs would have the potential to directly impact groundwater that is hydrologically connected to rivers or reservoirs. This would be an indirect, adverse impact on water users that utilize these groundwater wells. Potential impacts would occur seasonally when the water levels are lower than existing seasonal levels.

Operations under all alternatives include a deep drawdown at Fall Creek Reservoir in addition to other deep drawdowns depending on alternative implementation. Drawdown operations would occur annually. However, USACE has not identified any groundwater wells that are hydrologically connected to WVS reservoirs. Additionally, there was no documented impact on groundwater wells in areas downstream of WVS reservoirs during the 2024 deep drawdown operations. Consequently, drawdown operations would not likely result in any direct, adverse effects to water supply or indirect, adverse effects to water users reliant on groundwater wells during the 30-year implementation timeframe.

Water Availability in Dry Years under All Alternatives

Per the Willamette Basin Review Feasibility Study Biological Opinion (NMFS 2019b), delivery of water stored in the WVS reservoirs for municipal and industrial water supply and agricultural irrigation uses may cease or be curtailed in dry years, indirectly limiting availability for water uses. This would be a direct adverse effect to water supply under all alternatives but to varying degrees depending on alternative operations.

The indirect impact to water users from dry-year water supply management cannot be accurately assessed. However, it is anticipated that dry water-year effects would not be continuous over the full 30-year implementation timeframe, but dry water years could be re-occurring depending on annual climate conditions.

END NEW TEXT

No-action Alternative

Under the NAA, operations and maintenance would adhere to the 2019 water management objectives, which were developed to manage reservoir levels to balance the needs of all Congressionally authorized purposes, including the 2008 NMFS Biological Opinion minimum flow targets. The volume of municipal and industrial water storage agreements was assumed to be 73,920 acre-feet (the 2050 level of demand) (Table 3.13-2). Existing agricultural irrigation water service contract levels are assumed to be maintained at the existing conditions volume of 84,349 acre-feet under the NAA for the 30-year implementation timeframe.

Stored Water

The amount of stored water available for municipal and industrial storage agreements and agricultural irrigation water service contracts in the analysis area under the NAA would be determined on an annual basis based on realized stored water volumes across the WVS.

There would be a direct, substantial, beneficial effect on water supply under the NAA during most times of the year. NAA operations would result in stored water exceeding the volume of stored water needed to satisfy forecasted demands for consumptive uses during the 30-year implementation timeframe (Table 3.13-5).

Operations under the NAA would result in an indirect, beneficial effect from the release of stored water from the WVS reservoirs and withdrawal from downstream reaches for municipal and industrial purposes to satisfy new water storage agreements and for agricultural irrigation during the 30-year implementation timeframe (Appendix J, Water Supply Analysis). The maximum total volume of water stored system-wide in the WVS reservoirs would be more than 1.3 million acre-feet, resulting in enough stored water to meet municipal and industrial water supply and agricultural irrigation demands. There is an 80 percent likelihood that stored water would be available to satisfy municipal and industrial water storage agreements and agricultural irrigation water service contracts (Table 3.13-5).

Table 3.13-5. Stored Water Volumes Achieved in 80 Percent of the Modeled Period of Record under the No-action Alternative.

Reservoir	Peak Stored Water (acre feet)[1]	Percent Full (%)	Earliest Date of Maximum Storage[2]
Blue River	67,865	86	May 9
Cottage Grove	22,678	79	May 18
Cougar	102,211	75	May 9
Detroit	255,770	91	May 4
Dorena	53,064	82	May 15
Fall Creek	97,949	91	May 10
Fern Ridge	84,484	90	Apr 15
Foster	24,791	100	May 10
Green Peter	238,131	95	May 9
Hills Creek	124,882	64	Apr 16
Lookout Point	307,522	95	May 9
Willamette Valley System	1,323,316	83	May 16

[1] There is an 80 percent likelihood these values would be achieved or exceeded.

[2] The 80 percent exceedance date of maximum storage does not necessarily correspond to the same year as the peak stored water in column 2. This date provides an understanding of when peak storage could be expected.

Adverse effects on water supply would also occur under the NAA in some years. Stored water would not be available to meet all municipal and industrial storage agreements and agricultural irrigation water service contracts in the dry years during the 30-year implementation timeframe under the NAA. The 2008 NMFS Biological Opinion flow target would not be met in all years over the 30-year implementation timeframe, which could require a reduction in stored water available to satisfy municipal and industrial storage agreements.

River Flow

Under the NAA, there would be beneficial effects on water supply from river flows in the analysis area as a result of USACE operations over the 30-year implementation timeframe and from river flows not subject to USACE operations. NAA operations would include flows downstream of the WVS dams to meet or exceed the 2008 NMFS Biological Opinion flow targets in most years, which would continue to support existing water use during the 30-year implementation timeframe (Appendix J, Water Supply Analysis). Regardless of beneficial water supply effects, not all water uses would be satisfied in all years and in all months under the NAA due to hydrologic conditions not subject to USACE operations and maintenance, such as dry years where river flows are low, thereby adversely affecting water supply (Table 3.13-6).

Table 3.13-6. Summary of Direct Flow Effects to Water Supply under the No-action Alternative.

Location	Effects to River Flow [1]
North Santiam River	Flow at Mehama would drop below 1,000 cfs (2008 NMFS Biological Opinion flow target) from mid-July through August during very dry years. Flows would be above the target minimum flows in most years; therefore, effects would be beneficial.
South Santiam River	Flows at Waterloo on the South Santiam River would be close to or above the 2008 NMFS Biological Opinion target of 800 cfs in all but the driest years during the summer months; therefore, effects would be beneficial.
Santiam River	Flows at Jefferson on the Santiam River, downstream of the confluence of the North and South Santiam Rivers, would remain above 1,300 cfs in all but the driest years and only in August; therefore, effects would be beneficial.
Long Tom River	Flows at the Monroe gage on the Long Tom River would drop below 30 cfs in dry years. This target would be met in most years; therefore, effects would be beneficial.
McKenzie River	Flows at Vida on the McKenzie River would be above 1,500 cfs except during late summer and early fall in dry years; therefore, effects would be beneficial.
Middle Fork Willamette River	Flows at Jasper on the Middle Fork Willamette River, downstream of Hills Creek, Lookout Point, and Fall Creek Reservoirs, would be above 1,200 cfs, except during the driest years and in late summer; therefore effects would be beneficial.
Coast Fork Willamette River	Flows at Goshen on the Coast Fork Willamette River, downstream of Dorena and Cottage Grove Reservoirs, would remain above 150 cfs except in the late summer in very dry years; therefore effects would be beneficial.
Mainstem Willamette River	Flows at Harrisburg on the Willamette River, downstream of the McKenzie River confluence, would drop below 4,000 cfs in the driest years, but would remain above 4,200 cfs in most years; therefore, effects would be beneficial. Flows at Albany on the Willamette River, upstream of the Santiam River confluence, would drop below 4,000 cfs only in the driest years; therefore, effects would be beneficial. Flows at Salem on the Willamette River, downstream of the Santiam River confluence, would remain above 5,000 cfs and typically above 6,000 cfs in most years. Flows would rarely drop below 5,000 cfs and only in late summer during the driest years; therefore, effects would be beneficial.

[1]Effects are based on modeled data from control points that correspond to gages in the respective subbasins, or Mainstem Willamette River reaches.

cfs = cubic feet per second

Alternative 1—Improve Fish Passage through Storage-focused Measures

Alternative 1 is a storage-based alternative that would result in increased system-wide water supply stored in the conservation pool during the 30-year implementation timeframe. Operations would include releasing flow according to the originally authorized flow targets, which would be less than the 2008 NMFS Biological Opinion flow targets under the NAA (Appendix A, Alternatives Development).

Stored Water

As under the NAA, there would be a direct, substantial, beneficial effect on water supply under Alternative 1 during most times of the year. However, Alternative 1 operations would provide more stored water system wide than under the NAA. Alternative 1 operations would result in stored water exceeding the volume of stored water needed to satisfy forecasted demands for consumptive uses during the 30-year implementation timeframe (Table 3.13-7).

Table 3.13-7. Reservoir Stored Water Amounts Met in 80 Percent of Water Years under Alternative 1.

Reservoir	Peak Stored Water (acre feet)[1]	Percent Full (%)	Earliest Date of Maximum Storage[2]
Blue River	78,816	100	May 10
Cottage Grove	24,494	86	May 18
Cougar	136,750	100	May 9
Detroit	281,583	100	May 4
Dorena	62,202	96	May 19
Fall Creek	103,539	96	May 10
Fern Ridge	84,484	90	Apr 15
Foster	24,791	100	May 10
Green Peter	249,880	100	May 9
Hills Creek	194,440	100	May 13
Lookout Point	304,498	94	May 9
Willamette Valley System	1,527,597	96	May 19

[1] There is an 80 percent likelihood these values would be achieved or exceeded.

[2] The 80 percent exceedance date of maximum storage does not necessarily correspond to the same year as the peak stored water in column 2. This date provides an understanding of when peak storage could be expected.

There would continue to be an indirect, adverse effect on water users in the dry years under Alternative 1 but to a lesser extent than under the NAA. Stored water would increase by approximately 166,000 acre-feet in the dry years during the 30-year implementation timeframe under Alternative 1 as compared to the NAA. However, this amount of water supply would not be adequate to meet all municipal and industrial storage agreements and agricultural irrigation water service contracts in the dry years.

River Flow

Direct, beneficial effects on water supply and indirect, beneficial effects on water users from flows in the analysis area under Alternative 1 would be the same as under NAA operations during the 30-year implementation timeframe (Table 3.13-8).

Table 3.13-8. Summary of Direct Flow Effects to Water Supply under Alternative 1.

Location	Effects to River Flow[1]
North Santiam River	Effects would be the same as those described under the NAA.
South Santiam River	Effects would be the same as those described under the NAA.
Santiam River	Effects would be the same as those described under the NAA.
Long Tom River	Effects would be the same as those described under the NAA.
McKenzie River	Effects would be the same as those described under the NAA.
Middle Fork Willamette River	Effects would be the same as those described under the NAA.
Coast Fork Willamette River	Effects would be the same as those described under the NAA.
Mainstem Willamette River	Effects would be the same as those described under the NAA.

[1] Effects are based on data from gages in corresponding subbasins or Mainstem Willamette River reaches.

<u>Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative</u>

Operations under Alternative 2A would include integrated habitat and temperature minimum tributary flow targets and reduced Mainstem Willamette River flow targets. Flow targets would vary throughout the year, would be dependent on reservoir levels relative to the rule curve, and may require water sourced from the power and inactive pools.

Stored Water

As under the NAA, there would be a direct, substantial, beneficial effect on water supply under Alternative 2A during most times of the year. However, Alternative 2A operations would provide more stored water system wide than under the NAA. Alternative 2A operations would result in stored water exceeding the volume of stored water needed to satisfy the forecasted demands for consumptive uses during the 30-year implementation timeframe (Table 3.13-9).

There would continue to be an indirect, adverse effect on water users in the dry years under Alternative 2A but to a lesser extent than under the NAA. While stored water would increase by approximately 153,282 acre-feet in the dry years during the 30-year implementation timeframe under Alternative 2A as compared to the NAA, it would not be adequate to meet all municipal and industrial storage agreements and agricultural irrigation water service contracts in the dry years.

Table 3.13-9. Reservoir Stored Water Amounts Met in 80 Percent of Water Years under Alternative 2A.

Reservoir	Peak Stored Water (acre-feet)[1]	Percent Full (%)	Earliest Date of Maximum Storage[2]
Blue River	78,816	100	May 10
Cottage Grove	24,687	86	May 18
Cougar	134,335	98	May 9
Detroit	271,377	96	May 4
Dorena	60,038	93	May 19
Fall Creek	102,673	95	May 10
Fern Ridge	84,484	90	Apr 15
Foster	24,791	100	May 10
Green Peter	243,854	98	May 9
Hills Creek	188,553	97	May 13
Lookout Point	284,375	88	May 9
Willamette Valley System	1,476,598	93	May 19

[1] There is an 80 percent likelihood these values would be achieved or exceeded.

[2] The 80 percent exceedance date of maximum storage does not necessarily correspond to the same year as the peak stored water in column 2. This date provides an understanding of when peak storage could be expected.

River Flow

As under NAA operations, effects on water supply under Alternative 2A would be directly beneficial because flows in river reaches downstream of the dams would remain above flow targets in all but dry years. This would also result in an indirect, beneficial effect on water users as under the NAA (Table 3.13-10).

Table 3.13-10. Summary of Direct Flow Effects to Water Supply under Alternative 2A.

Location	Effects on River Flow[1]
North Santiam River	Effects would be the same as those described under the NAA.
South Santiam River	Effects would be the same as those described under the NAA.
Santiam River	Effects would be the same as those described under the NAA.
Long Tom River	Effects would be the same as those described under the NAA.
McKenzie River	Effects would be the same as those described under the NAA.
Middle Fork Willamette River	Effects would be the same as those described under the NAA.

Location	Effects on River Flow[1]
Coast Fork Willamette River	Effects would be the same as those described under the NAA.
Mainstem Willamette River	Effects would be the same as those described under the NAA.

[1] Effects are based on data from gages in corresponding subbasins or Mainstem Willamette River reaches.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

In addition to the fall drawdowns at Green Peter and Fall Creek Reservoirs under Alternative 2B operations, Cougar Reservoir would be drawn down to elevation 1,330 feet to use the diversion tunnel to pass fish in both the spring and fall.

Stored Water

As under the NAA, there would be a direct, beneficial effect on water supply and an indirect, beneficial effect on water users under Alternative 2B. However, the benefit under Alternative 2B operations would be slightly less beneficial than under NAA operations because, although stored water would be available for nearly all the forecasted consumptive use demands, it would not be enough to meet all the demands (Table 3.13-11).

Table 3.13-11. Reservoir Stored Water Amounts Met in 80 Percent of Water Years under Alternative 2B.

Reservoir	Peak Stored Water (acre-feet)[1]	Percent Full (%)	Earliest Date of Maximum Storage[2]
Blue River	78,816	100	May 10
Cottage Grove	24,704	86	May 18
Cougar	0	0	Feb 1
Detroit	271,377	96	May 4
Dorena	60,220	93	May 19
Fall Creek	102,694	95	May 10
Fern Ridge	84,484	90	Apr 15
Foster	24,791	100	May 10
Green Peter	243,854	98	May 9
Hills Creek	188,222	97	May 13
Lookout Point	292,232	90	May 9
Willamette Valley System	1,284,159	81	May 19

[1] There is an 80 percent likelihood these values would be achieved or exceeded.

[2] The 80 percent exceedance date of maximum storage does not necessarily correspond to the same year as the peak stored water in column 2. This date provides an understanding of when peak storage could be expected.

Blue River Reservoir water releases would compensate for reduced storage potential in Cougar Reservoir under Alternative 2B. This release would support water supply requirements on the McKenzie River and for demands on the Mainstem Willamette River, downstream of the McKenzie River confluence.

As under the NAA, there would continue to be an indirect, adverse effect on water users in the dry years under Alternative 2B during the 30-year implementation timeframe.

River Flow

As under NAA operations, effects on water supply under Alternative 2B would be directly beneficial because flows in river reaches downstream of the dams would remain above flow targets in all but dry years during the 30-year implementation timeframe. This would also result in an indirect, beneficial effect on water users as under the NAA (Table 3.13-12).

Table 3.13-12. Summary of Direct Flow Effects to Water Supply under Alternative 2B.

Location	Effects to River Flow[1]
North Santiam River	Effects would be the same as those described under the NAA.
South Santiam River	Effects would be the same as those described under the NAA.
Santiam River	Effects would be the same as those described under the NAA.
Long Tom River	Effects would be the same as those described under the NAA.
McKenzie River	The spring drawdown to elevation 1,330 feet at Cougar Reservoir would affect the flow at Vida on the McKenzie River differently than under NAA operations by season and by hydrologic conditions. Flows at Vida in the driest years could drop below 1,500 cfs in the late summer, but only in the driest years; therefore, effects would be the same as those described under the NAA.
Middle Fork Willamette River	Effects would be the same as those described under the NAA.
Coast Fork Willamette River	Effects would be the same as those described under the NAA.
Mainstem Willamette River	Effects would be the same as those described under the NAA.

[1] Effects are based on data from gages in corresponding subbasins or Mainstem Willamette River reaches.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

Unlike the NAA operations, Alternative 3A operations would combine spring spill and drawdowns with fall drawdowns at 6 of the 11 reservoirs: Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point Reservoirs.

Stored Water

Compared to the NAA, Alternative 3A would result in a direct, substantial, adverse effect on water supply because the combined operations would adversely affect system-wide conservation storage during the 30-year implementation timeframe (i.e., WVS combined storage of only 593,485 acre-feet) (Table 3.13-13).

Table 3.13-13. Reservoir Stored Water Amounts Met in 80 Percent of Water Years under Alternative 3A.

Reservoir	Peak Stored Water (acre-feet)[1]	Percent Full (%)	Earliest Date of Maximum Storage[2]
Blue River	78,816	100	May 10
Cottage Grove	24,289	85	May 18
Cougar	0	0	Feb 1
Detroit	0	0	Feb 1
Dorena	60,538	94	May 19
Fall Creek	103,484	96	May 10
Fern Ridge	84,484	90	Apr 15
Foster	24,791	100	May 10
Green Peter	243,937	98	May 9
Hills Creek	191,537	99	May 10
Lookout Point	7,030	2	Aug 13
Willamette Valley System	593,485	37	May 22

[1] There is an 80 percent likelihood these values would be achieved or exceeded.

[2] The 80 percent exceedance date of maximum storage does not necessarily correspond to the same year as the peak stored water in column 2. This date provides an understanding of when peak storage could be expected.

Due to conditions in the Willamette Basin Review Feasibility Study Biological Opinion (NMFS 2019b), water that would be stored in the WVS reservoirs would be used primarily to support minimum flows for fish and wildlife under Alternative 3A. The reduced storage as compared to the NAA would result in no water available for municipal and industrial water supply or agricultural irrigation water users during the 30-year implementation timeframe, and would be an indirect, substantial, adverse effect on these users.

River Flow

Direct effects on river flow supply and indirect effects to water users under Alternative 3A would be the same as described under the NAA except in the North Santiam River Subbasin (Table 3.13-14). In this subbasin, the spring drawdown at Detroit Reservoir would eliminate the ability to store water to augment naturally low flows in the summer as compared to the NAA during the 30-year implementation timeframe. This would be an indirect, adverse effect to water users dependent on flows below Detroit Dam.

Table 3.13-14. Summary of Direct Effects to Water Supply under Alternative 3A.

Location	Effects to River Flow[1]
North Santiam River	Due to the spring drawdown and need to pass inflows instead of storing water, flows at Mehama in the spring from March through early to late May, depending on the type of water year, would be higher under Alternative 3A as compared to the NAA. Starting in June, flows at Mehama could drop to less than 750 cfs for extended periods about 50 percent of the time. This could cause curtailment of water rights for municipal and industrial water supply and agricultural irrigation. Infrastructure at the City of Salem, Oregon drinking water intake facility and Santiam Water Control District at Geren Island would be impacted when flows are lower than 750 cfs due to physical limitations of the intake infrastructure. The effects from this alternative would be adverse.
South Santiam River	Effects would be the same as those described under the NAA.
Santiam River	Flows at Jefferson under Alternative 3A would be affected by the combination of a spring drawdown operation at Detroit Reservoir and fall drawdown operations at both Detroit and Green Peter Reservoirs, but would generally remain above 1,300 cfs; therefore, effects would be the same as those described under the NAA.
Long Tom River	Effects would be the same as those described under the NAA.
McKenzie River	Effects would be the same as those described under the NAA.
Middle Fork Willamette River	Effects would be the same as those described under the NAA.
Coast Fork Willamette River	Effects would be the same as those described under the NAA.
Mainstem Willamette River	Effects would be the same as those described under the NAA at Harrisburg and Salem. Flows at Albany would be lower than under the NAA from April through mid-June during the driest years and nearly equal to NAA flows during the summer months. Flows lower than biological minimum target would occur sporadically and not for extended periods of time, except during the driest years, when low flows may persist.

[1] Effects are based on data from gages in corresponding subbasins or Mainstem Willamette River reaches.

<u>Alternative 3B—Improve Fish Passage through Operations-focused Measures</u>

Stored Water

As under Alternative 3A, Alternative 3B operations would also combine spring spill and drawdowns with fall drawdowns at 6 of the 11 reservoirs: Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point Reservoirs, but would result in slightly higher combined stored water than under Alternative 3A.

Unlike the NAA, there would be a direct, substantial, adverse effect on water supply under Alternative 3B because the combined operations for fish passage would adversely affect system-wide conservation storage during the 30-year implementation timeframe (i.e., WVS combined water storage of only 765,837 acre-feet) (Table 3.13-15).

Table 3.13-15. Reservoir Stored Water Amounts Met in 80 Percent of Water Years under Alternative 3B.

Reservoir	Peak Stored Water (acre-feet)[1]	Percent Full (%)	Earliest Date of Maximum Storage[2]
Blue River	78,816	100	May 10
Cottage Grove	24,488	86	May 18
Cougar	0	0	Feb 1
Detroit	271,377	96	May 4
Dorena	60,378	93	May 19
Fall Creek	102,599	95	May 10
Fern Ridge	84,484	90	Apr 15
Foster	24,791	100	May 10
Green Peter	0	0	Feb 1
Hills Creek	4,006	2	Jul 7
Lookout Point	323,990	100	May 9
Willamette Valley System	765,837	48	Jun 2

[1] There is an 80 percent likelihood these values would be achieved or exceeded.

[2] The 80 percent exceedance date of maximum storage does not necessarily correspond to the same year as the peak stored water in column 2. This date provides an understanding of when peak storage could be expected.

Due to conditions in the Willamette Basin Review Feasibility Study Biological Opinion (USACE 2019a), water that would be stored in the WVS reservoirs would be used primarily to support minimum flows for fish and wildlife under Alternative 3B. The reduced storage as compared to the NAA would result in no water available for municipal and industrial drinking water users during the 30-year implementation timeframe and would be an indirect, substantial, adverse effect on these users.

River Flow

Effects on river flow water supply and to water users under Alternative 3B would be the same as described under the NAA except in the South Santiam River Subbasin (Table 3.13-16). In this subbasin, the spring drawdown at Green Peter Reservoir would eliminate the ability to store water to augment naturally low flows in the summer as compared to the NAA during the 30-year implementation timeframe. This would be an indirect, adverse effect to water users dependent on flows below Green Peter Dam.

Table 3.13-16. Summary of Direct Flow Effects to Water Supply under Alternative 3B.

Location	Effects to River Flow[1]
North Santiam River	Effects would be the same as those described under the NAA.
South Santiam River	Due to the spring drawdown operation, Green Peter Reservoir would rarely fill into the conservation pool, nearly eliminating the ability to augment naturally low flows in the summer. Due to the spring drawdown and need to pass inflows instead of storing water, flows at Waterloo in the spring from March through early to late May, depending on the type of water year, would be higher under Alternative 3B as compared to the NAA. Starting in June (May for driest years), flows at Waterloo could drop to near 100 cfs for extended periods about 25 percent of the time as there would be little to no water in the Green Peter Reservoir conservation pool to augment naturally low flows. Therefore, effects from this alternative would be adverse.
Santiam River	Effects would be the same as those described under the NAA.
Long Tom River	Effects would be the same as those described under the NAA.
McKenzie River	Effects would be the same as those described under the NAA.
Middle Fork Willamette River	Effects would be the same as those described under the NAA.
Coast Fork Willamette River	Effects would be the same as those described under the NAA.
Mainstem Willamette River	Effects would be the same as those described under the NAA.

[1] Effects are based on data from gages in corresponding subbasins or Mainstem Willamette River reaches.

Alternative 4—Improve Fish Passage with Structures-based Approach

Operations under Alternative 4 would include an integrated habitat and temperature flow regime.

Stored Water

As under the NAA, there would be a direct, substantial, beneficial effect on water supply under Alternative 4 during most times of the year. However, Alternative 4 operations would provide more stored water system wide than under the NAA. Alternative 4 operations would result in stored water exceeding the volume of stored water needed to satisfy the forecasted demands for consumptive uses during the 30-year implementation timeframe (Table 3.13-17). This would be an indirect, substantial, benefit to water users.

There would continue to be an indirect, adverse, effect on water users in the dry years under Alternative 4 but to a lesser extent than under the NAA. Regardless of this improvement , while stored water would increase by approximately 153,000 acre-feet in the dry years during the 30-year implementation timeframe under Alternative 4 as compared to the NAA, it would not be adequate to meet all municipal and industrial storage agreements and agricultural irrigation water service contracts in the dry years.

Table 3.13-17. Reservoir Stored Water Amounts Met in 80 Percent of Water Years under Alternative 4.

Reservoir	Peak Stored Water (acre-feet)[1]	Percent Full (%)	Earliest Date of Maximum Storage[2]
Blue River	78,816	100	May 10
Cottage Grove	24,483	86	May 18
Cougar	134,466	98	May 9
Detroit	271,377	96	May 4
Dorena	60,038	93	May 19
Fall Creek	102,649	95	May 10
Fern Ridge	84,484	90	Apr 15
Foster	24,791	100	May 10
Green Peter	243,863	98	May 9
Hills Creek	188,647	97	May 13
Lookout Point	291,052	90	May 9
Willamette Valley System	1,476,539	93	May 19

[1] There is an 80 percent likelihood these values would be achieved or exceeded.

[2] The 80 percent exceedance date of maximum storage does not necessarily correspond to the same year as the peak stored water in column 2. This date provides an understanding of when peak storage could be expected.

River Flow

Direct effects on river flow water supply and indirect effects to water users under Alternative 4 would be the same as described under the NAA (Table 3.13-18).

Table 3.13-18. Summary of Direct Flow Effects to Water Supply under Alternative 4.

Location	Effects to River Flow[1]
North Santiam River	Effects would be the same as those described under the NAA.
South Santiam River	Effects would be the same as those described under the NAA.
Santiam River	Effects would be the same as those described under the NAA.
Long Tom River	Effects would be the same as those described under the NAA.
McKenzie River	Effects would be the same as those described under the NAA.
Middle Fork Willamette River	Effects would be the same as those described under the NAA.
Coast Fork Willamette River	Effects would be the same as those described under the NAA.
Mainstem Willamette River	Effects would be the same as those described under the NAA.

[1] Effects are based on data from gages in corresponding subbasins or Mainstem Willamette River reaches.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Alternative 5 operations would include integrated habitat and temperature minimum mainstem and tributary flow targets similar to Alternative 2B operations but with higher targets on the Mainstem Willamette River.

Stored Water

Direct effects on stored water supply and indirect effects to water users would be the same as described under Alternative 2B although there would be slight differences in stored water amounts under Alternative 5 (Table 3.13-19).

Table 3.13-19. Reservoir Stored Water Amounts Met in 80 Percent of Water Years under Alternative 5.

Reservoir	Peak Stored Water (acre-feet)[1]	Percent Full (%)	Earliest Date of Maximum Storage[2]
Blue River	78,227	99	May 10
Cottage Grove	24,075	84	May 18
Cougar	0	0	Feb 1
Detroit	271,377	96	May 4
Dorena	58,552	91	May 19
Fall Creek	101,494	94	May 10
Fern Ridge	84,615	90	Apr 15
Foster	24,791	100	May 10
Green Peter	239,571	96	May 9
Hills Creek	162,494	84	May 13
Lookout Point	292,401	90	May 9
Willamette Valley System	1,269,122	80	May 19

[1] There is an 80 percent likelihood these values would be achieved or exceeded.

[2] The 80 percent exceedance date of maximum storage does not necessarily correspond to the same year as the peak stored water in column 2. This date provides an understanding of when peak storage could be expected.

River Flow

Direct effects on river flow to water supply and indirect effects to water users under Alternative 5 would be the same as described under the NAA (Table 3.13-20).

Table 3.13-20. Summary of Direct River Flow Effects to Water Supply under Alternative 5.

Location	Effects to River Flow[1]
North Santiam River	Effects would be the same as those described under the NAA.
South Santiam River	Effects would be the same as those described under the NAA.
Santiam River	Effects would be the same as those described under the NAA.
Long Tom River	Effects would be the same as those described under the NAA.
McKenzie River	Effects would be the same as those described under the NAA.
Middle Fork Willamette River	Effects would be the same as those described under the NAA.
Coast Fork Willamette River	Effects would be the same as those described under the NAA.
Mainstem Willamette River	Effects would be the same as those described under the NAA.

[1] Effects are based on data from gages in corresponding subbasins or Mainstem Willamette River reaches.

3.13.4 Interim Operations under All Action Alternatives Except Alternative 1

The Interim Operations are a set of operations for downstream fish passage and temperature management that would be implemented until the long-term measure for fish passage or temperature management is being used. These operations would result in decreased system-wide stored water in the conservation pool.

The timing and duration of Interim Operations would vary depending on a given alternative. Interim Operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternatives, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations will be implemented in succession with, and not in addition to, action alternative implementation.

3.13.4.1 Stored Water

There would be a slight, beneficial, direct effect on water supply and a slight, beneficial, indirect effect to users under Interim Operations during most times of the year because the amount of water stored system wide would be slightly more than the amount needed to support minimum flow targets during the 30-year implementation timeframe with 80 percent likelihood (Table 3.13-21). Stored water would be available to meet some municipal and industrial storage agreements and agricultural irrigation water service contracts under the Interim Operations.

Table 3.13-21. Reservoir Stored Water Amounts Met in 80 Percent of Water Years under Interim Operations.

Reservoir	Peak Stored Water (acre feet)[1]	Percent Full (%)	Earliest Date of Maximum Storage[2]
Blue River	71,571	91	May 10
Cottage Grove	23,426	82	May 18
Cougar	13,312	10	Jun 18
Detroit	253,917	90	May 4
Dorena	54,822	85	May 14
Fall Creek	99,897	92	May 10
Fern Ridge	84,615	90	Apr 15
Foster	24,791	100	May 18
Green Peter	215,986	86	May 9
Hills Creek	145,331	75	May 13
Lookout Point	194,090	60	Mar 22
Willamette Valley System	1,155,663	73	May 24

[1] There is an 80 percent likelihood these values would be achieved or exceeded.

[2] The 80 percent exceedance date of maximum storage does not necessarily correspond to the same year as the peak stored water in column 2. This date provides an understanding of when peak storage could be expected.

3.13.4.2 River Flow

Direct effects on river flow to water supply and indirect effects to water users under the Interim Operations would be the same as described under the NAA (Table 3.13-22).

Table 3.13.22. Summary of Direct River Flow Effects to Water Supply under Interim Operations.

Location	Effects to River Flow[1]
North Santiam River	Effects would be the same as those described under the NAA.
South Santiam River	Effects would be the same as those described under the NAA.
Santiam River	Effects would be the same as those described under the NAA.
Long Tom River	Effects would be the same as those described under the NAA.
McKenzie River	Effects would be the same as those described under the NAA.
Middle Fork Willamette River	Effects would be the same as those described under the NAA.
Coast Fork Willamette River	Effects would be the same as those described under the NAA.
Mainstem Willamette River	Effects would be the same as those described under the NAA.

[1] Effects are based on data from gages in corresponding subbasins or Mainstem Willamette River reaches.

3.13.4.3 Groundwater

Direct effects on groundwater supply and indirect effects on groundwater supply users under the Interim Operations would be the same as those described under the alternatives analyses (Section 3.13.3.2, Alternatives Analyses, Groundwater Supply and Use under All Alternatives).

3.13.5 Climate Change under All Alternatives

Climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions and independent of the WVS operations and maintenance activities over the 30-year implementation timeframe (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources, Section 3.1 Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

Regarding agricultural irrigation uses, Oregon's 2015 Statewide Long-Term Water Demand Forecast provided an estimated 35-year increase of 102,700 acre-feet of water per year under hotter, drier climate conditions (OWRD 2015)[5]. OWRD estimated an increase of 605,700 acre-feet of water per year diverted for agricultural irrigation use within the Willamette River Basin by 2050. This study looked only at the amount of water that may be needed under a future climate scenario for existing lands currently covered by irrigation water rights and did not include irrigation demand for new lands brought into agricultural production.

Climate change would have an adverse effect on water supply and to municipal and industrial water and agricultural irrigation users under any alternative. Increased climate variability in the spring shoulder months, drier hotter summers, and lower summer baseflow are the most impactful climate change factors affecting conservation season water supply operations. Consequently, water supply from water stored in analysis area reservoirs and groundwater wells and from river flow may be adversely affected in the long term under any alternative. Additionally, decreased summer baseflows would adversely affect water users under any alternative as there may not be adequate water in the rivers to satisfy existing water rights.

Climate change may result in less reliable refill of the reservoirs and drafting earlier in the year to minimum conservation elevations to support downstream minimum flow targets. Operations in reservoirs that have a spring drawdown for fish passage would refill less under climate change conditions because seasonal drier hydrologic conditions would start earlier under climate change conditions.

[5] The 2015 Statewide Long-Term Water Demand Forecast was the most current information available at the time the alternatives were analyzed regarding increased demands due to climate change.

River flow in the summer would likely decrease due to climate change because of lower snowpack, which sustains summer baseflows. Consequently, this would adversely affect water users because there may not be adequate water in the rivers to satisfy municipal and industrial water supply agreements.

END REVISED TEXT

Unknown Photo Credit (USACE Media Images Database)
Detroit Dam.

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Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.14 RECREATION RESOURCES

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3.14 Recreation Resources

THE RECREATION RESOURCES SECTION HAS BEEN REVISED IN ITS ENTIRETY FROM THE DEIS

Summary of changes from the DEIS:

- **The scope of review has been revised to address only effects on recreation opportunities. Economic effects from recreation opportunities under each alternative, including community impacts, are analyzed in Section 3.11, Socioeconomics. Information on the quality of recreation experiences has been deleted because it is subjective and, therefore, does not contribute to informed decision-making.**
- **Information on the analysis area has been updated to clarify the revised scope in FEIS Section 3.14.2.1, Analysis Area.**
- **Recreation opportunity descriptions have been updated in FEIS Section 3.14.2.2, Analysis Area Recreation Opportunities. Opportunities have been categorized as water-based, land-based, or river-based.**
- **Additional information on recreation site managing agencies or private organizations in the analysis area has been added in FEIS Section 3.14.2.3, Recreation Site Management.**
- **Additional information on wildfire activity has been added to Section 3.14.2.4, Analysis Area Wildfires, and to reservoir area descriptions as applicable.**
- **Additional information on visitation data collection has been provided in FEIS Section 3.14.2.5, Analysis Area Recreation Visitation, Visitation Data Collection Methodology.**
- **Reservoir area descriptions have been revised to focus on opportunities pertinent to the analysis of impacts and to delete extraneous information such as detailed descriptions of all amenities at a recreation site in FEIS Section 3.14.2.6, Recreation Opportunities at Willamette Valley System Reservoirs.**
- **Visitation data at each reservoir by activity type have been updated to the most recently available data to include USFWS-managed campground lands in FEIS Section 3.14.2.6, Recreation Opportunities at Willamette Valley System Reservoirs.**
- **Tables, including a summary of visitation by activity, land-based and water-based opportunities totals, total reservoir visitation by opportunity type, and a ranking of reservoir visitation by opportunity type, have been added to the end of FEIS Section 3.14.2.6, Recreation Opportunities at Willamette Valley System Reservoirs.**

Summary of changes from the DEIS, continued:

- **Additional information on river-based recreation has been added to FEIS Section 3.14.2.7, River-based Recreation.**
- **The analyses have been modified to compare degree of effect between each alternative and the degree of effect under the No-action Alternative rather than demonstrating a degree of change, which may minimize actual effect outcomes (e.g., a degree of change could be negligible, but the degree of effect remains substantially adverse when compared to the No-action Alternative). The criteria discussion reflects this modification (FEIS Section 3.14.3.1, Methodology, Effects Criteria).**
- **Direct and indirect effects criteria have been added to FEIS Section 3.14.3, Environmental Consequences.**
- **The DEIS analyses were also modified by correlating effects from operations under each alternative with visitor data as described in Section 3.14.3, Environmental Consequences. Definitions of direct and indirect effects have also been provided.**
- **Effects analyses are presented by water-based recreation opportunities, land-based recreation opportunities, and recreation site management categories under each alternative for consistent analyses comparison in FEIS Section 3.14.3.2, Alternatives Analyses. Direct and indirect effects have been identified under each alternative.**
- **Analyses of effects to managing agencies have been added in Section 3.14.3, Environmental Consequences.**
- **Information on river flows for river-based recreation has been added to Section 3.14.3, Environmental Consequences, River-based Recreation Opportunities Quantitative Methodology.**
- **Analysis includes effects of displaced recreation visitation from drawdown operations where applicable in FEIS Section 3.14.3.2, Alternatives Analyses.**
- **The Near-term Operations Measures analyses have been combined in FEIS Section 3.14.4 Interim Operations under All Alternatives Except Alternative 1. The term "Near-term Interim Operations" has been changed to "Interim Operations" throughout the EIS. Additional information on operations timing has been added.**

Summary of changes from the DEIS, continued:

- **The climate change analysis has been revised to include specific information pertinent to each alternative and wildfire-related effects in FEIS Section 3.14.5, Climate Change under All Alternatives. DEIS Information not supported by other FEIS analyses has been deleted.**

3.14.1 Introduction

THE DEIS HAS BEEN MODIFIED TO REVISE ALL INFORMATION IN THE FEIS

Recreation is a Congressionally authorized purpose for operations of the Willamette Valley System (WVS) dams (Chapter 1, Introduction, Section 1.10, Congressionally Authorized Purposes). This analysis of recreation resources focuses on recreation opportunities provided at managed recreation sites and facilities under each of the alternatives. Information specific to the various agencies and organizations managing recreation opportunities is provided. Economic impacts related to recreation, such as visitation, employment, and effects on local communities, are addressed in Section 3.11, Socioeconomics.

3.14.2 Affected Environment

3.14.2.1 Analysis Area

The analysis area is defined as the Willamette River Basin boundary, which encompasses 13 WVS dams and reservoirs (Chapter 1, Introduction, Section 1.1, Background) and numerous rivers. Recreation sites within the analysis area are managed by USACE and other agencies and organizations as described below. The analysis area overlaps with the Willamette National Forest, Umpqua National Forest, and Mt. Hood National Forest; however, none of the USACE reservoirs are located within the Umpqua National Forest or Mt. Hood National Forest. All or portions of Detroit, Big Cliff, Cougar, Blue River, Lookout Point, and Hills Creek Reservoirs are located within the Willamette National Forest.

3.14.2.2 Analysis Area Recreation Opportunities

Analysis Area Water-based Recreation Opportunities:

fishing, boating, swimming, waterskiing, and facilities such as boat ramps, marinas, and docks

Analysis Area Land-based Recreation Opportunities:

camping; picnicking; hiking; biking; cross-country skiing; snowshoeing; wildlife viewing; hunting; plant foraging; and sightseeing around reservoirs accessed by campgrounds, day use areas, trails, and local roads

Analysis Area River-based Recreation Opportunities:

boating, kayaking, rafting, canoeing, sailing, fishing, and swimming

The Willamette River Basin includes recreation opportunities associated with 13 dams and reservoirs managed by USACE, and river-based recreation (Section 13.4.2.7, River Recreation). Reservoirs within the Willamette Valley System (WVS) support numerous recreation opportunities. Within the WVS, USACE cooperates with the U.S. Forest Service (USFS), Oregon Parks and Recreation Department (OPRD), Oregon Department of Fish and Wildlife (ODFW), U.S. Bureau of Land Management (BLM), Lane County, Linn County, and private organizations to build and manage more than 50 recreation sites around USACE reservoirs.

Primary recreation uses in the analysis area are water-based. At the time the alternatives were analyzed, visitation for water-based recreation opportunities was highest at Fern Ridge and Foster Reservoirs.

Fishing is a key water-based activity at all WVS reservoirs. Reservoirs support fishing for a variety of species, particularly in Detroit, Green Peter, Lookout Point, and Hills Creek Reservoirs, which are the largest reservoirs in the WVS. Kokanee, smallmouth bass, rainbow trout, and crappie are the key fish species targeted in sport fishing in the larger reservoirs (Section 3.8, Fish and Aquatic Habitat). Fishing licenses are managed by ODFW (ODFW 2024d).

Fishing is a principal activity in the analysis area accessed primarily by boat ramps at developed recreation sites. However, this opportunity is restricted by seasonal low reservoir levels in all reservoirs (i.e., when water levels are below minimum pool level). Low reservoir levels preclude use of boat ramps during various months of a given year.

Consistent with water-based visitation, visitation for land-based recreation opportunities was also highest at Fern Ridge and Foster Reservoirs at the time the alternatives were analyzed. In addition to numerous land-based opportunities, the land-based hunting series in the analysis area includes deer, elk, bear, pronghorn, bighorn sheep, antlerless deer, and Rocky Mountain goat. Hunting licenses, tags, and permits are managed by ODFW (ODFW 2024d).

The analysis area also includes opportunities for wild plant foraging. The area supports many species popular with foragers such as huckleberries and mushrooms. Several agencies manage permits necessary for foraging—the BLM issues permits for truffle collection; the USFS Siuslaw National Forest, Umpqua National Forest, and Willamette National Forest issue permits to collect several types of mushrooms; and OPRD issues general consumption, plant harvest permits.

3.14.2.3 Recreation Site Management

USACE and several agencies and private organizations cooperate to build and manage recreation sites or to provide non-facility-related recreation opportunities in the analysis area as described below.

U.S. Army Corps of Engineers

USACE manages 64 recreation sites within the analysis area. These include 602 picnic sites, 178 camp sites, 14 swimming areas, 20 trails totaling 67 miles, 1 fishing dock, and 32 boat ramps.

U.S. Bureau of Land Management

BLM manages lands in the Willamette River Basin in the vicinity of the WVS and provides opportunities for plant foraging and hunting. BLM also manages developed recreation sites in the analysis area, including day use areas, hiking trails, boating, OHV trails, and dispersed camping.

Rivers designated as wild and scenic by Congress or the U.S. Department of Interior[1] are managed in the analysis area. BLM manages rivers designated as wild and scenic on lands managed by BLM. In the analysis area, these include Quartzville Creek, Molalla River, and sections of Elkhorn Creek.

Partner Agencies for Analysis Area Recreation Site Management:

Federal
U.S. Bureau of Land Management
U.S. Fish and Wildlife Service
U.S. Forest Service

State
Oregon Department of Fish and Wildlife
Oregon Parks and Recreation Department

County
Lane County
Linn County

U.S. Forest Service

Many recreation sites located within the Willamette National Forest are managed by the USFS. The National Forest spans 110 miles along the western slopes of the Cascade Mountain Range and offers visitors views of high mountains, narrow canyons, cascading streams, and wooded slopes (USFS 2021).

Recreation opportunities managed by the USFS include day-use areas, boat ramps, and several developed campsites as well as dispersed camping. Additionally, USFS manages hiking trails, plant foraging, and water-based activities. Hunting is also allowed on USFS-managed lands in the analysis area.

[1] The BLM is an agency under the U.S. Department of Interior.

USFS also manages rivers designated as wild and scenic on lands managed by the agency in the analysis area, including the McKenzie River, South Fork Clackamas, Fish Creek, Collawash River, Clackamas River, and sections of Elkhorn Creek.

Oregon Department Fish and Wildlife

ODFW manages fishing, big game, and game bird licensing in the analysis area. ODFW also manages several fish hatcheries and fish stocking operations and provides wildlife viewing areas throughout the analysis area.

Oregon Parks and Recreation Department

OPRD manages several sites throughout the analysis area, including developed campsites, day use areas, water-based activities, sightseeing, and other recreation opportunities.

Lane County

Lane County analysis area management includes several developed campsites, day use areas, water-based activities, sightseeing, and recreation opportunities.

Linn County

Linn County also manages developed campsites, day use areas, water-based activities, sightseeing, and other recreation opportunities.

Private Organizations

Several private organizations operate facilities associated with reservoir use in the analysis area (e.g., Kane's and Detroit Lake Marinas on Detroit Reservoir, the Eugene Yacht Club on Fern Ridge Reservoir, Oregon Association of Rowers, and University of Oregon boathouse on Dexter Reservoir). These facilities include camping and marinas for boating opportunities and providing food, gas, and recreation supplies.

3.14.2.4 Analysis Area Wildfires

Wildfires are a continuing threat in the analysis area. During the 2020 wildfire season, four wildfires—Beachie Creek, Lionshead, P-515[2], and Holiday Farm—damaged many recreation sites, forest structures, and road corridors in parts of the Willamette National Forest (USFS 2020a).

These wildfires greatly reduced the Willamette National Forest by burning 176,000+ acres of the total forested area (USFS 2024). Impacts to recreation opportunities from wildfires include area closures due to loss or for safety (e.g., trails, campgrounds, and access); vegetation loss

[2] 2020 wildfires in the North Santiam River Subbasin included the Beachie Creek, Lionshead, and P-515 Fires. These fires combined and formed the Santiam Fire. The Holiday Farm Fire occurred in the McKenzie River Subbasin (Section 3.6, Vegetation, Section 3.6.2.3, 2020 Wildfires).

important for sightseeing, plant foraging, and hiking; and wildlife habitat loss important for wildlife viewing and hunting. As a result of the wildfires, buildings at both private marinas on Detroit Reservoir were lost, but the lakes were drawn down during the fires, allowing flames to pass over the docks. The Kane and Detroit Lake Marinas were operational and rebuilding or expanding their facilities at the time the alternatives were analyzed.

Beachie Creek Fire

The Beachie Creek Fire, which began in August 2020, resulted in damage to highly valued natural and cultural resources, including:

- 31.1 miles of trails of concern (trails within moderate to high soil burn severity areas)
- 14 trailheads
- 3 campgrounds
- 3 day-use areas
- an historic guard station (USFS 2020b)

This wildfire included areas on the USFS Detroit Ranger District in the Willamette National Forest and a portion of the Clackamas River Ranger District. Closures to prevent the public from entering areas with hazard tree danger and debris flow damage were necessary at the time the alternatives were analyzed until hazards can be fully removed or signage can be placed to indicate the hazards present (USFS 2020b). As of July 2024, over 100 sites remained closed due to fire-related dangers (USFS 2024).

Lionshead Fire

The Lionshead Fire also began in 2020 in the Lionshead Canyon on the Confederated Tribes of Warm Spring Reservation, approximately 14 miles west of the Warm Springs community. Damage to highly valued natural and cultural resources included:

- 28 miles of trail with moderate to high soil burn severity
- 22 trailheads
- 18 campgrounds
- 3 day-use areas
- an historic guard station (USFS 2020c).

Closures to prevent the public from entering areas with hazard tree danger and debris flow damage are necessary until hazards can be fully removed or signage can be placed to indicate the hazards present. As of September 2024, several campgrounds and recreation trails remained closed due to fire-related damage (USFS 2020c).

Holiday Farm Fire

The Holiday Farm Fire began in September 2020 approximately 3 miles west of McKenzie Bridge, Oregon. Fire damage impacted 173,000 acres of mixed conifer forest supporting the following recreation opportunities:

- 3 campgrounds
- 2 boat ramps
- 1 trail
- Areas around the designated McKenzie Wild and Scenic River were damaged (USFS 2020d).

3.14.2.5 Analysis Area Recreation Visitation

Access to managed recreation sites is available year-round at some reservoirs in the analysis area. However, several of the reservoirs are heavily used for recreation purposes during the USACE operational conservation season[3] between April 1 and October 31 (Section 3.2.1.4, Hydrologic Processes, Flow Management Goals). The peak recreation season analyzed under the alternatives is May 15 to September 15.

Visitation to WVS reservoirs slowly increases from April to May, followed by peak visitation between Memorial Day and Labor Day. There is a decline in visitation after September. Visitation numbers do not necessarily reflect the carrying capacity of facilities at a reservoir because reservoirs vary in size and have different facilities that can support a varying number of visitors.

Maximum visitor capacity at reservoir campgrounds, picnic and day-use areas, and boat ramps (including parking areas) is regularly met throughout the analysis area, especially on weekends, during the peak recreation season. The three most visited reservoirs for recreation opportunities at the time the alternatives were analyzed, in order of most use and highest visitation numbers, were Fern Ridge, Foster, and Dexter Reservoirs. Fern Ridge and Foster Reservoirs were most visited for water-based recreation, but these reservoirs were also popular for land-based recreation. Visitors participating in land-based recreation at Dexter Reservoir were slightly higher than those participating in water-based recreation.

Detroit Reservoir is typically one of the most popular reservoirs in the analysis area with high visitation numbers, although 2022 visitation numbers used in this analysis do not reflect this information. Lower visitation numbers in 2022 likely resulted from the reservoir and surrounding area recovering from wildfire damage due to the Santiam Fire, including damage to recreation facilities, no access to potable water, and prohibited or limited public access in

[3] The term "conservation season" encompasses spring, summer, and fall seasons and is composed of the "conservation storage season" and the "conservation use season" (when reservoir water is used most often). The conservation season is in contrast to the flood season.

recovery areas. Additionally, visitors likely chose to recreate at surrounding reservoirs not impacted by the fires once access was allowed given the surrounding aesthetic damage and limited public services during recovery. Seasonally, Foster, Fern Ridge, and Detroit Reservoirs are the last to be drained to meet summer instream flow objectives; therefore, they provide recreation later into the summer season and had the highest overall visitation at the time the alternatives were analyzed (USACE 2019a).

Visitation at each reservoir at the time the alternatives were analyzed is described in Section 3.14.2.6, Recreation Opportunities at Willamette Valley System Reservoirs and represents 2022 data[4].

Summaries of visitation by activity type and opportunity type are provided in Table 3.14-25, Table 3.14-26, Table 3.14-27, and Table 3.14-28 at the end of Section 3.14.2.6, Recreation Opportunities at Willamette Valley System Reservoirs.

Visitation Data Collection Methodology

USACE collects data on annual visitation to each of its dams and reservoirs through the Natural Resources Management Assessment, Operations and Maintenance Business Information Link, Visitation Estimation & Reporting System (VERS), and National Recreation Reservation System. Data from these resources represent visitation to recreation sites, including campgrounds, managed by USACE, OPRD, Linn and Lane Counties, BLM, and USFS within the Willamette River Basin. A summary of these data is provided for each reservoir in a Value to the Nation Fast Facts report prepared by USACE and provided in Section 3.14.2.6, Recreation Opportunities at Willamette Valley System Reservoirs.

Data on the number of visits are collected over the Federal Fiscal Year, which begins October 1 and ends September 30. A “visit” is defined as the entry of one person onto a USACE site to engage in one or more recreation activities regardless of the length of stay.

Visitation data in Section 3.14.2.6, Recreation Opportunities at Willamette Valley System Reservoirs, do not reflect total exact recreation visitation numbers in the analysis area at the time the alternatives were analyzed because of data collection limitations[5] (Appendix K, Recreation Analysis). Specifically, visitation information represents managed and quantifiable recreation opportunities in, or associated with, developed recreation areas (e.g., camping in campgrounds, picnicking in day-use sites). Some estimations were made.

VERS data provide estimated visitation figures for campgrounds located on USACE/Federal fee-owned land and state- and county-managed campgrounds as well as other known campgrounds, including those operated by USFS. Camping visitation data include visitation

[4] 2022 visitation data were the most current data available at the time the alternatives were analyzed.

[5] See Appendix K, Recreation Analysis, for the sources of data presented in the visitation estimate tables throughout Section 3.14, Recreation. All information in the recreation opportunities tables were verified through internet searches and/or personal communications between July 2024 and August 2024.

estimates at all sites within the analysis area and within a 10-mile radius of the analysis area, which were identified using available Geographic Information System (GIS) geospatial data. This included Oregon State Parks and county- and privately managed recreation areas.

The estimated number of campers was assumed by number of sites, number of days a site is available annually, campsite capacity, and estimated occupancy percentage (Appendix K, Recreation Analysis). In cases where a particular recreation activity at a reservoir is not estimated by VERS, existing visitation and other data were used to estimate visitation for the activity. Information on other recreation opportunities from recreation management agencies and private organizations was not collected.

Data collection included a category for unspecified recreation activities that fall outside of those recorded at recreation sites. This “other” category is inclusive of hunting, special events or large gatherings, and other activities not captured in one of the listed categories. Recreation opportunities in the “other” category were not accounted for in the visitation numbers for total land-based or total water-based recreation opportunities because some land-based activities, such as hunting or special event attendance, occurred away from the reservoirs and are not expected to be impacted by implementation of any alternative.

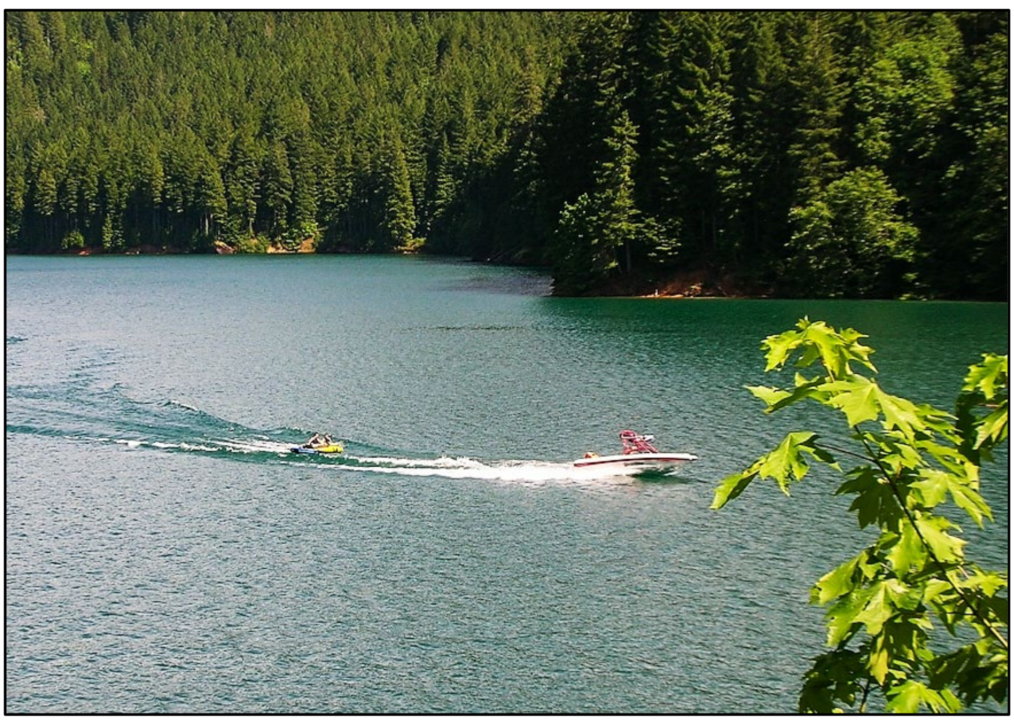

Photo by Christie Johnson (USACE Media Images Database).

Boating on Green Peter Reservoir.

3.14.2.6 Recreation Opportunities at Willamette Valley System Reservoirs

Detroit Reservoir

Detroit Dam and Reservoir are located in the rugged mountain forests below Mt. Jefferson at River Mile 49 on the North Santiam River, about 45 miles southeast of Salem, Oregon[6]. Recreation sites around Detroit Reservoir are accessible via North Santiam Highway (Oregon Route 22) and local roads.

Detroit Reservoir is a popular recreation area for water-based recreation, including boating, waterskiing, swimming, and fishing, and land-based recreation, including camping, picnicking, and sightseeing (Table 3.14-1) (Figure 3.14-1). The availability of boating and other water-based recreation is seasonally limited by operations to lower reservoir levels between fall and spring.

In 2022, visitors to Detroit Reservoir participated most in land-based recreation opportunities for a total of 126,045 visitors compared to 28,341 visits for participation in water-based recreation opportunities (Table 3.14-2). For reasons stated in Section 3.14.2.5, Analysis Area Recreation Visitation, these data do not accurately depict recreation visitation because Detroit Reservoir is typically one of the most popular reservoirs in the WVS basin with historically high visitation numbers.

Detroit Reservoir is a designated stop along the Mt. Jefferson Loop of the Oregon Cascades Birding Trail, a self-guided auto tour of nearly 200 birding destinations in the Oregon Cascades.

Wildlife viewing at Detroit Reservoir is supported by habitat for songbirds in hardwood stands, and osprey use of lakeshore snags and trees as roosts (i.e., places to rest or sleep) and nesting sites (USACE 2020e, USACE No Date-e).

Visitors to the Detroit reservoir fish for trout and kokanee using shore, motorized boat, float tube, fly, spin, and bait fishing methods. The reservoir is typically stocked with 1-pound hatchery trout. Harvesting Chinook salmon in the reservoir is prohibited, and any Chinook salmon accidentally caught must be released unharmed (USFS 2021; ODFW 2021b).

Detroit Lake Marina and Kane’s Marina are privately owned and located on the reservoir near the town of Detroit. The Detroit Lake Marina includes a food and supply store and rentable boats, canoes, kayaks, and jet skis, as well as a food vender, shower, parking, gas dock, and guest tie-up dock (Detroit Lake Marina 2021). Kane’s Marina is equipped with boat moorage and rentals, an RV park and day use area, fishing licenses and supplies, and a rustic tavern (Kane’s Marina No Date). Although multiple wildfires caused damage to both Kane’s Marina and Detroit Lake Marina, recreation opportunities such as mooring, rentals, and amenity access were available at both marinas at the time the alternatives were analyzed while both marinas continue to rebuild their facilities.

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[6] A river mile is a measure of distance in miles along a river from its mouth. River mile numbers begin at zero and increase further upstream.

Table 3.14-1. Recreation Opportunities at Detroit Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Mongold Day Use	OPRD	All Year	✓	✓				✓				✓	✓			
Detroit Lake State Park	OPRD	All Year	✓	✓	✓		✓	✓	274	✓	✓	✓	✓	✓	✓	
Upper Arm Day Use	USFS	All Year	✓	✓		✓	✓	✓				✓				
Detroit Flats Day Use	USFS	All Year	✓	✓		✓	✓	✓								
Santiam Flats Campground	USFS	May–Sept	✓	✓		✓			32		✓	✓				
Hoover Campground	Linn County	May–Sept	✓	✓		✓	✓		37		✓	✓	✓			
Piety Island Campground	USFS	All Year		✓					22			✓				
Cove Creek Campground	USFS	May–Sept	✓	✓			✓		63		✓	✓	✓	✓		
Southshore Campground	USFS	May–Sept	✓	✓			✓		30		✓	✓	✓			
Detroit Lake Marina	Private	May–Sept		✓										✓	✓	
Kane's Marina	Private	May–Sept	✓							✓					✓	

Source: USACE 2020e, USACE 2019h; Kane's Marina No Date; Detroit Lake Marina 2021 (verified in 2024)

OPRD = Oregon Parks and Recreation Department; USFS = U.S. Forest Service

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

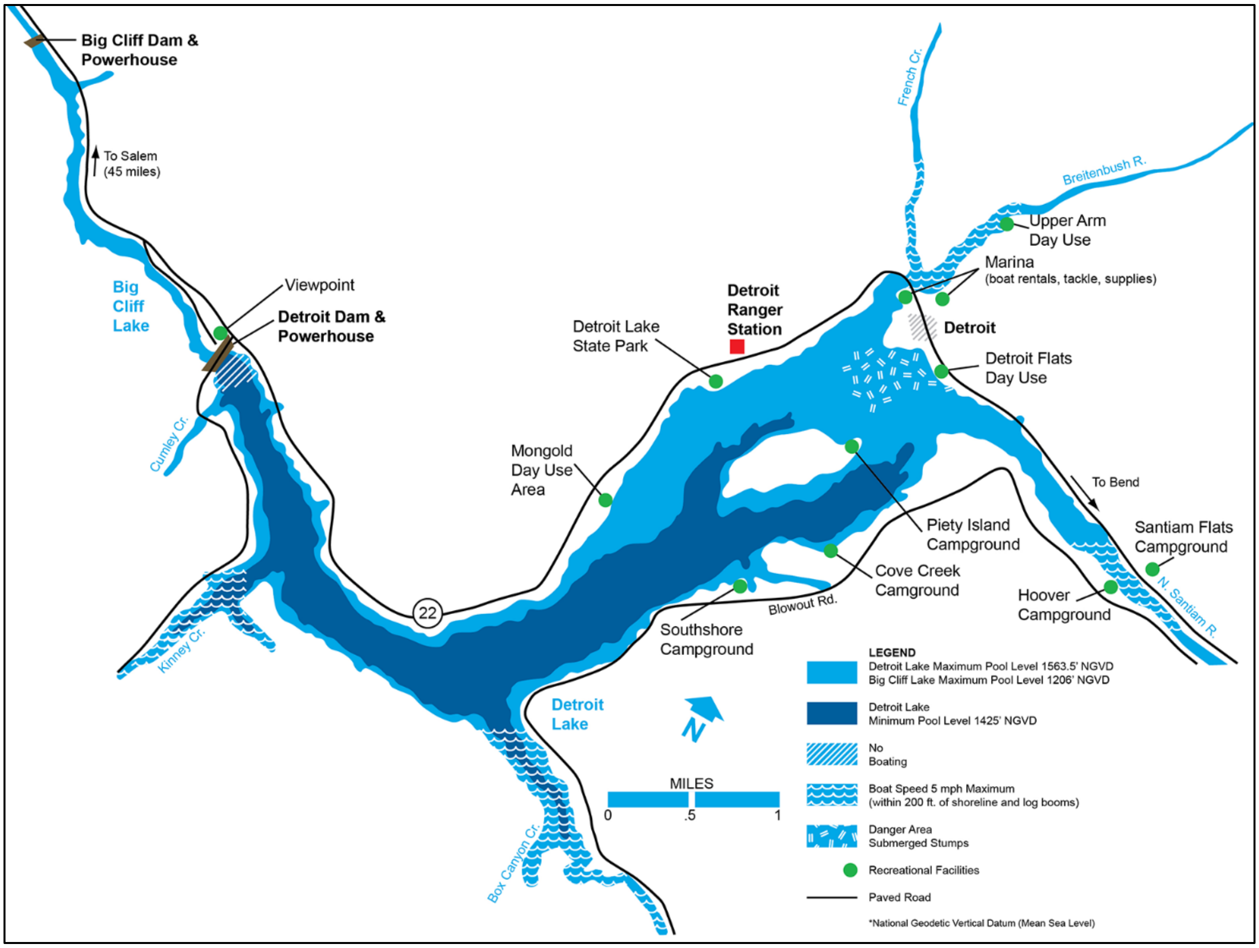


Figure 3.14-1. Recreation Sites at Detroit Reservoir.

Source: USACE No Date-e

Table 3.14-2. Visits to Detroit Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	4,514
Camping[3]	106,433
Swimming	1,455
Waterskiing[4]	8,967
Boating[4]	14,518
Sightseeing	15,098
Sport Fishing	3,401
Other	2,182
Total	**156,568**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[1]Source: USACE 2022h

[2] Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

[3]Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state sources as described in Section 1.1 of Appendix K, Recreation Analysis.

[4]Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Big Cliff Reservoir

Big Cliff Dam and Reservoir are located at River Mile 58.1 on the North Santiam River, 3 miles downstream of Detroit Dam, and is accessible from North Santiam Highway (Oregon Route 22). Due to its proximity to Detroit Reservoir and the smaller size of Big Cliff Reservoir, recreation opportunities at Big Cliff are closely connected to Detroit Reservoir opportunities (Figure 3.14-1). Like Detroit Dam, Big Cliff Dam is a designated stop along the Mt. Jefferson section of the Oregon Cascades Birding Trail where visitors can see osprey and songbirds.

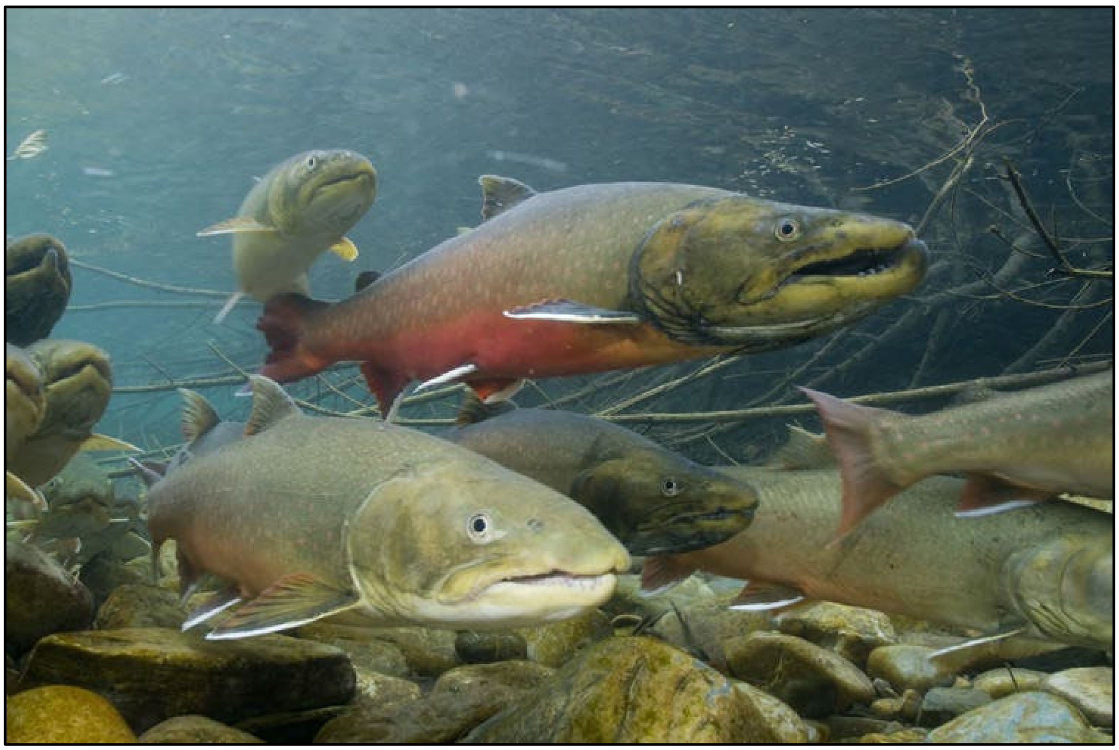
The water level of Big Cliff Reservoir fluctuates as much as 24 feet daily because the dam is used to regulate power-generating water releases from Detroit Dam. Consequently, developed recreation opportunities are limited at Big Cliff Dam or Reservoir. The boat ramp at Big Cliff Reservoir is permanently closed to vehicle traffic; however, non-motorized watercraft (e.g., kayaks) are allowed to use the ramp (USACE No Date-a).

Foster Reservoir

Foster Dam is located at River Mile 38.5 on the South Santiam River at the confluence of the South Santiam and Middle Fork Santiam Rivers. Recreation sites around Foster Reservoir are accessible via Foster Dam Road and Quartzville Road off of Santiam Highway (U.S. Highway 20) and other local roads.

Foster Reservoir is a popular recreation area for water-based recreation, including fishing and boating, and land-based recreation, including picnicking, camping, and sightseeing (Table 3.14-3) (Figure 3.14-2). In 2022, out of the 13 WVS reservoirs, Foster Reservoir was the second most visited (Table 3.14-28). In 2022, visitors participated most in water-based recreation opportunities with a total of 230,224 visitors compared to 204,785 visits for participation in land-based opportunities (Table 3.14-4, Table 3.14-27).

Foster Reservoir provides sport fishing opportunities and is typically stocked with trout; however, visitors to the reservoir can also catch smallmouth bass, yellow perch, catfish, bluegill, and crappie (ODFW 2021b). USACE manages Andrew S. Wiley Park, a year-round day use area at Foster Reservoir. Linn County completed a master plan in 2021 to upgrade Lewis Creek Park and Sunnyside Park amenities (Linn County Parks and Recreation 2021).



Unknown Photo Credit (USACE Media Images Database)

Bull Trout (*Salvelinus confluentus*).

Table 3.14-3. Recreation Opportunities at Foster Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Lakeshore Park Day Use	Linn County	All Year	✓	✓												
Andrew S. Wiley Park	USACE	All Year	✓	✓									✓			
Shea Point	Linn County	All Year	✓	✓		✓										
Calkins Ramp	Linn County	May–Sept	✓	✓									✓			
Gedney Creek Ramp	Linn County	May–Sept	✓	✓									✓			
Lewis Creek Park	Linn County	May–Sept	✓	✓		✓	✓	✓				✓			✓	
Sunnyside Park	Linn County	All Year	✓	✓	✓		✓		166	✓	✓	✓	✓	✓	✓	✓
Edgewater Park	Linn County	All Year		✓		✓	✓		49	✓	✓	✓		✓	✓	

Source: USACE 2020f, USACE 2019h (verified in 2024).

USACE = U.S. Army Corps of Engineers

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

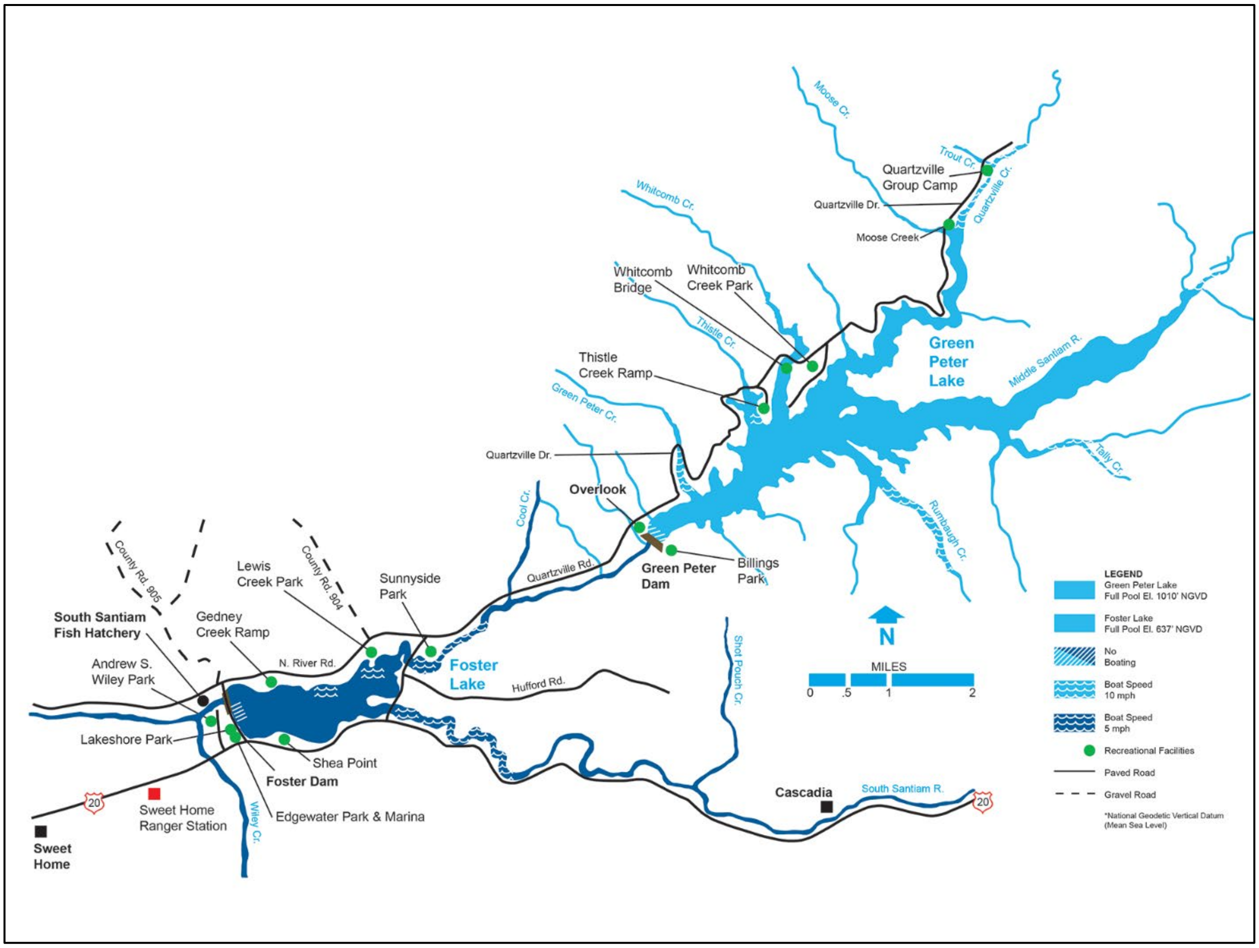


Figure 3.14-2. Recreation Sites at Foster and Green Peter Dams and Reservoirs.

Source: USACE No Date-j

Table 3.14-4. Visits to Foster Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	74,485
Camping[3]	55,948
Swimming	97,459
Waterskiing[4]	36,308
Boating[4]	58,781
Sightseeing	74,352
Sport Fishing	37,676
Other	17,071
Total	**452,080**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[1]Source: USACE 2022m

[2]Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, USCB 2021

[3]Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state sources as described in Section 1.1 of Appendix K, Recreation Analysis.

[4]Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Green Peter Reservoir

Green Peter Dam and Reservoir are located at River Mile 5.5 on the Middle Santiam River, 7 miles upstream of Foster Dam. Recreation sites around Green Peter Reservoir are accessible via Quartzville Drive off of Santiam Highway (U.S. Highway 20) and other local roads.

Like Foster Reservoir, Green Peter Reservoir is a popular recreation destination for water-based recreation, including fishing, boating, waterskiing, and swimming, and land-based recreation, including picnicking, camping, and sightseeing (Table 3.14-5) (Figure 3.14-2). Similar to the other dams and reservoirs, visitors can see osprey nests along the shorelines of the reservoir. Thistle Creek Park includes a 9-acre boat ramp area located on the north shore of the reservoir.

In 2022, visitors to Green Peter Reservoir participated most in water-based recreation opportunities with a total of 50,618 visits compared to 33,361 visits for participation in land-based opportunities (Table 3.14-6, Table 3.14-27).

USACE works with ODFW to provide resident game and non-game fisheries within the waters of the Middle Fork Santiam River Basin (USACE 2020f, No Date-k). Green Peter Reservoir is stocked annually with hatchery trout. In 2024, it was stocked with 24,400 trout as of July. Sport fishers at the reservoir can catch up to 25 kokanee per day, unlimited smallmouth bass, and up to 5 trout per day (ODFW 2021b).

Table 3.14-5. Recreation Opportunities at Green Peter Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Thistle Creek Park	Linn County	All Year	✓	✓									✓			
Whitcomb Creek Park	Linn County	May–Oct	✓	✓		✓	✓		85		✓	✓	✓			
Dam Overlook	USACE	All Year	✓	✓												
Billings Park	USACE	All Year	✓	✓												
Whitcomb Bridge Day Use	USACE	All Year	✓	✓												
Rocky Top Bridge Group Camp	Linn County	All Year					✓		10–12[2]		✓	✓				
Quartzville Group Camp	Linn County	May–Sept		✓					Up to 100 people		✓	✓				

Source: USACE 2020f, USACE 2019h (verified in 2024).

USACE = U.S. Army Corps of Engineers

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

[2] Campsite availability is weather-dependent.

Table 3.14-6. Visits to Green Peter Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	9,059
Camping[3]	11,711
Swimming	13,074
Waterskiing[4]	10,488
Boating[4]	16,979
Sightseeing	12,591
Sport Fishing	10,077
Other	533
Total	**84,512**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[1] Source: USACE 2022n

[2] Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

[3] Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state sources as described in Section 1.1 of Appendix K, Recreation Analysis.

[4] Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Cougar Reservoir

Cougar Dam and Reservoir are located at River Mile 4.4 of the South Fork McKenzie River, about 42 miles east of Eugene, Oregon. Recreation sites around Cougar Reservoir are accessible via Aufderheide Drive, accessible off McKenzie Highway (Oregon Route 126) as well as other local roads.

All recreation facilities at the reservoir are within the Willamette National Forest and are managed by the USFS. The USFS provides recreation opportunities for camping, boating, swimming, fishing, sightseeing, and waterskiing (Table 3.14-7) (Figure 3.14-3). In 2022, 21,884 visitors participated in land-based recreation opportunities compared to 13,288 visitors who participated in water-based opportunities (Table 3.14-8, Table 3.14-27). In late summer to early fall and through spring, water levels in the reservoir are frequently drawn down, making boat ramps inaccessible.

The reservoir is a designated stop along the Three Sisters section of the Oregon Cascades Birding Trail where visitors can spot American peregrine falcons around the cliffs above the reservoir (USACE No Date-d). There is a large nesting colony of cliff swallows southwest of the dam where visitors can also see violet-green and northern rough-winged swallows. Visitors may also see rock wren, canyon wren, bald eagle, belted kingfisher, and waterfowl such as bufflehead, goldeneyes, and common and hooded mergansers in the fall (The Oregon Birding Trails Working Group No Date).

Table 3.14-7. Recreation Opportunities at Cougar Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Echo Park	USFS	April–Sept	✓	✓		✓						✓	✓			
Slide Creek Campground	USFS	May–Sept	✓	✓			✓	✓	16		✓	✓	✓			
Sunnyside Campground	USFS	May–Sept		✓					13		✓	✓				
French Pete Campground	USFS	May–Sept		✓		✓	✓		17		✓	✓				
Delta Campground	USFS	Closed due to Holiday Fire as of 2024.														
Cougar Crossing	USFS	All Year	✓	✓					12		✓	✓	✓			

Source: USACE 2019h, USACE 2009c (verified in 2024).

USFS = U.S. Forest Service

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

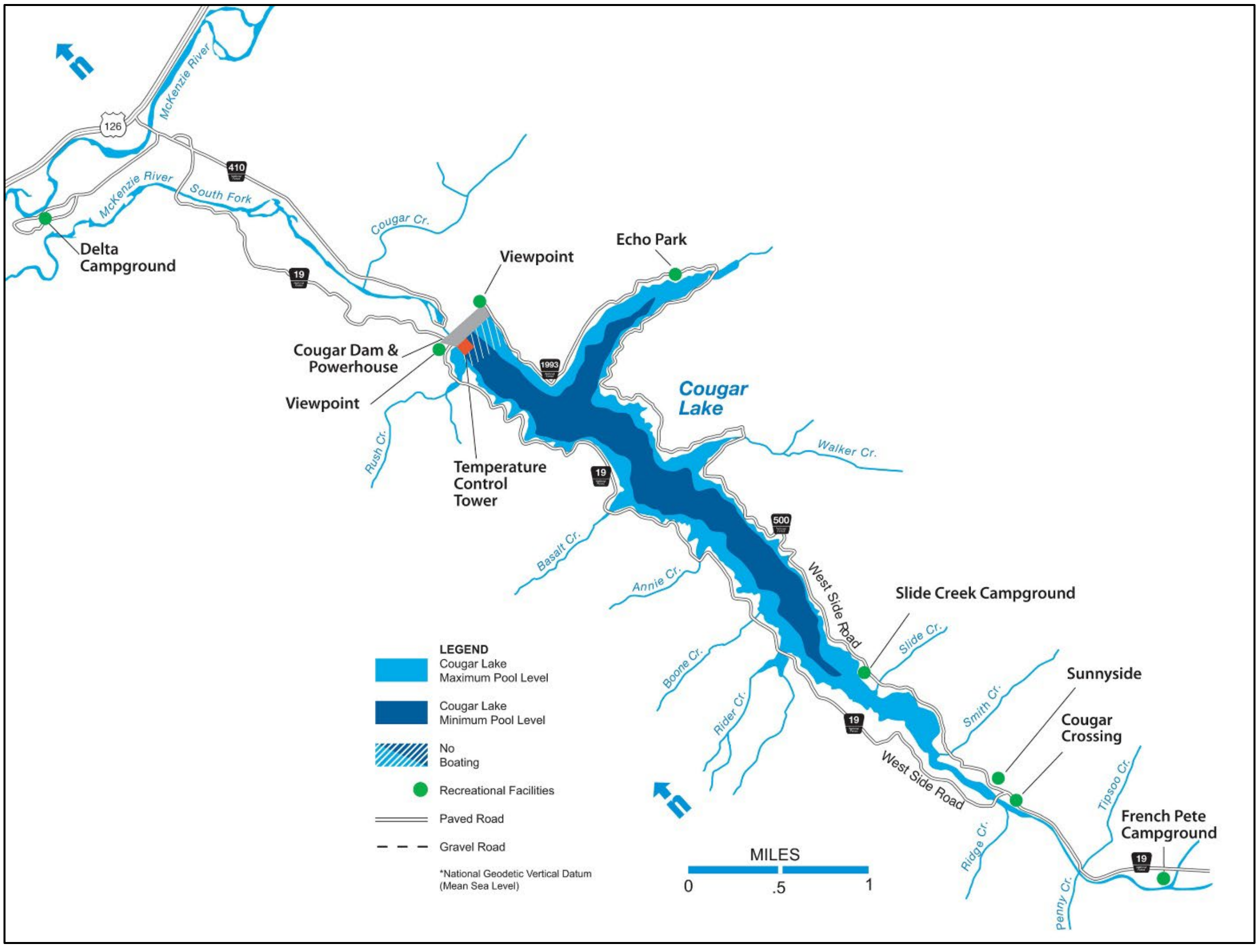


Figure 3.14-3. Recreation Sites at Cougar Dam and Reservoir.

Source: USACE No Date-d

Table 3.14-8. Visits to Cougar Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	5,489
Camping[3]	5,389
Swimming	1,768
Waterskiing[4]	2,819
Boating[4]	4,564
Sightseeing	11,006
Sport Fishing	4,137
Other	2,653
Total	**37,825**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[1] Source: USACE 2022g

[2] Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

[3] Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state sources as described in Section 1.1 of Appendix K, Recreation Analysis.

[4] Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Blue River Reservoir

Blue River Dam and Reservoir are located at River Mile 2 on the Blue River, a tributary of the McKenzie River, about 38 miles east of Eugene, Oregon. Recreation sites around Blue River Reservoir are accessible via Lucky Boy Road, which is accessible off of McKenzie Highway (Oregon Route 126) as well as other local roads. In 2022, visitors participated substantially more in land-based recreation opportunities with a total of 29,529 visitors compared to 2,708 visits for participation in water-based recreation opportunities (Table 3.14-10, Table 3.14-27).

The entire reservoir area is located within the Willamette National Forest. The USFS provides recreation opportunities at two campground sites and two boat ramps (USACE No Date-b) (Table 3.14-9) (Figure 3.14-4). Saddle Dam Ramp is a natural boat ramp located on a retired access road used by USACE for Blue River Dam and Saddle Dam construction. The boat ramp is typically closed from mid-October to mid-March or when the reservoir level is below 1,295 feet. Open and close dates may be earlier or later depending on water level fluctuation.

Wildlife viewing includes osprey, who use large trees and snags around the reservoir for roosts. USACE works with ODFW to provide resident game and non-game fisheries within the waters of the Blue River Reservoir. Sport fishers at the reservoir can catch warm water species and trout. In May of 2021, the reservoir was stocked with 1,500 legal-size and 50 trophy-size rainbow trout (ODFW 2021b). In 2024, 6,300 legal-sized and 0 trophy-sized rainbow trout were stocked as of July (ODFW 2024e).

Table 3.14-9. Recreation Opportunities at Blue River Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Mona Campground	USFS	May–Sept		✓			✓		23		✓	✓				
Lookout Campground	USFS	All Year	✓	✓			✓		20		✓	✓	✓			
Saddle Dam Ramp	USFS	April–Oct		✓								✓	✓			

Source: USACE 2019h, USACE 2009c (verified in 2024).

USFS = U.S. Forest Service

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

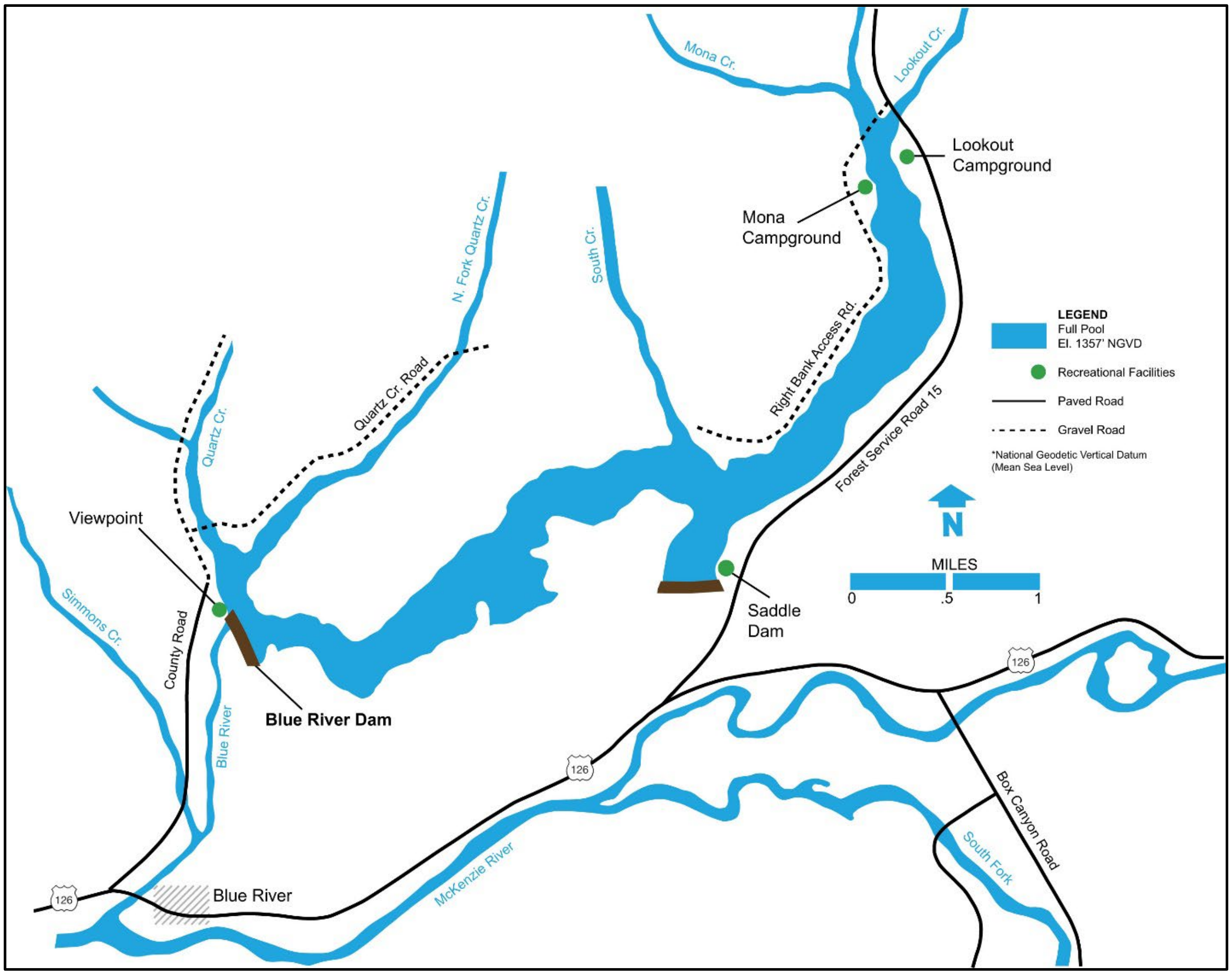


Figure 3.14-4. Recreation Sites at Blue River Dam and Reservoir.

Source: USACE No Date-b

Table 3.14-10. Visits to Blue River Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	2,472
Camping[3]	22,715
Swimming	789
Waterskiing[4]	29
Boating[4]	47
Sightseeing	4,342
Sport Fishing	1,843
Other	1,178
Total	**33,415**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

1 Source: USACE 2022e

2 Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

3 Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state sources as described in Section 1.1 of Appendix K, Recreation Analysis.

4 Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Lookout Point Reservoir

Lookout Point Dam and Reservoir are located at River Mile 21.3 on the Middle Fork Willamette River, about 22 miles southeast of Eugene, Oregon. Recreation sites around Lookout Point Reservoir are accessible via local roads off of Willamette Highway (Oregon Route 58). The reservoir area partially overlaps with the Willamette National Forest; the recreation areas within this National Forest are managed by USFS. USACE manages one day-use park, one boat ramp, and one campground.

Lookout Point is a popular recreation destination for water-based recreation, including fishing, boating, waterskiing, and swimming, and for land-based recreation, including picnicking, camping, and sightseeing (Table 3.14-11) (Figure 3.14-5). In 2022, visitors to Lookout Point Reservoir participated most in water-based recreation opportunities with a total of 42,681 visits compared to 36,932 visits for participation in land-based recreation opportunities (Table 3.14-12, Table 3.14-27).

Water access for recreation opportunities is provided at Meridian Park, which includes a boat ramp with a courtesy dock; however, access to the ramp is limited by seasonal water levels. Signal Point Ramp includes a boat ramp associated with a day-use area. The water southeast of the ramp area is a hazardous stump area, creating a collision hazard to boaters. Ivan Oakes Campground has direct access to the reservoir for water-based recreation.

Wildlife viewing at Lookout Point Reservoir is supported by habitat for species such as northern spotted owls and bald eagles nesting and wintering on Lookout Point (USACE No Date-m).

Photo by Jason Mrachina (USACE Media Images Database)

Bald eagle (*Haliaeetus leucocephalus*).

Table 3.14-11. Recreation Opportunities at Lookout Point Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Meridian Park	USACE	May–Sept	✓	✓		✓							✓			
Ivan Oakes Campground	USACE	May–Sept		✓		✓	✓		24			✓				
Signal Point Ramp	USACE	All Year	✓	✓		✓							✓			
Hampton Ramp	USFS	May –Sept	✓	✓								✓	✓			
Black Canyon Campground	USFS	May–Sept	✓	✓		✓	✓		75		✓	✓	✓			

Source: USACE 2019h, USACE 2009h (verified in 2024).

USACE = U.S. Army Corps of Engineers; USFS = U.S. Forest Service

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

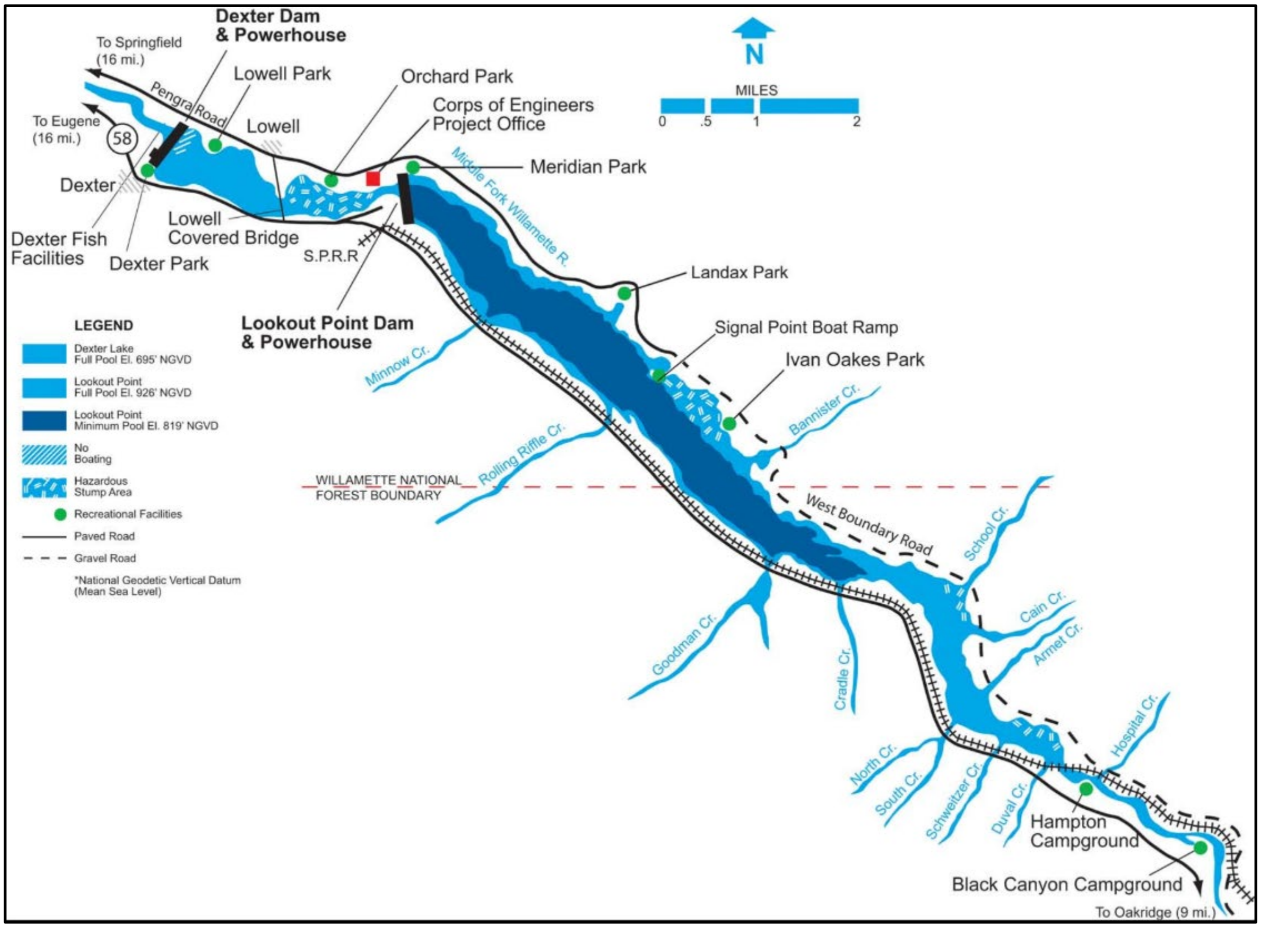


Figure 3.14-5. Recreation Sites at Lookout Point and Dexter Dams and Reservoirs.

Source: USACE No Date-m

Table 3.14-12. Visits to Lookout Point Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	6,176
Camping[3]	5,537
Swimming	11,796
Waterskiing[4]	9,410
Boating[4]	15,234
Sightseeing	25,219
Sport Fishing	6,241
Other	351
Total	**79,964**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[1] Source: USACE 2022p

[2] Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

[3] Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state as described in Section 1.1 of Appendix K, Recreation Analysis.

[4] Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Dexter Reservoir

Dexter Reservoir is located just downstream of Lookout Point Dam (Figure 3.14-5). Recreation sites around Dexter Reservoir are accessible via local roads off of Willamette Highway (Oregon Route 58). It is a heavily used recreation area with access to water-based opportunities, including fishing, boating, waterskiing, and swimming, and land-based opportunities, including picnicking and sightseeing (Table 3.14-13) (Figure 3.14-5). In 2022, visitors to Dexter Reservoir participated most in land-based recreation opportunities with a total of 160,071 visits compared to 158,951 visits for participation in water-based opportunities (Table 3.14-14, Table 3.14-27).

Hunting opportunities and wildlife viewing are supported by shoreline habitat for waterfowl, upland game birds, bald eagles, osprey, wintering elk, and other species (USACE 2009h, No Date-f). Dexter Reservoir is a designated stop along the McKenzie Loop of the Willamette Valley Birding Trail where visitors can see migratory and resident songbirds, osprey, and eagles along the northeast shoreline (USACE No Date-f). The reservoir is typically stocked with rainbow trout, but sport fishers can also catch largemouth and smallmouth bass (ODFW 2021b).

Dexter State Park is near an 18-hole disc golf course and is connected to Elijah Bristow State Park through a system of trails that follow the Middle Fork Willamette River. The Oregon Association of Rowers and the University of Oregon have boathouses at Lowell State Park and host regattas (rowing races) each spring (OPRD No Date).

Table 3.14-13. Recreation Opportunities at Dexter Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Dexter State Park	OPRD	All Year	✓	✓		✓							✓			
Lowell State Park	OPRD	All Year	✓	✓	✓		✓	✓					✓		✓	
Middle Fork Boat Ramp	USACE	All Year	✓	✓									✓			
South Side Fishing Area	USACE	All Year	✓	✓												
Orchard Park	USACE	May–Sept	✓	✓												

Source: USACE 2019h, USACE 2009h (verified in 2024)

OPRD = Oregon Parks and Recreation Department; USACE = U.S. Army Corps of Engineers

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

Table 3.14-14. Visits to Dexter Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	35,939
Camping	0
Swimming	53,376
Waterskiing[3]	31,099
Boating[3]	50,348
Sightseeing	124,132
Sport Fishing	24,128
Other	8,011
Total	**327,033**

[1] Source: USACE 2022i

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[2] Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

[3] Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Hills Creek Reservoir

Hills Creek Reservoir is located 3 miles upstream of Oakridge and about 40 miles southeast of Eugene, Oregon at River Mile 232 on the Middle Fork Willamette River. Recreation sites around Hills Creek Reservoir are accessible via local roads off Willamette Highway (Oregon Route 58).

The reservoir and its 44 miles of forested shoreline make Hills Creek Reservoir a popular destination for water-based and land-based recreation opportunities, including camping, boating, swimming, fishing, sightseeing, and waterskiing (Table 3.14-15) (Figure 3.14-6). All recreation facilities are within the Willamette National Forest and are managed by the USFS (USACE 2009g). In 2022, visitors to Hills Creek Reservoir participated most in land-based recreation opportunities with a total of 65,488 visits compared to 24,935 visits for participation in water-based opportunities (Table 3.14-16, Table 3.14-27).

Water-based opportunities are provided by the Bingham Boat Ramp located at the south end of the reservoir. The ramp requires higher reservoir levels to be accessible, whereas the Packard boat ramp (near the Packard Creek Campground) is usually accessible year-round.

Hills Creek is a designated stop along the Three Sisters section of the Oregon Cascades Birding Trail (USACE No Date-l). Fishers can catch crappie, largemouth bass, brown bullhead, catfish, and rainbow and cutthroat trout in Hills Creek Reservoir. Visitors can access the 27-mile Middle Fork Willamette Trail from the Sand Prairie Campground for hiking, horseback riding, and mountain biking. The Larison Creek Trail can be accessed from Packcard Creek Campground for hiking, horseback riding, and mountain biking opportunities.

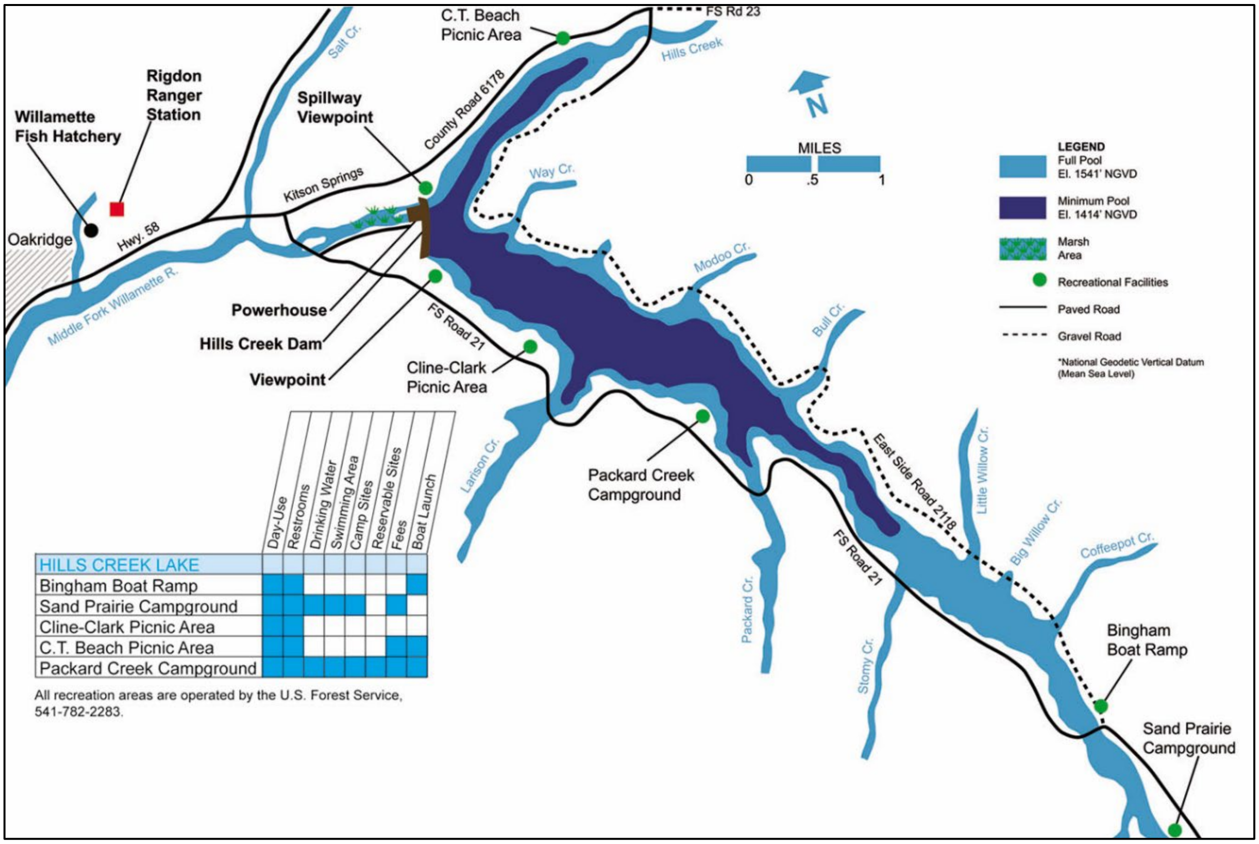
Table 3.14-15. Recreation Opportunities at Hills Creek Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Bingham Boat Ramp	USFS	All Year	✓	✓									✓			
Sand Prairie Campground	USFS	May–Sept	✓	✓					21			✓				
Cline-Clark Picnic Area	USFS	All Year	✓	✓												
C.T. Beach Picnic Area	USFS	All Year	✓	✓								✓	✓			
Packard Creek Campground	USFS	April–Sept	✓	✓			✓	✓	37		✓	✓	✓			

Source: USACE 2019h, USACE 2009g (verified in 2024)

USFS = U.S. Forest Service

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.



HILLS CREEK LAKE	Day-Use	Restrooms	Drinking Water	Swimming Area	Camp Sites	Reservable Sites	Fees	Boat Launch
Bingham Boat Ramp	■	■						■
Sand Prairie Campground	■	■	■	■	■		■	
Cline-Clark Picnic Area	■	■						
C.T. Beach Picnic Area	■	■					■	■
Packard Creek Campground	■	■	■	■	■	■	■	■

Figure 3.14-6. Recreation Sites at Hills Creek Dam and Reservoir.
Source: USACE No Date-l

Table 3.14-16. Visits to Hills Creek Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	6,636
Camping[3]	44,942
Swimming	2,138
Waterskiing[4]	6,795
Boating[4]	11,001
Sightseeing	13,910
Sport Fishing	5,001
Other	3,208
Total	**93,631**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[1] Source: USACE 2022o

[2] Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

[3] Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state sources as described in Section 1.1 of Appendix K, Recreation Analysis.

[4] Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Fall Creek Reservoir

Fall Creek Dam and Reservoir are at River Mile 7.2 on the Fall Creek tributary of the Willamette River, about 20 miles southeast of Eugene, Oregon. Recreation sites around Fall Creek Reservoir are accessible via local roads off of Willamette Highway (Oregon Route 58).

Fall Creek is a popular destination for water-based and land-based recreation, including fishing, boating, waterskiing, swimming, camping, sightseeing, and picnicking (USACE No Date-h) (Table 3.14-17) (Figure 3.14-7). In 2022, visitors to Fall Creek Reservoir participated substantially more in water-based recreation opportunities with 74,063 total visits compared to 40,758 visits for participation in land-based recreation opportunities (Table 3.14-18, Table 3.14-27).

Wildlife viewing is supported by 22 miles of forested shoreline habitat for a wide variety of wildlife, including waterfowl, upland game birds, songbirds, bald eagles, osprey, black-tailed deer and other species.

Fall Creek Reservoir is stocked with legal-size and pound-size rainbow trout, which can be caught all year. Visitors are permitted to catch five hatchery trout and an additional two wild trout daily. Fishing for salmon upstream of the dam is prohibited, but downstream of the dam, hatchery Chinook salmon, hatchery steelhead, and wild steelhead greater than 24 inches can be harvested all year (ODFW 2021b).

Table 3.14-17. Recreation Opportunities at Fall Creek Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Tufti Park	USACE	All Year	✓	✓		✓										
Cascara Campground	OPRD	May–Sept		✓			✓	✓	39			✓	✓			
Fisherman's Pt. Group Campground	OPRD	May–Sept		✓			✓		1		✓	✓				
Winberry Park	OPRD	May–Sept	✓	✓				✓				✓	✓			
North Shore Park	OPRD	April–Sept	✓	✓									✓			
Free Meadow	OPRD	May–Sept	✓	✓												
Lakeside One and Two	OPRD	May–Sept	✓	✓												

Source: USACE 2019h, USACE 2009e (verified in 2024)

OPRD = Oregon Parks and Recreation Department; USACE = U.S. Army Corps of Engineers

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

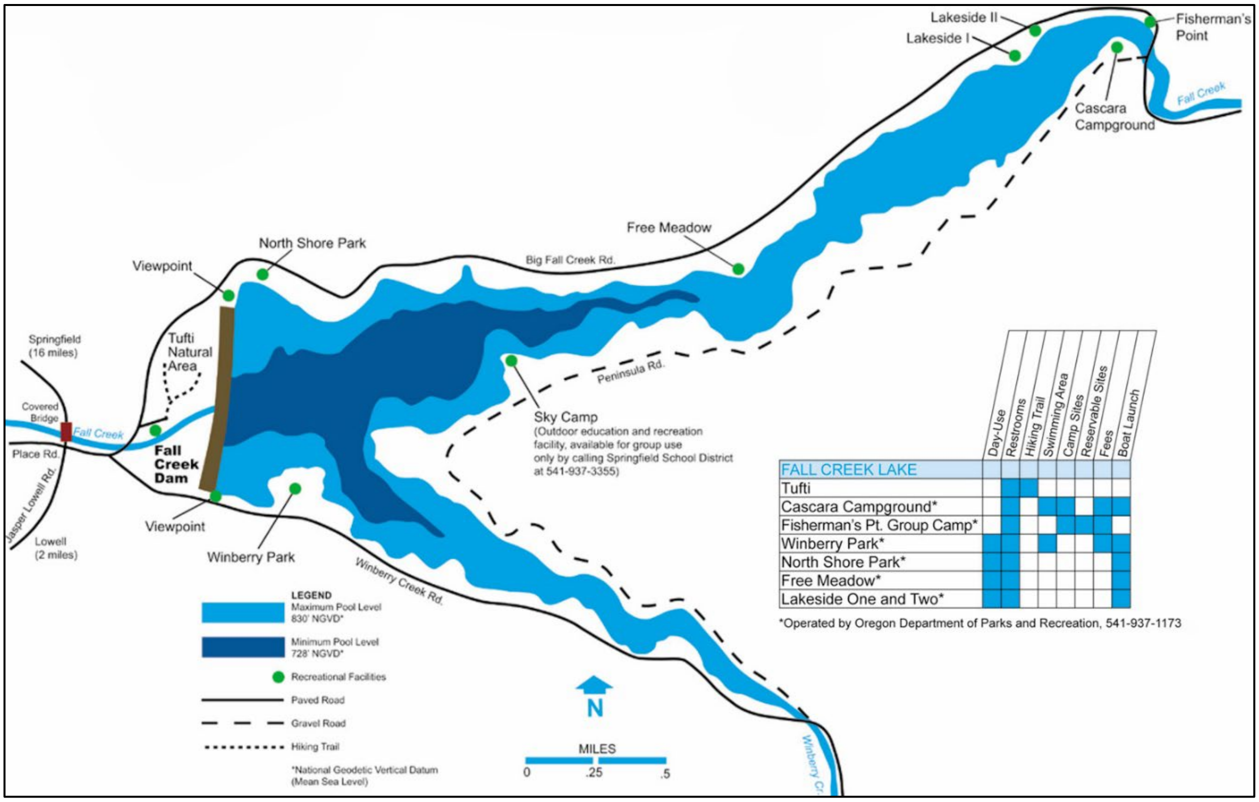


Figure 3.14-7. Recreation Sites at Fall Creek Dam and Reservoir.

Source: USACE No Date-h

Table 3.14-18. Visits to Fall Creek Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	20,116
Camping[3]	4,114
Swimming	31,567
Waterskiing[4]	11,595
Boating[4]	18,771
Sightseeing	16,528
Sport Fishing	12,130
Other	3,315
Total	**118,136**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[1] Source: USACE 2022k

[2] Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

[3] Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state sources as described in Section 1.1 of Appendix K, Recreation Analysis.

[4] Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Dorena Reservoir

Dorena Dam and Reservoir are located on the Row River, a tributary of the Willamette River. Recreation sites around Dorena Reservoir are accessible via local roads off of Pacific Highway (Interstate 5).

Recreation opportunities at Dorena Reservoir include water-based and land-based activities accessed by several day use and camping options, including two boat ramps (Table 3.14-19) (Figure 3.14-8). Baker Bay Park offers nearly the full suite of recreation amenities with the exception of recreational vehicle camping. In 2022, visitors to Dorena Reservoir participated slightly more in water-based recreation opportunities with 89,493 total visits compared to 86,629 visits for participation in land-based recreation opportunities (Table 3.14-20, Table 3.14-27).

Wildlife viewing around Dorena Reservoir is supported by habitat for a variety of wildlife and plants and is a designated stop along the Big River Loop of the Willamette Valley Birding Trail. Visitors can see rare birds such as purple martin, willow flycatcher, and yellow-breasted chat. Osprey and purple martin nest around the reservoir (USACE No Date-g). Sport fishers at Dorena Reservoir can catch rainbow trout (which are regularly stocked), largemouth bass, smallmouth bass, yellow perch, crappie, and bluegill (ODFW 2021b).

Table 3.14-19. Recreation Opportunities at Dorena Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Schwarz Campground	USACE	April–Sept		✓	✓	✓	✓		82		✓	✓		✓		✓
Harms Park	USACE	All Year	✓	✓		✓							✓			
Bake Stewart Park	USACE	All Year	✓	✓		✓										
Baker Bay Park	Lane County	April–Oct	✓	✓	✓	✓	✓	✓	48		✓	✓	✓	✓	✓	✓
Row River Trail	BLM	All Year	✓	✓		✓										

Source: USACE 2019h, USACE 2009d (verified in 2024)

BLM = Bureau of Land Management; USACE = U.S. Army Corps of Engineers

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

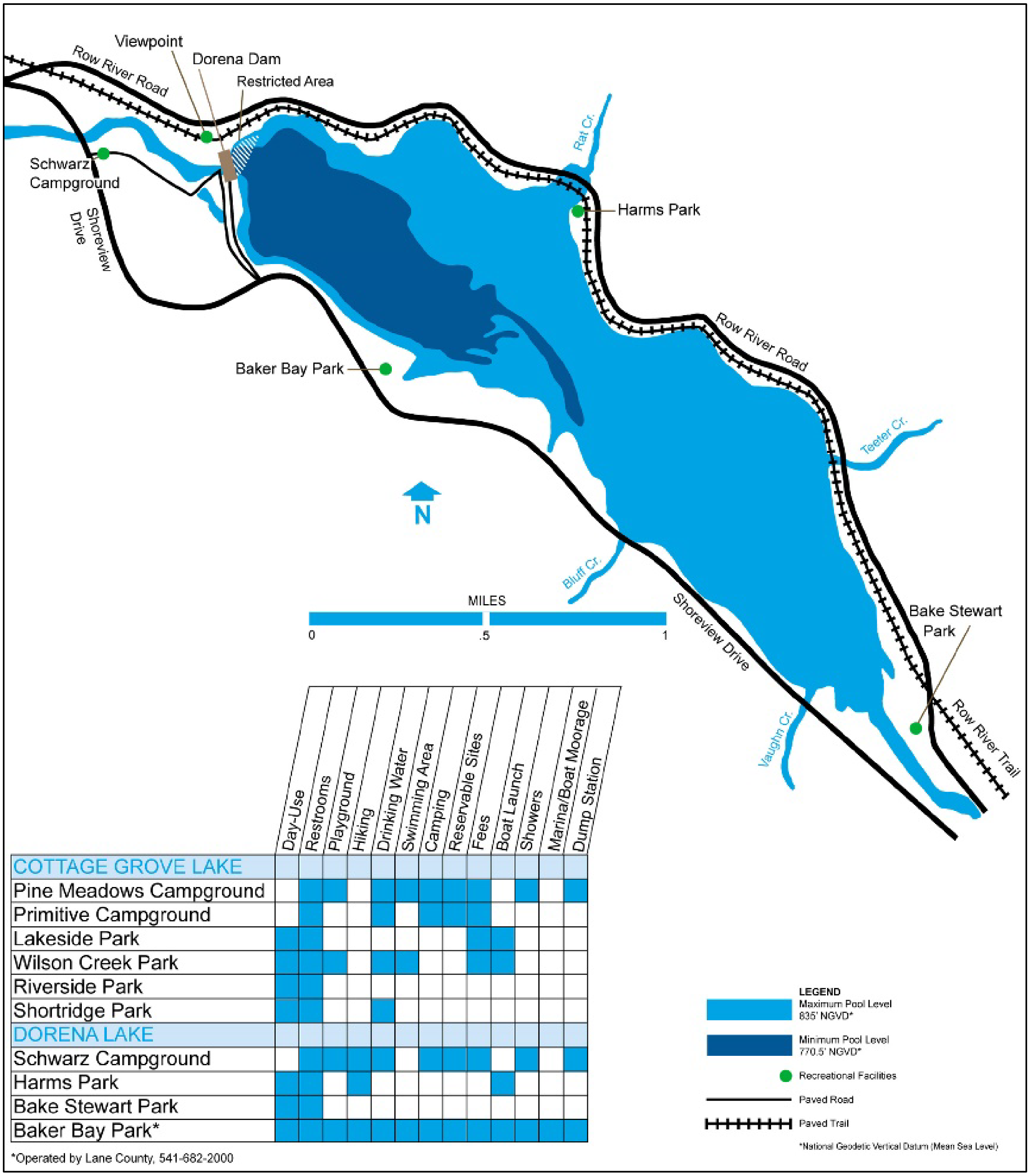


Figure 3.14-8. Recreation Sites at Dorena Dam and Reservoir.

Source: USACE No Date-g

Table 3.14-20. Visits to Dorena Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	20,539
Camping[3]	34,144
Swimming	35,022
Waterskiing[4]	16,465
Boating[4]	26,656
Sightseeing	31,946
Sport Fishing	11,350
Other	39,636
Total	**215,758**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[1] Source: USACE 2022j

[2] Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

[3] Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state sources as described in Section 1.1 of Appendix K, Recreation Analysis.

[4] Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Cottage Grove Reservoir

Cottage Grove Dam and Reservoir are located at River Mile 29 of the Coast Fork of the Willamette River. Recreation sites around Cottage Grove Reservoir are accessible via local roads off of Pacific Highway (Interstate 5).

Cottage Grove Reservoir is popular primarily for water-based recreation opportunities and associated picnicking while visiting reservoir recreation sites (Table 3.14-21) (Figure 3.14-9). In 2022, visitors to Cottage Grove Reservoir participated most in water-based recreation opportunities with a total of 164,638 visits compared to 81,647 visits for participation in land-based opportunities (Table 3.14-22, Table 3.14-27).

Cottage Grove Reservoir is a designated stop along the Big River Loop of the Willamette Valley Birding Trail where visitors can see rare birds such as purple martin, willow flycatcher, and yellow-breasted chat. Similar to Dorena Reservoir, osprey and purple martin nest along the reservoir (USACE No Date-c). Cottage Grove Reservoir is typically stocked with 1-pound rainbow trout; sport fishers can also catch spotted bass, largemouth bass, crappie, yellow perch, and bluegill (ODFW 2021b).

Table 3.14-21. Recreation Opportunities at Cottage Grove Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
Pine Meadows Campground	USACE	May–Sept		✓	✓		✓	✓	85		✓	✓		✓		✓
Pine Meadows Campground (undeveloped)	USACE	May–Sept		✓			✓		15		✓	✓				
Lakeside Park	USACE	All Year	✓	✓									✓			
Wilson Creek Park	USACE	May–Sept	✓	✓	✓		✓	✓					✓			
Riverside Park	USACE	May–Sept	✓	✓												
Shortridge Park	USACE	May–Sept	✓	✓												

Source: USACE 2019h, USACE 2009d (verified in 2024)

USACE = U.S. Army Corps of Engineers

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

COTTAGE GROVE LAKE	Day-Use	Restrooms	Playground	Hiking	Drinking Water	Swimming Area	Camping	Reservable Sites	Fees	Boat Launch	Showers	Marina/Boat Moorage	Dump Station
Pine Meadows Campground		X	X		X	X	X	X	X		X		X
Primitive Campground		X			X		X	X	X				
Lakeside Park	X	X							X	X			
Wilson Creek Park	X	X	X		X	X			X	X			
Riverside Park	X	X											
Shortridge Park	X	X			X								

Figure 3.14-9. Recreation Sites at Cottage Grove Dam and Reservoir.

Source: USACE No Date-c

Table 3.14-22. Visits to Cottage Grove Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	25,790
Camping[3]	30,585
Swimming	29,841
Waterskiing[4]	43,569
Boating[4]	70,537
Sightseeing	25,272
Sport Fishing	20,691
Other	6,111
Total	**252,396**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[1] Source: USACE 2022f

[2] Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

[3] Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state sources as described in Section 1.1 of Appendix K, Recreation Analysis.

[4] Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Fern Ridge Reservoir

Fern Ridge Dam and Reservoir are located at River Mile 23.6 on the Long Tom River tributary of the Willamette River, about 12 miles west of Eugene, Oregon. Recreation sites around Fern Ridge Reservoir are accessible via local roads off of Florence-Eugene Highway 126, Territorial Highway, and Oregon Routes 99 and 569.

Fern Ridge Reservoir is a popular destination for fishing, boating, waterskiing, swimming, camping, picnicking, hunting, and sightseeing supported primarily by day-use recreation sites (USACE No Date-i) (Table 3.14-23) (Figure 3.14-10). This reservoir is located near Eugene/Springfield, Oregon providing recreation opportunities to this densely populated metropolitan area.

In 2022, out of the 13 WVS reservoirs, Fern Ridge Reservoir was the most visited (Table 3.14-28). The large reservoir surface area and consistent winds make Fern Ridge one of the best sailing reservoirs in Oregon (USACE 2019a). In 2022, visitors to Fern Ridge Reservoir participated substantially more in water-based recreation opportunities with a total of 334,545 compared to 262,762 visits for land-based recreation opportunities (Table 3.14-24, Table 3.14-27).

Wildlife viewing is supported by thousands of acres of emergent marsh (shallow-water wetlands) that provides summer breeding habitat for a variety of water-bird species, including Oregon's largest breeding colony of purple martins. ODFW manages Fern Ridge Wildlife Area and East Kirk Park. The Fern Ridge Wildlife Area covers approximately half of the reservoir and consists of wetlands, wet prairie, oak and mixed woodlands, upland prairie, and freshwater aquatic habitats. It is a popular destination for water-based recreation, hunting, bird watching, hiking, and environmental education.

East Kirk Park is 1 of 11 management units within the Fern Ridge Wildlife Area; the eastern two-thirds of the area is designated for wildlife management and consists of woodland, meadow, marsh, and pond habitat. The western third of Kirk Park (West Kirk Park) is managed by USACE (ODFW 2020b).

USACE works with ODFW to provide resident game and non-game fisheries within the Long Tom River Basin (USACE No Date-i). Sport fishers at Fern Ridge Reservoir can catch largemouth bass, crappie, bluegill, and brown bullhead. Bass and crappie are available throughout the spring and summer (ODFW 2021b).

Photo by Lorelle Sherman (USACE Media Images Database)

Purple martin (*Progne subis arboricola*).

Table 3.14-23. Recreation Opportunities at Fern Ridge Dam and Reservoir.

Recreation Area	Managing Agency	Open	Day Use/Picnicking	Restrooms	Playgrounds	Hiking Trails	Drinking Water	Swimming Areas	Camping/Camp Sites	RV Camping/Utilities	Reservable Sites	Fees	Boat Ramp*	Showers	Marina/Boat Moorage	Dump Station
East Kirk Park	ODFW	All Year	✓	✓		✓						✓				
West Kirk Park	USACE	May–Sept	✓	✓		✓										
Richardson Park	Lane County	April–Oct	✓	✓	✓		✓	✓	88	✓	✓	✓	✓	✓	✓	✓
Orchard Pt. Park	Lane County	April–Oct	✓	✓	✓		✓	✓			✓	✓	✓		✓	
Perkins Peninsula Park	Lane County	April–Oct	✓	✓			✓	✓				✓	✓			
Zumwalt Park	Lane County	All Year	✓	✓												
Jeans Park	USACE	All Year	✓	✓		✓										
Shore Lane Park	USACE	May–Sept	✓	✓												
Fern Ridge Wildlife Area	ODFW	All Year	✓	✓		✓						✓				

Source: USACE 2019h, USACE 2009f (verified in 2024)

ODFW = Oregon Department of Fish and Wildlife; USACE = U.S. Army Corps of Engineers

*Boat ramp(s) unusable when the reservoir level is below minimum pool level.

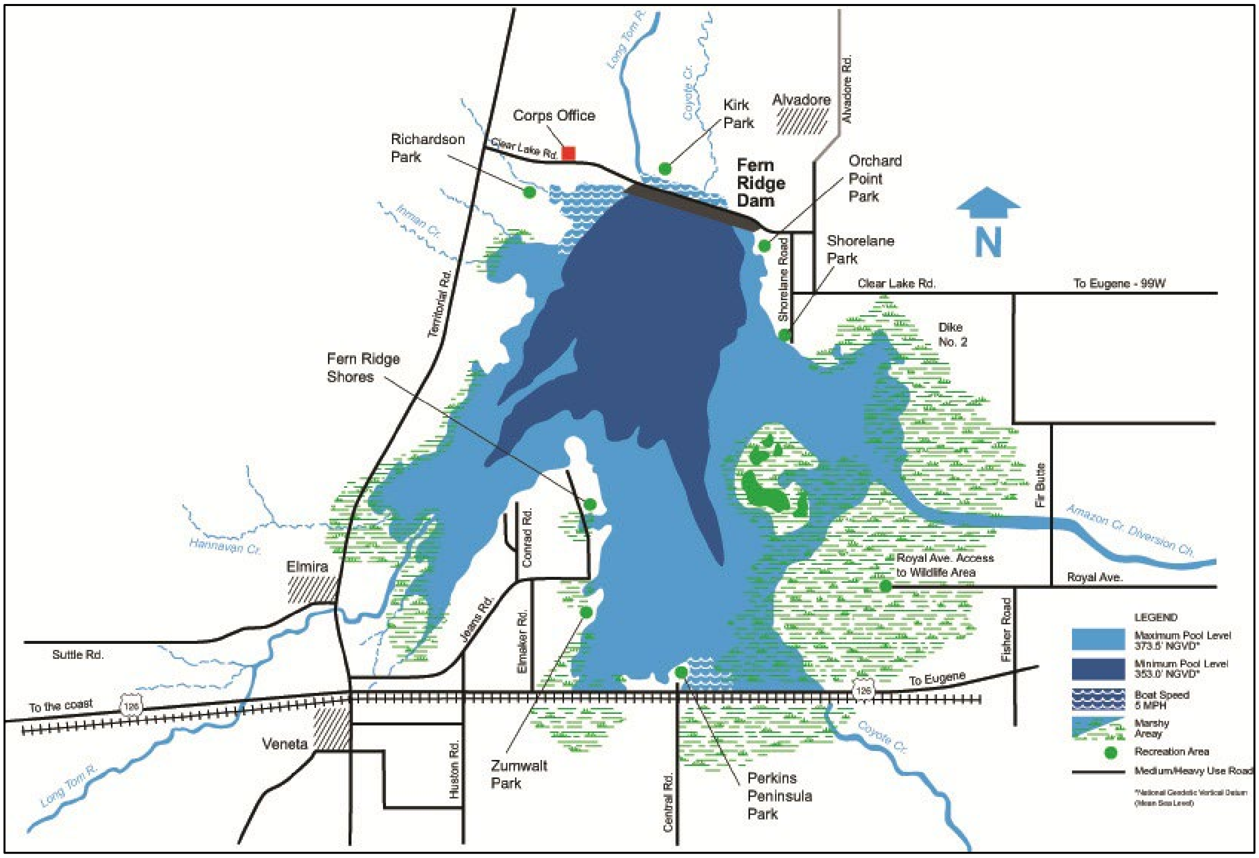


Figure 3.14-10. Recreation Sites at Fern Ridge Dam and Reservoir.

Source: USACE No Date-i

Table 3.14-24. Visits to Fern Ridge Reservoir, Federal Fiscal Year 2022.

Activity	2022 Estimated Visits[1,2]
Picnicking	121,231
Camping[3]	19,184
Swimming	179,081
Waterskiing[4]	44,849
Boating[4]	72,608
Sightseeing	122,347
Sport Fishing	38,007
Other	27,257
Total	**624,564**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

[1] Source: USACE 2022l

[2] Estimated adjusted visits are indexed from 2016 to 2022 using data from U.S. Census Bureau 1-year American Community Survey Count level data. Source: USCB 2016, 2021

[3] Number of campers are estimated for 2022 using GIS tools and data as well as local, county, and state sources as described in Section 1.1 of Appendix K, Recreation Analysis.

[4] Number of boaters and water skiers are estimated for 2022 using regression analysis as described in Section 1.1 of Appendix K, Recreation Analysis.

Table 3.14-25. Summary of Visitation in the Analysis Area by Recreation Activity.

Activity	2022 visits
Picnicking	332,446
Camping	340,702
Swimming	457,366
Waterskiing	222,393
Boating	360,044
Sightseeing	476,743
Sport Fishing	174,682
Other	111,506
Total	**2,475,882**

Note: Details of data sources are located in Appendix K, Recreation Analysis.

Table 3.14-26. Summary of Visitation by Recreation Opportunity.

Opportunity	2022 Visits
Water-based	1,214,485
Land-based	1,149,891

Note: Details of data sources are located in Appendix K, Recreation Analysis. Totals for land-based and water-based visitation do not include "other" category from the reservoir visitation numbers.

Table 3.14-27. Total Reservoir Visitation by Recreation Opportunity Type.

Reservoir	Total Recreation Visits	Water-based Recreation Total	Land-based Recreation Total
Detroit	156,568	28,341	126,045
Foster	452,080	230,224	204,785
Green Peter	84,512	50,618	33,361
Cougar	37,825	13,288	21,884
Blue River	33,415	2,708	29,529
Lookout Point	79,964	42,681	36,932
Dexter	327,033	158,951	160,071
Hills Creek	93,631	24,935	65,488
Fall Creek	118,136	74,063	40,758
Dorena	215,758	89,493	86,629
Cottage Grove	252,396	164,638	81,647
Fern Ridge	624,564	334,545	262,762
Total	**2,475,882**	**1,214,485**	**1,149,891**

Note: Details of data sources are located in Appendix K, Recreation Analysis. Totals for land-based and water-based visitation do not include "other" category from the reservoir visitation numbers.

Table 3.14-28. Ranking of Reservoir Visitation by Recreation Opportunity Type.

Reservoir	Water-based Recreation Ranking	Land-based Recreation Ranking
Detroit	9	4
Foster	2	2
Green Peter	7	10
Cougar	11	12
Blue River	12	11
Lookout Point	8	9
Dexter	4	3
Hills Creek	10	7
Fall Creek	6	8
Dorena	5	5
Cottage Grove	3	6
Fern Ridge	1	1

Note: Details of data sources are located in Appendix K, Recreation Analysis. Totals for land-based and water-based visitation do not include "other" category.

3.14.2.7 River-based Recreation

River-based opportunities along the Willamette River and its tributaries include boating, kayaking, rafting, canoeing, sailing, fishing, and swimming. Important recreation activities include summer rafting excursions and riverboat-based sportfishing for salmonids that run during multiple seasons. Riverine recreation in the WVS is widespread and abundant and no visitor tracking data are available.

Boating activities are provided by boat ramps and access points along analysis area river segments (Figure 3.14-11). The greatest concentration of boat ramps is located along the McKenzie River and North and South Santiam Rivers (USACE 2019a). A longstanding river-guiding and outfitting industry conducts business in the Willamette River Basin. This industry operates primarily on the North and South Santiam, McKenzie, and Middle Fork Willamette Rivers.

Various types of river-based recreation activities occur on the rivers downstream of the dams and reservoirs, each activity type with unique instream flow and water level requirements.

USACE does not release or regulate water specifically for downstream recreation. Regardless, the timing and quantity of flows from the 13 dams and reservoirs can affect downstream recreation opportunities, including along the Long Tom River (from Fern Ridge Dam to Willamette River), the Mainstem Willamette River, McKenzie River, and North and South Santiam Rivers.

Figure 3.14-11. Boating Access in the Willamette River Basin.

Source: USACE 2019a

Additionally, drop structures throughout the analysis area can limit or prohibit river-based recreation opportunities. The drop structure on the Long Tom River at River Mile 6.9 is tentatively scheduled for removal beginning in 2026 (Chapter 1, Introduction, Section 1.12.6, Long Tom River Ecosystem Restoration Project). Once completed, the drop structure removal project will reconnect the Long Tom River from River Mile 10.3 to the confluence of the Willamette River.

Innumerable parks and public spaces alongside watercourses in the Willamette River Basin are owned and managed by different entities, including municipal, state, and Federal governments and private organizations. Due to the approximately 11,200-square mile analysis area, information on parks and public spaces along the hundreds of river miles within the basin, a review of each recreation opportunity is out of scope for a programmatic NEPA analysis. However, subsequent tiered NEPA analyses will address site-specific effects to recreation opportunities as warranted.

Unknown Photo Credit (USACE Media Images Database)

Fishing on Cottage Grove Reservoir.

3.14.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives related to all recreation opportunities identified in the Affected Environment description (Section 3.14.2.2, Analysis Area Recreation Opportunities). The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

Direct effects would occur from:

- Alterations in land-based, water-based, or river-based recreation opportunities.
- Subsequent effects on visitors associated with the three types of opportunities.

Indirect effects would occur from:

- Overuse or over-demand of alternate recreation sites if a recreation opportunity is limited or prohibited at a given reservoir.
- Stress on other resources from use of alternate recreation sites such as reservoir-adjacent vegetation.

Direct impacts to recreation opportunities under each alternative are assessed relative to existing visitation. For example, a substantial impact to boating opportunities at a reservoir may not be a substantial, overall, direct or indirect, recreation effect if visitation to this reservoir is low. Conversely, a short-term impact to boating opportunities may be a substantial, overall, direct effect if boating is the primary activity supporting high visitation. Additionally, recreation opportunities are assessed for the broader WVS.

Economic and community effects from recreation opportunities are described in Section 3.11, Socioeconomics.

The quality of a recreation experience is subjective and is not analyzed. For example, effects on recreation experiences from routine and non-routine maintenance are not addressed. Similarly, impacts on viewsheds around dams and reservoirs may impact recreation opportunities under any alternative (e.g., from wildfire events); however, there are no data to support a direct correlation between viewshed impacts and recreation visitation in the analysis area.

It is assumed that recreation visitation would be substantially or completely reduced under any alternative if opportunities are limited or unavailable as described for the Detroit Reservoir area following the 2020 wildfires (Section 3.14.2.4, Analysis Area Wildfires). Wildfire effects are addressed in Section 3.14.5, Climate Change under All Alternatives. Effects on visitors to the analysis area from landscape alterations are address in Section 3.22, Visual Resources.

Additionally, deep drawdowns would deter safe access for other water-based activities such as swimming, non-motorized boat use, etc. Low reservoir levels under any alternative would impact all water-based opportunities by limiting or prohibiting access. During deep drawdowns, there would be no safe or sanctioned access to reservoir water for any water-based activity under any alternative.

3.14.3.1 Methodology

Data Collection

The Oregon Statewide Comprehensive Outdoor Recreation Plan (SCORP) identifies state-wide trends in recreation needs and participation. In addition to information provided by the SCORP, amenities and activities available at recreation sites managed by BLM, USFS, ODFW, OPRD, Lane County, Linn County, and private entities were sourced from the best available online resources maintained by the managing agency or by contacting an agency or organization directly. Information on fishing at each of the reservoirs was based on ODFW's Recreation Report for the Willamette Zone (Appendix K, Recreation Analysis).

USACE publishes *Value to the Nation Fast Facts Reports* that include statistics on the type of USACE-only recreation facilities, visitation, and economic effects of recreation opportunities associated with WVS reservoirs. Facilities not managed by USACE are not captured in the *Value to the Nation Fast Facts Reports*. Consequently, GIS analyses and other Federal, state, county, and local data were accessed to capture visitation effects. These data were limited to campground information.

Water-based Recreation Opportunities Quantitative Methodology

Overview

Total water-based opportunities are the primary recreation activities in the analysis area and impacts to these opportunities under the alternatives would be direct. Conversely, indirect impacts would occur to land-based opportunities from operations under the alternatives over the 30-year implementation timeframe and direct effects on water-based recreation would cause indirect effects on associated land-based recreation such as camping to support boating activity. Subsequently, indirect effects may also occur to agencies that manage recreation areas[7].

The quantitative analyses focus on drawdowns under the alternatives because of the direct impact on reservoir levels and, therefore, water-based recreation as compared to other proposed measures (e.g., use spillway for surface spill in summer). Boat ramp access was used as a proxy for effects on all water-based opportunities in analysis area reservoirs because of its direct correlation to reservoir levels.

Effects are described at the reservoir-specific level; however, analyses of the impact on recreation opportunities in the analysis area overall are also provided.

[7] Effects on private recreation operators are addressed as revenue impacts in Section 3.11, Socioeconomics.

Construction effects are addressed qualitatively. Subsequent tiered analyses would detail site-specific construction effects during the implementation phase, and any applicable permits would be obtained at that time (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act).

Routine and non-routine maintenance, which would occur under all alternatives during the 30-year implementation timeframe, is also analyzed qualitatively (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation).

Quantitative Methodology

To estimate the average annual number of boat ramp usable days, water surface elevation (WSE) data from a HEC-ResSim model were compared to boat ramp elevations at each reservoir during the peak recreation season from May 15 to September 15 (Appendix K, Recreation Analysis)[8]. WSE data from the HEC-ResSim model were available for 83 full water years[9].

For a boat ramp to be useable, the top of the boat ramp must be above the WSE, and the bottom of the ramp deep enough into the water level for a boat to be backed into the water. Therefore, the number of days in each water year season that the bottom of a given boat ramp elevation was lower than the WSE were counted as usable days, with the remaining days counted as unusable.

Reservoir recreation visitor data from USACE VERS, OPRD, Linn and Lane Counties, BLM, and USFS resources were used to estimate annual visitation[10]. A simplifying assumption was made that all reservoir visitations would occur during the peak recreation season from May 15 to September 15[11].

For the analyses, it was assumed that effects on visitation under each alternative would occur if there were deep drawdowns of a single or of multiple reservoirs in the fall and spring impacting the peak recreation season May 15 to September 15. Therefore, to calculate visitation under each alternative as compared to visitation under the No-action Alternative (NAA), it was

[8] Although climate-related changes may affect the peak recreation season during the 30-year implementation timeframe, the existing peak season was used as a constant for analysis purposes.

[9] A water year is from October 1 through September 30.

[10] While ODFW cooperates with USACE to provide recreation opportunities in the analysis area, agency licensing data do not support visitation data. For example, fishing licenses track species data, not number of visitors.

[11] Visitation data were not separated by month or season; all annual visitation was grouped into the peak recreational season (Appendix K, Recreation Analysis).

assumed that a majority of boaters and sport fishers would forego visiting a reservoir if the WSE would be below the bottom of boat ramps[12].

Land-based Recreation Opportunities Qualitative Analysis

Land-based recreation opportunities were analyzed qualitatively. The availability of land-based recreation opportunities would typically be unaffected by alternative drawdown measures (Section 3.14.2.2, Analysis Area Recreation Opportunities). While some land-based activities, such as picnicking or camping, may not be preferred during drawdown reservoir conditions, these opportunities would not be precluded under any alternative. However, recreation opportunities could be indirectly impacted by alternative measures requiring temporary recreation site or access road closures (Section 3.14.2.2, Analysis Area Recreation Opportunities).

Closures could result in further indirect effects from high demand for recreation facilities at other reservoir campgrounds, picnic areas, etc. Displacement of recreation visitors from one reservoir with closures to another reservoir with water-based opportunities could adversely impact the supply of recreation opportunities if high demand outweighs available opportunities (e.g., maximum campground or parking capacities). Further, adverse impacts to the natural environment could occur if visitors are at capacity in one location in the long term (e.g., one peak recreation season or multiple, consecutive seasons). This could include degradation of the surrounding natural environment, unauthorized dispersed recreation in nearby areas that support native vegetation, and impacts on wildlife habitat[13]. Additionally, dispersed camping in unauthorized areas would increase wildfire risks.

River-based Recreation Opportunities Quantitative Methodology

Existing data are available online that illustrate preferred river flow ranges in the McKenzie and North Santiam Rivers. River flows are measured at various gage locations that align with the HEC-ResSim model control points. Flows compared to flows under NAA operations from 11 gage locations throughout the analysis area were used as an indicator of general effects to river-based recreation (Appendix K, Recreation Analysis).

Effects of operations under the alternatives on river flows were analyzed by the frequency that average annual river flows fall within the high/low range of desired whitewater flows. Higher stream flows would increase river-based recreational carrying capacities and benefit activities such as white-water rafting.

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[12] Some boaters utilize a marina and, therefore, are not always dependent on the availability of reservoir boat ramps. Other boaters who use self-propelled boats such as kayaks do not need to use a ramp to access the water. Similarly, some sport fishers do not utilize boat ramps to fish; instead, they fish off the spillway, shoreline, or docks.

[13] The economic effects of displaced recreation are analyzed in Section 3.11, Socioeconomics.

Additionally, data published by river recreation groups that define generally desired whitewater upper and lower water flows at some river gage locations were plotted against HEC-ResSim flows to illustrate the average annual time period that flows are expected to be within the upper and lower bounds (Appendix K, Recreation Analysis, Section 4.2, Whitewater Recreation).

However, visitation estimates were not made for riverine areas because of the many access points available to recreators that are not managed by USACE. Therefore, river-based visitation data were not available at the time the alternatives were analyzed. Instead, flows under each alternative were used as an indicator of general effects to river-based recreation.

Effects Criteria

The degree of impact on recreation resources are discussed descriptively (e.g., slight, moderate[14], substantial). Similarly, the duration of an effect is qualitative; short-term implies an impact would occur or reoccur for a short period of time during the 30-year implementation timeframe. Long-term implies an impact would occur or reoccur over a long period of time and up to the 30-year implementation timeframe (i.e., effects that would occur over the 30-year implementation timeframe are considered long-term effects).

Specified criteria to describe the degree of effect are not provided because criteria based on anticipated differences in recreation opportunities under a given alternative as compared to the NAA would be speculative (e.g., what percent of a direct or indirect recreation opportunity modification constitutes a minor or major effect?). Therefore, descriptions of effects are more informative and accurate than attempting to assign specific criteria to adverse or beneficial effects.

The degree of effect for water-based recreation opportunities was derived from boater access and visitation data combined. Specifically, a substantial, direct adverse effect on an opportunity would occur if the following four conditions are met:

1. WSE is below the bottom of boat ramp(s) at a given reservoir.
2. Boat ramps are unusable at a given reservoir due to WSE elevation below ramps.
3. Boat ramp closures occur during the peak recreation season.
4. A given reservoir supports high visitation for water-based recreation activities.

However, to derive the total degree of effect, this outcome was then incorporated with visitation at each reservoir. Equating an impact on a water-based recreation opportunity with

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[14] "Negligible" is defined in its common use as "too slight or small in amount to be of importance" (Cambridge Dictionary). "Minor" is defined as comparatively unimportant (Merriam-Webster Dictionary). "Slight" is defined in its common use as "small of its kind, or in amount" (Merriam-Webster Dictionary). "Moderate" is defined in its common use as "average in amount, intensity, quality, or degree" (Oxford Languages). "Substantial" is defined in its common use as "considerable in quantity, great [in amount]" (Merriam-Webster Dictionary).

visitor interest provided a more accurate depiction of overall effect specific to each reservoir under each alternative than by assessing opportunity availability alone.

A summary of effects to recreation opportunities is provided in Table 3.14-29.

Table 3.14-29. Summary of Effects on Recreation Opportunities as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Water-based Opportunities	Substantial, beneficial. Potential direct, moderate to substantial, adverse effects during the latter portion of the recreation season in summer to some analysis area reservoirs depending on the amount of precipitation and timing of the drawdowns.	Same as the No-action Alternative at most reservoirs. Direct, slight, increased benefits at Detroit, Green Peter, Cougar, Hills Creek, Dorena, and Cottage Grove Reservoirs from earlier spring refill.	Same as No-action Alternative.	Same as the No-action Alternative at most reservoirs. Direct, substantial, adverse effects at Cougar Reservoir with slight to moderate, adverse effects on other analysis area reservoirs due to displaced visitor use.	Same as the No-action Alternative at some reservoirs. Direct, substantial, adverse effects at Lookout Point, Cougar, and Detroit Reservoirs with substantial adverse effects on other analysis area reservoirs due to displaced visitor use. Potential direct, substantial, adverse effects during the latter portion of the recreation season in late summer at Hills Creek, Blue River, and Green Peter Reservoirs.	Same as the No-action Alternative at some reservoirs. Direct, substantial, adverse effects at Green Peter, Hills Creek, and Cougar Reservoirs with substantial, adverse effects on other analysis area reservoirs due to displaced visitor use. Potential direct, substantial, adverse effects during the latter portion of the recreation season in late summer at Lookout Point, Detroit, and Blue River Reservoirs.	Same as No-action Alternative.	Same as Alternative 2B.
Land-based Opportunities	Substantial, beneficial because no change in land-based recreation opportunities.	Same as No-action Alternative.	Same as No-action Alternative.	Same as the No-action Alternative at most reservoirs. Reduced incentive to use facilities at Cougar Reservoir from lack of water-based opportunities.	Same as the No-action Alternative at some reservoirs. Reduced incentive to use facilities at Cougar, Detroit, and Lookout Point Reservoirs from lack of water-based opportunities.	Same as the No-action Alternative at some reservoirs. Reduced incentive to use facilities at Cougar, Green Peter, and Hills Creek Reservoirs from lack of water-based opportunities.	Same as No-action Alternative.	Same as Alternative 2B.
Recreation Site Management	Substantially beneficial. Potential indirect, moderate to substantial, adverse effects on management during the latter portion of the recreation season in late summer at some analysis area reservoirs depending on the amount of precipitation and timing of the drawdowns due to visitor displacement.	Same as the No-action Alternative at most reservoirs. Potential indirect, adverse impacts on management at Detroit, Green Peter, Cougar, Hills Creek, Dorena, and Cottage Grove Reservoirs due to increased visitor use.	Same as No-action Alternative.	Same as the No-action Alternative at most reservoirs. Indirect, adverse effects at Cougar Reservoir from management requirements. Potential indirect, adverse impacts on management at nearby reservoirs from displaced visitors and related management requirements.	Same as the No-action Alternative at some reservoirs. Indirect, adverse effects at Cougar, Detroit, and Lookout Point Reservoirs from management requirements. Potential indirect, moderate, adverse effects on management during the latter portion of the recreation season at Hills Creek, Green Peter, and Blue River Reservoirs from displaced, late summer visitor use.	Same as the No-action Alternative at some reservoirs. Indirect, adverse, substantial impacts at Green Peter, Hills Creek, and Cougar Reservoirs from management requirements. Potential indirect, moderate, adverse effects on management during the latter portion of the recreation season at Lookout Point, Detroit, and Blue River Reservoirs from late summer visitor use.	Same as No-action Alternative.	Same as Alternative 2B.

[1] Effects would occur annually during the peak recreation season May 15 to September 15. Some effects may occur into late summer past the peak recreation season as identified.

3.14.3.2 Alternatives Analysis

Congressionally Authorized Purpose under All Alternatives

Operations and maintenance under any alternative would continue to provide recreation opportunities throughout the analysis area per the Congressionally authorized recreation purpose for the WVS. However, there would be varying effects to these opportunities depending on the alternative, as analyzed below.

For example, alternatives that include a deep drawdown in the spring and fall would have substantial, local, long-term impacts to water-based recreation opportunities at the reservoir reoccurring over the 30-year implementation timeframe because the reservoir would not be refilled. Consequently, operations would not provide water-based recreation opportunities at any point during the peak recreation season.

Alternatively, a deep fall drawdown could impact the latter portion of the recreation season in late summer depending on timing of the start of the drawdown. Use of reservoirs for Congressionally authorized purposes other than recreation could be required during years of low or high precipitation. Depending on timing of drawdowns, late-season adverse effects could occur to water-based recreation opportunities at reservoirs where water-based recreation activities would be prohibited.

Although local impacts would occur from deep drawdowns, this would not minimize recreation opportunities or preclude visitation at other reservoirs in the analysis area. Recreation opportunities would be available at various WVS reservoirs during the peak recreation season and in late summer within the analysis area under any alternative.

Deep Fall Drawdown at Fall Creek under All Alternatives

A deep drawdown would occur at Fall Creek Reservoir under all alternatives; however, this drawdown would occur outside of the peak recreation season. Consequently, the drawdown would not affect visitors or recreation opportunities during the May 15 to September 15 peak recreation period.

Routine and Non-routine Maintenance Activities under All Alternatives

Routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation). Much routine maintenance involves activities such as guardrail painting that would have no effect on recreation opportunities. Non-routine rehabilitation to upgrade facilities may occur indoors and not within the proximity of recreation areas.

However, it is possible that construction activities under the action alternatives would have short-term, adverse effects on recreation facilities. For example, an upgrade to the Dexter Dam adult fish facility required closure of the Middle Fork Boat Ramp for 3 years. Effects such as these from routine and non-routine maintenance would be assessed under site-specific NEPA reviews.

Wild and Scenic River Designations

There would be no direct or indirect impact to any river designated as Wild and Scenic under any alternative because operations and maintenance would not be in conflict with Federal designation criteria or Federal agency management. Therefore, these river categories are not further analyzed.

Land-based Recreation Opportunities under All Alternatives

There would be no direct or indirect effects to most land-based opportunities described in Section 3.14.2.2, Analysis Area Recreation Opportunities. Operations and maintenance under any alternative would be localized to dam and reservoir areas and, therefore, would not impact sightseeing, hiking, biking, cross-country skiing, snowshoeing, or wildlife viewing around reservoirs. Additionally, hunting and plant foraging opportunities, which are located away from dam and reservoir sites, would not be impacted. No impact on these land-based recreation opportunities would occur at the overall analysis area level because there would be no impacts at the local reservoir level. Consequently, these recreation opportunities are not further analyzed.

River-based Recreation Opportunities under All Alternatives

Existing river-based recreation opportunities would not be affected under any alternative. Water-based recreation, including boating and sport fishing, would continue as under existing conditions under all alternatives. There would be no effect on the several parks and public spaces alongside watercourses in the Willamette River Basin.

As under existing conditions, USACE would not release or regulate water specifically for downstream recreation under any action alternative. River-based recreation opportunities in the WVS are widespread and abundant. Due to the variety of river-based opportunities and varying river level requirements to support river-based recreation opportunities, it is difficult to analyze effects to river-based recreation opportunities.

The timing and quantity of flows from the 13 dams and reservoirs could continue to affect downstream recreation opportunities, including along the Long Tom River (from Fern Ridge Dam to the confluence with the Willamette River), the Mainstem Willamette River, McKenzie River, and North and South Santiam Rivers. Revetments and drop structures would continue to limit or prohibit river-based recreation opportunities throughout the analysis area under the NAA over the 30-year implementation timeframe. However, the drop structure near the City of Monroe at River Mile 6.9 is tentatively scheduled for removal beginning in 2026. This removal will be a substantial, long-term benefit to in-river boater opportunities in the Long Tom River under the NAA.

No-action Alternative

Under the NAA, existing operations and maintenance of reservoirs would continue throughout the WVS for the 30-year implementation timeframe.

Water-based Recreation Opportunities

All water-based recreation opportunities would remain available and accessible throughout the analysis area during the peak recreation season under NAA operations during the 30-year implementation timeframe. Under NAA operations, conservation pools would continue to provide high reservoir water levels at all reservoirs during the peak recreation season, at which point the reservoirs with lower recreation demand would be used to meet summer instream flow requirements (measured at Albany and Salem gages).

Recreation would remain a high priority for management at Fern Ridge Reservoir (which had the highest visitation numbers for recreation in general and for water-based recreation opportunities at the time the alternatives were analyzed) under the NAA, and other WVS reservoirs would be drafted to meet downstream requirements prior to using Fern Ridge Reservoir under the NAA. Water from the Detroit, Foster, and Fern Ridge Reservoirs would be used last to meet flow requirements during the recreation season because of their water-based recreation importance.

Consequently, water-based recreation visitors would continue to directly benefit from operations under the NAA at all reservoirs and WVS-wide during the 30-year implementation timeframe. The substantial WVS-wide benefits would affect water-based visitors to all reservoirs combined during the peak recreation season (Table 3.14-26).

Water-based visitors to high-use reservoirs—Detroit, Fern Ridge, and Foster Reservoirs—would also directly benefit from NAA operations because high reservoir levels would be maintained until late in the recreation season during the 30-year implementation timeframe. Seasonality of visitor use data were not collected; therefore, it is assumed most water-based recreation occurs during the warm summer months and peak vacation periods. This assumption was factored into the moderate and minor degrees of effect from late season water levels at these reservoirs.

Exceptions to these benefits would occur during years of low precipitation, which would require use of reservoirs for Congressionally authorized purposes other than recreation. Depending on timing of drawdowns, late season adverse effects could be moderate to water-based recreation opportunities at reservoirs where water-based recreation activities are the primary recreation activities supported by operations, and they could be prohibited.

Although direct effects to recreation in years with low precipitation cannot be accurately assessed, it is assumed these operations would adversely affect water-based recreation by limiting use of boat ramps during the peak recreation season under the NAA. This direct effect could be substantial if persistent over an entire recreation season, or reoccurring over the 30-year implementation timeframe, and affecting several, high visitor-use reservoirs under NAA operations. However, adverse effects from reservoir use during low precipitation periods may be intermittent during the 30-year implementation timeframe. Additionally, not all WVS reservoirs may be adversely affected during the same recreation season by these potential conditions; water-based recreation opportunities may be available at some reservoir locations.

Land-based Recreation Opportunities

All land-based recreation opportunities would remain available and accessible throughout the analysis area during the peak recreation season under NAA operations during the 30-year implementation timeframe, including during years of low precipitation.

The incentive to use land-based recreation opportunities would be diminished by lack of water-based opportunities later in the recreation season in years with low precipitation; however, land-based opportunities would remain available. Further, land-based opportunities would be available throughout the analysis area although one or more reservoir drawdowns may result in unavailable water-based opportunities. Associated visitor displacement to other land-based recreation sites could increase impacts at other reservoirs from overuse, which would be a moderate to substantial, adverse effect in the long term, depending on site-specific conditions. However, the risk of potential wildfires could increase with dispersed recreation in unauthorized and unmanaged areas.

Recreation Site Management

Under the NAA, agencies and organizations that manage recreation opportunities in the analysis area at the time the alternatives were analyzed would continue to manage facilities and adjust recreation site and facility needs based on visitation. Current visitation data for the analysis area demonstrate that recreation sites are visited primarily for water-based opportunities. It is assumed that visitation primarily for water-based opportunities would continue during the 30-year implementation timeframe under the NAA.

During years of low precipitation, reservoirs are used for Congressionally authorized purposes other than recreation. Operations to address low precipitation may not affect all reservoirs in the analysis area. While recreation opportunities may be available at some reservoirs, visitation could shift from reservoirs with unavailable water-based recreation opportunities and could also cause overuse of facilities at reservoirs that are already at carrying capacity. This would result in associated, indirect, adverse effects to other recreation resources such as day-use areas or resources such as reservoir-adjacent vegetation.

Additionally, unauthorized dispersed use may occur, which could adversely impact native vegetation on agency-managed lands and may increase the risk of wildfires. Public safety risk may also increase at reservoirs closed to water-based recreation but used for land-based recreation opportunities. These would be adverse effects on managing agencies and organizations as they adjust to user shifts, requiring staffing and financial resources to manage impacts and possible financial burdens including lost revenue (Section 3.11, Socioeconomics). The degree of effect cannot be assessed, however, because adverse conditions would be site-specific, and the duration is unknown.

Alternative 1—Improve Fish Passage through Storage-focused Measures

Under Alternative 1, USACE would implement measures to maximize the refill volumes of conservation pools within the analysis area reservoirs to benefit refill objectives and to meet authorized purposes that depend on full reservoirs, including recreation. This would increase the likelihood of refilling the reservoirs in the spring and would result in high reservoir water levels to provide recreation opportunities during the recreation season.

Compared to the NAA:

- Operations at Detroit and Green Peter Reservoirs would result in fill earlier in the recreation season with higher reservoir levels later into the recreation season.
- Operations at Cougar Reservoir would store more water during the recreation season.
- Operations at Hills Creek Reservoir would result in fill earlier in the recreation season.
- Operations at Dorena and Cottage Grove Reservoirs would result in higher reservoir levels during the recreation season.

Water-based Recreation Opportunities

As under the NAA, all water-based recreation opportunities would remain available and accessible throughout the analysis area during the peak recreation season under Alternative 1 operations during the 30-year implementation timeframe. Operations under Alternative 1 would result in slightly higher reservoir levels from earlier refills and higher levels remaining later in the year. Consequently, there would be slight, direct benefits to recreation opportunities and visitors at reservoirs that would be more likely to provide water-based recreation for the duration of the recreation season. These include Detroit, Green Peter, Cougar, Hills Creek, Dorena, and Cottage Grove Reservoirs. Slight, direct benefits would reoccur over the 30-year implementation timeframe.

Recreation opportunities and benefits to recreation visitors under Alternative 1 would be the same as under NAA operations at Foster, Fern Ridge, Blue River, and Fall Creek Reservoirs.

Effects on recreation opportunities and visitors during years of low precipitation under Alternative 1 would be the same as described under the NAA operations.

Land-based Recreation Opportunities

Effects on land-based recreation opportunities and visitors under Alternative 1 would be the same as those described under the NAA, including impacts during years of low precipitation.

Recreation Site Management

Unlike the NAA, recreation site management under Alternative 1 could be indirectly impacted by a possible increase in water-based recreation visitors utilizing existing land-based facilities such as day-use areas; campgrounds; and associated parking, boat ramps, and restrooms in the spring from earlier reservoir refill. This increase in use could occur at Detroit, Green Peter, Cougar, Hills Creek, Dorena, and Cottage Grove Reservoirs where refill volumes would be maximized during the peak recreation season and more likely to provide recreation early and later in the season compared to the NAA. Adverse effects from increased demands on recreation facilities would be reoccurring over the 30-year implementation timeframe.

Under the NAA operations, recreation facilities would remain at carrying capacity in the analysis area during the peak recreation season. Alternative 1 operations could, therefore, increase the need for management resources with additional visitor demands at Detroit, Green Peter, Cougar, Hills Creek, and Cottage Grove Reservoirs. This would be a long-term, adverse effect on managing agencies, but the degree of effect cannot be assessed without site-specific information and combined information on impacts at more than one reservoir over a 30-year implementation timeframe.

If needed under Alternative 1, upgrades or construction of new facilities at a given reservoir to meet opportunity demands would require funding sources, placing financial burdens on managing agencies and organizations not realized under the NAA. Some may financially benefit from increased visitor use where fees and permits are required, although these benefits and compensation from fees for total costs of upgrades cannot be accurately assessed.

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Alternative 2A includes a combination of modified operations and structural improvements to balance water management flexibility and to meet ESA-listed fish obligations. Compared to the NAA, Alternative 2A includes a deep fall drawdown of the Green Peter Reservoir.

Water-based Recreation Opportunities

Effects to water-based recreation opportunities would be the same as those described under the NAA. As under the NAA, all water-based recreation would remain available and accessible throughout the analysis area during the peak recreation season under Alternative 2A operations during the 30-year implementation timeframe. Unlike the NAA operations, Alternative 2A includes a deep fall drawdown of the Green Peter Reservoir. However, the timing of this drawdown would be outside of the peak recreation season and would not affect water-based recreation opportunities, which would remain the same as under the NAA.

Effects on recreation opportunities and visitors during years of low precipitation under Alternative 2A would be the same as described under the NAA operations.

Land-based Recreation Opportunities

Effects on land-based recreation opportunities and visitors under Alternative 2A would be the same as those described under the NAA, including impacts associated with years of low precipitation.

Recreation Site Management

Effects on recreation site management under Alternative 2A operations would be the same as those described under the NAA, including impacts associated with years of low precipitation.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Operations under Alternative 2B over the 30-year implementation timeframe would be the same as those described under Alternative 2A. However, Alternative 2B also includes deep fall and spring drawdowns at Cougar Reservoir, which would result in adverse effects on recreation opportunities during the peak recreation season.

Water-based Recreation Opportunities

Effects to water-based recreation opportunities would be the same as those described under the NAA with the exception of effects at Cougar Reservoir. The combination of a deep fall drawdown and a deep spring drawdown would prevent a Cougar Reservoir refill during the peak recreation season. Consequently, operations at Cougar Reservoir would not provide water-based recreation opportunities.

This would cause local, direct effects to water-based recreation at Cougar Reservoir. These effects would be reoccurring over the 30-year implementation timeframe because refill would not occur and would, therefore, not provide water-based recreation opportunities at any time during the recreation season. However, compared to other reservoirs in the analysis area, Cougar Reservoir supports low visitation numbers, especially for water-based recreation. Although impacts on water-based recreation opportunities would be substantial, they would not affect a substantial number of visitors. Overall, impacts would be minor or moderate to visitors from Alternative 2B operations as compared to the NAA.

Effects on recreation opportunities and visitors during years of low precipitation under Alternative 2B would be the same as described under the NAA operations. Low precipitation year effects at Cougar Reservoir would not be relevant to recreation opportunities in dry years because there would be no water-based recreation at this reservoir in any year during the peak recreation season.

Land-based Recreation Opportunities

Effects on land-based recreation opportunities under Alternative 2B would be the same as those described under the NAA, including impacts associated with years of low precipitation.

There would be no indirect effects on land-based recreation opportunities at Cougar Reservoir because although the incentive to use land-based recreation opportunities would be diminished by lack of water-based opportunities, land-based opportunities would remain available. Further, land-based opportunities would be available throughout the analysis area. Unlike NAA operations, operations under Alternative 2B could increase impacts at other reservoirs and surrounding areas from overuse, which would be a minor to moderate, adverse effect in the long term due to the lower numbers of recreation visitors displaced from Cougar Reservoir compared to other analysis area reservoirs.

Recreation Site Management

Unlike NAA operations, indirect, adverse effects to recreation site management under Alternative 2B at Cougar Reservoir would be reoccurring during the 30-year implementation period due to the deep fall and spring reservoir drawdowns making the reservoir inaccessible for water-based recreation. USFS manages all recreation facilities at Cougar Reservoir, including several campgrounds, day-use areas, and boat ramps. Lack of use may incur unknown management requirements possibly related to closures and safety, and financial burdens including lost revenue.

As under NAA operations, recreation facilities would remain at carrying capacity in the analysis area during the peak recreation season. Alternative 2B operations at Cougar Reservoir could, therefore, increase the need for management resources with additional visitor demands at other reservoirs including nearby Blue River Reservoir, which is also managed by USFS. This would be a long-term, adverse effect on USFS management.

The degree of effect cannot be assessed without site-specific information and combined information on impacts at more than one reservoir over a 30-year implementation timeframe. However, adverse effects from increased visitation at Blue River Reservoir could be substantial because although visitation numbers at Cougar Reservoir are lower compared to the overall analysis area, Blue River Reservoir operates at visitor capacity during the peak recreation season. A shift in visitors from Cougar Reservoir to any other analysis area reservoir would increase competition for available land-based recreation opportunities.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

Operations under Alternative 3A would include deep fall season drawdowns at Lookout Point, Hills Creek, Green Peter, Detroit, Blue River, and Cougar Reservoirs and spring drawdowns at Lookout Point, Detroit, and Cougar Reservoirs.

Water-based Recreation Opportunities

Due to the combination of deep fall reservoir drawdowns and spring reservoir drawdowns, Cougar, Detroit, and Lookout Point Reservoirs would not be refilled during the peak recreation season and operations would not provide water-based recreation opportunities. Compared to the NAA, direct, adverse effects to water-based recreation opportunities at these reservoirs would be substantial and reoccurring during the 30-year implementation period.

Deep fall drawdowns at Hills Creek, Green Peter, and Blue River Reservoirs under Alternative 3A could have direct, substantial adverse effects to visitors during the latter portion of the peak recreation season depending on the amount of precipitation during the summer and timing of drawdown initiation at each reservoir.

Additionally, in combination, the lack of available water-based recreation at several reservoirs would be a substantial, direct adverse effect on water-based recreation opportunities in the analysis area overall as compared to NAA operations.

Adverse effects from displaced recreation use would be the same as described under Alternative 2B, but more substantial in geographic scope. Additionally, visitation at Detroit Reservoir is typically high during the recreation season. Lack of water-based recreation opportunities at this reservoir would be a direct, substantial adverse effect on local water-based recreation and on analysis area recreation opportunities from displaced use.

Effects on recreation opportunities and visitors during years of low precipitation under Alternative 3A would be the same as described under the NAA operations.

Land-based Recreation Opportunities

There would be no indirect effects on land-based recreation opportunities at Cougar, Detroit, and Lookout Point Reservoirs because although the incentive to use land-based recreation opportunities would be diminished by lack of water-based opportunities, land-based opportunities would remain available. Further, land-based opportunities would be available throughout the analysis area.

Unlike NAA operations, operations under Alternative 3A could increase impacts at other reservoirs and surrounding areas from overuse, which would be a moderate to substantial, adverse effect in the long term. Detroit Reservoir supports high land-based recreation visitation while Lookout Point and Cougar Reservoirs support lower visitation.

Additionally, there may be displacement from Hills Creek, Green Peter, and Blue River Reservoirs of land-based recreation visitors during the latter part of the recreation season depending on timing of the drawdowns. Unlike the NAA, combined, displaced recreation visitors could place substantial burdens on other land-based recreation areas in the analysis area by increasing competition for available recreation resources. This indirect adverse effect would be reoccurring during the 30-year implementation timeframe under Alternative 3A.

Effects on recreation opportunities and visitors during years of low precipitation under Alternative 3A would be the same as described under the NAA operations.

Recreation Site Management

Unlike NAA operations, indirect adverse impacts to recreation site management at Cougar, Detroit, and Lookout Point Reservoirs under Alternative 3A would be substantial and reoccurring during the 30-year implementation period. Deep fall drawdowns at Hills Creek, Green Peter, and Blue River Reservoirs could have indirect, moderate adverse effects on recreation site management during the latter portion of the recreation season depending on the timing of drawdown initiation.

USFS manages several facilities, including campgrounds, day-use areas, and boat ramps, at Cougar, Detroit, and Lookout Point Reservoirs. USACE manages day-use areas, boat ramps, and a campground at Lookout Point Reservoir. Other facilities at Detroit Reservoir are managed by OPRD and Linn County, and there are two privately-owned marinas at Detroit Reservoir. Unlike NAA operations, lack of use may incur unknown management requirements possibly related to closures and safety, and financial burdens including lost revenue to agencies and organizations.

As under the NAA operations, recreation facilities would remain at carrying capacity in the analysis area during the peak recreation season. Alternative 3A operations at Cougar, Detroit, and Lookout Point Reservoirs could, therefore, increase the need for management resources with additional visitor demands at other reservoirs and adverse effects from dispersed use in unauthorized areas including vegetation damage and increased risks of wildfire. This would be a long-term, moderate to substantial adverse effect on agency and organization management.

The degree of effect cannot be assessed without site-specific information and combined information on impacts at more than one reservoir over the 30-year implementation timeframe. However, adverse effects from increased visitation related to lack of water-based recreation and, therefore, land-based recreation, at Detroit Reservoir alone could be substantial because all analysis area reservoirs operate at visitor capacity during the peak recreation season. A shift in visitors from three to possibly six reservoirs to any other analysis area reservoir would substantially increase competition for available land-based recreation opportunities.

<u>Alternative 3B—Improve Fish Passage through Operations-focused Measures</u>

Operations under Alternative 3B would the same as under Alternative 3A. However, operations would include a spring drawdown implemented at a different combination of reservoirs. Alternative 3B would include deep fall season drawdowns at Lookout Point, Hills Creek, Green Peter, Detroit, Blue River, and Cougar Reservoirs (as under Alternative 3A) and spring drawdowns at Green Peter, Hills Creek, and Cougar Reservoirs. The drawdowns at Cougar Reservoir would be to the diversion tunnel and deeper than the drawdown under Alternative 3A operations.

Water-based Recreation Opportunities

Direct, adverse effects on water-based recreation opportunities in the analysis area under Alternative 3B would be similar to those under Alternative 3A except they would impact different reservoirs. Direct, adverse effects at the local reservoir level would be substantial at Green Peter, Hills Creek, and Cougar Reservoirs because they would not be refilled during the peak recreation season and would not provide water-based recreation opportunities. Direct impacts to water-based recreation opportunities at these reservoirs would be substantial and reoccurring during the 30-year implementation period.

Deep fall drawdowns at Lookout Point, Detroit, and Blue River Reservoirs under Alternative 3B could have direct, substantial adverse effects to visitors during the latter portion of the peak recreation season depending on the amount of precipitation during the summer and timing of drawdown initiation at each reservoir.

Additionally, in combination, the lack of available water-based recreation at several reservoirs would be a substantial, direct adverse effect on water-based recreation opportunities in the analysis area overall as compared to NAA operations.

Adverse effects from displaced recreation use would be the same as described under Alternative 2B, but more substantial in geographic scope. Although these reservoirs do not have the highest visitation in the analysis area, Alternative 3B operations would have substantial, adverse direct effects due to potential displacement of visitors to other reservoirs, increasing competition for recreation resources that are at carrying capacity during the peak recreation season.

Effects on recreation opportunities and visitors during years of low precipitation under Alternative 3B would be the same as described under the NAA operations.

Land-based Recreation Opportunities

Effects on land-based recreation opportunities and visitors under Alternative 3B would be the same as those described under Alternative 3A but at the reservoirs analyzed under Alternative 3B, including impacts associated with years of low precipitation.

Recreation Site Management

Effects on recreation site management under Alternative 3B would be similar to those described under Alternative 3A during the 30-year implementation timeframe. However, unlike NAA operations, substantial, indirect effects would occur at Green Peter, Hills Creek, and Cougar Reservoirs from lack of use and may incur unknown management requirements possibly related to closures and safety, and financial burdens including lost revenue (Section 3.11, Socioeconomics). USFS manages several recreation facilities at Hills Creek and Cougar Reservoirs and Linn County manages facilities at Green Peter Reservoir.

Under Alternative 3B, visitors could be displaced to Blue River and/or Foster Reservoirs which are near Cougar and Green Peter Reservoirs, respectively. Foster Reservoir supports high visitation relative to its small size. Shifts in visitation would cause indirect, substantial, adverse effects to manage increased competition for recreation resources and surrounding environmental impacts. Adverse effects from dispersed use in unauthorized areas could include vegetation damage and increased risks of wildfire. These effects would be long term.

Unlike NAA operations, deep fall drawdowns at Lookout Point, Detroit, and Blue River Reservoirs could have indirect, moderate adverse effects on recreation site management during the latter portion of the recreation season depending on the timing of drawdown initiation. However, indirect effects at Detroit Reservoir could be substantial regardless of late recreation season operations because of the high visitation at this reservoir. Financial and staff resource adjustments could be required to compensate for a lack of visitation at Detroit Reservoir.

Alternative 4—Improve Fish Passage with Structures-based Approach

Alternative 4 is a structures-based approach to improve fish passage through the WVS dams to increase the survival of ESA-listed fish.

Water-based Recreation and Land-based Recreation Opportunities and Recreation Site Management

Effects to water-based and land-based recreation opportunities and to recreation site management under Alternative 4 would be the same as those described under the NAA, including impacts during years of low precipitation.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Operations under Alternative 5 would be the same as operations under Alternative 2B. However, the Alternative 2B integrated temperature and habitat flow regime would be replaced by a refined integrated temperature and habitat flow regime under Alternative 5.

Water-based Recreation and Land-based Recreation Opportunities and Recreation Site Management

Effects to water-based and land-based recreation opportunities and to recreation site management under Alternative 5 would be the same as those described under Alternative 2B, including impacts during years of low precipitation.

3.14.4 Interim Operations under All Action Alternatives Except Alternative 1

The timing and duration of Interim Operations would vary depending on a given alternative. Interim Operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations will be implemented in succession with, and not in addition to, action alternative implementation.

The Interim Operations include a deep fall drawdown at Lookout Point Reservoir and low refill target elevation and a deep fall drawdown and delayed spring refill at Cougar Reservoir. Deep fall reservoir drawdowns would occur at Green Peter and Fall Creek Reservoirs but would occur outside of the peak recreation season and is, therefore, not analyzed below[15].

Water-based Recreation Opportunities

Due to the combination of deeper fall reservoir drawdowns and slower/lower spring refill, Lookout Point and Cougar Reservoirs would not refill during the recreation season and would not provide water-based recreation opportunities. Direct, adverse effects to water-based recreation opportunities at these reservoirs would be substantial and reoccurring during the Interim Operations period. Recreation opportunities would remain available at all other WVS reservoirs during the peak recreation season under Interim Operations.

Visitation at Lookout Point and Cougar Reservoirs is low compared to other reservoirs in the analysis area. Consequently, these Interim Operations would result in indirect, moderate, adverse effects to water-based recreation opportunities but would occur during the peak recreation season each year during the Interim Operations timeframe. Although visitation is low at these two reservoirs compared to recreation visitation at other WVS reservoirs, there is a potential for displacement of visitors to other reservoirs during the annual peak recreation season. This would place additional pressure on recreation opportunities and management at other reservoirs that operate at carrying capacity during the recreation season under existing conditions and under the NAA.

Similar to the NAA, exceptions would occur during years of low precipitation, which would require use of reservoirs for Congressionally authorized purposes other than recreation. Although direct effects to recreation in years with low precipitation cannot be accurately assessed, it is assumed these operations would adversely affect water-based recreation by limiting use of boat ramps during the peak recreation season under Interim Operations. This direct effect could be substantial if persistent over an entire recreation season and affecting several, high visitor-use reservoirs. Adverse effects from reservoir use during low precipitation periods may be intermittent during the 30-year implementation timeframe.

[15] Implementation of Interim Operations would range from near-term to the full 30-year implementation timeframe. Analyzing effects specific to a given time or timeframe within the full 30-year implementation timeframe would be speculative because site-specific information was not available when the alternatives were analyzed.

Land-based Recreation Opportunities

There would be no indirect effects on land-based recreation opportunities at Lookout Point and Cougar Reservoirs during Interim Operations because although the incentive to use land-based recreation opportunities would be diminished by lack of water-based opportunities, land-based opportunities would remain available. Further, land-based opportunities would be available throughout the analysis area during the Interim Operations timeframe.

Unlike NAA operations, Interim Operations could increase impacts at other reservoirs and surrounding areas from overuse, which would be a minor to moderate, adverse effect in the long term because of low visitation at these two reservoirs under existing conditions. Displaced recreation visitors could place burdens on other land-based recreation areas in the analysis area by increasing competition for available recreation resources. This indirect, adverse effect would be reoccurring during the 30-year implementation timeframe under the Interim Operations.

Similar to the NAA, exceptions would occur during years of low precipitation, which would require use of reservoirs for Congressionally authorized purposes other than recreation. Although indirect effects to land-based recreation opportunities in years with low precipitation cannot be accurately assessed, it is assumed operations that result in low reservoir levels would indirectly affect land-based activities such as picnicking at day-use areas or camping because of lack of visitor interest to use these areas. This indirect effect could be substantial if persistent over an entire recreation season and affect several, high visitor-use reservoirs in addition to Lookout Point and Cougar Reservoirs.

Recreation Site Management

Direct effects to recreation site management at Cougar Reservoir and Lookout Point Reservoir would likely occur during the Interim Operations timeframe due to the deep drawdowns making the reservoirs inaccessible for water-based recreation. Unlike NAA operations, lack of use at these reservoirs under the Interim Operations may incur unknown USACE and USFS management requirements possibly related to closures and safety, and financial burdens including lost revenue.

USFS manages all recreation facilities at Cougar Reservoir, including several campgrounds, day-use areas, and boat ramps. USFS manages several recreation facilities at Lookout Point Reservoir, including a campground, day-use areas, and two boat ramps. USACE manages day use areas, boat ramps, and a campground at Lookout Point Reservoir. Due to the lack of water-based recreation opportunities at these reservoirs during the recreation season, visitation to the impacted reservoirs would likely shift to nearby reservoirs (for example Blue River Reservoir is near Cougar Reservoir and Dexter Reservoir is near Lookout Point Reservoir).

As under the NAA operations, recreation facilities would remain at carrying capacity in the analysis area during the peak recreation season. Interim Operations at Lookout Point and Cougar Reservoirs could, therefore, increase the need for management resources with additional visitor demands at other reservoirs. This would be a long-term, adverse effect on agency management, but visitor displacement would be low.

The degree of effect on recreation opportunities and management cannot be assessed without site-specific information and combined information on impacts at more than one reservoir over the 30-year implementation timeframe. A shift in visitors from 2 of 13 reservoirs to any other analysis area reservoir would not likely substantially increase competition for available land-based recreation opportunities.

3.14.5 Climate Change Effects under All Alternatives

Climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions and independent of the WVS operations and maintenance activities over the 30-year implementation timeframe (Climate Impacts Group 2010; RMJOC 2020) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources, Section 3.1 Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

It is assumed that wildfires would continue in the analysis area during the 30-year implementation timeframe (Appendix F1, Qualitative Assessment of Climate Change Impacts, Appendix F2, Supplemental Climate Change Information). Wildfires would impact analysis area recreation opportunities as described in Section 3.14.2.4, Analysis Area Wildfires.

Precipitation and temperature trends would decrease water quantity, which are anticipated to have a direct, adverse effect on reservoir levels necessary for water-based recreation opportunities. Increased climate variability in the spring shoulder months, drier hotter summers, and lower summer baseflow are the most impactful climate change factors affecting reservoir elevations (Section 3.13, Water Supply).

Indirect effect from on water-based recreation opportunities from potentially lowered reservoir levels related to climate change conditions cannot be accurately assessed, but it is anticipated to be adverse at more than one reservoir during the annual peak recreation season as climate change conditions worsen.

Related effects on recreation management are also anticipated to be adverse as visitor use displacement increases, adding pressure to recreation areas operating at capacity and on natural areas used for unauthorized dispersed recreation. Dispersed recreation could increase climate-related wildfire risk. Climate change impacts will likely incur unknown agency and organization management adjustments and financial burdens, including lost revenue throughout the analysis area over the 30-year timeframe, intensifying in degree of effect as climate change conditions worsen.

Photo by Tom Conning (USACE Media Images Database)

Canoeing the Long Tom River.

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

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SECTION 3.15 LAND USE

3.15 Land Use

THE DEIS LAND USE SECTION HAS BEEN DELETED IN THE FEIS

Summary of changes from the DEIS:

- **After considering analyses in the DEIS, there is no potential for a significant impact to occur to land use under any of the alternatives, including the No-action Alternative, over the 30-year implementation timeframe. NEPA regulations do not define "land use," and this is not a required category of analysis under 40 CFR 1500. However, an agency's proposed action could alter land uses by converting one type of use to another (e.g., open spaces to urban development) or may be incompatible with zoning ordinances that specify allowed types of use. Under these circumstances, it would be consistent with the purpose of NEPA to analyze potential impacts on uses of land. However, there would be no changes in land uses under the USACE Proposed Action. Further, no changes in land use would occur under any alternative.**
- **USACE analyzed potential effects to land cover in the DEIS. Land use and land cover are not always identical. For example, land used for timber harvest and land used for wilderness share the same forested land cover category but different uses. No land cover would be altered under any alternative.**
- **Land cover was analyzed by addressing potential effects to vegetation, wetlands, visual conditions, and reservoirs through sediment from drawdowns under the alternatives, which were disclosed in DEIS Section 3.15 and Section 4.15, Land Use. However, detailed effects analyses to these resources are analyzed in DEIS and FEIS Section 3.6 and Section 4.6, Vegetation; Section 3.7 and Section 4.7, Wetlands; Section 3.22 and Section 4.22, Visual Resources; and Section 3.5 and Section 4.5, Water Quality.**
- **Land activities are generally supported by designated land uses. For example, urban neighborhoods are found in urban land use areas. All land use activities associated with the Willamette Valley System are described in Chapter 3.0, Affected Environment and Environmental Consequences (e.g., wildlife management, recreation opportunities, cultural resources).**
- **Deletion of Section 3.15 and Section 4.15, Land Use, is supported by 40 CFR 1501.1(d) and 1500.4(g) (identifying significant environmental issues and de-emphasizing insignificant issues), 1501.7 (identification of significant issues related to the Proposed Action), and 1500.1(b) (NEPA documents must concentrate on issues that are 'truly significant' to the Proposed Action).**

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SECTION 3.16 HAZARDOUS MATERIALS

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3.16 Hazardous Materials

THE HAZARDOUS MATERIALS SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **Information on chemicals used during operations and maintenance of the WVS has been updated in Table 3.16-1.**
- **The DEIS effects analyses of Near-term Operation Measures have been deleted because the potential effects would be the same as the direct and indirect effects analyzed under all alternatives (Note the term “Near-term Operations” has been changed to “Interim Operations” throughout the EIS).**
- **The definition of short-term and medium-term effects criteria has been expanded in Table 3.16-2.**
- **The summary of environmental consequences has been updated in Table 3.16-3, Summary of Effects from Hazardous Materials Use on Natural Resources and the Public.**
- **Oil spill prevention information has been updated in Section 3.16.2.6, Oil Spills and Above-ground Storage Tanks.**
- **Information on routine and non-routine maintenance has been provided to clarify distinctions with construction-related activities in Section 3.16.3.2, No-action Alternative, Construction, Demolition, and Maintenance.**
- **Effects analyses from climate change have been combined for all alternatives in Section 3.16.3.4.**

3.16.1 Introduction

Hazardous materials are defined by the EPA and Occupational Safety and Health Administration (OSHA) as substances that are hazardous to the health of people, plants, or animals. These include materials that are stored and used for operations and maintenance activities in the Willamette Valley System (WVS), such as corrosives, flammables, and toxic agents that can cause harm to human health and the environment.

3.16.2 Affected Environment

The initial construction of the WVS occurred over 80 years ago, which created a system that requires the use of hazardous materials for activities such as construction, demolition, and maintenance (e.g., storage and use of compressed gasses, management of lead-based paint (LBP) and asbestos-containing materials (ACM), and use of other hazardous materials); operations and maintenance of adult fish facilities and hatchery facilities; and the operations and maintenance of oil-filled equipment. Additionally, the proliferation of invasive species has required pesticides (primarily herbicides) to be used throughout the analysis area on an as-needed basis (Section 3.6, Vegetation). The information below describes the Affected Environment and programs related to these activities.

The analysis area for hazardous materials is the WVS. Hazardous materials are primarily used in the WVS at dams, fish collection and hatchery facilities, and construction sites for operations and maintenance activities and are, therefore, localized to dams and reservoirs. Hazardous waste is analyzed in Section 3.18, Public Health – Hazardous, Toxic, and Radioactive Waste.

3.16.2.1 Federal and State Regulations and Hazard Communication and Training

Several Federal and state regulations apply to the use of hazardous chemicals. Each of these regulations is identified below under descriptions of either an operation activity (e.g., construction) or a hazardous material (e.g., pesticides).

OSHA requires workers be informed of and able to identify hazardous chemicals as well as protect themselves from hazardous chemical exposures (29 CFR 1900.1200). USACE implements its Safety and Occupational Health Requirements, revised as needed, to comply with this Federal regulation (USACE 2024a). This program includes but is not limited to employee training, safety data sheets, container labeling, chemical inventory lists, personal protective equipment for spills, and methods to reduce or to prevent exposure.

Health and safety training occurs to provide new employees with proper information and occurs whenever a new chemical is introduced into a work area. Training includes information on the Hazard Communication Program and Safety Data Sheets, hazards associated with chemicals, techniques and observations used to detect the presence or release of a chemical, procedures to prevent exposure, and emergency procedures.

USACE also performs regular employee training on equipment, procedures, regulations, facility operations, and site-specific protocols as applicable. Annual oil spill training for dam and reservoir staff is conducted in accordance with 40 CFR 112.7(f). Employees who handle petroleum products are trained in areas of drum handling, petroleum transfers, methods of identifying oil levels on oil-filled operating equipment, incident command, and the operation of pumps and/or sumps. Additionally, designated first responders are trained and authorized to safely respond to a spill emergency and execute a Spill Response Plan.

3.16.2.2 Construction

Construction activities, such as dam and building maintenance and repairs, and new construction can potentially introduce hazardous materials into the environment without protective measures. Workers, the public, and wildlife might be exposed to this contamination, which could cause health issues depending on the contaminant type, concentration, and exposure duration as well as the receptor's characteristics, such as age.

Accidental releases from construction, typically associated with improper chemical management, are also sources of possible impacts to public health and safety. Spills can cause soil and water contamination and create exposure pathways to workers, the public, and wildlife. The severity of risks and effects from spills are determined by spill composition and quantity. For example, a common material used for construction that could be spilled at a project site is diesel fuel, which is an irritant of the lungs and skin. High levels of diesel exposure can cause nervous system damage or death (HHS 1995). Other common hazardous chemicals around construction sites include aerosols, solvents, and adhesives.

3.16.2.3 Compressed Gases

Compressed gases are stored and used at dams, fish facilities, and construction sites for controlling valves, oxygenating water, anesthetizing fish, and performing repairs and maintenance that require welding, cutting, and brazing. Hazards associated with compressed gases include oxygen displacement, fires, explosions, and toxic gas exposures as well as the physical hazards associated with high pressure systems (OSHA No Date). Compressed nitrogen is used in transformers and emergency valves, and oxygen and CO_2 are used for fish operations. Acetylene, argon mixture, helium mixture, and oxygen are used for welding, cutting, and brazing. Carbon dioxide is also used in all turbine generator fire suppression systems.

USACE mitigates hazards by adhering to the general requirements for compressed gasses in 29 CFR part 1910.101 and the welding, cutting, and brazing requirements found in 29 CFR part 1910.253. Additionally, Best Management Practices (BMPs) are implemented, such as securing cylinders and keeping them away from heat sources.

3.16.2.4 Lead-based Paint and Asbestos-containing Materials

Most facilities within the WVS were constructed between 1945 and 1970 and contain some amount of lead-based paint (LBP) and asbestos-containing materials (ACM) from both original construction and operations and maintenance activities. More information is known about the extent of ACM in the WVS than LBP due to the cost-effectiveness of testing.

In the 1990s, efforts were made to remove ACM throughout the WVS, but some materials remain. Some areas and materials containing ACM identified during a 2014 survey included components of electrical wiring and electrical control cabinets, glues and sealants, insulation, and gaskets, although more could exist. LBP is assumed to be present on old building and equipment parts that may need to be removed or replaced as part of operations and maintenance activities; therefore, all paint is treated as LBP until it can be verified.

Before any materials are removed as part of operations and maintenance, suspected areas are tested for asbestos. Damaged ACM is repaired or removed by certified project personnel or certified contractors and all waste disposed of following all OSHA, Environmental Protection Agency (EPA), Oregon Department of Environmental Quality (ODEQ), and Lane (County) Regional Air Protection Agency (LRAPA) rules regarding asbestos removal and disposal.

Although an inconclusive survey for LBP has occurred, LBP is expected on old parts being removed or replaced. Before any paint is removed, paint is first tested with lead check swabs. Any contractors removing paint must treat the paint as if it is lead-containing and use an LBP stabilizer to reduce hazardous waste generation. After removal, the debris is tested using the EPA's Toxicity Characteristic Leachate Procedure to determine its waste status. BMPs are also used where applicable, which include paint removal gels or the use of hooded needle guns that mechanically remove and vacuum paint residue.

3.16.2.5 Underground Storage Tanks

Only one underground storage tank exists in the WVS. This tank is located at Cougar Dam and formerly stored heating oil but was closed in place prior to 2008. Funding has been requested to remove this former storage tank.

3.16.2.6 Oil Spills and Above-ground Storage Tanks

Oil spills are a public health, safety, and environmental concern at dams. Dams rely on a variety of oil-filled equipment to operate. The area that has the highest risk for large spills is a powerhouse, as it typically contains large oil and fuel-filled equipment such as transformers, turbines, reciprocating internal combustion engines, generators, and related above-ground storage tanks.

Smaller equipment and containers of oil less than 55 gallons are also common around a powerhouse. While no oil discharges greater than 30 gallons are known to have occurred at USACE WVS dams, several spills of less than 1 gallon have occurred. In all cases, USACE responded swiftly by isolating the source of the leak; deploying absorbent pads, booms, and skimmers; and notifying non-governmental organizations and partner agencies such as the National Response Center, the Oregon Emergency Response System, and the Oregon Department of Fish and Wildlife. The eight USACE power-producing dams in the WVS are currently undergoing National Pollutant Discharge Elimination System (NPDES) permit processing, and it is anticipated that they will be permitted to discharge a daily maximum of 10 parts per million (ppm) of oil and grease per day under Section 402 of the Clean Water Act.

USACE implements an EPA Spill Prevention, Control, and Countermeasure Plan at each dam and reservoir that describes oil handling operations, spill prevention practices, discharge or drainage controls, and the personnel, equipment, and resources at the project used to prevent oil spills from reaching navigable waters or adjoining shorelines.

Powerhouse transformers and their oil storage tanks typically contain the largest volumes of oil on site, upward of several thousand gallons in some cases (Figure 3.16-1). All oil-containing equipment and storage containers in the powerhouse and dam are regularly maintained and inspected in accordance with the preventative maintenance schedule established for each

Figure 3.16-1. Primary Transformer Insulating Oil Stored in the Oil Treatment and Storage Room of the Detroit Dam Powerhouse.

piece of equipment. Operational procedures are also in place to minimize spills related to human error and equipment failure. Additionally, oil-filled equipment and storage containers constructed of steel are stored at ambient temperature and pressure, which is compatible with petroleum products, thereby minimizing the potential of a release.

Above-ground oil storage tanks and equipment located in or around powerhouses generally have multiple levels of containment. Drain covers and plugs are placed near all floor drains in the vicinity of oil reservoirs at the powerhouses and dams, which can be deployed in the event of a spill to allow rooms with oil-containing equipment and storage containers to act as secondary containment. Smaller containers of oil such as drums are stored over mobile pallets capable of containing minor spills.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION

Combined dewatering and drainage sumps are another possible source of oil releases. All drains adjacent to oil-filled equipment in these powerhouses and dams lead to a sump, which is automatically discharged to the river. All power-producing facilities are scheduled for powerhouse Oil Spill Prevention System projects. These projects include oil-water separators constructed at sump discharge points to prevent an oil release.

At the time the alternatives were analyzed, Oil Spill Prevention System projects had been completed at Cougar, Foster, and Hills Creek Dams; oil-water separators were functioning and online. Oil spill prevention measures were in place at Detroit, Green Peter, and Lookout Point Dams while Oil Spill Prevention projects were being completed. These measures include operation of sump oil skimmers, which remove any oil before discharge.

END REVISED TEXT

Current operational techniques to mitigate potential sump oil discharges from both dams and powerhouses involves leaving a column of water in the sump, which keeps the floating oil away from pump intakes. Alarms are present on all substantial oil-containing equipment in powerhouses that alert operators to a potential release. If a large amount of oil accumulates in the sump, the operator can disable the drainage pump, allowing the sump to act as secondary containment for the oil spill. Then, designated personnel can access the sump and begin the cleanup process using absorbent materials or an oil skimmer. At the time the alternatives were analyzed, Foster and Green Peter Dams were the only power-producing dams that did not have separated sumps.

An individual turbine may contain upward of a thousand gallons of oil, which has the potential to leak into river water via the oil cooling system, though this is considered unlikely. It was determined to be cost prohibitive to install measures to address oil cooler system leaks as it would require substantial facility alterations that could compromise system safety. Regular replacement of cooling coils is performed to reduce release risk.

Oil releases could also occur at dam intake towers. Sources of oil include emergency diesel generator fuel tanks, spillway gate gearboxes, and the hydraulic fluid reservoirs that support adjusting the flow of the regulating outlets. However, leaks from these oil sources are contained within secondary containment areas that have drains equipped with valves and, in some cases, filters that utilize oil solidification technology.

3.16.2.7 Adult Fish Facility and Hatchery Chemicals

USACE operates five adult fish facilities and five hatcheries that anesthetize fish with chemicals to minimize stress and damage during handling. A variety of chemicals and disinfectants are also used at these facilities to control microorganisms and to prevent diseases (Table 3.16-1).

Table 3.16-1. Hazardous Chemical Names, Uses, and Hazards at Willamette Valley System Adult Fish Facilities and Hatchery Facilities.

Chemical Trade Name	Use	Hazard
Formalin	Controls parasites, fungi, and protozoa	Flammable; acute oral and inhalation toxicity
Ovadine	Disinfects fish eggs	Eye irritant
Chloramine-T	Controls fish gill bacterial outbreaks	Skin and eye irritant
Diquat	Controls general bacteria	Eye and respiratory system irritant
Tricaine-S	Immobilizes and sedates fish	Skin, eye, and respiratory system irritant
Argentyne	Disinfectant – used for a wide range of bacteria, fish egg fungi and viruses	Irritant; minimal toxicity from iodine at recommended concentrations
Ethyl alcohol	Disinfectant	Eye and skin irritant; flammable
Hydrogen peroxide	Disinfects fish eggs	Irritates eyes, nose, skin, and throat
Iodine	Disinfectant	May cause itching, rashes, and allergies
Novaqua	Water conditioner; dechlorinates and removes toxic heavy metals	Eye irritant; slippery; may cause gastric distress if swallowed
Parasite-S	Aqueous formaldehyde solution that controls external protozoa and parasites on fish	Toxic to fish in high concentrations; moderate fire and explosion hazard when exposed to flame or heat; carcinogenic if inhaled

Source: ODFW 2021c; ODFW 2021d; Sigma Aldrich 2021; Syndel 2015; Syndel 2017; Syngenta 2002; Thermofisher 2010.

All chemicals are stored in secure locations according to their safety data sheets and product labels. Chemical storage rooms have containment systems built into their floors and eyewash and shower stations.

3.16.2.8 Pesticides

Herbicides and insecticides are types of pesticides. These chemicals are applied as spot treatments on a small scale as part of routine maintenance to prevent the establishment of new invasive species, manage/control existing populations, and enhance habitat for native species.

Species of exotic blackberries, grasses, and weeds are controlled around the Blue River, Cottage Grove, Dexter, Dorena, Fall Creek, Fern Ridge, Foster, Hills Creek, and Lookout Point Reservoirs. The most used chemicals are the herbicides triclopyr choline and glyphosate (USACE 2021a). Triclopyr choline is considered hazardous under 29 CFR 1910.1200 due to acute toxicity and eye irritation (Dow 2016). Flying insects, such as hornets and wasps, are controlled around structures as needed using an insecticide spray containing tetramethrin, which is not considered hazardous (ARI 2014). These chemicals are stored in a secure cabinet in the Fern Ridge Dam warehouse for immediate use and in the Dexter Service Building receiving warehouse. Aerosol sprays for insect control are stored in secure cabinets at all work locations in the WVS.

Most applications are conducted away from water. When necessary, aquatic-labeled herbicides are applied at least 6.5 feet (2 meters) from bodies of water, and extra caution is used near fish-bearing water. All pesticide use complies with an ESA consultation between the EPA and the National Marine Fisheries Service and the NPDES Pesticide General Permit issued by the ODEQ. No chemicals are used that are listed on the EPA's Restricted Use Products Report.

3.16.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives related to hazardous materials. The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

3.16.3.1 Methodology

The potential effects from hazardous materials were assessed by examining ongoing trends in the presence and use of hazardous materials in the WVS (fuel, oil, pesticides, compressed gasses, LBP, ACM) and the subsequent presence of the materials in soil, sediment, air, and water (exposure pathways). Additionally, measures, construction, and routine maintenance incorporated under the alternatives were assessed for potential effects related to hazardous materials use (Chapter 2, Alternatives, Section 2.10, Alternatives Considered in Detail). Construction effects are addressed qualitatively because site-specific analyses are needed, which would occur prior to construction initiation.

Diesel trucks would be used under all alternatives to transport fish during trap-and-haul operations in the WVS. There is a possibility of diesel fuel leaks from truck accidents or from latent vehicle maintenance. However, such leaks would be small, localized, and inconsequential compared to the number and amount of other vehicle use in the analysis area and the oil- and fuel-containing recreational equipment used in reservoirs and rivers in the WVS vicinity (e.g., boats, jet-skis, etc.). Consequently, potential impacts from trap-and-haul vehicle use are not analyzed under any alternative.

Scientific literature, news releases, and documents such as inventories, reports, and safety data sheets were used to predict the severity of the threat that hazardous materials pose to natural resources and to the public over the 30-year implementation timeframe under each alternative. Anticipated effects resulting from climate change under each alternative were also analyzed (see also Section 4.16, Cumulative Effects, Hazardous Materials).

The environmental effects criteria and a summary of effects are provided in Table 3.16-2 and Table 3.16-3, respectively.

THE FOLLOWING TABLES HAVE BEEN REVISED FROM THE DEIS

Table 3.16-2. Hazardous Materials Environmental Effects Criteria.

Degree of Adverse or Beneficial Effect	Criteria
None/Negligible	Emission, discharge, or deposition of hazardous materials in soil, sediment, air, and/or water and the environmental effects from such would not be measurable.
Minor	Emission, discharge, or deposition of hazardous materials in soil, sediment, air, and/or water and the environmental effects from such would be measurable but near the detection limit.
Moderate	Emission, discharge, or deposition of hazardous materials in soil, sediment, air, and/or water and the environmental effects from such would be measurable and moderately above the detection limit. Mitigation measures would be required to offset adverse effects, but long-term changes to the environment would be expected.
Major	Emission, discharge, or deposition of hazardous materials in soil, sediment, air, and/or water and the environmental effects from such would be readily measurable and clearly above the detection limit. Mitigation measures would be required to offset adverse effects, but long-term changes to the environment would be expected.
Duration	
Short-term	Alteration lasts for the duration of small construction projects, routine maintenance, or measure implementation, but is continuous for less than 2 years.
Medium-term	Alteration is limited to the duration of large construction projects, routine maintenance, or measure implementation, but is continuous for a period of 2 to 5 years.
Long-term	Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (e.g., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently.
Extent	
Local	Effects would be confined to the area near a dam and reservoir.
Regional	Effects would be perceived throughout a single county, multiple counties, or the entire Willamette River Basin.
Statewide	Effects would be perceived throughout the entire state.

Table 3.16-3. Summary of Effects from Hazardous Materials Use on Natural Resources and the Public as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Chemicals	Negligible adverse, localized, long-term	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Hatchery Pesticides	Minor adverse, localized, long-term	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Construction, Demolition, Maintenance	Negligible to minor adverse, localized, short- to medium-term (however, construction, etc. would continue for 30-year implementation timeframe)	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Oil Spills	Minor adverse, localized, short- to medium-term; Region-wide, long-term as dams continue to discharge oil over the 30-year implementation timeframe	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative

[1] Extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the lesser beneficial effect does not occur at that reservoir. This follows the approach to present the most conservative degree of potential effects in this summary instead of omitting reservoirs where less severe or more beneficial effects would occur.

3.16.3.2 Alternatives Analyses

No-action Alternative

Under the No-action Alternative (NAA), the existing operations and maintenance of the WVS would continue, which includes water quality, flow, adult fish facility, downstream fish passage, and upstream fish passage operations and associated measures incorporated under the NAA (Chapter 2, Alternatives, Section 2.10.3, No-action Alternative). All ongoing, scheduled, and routine and non-routine maintenance activities for the USACE-managed infrastructure in the Willamette River Basin and all USACE-managed structural features, including those recently constructed or that were reasonably foreseeable in 2019 would occur under the NAA (Chapter 2, Alternatives, Section 2.10.3, No-action Alternative; Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation). These activities, aside from the continued operations and maintenance of existing adult fish facilities, would have no effect on natural resources or the public from hazardous materials.

Operations and maintenance of the WVS under the NAA would include storage and use of compressed gasses, management of LBP and ACM and other hazardous materials, fish collection and hatchery chemical use, pesticide use, and the operation of oil-filled equipment.

The underground storage tank at Cougar Dam would remain closed under the NAA, and USACE would continue to request funding to remove this tank.

USACE would continue to implement its Safety and Occupational Health Requirements, including training, to comply with Federal OSHA regulations (USACE 2024a) (Section 3.16.2.1, Federal and State Regulations and Hazard Communication and Training).

Fish Collection and Hatchery Chemicals and Pesticides

Under the NAA, chemicals would continue to be stored and used at the five adult fish facilities and five hatchery facilities (Section 3.16.2.7, Adult Fish Facility and Hatchery Chemicals). USACE may use hazardous chemicals to clean equipment and anesthetize fish at these facilities. These facilities would continue to be operated in accordance with NPDES permits as applicable to address application of all chemical use. Further, employees would continue to receive training and would use safety equipment (Section 3.16.2.1, Federal and State Regulations and Hazard Communication and Training).

Because of these safety measures, the effects to natural resources and to the public from adult fish facility and hatchery operation chemical use would be negligible adverse under the NAA. Although chemical use would be localized to these facilities, any associated risks with use would be long-term over the 30-year implementation timeframe.

Pesticides would be used basin-wide on an as-needed basis under the NAA (Section 3.16.2.7, Adult Fish Facility and Hatchery Chemicals). Most applications would continue to be conducted away from water (Section 3.16.2.8, Pesticides). When necessary, aquatic-labeled herbicides would be applied at least 6.5 feet (2 meters) from bodies of water and extra caution used near fish-bearing water. Chemicals would be securely stored. Pesticides would continue to be used only as permitted and in compliance with safe application regulations (Section 3.16.2.1, Federal and State Regulations and Hazard Communication and Training; Section 3.16.2.8, Pesticides).

Overall, the effects from pesticide use under the NAA would be minor adverse because most chemicals and pesticides are non-hazardous, their applications would be localized, and their use would be controlled and mitigated by Federal safety protocols. Although any given pesticide use would be localized, any risks associated with use would be long-term over the 30-year implementation timeframe.

Construction, Demolition, and Maintenance

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION

Construction and demolition may occur throughout the analysis area under the NAA on a site-specific basis and associated with measures under the NAA (Chapter 2, Alternatives, Section 2.10.3, No-action Alternative). Generally, construction activities, particularly those involving demolition, could potentially release ACM and/or LBP into the air. Such potential effects would be assessed under additional National Environmental Policy Act reviews.

Routine and non-routine maintenance would occur under all alternatives during the 30-year implementation timeframe. All maintenance and construction activities would follow applicable BMPs and environmental regulations to avoid disturbing ACM and LBP (Section 3.16.2.4, Lead-based Paint and Asbestos-containing Materials). Further, USACE would continue to implement safety training and communications protocols under the NAA (Section 3.16.2.1, Federal and State Regulations and Hazard Communication and Training). Consequently, effects are anticipated to be negligible.

END REVISED TEXT

Construction, demolition, and maintenance under the NAA could require the use of hazardous materials such as diesel and gasoline for fueling equipment; aerosols, solvents, and adhesives for interior finishes; and compressed gasses for welding, cutting, and brazing. USACE would continue to mitigate the hazards posed by compressed gasses by adhering to the general requirements for compressed gasses in 29 CFR part 1910.101 and the welding, cutting, and brazing requirements found in 29 CFR part 1910.253. Additionally, BMPs are used, which include securing cylinders and keeping them away from heat sources (Section 3.16.2.3, Compressed Gases).

Typically, effects to natural resources or to the public from hazardous materials used in construction are associated with accidental spills resulting from improper chemical management. Spills could have a wide range of effects depending on the chemical type, quantity, and location of the spill. Some contaminants may affect soil, surface water, groundwater, or any combination thereof. For example, high levels of acute diesel exposure can cause nervous system damage or death in humans and animals (HHS 1995). Toluene, a common solvent and component of fuels, paints, and adhesives, has a moderate chronic toxicity to aquatic life and can cause a range of upper respiratory, cardiac, and reproductive issues (EPA 2016a; NPI No Date-a; NPI No Date-b).

Despite these effects, a 2015 study that considered the environmental impacts of construction activities did not rank hazardous material spills to soil or water in the top 20 most important issues (Ansah 2015). This is because the environmental effects from spills at construction sites can be readily mitigated by following BMPs like maintaining a clean working environment and adhering to proper storage and fueling guidelines (Section 3.16.2.3, Compressed Gases). If a spill occurs under the NAA, it would be limited to the immediate area because USACE would implement or require BMPs to stop the source, contain the spill, apply absorbents, and remove affected soil in accordance with applicable BMPs.

Overall, the effects to natural resources and to the public from construction, demolition, and maintenance under the NAA would likely be negligible to minor adverse because hazards would be mitigated by Federal safety protocols and implementation of BMPs. Hazardous material risk would be localized and short- to medium-term (e.g., 1 week to 2 years depending on the project), but these localized effects would continue for the 30-year implementation timeframe. Accurate effects analyses of any construction activity will be prepared in subsequent, tiered National Environmental Policy Act reviews.

Oil-filled Systems

The greatest concern from hazardous material release into the environment in the WVS is due to the operation of oil-filled systems, which are primarily at hydropower-generating facilities (Section 3.16.2.6, Oil Spills and Above-ground Storage Tanks). Oil-filled systems are the largest threat due to the volume of stored oil and proximity to surface water. Oil spills are a possibility when equipment malfunctions or accidents occur.

Although other oil-filled equipment exists at hydropower dams, the equipment that presents the greatest oil-spill hazards are electrical transformers and turbines as well as their auxiliary equipment such as pumps and above-ground storage tanks.

Selective withdrawal structures effectively serve as hydropower turbine intakes and would require oil-filled systems to adjust the gates that control water flows. A selective withdrawal structure is located at Cougar Dam and would be the only operating structure under the NAA. This structure, along with adult fish facility structures, could require the installation of emergency diesel generators to provide power during an emergency under the NAA.

The environmental effects of oil spills can vary depending on the amount and type spilled and the character of the receiving water body. Effects on vertebrates can range from minor to major nervous system and reproductive damage to individual birds, mammals, and humans to broader effects such as the decline or loss of key organisms and/or habitats in an ecosystem (EPA 1999; ITOPF No Date).

Hazardous material risk to natural resources and to the public from oil-filled systems under the NAA would be minor adverse because, while USACE would be permitted to discharge small amounts of oil from the WVS, it would continue to implement Federal hazard safety protocols such as the EPA Spill Prevention, Control, and Countermeasure Plan; BMPs; and requirements under NPDES permits. USACE would also continue to implement safety training and communications protocols under the NAA (Section 3.16.2.1, Federal and State Regulations and Hazard Communication and Training). Further, the likelihood of a large spill from the WVS is historically low (Section 3.16.2.6, Oil Spills and Above-ground Storage Tanks).

Risks to natural resources and to the public from oil-filled systems would primarily be localized because they would be contained at the WVS dams and reservoirs through procedures such as use of secondary containment, drains, and specialized equipment (Section 3.16.2.6, Oil Spills and Above-ground Storage Tanks). However, due to the nature of hydroelectric power generation, oil has the potential to enter nearby water and travel downstream. Therefore, although unlikely, effects could potentially be regional in extent, such as if a secondary containment overflowed or failed, a drain was clogged, or there was a malfunction in the turbine cooling system.

The duration of effects from localized oil-filled system risks would depend on localized containment timeframes but would likely be short- to medium-term. The WVS-wide risk (i.e., region-wide risk) of oil-filled system impacts, however, would be long-term because dams would continue to discharge oil for the 30-year implementation timeframe.

<u>All Action Alternatives</u>

Direct, indirect, and climate change effects to natural resources and to the public from hazardous material risk would be the same as those described under the NAA. Although more construction-related activities would occur under each of the action alternatives as compared to the NAA, overall effects are not expected to increase and would be the same as described under the NAA. This outcome would be due to implementation of safety measures and training under all alternatives (Section 3.16.2.1, Federal and State Regulations and Hazard Communication and Training).

As under NAA operations, selective withdrawal structures effectively serve as hydropower turbine intakes and would require oil-filled systems to adjust the gates that control water flows. These structures, along with adult fish facility structures (excluding Foster Dam) and deep fall drawdowns at Detroit, Green Peter, and Lookout Point Dams, would require the installation of emergency diesel generators.

The current emergency diesel generators cooling water intakes are located too high to be used during deep drawdowns at Detroit, Green Peter, and Lookout Point Dams. These oil-filled systems would provide new, additional sources for potential oil spills during operation at these dams. However, construction of these facilities would include secondary containment and drains to prevent spills from reaching the water; generators and any supporting equipment would be added to and managed under a facility Spill Prevention, Control, and Countermeasure Plan as applicable.

No long-term construction, demolition, or maintenance work is identified under the action alternatives that would alter anticipated effects as compared to the NAA.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION

3.16.4 Climate Change under All Alternatives

Impacts related to hazardous chemical use resulting from climate change would be narrowed to vegetation management under all alternatives. No other operations or maintenance activity described in Section 3.16.2, Affected Environment, would be expected to change as a result of climate change in regard to how these activities present hazardous materials risks to natural resources and to the public.

Climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions and independent of the WVS operations and maintenance activities over the 30-year implementation timeframe (Climate Impacts Group 2010; RMJOC 2020) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources: Section 3.1 Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

Wetter winters and drier summers would be expected to lead to changes in vegetation community composition and distribution over time, as drought-tolerant species become more predominant and invasive plants potentially encroach further into communities of native species (Section 4.6.2, Cumulative Effects to Vegetation by Alternative). Pest species, including those that are invasive, are managed using a variety of pesticides basin wide. The quantity of pesticides used to control invasive species would be expected to increase proportionally as invasive species proliferate throughout the WVS over time because of climate change-related conditions

Overall, effects to natural resources and to the public from increased pesticide use under all alternatives because of climate change would continue to be minor adverse because most pesticide types would not likely change and would remain primarily non-hazardous[1]. As under the NAA analysis, pesticide applications would be localized, and their use would be mitigated by Federal safety protocols. Although pesticide use would be localized, any risks associated with

[1] It is possible that new pesticide formulas would become available during the 30-year implementation timeframe. However, an analysis of such availability is not practicable because these are unknown chemicals and, therefore, considered speculative.

use to address increases in noxious weed establishment would be long-term over the 30-year implementation timeframe.

END REVISED TEXT

Photo by Tom Conning (USACE Media Images Database)

Blue River Dam and Reservoir Built in 1969.

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Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.17 PUBLIC HEALTH AND SAFETY—HARMFUL ALGAL BLOOMS

3.17 Public Health and Safety—Harmful Algal Blooms

THIS DEIS SECTION HAS BEEN DELETED FROM THE FEIS

Summary of changes from the DEIS:

- **After considering analyses in the DEIS, this information was found primarily redundant with the analyses of harmful algal blooms in Section 3.5, Water Quality. Section 3.5, Water Quality, has been updated in the FEIS to incorporate information from DEIS Section 3.17, Public Health and Safety—Harmful Algal Blooms, as necessary to provide full disclosure of these potential risks.**
- **See 40 CFR 1500.1(b) (NEPA documents should not "ammas needless detail"), id. at (d) ("NEPA's purpose is not to generate paperwork—even excellent paperwork—but to foster excellent action"), 1502.1 (Agencies…shall reduce paperwork and the accumulation of extraneous background data), and 1503.4(c) (changes to a DEIS are to be circulated in the FEIS).**

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.18 PUBLIC HEALTH AND SAFETY—HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

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3.18 Public Health and Safety—Hazardous, Toxic, and Radioactive Waste

THIS SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **Cross-references to related analyses on hazardous material use and management in Section 3.16, Hazardous Materials, and to mercury in Section 3.5, Water Quality, have been added.**
- **Consistent information between this section and Section 3.5, Water Quality, regarding mining has been provided.**
- **Legacy contamination has been defined.**
- **The definitions of short-term, medium-term, and regional effects criteria have been expanded in Table 3.18-5.**
- **The effects analyses from Near-term Operation Measures have been deleted because the potential effects would be the same as the direct and indirect effects analyzed under all alternatives (Note that the term "Near-term Operations" has been changed to "Interim Operations" throughout the EIS).**
- **The summary of effects to public health and safety from hazardous, toxic, and radioactive waste has been updated in Table 3.18-6.**

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION

3.18.1 Introduction

This section addresses hazardous, toxic, and radioactive waste (HTRW) in the Willamette Valley System (WVS) and the Willamette River Basin. The acronym "HTRW" is a programmatic definition used generally to describe pollutants released to the environment on USACE-managed and operated lands. HTRW is meant to encompass all Federal and state environmental regulations and is primarily informed by the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Within the WVS, there are continuing and well-established efforts toward RCRA compliance and establishing a CERCLA process. RCRA is the general framework for pollution prevention and CERCLA is the framework for site remediation.

Additional information on hazardous material use and management for operations and maintenance of the WVS is provided in Section 3.16, Hazardous Materials. Additional information on mercury effects to water quality is provided in Section 3.5, Water Quality, including related information on Black Butte Mine.

3.18.2 Affected Environment

Hazardous and toxic waste was historically and is currently generated in the WVS. Generation of this waste results from historical activities, ongoing and routine and non-routine operations and maintenance, and initial construction. The analysis area for HTRW is the WVS, but also includes some nearby facilities on private property within the Willamette River Basin such as mines, from which contamination has migrated onto USACE property. Rather than being organized by subbasins, this section begins with a regulatory overview, is then organized by activity, and concludes with legacy environmental contamination.

END REVISED TEXT

3.18.2.1 Regulatory Overview

This section focuses on the regulatory framework of hazardous wastes and Superfund sites. Hazardous wastes are defined and regulated by RCRA. RCRA defines hazardous waste as a waste that exhibits ignitability, corrosivity, reactivity, or toxicity, or is listed on one of the U.S. Environmental Protection Agency's (EPA) lists of wastes from non-specific sources, specific sources, or discarded commercial chemical products.

RCRA establishes the framework to manage hazardous waste from "cradle to grave" and stipulates requirements for waste generators as well as transporters and treatment, storage, and disposal facilities. Waste generators are generally grouped into three categories, each with different requirements that depend on the quantity of waste produced and/or stored on site:

1. Large Quantity Generators (LQGs)
2. Small Quantity Generators
3. Conditionally Exempt Small Quantity Generators (CESQGs) or Very Small Quantity Generators

EPA delegates primary responsibility for implementing the RCRA hazardous waste program to individual states. Delegation ensures national consistency and minimum standards while providing flexibility to states in implementing rules.

EPA funding and authority oversight of contaminated site cleanup is supported by CERCLA (also known as Superfund). This act also forces parties responsible for contamination to either perform site cleanup or to reimburse the government for EPA-led cleanup.

3.18.2.2 Hazardous Waste Generation and Storage at Willamette Valley System Dams

Each of the 13 dams within the WVS are small waste generators, meaning dam operations produce only small amounts of waste from normal operations and maintenance. The 13 USACE dams that comprise the WVS are each considered CESQGs as defined in Chapter 16 of Oregon's Small Quantity Hazardous Waste Generator Handbook (ODEQ 2024b). CESQGs produce up to 220 pounds (100 kg) of hazardous waste or hazardous waste residues (including contaminated soils) per month, or less than 2.2 pounds (1 kg) of acute hazardous waste per month.

Some of the hazardous waste generated and stored at WVS dams includes solvents, off-specification fuels, contaminated oils from turbines and transformers, lead-based paint (LBP) debris from demolition or renovation, and universal waste such as aerosol cans and lamps (Section 3.16, Hazardous Materials). Detroit, Fall Creek, and Foster Dams have dedicated hazardous waste storage buildings that are fire rated and include secondary containment for spills. The generation of very small quantities of hazardous waste at WVS facilities would occur during the 30-year implementation timeframe under any alternative.

Management of hazardous waste within the WVS complies with all applicable Federal, state, and local requirements. Requirements include inventorying and reporting under Title III of CERCLA, also known as the Emergency Planning and Community Right to Know Act, and in accordance with regulations identified in 40 CFR 262, Standards Applicable to Generators of Hazardous Waste, and Oregon Administrative Rules (OAR) 340-100, Hazardous Waste Management. CESQGs may store up to 2,200 pounds (1,000 kg) of hazardous waste before the waste must be shipped to a permitted off-site treatment, disposal, or recycle facility.

3.18.2.3 Transport of Hazardous Wastes

The transport of hazardous wastes on public roadways is controlled by U.S. Department of Transportation regulations. Any transport of such wastes to or from a site must be done in compliance with these regulations to protect public health and safety. If a WVS waste-generating facility qualifies for the exemptions found in 40 CFR 262.14, which stipulates the conditions by which CESQGs would not be subjected to some requirements and conditions of RCRA, hazardous waste from that facility would be transported by USACE to the Lane County Waste Management Facility located in Eugene, Oregon or USACE would contract to a commercial carrier authorized to transport hazardous waste to a collection facility. Hazardous wastes are properly disposed of in accordance with RCRA regulations.

If a WVS waste-generating facility does not qualify for the exemptions found in 40 CFR 262.14, hazardous waste from that facility would be transported by commercial carriers contracted by USACE in accordance with hazardous substances shipping requirements of CFR Title 49 and in compliance with the Federal Motor Carrier Safety Regulations of the U.S. Department of Transportation, Parts 383, 390, 397, and 399. WVS facilities generally remain in compliance with 40 CFR 262.14 due to the small amounts of hazardous waste generated.

In the event of a release or spill during transport, the transportation company would be responsible for response and cleanup. USACE specifies that the contract carriers be licensed and inspected as required by the Oregon Department of Environmental Quality (ODEQ) and Oregon Department of Transportation. The permits, licenses, and certificates are the responsibility of the carrier.

CFR Title 49 requires that all shipments of hazardous substances be properly identified and placarded. Shipping documents must be accessible and include safety data sheets that contain information describing the following:

- hazardous substance
- immediate health hazards
- fire and explosion risks
- immediate precautions
- firefighting information
- procedures for handling leaks or spills
- first aid measures
- emergency response telephone numbers

3.18.2.4 Legacy Environmental Contamination

Legacy environmental contamination exists within the Willamette River Basin and is managed under the WVS CERCLA process. Contamination is a result of historical mining activities and initial construction and operations and maintenance of the WVS. Contamination from historic mining operations primarily consists of heavy metals, which include but are not limited to arsenic, mercury, and chromium (Section 3.5, Water Quality).

Contamination from the construction of the WVS includes hazardous or toxic substances such as diesel, polychlorinated biphenyls (PCBs), and heavy metals (Section 3.16, Hazardous Materials). Specific sites and sources are detailed below.

3.18.2.5 Mercury and Mine Waste Sites

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION

Mining contamination has been determined by EPA to be a serious risk to public health and safety due to the acute and chronic effects of mercury exposure (EPA 2021g). Mercury can have severely negative health effects on humans and wildlife, depending on several factors. Exposures to inorganic mercury (Hg) are most common when liquid mercury is spilled and the vapors are inhaled. However, mercury in its methylated form (CH_3Hg) is more toxic to vertebrates than inorganic mercury (EPA 2021g).

Mercury methylation occurs because of naturally occurring sulfate-reducing bacteria acting on inorganic mercury. Methylmercury is fat-soluble, allowing it to easily bioaccumulate in organisms like fish and animals higher on the food chain that eat fish, including humans. Because of this, Oregon has a statewide consumption advisory on bass sportfish as well as more detailed advisories based on the consumer’s age, the water body fished, and the type of fish

(Table 3.18-1 and Table 3.18-2) (OHA No Date-b). All Willamette River Basin subbasins and the mainstem Willamette River have Total Maximum Daily Load allocations set by the state for mercury, which are presented in Section 3.5.1.1, Water Quality Regulations, Federal Clean Water Act and Oregon State Regulations, Table 3.5-1.

Table 3.18-1. Oregon Mercury Fish Tissue Concentrations Found in Bass compared to the Health Criteria.

	Mercury Concentration(s)
Statewide range found in Oregon bass fish[1]	0.08 to 0.86 (mg/kg)
Oregon ODEQ Health Criteria[2]	0.04 (mg/kg)

mg/kg = milligram per kilogram

[1] Data reported by the Oregon Health Authority from Hillwig and Farrer 2016; ODEQ 2015; and reported in mg of total mercury per kg of fish tissue.

[2] Data from ODEQ 2021d, reported in mg of methylmercury per kg of fish tissue.

Table 3.18-2. Oregon Health Authority Fish Advisories and Consumption Guidelines[2]

Location	Contaminant	Affected Fish	Meals per Month – Vulnerable Populations	Meals Per Month – All Populations
Lower Willamette River	PCB[1]	All fish	Dependent on fish type	Dependent on fish type
Cottage Grove Reservoir	Mercury[3]	All fish except stocked rainbow trout less than 12 inches	0	4
Dorena Reservoir	Mercury[3]	All fish except stocked rainbow trout less than 12 inches	1	4
Willamette River (from the Columbia River to Eugene)	Mercury[3]	All fish	1	4

[1] PCBs are considered by Oregon Health Authority to be polychlorinated biphenyls, dioxins, and certain pesticides.

[2] Data from OHA No Date-b.

[3] Methylmercury

Although mercury is an element that occurs naturally in geologic formations within the earth, it is sequestered and its presence in rocks does not typically cause problems unless extracted by humans.

A primary global source of mercury is mining (AMAP/UN Environment 2019). Oregon has a rich history of mining (DOGAMI No Date), including the mining of cinnabar (mercury ore, Hg-S). Legacy contamination exists from historical mining activities in the analysis area (Jackson, Eagles-Smith, and Emery 2019), where hydrologic events have moved contamination onto USACE property (EPA 2018). Legacy contamination sources in the WVS and the type and extent of contamination are discussed below.

Black Butte Mine

The Black Butte Mine is located within the Coast Fork Willamette River Subbasin, 9.3 miles upstream of Cottage Grove Reservoir to the north (Eckley et al. 2015). The mine was used for cinnabar mining to produce quicksilver (liquid mercury) but operations ceased in the late 1960s (Section 3.5.1.2, Water Quality Parameter and Subbasin Conditions, Mercury Conditions in the Coast Fork Willamette River and Long Tom River Subbasins).

Mine waste materials, such as tailings and waste rock, contain mercury and other heavy metals. Subsequently, mercury, arsenic, and other metals have been released into Cottage Grove Reservoir and the Coast Fork Willamette River from hydrologic processes eroding and transporting mine waste materials (EPA 2018).

Mercury primarily exists as inorganic mercury in rock and sediment in the subbasin and as methylmercury in fish tissue within the analysis area. Due to its public health risk, the Black Butte Mine was added to the EPA's Superfund National Priorities List in 2010, making it eligible for Federal funding to provide long-term cleanup under CERCLA.

Some CERCLA sites, such as the Black Butte Mine site, are divided into "Operable Units" based on features such as geographic region:

Operable Unit 1:

Includes the former mining area and the abandoned underground mine as well as adjacent reaches of Furnace Creek and Dennis Creek.

Operable Unit 2:

Includes Little River from the confluence of Furnace Creek through the Coast Fork Willamette River to Cottage Grove Reservoir.

Operable Unit 3:

Includes the full pool elevation of Cottage Grove Reservoir and the wetland area near the Coast Fork Willamette River confluence with Cottage Grove Reservoir.

In 2018, two removal actions occurred in which Furnace Creek, the primary source of mercury-contaminated soil, was excavated. These actions focused on reducing material that is easily mobilized downstream or has a substantial contact risk to people. After 13,100 cubic yards of contaminated soils were removed and stored in an onsite repository, the Furnace Creek stream channel and banks were restored, stabilized, and the area was seeded with native plants.

The EPA began sediment sample collection in 2021 from Cottage Grove Reservoir relating to the Black Butte Mine clean up. Although two removal actions have occurred at the Black Butte Mine site, mercury- and other heavy metal-containing sediment still exists in the area. One time-critical removal action and one non-time-critical removal action were completed by the EPA during early action work at the mine site (EPA 2020a).

CDM Smith, the EPA's prime contractor for the Black Butte Mine removal actions, determined in a post-removal risk assessment that total cancer risks associated with residential exposure were within the EPA's acceptable risk range but above the ODEQ range (CDM Smith 2020; EPA 2005). The noncancer hazard for a child was still above the threshold, primarily due to exposure to arsenic-contaminated sediment (CDM Smith 2020). However, Black Butte Mine remains an active CERCLA site at the time the alternatives were analyzed. It also remains on the Superfund National Priorities List, and it was in the remedial investigation/feasibility study phase at the time the alternatives were analyzed.

Bohemia Mining District

The Bohemia Mining District is a 9-square mile area located approximately 18 miles upstream of Dorena Reservoir to the southeast. This mining district contained multiple mines that used inorganic mercury for over 60 years to recover gold and silver as part of an amalgamation[1] process (Hygelund, Ambers, and Ambers 2001). Dorena Reservoir contains mercury due to mining activities from the Bohemia Mining District; however, these mining activities resulted in relatively lower contamination levels as compared to the activities conducted at the Black Butte Mine (Section 3.5, Water Quality, Coast Fork Willamette River and Long Tom River Subbasins).

Limited inspections for hazardous waste and materials have occurred within the Bohemia Mining District because only part of the property is Federally managed by the U.S. Forest Service and the rest of the property is privately owned. While some contamination certainly exists due to the history of the area, the contamination has not warranted listing as a brownfield site[2] or on the EPA's Superfund National Priorities List (ODEQ 2021c).

Fish in the Dorena Reservoir were contaminated with mercury, but the source was unconfirmed until a 2001 study by Hygelund et al. That study analyzed the mercury content of fine-grained sediment samples from streams that drain the Bohemia Mining District, streams that do not drain the Bohemia Mining District, mine waste piles, and Dorena Reservoir sediment (i.e., Coast Fork Willamette River Subbasin) (Table 3.18-3). The study concluded that the source of the mercury contamination in the Dorena Reservoir Watershed is the Bohemia Mining District, but was not able to rule out the naturally occurring high mercury content of soils and rock in the area as a source (Hygelund, Ambers, and Ambers 2001). A fish consumption advisory is still in effect for Dorena Reservoir, along with Cottage Grove Reservoir, by the Oregon Health Authority (Table 3.18-2).

[1] Amalgamation is a chemical process that uses mercury as a bonding agent for various metals. In the gold mining process, mercury is added to a slurry of ore; the gold within the ore bonds with the mercury. Mercury is then distilled out of the slurry, leaving only gold remaining.

[2] A brownfield site is a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.

Table 3.18-3. Mercury Concentrations in the Dorena Reservoir Watershed.

Sample Area	Mercury Concentration (ppm)[1]
Sediment in streams not draining the mining district	0.006
Sediment in streams draining the mining district	0.14 - 1.339
Dorena Reservoir sediment	0.025 - 0.095
Mine waste rock[2]	10 - 50

ppm = parts per million

[1] Data from Hygelund, Ambers, and Ambers 2001.

[2] Material that is removed from a mine as part of the mining process but has no economic value.

3.18.2.6 Comprehensive Environmental Response, Compensation, and Liability Act Sites

The other primary source of WVS legacy contamination is waste from initial construction and previous operations and maintenance of dams. Contaminants such as petroleum, solvents, metals, and PCBs exist at historical disposal sites throughout several of the WVS dams and reservoirs.

CERCLA provides a Federal fund to clean up uncontrolled or abandoned hazardous waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. The CERCLA process has nine steps:

1. Preliminary Assessment/Site Inspection: Review historical information and visit the site to evaluate the potential for hazardous substance releases.
2. National Priority Listing: Rank hazards using the EPA's Hazard Ranking System, which quantifies risks and prioritizes which sites warrant further investigation. Only the most hazardous sites are listed.
3. Remedial Investigation/Feasibility Study: Characterize the nature and extent of contamination as well as assess threats to human health and the environment. Evaluate performance and cost of various contaminant treatment options.
4. Records of Decision: Explain which cleanup alternative will be used.
5. Remedial Design/Remedial Action: Develop and implement detailed cleanup plans.
6. Construction Completion: Complete all necessary construction outlined during the Remedial Design step.
7. Post Construction Completion: Continue to monitor the site.
8. National Priorities List Deletion: Delete the site from the list once cleanup goals have been achieved.
9. Site Reuse/Redevelopment: Reuse or redevelop the site in a safe manner agreeable with local plans.

Sites were in various stages of the CERCLA process at the time the alternatives were analyzed (Table 3.18-4). The only site within the analysis area that has been placed on the National Priorities List is the Black Butte Mine because its contamination source fundamentally differs from the majority of other WVS CERCLA sites.

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Table 3.18-4. Willamette Valley System CERCLA Site Summaries.

Dam	Contamination Source	Contaminants	CERCLA Progress	Summary
Big Cliff	Project construction waste disposal	Petroleum Heavy metals Arsenic Volatile Organic Compounds (VOCs; submerged[2])	Feasibility study completed October 2021. Remediation Design funded in Fiscal Year 2024.	Contaminants present in sediment from improper waste disposal during the initial construction of the dam. Surface water sampling suggests no risks to downstream communities.
Blue River	Project construction waste disposal	Heavy metals Pesticide (submerged[2])	Site Investigation complete. Funding has been requested to perform a Remedial Investigation.	Contaminants present in sediment near the saddle dam, although not necessarily in levels high enough to warrant a cleanup. Further investigation is recommended.
Cottage Grove[1]	Private mercury mine (Black Butte)	Mercury Arsenic	One time-critical and one non-time-critical removal action complete. Long-term monitoring is in progress, but ongoing investigations are occurring that may result in further removal action(s).	Per the EPA: Contaminants present in Cottage Grove sediment from the upstream Black Butte cinnabar mine. 13,100 cubic yards of contaminated soil were removed from the mine during a removal action in 2018. Black Butte Mine was in the remedial investigation/feasibility study phase at the time the alternatives were analyzed.
Cougar	Project construction dust abatement.	Petroleum	Small site cleanup was completed in 1990s. Site investigation complete in 2015. No further action required.	Petroleum-contaminated soils were discovered during operations and maintenance activities. 7,000 cubic yards of soil removed. No further action. No specific evidence of hazmat identified.

Dam	Contamination Source	Contaminants	CERCLA Progress	Summary
Detroit	Project construction waste disposal	Petroleum Heavy metals PCBs	Small site cleanup. Site investigation complete. Remedial Investigation is funded for Fiscal Year 2024.	Multiple contamination sites in the area. Cleanup documentation is limited, but at least three separate contaminated soil removal actions took place in the 1990s. Further investigation is recommended.
Dexter	Domestic and project construction waste disposal	PCBs Mercury	The Site Investigation is incomplete but current data indicates that a Remedial Investigation is required. Funding has been requested to perform a Remedial Investigation.	Solid waste roadside dump near powerhouse. Further investigation is recommended.
Dorena	Project waste disposal	VOCs Heavy metals	Site investigation complete. Funding has been requested to remove the solid waste.	Contaminants present but near background levels consistent with that reported in the area. Sampling suggests there is no significant threat to humans or the environment.
Fall Creek	Project operations and maintenance chemical storage	Lead Arsenic	Site Investigation complete.	Contaminants present from former chemical storage area. Several cleanup operations occurred, but documentation is unclear. No further steps will be taken to list this site on the National Priorities List.

Dam	Contamination Source	Contaminants	CERCLA Progress	Summary
Green Peter	Project waste disposal	Petroleum Solvents Heavy metals	Small site cleanup. Site Investigation complete. Funding has been requested to perform a Remedial Investigation.	Some level of cleanup has occurred for petroleum-contaminated soils, but documentation is unclear. Contaminants present from disposal of various toxic and hazardous wastes.

Source: EPA 2011; USACE 2013c; USACE 2014d; USACE 2014e; USACE 2015j; USACE 2015k; USACE 2021c; USACE No Date-n

[1] The Cottage Grove Reservoir contamination is a product of historical mining activities and not related to USACE activities. Cottage Grove is the only CERCLA site in this summary that is not from USACE-related activities.

[2] Contaminants are generally submerged below the surface of the reservoir. Contaminants are located at historical landfills and contractor work areas that were used during the initial construction of the dams but are now covered with water for most of the year.

3.18.3 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives related to public health and safety from hazardous, toxic, and radioactive waste (HTRW). The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

3.18.3.1 Methodology

The potential effects to public health and safety from HTRW were assessed by examining ongoing trends in legacy contamination and the generation, storage, and presence of hazardous waste in soil, sediment, air, and water (exposure pathways) in the analysis area. Effects on public health and safety would be indirect because a means of exposure is required. Effects were analyzed with respect to how they could be affected by the action alternatives using information from USACE, scientific literature, and reports. This information was then used to qualitatively predict the severity of the threat that HTRW poses to public health and safety over the 30-year implementation timeframe. Effects under all alternatives would be indirect because a means of exposure is required.

The environmental effects criteria and a summary of effects are provided in Table 3.18-5 and Table 3.18-6, respectively.

THE FOLLOWING TABLES HAVE BEEN REVISED IN THE FEIS

Table 3.18-5. Hazardous, Toxic, and Radioactive Waste Environmental Effects Criteria.

Degree of Adverse or Beneficial Effect	Definition
None/Negligible	The risk to public health from HTRW would be nondetectable or very small.
Minor	The risk to public health from HTRW would be measurable but below regulatory standards.
Moderate	The risk to public health from HTRW would be measurable and near (slightly above or below) regulatory standards. Mitigation measures would be necessary and would reduce the risk of adverse public health effects.
Major	The risk to public health from HTRW would be readily measurable and substantially above regulatory standards. Mitigation measures would be required to decrease the risk of adverse public health effects.
Duration	
Short-term	Alteration lasts for the duration of small construction projects, routine maintenance, or measure implementation but is continuous for less than 2 years.
Medium-term	Alteration is limited to the duration of large construction projects, routine maintenance, or measure implementation but is continuous for a period of 2 to 5 years.

Degree of Adverse or Beneficial Effect	Definition
Long-term	Alteration is permanent/lasts during the 30-year implementation timeframe or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (i.e., recurring) (e.g., deep drawdowns that occur for a 3-week period in the fall and/or spring) or the alteration occurs intermittently.
Extent	
Local	Effects would be confined to the project area.
Regional	Effects would be perceived throughout a single county, multiple counties, or the entire analysis area (i.e., all dams in the WVS).
Statewide	Effects would be perceived throughout the entire state.

Table 3.18-6. Summary of Effects to Public Health and Safety from Hazardous, Toxic, and Radioactive Waste.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Waste Generation from Operations and Maintenance	Negligible to minor adverse, long-term, regional in extent	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Waste from Legacy Contamination	Minor to moderate adverse, long-term, regional in extent	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Risk from Sites on National Priorities List	Negligible to minor adverse, long-term, regional in extent	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative

3.18.3.2 Alternatives Analyses

No-action Alternative

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION

Operations and Maintenance

Under the No-action Alternative (NAA), the existing operation and maintenance of the WVS would continue, which would include the generation, storage, and transportation of hazardous waste. All ongoing, scheduled, and routine and non-routine maintenance activities for USACE-managed infrastructure in the Willamette River Basin and all USACE-managed structural features would occur under the NAA. This includes structures recently constructed or that were reasonably foreseeable when the alternatives were analyzed (Chapter 2, Alternatives, Section 2.10.3, No-action Alternative; Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation). However, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities

Hazardous waste would continue to be generated, stored, and transported throughout the analysis area over the 30-year implementation timeframe from the operation, maintenance, repair, replacement, and rehabilitation of the WVS. These activities would include, but would not be limited to, the lubrication oil of hydropower turbines and electrical transformers as well as smaller sources such as maintenance, construction, and demolition. Although regional in extent (i.e., at each dam in the analysis area), direct adverse effects to public health and safety from HTRW from the existing operation and maintenance of the WVS in the analysis area would be negligible to minor because effects would be localized to dams and would be managed under regulatory compliance requirements.

USACE operations and maintenance activities have historically produced hazardous waste far below the CESQG limit of 220 pounds per month. There was one exceedance that occurred more recently in 2007; however, this exceedance only occurred due to a powerhouse fire at the Detroit Dam. Therefore, the extent of the effects would be medium as the compliant storage and handling of hazardous waste would occur within the analysis area. The waste generator status of dams as CESQGs are not expected to change during the 30-year implementation timeframe; USACE would continue complying with all applicable regulations.

Construction projects could have direct, short-term, medium-term, or long-term adverse effects to HTRW depending on the magnitude and duration of the construction project because they would potentially generate HTRW. These effects could occur throughout the 30-year timeframe depending on the timing and duration of the construction project, which will be further analyzed in additional National Environmental Policy Act reviews.

Legacy Contamination

Legacy contaminants would remain in the WVS during the 30-year implementation timeframe such as arsenic in Big Cliff and Cottage Grove Reservoirs. Mercury is the largest threat to public health and safety from legacy contamination in the WVS, not only due to its neurotoxicity, but because it can accumulate in fish tissue, which can cause exposure to the public beyond the analysis area. The risk to public health and safety from mercury contamination would range from measurable but below regulatory standards to near regulatory standards depending on quantity, type, and origin of fish consumed. Consequently, effects from legacy contamination of mercury would be adverse and minor to moderate. Effects would occur over the 30-year implementation timeframe and throughout the WVS.

Sites on the National Priorities List

No sites in the analysis area have public health risk levels high enough to warrant listing on the National Priorities List, with the exception of Black Butte Mine. The mere presence of contamination at other sites poses a “non-zero” risk to public health and safety under the NAA in the analysis area.

The risk of a direct or indirect adverse effect from Black Butte Mine, or other future listings, in the analysis area over the 30-year timeframe would be negligible to minor. This is because effects would be reduced by using administrative controls such as signage, security patrols, and fencing, which would discourage and restrict access to this area where the public could be exposed to contamination under the NAA. Additionally, risks to public health are being addressed because Black Butte Mine remained an active CERCLA site at the time the alternatives were analyzed. It also remained on the Superfund National Priorities List, and it was in the remedial investigation/feasibility study phase at the time the alternatives were analyzed.

All Action Alternatives

Direct effects to the public from HTRW related to operations and maintenance, legacy site contamination, and National Priorities listings would be the same for all action alternatives as those described under the NAA. Construction-related activities would occur under the action alternatives as compared to the NAA. However, overall effects would be the same or slightly, but not appreciably, larger as compared to the NAA. Construction activities would vary based on the project and location, and effects would not substantially increase in intensity as they would occur throughout the WVS. Appropriate best management practices would be implemented for all construction projects.

While long-term construction, demolition, or maintenance projects are identified under the action alternatives, any HTRW generated onsite is not expected to exceed the CESQG regulatory thresholds as compared to the NAA. The waste generator status of dams as CESQGs is not expected to change during the 30-year implementation timeframe; USACE would continue to comply with all applicable regulations.

3.18.4 Climate Change Effects under All Alternatives

Climate change presents indirect risks to public health and safety from HTRW under all alternatives. Operations or maintenance activities would not likely change under any alternative as a result of climate change in regard to how these activities present risks to public health and safety from HTRW.

Climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions and independent of the WVS operations and maintenance activities over the 30-year implementation timeframe (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources, Section 3.1, Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

Climate change is expected to exacerbate the frequency and severity of natural disasters such as wildland fires and floods. Increasing the severity of fires and floods could potentially compromise contamination sites and to a lesser degree hazardous waste storage facilities.

Fires could make contaminants, especially volatile compounds like solvents and some forms of petroleum, airborne, which would increase the potential for public exposure beyond dam locations. Fires could also potentially destroy hazardous waste management infrastructure, such as buildings and containers, and expose waste to the elements.

Floods and fires could both spread and expose contamination that had previously not been a risk to the public. However, flooding is a larger concern in tidally influenced areas, and the analysis area is not tidally influenced. Further, the WVS waste storage facilities (at Detroit, Fall Creek, and Foster Dams) are fire-rated. Additionally, wildfire risk management practices are used to minimize the risk of fires spreading to the facilities, such as trimming tree limbs 30 feet from structures and 6 feet from the ground; therefore, the risks of wide-spread HTRW impacts from climate-related flood or fire changes would be negligible to minor.

END REVISED TEXT

US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.19 PUBLIC HEALTH AND SAFETY—DRINKING WATER

TABLE OF CONTENTS

LIST OF TABLES

3.19 Public Health and Safety—Drinking Water

THIS SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **Information on the relationship between USACE Congressionally authorized purposes for WVS operations and maintenance and drinking water has been added in FEIS Section 3.19.1, Introduction.**
- **This section has been aligned with Section 3.5, Water Quality and Section 3.13, Water Supply, by adding relevant, consistent information.**
- **Information to clarify the source of drinking water for analysis area municipalities has been provided in FEIS Table 3.19-1.**
- **Information on the Oregon Drinking Water Quality Act, Clean Water Act Section 303(d) impaired waters, Oregon Health Authority guidelines and advisories, and USACE public notices has been updated in FEIS Section 3.19.2.2, Drinking Water Regulatory Background, Oregon State Regulations.**
- **DEIS Table 3.19-2, Partial List of Contaminants Regulated under the National Primary Drinking Water Regulations and Table 3.19-3, List of Secondary National Drinking Water Regulations, have been deleted. This information is not applicable to USACE operations or Congressionally authorized purposes and does not add to a meaningful analysis of potential effects under the alternatives. Regulation of contaminants in these tables apply only to municipalities managing public water systems.**
- **DEIS Section 3.19.2.3, Monitoring, has been deleted. Information has been moved to other, applicable sections or deleted because the alternatives would not include monitoring for drinking water quality, which is a municipality responsibility.**
- **Additional information on groundwater well existing conditions has been added to FEIS Section 3.19.2.3, Groundwater and Surface Water Regulatory Background.**
- **The scope of the environmental consequences analyses has been clarified in FEIS Section 3.19.3, Environmental Consequences. Potential direct and indirect effects have been clarified.**

Summary of changes from the DEIS, continued:

- **Methodology has been revised in FEIS Section 3.19.3.1 to further explain the qualitative analysis approach. Information on potential effects from construction and routine and non-routine maintenance and effects on groundwater wells has been added. DEIS Table 3.19-4, Effects Criteria, has been deleted because the criteria were based on a quantitative analysis inconsistent with the FEIS qualitative analysis approach.**
- **DEIS Table 3.19-4, Summary of Effects to Public Health and Safety, has been revised to summarize qualitative analyses (FEIS Table 3.19-2).**
- **The alternatives analyses have been modified to provide additional rationale for effects conclusions (FEIS Section 3.19.3.2, Alternatives Analyses). For example, water supply from reservoir storage and river flow have been clarified. Hatchery effects have been deleted because hatchery effluent and released water is treated and does not impact drinking water under any alternative. Degrees of direct effect have been re-focused from effects on reservoir refill to effects on water supply.**
- **Analyses of construction, routine and non-routine maintenance, groundwater supply, water quality, and effects on treatment facility operations have been added to FEIS Section 3.19.3.2, Alternatives Analyses.**
- **Information on water availability for drinking water use in dry years has been provided in FEIS Section 3.19.3.2, Alternatives Analyses.**
- **The effects analyses from Near-term Operation Measures have been revised in FEIS Section 3.19.4. The term "Near-term Operations" has been changed to "Interim Operations" throughout the EIS.**
- **The climate change analysis has been revised to reflect anticipated water quality and water supply effects in FEIS Section 3.19.5, Climate Change under All Alternatives.**

3.19.1 Introduction

THE DEIS HAS BEEN MODIFIED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

Public health and safety can be at risk from adverse effects to consumer drinking water. Consumer drinking water and public water systems in the analysis area are regulated by Federal and Oregon State laws. The Willamette Valley System (WVS) is not a public water system under Federal or state regulations.

USACE operations store and release water in the WVS for multiple Congressionally authorized purposes, including municipal and industrial water supply and water quality (Chapter 1, Introduction, Section 1.10, Congressionally Authorized Purposes). The Willamette River and its tributaries, along with groundwater, are the major sources of water for municipal and industrial needs in the analysis area. Currently, USACE operates releases and subsequent downstream flows in the analysis area under the 2008 National Marine Fisheries Service (NMFS) Biological Opinion (NMFS 2008) (Chapter 1, Introduction, Section 1.3.3, Willamette Valley System Endangered Species Act and National Environmental Policy Act History since 2008).

At the time the alternatives were analyzed, population growth created a demand for water that would exceed existing supplies for many municipal and industrial systems throughout the Willamette River Basin in the near future. This need was one of the factors that led to the Willamette Basin Review Feasibility Study (USACE 2019a) (Chapter 1, Introduction, Section 1.3.3, Willamette Valley System Endangered Species Act and National Environmental Policy Act History since 2008), which resulted in a total of 159,750 acre-feet of conservation storage reallocated to the purpose of municipal and industrial water supply.

Demands for water stored in the WVS to supply municipal and industrial water are spread across all subbasins (USACE 2019a). However, the greatest demand is on the Mainstem Willamette River (Section 3.13, Water Supply, Table 3.13-3).

While operations of the WVS store water for municipal and industrial uses, USACE is not authorized to provide drinking water for consumer use. Similarly, while water quality is an authorized purpose, USACE is not responsible for the quality of water that is then used for drinking water. Drinking water quality is the responsibility of municipalities that own and operate public water systems.

At the time the alternatives were analyzed, the injunction deep drawdown operations at Green Peter Dam mobilized large amounts of sediment at Green Peter dam. The drawdown was halted over concerns by communities in Linn County, Oregon that the sediment would overwhelm the surrounding cities' drinking water systems (USACE 2024b).

This section provides an overview of drinking water use, supply sources, public water systems, contaminants, and regulations applicable to water used from WVS operations as drinking water. This section combines analysis information from the water quality and water supply sections as they pertain to drinking water.

Detailed descriptions of existing water quality conditions below WVS reservoirs and effects under each alternative are provided in Section 3.5, Water Quality. Information on municipal and industrial water supply and users within the analysis area, including water rights, storage agreements, and water service contracts, are provided in Section 3.13, Water Supply.

END NEW TEXT

3.19.2 Affected Environment

The drinking water analysis area is defined broadly as the geographic boundaries of the Willamette River Basin, which encompasses groundwater and surface water sources that communities rely on for public drinking water (Table 3.19-1). At the time the alternatives were analyzed, a greater population was supplied drinking water from Mainstem Willamette River surface water upstream (south) of Salem, Oregon (118,975 population supplied) than below (north of) Salem (45,800 population supplied) (OHA 2024b).

Most of the Portland metropolitan area, which is north of Salem, is served by drinking water sourced from the Bull Run River (outside of the analysis area) and not from the Mainstem Willamette River (OHA 2024c). As population increases throughout the Willamette River Basin, municipal and industrial needs will increase, putting pressure on existing water supplies.

Table 3.19-1. Public Water Systems in the Willamette River Basin and Water Source.

Subbasin	Source Water Bodies[1]	Public Water System
North Santiam River	Detroit Reservoir, North Santiam River	City of Detroit, City of Gates, Lyons-Mehama Water District, Salem Public Works (City of Salem), City of Albany, City of Jefferson, Stayton Water Supply
South Santiam River	South Santiam River	City of Sweet Home, City of Lebanon
McKenzie River	Blue River, McKenzie River	Springfield Utility Board, Eugene Water and Electric Board, Rainbow Water District
Middle Fork Willamette River	Dexter Reservoir, Middle Fork Willamette River	Springfield Utility Board, City of Lowell
Coast Fork Willamette River	Coast Fork Willamette River, Row River	City of Creswell, City of Cottage Grove
Long Tom River	Long Tom River	City of Monroe
Long Tom River	Groundwater wells	City of Elmira, City of Veneta City of Veneta also supplements drinking water purchased from the Eugene Water and Electric Board (the Board sources surface water from the McKenzie River)
Mainstem Willamette River	Mainstem Willamette River	City of Corvallis, City of Wilsonville, City of Sherwood, Village of Adair, Willamette Water Supply System Commission (under construction)

Source: OHA 2025a, OHA 2024b

[1] The majority of municipal water in the analysis area is withdrawn downstream of the WVS reservoirs.

The Willamette Water Supply System Commission (WWSS Commission) is an Oregon intergovernmental organization formed by Tualatin Valley Water District (TVWD), the City of Hillsboro, and the City of Beaverton. The WWSS Commission was formed to build the Willamette Water Supply System (WWSS) in response to planned growth in their service areas. The WWSS also provides additional water supply to Washington County in the Portland metropolitan area (WWSSC 2024). When completed, the pipeline and water treatment facility, sourced from the lower Mainstem Willamette River, will serve approximately 380,243 additional people. Once online, the highest level of Willamette River water sourced for drinking water would convert from upstream to downstream of Salem (OHA 2024b).

3.19.2.1 Drinking Water Contaminants and Treatment

Contamination of drinking water sources can be caused by animal waste, improper disposal of chemicals, naturally occurring substances within a watershed, and pesticide use. In the Willamette Valley, approximately 33 percent of rural water wells contained at least one pesticide from historical uses (ODEQ 2017). For example, USACE commonly uses pesticides such as triclopyrcholine and glyphosate for routine maintenance (Section 3.16, Hazardous Materials).

Water can dissolve substances from human activities or animals as it runs over land or percolates through the ground and then enters drinking water sources. Contaminants that can be found in drinking water include microbial contaminants such as viruses and bacteria, inorganic contaminants such as salts and metals, pesticides and herbicides, other chemicals, and radioactive contaminants that may be naturally occurring (City of Sweet Home Public Works 2021).

The proper treatment, disinfection, and distribution of clean drinking water is vital to the prevention of public health risks in the analysis area. Water sourced from downstream of the WVS reservoirs is treated by a combination of filtration, aeration, and disinfection at a public water treatment facility before it is distributed.

Harmful Algal Blooms

Some algal blooms are harmful if people or pets come in contact with polluted water or consume tainted fish or shellfish (EPA 2022d) (Section 3.5.1.2, Water Quality Parameters and Subbasin Conditions, Harmful Algal Blooms).

In addition to direct harm to people and pets, harmful algal blooms can cause challenges to the delivery of safe drinking water. Potential negative impacts to drinking water utility systems include unpleasant taste and odor; interference with water treatment plant operations such as floc formation, filtration, and chlorination; increased levels of disinfection by-product precursors; and if not addressed, pass-through of cyanotoxins into finished drinking water (EPA 2024b). Finished water is water that has been treated and is ready to be delivered to customers (EPA 2012).

Turbidity

Turbidity is the cloudiness of water due to suspended particles (Section 3.5, Water Quality, Section 3.5.1.2, Water Quality Parameters and Subbasin Conditions, Turbidity). Materials that cause water to be turbid include clay, silt, very tiny inorganic and organic matter, algae, dissolved colored organic compounds, and plankton and other microscopic organisms (USGS 2018). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites, and some bacteria (EPA 2022a).

High turbidity events can occur due to very heavy rainfall or rapid snowmelt causing rapid runoff in the watershed. Deep reservoir drawdowns can liberate previously stable sediments and contribute to elevated levels of turbidity downstream of the reservoir. Increased levels of turbidity can cause water treatment facility operations to be impacted, leading to the potential for disruption in drinking water service.

Additional pretreatment may be necessary to reduce turbidity. Municipal water quality monitoring allows the water treatment facility to receive advanced notice if pretreatment processes are necessary or if the facility must prepare to close.

3.19.2.2 Drinking Water Regulatory Background

Federal and Oregon State drinking water regulations protect drinking water sources, including lakes, rivers, streams, springs, and groundwater wells and regulate the operation and maintenance of drinking water treatment facilities in Oregon. USACE operations are not subject to Federal or state drinking water regulations.

Federal Regulations

Safe Drinking Water Act

The Federal Safe Drinking Water Act was passed in 1974 to protect public health by regulating the national drinking water supply. The Safe Drinking Water Act authorizes the U.S. Environmental Protection Agency (EPA) to set standards for drinking water. Drinking water sources covered under the act include groundwater and surface waters such as rivers, lakes, streams, reservoirs, springs, ponds, and wells.

The act originally focused on treatment as the means of providing safe drinking water at the tap. However, the 1996 amendments expanded the existing law by adding protections at drinking water sources, providing for operator training, providing funding for water system projects, and recognizing public information as important components of safe drinking water (EPA 2004).

Environmental Protection Agency Standards

The EPA drinking water standards regulate over 90 contaminants in community and non-community water systems as defined under the National Primary Drinking Water Regulations

(40 CFR 141). These standards are grouped in two categories: the National Primary Drinking Water Regulations (or primary standards) and the National Secondary Drinking Water Regulations (or secondary standards). Primary drinking water standards are legally enforceable. Primary standards set mandatory water quality standards or "maximum contaminant levels" to protect the public against drinking water contaminants. Secondary standards are non-enforceable and provide guidelines for aesthetic considerations such as taste, color, and odor (EPA 2021h).

Oregon State Regulations

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

The Oregon Drinking Water Quality Act enacted in 1981 ensures safe drinking water, provides a regulatory program for drinking water, and provides a means to improving inadequate drinking water systems (OHA No Date-c). USACE operations are not subject to Oregon State drinking water regulations, which "apply to all public water systems providing piped water for human consumption…" (ORS 333-061-0010(1)).

END NEW TEXT

The Oregon Health Authority regulates drinking water under Oregon State law and the Federal Safe Drinking Water Act and works with Oregon Department of Environmental Quality (ODEQ) on drinking water source protection to prevent public health risks. The ODEQ works to protect drinking sources by implementing the Clean Water Act, identifying the source waters in watersheds and aquifers for surface water and groundwater for public water supply systems, and developing water assessments and guides for community public water systems (ODEQ 2021e).

If drinking water is found to be contaminated, a water advisory is issued by public water system officials (CDC 2020). The Oregon Health Authority Drinking Water Advisories website posts current drinking water advisories in Oregon. It includes information such as the source of water (surface water or groundwater), the reason for the advisory (e.g., nitrate, *E. coli*, arsenic), and the towns or communities affected (OHA No Date-d).

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

ODEQ added Willamette River Basin rivers and streams to the Clean Water Act Section 303(d) list of impaired waters in 1998 for exceeding standards for biological criteria, temperature, and bacteria. ODEQ has also prepared an Integrated Report of impaired water bodies, including those downstream of USACE-managed WVS dams. Section 3.5, Water Quality, Section 3.5.1.1, Water Quality Regulations, Table 3.5-1, provides details on impaired water bodies downstream of the Willamette Valley System dams, including identification of harmful algal blooms and turbidity (current as of 2022).

The Oregon Health Authority also implements cyanobacteria toxin guidelines and threshold levels for recreation and drinking waters for the public (OHA 2020). Information provided by the Oregon Health Authority with current and archived algae bloom recreational advisories includes Willamette Valley reservoirs (OHA 2020). Oregon Health Authority is notified if levels are above the toxin threshold following USACE staff water sampling. The Oregon Health Authority then assesses the need for a public advisory for a particular water body.

Since 2005, Oregon Health Authority has posted advisories based on sample results that exceed the cyanotoxin threshold levels in Oregon waters for drinking water (Section 3.5, Water Quality, Section 3.5.1.2, Water Quality Parameters and Subbasin Conditions, Harmful Algal Blooms, Table 3.5-8). Harmful algal bloom advisories have been issued at USACE-managed reservoirs (Section 3.5, Water Quality, Section 3.5.2.1, Water Quality Parameters and Subbasin Conditions, Harmful Algal Blooms, Figure 3.19-57).

The harmful algal bloom criteria have evolved from 2005 to present (Section 3.5, Water Quality, Section 3.5.2.1, Water Quality Parameters and Subbasin Conditions, Harmful Algal Blooms, Figure 3.5-58). Currently, if microcystin exceeds 8 µg/L (*Microcystis* sp.), the Health Authority will post an advisory for the water body. Advisories are posted on the Oregon Heath Authority Cyanobacteria (Harmful Algae) Blooms public website. Advisories are updated as further water testing is conducted until the toxin levels are reduced below the Health Authority toxin threshold (OHA 2022a).

Additionally, USACE has placed informational signage near boat ramp areas at USACE facilities to bring awareness to the public regarding harmful algal blooms. USACE also reviews Landsat satellite imagery of reservoirs for potential algae bloom activity, which is publicly provided on the USACE Water Management Water Quality Reports website (USACE 2022e).

END NEW TEXT

3.19.2.3 Groundwater and Surface Water Regulatory Background

Groundwater is a critical source of drinking water in Oregon. Approximately 35 percent of people rely solely on groundwater for drinking water, 10 percent rely on surface water, and 55 percent rely on a combination of both (OHA 2018). EPA has issued Surface Water Treatment Rules and a Ground Water Rule for public drinking water systems. USACE operations are not subject to this rule because the WVS is not operated as a public water system under its Congressionally authorized purposes.

Groundwater wells can be contaminated by surface pollutants such as microbial contamination, fertilizers and pesticides, and arsenic[1].

ODEQ is designated as the lead agency for implementation of the Wellhead Protection Program. The program was implemented to “protect wellhead areas within their jurisdiction

[1] The Oregon Health Authority does not maintain a list of public water systems in Oregon that are exposed to groundwater contamination from active chemical cleanup sites.

from contaminants which may have any adverse effect on the health of persons" (OHA No Date-c). The Wellhead Protection Program provides incentives for community participation in the program, provides a detailed guidance manual for local implementation, and promotes public awareness of the impact of land use on drinking water, among other initiatives.

With the 1996 amendment of the Federal Safe Drinking Water Act, states were required to develop Source Water Assessment Programs. As such, Oregon has been working to expand the Wellhead Protection Program to develop a Drinking Water Protection Program that includes surface water sources (OHA No Date-e). Private drinking water wells that serve fewer than 25 people are not regulated by the Safe Drinking Water Act (EPA 2004).

Source water assessments were completed in Oregon in 1999 and 2005 with updates in 2016 and 2017 (OHA 2018). Source water assessments for individual community public water systems that rely on surface water within the analysis area can be found on the ODEQ website. The assessments indicate the potential contaminant sources within the watershed areas of the water supply.

Surface Water Treatment Rules

Require all utilities with a surface water supply, or a groundwater supply influenced by surface water, to provide adequate disinfection to prevent illness from pathogens (EPA 2021i), which include *Legionella*, *Giardia lamblia*, and *Cryptosporidium*.

Ground Water Rule

Provides protection for ground water sources that can be susceptible to fecal contamination. It applies to public water systems that use groundwater as a drinking water source (EPA 2023b).

Communities use the source water assessments to develop strategies to protect drinking water sources based on land uses within the water supply area and the inventory of potential contaminants (ODEQ 2019b). Strategies for source water protection include mapping source water protection areas, inventorying known and potential contamination sources, and developing action plans to prevent contamination.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

USACE has not identified any groundwater wells that are hydrologically connected to WVS reservoirs (OHA 2025b).

Groundwater wells that are hydrologically connected to rivers downstream of USACE reservoirs benefit from augmented streamflows, especially during dry years, which helps to maintain the water table at levels accessible by groundwater wells.

END NEW TEXT

3.19.3 Environmental Consequences

THE DEIS HAS BEEN MODIFIED TO INCLUDE OR TO REVISE THE FOLLOWING INFORMATION

This section discusses the potential direct, indirect, and climate change effects of the alternatives related to public health and safety risk from drinking water quality and water supply effects. The discussion includes the methodology used to assess effects and a summary of the anticipated effects. The supporting water supply analysis is provided in Section 3.13, Water Supply and in Appendix J, Water Supply Analysis. Although USACE is not responsible for drinking water supply or treatment, effects to drinking water from WVS operations would be the result of:

- Direct effects to water supply necessary for drinking water use. Adverse or beneficial effects on drinking water could occur from operational effects to available water. If water is not available to supply drinking water needs under an alternative, then a direct adverse effect would occur to the health and safety of analysis area communities. If water availability improves relative to the No-action Alternative (NAA), then a public health and safety benefit would be realized.

- Indirect effects to drinking water quality could occur if water quality is adverse below a dam, affecting a drinking water source under any alternative. Subsequent direct effects on drinking water quality would be the result of post-treatment conditions and not the result of WVS operations.

3.19.3.1 Methodology

The expected effects from water quality and water supply under each alternative is integral to the assessment of drinking water conditions in the analysis area. Consequently, information from these analyses is synthesized into the drinking water analyses (Section 3.5, Water Quality; Section 3.13, Water Supply).

The degree of impact to drinking water parameters described in Section 3.19.2.1, Drinking Water Contaminants and Treatments, are assessed qualitatively and discussed descriptively (e.g., slight[2], substantial). Quantitative criteria to describe the degree of effect are not applicable for this analysis because the WVS is not operated as a drinking water supply. Therefore, there are no quantitative data under each alternative to assess drinking water impacts from water quality or water supply effects; descriptions of these effects are more informative and accurate than attempting to assign defined degree criteria to adverse or beneficial effects.

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[2] "Slight" is defined in its common use as "small of its kind, or in amount" (Merriam Webster Dictionary). "Moderate" is defined in its common use as "average in amount, intensity, quality, or degree" (Oxford Languages). "Substantial is defined in its common use as "considerable in quantity, great [in amount]" (Merriam Webster Dictionary).

Direct effects to water supply are described qualitatively by stored water and river flow water supply. Subsequent indirect effects to drinking water users are related to these sources of water supply.

Construction and routine and non-routine maintenance effects are also addressed qualitatively because site-specific NEPA analyses would be needed to assess actual effects that would occur during the 30-year implementation timeframe. Construction would not occur under the NAA.

Routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities. (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation).

The summary of potential effects to public health and safety from effects to drinking water are provided in Table 3.19-2.

Table 3.19-2. Summary of Effects to Public Health and Safety from Effects to Drinking Water[1].

Effect Category[2]	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Water Quality	**Turbidity –** Adverse, but benefits from sediment trapped at all reservoirs during high-flow events. Minor, short-term, adverse below Fall Creek Reservoir.	**Turbidity –** Same as No-action Alternative.	**Turbidity –** Same as No-action Alternative but substantially more adverse below Foster Reservoir.	**Turbidity –** Same as No-action Alternative but substantially more adverse below Foster and Cougar Reservoirs.	**Turbidity –** Same as No-action Alternative below Hills Creek Reservoir. Slightly more adverse below Cougar Reservoir. Substantially more adverse below Dexter, Foster, and Big Cliff Reservoirs.	**Turbidity –** Substantially more adverse below Hills Creek, Dexter, Cougar, Foster, and Big Cliff Reservoirs.	**Turbidity –** Same as No-action Alternative.	**Turbidity –** Same as No-action Alternative but substantially more adverse below Foster and Cougar Reservoirs.
	Harmful Algal Blooms – Slightly adverse.	**Harmful Algal Blooms –** Slightly more adverse.	**Harmful Algal Blooms –** Slightly more adverse. Moderately more adverse in Foster Reservoir.	**Harmful Algal Blooms –** Slightly more adverse. Moderately more adverse in Foster and Cougar Reservoirs.	**Harmful Algal Blooms –** Moderately more adverse, but slightly more adverse in Hills Creek Reservoir.	**Harmful Algal Blooms –** Moderately more adverse below the same reservoirs as for turbidity.	**Harmful Algal Blooms –** Slightly more adverse.	**Harmful Algal Blooms –** Slightly more adverse. Moderately more adverse in Foster and Cougar Reservoirs.
Water Supply	**Groundwater –** No effect.	**Groundwater –** Same as No-action Alternative.	**Groundwater –** Same as No-action Alternative.	**Groundwater –** Same as No-action Alternative.	**Groundwater** Same as No-action Alternative.	**Groundwater –** Same as No-action Alternative.	**Groundwater –** Same as No-action Alternative.	**Groundwater –** Same as No-action Alternative.
	Stored Water – Substantial beneficial.	**Stored Water –** Same as No-action Alternative.	**Stored Water –** Same as No-action Alternative.	**Stored Water –** Slightly less beneficial than under the No-action Alternative.	**Stored Water** Substantial, adverse.	**Stored Water –** Substantial adverse.	**Stored Water –** Same as No-action Alternative.	**Stored Water –** Slightly less beneficial than under the No-action Alternative.
	River Flow – Beneficial but not all uses satisfied in all years.	**River Flow –** Same as No-action Alternative.	**River Flow –** Same as No-action Alternative.	**River Flow –** Same as No-action Alternative.	**River Flow** Same as No-action Alternative except adverse effects below Detroit Reservoir.	**River Flow –** Same as No-action Alternative except adverse effects below Green Peter Reservoir.	**River Flow –** Same as No-action Alternative.	**River Flow –** Same as No-action Alternative.

[1] All effects would be long term, occurring or reoccurring over the 30-year implementation timeframe.

[2] See Figures 3.5-59 through 3.5-63 in Section 3.5, Water Quality.

3.19.3.2 Alternatives Analyses

Construction and Routine and Non-routine Maintenance Activities under All Alternatives

Effects to water supply available for drinking water may occur as part of specific construction activities during alternative implementation and would be the same under any alternative involving construction. Effects may result from temporary drawdowns of reservoirs during the conservation season. However, subsequent tiered analyses would detail site-specific construction effects during the implementation phase (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act). Additional analyses are not provided under each alternative.

Similarly, routine and non-routine maintenance would occur under all alternatives during the 30-year implementation timeframe (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation). There would not likely be direct adverse impacts on water supply available for drinking water from routine maintenance activities because most would occur on dam structures and not require activities that would affect reservoir storage.

Non-routine, major maintenance activities may temporarily adversely affect water supply available for drinking water from construction. Major maintenance would require site-specific NEPA review prior to initiation at any location in the analysis area. Additional analyses are not provided under each alternative.

Groundwater Supply for Drinking Water under All Alternatives

There would not likely be any direct effect to groundwater supply or indirect effect to water supply users for drinking water in the analysis area from operations under any alternative during the 30-year implementation timeframe.

System operations that result in greatly reduced summer flows downstream of a dam or deep drawdowns of the reservoirs would have the potential to directly impact groundwater that is hydrologically connected to rivers or reservoirs. This would be an indirect, adverse impact to water users that utilize these groundwater wells, including drinking water users. Potential impacts would occur seasonally when the water levels are lower than existing seasonal levels.

Operations under all alternatives include a deep drawdown at Fall Creek Reservoir in addition to other deep drawdowns, depending on alternative implementation. Drawdown operations would occur annually. However, USACE has not identified any groundwater wells that are hydrologically connected to WVS reservoirs. Consequently, drawdown operations would not likely result in any direct, adverse effects to water supply or indirect, adverse effects to drinking water users reliant on groundwater wells over the 30-year implementation timeframe.

Water Quality and Treatment Facility Operations under All Alternatives

Drinking water quality could be adversely affected by the liberation of previously stored sediments caused by construction activities or by deep reservoir drawdowns over the 30-year implementation timeframe. These effects would be basin-wide. Both USACE operations could cause an increase in the amounts of turbidity and harmful algal blooms discharged downstream into drinking water sources. These conditions would result in indirect, adverse, temporary treatment costs of additional chemicals, testing, and facility maintenance as well as administrative costs and delays in drinking water supplied to affected communities (Section 3.11, Socioeconomics).

Turbidity

Sediment-related processes would occur in all subbasins under all alternatives, resulting in adverse water quality from turbidity. The degree of effect to water quality depends on geography, climate conditions, and seasonal reservoir operations affecting turbid water conditions in the analysis area. However, continued benefits in water quality from turbidity would occur because WVS reservoirs can trap sediment from the upstream watershed during high-flow events (Section 3.5, Water Quality, Section 3.5.2.2, Alternatives Analyses, No-action Alternative, Turbidity).

Under the NAA, there would be a deep fall drawdown at Fall Creek Reservoir resulting in temporary elevation of suspended sediment levels discharged from the dam (USGS 2023). Minor, short-term, adverse effects from temporary elevated turbidity may occur under the NAA at this location over the 30-year implementation timeframe.

Turbidity would become more adverse under all action alternatives as compared to the NAA with the exception of Alternative 1 and Alternative 4 (Section 3.5, Water Quality, Figures 3.5-59 through 3.5-63). Increased adverse conditions would vary depending on alternative and location downstream of a given dam. Adverse conditions would range from slightly more adverse than under NAA operations as measured at the Salem gage under Alternative 2B and Alternative 5 (Preferred Alternative) to substantially more adverse below Hills Creek, Dexter, Cougar, Foster, and Big Cliff Dams under Alternative 3B.

Harmful Algal Blooms

Under the NAA, operations at dams with deep outlets would continue to avoid releasing surface water that may contain cyanotoxins when conditions allow, having a beneficial effect on downstream water quality. However, due to the potential for harmful algal blooms to occur at some reservoirs in some years and under various conditions, a slight adverse effect from harmful algal blooms is expected under the NAA over the 30-year implementation timeframe (Section 3.5, Water Quality, Section 3.5.2.2, Alternatives Analyses, No-action Alternative, Harmful Algal Blooms).

Harmful algal bloom impacts on water quality would become slightly more adverse to moderately more adverse under all action alternatives (Section 3.5, Water Quality, Figures 3.5-59 through 3.5-63).

Turbidity and Harmful Algal Bloom Effects to Drinking Water and Facility Operations

All adverse water quality resulting from USACE operations and maintenance under any alternative would be addressed by water treatment and would remain compliant with Federal and state regulations for safe drinking water.

Specifically, water sourced from downstream of the WVS reservoirs would continue to be treated by a combination of filtration, aeration, and disinfection at a public water treatment facility before it is distributed within the analysis area under any alternative over the 30-year implementation timeframe.

Elevated turbidity and harmful algal blooms and subsequent treatment requirements could temporarily include increased costs of additional chemicals; testing; and facility maintenance, repairs, and/or equipment replacement. Adverse effects to communities could also include temporary loss of drinking water access and the requirement to supplement potable water.

Water Availability in Dry Years under All Alternatives

Per the Willamette Basin Review Feasibility Study (USACE 2019a), delivery of water stored in the WVS reservoirs for agricultural irrigation and municipal and industrial uses may be ceased or curtailed in dry years, limiting availability for drinking water. This would be an adverse effect to system's reliant on stored water for drinking water supply under all alternatives and would impact several communities in the analysis area but to varying degrees depending on alternative operations.

The impact to drinking water users from dry-year water management cannot be accurately assessed. However, it is anticipated that dry water-year effects would not be continuous over the full 30-year implementation timeframe, but dry water years could be re-occurring depending on annual climate conditions.

No-action Alternative

Stored Water

The maximum total volume of water stored system-wide in the WVS reservoirs would continue to meet municipal and industrial water supply demands under the NAA. There would be a direct, substantial, beneficial effect on water supply under the NAA during most times of the year. NAA operations would result in enough stored water needed to satisfy forecasted demands for consumptive uses during the 30-year implementation timeframe (Section 3.13, Water Supply, Table 3.13-5), except during dry years. This would be a continued, indirect, substantial benefit to drinking water users in the analysis area over the 30-year implementation timeframe.

River Flow

Under the NAA, there would be beneficial effects to water supply from river flows in the analysis area as a result of USACE operations over the 30-year implementation timeframe and from river flows not subject to USACE operations. This would be a continued, indirect benefit for municipal drinking water users. NAA operations would include flows downstream of the WVS dams to meet or exceed the 2008 NMFS Biological Opinion flow targets in most years, which would continue to support existing water use during the 30-year implementation timeframe (Appendix J, Water Supply Analysis). Regardless of beneficial water supply effects, not all water uses would be satisfied in all years and in all months under the NAA due to hydrologic conditions not subject to USACE operations and maintenance, such as dry years where river flows are low, thereby adversely affecting water supply (Section 3.13, Water Supply, Table 3.13-6).

Alternative 1—Improve Fish Passage through Storage-focused Measures

Stored Water

As under the NAA, there would be a direct, substantial, beneficial effect to water supply under Alternative 1 during most years. However, Alternative 1 operations would provide more stored water system wide than under the NAA. Alternative 1 operations would result in enough stored water to satisfy forecasted demands for consumptive uses during the 30-year implementation timeframe (Section 3.13, Water Supply, Table 3.13-7), except during very dry years. This would be a continued, indirect, substantial benefit to drinking water users in the analysis area over the 30-year implementation timeframe.

There would continue to be an indirect, adverse effect to drinking water users in the dry years under Alternative 1 but to a lesser extent than under the NAA. Stored water would increase by approximately 166,000 acre-feet in the dry years during the 30-year implementation timeframe under Alternative 1 as compared to the NAA. However, this amount of water supply would not be adequate to meet all municipal and industrial storage agreements in the dry years.

River Flow

Direct, beneficial effects to water supply and indirect, beneficial effects to drinking water users from flows in the analysis area under Alternative 1 would be the same as under NAA operations during the 30-year implementation timeframe (Section 3.13, Water Supply, Table 3.13-8).

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Stored Water

As under the NAA, there would be a direct, substantial, beneficial effect to water supply under Alternative 2A during most years. However, Alternative 2A operations would provide more stored water system wide than under the NAA. Alternative 2A operations would result in enough stored water to satisfy the forecasted demands for consumptive uses during the 30-

year implementation timeframe (Section 3.13, Water Supply, Table 3.13-9). This would be a continued, indirect, substantial benefit to drinking water users in the analysis area over the 30-year implementation timeframe.

There would continue to be an indirect adverse effect to drinking water users in the dry years under Alternative 2A but to a lesser extent than under the NAA. While stored water would increase by approximately 153,282 acre-feet in the dry years during the 30-year implementation timeframe under Alternative 2A as compared to the NAA, it would not be adequate to meet all municipal and industrial storage agreements in the dry years.

River Flow

As under NAA operations, effects to water supply under Alternative 2A would be directly beneficial because flows in river reaches downstream of the dams would remain above flow targets in all but dry years. This would also result in an indirect, beneficial effect to drinking water users as under the NAA (Section 3.13, Water Supply, Table 3.13-10).

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Stored Water

As under the NAA, there would be a direct, beneficial effect to water supply and an indirect, beneficial effect to drinking water users under Alternative 2B. However, the benefit under Alternative 2B operations would be slightly less beneficial than under NAA operations because, although stored water would be available for nearly all the forecasted consumptive use demands, it would not be enough to meet all the demands (Section 3.13, Water Supply, Table 3.13-11) in all years.

Blue River Reservoir water releases would compensate for reduced storage potential in Cougar Reservoir under Alternative 2B. This release would support water supply requirements on the McKenzie River and for water supply demands on the Mainstem Willamette River, downstream of the McKenzie River confluence.

As under the NAA, there would continue to be an indirect, adverse effect to drinking water users in the dry years under Alternative 2B during the 30-year implementation timeframe.

River Flow

As under NAA operations, effects to water supply under Alternative 2B would be directly beneficial because flows in river reaches downstream of the dams would remain above flow targets in all but dry years during the 30-year implementation timeframe. This would also result in an indirect, beneficial effect to drinking water users as under the NAA (Section 3.13, Water Supply, Table 3.13-12).

Alternative 3A—Improve Fish Passage through Operations-focused Measures

Unlike the NAA operations, Alternative 3A operations would combine spring spill and drawdowns with fall drawdowns at 6 of the 11 reservoirs: Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point Reservoirs.

Stored Water

Compared to the NAA, Alternative 3A would result in a direct, substantial, adverse effect to water supply because the combined operations would adversely affect system-wide conservation storage during the 30-year implementation timeframe (Section 3.13, Water Supply, Table 3.13-13). The reduced stored water as compared to the NAA would result in no water available for municipal and industrial water supply during the 30-year implementation timeframe and would be an indirect, substantial, adverse effect to drinking water users in the analysis area.

River Flow

Direct effects to river flow water supply and indirect effects to drinking water users under Alternative 3A would be the same as described under the NAA except in the North Santiam River Subbasin (Section 3.13, Water Supply, Table 3.13-14). In this subbasin, the spring drawdown at Detroit Reservoir would eliminate the ability to store water to augment naturally low flows in the summer as compared to the NAA during the 30-year implementation timeframe. This would be an indirect adverse effect to drinking water users dependent on flows below Detroit Dam.

Alternative 3B—Improve Fish Passage through Operations-focused Measures

Stored Water

As under Alternative 3A, Alternative 3B operations would also combine spring spill and drawdowns with fall drawdowns at 6 of the 11 reservoirs: Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point Reservoirs, but would result in slightly higher combined stored water than under Alternative 3A.

Unlike the NAA, there would be a direct, substantial, adverse effect on water supply under Alternative 3B because the combined operations for fish passage would adversely affect system-wide conservation storage during the 30-year implementation timeframe (Section 3.13, Water Supply, Table 3.13-15).

Due to conditions in the Willamette Basin Review Feasibility Study Biological Opinion (USACE 2019a), water that would be stored in the WVS reservoirs would be used primarily to support minimum flows for fish and wildlife under Alternative 3B. The reduced stored water as compared to the NAA would result in no water available for municipal and industrial drinking water users during the 30-year implementation timeframe and would be an indirect, substantial, adverse effect on these users in the analysis area.

River Flow

Direct effects on river flow water supply and indirect effects to drinking water users under Alternative 3B would be the same as described under the NAA except in the South Santiam River Subbasin (Section 3.13, Water Supply, Table 3.13-16). In this subbasin, the spring drawdown at Green Peter Reservoir would eliminate the ability to store water to augment naturally low flows in the summer as compared to the NAA during the 30-year implementation timeframe. This would be an indirect adverse effect to drinking water users dependent on flows below Green Peter Dam.

Alternative 4—Improve Fish Passage with Structures-based Approach

Stored Water

As under the NAA, there would be a direct, substantial beneficial effect to water supply under Alternative 4 during most times of the year. However, Alternative 4 operations would provide more stored water system wide than under the NAA. Alternative 4 operations would result in enough stored water to satisfy forecasted demands for consumptive uses during the 30-year implementation timeframe (Section 3.13, Water Supply, Table 3.13-17). This would be an indirect, substantial benefit to drinking water users.

There would continue to be an indirect, adverse, effect to drinking water users in the dry years under Alternative 4 but to a lesser extent than under the NAA. Regardless of this improvement as compared to NAA operations, while stored water would increase by approximately 153,000 acre-feet in the dry years during the 30-year implementation timeframe under Alternative 4 as compared to the NAA, it would not be adequate to meet all municipal and industrial storage agreements in the dry years.

River Flow

Direct effects to river flow water supply and indirect effects to drinking water users under Alternative 4 would be the same as described under the NAA (Section 3.13, Water Supply, Table 3.13-18).

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Stored Water

Direct effects to stored water supply and indirect effects to drinking water users would be the same as described under Alternative 2B although there would be slight differences in stored water amounts under Alternative 5 (Section 3.13, Water Supply, Table 3.13-19).

River Flow

Direct effects to river flow on water supply and indirect effects to drinking water users under Alternative 5 would be the same as described under the NAA (Section 3.13, Water Supply, Table 3.13-20).

3.19.4 Interim Operations under All Action Alternatives Except Alternative 1

The Interim Operations are a set of operations for downstream fish passage and temperature management that would be implemented until the long-term measure for fish passage or temperature management is being used. These operations would result in decreased system-wide stored water in the conservation pool.

The timing and duration of Interim Operations would vary depending on a given alternative. Interim Operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternatives, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations will be implemented in succession with, and not in addition to, action alternative implementation.

3.19.4.1 Turbidity

Under Interim Operations, effects to water quality from turbidity would be the same as those described under the direct and indirect effects throughout the analysis area. However, effects in the Middle Fork Willamette River Subbasin and the South Santiam River Subbasin would be substantially more adverse than those described under the NAA during the 30-year implementation timeframe.

Interim Operations would cause an increase in sediment and turbidity levels downstream of Lookout Point, Dexter, Green Peter, and Foster Reservoirs because of deeper drawdowns. Deep drawdowns increase the potential for bank erosion and sloughing as compared to NAA operations. While some fine-grained sediment that enters Dexter Reservoir from Lookout Point Reservoir may partially settle, most fine-grained sediment would pass through Dexter Reservoir and be transported downstream, likely resulting in increased turbidity downstream during deeper drawdowns compared to NAA operations.

Substantial, adverse effects to water quality would result in similar effects on drinking water users to the extent that supply is sourced below Lookout Point and Green Peter Reservoirs.

3.19.4.2 Harmful Algal Blooms

Under Interim Operations, effects to water quality from harmful algal blooms would be moderately more adverse as compared to slightly adverse conditions described under the NAA during the 30-year implementation timeframe. Interim Operations would cause an increase in sediment and nutrient loading into Lookout Point and Green Peter Reservoirs because of deeper drawdowns that increase the potential for bank erosion and sloughing as compared to NAA operations.

Moderately more adverse effects to water quality would result in similar effects to drinking water users to the extent that supply is sourced below Lookout Point and Green Peter Reservoirs.

3.19.4.3 Stored Water

There would be a slight, beneficial, direct effect on water supply and a slight, beneficial, indirect effect to users under Interim Operations during most times of the year because the amount of water stored system wide would be slightly more than the amount needed to support minimum flow targets during the 30-year implementation timeframe with 80 percent likelihood (Section 3.13, Water Supply, Table 3.13-21). Stored water would be available to meet some municipal and industrial storage agreements and agricultural irrigation water service contracts under Interim Operations.

3.19.4.4 River Flow

Direct effects to river flow on water supply and indirect effects to drinking water users under the Interim Operations would be the same as described under the NAA (Section 3.13, Water Supply, Table 3.13-22).

3.19.5 Climate Change under All Alternatives

Climate change is expected to result in wetter winters, drier summers, lower summer stream flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the Willamette River Basin as compared to existing conditions and independent of the WVS operations and maintenance activities over the 30-year implementation timeframe (Appendix F1, Qualitative Assessment of Climate Change Impacts, Chapter 4, Projected Trends in Future Climate and Climate Change; Appendix F2, Supplemental Climate Change Information, Chapter 3, Supplemental Data Sources, Section 3.1 Overview of RMJOC II Climate Change Projections). The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

3.19.5.1 Drinking Water Quality

Climate change effects are anticipated to slightly or moderately worsen turbidity and harmful algal bloom water quality conditions under all alternatives as described in Section 3.5, Water

Quality, Section 3.5.4, Climate Change. Under most alternatives, turbidity may have slight adverse effects to water quality during high flow events in winter and spring when reservoirs are at capacity and USACE is unable to store sediment-laden inflows compared to 2019 conditions. However, reservoirs trap sediment from high upstream flows, which would be a continued direct benefit to water quality conditions and an indirect benefit to drinking water users over the 30-year implementation timeframe.

Harmful algal blooms may also have slightly adverse effects on water quality under most alternatives when late summer inflows are lower compared to 2019 conditions. However, harmful algal blooms may be influenced by reservoir storage and time of year resulting from climate change conditions over the 30-year implementation timeframe.

Turbidity and harmful algal bloom effects would be more adverse under Alternative 3A and Alternative 3B because of decreased water storage and an increase in spill operations.

However, it is anticipated that municipal water systems would continue to adjust to water quality and adverse conditions over the 30-year implementation timeframe per Federal and state laws. Specifically, water sourced from downstream of the WVS reservoirs would continue to be treated by a combination of filtration, aeration, and disinfection at a public water treatment facility before it is distributed within the analysis area under any alternative over the 30-year implementation timeframe.

Under all alternatives, elevated turbidity and harmful algal blooms and subsequent treatment requirements could include temporary increased costs of additional chemicals; testing; and facility maintenance, repairs, and/or equipment replacement. Adverse effects to communities could also include temporary loss of drinking water access and the requirement to supplement potable water. These costs and requirements could occur more often than under existing conditions under any alternative implementation as a result of continue climate change-related water quality conditions.

3.19.5.2 Drinking Water Availability

Climate change would have an adverse effect on water supply and to municipal and industrial water users under any alternative. Increased climate variability in the spring shoulder months, drier hotter summers, and lower summer baseflow are the most impactful climate change factors affecting conservation season water supply operations. Consequently, water supply from water stored in analysis area reservoirs, groundwater wells, and from river flow may be adversely affected in the long term under any alternative. Additionally, decreased summer baseflows would adversely affect water users under any alternative because there may not be adequate water in the rivers to satisfy existing water rights.

Operations in reservoirs that have a spring drawdown for fish passage would not likely refill because seasonal drier hydrologic conditions would start earlier under climate change conditions.

River flow in the summer would likely decrease due to climate change because of lower snowpack, which sustains summer baseflows. Consequently, this would adversely affect drinking water users because there may not be adequate water in the rivers to satisfy existing water rights.

END NEW OR REVISED TEXT

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.20 ENVIRONMENTAL JUSTICE

3.20 Environmental Justice

THE DEIS ENVIRONMENTAL JUSTICE SECTION HAS BEEN DELETED IN THE FEIS

Summary of changes from the DEIS:

- **Executive Order 14148 was rescinded on January 20, 2025 by Executive Order. Executive Order 14173 was rescinded on January 21, 2025 by Executive Order. The two 2025 Executive Orders rescinded the previous Executive Orders requiring agencies to analyze environmental justice-related effects from proposed actions. In compliance with these 2025 directives, environmental justice analyses have been removed from the FEIS.**

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.21 CULTURAL RESOURCES

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3.21 Cultural Resources

THE CULTURAL RESOURCES SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED OR MOVED TO A NEW APPENDIX
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **Information on the analysis area has been updated to clarify geographic boundaries.**
- **Information has been moved to appropriate sections. Terminology has been defined.**
- **DEIS Table 3.21-1, Willamette Valley System Construction Dates and Authorizing Acts, has been moved to Chapter 1, Section 1.1, Background.**
- **DEIS Table 3.21-4, U.S. Army Corps of Engineers-constructed Fish Hatcheries, has been moved to Chapter 1, Section 1.9.2, Willamette Hatchery Mitigation Program.**
- **Documented archaeological resources in the Willamette Valley System have been added as Table 3.21-1.**
- **Additional information on Tribal Resources important to the Confederated Tribes of the Warm Springs Reservation of Oregon has been added to Section 3.21.2.5, Cultural Resources Documentation in the Analysis Area.**
- **Additional information on downstream cultural resources has been added to Section 3.21.2.5, Cultural Resources Documentation in the Analysis Area, and to a new appendix: Appendix T, Cultural Resources Effects Analyses.**
- **Additional information on the National Historic Preservation Act compliance requirement has been added to Section 3.21.3, Federal Laws and U.S. Army Corps of Engineers Regulations.**
- **The Environmental Consequences section has been reformatted to streamline information or to combine information under applicable subsections (Section 3.21.4). Statistical details supporting the action alternatives analyses have been moved to a new appendix: Appendix T, Cultural Resources Effects Analyses.**

Summary of changes from the DEIS, continued:

- **Information has been added to the effects criteria table to incorporate built resources criteria (Table 3.21-6). A summary table of overall effects to cultural resources has been added (Table 3-21-7). The percentages of the WVS archaeological sites and historic districts that would be adversely affected under the alternatives are presented in Table 3.21-8 and Table 3.21-9, respectively.**
- **Analyses of impacts associated with routine scheduled and unscheduled maintenance has been added (Section 3.21.4, Environmental Consequences).**
- **Near-term Operations Measures effects have been summarized, and the title has been changed to Interim Operations in Section 3.21.6, Interim Operations under All Action Alternatives except Alternative 1.**
- **Climate change effects under all alternatives have been summarized in Section 3.21.7, Climate Change under All Alternatives.**
- **Capitalizations for "tribe" and "tribal" follow the 2016 Government Publishing Office editing conventions, which are supported by the Bureau of Indian Affairs Editorial Guide.**

3.21.1 Introduction

Cultural resources refer to physical manifestations that represent the heritage of a place and are associated with peoples who have historical connections to that place. Cultural resources as assessed below include:

- Pre-contact and historical archaeological objects, features, and deposits located above or below the ground surface that are tangible evidence of prior human occupation or use in a particular area.
- Architecture or elements of the built environment referred to as built resources for this analysis.
- Places or landscapes that a group of people consider culturally important because of events or practices that have occurred at the location. Places and landscapes include traditional cultural properties or historic properties of religious and cultural significance to Indian tribes.

3.21.2 Affected Environment

The Affected Environment summarizes 15,000 years of upper Willamette Valley cultural history presented as:

1. Pre-contact Background
2. Ethnographic Summary
3. Historic Background
4. U.S. Army Corps of Engineers Willamette Valley System
5. Cultural Resources Documentation in the Analysis Area

This information provides context on past human activity that resulted in the cultural resources known to be present in the analysis area. The analysis area is confined to the Willamette River Basin and is composed of three parts:

1. Approximately 55,000 acres at the 13 Willamette Valley System (WVS) operating projects that contain the dam and powerhouse operational areas, associated reservoirs, and surrounding uplands.
2. The geographic boundaries of the Willamette River Basin that begin south of Cottage Grove and extend approximately 187 miles to the north where the Willamette River flows into the Columbia River.
3. Discrete and limited sections of the Calapooia, Clackamas, and Molalla Rivers and Mill Creek where revetments, embankments, or levees are located that could be modified under some of the alternatives but are not downstream of the WVS and not regulated by USACE (Appendix S, USACE-managed Dams, Reservoirs, and Bank Protection Structures).

3.21.2.1 Pre-contact Background

The earliest archaeological evidence of human occupation in the upper Willamette Valley is associated with Clovis and Western Stemmed Tradition projectile points[1] belonging to the Paleo-Indian period (time range of 15,000 to 9,000 years B.P.[2]), many of which were recovered at USACE reservoirs (Aikens et al. 2011; Lewis 2020). Paleo-Indian peoples have been characterized as highly mobile, spear-carrying, big game hunters, though acorn and hazelnut use has been identified in a handful of Willamette Valley sites, dating to approximately 10,000 years B.P.

[1] Pointed objects created by people to haft onto a shaft to project at targets, typically moving animals or other people.

[2] B.P. = before present.

The transition to Early Archaic archaeological cultures (time range of 9,000 to 6,000 years B.P.) is indicated by an increase in the diversity of flaked stone artifacts. The earliest camas ovens in the Willamette Valley date to this period, showing that people mass-processed camas bulbs by 8,500 years B.P. Plant processing equipment also suggests population growth in the Willamette Valley (Lewis 2020).

More camas ovens, diverse groundstone, and wide-necked flaked stone dart points used with darts and atlatls[3] are representative of technologies of the Willamette Valley Middle Archaic period (time range of 6,000 to 2,000 years B.P.). Groundstone bowls and oven features associated with charred camas bulbs, hazelnuts, and acorns suggest an increase in plant processing and storage. Collectively, these are archaeological markers associated with more sedentary lifestyles. Archaeological research shows that Middle Archaic lifeways included summer trips to the High Cascade Mountains to collect resources unique to the Cascade Mountains, including obsidian (Lewis 2020).

Archaeologists believe Late Archaic (2,000 to 250 years B.P.) culture and technologies became increasingly more localized. Additionally, there is continuity between Late Archaic archaeological patterns and historically recorded ethnic and linguistic boundaries. Late Archaic archaeological toolkits include small projectile points for use with arrows and bow and groundstone plant processing technologies. The Late Archaic is also marked by increased sedentism, expanded diets, and status displays with trade goods. Ethnographic collections and associated Grand Ronde oral histories indicate an established Pacific Northwest-wide trade network that existed prior to Euroamerican contact and thrived into the Historic period (Lewis 2020).

3.21.2.2 Ethnographic Summary

At the time of Euroamerican contact, the Willamette Valley was a culturally distinct region of several groups of peoples who based identity on affiliations, geography, and subsistence practices (Lewis 2020). Ethnographers, however, commonly refer to Willamette Valley peoples in linguistic terms of either “Kalapuya-” or “Molalla”-speaking (Lewis 2020).

Cultural practices of the Kalapuya and Molalla were similar despite linguistic, geographic, and subsistence differences. There are fewer ethnographic and historical accounts that describe Molalla lifeways, traditions, and customs, which has resulted in some generalizations between the two groups in academic literature (Lewis 2020).

Kalapuyan groups mostly lived in the Willamette Valley bounded on the west by the Coast Range, the south by the Calapooya Mountain Range, the north by the falls of the Willamette River, and the east by the Cascade Mountains (Lewis 2020). One group, the Yoncalla, lived on the south side of the Calapooya Mountain Range. The ethnographic record identifies several

[3] A throwing board that allows a person to propel a dart farther and faster than if thrown by hand.

cultural groups as Kalapuyan, including the Tualatin, Yamhill, Luckiamute, Santiam, Yoncalla, Mary's River, McKenzie, and Calapooia (Lewis 2020).

Kalapuyan peoples settled in small family groups and occupied multiple dispersed base camps that targeted seasonally available plants, mammals, fish, and birds. In the summer, Kalapuya people camped on river floodplains but congregated in larger villages on the valley floor in the winter (Lewis 2020).

The Molalla inhabited the western foothills of the Cascade Mountains along the Willamette Valley as far west as the eastern side of the confluence of the Willamette and Columbia Rivers. Molalla territory included the Oregon City falls, Molalla River tributaries, and southwestern tributaries of the Clackamas River (Lewis 2020).

Northern Molalla peoples inhabited the Santiam and Willamette River west of Mt. Hood and lands to the north along the western and high lands of the Cascade Mountains. Southern Molalla culture and history are not well documented except for a handful of post-contact accounts of Molalla living in the valley of the Middle Fork Willamette River (Lewis 2020).

Molalla families inhabited the Cascade Mountains during the summer and the Willamette Valley during the winter for seasonal resource procurement (Lewis 2020). One 30-family Klamath-Molalla group inhabited the Middle Fork area of the Willamette River near Butte Disappointment, just south of Fall Creek Lake, at a placed called "Demijohn's Tower" (Lewis 2020).

The Molalla and Kalapuya participated in a complex trade network that extended beyond the Willamette Valley to peoples living on the Oregon coast and Columbia River, in northern California, and east of the Cascade Mountain crest. Trade as well as intermarriage was facilitated by extensive trail systems throughout western Oregon (Lewis 2020).

3.21.2.3 Historic Background

European epidemics among native populations in the Pacific Northwest preceded direct Euroamerican contact and caused drastic indigenous depopulation in the late 1700s, with smallpox spreading from the coast to the interior (Lewis 2020). In the early 1800s, native populations came into direct contact with non-indigenous explorers and their populations continued to substantially decline due to malaria, venereal diseases, exposure, and starvation. While early explorers, such as Lewis and Clark, documented large Kalapuya populations in the early 1800s, only a few hundred indigenous people were known to be living in the Willamette Valley by the 1840s (Lewis 2020).

Kalapuya peoples living along the Middle Fork of the Willamette River in the vicinity of present-day Eugene, Oregon and the Fall Creek Lake area first came into contact with Euroamericans in 1812 (Lewis 2020). By the mid-1820s, explorers and fur seekers were regular fixtures in the upper Willamette Valley (Beckham and Toepel 1982).

By the 1840s, settlers arrived in droves. The Donation Land Act of 1850 and the Homestead Act of 1862 spurred successive waves of thousands of mostly Euroamerican settlers to the Willamette Valley. As desirable locations on the valley floor became increasingly populated, settlers continued to move into the foothills, displacing indigenous peoples and exacerbating already heavy competition for resources (Beckham and Toepel 1982).

Euroamerican settlement fostered Federal Indian policy that first sought to eliminate indigenous peoples, and then strove to contain and isolate those who remained. Multiple unratified treaties, drafted in the 1850s, provided for land reservations and subsistence rights in usual and accustomed areas within Kalapuya and Molalla homelands if they agreed to cede millions of acres of their territories. Eventually, treaties ratified in 1855 extinguished Kalapuya and Molalla land titles for very small land reservations and required relocation to the Grand Ronde Reservation.

In 1856, the Federal government required Willamette Valley tribes to go to the Grand Ronde or Oregon Coast (or Siletz) Reservations. Most Kalapuya and Molalla people ended up at the Grand Ronde Reservation; however, individuals, families or small groups also incorporated into the Klamath or Warm Springs Reservations. People who chose to remain either went into hiding (physically or socially—passing as Euroamerican), or they were subject to varying levels of hostilities from Euroamerican communities and government agents (Lewis 2020).

Into the early 20th century, indigenous people continued to inhabit the Willamette Valley, though in a modified capacity, and census records, which show extremely low numbers of indigenous peoples, are a poor indication of actual use. For peoples who were farther removed, such as those living on the Warms Springs Reservation, people continued to return to the Willamette Valley for paid labor and resource procurement (Lewis 2020).

Late 1800s government-funded travel routes, such as the Oregon and California Railroad and the Oregon Central Military Road, supported continued expansion of Euroamerican populations into the Willamette foothills. Settlers were able to clear land for agricultural purposes, and easier travel facilitated development of a booming timber industry through the middle of the 20th century. Ultimately, land-managing agencies had pivotal roles in the local valley economy (Beckham and Toepel 1982).

The revestment [return of land to the government] of the Oregon and California Railroad grant lands in 1916 and the creation of the Cascade National Forest (later the Willamette National Forest) prior to World War I fostered extensive government land management in the upper Willamette Valley. Eventually, following World War II, functions of the Federal General Land Office were broadened under the new U.S. Bureau of Land Management, and specific policies of timber harvest and sales from the Oregon and California Railroad and other public lands assumed increasing importance in the region’s economy (Beckham and Toepel 1982).

3.21.2.4 Flood Control in Oregon and the Willamette River Basin, and Development of the U.S. Army Corps of Engineers Willamette Valley System

In 1871, USACE established the Portland District to ensure control of the Columbia and Willamette Rivers as navigable waterways (Willingham 1983). The Portland District "improved" waterways of the region including navigation channels on the Oregon Coast (by the 1880s), the first canal project on the Columbia River (Cascade Locks and Canal, in 1896), and The Dalles-Celilo Canal (built between 1905 and 1915). Local efforts resulted in several private water resource projects, including the Willamette Falls Locks built in 1873, which the Portland General Electric Company (formerly the Willamette Falls Canal and Locks Company) sold to USACE in 1915 (Willingham 1983).

By the 1920s, state and local entities attempted to promote more Federally funded navigation and flood control on the Columbia River. The Willamette Valley Association, founded in 1933, spearheaded similar efforts for the upper Willamette Valley. Grassroots lobbying efforts were instrumental to congressional passage of the Flood Control Act of 1936, which prioritized flood control in the USACE mission. The Act became the basis for USACE to plan, design, and ultimately construct the first dams in the upper Willamette Valley (Beckham and Toepel 1982; Willingham 1983) (Section 1.1, Background).

The flood control and navigation efforts inundated, destroyed, or cut off access to places and resources integral to the Native American economy of the Pacific Northwest, including several notable points along the rivers where large gatherings had occurred for centuries and where sizeable fish runs had sustained local populations.

3.21.2.5 Cultural Resources Documentation in the Analysis Area

<u>Documented Resources and National Register of Historic Places Eligibility</u>

Archaeological Resources

The lengthy human habitation of the Willamette Valley has left tangible markers on the landscape now managed by USACE. There are 461 documented pre-contact, historic, and multi-component archaeological resources within, or intersecting with, the footprints of the 13 WVS dam and reservoir areas (Table 3.21-1).

Table 3.21-1. Documented Archaeological Resources in the Willamette Valley System.

Dam	Archaeological Resources
Big Cliff	2
Blue River	12
Cottage Grove	24
Cougar	31
Detroit	31
Dexter	12
Dorena	14
Fall Creek	55
Fern Ridge	181
Foster	38
Green Peter	20
Hills Creek	4
Lookout Point	37
Total	461

These resources range in age from the earliest documented Paleo-Indian Period projectile points to dam construction work areas created between 1940 and 1973 A.D.[4] Archaeological resource types include:

- Isolated artifacts and features
- Task sites
- Debris sites
- Historic cemeteries
- Residential sites
- Transportation/travel corridors
- Townsites
- Rock features
- Rock shelters
- Lithic scatters

Most of the archaeological resources in the WVS have not been evaluated for listing in the National Register of Historic Places (428 resources or 93 percent). Six percent (27 resources) have been determined not eligible for listing in the National Register, and 1 percent (six resources) have been determined eligible for listing in the National Register. Three of the six eligible sites are located in the timbered landscape near Cougar Reservoir, and one is located on the shoreline of Hills Creek Reservoir.

In the 1980s, archaeologists working for the U.S. Forest Service identified these sites as upland lithic scatters and made determinations of eligibility based on their research potential to

[4] A.D. = anno domini

provide more information related to the Willamette Valley archaeological record and early human use of the West Cascade Mountains. Two other sites in the WVS eligible for National Register of Historic Places listing are historic-age resources located at Lookout Point Reservoir.

The Armet Townsite and the Central Oregon Military Road were both determined eligible in 2019. The Armet Townsite was a small community located along the Cascade Route of the South Pacific Railroad that existed from 1887 until 1947. People who lived there were ultimately displaced in the early 1950s when Lookout Point Dam was constructed and the reservoir created and filled.

The Armet Townsite is no longer standing. The former location experiences seasonal inundation from Lookout Point Reservoir operations. It was determined to be eligible for National Register of Historic Places listing due to its research potential to understand historic settlement of the Middle Fork Willamette River Subbasin.

The Federal government sanctioned construction of the Oregon Central Military Road in the 1860s to 1870s to provide a travel route from Eugene, Oregon to Boise, Idaho. The segment that overlaps with Lookout Point Reservoir, the Butte Disappointment to Big Pine Openings segment, was constructed in 1865.

Construction of the road facilitated overland travel and non-indigenous expansion into the Middle Fork Willamette River Subbasin. The general path that overlaps with Lookout Point Dam and Reservoir was used as a road and railroad line until the mid-20th century with the construction and eventual filling of Lookout Point Reservoir. Portions of the route are seasonally inundated by Lookout Point Reservoir operations.

The road was originally determined eligible for National Register listing in 1981. In 2019, USACE confirmed that the “Lookout Point Reservoir Stretch” retained sufficient integrity of the original roadbed to still be eligible for listing as an important linear feature related to 19th century travel and non-indigenous settlement of the Willamette Valley, State of Oregon, and greater Pacific Northwest.

Historic Districts

Portions of the WVS built environment are also eligible for National Register of Historic Places listing and consists of 13 historic districts with 89 contributing resources that were constructed between 1940 and 1973 (Table 3.21-2).

Table 3.21-2. Built Resources in the Willamette Valley System.

Dam	Contributing Built Resources in WVS Historic Districts
Big Cliff	3
Blue River	4
Cottage Grove	6
Cougar	6
Detroit	4
Dexter	5
Dorena	6
Fall Creek	3
Fern Ridge	23*
Foster	10
Green Peter	9
Hills Creek	4
Lookout Point	6
Total	**89**

*Includes the lower Long Tom River-constructed channel

Under the National Historic Preservation Act, the WVS historic districts are considered locally significant and eligible for listing in the National Register of Historic Places due to the impact of the WVS on development of the Willamette Valley Basin in Lane, Linn, Marion, and Benton Counties between 1940 and 1973 (known as the Period of Significance) (Section 3.21.3, Federal Laws and U.S. Army Corps of Engineers Regulations). During this time, construction of the dams, reservoirs, appurtenant infrastructure, fish passage systems, and hatcheries as well as recreation sites of the WVS had major influences on the Willamette Valley through implementing a flood control mission that changed the way people settled the landscape, earned a living, accessed river resources, and recreated in the Willamette Valley.

Construction of a series of large-scale infrastructure dams and reservoirs mobilized the local workforce, providing job opportunities and civil pride in American ingenuity and engineering feats. These dams and reservoirs developed recreational opportunities and related commerce throughout the Willamette Valley, instilled in the public that reservoirs and dams are places to recreate, developed and provided hydropower, impacted native fish runs, and subsequently motivated interested parties to address these impacts.

Construction of the WVS also applied innovative engineering (research and design) to facilitate anadromous fish passage and to boost local fish populations through hatchery programs. Contributing resources of the WVS historic districts retain integrity, can be dated to the Period of Significance, and are directly associated with historical themes that make the WVS historically significant to the history of the Willamette Valley (Table 3.21-3).

Table 3.21-3. Count and Contributing Resource Types of the WVS Historic Districts.

Resource Type	Contributing Resources	Notes
Dam	13	All dams are contributing
Powerhouse	8	All powerhouses, except Dexter Dam, are contributing
Reservoir	13	All reservoirs are contributing
Stilling Basin	1	Foster Dam
Ancillary Dikes/Levees	2	Fern Ridge Dam
Saddle Dam	1	Blue River Dam
Engineering Project Office	3	Cougar, Dorena, and Hills Creek Dams
Caretaker's Facility	2	Fern Ridge and Foster Dams
Garages	2	Fern Ridge and Foster Dams
Fish Passage Facilities	4	Dexter, Foster, and Green Peter Dams
Recreation Areas	30	All projects, except Big Cliff, Dexter, and Hills Creek Dams
Channel/Drop Structures	10	Lower Long Tom Constructed Channel (part of Fern Ridge Dam)

Tribal Resources

USACE identified four Federally recognized tribes that would have traditional cultural properties and historic properties of religious and cultural significance to Indian tribes in the WVS:

- The Confederated Tribes of the Grand Ronde Community of Oregon
- The Confederated Tribes of the Siletz Indians
- The Confederated Tribes of the Warm Springs Reservation of Oregon
- The Cow Creek Band of Umpqua Tribe of Indians

In 2019 to 2021, USACE contracted with the Confederated Tribes of the Grand Ronde Community of Oregon to identify resources important to the Tribe. This work resulted in a WVS-wide "ethnographic survey of the cultural landscape through the lens of the [Grand Ronde] community" (Archuleta and Rempel 2022). Archuleta and Rempel (2022) considered the WVS holistically to characterize the traditional cultural landscape of the Willamette Valley rather than provide an inventory of discrete traditional cultural properties or historic properties of religious and cultural significance to Indian tribes. The authors explain:

> Traditional cultural landscapes and historical properties of religious and cultural significance to Indian tribes span the entirety of the Willamette Valley where indigenous people once lived and where they continue to live, travel, gather, hunt, fish, congregate, worship, and recreate.

It is apparent from this study that the Tribe has a rich, long, and intricately woven connection with the upper Willamette Valley and directly with those areas managed by the USACE and other state and federal agencies. It demonstrates that though the dams and reservoirs today are discreetly bounded areas, they are connected to many places of importance to the Tribe... (Archuleta and Rempel, 2022).

In 2022–2023, USACE also contracted with GeoVisions to conduct a preliminary inventory of traditional cultural properties and historic properties of religious and cultural significance to Indian tribes for the Confederated Tribes of the Warm Springs Reservation of Oregon. Based on interviews with tribal members, Dewan and Galloway (2023) noted that the Tribe's understanding of landscape use is not consistent with assigning boundaries to properties. They further specified that because the entirety of the Willamette Valley is important to the Tribe it "is a Historic Property of Religious and Cultural Significance to the CTWRSO [Confederated Tribes of the Warm Springs Reservation of Oregon]."

To date, USACE has not completed adequate surveys to identify traditional cultural properties or historic properties of religious and cultural significance to Indian tribes. Work with the Confederated Tribes of the Grand Ronde Community of Oregon and the Confederated Tribes of the Warm Springs Reservation of Oregon are starting points for communication between USACE and the Tribes on how to best match bureaucratic definitions with each Tribe's worldview and needs.

USACE recognizes that Kalapuya and Molalla peoples have inhabited the Willamette Valley for millennia, and members of Federally recognized tribes living in and outside of the Willamette Valley share deep connection to the Willamette Valley. Consequently, there are likely many tribal traditional cultural properties and historic properties of religious and cultural significance to Indian tribes that overlap with the WVS. USACE does not know of non-indigenous communities that might have traditional cultural properties in the WVS.

<u>Cultural Resources Downstream of the WVS</u>

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

Cultural resources are present downstream of the 13 WVS dams and located along the 465 miles of riverbank controlled by the WVS (Appendix T, Cultural Resources Effects Analyses). These include thousands of archaeological sites that can be dated to the Paleo-Indian, Archaic, and Historic periods (dating from 15,000 years to 50 years B.P.).

Pre-contact and historic archaeological sites would be present anywhere Kalapuya and Molalla-speaking peoples lived and traded with other indigenous groups throughout the Pacific

Northwest, and where non-indigenous peoples colonized and developed the Willamette Valley within the last 250 years. Many of these sites are eligible for listing or listed in the National Register of Historic Places.

Built resources that also number in the thousands are present along these waterways and provide evidence of settlement, development, and industrialization of the Willamette Valley, typically near or within the small communities that are present along the rivers as well as within the larger more established areas of Cottage Grove, Oakridge, Lowell, Eugene, Salem, Sweet Home, and Portland, Oregon. Several larger communities boast historic districts that are listed or could be listed in the National Register of Historic Places.

The lands and waterways downstream of the WVS are not managed by the Corps and are a mix of other Federal, tribal, state, municipal, county, and private ownership. These non-Corps lands have been surveyed to varying degrees. There is no efficient way to obtain related resource data within the 465-mile riverine setting that would allow for a quantitative analysis, except for some inventory data related to revetments in the Willamette River Basin.

END NEW TEXT

U.S. Army Corps of Engineers Programs in the Upper Willamette River Basin

USACE has a structural footprint, with historic-age components, that extends beyond the WVS with the Willamette River Basin Bank Protection Program; the Willamette Hatchery Mitigation Program; Fish Mitigation Program; and the Research, Monitoring, and Evaluation Program (Chapter 1, Introduction, Section 1.9, U.S. Army Corps of Engineer's Programs and Planning in the Willamette River Basin). The Bank Protection Program constructed 223 flood control structures in the Willamette River Basin of which 193 are still active and are at least 50 years of age. These resources have not been evaluated for listing in the National Register of Historic Places.

USACE constructed and operates five adult fish collection facilities and funds the operations and maintenance of five hatcheries that are downstream from the WVS dams (Chapter 1, Introduction, Section 1.9.2, Willamette Hatchery Mitigation Program). All collection facilities and hatcheries have components at least 50 years of age, although the majority have been intensely modified or upgraded with new facilities to support fish populations in the Willamette River Basin. For any activities that require modification to the built environment that support these USACE programs, an inventory and evaluation is required to determine if the infrastructure or components are eligible for listing in the National Register of Historic Places.

3.21.3 Federal Laws and U.S. Army Corps of Engineers Regulations

Section 106 of the National Historic Preservation Act (NHPA), as amended, and the Act's implementing regulations, *Protection of Historic Properties*, 36 CFR Part 800, requires Federal agencies to consider the effects of their undertakings on historic properties. An undertaking is any project, activity, or program that a Federal agency funds, permits, licenses, or approves, in whole, or in part.

Federal agencies must identify, evaluate for significance and potential listing in the National Register of Historic Places, and resolve adverse effects to cultural resources that are identified as historic properties when assessing the potential effects of an undertaking. Historic properties:

- Typically, but not always, at least 50 years old;
- Retain integrity related to location, design, setting, materials, workmanship, feeling, or association;
- Are associated with significant historical events or people;
- Are representative of a distinctive style of construction;
- Retain stylistic elements representative of a master artisan; or
- Likely provide important information about the past through continued study (NPS 1997).

USACE uses a program-level programmatic agreement (Agreement) to comply with Section 106 of the NHPA for WVS operations and maintenance. This document was executed on June 7, 2022 with considerable involvement by several Federal, state, and tribal partners and other interested parties (as defined in 36 CFR Part 800.6(c)(2))[5].

The Agreement modifies the Section 106 process to follow a streamlined and standardized approach to manage cultural resources that have the potential to be impacted by USACE undertakings related to current and future operations and maintenance of the WVS. This applies to large-scale operational activities as well as to site-specific and structural activities that would be assessed through a tiered NEPA approach (Chapter 1, Introduction, Section 1.3.1.1, Programmatic Reviews and Subsequent Tiering under the National Environmental Policy Act).

Per Agreement Stipulation VII (Historic Property Management Plan), USACE and consulting parties have developed a companion document referred to as an historic property management plan (Management Plan) that outlines streamlined management and protection measures for historic properties that would be affected by operations and maintenance of the WVS. The Agreement provides a process to resolve adverse effects that would occur as the result of an undertaking. The Management Plan provides standardized avoidance, minimization, and mitigation measures that USACE may implement, as appropriate, depending

[5] The Agreement is a publicly available document. Contact USACE, Portland District, Environmental Resources Branch. The Agreement Whereas Clauses list invited and participating parties as well as their role in the consultation process, as defined in 36 CFR Part 800. Appendix A of the Agreement provides definitions of types of parties that are involved in the 36 CFR Part 800 consultation process.

on the scope, scale, and nature of the undertaking and the finding of effect (as defined by NHPA). USACE implements the process defined in 36 CFR Part 800 to comply with NHPA.

USACE also protects archaeological resources that are at least 100 years old from vandalism and unauthorized collection by complying with the Archaeological Resources Protection Act. The Native American Graves Protection and Repatriation Act also directs USACE to identify and protect Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony of any age that are under Federal management and to return them to lineal descendants.

> USACE Engineering Regulations 1130-2-540, *Cultural Resources Management*, guides how the agency complies with NHPA, Archaeological Resources Protection Act, and the Native American Graves Protection and Repatriation Act.

3.21.4 Environmental Consequences

This section discusses the potential direct, indirect, and climate change effects of the alternatives related to cultural resources. Cultural resources effects are analyzed as impacts to archaeological sites and built resources in the historic districts under each alternative. The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

As noted in Section 3.21.1.5, Cultural Resources Documentation in the Analysis Area, to date, there are no identified traditional cultural properties or historic properties of religious and cultural significance to Indian tribes documented in the 13 dam and reservoir areas. Consequently, the analyses of effects do not address traditional cultural properties or historic properties of religious and cultural significance to Indian tribes.

Additional detail supporting the action alternatives analyses are in Appendix T, Cultural Resources Effects Analyses.

3.21.4.1 Methodology

Overview

The methodology used to determine potential effects to cultural resources and the nature of those effects are discussed below by resource type, including archaeological sites and built resources in the historic districts.

In the WVS, archaeological sites are most vulnerable to surface exposure and to erosion that destroys the physical integrity of sites and exposes artifacts to humans who may illegally collect artifacts or vandalize sites. Public use of the 13 reservoirs occurs year-round, and it is a long-standing pastime for people to visit the reservoirs when reservoir beds are exposed and to partake in unauthorized collection of artifacts.

Built resources are most vulnerable to physical modifications of existing infrastructure that change aspects of contributing elements that are part of its historic fabric and make it eligible for listing in the National Register of Historic Places. The addition of new structures can introduce incompatible elements that degrade the aesthetic of historic districts.

Surveys

USACE does not have a comprehensive or nuanced understanding of contemporary archaeological resource conditions. Sixty-two percent (287 resources) were recorded between 20 and 60 years ago, while 66 percent (306 resources) were recorded more than 5 years ago. Assessment of site condition has been anecdotal, inconsistent, and irregular; USACE has not systematically studied rates of site erosion or exposure in the WVS. This lack of information limits the ability of USACE to understand how site integrity has changed over time, how impacts are differentially affecting sites, or even the proportions of resources that are in poor or stable condition.

Between 1953 and 2022, USACE cultural resource specialists conducted numerous surveys within the footprint of the 13 WVS dams and reservoirs to document cultural resources of the upper Willamette Valley. Results of these surveys and related resource forms allow for a quantitative component of analysis.

The 465-mile riverine setting downstream of the WVS has been differentially managed and surveyed over many decades by numerous Federal, state, tribal, municipal, and county land managers, and private owners. The areas downstream of the 13 dams are not USACE-managed. Consequently, there is no efficient way to obtain related resource data that would allow for a quantitative analysis of impacts under each of the alternatives.

USACE maintains inventory data related to revetments in the Willamette River Basin that allow for quantitative analysis. Cultural resources are highly susceptible to unauthorized excavation and collection, and as a result, analyses of cultural resources are necessarily broad; quantitative results are averaged and aggregated.

Qualitative and Quantitative Analyses

The cultural resources effects analysis includes qualitative discussions of how activities under alternatives would directly impact a resource type (e.g., erosion, exposure, modification, etc.) and quantitative analysis of the number of cultural resources that would be directly exposed to an action by alternative.

The extent of exposure of inundated archaeological resources was modeled to compare effects across alternatives. The analyses required two variables: (1) the period of exposure, or the number of days that a portion of the reservoir would be exposed, and (2) the area of the archaeological resources. Archaeological resources can vary greatly in size, from isolated features covering just a few feet to large linear features that stretch for miles.

One way to combine these two variables (time and area) for comparison purposes is to multiply the acreage of archaeological resources in a reservoir by the number days that those acres would be exposed, or an "acre-day" over the course of 1 water year. A single acre-day is the amount of exposure created when an archaeological site covering 1 acre is exposed for 1 day. In the same way, a half-acre site exposed for 2 days would also be 1 acre-day of exposure. Ten acres of archaeological site exposed for 10 days would be 100 acre-days, etc. Additional methodology detail is provided in Appendix T, Cultural Resources Effects Analyses.

Measures with Effects to Cultural Resources under Each Alternative

Operational measures (as opposed to structural measures) would occur under all alternatives, which may adversely affect cultural resources. Although specific measure implementation would vary by alternative, they would be large in scale and would continuously and directly affect many cultural resources, most notably several hundred archaeological sites, throughout an entire reservoir and across several reservoir projects throughout the 30-year implementation timeframe (Table 3.21-4). Impacts from operational measures to archaeological sites would be permanent and, therefore, would extend well beyond 30 years.

Table 3.21-4. Measures that Would Cause Adverse Effects to Archaeological Sites.

Measure Number	Measure Description	Reservoir Elevation Change	Deep Drawdown	Notes
721	Use spillway for surface spill in summer	Yes	No	Assumes water levels higher than spillway crest to implement.
30a	Integrated temperature and habitat flow regime	Yes	No	Flows (and elevations) are based on fullness of reservoir on June 1.
30b	Refined Integrated temperature and habitat flow regime	Yes	No	
304	Augment instream flows by using the power pool	Yes	No	Can draft to minimum power pool.
718	Augment instream flows by using the inactive pool	Yes	No	Can draft to 10 feet above regulating outlets.
723	Reduce minimum flows to Congressionally authorized minimum flow requirements	See text in Notes column	No	Reduction in flows would support ability to maintain the rule curve, more stable elevation changes.
40	Deeper fall reservoir drawdowns for downstream fish passage	Yes	Yes	Target elevation 25 feet above regulating outlets

Measure Number	Measure Description	Reservoir Elevation Change	Deep Drawdown	Notes
714	Pass water over spillway in spring for downstream fish passage	Yes	No	All flows to go over the spillway when greater than 25 feet over the spillway
720	Deep spring reservoir drawdown to regulating outlet (to diversion tunnel at Cougar Dam under Alternatives 2B and 3B) for downstream fish passage	Yes	Yes	Target elevation 25 feet above regulating outlets

Several structural measures are proposed under the action alternatives that have the potential to affect the built environment of the 13 historic districts in the WVS (Table 3.21-5). These include small and large modifications to existing infrastructure to constructing new buildings and facilities to support upstream and downstream fish passage. When assessing potential effects to built resources, the permanence of the action must be considered as well as if the changes would occur to resources contributing to historic districts and the overall effect to the historic fabric of the district itself.

Table 3.21-5. Measures that Would Cause Adverse Effects to Built Resources.

Measure Number	Measure Description	Add New Structures	Modify Existing Structure	Notes
105	Construct water temperature control tower	Yes	No	Modifies the character of resource type and overall aesthetic of a historic district.
174	Structural improvements to reduce TDG	No	Yes	Modifies internal of minor external components/aspects that do not impact the overall character of a resource type or aesthetic of a historic district.
479	Foster Dam fish ladder improvement	No	Yes	Modifies the character of resource type and overall aesthetic of a historic district.
392	Construct structural downstream fish passage	Yes	Yes	Modifies the character of resource type and overall aesthetic of a historic district.
52	Provide Pacific lamprey infrastructure	Yes	Yes	Modifies the character of resource type and overall aesthetic of a historic district.

Measure Number	Measure Description	Add New Structures	Modify Existing Structure	Notes
639	Restore upstream and downstream passage at drop structures	Yes	Yes	Modifies the character of resource type and overall aesthetic of a historic district.
722	Construct adult fish facility	Yes	Yes	Modifies the character of resource type and overall aesthetic of a historic district.
726	Maintenance of existing and new fish release sites above dams	Yes	Yes	Assumes site-specific addition or modification that does not or is less likely to impact the overall character of a resource type or aesthetic of a historic district.
9	Maintain bank protection structures using nature-based engineering or alter revetments for aquatic ecosystem restoration	N/A	N/A	Unknown effects. Outside of the 13 historic districts, but historic in age, requires inventory and evaluation.

N/A = not applicable

Due to the longevity and widescale nature of these operational measures and the overarching WVS flood risk management mission, which requires activities that affect large numbers of documented archaeological sites, the evaluation criteria to assess potential effects to cultural resources is best understood holistically and by the proportion of the known population that would be affected. The criteria for evaluating the potential impacts under each alternative address effects at the population level and by cultural resource type (archaeology and built resources).

The cultural effects criteria and a summary of effects are provided in Table 3.21-6 and Table 3.21-7, respectively. Additionally, the percentages of the WVS archaeological sites and historic districts that would be adversely affected under the alternatives are presented in Table 3.21-8 and Table 3.21-9, respectively.

Table 3.21-6. Archaeological Site and Built Environment Resources Effects Criteria.

Degree of Adverse or Beneficial Effect	Criteria
Negligible/None	• Adverse or beneficial effects would occur to zero or a limited number of each resource type (archaeological sites or built resources) and would be a limited proportion of all known instances of that resource type by reservoir (less than 1 percent). • There would be no or only a negligible impact to the population of a known cultural resource type in the WVS. • Effects would not be demonstrable at the local or basin level. • For archaeological resources, any damage would be permanent but apply to less than 1 percent of WVS archaeological resources. • For built resources, these changes would be short-term and easily reversible or would result in no change to current conditions. Any internal changes would not be noticeable on the external face of a resource.
Minor	• Adverse or beneficial effects would occur to a small number of each resource type (archaeological sites or built resources) and would be a small proportion of all known instances of that resource type by reservoir (1.1 to 5 percent). • The impact to the population of a known cultural resource type in the WVS would be minor. • Effects would be demonstrable at the local or basin level. • For archaeological resources, any damage would be permanent but would apply to 1.1 to 5 percent of WVS archaeological resources. • For built resources, these impacts would be short-term, or if longer-term, easily reversible. Changes (internal or external) would not alter the aesthetic of the resource type and/or historic district.
Moderate	• Adverse or beneficial effects would occur to many of each resource type (archaeological sites or built resources) and would be a greater proportion of all known instances of that resource type by reservoir (5.1 to 10 percent).

Degree of Adverse or Beneficial Effect	Criteria
	• The impact to the known population of the cultural resource type in the WVS would be moderate. • Effects would be demonstrable at the local or basin level. • For archaeological resources, any damage would be permanent but would apply to 5.1 to 10 percent of WVS archaeological resources. • For built resources, these impacts would be long-term but potentially reversible. Changes (internal or external) would alter the aesthetic of the resource type and/or historic district.
Major	• Adverse or beneficial effects would occur to a high proportion of each resource type (archaeological sites or built resources) by reservoir (greater than 10 percent). • Effects to the population of known instances of that cultural resource type in the WVS would be major. • Effects would be demonstrable at the local or basin level. • If effects are adverse, these impacts would be permanent and irreversible. For archaeological resources, any damage would be permanent but would apply to more than 10 percent of WVS archaeological resources. • In the case of built resources, effects would be long-term and could be reversible but would require substantial resources to revert to prior conditions. Changes (internal or external) would alter the aesthetic of the resource type and/or historic district. • If effects are beneficial, they would result in rehabilitation to original conditions or stabilization that stops future degradation to the resource. Stabilization could be applicable to archaeological sites and built resources.

Table 3.21-7. Summary of Effects to Cultural Resources as Compared to the No-action Alternative.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Annual drawdowns and refill that would erode physical integrity of archaeological sites in reservoirs and expose them to unauthorized collection by the public.	Major, adverse effects at all reservoirs, except Big Cliff and Dexter Reservoirs.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Deep drawdowns that would increase erosion and exposure of archaeological sites in reservoirs.	Major, adverse effect at Fall Creek Reservoir.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Major, adverse effects at Lookout Point, Fall Creek, Hills Creek, Cougar, Blue River, Green Peter, Detroit Reservoirs.	Major, adverse effects at Lookout Point, Fall Creek, Hills Creek, Cougar, Blue River, Green Peter, Detroit Reservoirs.	Same as No-action Alternative.	Major adverse effects at Fall Creek, Cougar, Green Peter Reservoirs.
Modify existing or build new structures that would change the aesthetic of a resource type or historic district.	None	Moderate to major, adverse effects at Fern Ridge, Dexter, Lookout Point, Foster Green Peter Detroit Reservoirs.	Moderate to major, adverse effects at Dexter, Lookout Point, Cougar Foster, Green Peter, Detroit Reservoirs.	Moderate to major, adverse effects at Dexter, Lookout Point, Cougar Foster, Green Peter, Detroit Reservoirs.	Moderate to major, adverse effects at Hills Creek, Cougar, Blue River, Green Peter Reservoirs.	Moderate to major, adverse effects at Hills Creek, Cougar, Blue River, Green Peter Reservoirs.	Moderate to major, adverse effects at Dexter, Lookout Point, Hills Creek, Cougar Foster, Big Cliff Detroit Reservoirs.	Moderate to major, adverse effects at Dexter, Lookout Point, Cougar, Foster, Green Peter, Detroit Reservoirs.

Table 3.21-8. Percent of Willamette Valley System Archaeological Sites that Would Be Adversely Affected under All Alternatives.

	NAA	Alt 1	Alt 2A	Alt 2B	Alt 3A	Alt 3B	Alt 4	Alt 5
Percent of Sites (%)	80	80	80	80	80	80	80	80

Table 3.21-9. Percent of Willamette Valley System Historic Districts that would be Adversely Affected under All Alternatives.

	NAA	Alt1	Alt 2A	Alt 2B	Alt 3A	Alt 3B	Alt 4	Alt 5
Percent of Districts (%)	0	46	46	46	31	31	54	46

3.21.4.2 Alternatives Analyses

No-action Alternative

Archaeological Sites

Under the NAA, annual draft and fill of the WVS, which causes erosion to landforms and archaeological sites, would continue to occur. Of the 461 archaeological sites documented at the WVS, 369 (80 percent) are located in or adjacent to reservoir environments and would be at risk of adverse impacts under the NAA.

The NAA would result in direct adverse effects because 164,109 acre-days of archaeological site exposure would continue to occur across 11 of the 13 reservoirs that would experience water level elevation change in a water year (Big Cliff and Dexter Reservoirs would maintain high elevations and, therefore, would not likely contribute to archaeological site exposure risk). This system-wide exposure extent combined with indirect adverse effects described below would result in major adverse impacts within the analysis area. Impacts to archaeological sites would be long-term and WVS-wide.

During draft and fill cycles under the NAA, archaeological sites located within 3 feet of the drawdown elevation (either above or below the elevation line) would be exposed to wind and resulting wave action that would cut into soils and disturb archaeological materials contained in the soils. Reservoir soils would be routinely desaturated and then inundated and as a result would not have much if any stabilizing vegetation cover. These unprotected soils would subsequently be susceptible to various forms of erosion (Appendix C, River Mechanics and Geomorphology; Section 3.4, Geology). Combined, these routine changes in reservoir elevation resulting in sediment movement, particle sorting, and removal of fine-grained sediments would slowly deflate archaeological sites and expose archaeological materials to the surface of the reservoir beds under the NAA.

WVS archaeological resources have been experiencing this cyclical inundation and exposure for 5 to 8 decades, depending on the reservoir. This has resulted in noticeable erosion and exposure damage to all resources known to be present in the reservoirs. Additional adverse effects may occur to archeological sites that are not yet surveyed and documented (Section 3.21.4.1, Methodology, Surveys). Under the NAA, a fall deep drawdown would occur at Fall Creek Reservoir, which would increase exposure and erosion of archaeological sites.

Indirect adverse effects under the NAA would include public-induced effects. The public consistently recreates at the reservoirs when water levels are low, and it is a common pastime to partake in unauthorized artifact collection within the WVS. Additionally, the public would likely knowingly or unknowingly dig into and damage the physical integrity of archaeological sites through unauthorized recreation that occurs at the reservoirs (e.g., driving vehicles, rockhounding, or metal detecting in the reservoirs) under NAA conditions.

The cycle of erosion and exposure is well known, and law enforcement officers increase patrols of reservoirs during drawdowns after a heavy rainfall specifically because the rains would have washed away more soils and exposed artifacts. Unauthorized collection has been documented at all 13 WVS dams and reservoirs.

Downstream archaeological sites would benefit from continued flood risk operations of the WVS because current operations reduce flooding risk. Archaeological sites would not be destabilized or eroded because USACE would manage downstream water flows to stay within channel capacity. The beneficial effects would be major, long-term, and basin-wide.

Routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation). Maintenance activities would have the potential to cause direct effects to archaeological sites through ground disturbance and staging of equipment or short-term reservoir elevation changes that would cause erosion and exposure of archaeological resources. Information on possible maintenance projects is not available at this time; site-specific analyses would be conducted to identify potential impacts to archaeological resources.

Built Resources

No new construction or modification to the 13 historic districts would occur under the NAA and, therefore, is not anticipated to have adverse effects to the historic WVS (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation). Routine scheduled and unscheduled maintenance would have direct adverse effects to built resources if a modification of character-defining aspects of a structure or the historic district were implemented. Information on possible maintenance projects was not available when the alternatives were analyzed. Site-specific analyses would be conducted to identify potential impacts to built resources of the WVS historic districts as proposed projects are designed.

Alternative 1—Improve Fish Passage through Storage-focused Measures

Archaeological Sites

Adverse and beneficial effects anticipated under Alternative 1 within the analysis area would be the same as those described under the NAA. These effects would be major, long-term, and basin-wide. However, while major adverse effects would continue to occur to archaeological sites from system-wide reservoir exposure and the deep drawdown at Fall Creek, there would be a slight beneficial effect under Alternative 1 because of fewer acre-days of site exposure as compared to the NAA (Appendix T, Cultural Resources Effects Analyses).

Alternative 1 would include implementation of Measure 723, which would reduce minimum flows to Congressionally authorized minimum flow requirements at all of the reservoirs except Dexter, Foster, and Big Cliff. This operation would likely result in minor, short-term benefits to archaeological resources on a system-wide level because more water would be stored than under the NAA with a higher likelihood of following the rule curve in a consistent pattern. Specifically, there would be an expected system-wide 3 percent decrease in acre-days of site exposure between the NAA (164,109 acre-days) and Alternative 1 (158,734 acre-days).

Indirect adverse effects from public disturbance to archaeological sites under Alternative 1 would be the same as those described under the NAA. Potential effects to archaeological sites from routine scheduled and unscheduled maintenance would also be the same as those described under the NAA.

Built Resources

Operations under Alternative 1 have the potential to cause moderate to major adverse effects to 6 of the 13 historic districts (or 46 percent) because several measures would involve substantial modifications to infrastructure in historic districts that would be extremely difficult or impossible to revert to their original condition. Routine scheduled and unscheduled maintenance would have the potential to cause the same adverse effects to built resources of the WVS historic districts as those described under the NAA.

Alternative 2A—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Archaeological Sites

As under the NAA, major adverse effects would be expected to archeological sites under Alternative 2A. Moreover, these adverse effects would be more substantial than under the NAA. These effects would be major, long-term, and basin-wide.

Implementation of Measure 40 under Alternative 2A would result in a deeper fall reservoir drawdown at Green Peter Reservoir (780 feet) and at Fall Creek Reservoir. In contrast, under the NAA, operations would include a deep drawdown only at Fall Creek Reservoir. Deep fall drawdowns would increase erosion and site exposure at Green Peter and Fall Creek Reservoirs.

Consequently, a greater number of documented archaeological sites would be subject to increased site exposure risk from erosion than under the NAA.

Alternative 2A would include implementation of integrated temperature and habitat flow Measure 30a, which would minimally alter reservoir elevations system wide. Under Alternative 2A, there would be a 2 percent increase in reservoir exposure when compared to the NAA.

However, some operations would result in increases in acre-days of site exposure while others would result in decreased acre-days (Appendix T, Cultural Resources Effects Analyses). For example, operations at Green Peter Reservoir would result in major adverse effects to archaeological sites because of a 16 percent increase in acre-day site exposure compared to the NAA. Conversely, operations at Hills Creek Reservoir would result in major beneficial effects from a 12 percent decrease in acre-days of archaeological site exposure. Under Alternative 2A, these two operations represent the high and low margins of exposure risk among all analysis area reservoirs.

Overall, however, there would continue to be major adverse effects to archaeological sites under Alternative 2A as compared to the NAA. Indirect adverse effects from public disturbance to archaeological sites under Alternative 2A would be the same as those described under the NAA.

Potential effects to archaeological sites from routine scheduled and unscheduled maintenance would also be the same as those described under the NAA.

Built Resources

Operations under Alternative 2A have the potential to cause moderate to major effects to 6 of the 13 historic districts (or 46 percent) because proposed changes have the potential to substantially modify character-defining features of the WVS historic districts. Effects to built resources would be long-term to permanent and system-wide.

Potential effects to built resources due to routine scheduled and unscheduled maintenance would also be the same as those described under the NAA.

Alternative 2B—Integrated Water Management Flexibility and ESA-listed Fish Alternative

Archaeological Sites

As under the NAA, major adverse effects would be expected to archeological sites under Alternative 2B. Moreover, these adverse effects would be more substantial than under the NAA. These effects would be major, long-term, and WVS-wide.

There would be an increase in the number of reservoirs operated for deep drawdowns under Alternative 2B as compared to NAA operations from one under the NAA to three reservoirs under Alternative 2B. This would result in more system-wide adverse effects under Alternative 2B than under the NAA.

Operations under Alternative 2B would include a deep spring reservoir drawdown from Measure 720 implementation, and deep fall reservoir drawdowns from Measure 40 implementation at Fall Creek Reservoir (690 feet), Cougar Reservoir (1,330 feet), and Green Peter Reservoir (780 feet). Additionally, structural measures would be implemented at Lookout Point, Foster, and Detroit Dams to facilitate downstream fish passage. As described with Alternative 2A, deep drawdowns and construction activities would adversely impact archaeological sites from erosion, exposure, and disturbance.

Furthermore, portions of Cougar Reservoir are exceedingly steeply sloped and experience several forms of sheet erosion and mass wasting events during routine drafting. Consequently, deep drawdowns in the fall and spring would have major impacts to reservoir slope stability and subsequently to archaeological sites present. Operations at Cougar Reservoir would include two cycles of draft and fill in one water year, which would double impacts to archaeological sites compared to impacts that would occur under the NAA.

Under Alternative 2B, there would be a 4 percent increase in reservoir exposure when compared to the NAA. Operations would substantially lengthen the amount of time that sites at Cougar and Green Peter Reservoirs would be exposed to the indirect effect of human-induced impacts (Appendix T, Cultural Resources Effects Analyses). Specifically, the length of exposure time at Cougar Reservoir would be increased to 22 percent, Green Peter Reservoir to 16 percent, and Lookout Point and Detroit Reservoirs to 6 percent as compared to NAA exposure times. Cougar and Green Peter Reservoirs experience high volumes of recreationalists when roads are passable and not snowed in; consequently, unauthorized artifact collection would likely increase during peak recreation seasons in these reservoirs.

Built Resources

Operations under Alternative 2A have the potential to cause moderate to major effects to 6 of the 13 historic districts (or 46 percent) because proposed changes have the potential to substantially modify character-defining features of the WVS historic districts. Effects to built resources would be long-term to permanent and system-wide. Effects to built resources due to routine scheduled and unscheduled maintenance would be the same as those described under the NAA.

Alternative 3A—Improve Fish Passage through Operations-focused Measures

Archaeological Sites

Operations under Alterative 3A would deviate substantially from NAA operations with a subsequent increase in potential adverse impacts to archaeological resources. Moreover, these adverse effects would be more substantial than under the NAA. These effects would be major, long-term, and WVS-wide.

Under Alternative 3A, deeper fall reservoir drawdowns under Measure 40 would occur in seven reservoirs compared to one reservoir under NAA operations, including Fall Creek (690 feet), Blue River (1,165 feet), Hills Creek (1,446 feet), Green Peter (780 feet), Detroit (1,375 feet), Lookout Point (761 feet), and Cougar (1,517 feet) Reservoirs. Spring reservoir drawdowns under Measure 720 would occur at Detroit, Lookout Point, and Cougar Reservoirs (to the same elevations as Measure 40).

Under Alternative 3A, accelerated erosion would impact slope stability and the archaeological sites present at each of these reservoirs, but at a much larger scale than under the NAA. Over 50 percent of reservoirs and associated archaeological sites would be vulnerable to increased erosion from the fall deep drawdowns, and nearly 25 percent of reservoirs would experience additional erosion by doubling the cycle of draft and fill that would occur in one water year.

Unique to Alternative 3A, there would be a 44 percent increase in site exposure from exposures under the NAA in the analysis area (Appendix T, Cultural Resources Effects Analyses). Consequently, adverse effects to archaeological sites at the seven reservoirs would be substantially high because operations under Alternative 3A would greatly lengthen the amount of time that sites at Detroit, Lookout Point, Cougar, Green Peter, and Hills Creek Reservoirs would be exposed to indirect effects of human-induced impacts. High volumes of recreation and known unauthorized collection issues occur at each reservoir. It is anticipated that unauthorized artifact collection would increase in the spring and fall.

Built Resources

Alternative 3A has the potential to cause moderate to major effects to 4 of the 13 historic districts (31 percent) because proposed changes have the potential to substantially modify character-defining features of the WVS historic districts. Effects to built resources would be long-term to permanent and system-wide. Effects to built resources due to routine scheduled and unscheduled maintenance would be the same as those described under the NAA.

Alternative 3B—Improve Fish Passage through Operations-focused Measures

Archaeological Sites

Effects to archaeological sites under Alternative 3B would be nearly the same as those described under Alternative 3A. Under Alternative 3B, there would be a 31 percent increase in site exposure from exposures under the NAA in the analysis area as compared to 44 percent under Alternative 3A.

Operations under Alternative 3B would be the same as under Alternative 3A except that the fall deep drawdown at Cougar Reservoir would pass through a diversion tunnel. Also, spring reservoir drawdowns under Measure 720 would occur at two different reservoirs than those proposed under Alternative 3A and would include operations at Hills Creek, Cougar, and Green Peter Reservoirs. As under Alternative 3A, accelerated erosion would impact slope stability and the archaeological sites present in the reservoirs, at a similar scale, but with slightly different locations during the spring.

Operations under Alternative 3B would also greatly lengthen the amount of time of site exposure at Detroit, Foster, Hills Creek, Cougar, Lookout Point, and Green Peter Reservoirs (Appendix T, Cultural Resources Effects Analyses). This would result in indirect adverse effects to archeological sites because of lengthened exposure for human-induced disturbance. Unauthorized artifact collection would increase from adverse levels under the NAA in the spring and fall at these reservoirs.

Unauthorized collection would continue in Fall Creek Reservoir during the deep fall drawdown; however, site exposure would remain unchanged from exposure under the NAA. There would be a minor increase in site exposure days at Blue Creek Reservoir (3 percent) with subsequent increases in unauthorized artifact collection. Conversely, there would not be an increase in exposure days in Cottage Grove and Fern Ridge Reservoirs and therefore no increased opportunities for unauthorized collection under Alternative 3B as compared to the NAA.

Built Resources

Alternative 3B has the potential to cause moderate to major effects to 4 of the 13 historic districts (31 percent) because proposed changes have the potential to substantially modify character-defining features of the WVS historic districts. Effects to built resources would be long-term to permanent and system-wide. Effects to built resources due to routine scheduled and unscheduled maintenance would be the same as those described under the NAA.

Alternative 4—Improve Fish Passage with Structures-based Approach

Archaeological Sites

Adverse and beneficial effects anticipated under Alternative 4 within the analysis area would be the same as those described under the NAA. These effects would be major, long-term, and WVS-wide. However, while major adverse effects would continue to occur to archaeological sites from reservoir exposure, there would be a slight beneficial effect under Alternative 4 because of fewer acre-days of site exposure as compared to the NAA (Appendix T, Cultural Resources Effects Analyses). Further, additional deep drawdowns beyond those at Fall Creek Reservoir would not occur under Alternative 4. However, more structure-based measures to accomplish downstream fish passage would occur under Alternative 4 than under the NAA.

Operations under Alternative 4 would result in a minor increase in system-wide site exposure of 3 percent as compared to the NAA. The most impacted reservoirs would be Detroit (6 percent) and Green Peter (17 percent) Reservoirs. There would be either negligible or minor adverse or beneficial changes in site exposure from the NAA at all other reservoirs (Appendix T, Cultural Resources Effects Analyses). Although there would be minor increases in exposures, unauthorized artifact collection would continue to be a major adverse, indirect effect on archeological sites at these reservoirs as under the NAA.

Built Resources

Alternative 4 would result in the highest percent of adversely impacted historic districts of all alternatives. Operations under Alternative 4 have the potential to cause moderate to major effects to 7 of the 13 historic districts (54 percent) that would be long-term and WVS-wide. Proposed changes have the potential to substantially modify character-defining features of the WVS historic districts. Effects to built resources would be long-term to permanent and system-wide. Effects to built resources due to routine scheduled and unscheduled maintenance would be the same as those described under the NAA.

Alternative 5—Preferred Alternative—Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Archaeological Sites

Effects to archaeological sites under Alternative 5 would be nearly the same as those described under Alternative 2B. These effects would be major, long-term, and WVS-wide.

Under Alternative 2B and Alternative 5, there would be a 4 percent increase in site exposure from exposure under the NAA. Operations under Alternative 5 would be similar to those under Alternative 2B, except there would also be a deeper fall drawdown at Fall Creek Reservoir with implementation of Measure 40 under Alternative 5. The deeper Fall Creek drawdown would contribute to adverse effects as compared to the NAA and to Alternative 2B by increasing archaeologic site exposure in the analysis area.

Indirect effects from human-induced site disturbance under Alternative 5 would be the same as those described under Alternative 2B. Under Alternative 5, adverse effects to archaeological sites at Cougar, Fall Creek, and Green Peter Reservoirs would be substantially high.

Built Resources

Effects to historic districts in the analysis area under Alternative 5 would be the same as those described under Alternative 2B.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

3.21.5 Effects to Downstream Cultural Resources under All Alternatives

USACE flood data indicates that the WVS has substantially reduced flooding along the 465 river miles that are downstream of the WVS (Section 3.2, Hydrological Processes). Levees, revetments, and other modifications have been placed downstream specifically to reduce flooding throughout the system where there are human populations and agricultural lands.

All alternatives would continue to meet flood risk management authorizations (Chapter 1, Introduction, Section 1.10, Congressionally Authorized Purposes). Consequently, cultural resources downstream of the WVS dams would be beneficially affected by the continued operation of the WVS under all alternatives and to the adherence to operations that reduce flood risk and maintain water discharge that remains within channel capacity. While operations under all alternatives including the NAA would generally support site stabilization rather than erosion, the number of downstream archaeological resources and built resources is unknown, and the benefits are not quantifiable.

3.21.6 Interim Operations under All Action Alternatives Except Alternative 1

The timing and duration of Interim Operations would vary depending on a given alternative. Interim operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations will be implemented in succession with, and not in addition to, action alternative implementation.

Major and long-term adverse impacts to archaeological sites under the Interim Operations would be the same under all action alternatives (except Alternative 1) because of the erosion effect of any drawdown and associated site exposure risks. Operations that focus on deep drawdowns, earlier drawdown, and delayed refills for downstream fish passage would greatly increase the erosion and exposure of archaeological sites at the reservoir level, which would be a continuation of major adverse effects under the NAA.

Archaeological resources would continue to steadily degrade with routine draft and fill operations. Delayed fills and early seasonal drawdowns would extend the length of time that most of the reservoir bed is exposed outside of the storage season (Table 3.21-10).

END NEW TEXT

Table 3.21-10. Interim Operations that Would Cause Adverse Effects to Archaeological Sites.

Reservoir	Operation	Reservoir Elevation Change	Deep Drawdown
Green Peter	Utilize spillway for improved downstream fish passage in the spring; perform spill operation until May 1 or for 30 days, whichever is longer.	Yes	No
Green Peter	Deep drawdown and regulating outlet prioritization for improved downstream fish passage.	Yes	Yes

Reservoir	Operation	Reservoir Elevation Change	Deep Drawdown
Foster	Earlier fall drawdown to reach 620 to 625 feet by October 1.	Yes	No
Foster	Delay refill and utilize spillway in the spring for improved downstream fish passage.	Yes	No
Cougar	Deep drawdown and regulating outlet prioritization for improved downstream fish passage.	Yes	Yes
Cougar	Delayed reservoir refill and regulating outlet prioritization for improved downstream fish passage.	Yes	No
Lookout Point	Deep drawdown and regulating outlet prioritization for improved downstream fish passage.	Yes	Yes
Lookout Point	Utilize spillway for improved downstream fish passage in the spring.	Yes	No

*Some aspects of this operation would not have adverse effects to archaeological sites.

Indirect adverse effects from public disturbance to archaeological sites under any of the action alternatives would be the same as those described under the NAA.

It is probable that within 15 years, the majority of sites that are present in the Green Peter, Foster, Cougar, and Lookout Point Reservoirs would be mostly or completely destroyed due to activities that directly cause erosion and exposure and indirectly cause unauthorized collection. However, in comparison to Interim Operations under most action alternatives, fewer sites would be adversely affected during implementation of spring measures under Alternative 1 than when other seasonal deep drawdowns and delayed refills occur. Planned fills in the spring would be controlled and would be kept at steady elevations as much as possible, resulting in infrequent or short-lived fluctuations in water elevation (which would increase site erosion within a narrow elevation range). Stable water elevations would minimize archaeological site exposures during the spring operations period under Alternative 1.

None of the Interim Operations Measures are structural; therefore, they would have no effect to the built resources of the analysis area.

3.21.7 Climate Change under All Alternatives

Climate change would continue to increase adverse impacts to cultural resources under all alternatives due to more winter rainfall that erodes exposed reservoir beds and would expose archaeological materials for unauthorized collection (Warner et al. 2015) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.5, Changes in Winter Atmospheric

Rivers; Appendix F2, Supplemental Climate Change Information, Section 3.1.2, Precipitation). Warmer weather in the summer and limited water would also expose sites higher in the elevation pools that would allow people access for unauthorized collection from those sites (Fourth Annual Climate Change Assessment 2018) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.1.2, Fourth National Climate Assessment; Appendix F2, Supplemental Climate Change Information, Section 3.1.1, Temperature).

Specific anticipated effects on archaeological resources from the alternatives include the following:

Impacts under the NAA and Alternative 4 would be the same, with continuation of major adverse effects to archaeological sites exacerbated by climate change conditions and responsive operations causing continued slope erosion and site exposure.

Under Alternative 1, more water would be retained at the reservoirs from implementation of Measure 723 as compared to the NAA, which would potentially reduce shifts in reservoir elevations that can affect archaeological resources. An estimated 3 percent decrease in site exposure under Alternative 1 may indicate continued slight benefits in the WVS in relation to continued climate change effects over the 30-year implementation timeframe.

Reservoir elevations may fluctuate to meet integrated temperature and habitat flow targets under Alternative 2A with increasingly hotter and drier summers. Consequently, this would increase the risk of archaeological site exposure during the 30-year implementation timeframe.

Archaeological sites would continue to degrade under Alternative 2B and Alternative 5 in combination with climate change conditions and associated reservoir operations. However, sites at Cougar, Fall Creek, and Green Peter Reservoirs would likely degrade from erosion and exposure at an accelerated rate as compared to the NAA. Cougar Reservoir slopes would experience substantial erosion resulting from two draft and fill cycles within a given water year in addition to potential operational adjustments for climate change effects.

Under Alternative 3A and Alternative 3B, archaeological sites may be entirely eroded in the seven reservoirs that experience deep drawdowns. Sites may be fully eroded at Detroit, Cougar, and Lookout Reservoirs within 10 to 15 years because of spring and fall deep drawdowns and double the draft and fill cycles as compared to the NAA. Responses to operations for climate change-related management would not improve this outcome.

Under Alternative 3B, climate change would further exacerbate adverse effects to archaeological sites, specifically in reservoirs that would experience spring and/or fall deep drawdowns. Low reservoir elevations in the spring would likely continue into summer, resulting in exposed and accessible reservoir beds. If target summer elevations are met under Alternative 3B, deep fall drawdowns would impact vulnerable slopes and give way to heavy winter rains that continue to erode and degrade reservoir landforms and archaeological sites as compared to the NAA.

Downstream archaeological sites and built resources could be adversely affected by climate change due to increased winter rainfall that might result in bank erosion.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

3.21.8 Mitigating Adverse Effects to Cultural Resources

The annual draft and fill cycle of the WVS common among all alternatives would have cyclical, incremental, and permanent major adverse effects to 80 percent of documented archaeological sites that are present in the WVS (Table 3.21-8). The spring and/or fall deep drawdowns would also have adverse effects to archaeological resources in reservoirs and would accelerate erosion and exposure already caused by the annual draft and fill cycle. Among the action alternatives, a deep drawdown would occur at one or more reservoirs, although the locations and timing would vary.

For built resources, moderate to major long-term adverse effects would occur to between 31 percent and 54 percent of WVS historic districts among all alternatives with the exception of the NAA (Table 3.21-9). Operations under the NAA would not include any structural measures that would modify the WVS historic districts.

Effects to traditional cultural properties and historic properties of religious and cultural significance to Indian tribes were beyond the scope of this analysis due to data gaps (see Section 3.24, Tribal Resources, for a related discussion).

In general, the degree of long-term and permanent adverse impacts to archaeological sites and to built resources would be major. USACE collaborated with Federal, state, and tribal partners and interested parties to draft the WVS Agreement and then a Management Plan to act as a guide for future USACE historic properties management (Section 3.21.3, Federal Laws and U.S. Army Corps of Engineers Regulations). The Management Plan outlines current efforts by USACE to meet its Section 106 NHPA responsibilities, including the system-wide site condition assessment and six-reservoir testing efforts and future efforts that the agency could take to resolve adverse effects. The Management Plan is designed as a living document that can be updated to include defined steps that consulting parties may agree on to resolve any adverse effects (see Agreement Stipulation XVI Amendments).

Potential options to address adverse effects could include the following:

- Implement standard mitigation measures included in the Management Plan that would comprehensively document and foster widespread outreach regarding any built resources that would be adversely affected by activities implemented under the alternatives. These measures could be site-specific or implemented programmatically across the WVS historic districts. Mitigation measure options include photo documentation for character-defining features, photo documentation for contributing resources, interpretative panel installation, national register nomination, or property preservation.

- Implement aspects of the unauthorized collection prevention strategy. This could include creating and disseminating educational materials; conducting outreach to the public on heritage preservation and conservation ethics; implementing a signage program at recreation sites and access points throughout the WVS; coordinating with Federal, state, and tribal partners and special interest groups to develop site stewardship programs.
- Implement an archeological site testing program to identify sites retaining intact subsurface deposits. This could be paired with stabilizing archaeological sites and/or reservoir banks to halt ongoing or predicted near-future erosion of cultural resources. This could also be paired with a data recovery program to salvage data from sites that are low in the reservoir and cannot be stabilized.
- Develop a research program targeted to archaeological resources in reservoir environments. Focus on methods other than excavation to address USACE management needs, Willamette Valley archaeological topics, and/or tribally developed research interests.
- Work with tribal partners to continue identifying traditional cultural properties/historic properties of religious and cultural significance to Indian tribes, streamline NEPA and NHPA compliance for USACE land use planning efforts to promote early and proactive engagement with tribal partners, and develop policies that maximize tribal access to traditional cultural properties/historic properties of religious and cultural significance to Indian tribes.

END NEW TEXT

US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.22 VISUAL RESOURCES

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3.22 Visual Resources

THE VISUAL RESOURCES SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **The analysis area has been defined; a detailed description of the Affected Environment has been added including visual effects from 2020 wildfires.**
- **Information on Visual Resource Management objectives has been removed. The U.S. Army Corps of Engineers does not manage under these objectives, which are U.S. Bureau of Land Management planning objectives.**
- **The visual resource inventory process has been updated to clarify how visual values and effects from maintenance activities were derived.**
- **The analyses of effects to visual resources have been modified and clarified as an effect resulting from visual contrast. Visual values are incorporated into the outcome of this effect.**
- **Additional analyses have been added to address effects from routine and non-routine maintenance activities under all alternatives and to include beneficial effects.**
- **Analyses of Scenic Quality Ratings and foreground-middle ground visibility has been added to the No-action Alternative.**
- **DEIS visitor data have been updated in the FEIS consistent with 2022 data in Section 3.14, Recreation Resources and the revised Appendix R, Visual Resources Inventory. This was the best available information at the time the alternatives were analyzed.**
- **DEIS visitor spending has been deleted in the FEIS. The amount spent by visitors at a given dam cannot be correlated to public interest, which is more accurately represented by visitor numbers. Visitor numbers are the primary metric to assess aesthetic quality impacts on viewers from alternative implementation. See Appendix R, Visual Resources Inventory, for more detail on this DEIS modification.**
- **Photographs were added depicting visual conditions during reservoir drawdowns. Photographs of dams were also added just prior to FEIS publication; they do not have figure numbers because of document development timing constraints.**
- **Additional information has been added to the climate change analysis.**

3.22.1 Introduction

Visual resources consist of all features that give a landscape its visually aesthetic qualities. This includes landforms, vegetation, water surfaces, and physical changes made by human activities. Landscape features provide viewers with an overall impression of an area; this overall impression can be referred to as the area's visual character. Visual character is encompassed within a viewshed, or the physical area seen from vantage points in the analysis area.

3.22.2 Affected Environment

The Willamette Valley System (WVS) comprises 13 existing dams and reservoirs along with hatcheries, fish facilities, revetments, and associated operational features. These existing features are only a portion of the visual qualities within the Willamette River Basin (Section 3.22.2.1, Willamette River Basin Visual Quality Context and Public Use). Other features include roads; urban areas; open, natural space; mountains; recreation sites; trails, etc.

The analysis area for the visual resources assessment includes WVS dams and reservoirs where new construction or substantial changes to reservoir water levels would occur under the alternatives, which may impact visual character. Specifically, the visual resource analysis area includes Lookout Point, Detroit, Green Peter, Hills Creek, Dexter, Cougar, Blue River, Foster, and Fall Creek Dams and Reservoirs (Figure 3.22-1). Other dams and reservoirs in the WVS would not be structurally modified under the alternatives and, therefore, no substantial changes in visual character are anticipated in comparison to existing conditions.

3.22.2.1 Willamette River Basin Visual Quality Context and Public Use

The Willamette Valley, or Willamette River Basin, is bounded by the Cascade Range to the east, the Coast Range on the west, and the Calapooya Mountains to the south. The river valley extends approximately 187 miles to the north where it flows into the Columbia River (USACE 2019a) (Figure 3.22-1). The valley consists of nearly level to gently sloping broad alluvial floodplains, scattered low hills, and adjacent mountain foothills (Morlan et al. 2010)[1].

While forested land covers approximately 70 percent of the Willamette River Basin, agricultural land accounts for approximately 22 percent of the Basin. Urban land covers approximately 6 percent of the Basin and is mostly congregated in the valley along the mainstem of the Willamette River (EPA 2013b).

Since the 1850s, the Willamette River Basin has been dramatically altered by agricultural, hydropower, and urban development, which has substantially affected oak woodland, grassland, and wetland habitats (OPRD 2017). Dams, diversions, revetments, and similar alterations have largely disconnected the Willamette River and reduced its associated original wetland area by approximately 57 percent (Morlan et al. 2010).

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[1] See Section 3.4, Geology, for detailed descriptions of analysis area landforms.

The historic visual character of the Willamette River Basin has been substantially modified by creation of the 13 dams and reservoirs, hatcheries, and over 200 bank protection structures since the late 1930s (Chapter 1, Introduction, Section 1.7, U.S. Army Corps of Engineers'-managed Dams, Reservoirs, and Bank Protection Structures in the Willamette River Basin). These features have been an integral component of the Basin visual character for over 80 years.

Some aesthetic value has been re-established in the WVS through the creation of parks, recreational reservoirs and beaches, trails, and other scenic viewpoints accessible to the public. In 2022, almost 1,700,000 visitors were recorded within the Willamette River Basin (USACE 2022q).

Wildfires are a continuing threat in the Willamette River Basin and have altered the visual character by introducing substantial visual contrast and decimating existing high value characteristics. During the 2020 wildfire season, four wildfires—Beachie Creek, Lionshead, P-515[2], and Holiday Farm—damaged many recreation sites, forest structures, and road corridors in parts of the Willamette National Forest (USFS 2020a) (Section 3.6, Vegetation, Section 3.6.2.3, 2020 Wildfires).

These wildfires greatly reduced the Willamette National Forest by burning 176,000+ acres of the total forested area (USFS 2024). Buildings at both private marinas on Detroit Reservoir were lost, but the lakes were drawn down during the fires, allowing flames to pass over the docks.

[2] 2020 wildfires in the North Santiam River Subbasin included the Beachie Creek, Lionshead, and P-515 Fires. These fires combined and formed the Santiam Fire. The Holiday Farm Fire occurred in the McKenzie River Subbasin (Section 3.6, Vegetation, Section 3.6.2.3, 2020 Wildfires).

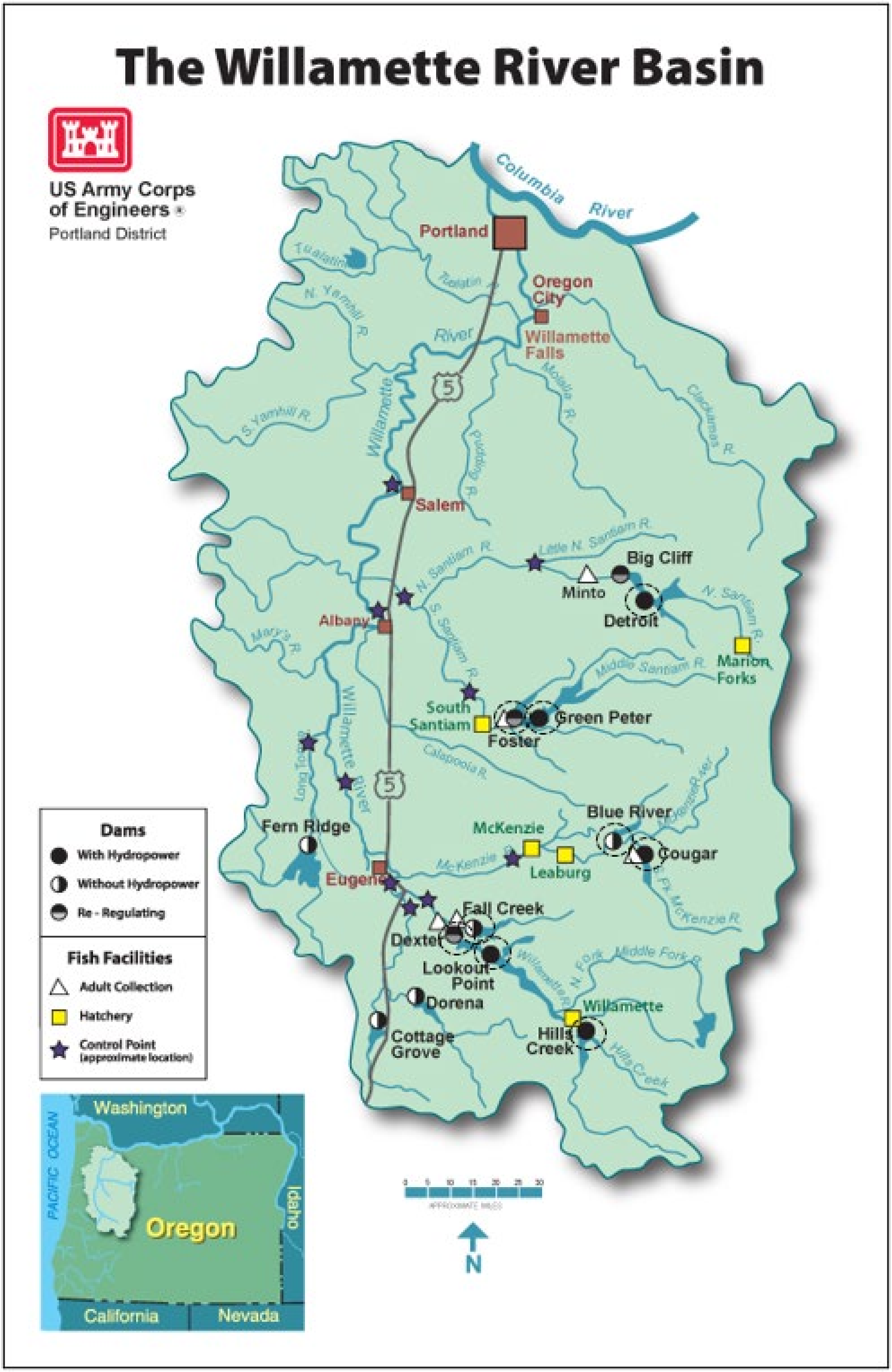

Figure 3.22-1. Dams and Reservoirs in the Visual Resources Analysis Area.

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

3.22.3 Assessing Visual Quality

The U.S. Bureau of Land Management (BLM) has developed a Visual Resource Management (VRM) system, which is often used by other agencies and organizations to inventory visual resources and to assess potential impacts. VRM includes a mechanism for identifying visual resource values, minimizing the impacts of surface-disturbing activities on visual resources, and maintaining the scenic value of tracts of land. The VRM process involves (1) preparing an inventory of scenic values of a landscape and (2) analyzing effects based on the inventory (BLM No Date-a).

While the U.S. Army Corps of Engineers, Portland District, does not apply the BLM visual resource management objectives to its planning, the VRM system has been adapted to only the assessment of visual resources in the analysis area. The BLM VRM system is particularly useful in assessing effects at a programmatic level, which is consistent with the Proposed Action (Chapter 2, Alternatives).

3.22.3.1 Visual Resource Inventory Process

A visual resource inventory consists of a three-step process. Results of this combined process are then converted into visual resource classifications as described below:

1. Assessing and rating the intrinsic scenic quality of a particular tract of land through the VRM Scenic Quality Rating process.
2. Measuring public concern for the scenic quality of the tract through the VRM Sensitivity Level Analysis.
3. Classifying the distance by which tracts of land are visible from travel routes or observation/viewpoints.

Scenic Quality Ratings

A Scenic Quality Rating is a measure of the visual appeal of a given tract of land (i.e., landscape) based on physiographic characteristics, such as landforms, vegetation, and water; similar visual patterns, such as texture, color, and light; or areas of similar impact from human-made modifications, such as cultural modifications and scarcity. These are factors used in the rating process (BLM 1986a).

Each key factor has its own rating criteria based on its qualities and features (e.g., clean and clear water has a higher rating compared to no water). The rating criteria total score translates into the scenic quality rating of A, B, or C (most to least scenic) (Appendix R, Visual Resources Inventory).

Sensitively Level Analysis

For this analysis, the Sensitivity Level Analysis is a measure of public concern for scenic quality. The landscape being inventoried is assigned high, moderate, or low sensitivity levels by assessing the amount of use at each dam.

Visibility Analysis

Visual resources are categorized based on how visible a tract of land is from travel routes or observation/viewpoints. The view of an area from a specific vantage point is referred to as a viewshed.

There are three distance zones applied to a visibility, or viewshed, analysis and include:

1. Foreground-middle ground (visible within 3 to 5 miles from highways, rivers, or other viewpoints).
2. Background (visible within 5 to 15 miles from a viewpoint).
3. Seldom seen (unseen from a viewpoint).

Assigning Visual Value from the Visual Resource Inventory

Based on results of the inventory steps above, visual resources are assigned one of four classes, with Class I resources having the greatest relative visual values and Class IV resources having the least relative value.

3.22.3 Visual Resource Inventory of Dams and Reservoirs in the Analysis Area

A visual resource inventory was conducted on the dams and reservoirs in the analysis area. These dams and reservoirs substituted for the BLM Visual Resource Inventory "tracts of land" as discussed above (Scenic Quality Ratings). Results of the inventory are summarized below (Table 3.22-1 through Table 3.22-4). Appendix R, Visual Resources Inventory, provides details to support these inventory conclusions.

3.22.3.1 Scenic Quality Inventory Summary

Table 3.22-1. Visual Resource Inventory Scenic Quality Ratings by Dam and Reservoir in the Analysis Area.

Key Scenic Quality Factors	Scenic Quality Rating Scores[1] by Dam and Reservoir								
	Detroit	Foster	Green Peter	Cougar	Blue River	Lookout Point	Hills Creek	Dexter	Fall Creek
Landform	1	1	1	1	1	1	1	1	1
Vegetation	3	3	3	3	3	3	3	3	3
Water	5	5	5	5	5	5	5	5	5
Color	3	3	3	3	3	3	3	3	3

Key Scenic Quality Factors	Scenic Quality Rating Scores[1] by Dam and Reservoir								
	Detroit	Foster	Green Peter	Cougar	Blue River	Lookout Point	Hills Creek	Dexter	Fall Creek
Influence of Adjacent Scenery	0	0	0	0	0	3	0	0	0
Scarcity	1	3	3	3	1	3	1	3	1
Cultural Modifications	0	0	0	0	0	0	0	0	0
Overall Score	**13**	**15**	**15**	**15**	**13**	**18**	**13**	**15**	**13**
Scenic Quality Rating[2]	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**

[1] Numerical scenic quality rating scores were adapted from the BLM Visual Resource Inventory Manual (BLM 1986b) (see FEIS Section 3.22.3.1, Visual Resource Inventory Process, Scenic Quality Ratings).

[2] A = scenic quality rating score of 19 or more, B = scenic quality rating score of 12 to 18, C = scenic quality rating score of 11 or less.

3.22.3.2 Sensitivity Level Analysis Summary

Factors of public concern applied to assess public sensitivity pertaining to each of the nine dams and reservoirs were measured as the amount of use at each location in the analysis area. Data from USACE Fiscal Year 2022 were applied to document the number of visits at each of the nine dams and reservoirs (citations provided in Table 3.22-2).

Table 3.22-2. Visual Resource Inventory Sensitivity Level Analysis Factors and Ratings.

Factors of Public Concern	Rating[1]		
	High	Moderate	Low
Amount of Use*	Greater than 75,000 visits	50,000 – 75,000 visits	Less than 50,000 visits

* USACE Fiscal Year 2022 Data. USACE 2022e, 2022f, 2022g, 2022h, 2022i, 2022j, 2022k, 2022l, 2022m, 2022n, 2022o, 2022p.

[1] Ratings were adopted from the BLM Visual Resource Inventory Manual (BLM 1986b).

Ratings for the sensitivity analysis are represented as metrics rather than numerically. Metrics of low, moderate, and high were assigned to the 2022 data to rate the number of visits as adopted from the BLM Visual Resource Inventory Manual (BLM 1986b).

These metrics were assigned subjectively to best cover the data range and to assess specific conditions in the analysis area. For example, the number of visitors in 2022 at the nine dams and reservoirs ranged from tens of thousands to hundreds of thousands. Therefore, a metric was established to best capture low, moderate, and high values within that data range (Table 3.22-2). Results are summarized by dam and reservoir (Table 3.22-3).

Visitation numbers in 2022 differ from the 2019 numbers assessed in the DEIS. This is likely because areas surrounding the WVS dams and reservoirs were recovering from wildfire damage due to the Santiam Fire, including damage to recreation facilities, no access to potable water, and prohibited or limited public access in recovery areas. Additionally, visitors likely chose to recreate at surrounding reservoirs not impacted by the fires given the surrounding aesthetic damage and limited public services during recovery. This visitor displacement altered visitation numbers at some dams.

Table 3.22-3. Visual Resource Inventory Sensitivity Level Analysis Summary by Dam and Reservoir in the Analysis Area.

Factors of Public Concern	Sensitivity Level Rating by Dam and Reservoir[1]								
	Detroit	Foster	Green Peter	Cougar	Blue River	Lookout Point	Hills Creek	Dexter	Fall Creek
Amount of Use and Overall Rating	High	High	High	Low	Low	Moderate	High	High	High

[1] USACE Fiscal Year 2022 Data. USACE 2022e, 2022f, 2022g, 2022h, 2022i, 2022j, 2022k, 2022l, 2022m, 2022n, 2022o, 2022p.

END REVISED TEXT

3.22.3.3 Visibility Analysis Summary

Visibility of each of the nine dams and reservoirs from travel routes and observation/viewpoints was assessed (Table 3.22-4). All nine dams and reservoirs are within the foreground-middle ground distance zones because of visibility from viewpoints less than 3 miles to 5 miles from these locations in the Willamette River Basin (Section 3.22.3.1, Visual Resource Inventory Process, Visibility Analysis).

Table 3.22-4. Visual Resource Inventory Distance Zones between Dam and Reservoir in the Analysis Area and Viewpoints.

Distance Zones	Dam and Reservoir								
	Detroit	Foster	Green Peter	Cougar	Blue River	Lookout Point	Hills Creek	Dexter	Fall Creek
Foreground-middle ground	X	X	X	X	X	X	X	X	X
Background	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Seldom Seen	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A = not applicable

3.22.3.4 Visual Value Methodology and Summary

The information above was combined to develop visual values in the analysis area using the following methodology:

1. Scores from the Scenic Quality Inventory, Sensitivity Level Analysis, and Visibility Analysis were aggregated to determine the visual resource inventory classification for each dam and reservoir in the analysis area (Table 3.22-5).
2. Classifications were then assigned to each dam and reservoir to establish the visual value (Table 3.22-6). Classifications include Class I areas, which have high visual value; Class II areas, which have moderate to high visual value; Class III areas, which have moderate visual value; and Class IV areas, which have low visual value.

   For example, if a dam and reservoir were not in a special area and received a scenic quality rating of C, a visual sensitivity rating of moderate, and a distance rating of foreground–middle ground, that dam and reservoir would be considered a Class IV area, which has low visual value. In some cases where a dam and reservoir were rated between two classification levels, the lower-level classification was assigned.

Table 3.22-5. Visual Resource Inventory Classifications[1] Summary.

Visual Resource Inventory Factors		Visual Resource Inventory Ratings				
Special Areas[2]		I		I		I
Scenic Quality	**A**	II		II		II
	B	II	III*	III	IV*	IV
	C	III	IV*	IV		IV
Visual Sensitivity Levels		High		Moderate		Low
Distance Zones		Foreground – Middle Ground				

[1] Visual Resource Inventory Classifications adopted from BLM Visual Resource Inventory Manual (BLM 1986b).

[2] Special areas refer to areas with high visual value that require special consideration for protection of visual values and preservation of the natural landscape setting.

Table 3.22-6. Visual Resource Inventory Classification and Visual Value by Dam and Reservoir in the Analysis Area.

Classification and Visual Value	Detroit	Foster	Green Peter	Cougar	Blue River	Lookout Point	Hills Creek	Dexter	Fall Creek
Classification Rating	III	II	III	IV	IV	IV	IV	II	III
Visual Value	Moderate	Moderate to High	Moderate	Low	Low	Low	Low	Moderate to High	Moderate

3.22.4 Visual Quality of Dams and Reservoirs in the Analysis Area

This section summarizes results of the visual resource inventory as applied to each of the nine dams and reservoirs. Dam and reservoir features are visible from all reservoirs by recreationists (e.g., boaters), from the dams themselves, and from recreation sites within the viewshed of each dam and reservoir. Inventory specifics are provided below for each dam and reservoir.

3.22.4.1 Detroit Dam and Reservoir

Detroit Dam is a massive concrete structure that is 463 feet high and 1,523 feet wide. The dam includes gated spillways and two hydropower generating units. Detroit Reservoir is 9 miles long and encompasses an area of 3,500 acres when the reservoir is full (USACE No Date-e).

Detroit Dam dominates the scenic viewshed[3] and is commonly used as a scenic viewpoint for the dam itself (Figure 3.22-2). It is a designated stop along the Mt. Jefferson section of the Oregon Cascades Birding Trail. Viewers can also observe Big Cliff Reservoir below the dam, Detroit Reservoir above the dam, and rock faces and trees along North Santiam Highway (Figure 3.22-3) (Google Earth No Date).

Unknown Photo Credit (USACE Media Images Database)

Detroit Dam.

[3] The view of an area from a specific vantage point is referred to as a "viewshed."

Figure 3.22-2. View of Detroit Reservoir from Detroit Dam.

Source: Google Earth No Date

From the Visual Resource Inventory on Detroit Dam and Reservoir, the Scenic Quality rating score is 13, which equates to an overall Scenic Quality Rating of B (Table 3.22-1). The presence of water in the reservoir from viewpoints contributes to this score. The Sensitivity Level is high (Table 3.22-3).

Figure 3.22-3. Detroit Reservoir as Viewed from North Santiam Highway.

Source: Google Earth No Date

The dam and reservoir are categorized within the foreground-middle ground distance zone due to visibility from highways and viewpoints of less than 3 miles to 5 miles away (Table 3.22-4). Detroit Dam and Reservoir are rated as a Class III area, which is of moderate visual value (Table 3.22-6).

3.22.4.2 Foster Dam and Reservoir

Foster Dam is a rock-filled structure that includes a concrete gated spillway. The dam is 126 feet high and 4,565 feet wide and paved to enable drivers to cross over. Foster Reservoir is 3.5 miles long and encompasses an area of 1,220 acres when the reservoir is full (USACE No Date-j).

Visitors who cross the dam can view Foster Reservoir above the dam (Figure 3.22-4). Visitors can also see the South Santiam River, marinas, parks, and the South Santiam Fish Hatchery below the dam (Google Earth No Date). Foster Reservoir supports parks, boat ramps, marinas, and observation points to allow scenic views of the water, trees, shrubs, and rare wildlife and amphibians (Section 3.9, Wildlife and Habitat) (USACE No Date-j).

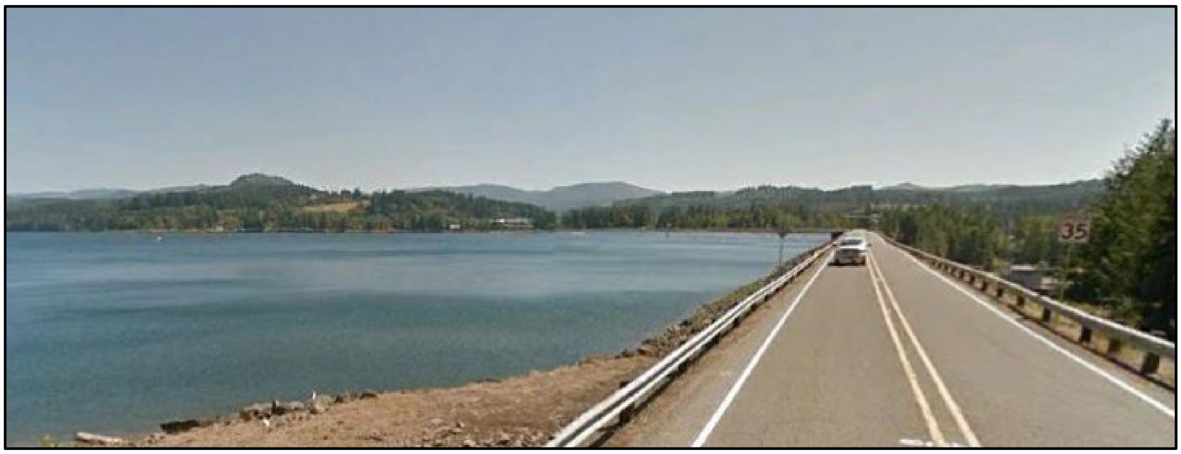

Figure-3.22-4. Road Crossing Foster Dam with Foster Reservoir.
Source: Google Earth No Date

From the Visual Resource Inventory on Foster Dam and Reservoir, the Scenic Quality rating score is 15, which equates to an overall Scenic Quality Rating of B (Table 3.22-1). The presence of water and rare wildlife within this viewshed contributed to this score. The Sensitivity Level is high due to the high amount of use (Table 3.22-3).

The dam and reservoir are categorized within the foreground-middle ground distance zone due to visibility from highways and viewpoints of less than 3 miles to 5 miles away (Table 3.22-4). Foster Dam and Reservoir are rated as a Class II area, which is of moderate to high visual value (Table 3.22-6).

Unknown Photo Credit (USACE Media Images Database)

Foster Dam.

3.22.4.3 Green Peter Dam and Reservoir

Green Peter Dam is located near an urban area 11 miles northeast of Sweet Home, Oregon. The concrete dam is 327 feet high and 1,500 feet wide. It includes a gated spillway and two hydropower generating units. Green Peter Reservoir is 10 miles long and encompasses an area of 3,720 acres when the reservoir is full (USACE No Date-k).

North River Road is lined with trees on the dam side and rocky cliffs on the opposite side, obstructing motorists' view of the dam itself (Google Earth No Date). The overlook at the dam provides scenic views of the dam structure, while other boat ramps and parks along the 10-mile reservoir shoreline offer scenic views of water, vegetation, and rolling hills topped with various tree species. Osprey are also known to nest along the shorelines of the reservoir and may enhance aesthetic views of the area.

From the Visual Resource Inventory on Green Peter Dam and Reservoir, the Scenic Quality rating score is 15, which equates to an overall Scenic Quality Rating of B (Table 3.22-1). The presence of water and the potential to see osprey nests along the shorelines in this viewshed contributed to this score. The Sensitivity Level is high, likely because of its close proximity to an urban area, which supports accessible visitation (Table 3.22-3).

The dam and reservoir are categorized within the foreground-middle ground distance zone due to visibility from highways and viewpoints of less than 3 miles to 5 miles away (Table 3.22-4). Green Peter Dam and Reservoir are rated as a Class III area, which is of moderate visual value (Table 3.22-6).

Unknown Photo Credit (USACE Portland District Media Images)
Green Peter Dam and Reservoir.

3.22.4.4 Cougar Dam and Reservoir

Cougar Dam is located on the South Fork McKenzie River about 42 miles east of Eugene, Oregon. The rock-filled structure is 452 feet high and 1,600 feet wide and contains a gated concrete spillway, powerhouse, fish ladder, and temperature control tower that includes a portable floating fish collector. Cougar Reservoir is 6 miles long and encompasses an area of 1,280 acres when the reservoir is full (USACE No Date-d).

The Cougar Dam Overlook located on the northeast side of the dam allows viewers to look below the massive dam to the South Fork McKenzie River and above the dam to Cougar Reservoir (Figure 3.22-5), which is surrounded by forests and steep rocky cliffs (Google Earth No Date). The area contains many parks, campgrounds, and creeks; the reservoir itself is a designated stop along the Three Sisters section of the Oregon Cascades Birding Trail, where American peregrine falcons have been observed around the cliffs of the reservoir (USACE No Date-d).

Figure 3.22-5. View of the Cougar Reservoir from the Cougar Dam Overlook.
Source: Google Earth No Date

From the Visual Resource Inventory on Cougar Dam and Reservoir, the Scenic Quality rating score is 15, which equates to an overall Scenic Quality Rating of B (Table 3.22-1). The presence of water and the Three Sisters section of the Oregon Cascades Birding Trail in this viewshed contributed to this score. The Sensitivity Level is low (Table 3.22-3).

The dam and reservoir are categorized within the foreground-middle ground distance zone due to visibility from highways and viewpoints of less than 3 miles to 5 miles away (Table 3.22-4). Although located within these viewpoints, Cougar Dam and Reservoir are rated as a Class IV area, which is of the least visual value (Table 3.22-6).

Unknown Photo Credit (USACE Media Images Database)

Cougar Dam.

3.22.4.5 Blue River Dam and Reservoir

Blue River Dam is located 38 miles east of Eugene, Oregon. The rock-filled structure is 270 feet high and 1,265 feet wide and includes a gated concrete spillway. Blue River Reservoir is approximately 6.5 miles long and encompasses an area of 1,009 acres when the reservoir is full (USACE No Date-b).

A viewpoint located on the northeast end of the dam provides observers with a scenic view of the dam's massive structure, along with views of Blue River below the dam and the reservoir above the dam (Google Earth No Date). Ospreys have been known to roost (rest or sleep) in large trees and snags (USACE No Date-b). Forest and steep, rocky cliffs encompass most of the reservoir, while boat ramps and campgrounds provide access to the scenic views of the reservoir and surrounding forests (Section 3.14, Recreation Resources) (USACE No Date-b).

From the Visual Resource Inventory on Blue River Dam and Reservoir, the Scenic Quality rating score is 13, which equates to an overall Scenic Quality Rating of B (Table 3.22-1). The presence of water in this viewshed contributed to this score. The Sensitivity Level is low (Table 3.22-3).

The dam and reservoir are categorized within the foreground-middle ground distance zone due to visibility from highways and viewpoints of less than 3 miles to 5 miles away (Table 3.22-4).

Although located within these viewpoints, Blue River Dam and Reservoir are rated as a Class IV area, which is of the least visual value (Table 3.22-6).

Unknown Photo Credit (USACE Portland District Media Images)

Blue River Dam and Reservoir.

3.22.4.6 Lookout Point Dam and Reservoir

Lookout Point Dam is located on the Middle Fork Willamette River about 22 miles southeast of Eugene, Oregon. It is an earth- and gravel-filled dam that is 276 feet high and 3,381 feet wide. The dam features also include a concrete gated spillway, powerhouse, and the Dexter Service Building—a USACE office. Lookout Point Reservoir is over 14 miles long and encompasses an area of 4,360 acres when the reservoir is full (USACE No Date-m).

Visitors to the dam can stop at Meridian Park and observe the expansive reservoir surrounded by rocky cliffs and rolling hills topped with various tree species (Figure 3.22-6). The area surrounding the reservoir includes several parks, boat ramps, and creeks that provide scenic views of the water, vegetation, and rolling forested hills. The reservoir and rolling hills to the northeast are visible from Willamette Highway through breaks in the tree line (Google Earth No Date).

Visitors may also spot rare wildlife species near the dam. Bald eagles are known to winter and regularly nest in the area (USACE No Date-m). Lowell Covered Bridge is located west of the dam and provides views of the dam, surrounding water bodies, forests, and rolling hills (Google Earth No Date).

Figure 3.22-6. View of Lookout Point Reservoir from Lookout Point Dam.
Source: Google Earth No Date

From the Visual Resource Inventory on Lookout Point Dam and Reservoir, the Scenic Quality rating score is 18, which equates to an overall Scenic Quality Rating of B (Table 3.22-1). The presence of water, rare wildlife, and views of the dam from Lowell Covered Bridge in this viewshed contributed to this score. The Sensitivity Level is moderate (Table 3.22-3).

The dam and reservoir are categorized within the foreground-middle ground distance zone due to visibility from highways and viewpoints of less than 3 miles to 5 miles away (Table 3.22-4). Although the scenic quality of the area includes unique features, Lookout Point Dam and Reservoir are rated as a Class IV area, which is of the least visual value (Table 3.22-6).

Unknown Photo Credit (USACE Media Images Database)

Lookout Point Dam.

3.22.4.7 Hills Creek Dam and Reservoir

Hill Creek Dam is located 4 miles southwest of Oakridge, Oregon. It is an earth-filled dam that rises 304 feet high and 2,235 feet wide. The dam features include a gated concrete spillway, two hydropower generating units, a powerhouse, an outlet to regulate reservoir levels, a hatchery, and a ranger station located west of the dam. Hills Creek Reservoir is approximately 8 miles long and encompasses an area of 2,735 acres when the reservoir is full (USACE No Date-l).

The area around the reservoir contains picnic areas, campgrounds, creeks, and multiple viewpoints of the dam. A stop along the Three Sisters section of the Oregon Cascades Birding Trail also offers views of the dam and reservoir. From scenic viewpoints in this area, visitors can observe the massive earthen structure, the reservoir, forested hills, and wildlife such as birds (USACE No Date-l).

From the Visual Resource Inventory on Hills Creek Dam and Reservoir, the Scenic Quality rating score is 13, which equates to an overall Scenic Quality Rating of B (Table 3.22-1). The presence of water in this viewshed contributed to this score. The Sensitivity Level is high (Table 3.22-3).

The dam and reservoir are categorized within the foreground-middle ground distance zone due to visibility from highways and viewpoints of less than 3 miles to 5 miles away (Table 3.22-4). Hills Creek Dam and Reservoir are rated as a Class IV area, which is of the least visual value (Table 3.22-6).

Photo by Lauren Bennett (USACE Media Images Database)

Hills Creek Dam and Reservoir.

3.22.4.8 Dexter Dam and Reservoir

Dexter Dam is located about 22 miles southeast of Eugene, Oregon. It is an earth- and gravel-filled embankment dam that is 93 feet high and 2,739 feet wide with concrete gated spillways, a powerhouse, and a fish facility. Dexter Reservoir is almost 3 miles long and encompasses an area of 1,024 acres when the reservoir is full (USACE No Date-f).

Willamette Highway runs along the southern edge of Dexter Reservoir and provides scenic views of the water, trees, and hills, while Shore Line Drive runs northeast of the dam into the City of Lowell, where it crosses the reservoir at the Lowell Covered Bridge (Figure 3.22-7) (Google Earth No Date). The combination of natural landscape and urban structures such as the dam, a unique covered bridge, and the City of Lowell on the northern embankment provide a diverse assortment of landscape features for visitors to observe.

Figure 3.22-7. Lowell Covered Bridge and Dexter Reservoir.
Source: Google Earth No Date

From the Visual Resource Inventory on Dexter Dam and Reservoir, the Scenic Quality rating score is 15, which equates to an overall Scenic Quality Rating of B (Table 3.22-1). The presence of water and views of Lowell Covered Bridge, the City of Lowell, and other urbanized features that mix with the natural landscape in this viewshed contributed to this score. The Sensitivity Level is high (Table 3.22-3).

The dam and reservoir are categorized within the foreground-middle ground distance zone due to visibility from highways and viewpoints of less than 3 to 5 miles away (Table 3.22-4). Dexter Dam and Reservoir are rated as a Class II area, which is of moderate to high visual value (Table 3.22-6).

Photo by Amy Echols (USACE Media Images Database)
Dexter Dam.

3.22.4.9 Fall Creek Dam and Reservoir

Fall Creek Dam is located on Fall Creek, a major tributary to the Middle Fork Willamette River, 1 mile upstream of Unity, Oregon and 25 miles upstream of Eugene and Springfield, Oregon. It is a rock-filled, earth dam that is 205 feet high and 5,050 feet wide with a concrete spillway, two spillway gates, and a regulating outlet. Fall Creek Reservoir is 6.8 miles long and encompasses an area of 1,820 acres when the reservoir is full (USACE No Date-h).

North Shore Park and Winberry State Recreation Site are located on the north and south sides of the dam, respectively. Big Fall Creek Road stretches along the north side of the reservoir while Peninsula Road traverses the southern shore. These roads provide scenic views of the forested landscape with breaks in the tree line opening to views of the reservoir. Fall Creek State Recreation Area and Cascara Campground are in northeast corner of the reservoir away from the dam (Section 3.14, Recreation Resources). These recreation sites support dense forested habitat along the narrowing stretches of Fall Creek Reservoir.

From the Visual Resource Inventory on Fall Creek Dam and Reservoir, the Scenic Quality rating score is 13, which equates to an overall Scenic Quality Rating of B (Table 3.22-1). The presence of water in this viewshed contributed to this score. The Sensitivity Level is high (Table 3.22-3).

The dam and reservoir are categorized within the foreground-middle ground distance zone due to visibility from highways and viewpoints of less than 3 miles to 5 miles away (Table 3.22-4).

Fall Creek Dam and Reservoir are rated as a Class III area, which is of moderate visual value (Table 3.22-6).

3.22.5 Environmental Consequences

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

This section discusses the potential direct, indirect, and climate change effects of the alternatives to the visual quality of the analysis area described in the Affected Environment. The discussion includes the methodology used to assess effects and a summary of the anticipated effects.

3.22.5.1 Methodology

Visual quality effects are defined as effects from visual contrast that would occur at the dams and reservoirs in the analysis area from implementation of alternatives. Overall, effects were assessed by comparing visual contrast against visual values at each dam and reservoir to determine the level of effect under each alternative. The following methodology was applied:

1. Design elements were used to compare the visual contrast between the existing, surrounding landscape and elements that would be introduced under each alternative (BLM 1986a). Alterations in these design elements from alternative measures determined the degree of contrast, which depended on the level of contrast between the design elements present in the existing landscape, and elements that would be introduced or modified under an alternative.

   VRM design elements include:

   - **Form**. Defined by changes in the shape or mass of landforms or structures. The degree of change depends on how dissimilar the introduced forms are to those continuing to exist in the landscape.
   - **Line**. Defined by changes in edge types and interruption or introduction of edges, bands, and silhouette lines. New lines may differ in their sub-elements (boldness, complexity, and orientation) from existing lines in the surrounding landscape.
   - **Color**. Defined by changes in value and hue that create the greatest contrast. Other factors such as chroma, reflectivity, and color temperature may also increase the contrast when compared to the surrounding landscape.
   - **Texture**. Defined by changes in grain, density, and internal contrast. Other factors such as irregularity and directional patterns of texture may affect the rating.
2. The degree of contrast change in the existing landscape was correlated to the magnitude of effects (Table 3.22-7), which could be adverse or beneficial based on the perspective of the observer. Measures that would produce no degree of contrast or alteration in the landscape, or the level of that modification would not be seen and would not attract attention, were considered negligible effects. Measures that would

produce a high degree of contrast or alteration in the landscape, to the level that the modification demanded attention, could not be overlooked, and dominated the landscape, were considered major effects.

3. Existing visual values at each dam and reservoir from Table 3.22-6 were then factored into the overall assessment on visual resources from contrast effects. For example, if a high degree of contrast would occur in the existing landscape and there is also high visual value at this location, there would be a heightened potential to adversely affect viewers. However, if a high degree of contrast would occur but there is low visual value in the dam, then there would be minimal potential to affect viewers from the activity resulting in the high visual contrast to the viewshed.
4. The extent of a potential adverse or beneficial environmental effect was derived from the amount of use recorded at each location (Section 3.22.3.2, Sensitivity Level Analysis Summary). Durations range from short term, medium term, and long term.
5. A design element analysis was not conducted for effect from routine and non-routine maintenance activities. Effects from these activities were assessed qualitatively because specific maintenance activities will vary substantially in type, location, and seasonality, and were unknown at the time the alternatives were analyzed.

The visual resources environmental effects criteria are provided in Table 3.22-7. A summary of effects to visual resources is provided in Table 3.22-8.

Table 3.22-7. Visual Resources Environmental Effects Criteria.

Adverse or Beneficial Effects	Definition
Degree of Contrast	
None or Negligible	A modification cannot be seen, or if seen, does not attract attention.
Minor	A modification can be seen, but does not attract attention.
Moderate	A modification begins to attract attention and begins to dominate the characteristic landscape.
Major	A modification demands attention, cannot be overlooked, and dominates in the landscape.
Duration	
Short Term	Alteration lasts for the duration of a small construction project and is continuous for less than 2 years.
Medium Term	Alteration is limited to the duration of large construction projects and is continuous for a period of 2 to 5 years.
Long Term	Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (i.e., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently.
Extent	
Small	Visual quality is altered for less than 50,000 visitors.
Medium	Visual quality is altered for 50,000 to 75,000 visitors.
Large	Visual quality is altered for more than 75,000 visitors.

THE DEIS HAS BEEN REVISED TO INCLUDE ADDITIONAL INFORMATION RELATED TO MAINTENANCE ACTIVITIES IN THE FOLLOWING TABLE

Table 3.22-8. Summary of Effects on Visual Resources as Compared to the No-action Alternative[1].

Degree of Adverse or Beneficial Effect and Extent	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Short-term Duration								
Degree	Negligible to major adverse	Moderate to major adverse	Moderate to major adverse	Moderate to major adverse	Moderate to major adverse	Moderate to major adverse	Moderate to major adverse	Moderate to major adverse
Extent	• Large for drawdowns (Fall Creek Dam) • Small to large depending on exterior maintenance activity	• Large (Foster Dam, Fall Creek Dam) • Same as the No-action Alternative for exterior maintenance	• Large (Foster Dam, Green Peter Dam, Fall Creek Dam) • Same as the No-action Alternative for exterior maintenance	• Small (Cougar Dam) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam) • Same as the No-action Alternative for exterior maintenance	• Small (Hills Creek Dam, Cougar Dam, Blue River Dam) • Medium (Lookout Point) • Large (Green Peter Dam, Fall Creek Dam, Detroit Dam) • Same as the No-action Alternative for exterior maintenance	• Small (Hills Creek Dam, Cougar Dam, Blue River Dam) • Medium (Lookout Point) • Large (Green Peter Dam, Fall Creek Dam, Detroit Dam) • Same as the No-action Alternative for exterior maintenance	• Large (Foster Dam, Fall Creek Dam) • Same as the No-action Alternative for exterior maintenance	• Small (Cougar Dam) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam) • Same as the No-action Alternative for exterior maintenance
Medium-term Duration								
Degree	None	Minor adverse	Minor adverse	Minor adverse	Minor adverse	Minor adverse	Minor adverse	Minor adverse
Extent	None	• Medium (Lookout Point) • Large (Detroit Dam, Green Peter Dam)	• Small (Cougar Dam) • Medium (Lookout Point) • Large (Detroit Dam, Green Peter Dam)	• Medium (Lookout Point) • Large (Detroit Dam, Green Peter Dam)	• Small (Blue River Dam, Hills Creek Dam) • Large (Green Peter Dam)	• Small (Blue River Dam, Hills Creek Dam) • Large (Green Peter Dam)	• Small (Hills Creek Dam, Cougar Dam) • Medium (Lookout Point) • Large (Detroit Dam, Dexter Dam)	• Medium (Lookout Point) • Large (Detroit Dam, Green Peter Dam)
	Long-term Duration (Permanent, Intermittent, and/or Recurring)							
Degree	Moderate adverse	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial
Extent	• Large (Fall Creek Dam)	• Medium (Lookout Point) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam, Detroit Dam)	• Small (Cougar Dam) • Medium (Lookout Point) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam, Detroit Dam)	• Small (Cougar Dam) • Medium (Lookout Point) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam, Detroit Dam)	• Small (Hills Creek Dam, Cougar Dam, Blue River Dam) • Medium (Lookout Point) • Large (Green Peter Dam, Fall Creek Dam, Detroit Dam)	• Small (Hills Creek Dam, Cougar Dam, Blue River Dam) • Medium (Lookout Point) • Large (Green Peter Dam, Fall Creek Dam, Detroit Dam)	• Small (Hills Creek Dam, Cougar Dam) • Medium (Lookout Point) • Large (Foster Dam, Dexter Dam, Fall Creek Dam, Detroit Dam)	• Small (Cougar Dam) • Medium (Lookout Point) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam, Detroit Dam)
Duration Type	Recurring for drawdowns and maintenance, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.

[1] Note a range of effects may occur under each alternative, reflecting maintenance activities and drawdowns. Where a range of potential effects would occur, the most severe magnitude of adverse effects and the least magnitude of beneficial effects for each alternative is listed to present the most conservative range of potential effects. The extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the least beneficial effect does not occur at that reservoir.

3.22.5.2 Alternatives Analyses

<u>**No-action Alternative**</u>

Routine and Non-routine Maintenance Activities at All Dams

Routine and non-routine maintenance would continue under all alternatives basin wide; however, it is unknown where activities associated with maintenance would occur, the extent of these activities, or the seasonality of these activities (Chapter 1, Introduction, Section 1.11.3, Operation, Maintenance, Repair, and Rehabilitation).

Examples of routine maintenance activities would range from repainting a rusty guardrail or replacement of lightbulbs to more substantial maintenance and rehabilitation activities such as the repair, replacement, or rehabilitation of entire facility components (e.g., the replacement of the slide gate seals or repair of hydraulics in a dam). These collective activities would occur at all facilities in the WVS under all alternatives including within and around the dams and powerhouses, adult fish facilities, and hatcheries.

Unscheduled maintenance would occur any time a repair issue is identified, including an unforeseen maintenance issue or emergency that requires a facility feature, such as a generating unit, to be taken offline to resolve the issue. The timing, duration, and extent of these maintenance activities are unforeseeable (Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation).

Major rehabilitation is defined as structural modifications to restore or to ensure continuation of an existing facility’s functions or outputs. This does not include normal maintenance of existing capabilities or prevention of deterioration. Examples of non-routine, rehabilitation maintenance include powerhouse modernization and major facility upgrades (Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation).

Routine and Non-routine Maintenance Effects to Visual Resources at All Dams

Under all alternatives, routine maintenance activities could alter the existing visual character within the immediate vicinity of a given dam if not conducted indoors. However, routine maintenance that does not involve construction activities would not impact a dam viewshed. The scope of possible routine maintenance construction was unknown at the time the alternatives were analyzed.

While no major construction projects are foreseen under the NAA, major non-routine, rehabilitation maintenance may occur at any given dam (e.g., powerhouse modernization). There would be no effect on visual character surrounding the dam if major maintenance is conducted indoors. Minor to major effects to visual resources could occur if maintenance is conducted outdoors and within the viewshed of the dam. Scenic inventory of landforms, vegetation, water, and scenic views would only be affected if non-routine maintenance results in a highly visible exterior infrastructure addition or modification; however, those interested in viewing dam infrastructure may gain additional features in the viewshed with the new structures.

Overall, adverse effects to visual character would range from none to major depending on the type of construction needed to accomplish exterior routine or non-routine maintenance projects. Impacts to viewers would depend on the visual value at a given dam where maintenance activities would occur (Table 3.22-6). For example, the adverse visual effect from non-routine maintenance could be major at Cougar Dam because of contrast to the viewshed; however, the low visual value at this dam would minimize this adverse visual effect to viewers. Conversely, there may be negligible to major beneficial impacts to viewers attracted to dams specifically to view routine- and non-routine-related construction activities under the NAA.

The extent of adverse or beneficial visual impacts would range from small to large, depending on the number of visitors that would be adversely affected by maintenance activities at a given dam. The duration would be likely be short-term from most routine or non-routine maintenance activities and would not be permanent.

Scenic Quality Ratings would not be altered at any dam from routine or non-routine maintenance activities because viewshed character would not be substantially altered. The exception would be a major feature alteration to a dam from non-routine maintenance requiring major structural modifications such as facility upgrades (Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation). However, these are unforeseen and not anticipated under the NAA. Further, major maintenance may occur indoors and not in the viewshed of a given dam.

Foreground-middle ground visibility distances from viewpoints in the analysis area to natural areas surrounding all dams would not likely be altered under the NAA from routine and non-routine maintenance activities because no substantial new design feature is anticipated that would affect visibility. Visual value classifications would not change at any dam because there would be no substantial long-term visual change from existing conditions because of maintenance activities.

Reservoir Drawdowns

Operations and maintenance under the NAA would also include the seasonal system operation of reservoir water control at all reservoirs (Section 1.11, Willamette Valley System Operations and Annual Operations Planning).

In addition, Fall Creek Reservoir would continue to be drawn down annually to its lowest outlet for a few weeks annually in November, potentially lasting into December. Reservoir drawdown at Fall Creek Reservoir was the only measure analyzed under the NAA, as it is the only measure that would potentially affect visual resources.

Reservoir Drawdown Effects to Visual Resources

Under the NAA, shoreline erosion in all reservoirs under continued operations is not expected to occur, given that the drawdowns would only last for a few weeks. However, while drawdown effects already occur within the existing landscape, sediment transport and reservoir drawdowns under the NAA would continue to noticeably alter design elements in the landscape.

Under the NAA, suspended solids would mobilize as the drawdowns occur. This would lead to sediments, organic materials, and other debris being washed downstream and affecting water color and clarity (USACE No Date-p). This would also continue to have a noticeable, short-term, adverse effect on the visual character of the dam and reservoir area by altering the basic design elements of color, texture, and form (Figure 3.22-8 and Figure 3.22-9).

Water color associated with suspended solids in all reservoirs would change slightly under the NAA to a darker color with the introduction of darker clays, silts, and sediments. Texture would change slightly with the introduction of grainy sediment particles and other larger suspended particulate materials. Form would change slightly with the introduction of a variety of irregular shapes, sizes, and masses from the suspended solids.

Reservoir drawdowns under continued operations could also reveal mudflats, substrate, tree stumps, and other submerged littoral zone attributes (submerged vegetation, roots, sediments, rocks, snails, shells, etc.), and would adversely affect existing design elements of color, texture, line, and form:

- Water color would change substantially with the loss of surface water and the exposure of previously submerged littoral zone attributes containing darker colors.
- Texture would change substantially from a smooth water surface to a rough, grainier surface with the exposure of mudflats or other submerged substrate.
- Line would also change substantially from the solid, smooth, and curved lines of the water surface and edge to jagged, irregularly shaped lines with the introduction of submerged littoral zone attributes.
- Form would change substantially from the uniform and ubiquitous shape and mass of the reservoirs to a variety of irregular shapes, sizes, and masses with the exposure of submerged littoral zone attributes.
- Typical vegetation coverage around the reservoirs would be unlikely to change, meaning trees, grasses, and other plants would not be expected to expand into the reservoir. Effects would be long-term and recurring in all WVS reservoirs because water level changes would occur annually.

Figure 3.22-8. View of Detroit Reservoir at Full Capacity during the Summer Months.

Figure 3.22-9. View of Detroit Reservoir at Low Pool Elevation during the Winter Months.

THE DEIS HAS BEEN REVISED TO INCLUDE THE FOLLOWING INFORMATION IN THE FEIS

The degree of adverse effect from these drawdown conditions on the visual landscape would likely be moderate under the NAA depending on operations at a given reservoir. However, the visual value at any given reservoir could either minimize or intensify the degree of impact to viewers.

For example, the adverse visual effect from drawdown contrast on the landscape could be major at Cougar Dam; however, the low visual value at this dam would minimize this adverse visual effect to viewers (Table 3-22-6). Conversely, a major visual effect at Dexter Reservoir on the viewshed from a drawdown contrast to the landscape may also be a major impact on viewers because of its existing moderate to high visual value.

END NEW TEXT

Drawdowns at Fall Creek Dam

In addition to continued operations at all dams under the NAA, Fall Creek Reservoir would continue to be drawn down to its lowest outlet on an annual basis. While drawdown effects already occur within the existing landscape at Fall Creek Dam, sediment transport and reservoir drawdowns would continue to noticeably alter design elements in the landscape (Figure 3.22-10 and Figure 3.22-11).

Sediment transport and reservoir drawdown contrast effects would be adverse and moderate in the short term and long term, as effects would begin to attract attention to this reservoir with moderate visual value and would begin to dominate the characteristic landscape.

Visual effects would be large in extent because Fall Creek Dam recorded greater than 75,000 visitors in 2022; visitation would not be expected to change because water levels already fluctuate seasonally at all dams throughout the WVS.

The Scenic Quality Rating would not be modified at Fall Creek Dam or at any dam under the NAA because water clarity and coloration would return to existing conditions in the days to weeks that follow a transport event; water would eventually refill the reservoir; and landforms, vegetation, scenic views, and the overall scenic inventory would be expected to remain the same.

Foreground-middle ground visibility distances from viewpoints in the analysis area to natural areas surrounding Fall Creek Dam and Reservoir and all dams would not be altered under the NAA due to drawdowns. The moderate visual value classification for Fall Creek Dam and Reservoir and all dams would not change because there would be no substantial, long-term visual change from existing conditions from drawdowns.

Figure 3.22-10. View of Fall Creek Dam and Reservoir at Full Capacity.

Figure 3.22-11. View of Fall Creek Dam and Reservoir during a Deep Reservoir Drawdown to 10 feet above the Regulating Outlets.

Effects to Visual Resources under All Action Alternatives

Viewsheds would be altered at any given dam and reservoir under the action alternatives as compared to the NAA from construction and drawdown measures, including selective withdrawal structures, structural downstream fish passage as floating fish screens or weirs, and adult fish facilities; deep fall reservoir drawdowns for fish passage; and spring reservoir drawdowns for downstream fish passage. As under the NAA, routine and non-routine maintenance activities would also occur under all action alternatives. Site-specific project details for each construction measure or maintenance activity are not known but will be determined during the implementation phase. Subsequent NEPA analyses would assess detailed site-specific effects on visual resources from any construction.

Specific to the dam and reservoir location for implementation of construction or drawdown measures would result in differences in effects to visual resources and to viewers under the action alternatives as compared to the NAA. Specifically:

- Under Alternative 1, the extent of effects would be medium at Lookout Point Dam; and large at Green Peter Dam, Foster Dam, Fall Creek Dam, and Detroit Dam.
- Under Alternatives 2A, 2B, and 5, the extent of effects would be small at Cougar Dam; medium at Lookout Point Dam; and large at Foster Dam, Green Peter Dam, Fall Creek Dam, and Detroit Dam.
- Under Alternative 3A and Alternative 3B, the extent of effects would be small at Cougar Dam, Blue River Dam, and Hills Creek Dam; medium at Lookout Point Dam; and large at Green Peter Dam and Fall Creek Dam, and Detroit Dam.
- Under Alternative 4, the extent of effects would be small at Hills Creek Dam and Cougar Dam; medium at Lookout Point Dam; and large at Foster Dam, Fall Creek Dam, and Detroit Dam.

Routine and Non-routine Maintenance and Construction Activities

As under the NAA, routine, planned or unscheduled, non-routine maintenance construction activities would occur in the analysis area (Section 1.11.3, Operation, Maintenance, Repair, Replacement, and Rehabilitation). Effects from routine and non-routine maintenance activities under the action alternatives would be the same as those described under the NAA.

Construction activities and equipment associated with the features listed above would include trucks, work vehicles, excavators, bulldozers, machinery, and building materials. Unlike the NAA, where these activities would not occur, these construction elements would likely be visible to observers in the vicinity of the dams and reservoirs during the duration of construction phases under the action alternatives. However, these vehicles and equipment would not drastically alter any of the basic design elements or the visual character of the viewshed or surrounding landscapes.

Consequently, construction activities under action alternative measures would result in adverse, minor effects to visual resources as compared to the NAA, as the vehicles and equipment would be seen but would not attract attention and would not dominate the landscapes. Conversely, there may be negligible to major beneficial impacts to viewers attracted to dams specifically to view construction-related activities under the action alternatives.

The extent of adverse or beneficial visual impacts would range from small to large depending on the number of visitors that would be adversely affected by construction activities at a given dam under a given action alternative. The duration of effect would likely be short- to medium-term from construction activities and would not be permanent.

Scenic Quality Ratings would not be modified at any of the dams under any alternative because of construction activities because these activities would not be permanent. Similarly, foreground-middle ground visibility distances from viewpoints in the analysis area to natural areas surrounding the dams and reservoirs under all action alternatives would not be altered by temporary construction activities. Visual value classifications of any dam or reservoir affected by temporary construction activities would not be expected to change because there would be no substantial, long-term visual change as compared to the NAA from construction activities.

Selective Withdrawal Structures, Structural Downstream Fish Passages, and Adult Fish Facilities

Under the action alternatives, selective withdrawal structures, structural downstream fish passages as floating fish screens or weirs, and adult fish facilities would be new, permanent elements in the visual landscape. Site-specific designs for these structures would be prepared during construction design phases. Features are generally described as the following:

- Water control towers would be several hundred feet in height similar to the existing tower at Cougar Dam (Figure 3.22-12).
- Adult fish facilities would resemble those at Cougar (Figure 3.22-13), Dexter, Fall Creek, and Foster Dams, featuring any combination of buildings, fish ladders, and fish sorting areas and pools.
- Floating fish screens would generally include large platforms that connect to selective withdrawal structures and float on the water surface (Figure 3.22-14).
- Weirs generally feature a rock-filled structure with concrete, gated spillways (Figure 3.22-15).

Figure 3.22-12. Water Control Tower at Cougar Dam (a selective withdrawal structure).

Figure 3.22-13. Cougar Dam Adult Fish Facility.

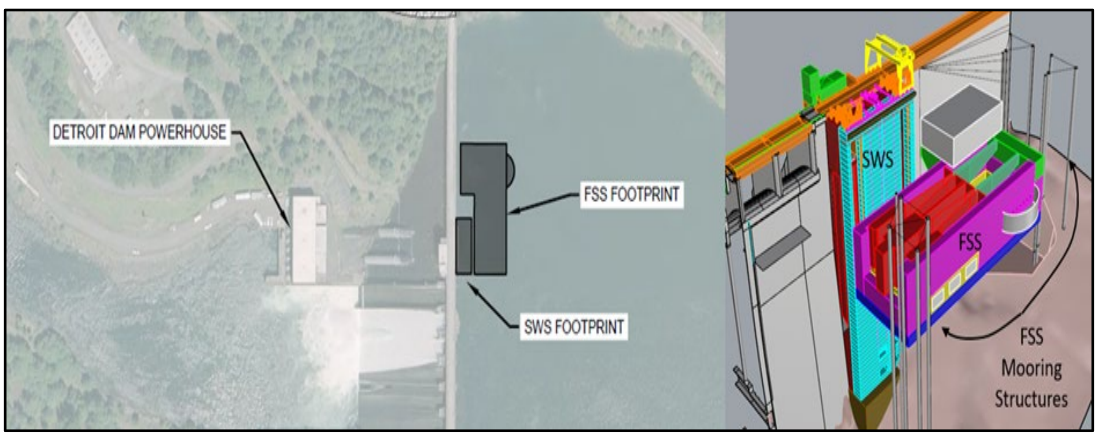

Figure 3.22-14. Proposed Detroit Water Control Tower with Attached Floating Screen Structure.

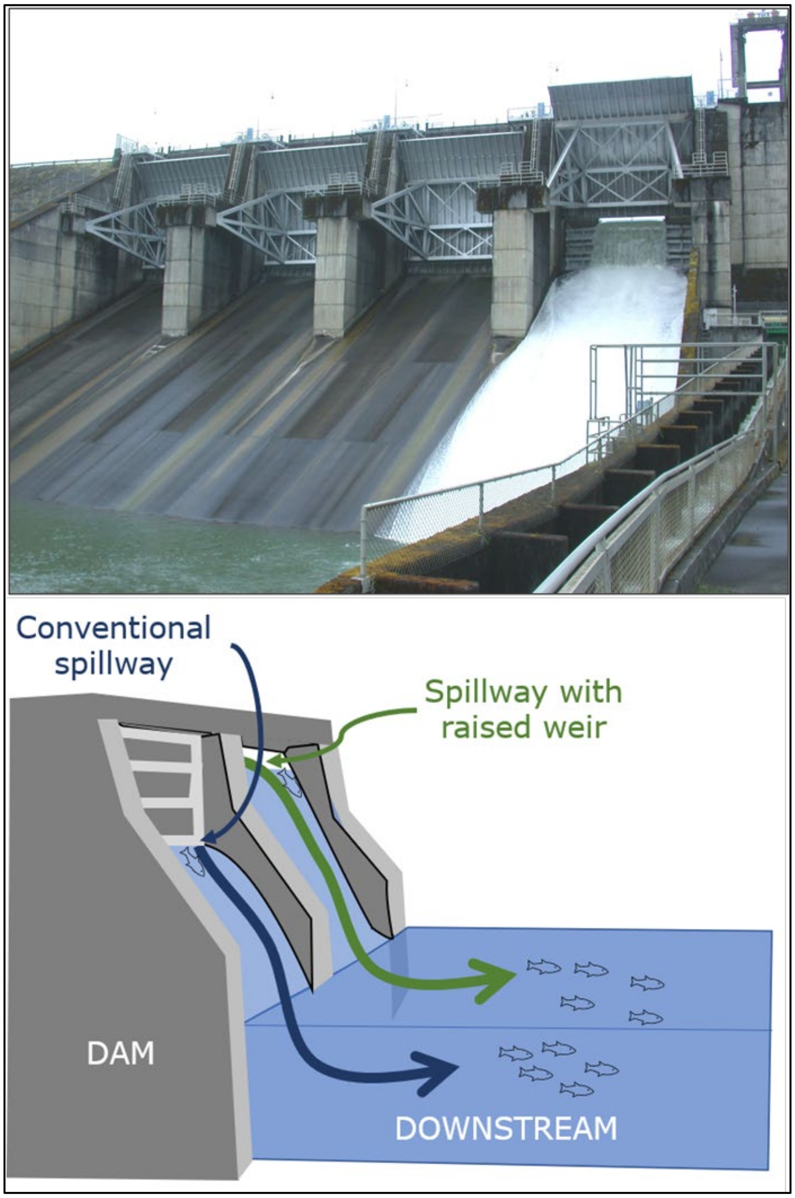

Figure 3.22-15. Foster Dam Spillway Weir (top) and General Weir Configuration (bottom).

Although water control towers, structural downstream fish passages, and adult fish facilities would be newly added and highly visible features into a viewshed, they would not likely dominate the visual character of a dam or reservoir because they would be consistent with other dam features. For example, new features would blend into the already existing landscape of the dams by generally matching in color, texture, line, and form. These structures would likely use similar building materials to the dams, match the gray coloration of the dams, contain a similar rectangular form that is comparable to the dams, have straight lines comparable to the dams, and have similar grain, density, and overall textured contrast similar to the dams. Further, the height of towers and size of floating platforms would be located within a dam and reservoir footprint and would be consistent with surrounding dam and reservoir hardscape elements.

Because these structures would not drastically alter any of the basic design elements in the landscapes under any action alternative as compared to the NAA, the magnitude of adverse and beneficial effects would be minor, as these structures would be seen but would not attract attention and would not dominate the landscapes. There would be a long-term effect to the landscapes because these structures would be permanent.

Unlike the NAA, new features may add to the visual interest that dams already provide to viewers, which would be a beneficial effect based on the perspective of the observer and based on visual values at each dam (Table 3.22-6).

Scenic Quality Rating would not be modified at any of the dams under any alternative because of the structures. Water control towers, downstream fish passage structures, and adult fish facilities would alter the viewshed with their physical presence, but the structures would mostly blend into the existing landscape and be consistent with existing dam and reservoir physical features. Overall, scenic inventory of landforms, vegetation, water, and scenic views may be slightly affected because of the structures; however, those interested in viewing dam infrastructure would gain additional features in the viewshed with the new structures.

The amount of use at all dams under any alternative may be slightly, but not considerably, affected because, as under the NAA, many of these structures already exist throughout the WVS. As under the NAA, foreground-middle ground visibility distances from viewpoints in the analysis area to natural areas surrounding the dams and reservoirs under all alternatives would not be altered.

Visual value classifications of any dam or reservoir affected by new features would not be expected to change because there would be no substantial, long-term visual change from new features as compared to the visual character of dams and reservoirs under the NAA.

Reservoir Drawdowns

Effects to visual resources from reservoir drawdowns at all dams and reservoirs under all alternatives would be similar to those described under the NAA. Sediment transport and reservoir drawdowns would noticeably alter design elements in the landscape; however, these effects already occur within the existing landscape.

Potential adverse effects from sediment transport and reservoir drawdowns would be adverse and moderate in the short term and long term, as effects would begin to attract attention and begin to dominate the visual character of the surrounding landscape. As under the NAA, visitation at most dams under the action alternatives would not likely change because water levels already fluctuate seasonally at all dams throughout the WVS (this visual characteristic is known and expected by visitors).

The most substantial visual resource effects would occur under Alternatives 2B, 3A, and 3B where refill would not occur during the peak, summer recreation season and deep drawdowns would occur during the late summer/early fall months under Alternative 3A and Alternative 3B. Cougar Reservoir would not be filled during peak, high visitor-use, summer months under all three alternatives. Additionally, Lookout Point and Detroit Reservoirs would not be refilled during the peak recreation season under Alternative 3A. Green Peter and Hills Creek Reservoirs would not be refilled during this season under Alternative 3B.

Deep drawdowns would occur during the late summer/early fall recreation season at Hills Creek, Green Peter, and Blue River Reservoirs under Alternative 3A and at Lookout Point, Detroit, and Blue River under Alternative 3B. The visual effect from the lack of a lake-like appearance would be visible from numerous vantage points accessed by summer and early fall users. This effect could be more severe during typically scenic, early fall months.

As under the NAA, Scenic Quality Ratings at any dam under any action alternative would not be modified because water clarity and coloration would return to existing conditions in the days to weeks that follow a transport event; water would eventually refill the reservoir; and landforms, vegetation, scenic views, and the overall scenic inventory would be expected to remain the same.

As under the NAA, foreground-middle ground visibility distances from viewpoints in the Affected Environment to natural areas surrounding the dams and reservoirs would not be altered under any action alternative. Visual value classifications of any dam or reservoir affected by reservoir drawdowns would not be expected to change.

3.22.6 Interim Operations under all Alternatives Except Alternative 1

The timing and duration of Interim Operations would vary depending on a given alternative. Interim operations could extend to nearly the 30-year implementation timeframe under Alternatives 2A, 2B, 4, and 5. However, Interim Operations under Alternative 3A and Alternative 3B may not be fully implemented or required because long-term operational strategies for these alternatives are intended to be implemented immediately upon Record of Decision finalization.

Interim Operations are not an alternative (Chapter 2, Alternative, Section 2.8.5, Interim Operations). Interim Operations analyses did not include consideration of the impacts assessed under action Alternatives 2A, 2B, 3A, 3B, 4, and 5 because Interim Operations will be implemented in succession with, and not in addition to, action alternative implementation.

The magnitude of effects on visual resources from Interim Operations would be moderate in the short term or in the medium term at all the dams from the following measures:

- Deep drawdown and regulating outlet prioritization for improved downstream fish passage at Green Peter, Cougar, Fall Creek, and Lookout Point Dams.

- Delayed reservoir refill and regulating outlet prioritization for improved downstream fish passage at Cougar Dam. Lower refill target elevation at Lookout Point.
- Delayed reservoir refill and utilization of the spillway in the spring for improved downstream fish passage at Foster Dam.

As under the NAA, potential adverse effects from revealed mudflats, substrate, tree stumps, and other submerged littoral zone attributes would be moderate in magnitude from Interim Operations.

Effects would be large in extent at Green Peter, Foster, and Fall Creek Dams and Reservoirs because these dams recorded greater than 75,000 visitors in 2022, and would be medium at Lookout Point Dam and Reservoir because this dam recorded between 50,000 to 75,000 visitors, and small at Cougar Dam and Reservoir because this dam recorded less than 50,000 visits in 2022.

3.22.7 Climate Change under All Alternatives

Climate change would adversely affect visual resources surrounding the dams and reservoirs over the 30-year implementation timeframe under all alternatives because of changes to the visual landscape from climate alterations. Such alterations would modify the existing design elements in the landscape, which may be temporary or permanent depending on the type and severity of the climate conditions. Climate change conditions would occur regardless of the alternative implemented. The Implementation and Adaptive Management Plan incorporates climate change monitoring and potential operations and maintenance adaptations to address effects as they develop (Appendix N, Implementation and Adaptive Management Plan).

Under all alternatives, increased variability in spring precipitation may result in less reliable reservoir refill during the 30-year implementation timeframe (Section 3.2, Hydrologic Processes) (Warner et al. 2015) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.5, Changes in Winter Atmospheric Rivers; Appendix F2, Supplemental Climate Change Information, Section 3.1.2, Precipitation). Drawdowns may be more rapid to meet downstream minimum flow targets as climate conditions change, which would present landslide risk at some dams in the analysis area (Section 3.4, Geology and Soils). Landslides would result in highly visible landscape contrast and would alter the surrounding viewshed for an extended period or permanently during the 30-year planning timeframe.

Additional landscape alterations would include increased shoreline exposure if a lack of precipitation due to climate change causes a need for deep drafts to maintain outflows (Section 3.4, Soils and Geology). Increased shoreline exposure would also result in increased visual contrast and would alter the existing landscape for unknown timeframes.

3.22.7.1 Wildfires

Wildfire intensity and frequency associated with climate change would drastically alter the design elements associated with forested, natural landscapes in the affected environment by substantially changing the color, form, and texture due to the burnt, darkened, and decimated landscapes that follow wildfires. Periodically, wildfire ash would deposit in reservoirs, streams, and rivers, increasing turbidity and affecting the visual quality of those water bodies (Oregon Department of Energy 2023) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.8, Summary of Projected Trends in Climate; Appendix F2, Supplemental Climate Change Information, Section 3.1.5, Wildfire Danger).

Wildfires would also harm or potentially destroy recreation sites, trails, and large areas of forested landscape. These changes would result in substantial decreases in visual value in any area that is impacted by wildfires. Consequently, Scenic Quality Ratings and sensitivity levels would be substantially adversely affected.

Foreground-middle ground visibility distances from viewpoints in the analysis area to natural areas surrounding the dams and reservoirs would not be altered under any action alternative, but adverse visual quality in these viewsheds would be severe depending on the magnitude of a given wildfire. For example, if wildfires decimate a large extent of the viewshed surrounding a dam and reservoir, the addition of a large water control tower and large floating structures in the viewshed under an action alternative would enhance visual contrast within a new visual landscape post-fire.

3.22.7.2 Temperature

Ambient air temperature changes, low summer flows, and reservoir evaporation could potentially affect visual resources at dams and reservoirs by lowering reservoir levels and altering design elements associated with surface water landscapes to those associated with terrestrial landscapes. Long-lasting droughts and warm conditions could compromise earth dams, such as Fall Creek Dam, as soils crack from drying, potentially eroding and altering landscape characteristics (Fourth Annual Climate Change Assessment 2018) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.1.2, Fourth National Climate Assessment; Appendix F2, Supplemental Climate Change Information, Section 3.1.1, Temperature).

Warmer temperatures from climate change could also provide favorable conditions for the propagation of harmful algal blooms, which can discolor, cloud, or cover the water’s surface adversely affecting visual quality (Section 3.5, Water Quality).

3.22.7.3 Precipitation

As a result of changes in annual precipitation and precipitation amounts, climate change could also exacerbate long-term, recurring effects from drawdowns and further change the design elements of color, texture, and form (Warner et al. 2015) (Appendix F1, Qualitative Assessment of Climate Change Impacts, Section 4.5, Changes in Winter Atmospheric Rivers; Appendix F2, Supplemental Climate Change Information, Section 3.1.2, Precipitation). Direct effects on shoreline erosion could occur and cause sedimentation and increased turbidity, affecting water color and clarity if reservoir levels are lowered due to low summer flows and long-lasting droughts.

Indirect effects to color would then occur as water changes slightly to a darker color with the introduction of darker clays, silts, and sediments; texture would change slightly with the introduction of grainy sediment particles and other larger suspended particulate materials; and form would change slightly with the introduction of a variety of irregular shapes, sizes, and masses from the suspended solids. As such, climate change and the drawdowns would result in moderate to major recurring effects on visual resources in the long term and effects would be large in extent.

END REVISED OR NEW TEXT

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.23 NOISE

3.23 Noise

THE DEIS NOISE SECTION HAS BEEN DELETED IN THE FEIS

Summary of changes from the DEIS:

- **After considering analyses in the DEIS, there is no potential for a significant impact to occur to noise levels under any of the alternatives, including the No-action Alternative, over the 30-year implementation timeframe. Per the DEIS analysis, noise impacts under the alternatives would be generated from construction activities and facilities operations. However, these actions are ongoing, and activities under the alternatives would not measurably increase the ambient noise levels above existing conditions. Existing condition noise levels do not carry beyond the vicinity of a dam or reservoir.**
- **Per the DEIS analysis, noise "receptors" (i.e., those who would hear activity noise) would be primarily recreationists in campgrounds and on trails and reservoirs. There may be little recreation use in the area depending on the time of year that noise activities would occur. Lastly, increases in noise levels would be temporary and would remain localized/would not travel beyond a dam or reservoir site.**
- **Deletion of Section 3.23 and Section 4.23, Noise, is supported by 40 CFR 1501.1(d) and 1500.4(g) (identifying significant environmental issues and deemphasizing insignificant issues), 1501.7 (identification of significant issues related to the Proposed Action), and 1500.1(b) (NEPA documents must concentrate on issues that are 'truly significant' to the Proposed Action).**

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.24 TRIBAL RESOURCES

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3.24 Tribal Resources

THE TRIBAL RESOURCES SECTION HAS BEEN REVISED FROM THE DEIS
REPEATED INFORMATION HAS BEEN DELETED OR MOVED TO APPENDIX O
INSERTION OF LARGE AMOUNTS OF TEXT IS IDENTIFIED; MINOR EDITS ARE NOT DENOTED

Summary of changes from the DEIS:

- **Duplicative summaries of direct and indirect effects from other Chapter 3 sections have been removed.**
- **Clarifications have been made regarding tribal involvement in EIS development in Section 3.24.2, Affected Environment.**
- **Information on tribal perspectives has been moved to Appendix O, Tribal Coordination and Perspectives. The summary table has been updated (Table 3.24-2).**
- **Information on consideration of traditional cultural properties and historic properties of religious and cultural significance to Indian tribes has been clarified in Section 3.24.3, Environmental Consequences.**
- **Cross references to other EIS sections have been added where applicable.**
- **Consistent terminology has been applied and defined as applicable.**
- **Grammatical clarifications have been made.**
- **Capitalizations for 'tribe' and 'tribal' follow the 2016 Government Publishing Office editing conventions, which are supported by the Bureau of Indian Affairs Editorial Guide.**

3.24.1 Introduction

Tribal resources are multifaceted; defining these resources is dependent on legal and social circumstances. To analyze the alternatives, tribal resources include lands and resources defined as Indian Trust Assets (ITAs); treaty and reserved rights that occur on and off Indian trust lands; and the lands and resources that are in the homelands, ancestral territories, and usual and accustomed places of tribes but are now owned by the Federal Government.

The Federal Government has a legal "trust responsibility" to ensure that it supports tribal self-governance, economic prosperity, access to treaty resources, and rights of access and use of natural and cultural resources on ancestral lands. This trust doctrine is elemental to the treaties that serve as the foundation for tribal legal standing as domestic sovereign nations. This unique relationship between Federally recognized Indian tribes and the Federal Government is based on nearly 250 years of treaties, case law, Federal statute, and executive orders.

Indian tribes ceded millions of acres of tribal lands to the Federal Government between 1798 and 1871 in return for much smaller land reservations and Federally guaranteed rights, assets, and support intended to ensure the well-being and continuance of Indian tribes. As a result, Indian peoples were removed from the Willamette Valley and relocated to land reservations on the margins of the Willamette Valley.

It was during the reservation era that lawmakers developed a system to place these tribal lands and resources in the care of the Federal Government (now known as ITAs). In this legal relationship, the Federal Government acts as a trustee of assets for the tribe, or beneficiary. The Federal Government has a fiduciary responsibility to ensure that those assets are managed for the benefit of Indian tribes or individuals.

ITAs can include reserved tribal lands; minerals on trust lands; hunting, fishing, and gathering rights typically on trust lands; and water rights that can be on or off tribal lands (USDI No Date-a, No Date-b; U.S. DHHS No Date; Tsosie 2003). Treaty and reserved rights are another component of tribal resources but are not categorically defined as ITAs (USDI No Date-a, No Date-b).

3.24.1.1 Rights and Treaties

During the treaty-signing era, Indian tribes granted lands and rights to the Federal Government while explicitly retaining certain rights (as written in the treaties), but they also retained or reserved those rights not expressly granted to the Federal Government. For example, unless a treaty (or statute) explicitly nullified hunting, fishing, and gathering rights throughout their original homelands, a tribe would retain this right as the original owner.

All major treaties signed by tribes of the Willamette Valley occurred prior to Oregon statehood in 1859 (between 1853 and 1855). The descendants of the original Willamette River Basin peoples are now represented by several Federally recognized tribes; the management of natural and cultural resources on trust lands, ancestral territories, and usual and accustomed areas are of primary concern to these tribes. The entire Willamette Valley System (WVS) lies within the ceded lands of the Confederated Tribes of the Grand Ronde Community of Oregon

Tribal members have the legal right to use and derive profit or benefit from property that belongs to the Federal Government because of treaty and reserved rights. The governance of ITAs is explicit because a given resource is managed only to provide benefit to Indian tribes and individuals, whereas the full expression of treaty and reserved rights off tribal trust lands can be unclear, especially when these rights conflict with “public trust” and Federal lands (Tsosie 2003).

The Federal Government owns and manages approximately 640 million acres of land (CRS 2021; NALC No Date; USGAO No Date). This is approximately 28 percent of the total area of the United States, which is 2.7 billion acres. Four land managing agencies oversee most public lands (606.5 million acres or 95 percent), including the U.S. Forest Service, U.S. Fish and Wildlife

Service, National Park Service, and U.S. Bureau of Land Management. USACE also manages nearly 9 million acres of public lands.

Each of these agencies has a different mission statement, but the concept of public trust is that all Federal agencies employ ethical management and stewardship of public lands and resources for the continued benefit of the American public. This is a major tenet of the four land-managing agencies. Americans recreate on, have access to natural and cultural resources, and enjoy public lands per this public trust, which can directly impact how tribes can access and use treaty and reserved rights. An example of this management conflict is when public recreational activities are incongruous with management of tribal sacred sites (Tsosie 2003).

3.24.1.2 Traditional Tribal Lands

More generally, treaty and reserved rights that are off Indian trust lands occur on public lands and are within the homelands, ancestral territories, or usual and accustomed areas of tribes. Traditional tribal lands are where indigenous communities lived, traveled, and traded for millennia before European and Asian colonizers, explorers, and immigrants came to what is now known as the State of Oregon in the 16th century and to the Willamette Valley in the early 19th century. By their reckoning, Willamette Valley tribes have lived here since “time immemorial,” and it is a historical fact that the tribes were unwillingly divested of their homelands through deceit and force. The tribes may have ceded the lands of the Willamette Valley and the majority of the State of Oregon to the Federal Government, but this did not sever their connection to the area.

3.24.1.3 Federal Indian Policy

Federal Indian policy of the last 50 years has moved toward supporting self-determination[1] and prosperity for Indian tribes. As such, USACE adheres to the following tenets:

- Tribal governments are sovereign nations, and USACE recognizes the right of tribes to self-government.
- USACE will work to meet trust obligations, protect trust resources, and obtain tribal views of trust and treaty responsibilities.
- USACE leaders will meet with the leaders of tribal governments on a government-to-government level. USACE recognizes that tribes have a right to be treated in accordance with the principles of self-determination.
- USACE will collaboratively involve tribes, before and throughout the decision-making process, to ensure a timely exchange of information, to account for disparate viewpoints, and to use a fair and impartial dispute resolution process.

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[1] The term “self-determination” is specific to tribal policy as used in this EIS. Laws and policies are established to promote Indian self-determination (https://crsreports.congress.gov/product/pdf/IF/IF11877/2).

- USACE will search for ways to involve tribes in programs, projects, and other activities that build their economic capacity and to manage tribal resources while preserving cultural identities.
- USACE will act to fulfill its obligations to preserve and protect trust resources and to consider the potential effects of its programs on natural and cultural resources (USACE No Date-q).

Similarly, in November 2021, the Advisory Council on Historic Preservation, the Department of Defense (which oversees USACE), the Department of the Interior, the White House Council on Environmental Quality, and 12 other departments and independent agencies executed the *Memorandum of Understanding Regarding Interagency Coordination and Collaboration for the Protection of Tribal Treaty Rights and Reserved Rights* (ACHP et al. 2021). Through this document, the signatory agencies stated:

> Treaty-protected rights to use of and access to natural and cultural resources are an intrinsic part of tribal life and are of deep cultural, economic, and subsistence importance to tribes. Many treaties protect not only the right to access natural resources, such as fisheries, but also protect the resource itself from significant degradation. Under the U.S. Constitution, treaties are part of the supreme law of the land, with the same legal force and effect as federal statutes. Pursuant to this principle, and its trust relationship with federally recognized tribes, the United States has an obligation to honor the rights reserved through treaties, including rights to both on and, where applicable, off-reservation resources, and to ensure that its actions are consistent with those rights and their attendant protections. Accordingly, the Parties recognize the need to consider and account for the effects of their actions on the habitats that support treaty-protected rights.
>
> The Supreme Court has explained that Indian treaties are to be interpreted liberally in favor of tribes, giving effect to the treaty terms as tribes would have understood them, with ambiguous provisions interpreted for their benefit…This means that federal agencies must give effect to treaty language and ensure that federal agency actions do not conflict with tribal treaty and reserved rights…Integrating consideration of tribal treaty and reserved rights into agency decision-making and regulatory processes is consistent with the Federal Government’s trust responsibility to federally recognized tribes and to fundamental principles of good government. Treaties themselves are the source of legal authority to ensure that agency processes account for reserved treaty rights.

Executive Orders that guide USACE Tribal Policy Principles

Executive Order 13175, dated November 6, 2000, Consultation and Coordination with Indian Tribal Governments

Presidential Memorandum, dated April 29, 1994, Government-to-Government Relations with Native American Tribal Governments

Presidential Memorandum, dated November 5, 2009, Tribal Consultation

Office of the Secretary of Defense Trust Responsibility and Consultation Matrix

In addition to the United States Constitution, case law, and Executive Orders, USACE also complies with numerous environmental and cultural resources protection laws that require early and meaningful consultation and collaboration with tribes to identify, manage, and assess and mitigate effects to resources and lands that are important to the tribes (e.g., USACE No Date-r, No Date-s). Major laws include the National Environmental Policy Act of 1969 (NEPA), Endangered Species Act of 1973 (ESA), the National Historic Preservation Act of 1966 (NHPA), and the Native American Graves Protection and Repatriation Act, of 1990 (NAGPRA).

3.24.2 Affected Environment

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

All resources analyzed in the EIS are tribal resources. It is impracticable to document all treaty rights and reserved rights, ancestral territories and usual and accustomed areas, and the resources held within to attempt to quantify tribal resources potentially affected by implementation of any alternative. The entirety of the Willamette River Basin landscape and resources are tribal resources when taking the views and beliefs of the tribes into consideration. Consequently, the analysis area broadly covers the Willamette River Basin. The Willamette River Basin encompasses the WVS—the 13 dams and reservoirs managed by USACE.

The health and viability of the economy, environment, and society of the Willamette Valley and connected areas are important to the individual American citizens who also belong to sovereign nations of Federally recognized tribes. Federally recognized tribes with a vested interest in and deep historical connection to the Willamette Valley have reiterated this through the consultation process with USACE on a government-to-government basis and through project-specific consultation that has and continues to occur.

There are 10 Federally recognized Indian tribes with interests pertaining to the analysis area, which were consulted for EIS development[2] (Appendix O, Tribal Coordination and Perspectives):

- Confederated Tribes and Bands of the Yakama Nation (Yakama)
- Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI)

[2] In response to USACE requests for consultation dated September 30, 2021, representatives from the CTCLUSI, Coquille, and Klamath Tribes declined to consult on EIS development and deferred to other tribes.

- Confederated Tribes of the Grand Ronde Community of Oregon (Grand Ronde)
- Confederated Tribes of Siletz Indians (Siletz)
- Confederated Tribes of the Umatilla Indian Reservation (Umatilla)
- Confederated Tribes of Warm Springs Reservation of Oregon (Warm Springs)
- Coquille Indian Tribe (Coquille)
- Cow Creek Band of Umpqua Tribe of Indians (Cow Creek)
- Klamath Tribes (Klamath)
- Nez Perce Tribe (Nez Perce)

In response to USACE's requests to consult, the Coquille, CTCLUSI, and Klamath Tribes deferred involvement to the appropriate tribes, while the Cow Creek, Grand Ronde, Siletz, Nez Perce, Umatilla, Warm Springs, and Yakama Tribes have expressed continued interest in EIS development.

USACE routinely consults with the Cow Creek, Grand Ronde, Siletz, and Warm Springs Tribes for WVS actions that require NEPA review and undertakings that require NHPA compliance (Chapter 1, Introduction, Section 1.3.1, National Environmental Policy Act; Section 3.21.2, Federal Laws and U.S. Army Corps of Engineers Regulations). As a result, USACE invited the four Tribes to participate as Cooperating Agencies in development of the EIS. Only the Grand Ronde Tribe signed a Memorandum of Understanding with USACE to formalize their cooperator status. USACE did not invite other tribes to participate as Cooperating Agencies.

In 2020–2022, USACE also partnered with the Cow Creek, Grand Ronde, Siletz, and Warm Springs Tribes, as well as several Federal and state partners and other interested parties, to execute a program-level programmatic agreement. This agreement modifies the NHPA Section 106 process to follow a streamlined and standardized approach to manage historic properties that have the potential to be impacted by USACE undertakings[3] related to the current and future operations of the WVS (Section 3.21.2, Federal Laws and U.S. Army Corps of Engineers Regulations).

3.24.2.1 Tribal Interests in the Analysis Area

The Cow Creek, Grand Ronde, Nez Perce, Siletz, Umatilla, Warm Springs, and Yakama Tribes have treaties that serve as the legal foundations connecting them with the Willamette Valley (Table 3.24-1). The Tribes have distinct but sometimes overlapping interests. The Grand Ronde, Siletz, and Cow Creek Tribes tend to have interests centered within the Willamette Valley (although interests expand beyond the Willamette Valley), while the Yakama, Umatilla, and Nez

[3] An undertaking is any project, activity, or program that a Federal agency funds, permits, licenses, or approves, in whole, or in part.

Perce Tribal interests are centered in the Columbia Plateau. The Warm Springs Tribe has interests that extend to both the Columbia River and Willamette Valley.

Table 3.24-1. Affected Indian Tribes and Willamette River Basin-relevant Treaties.

Federally Recognized Tribe(s)	Treaties
Confederated Tribes of the Grand Ronde Community of Oregon	Rogue River Treaty, September 10, 1853 Treaty with Cow Creek Band of Umpqua, September 19, 1853 Rogue River Treaty, November 15, 1854 Treaty with the Chasta, Scoton, and Umpqua, November 18, 1854 Treaty with the Umpqua and Kalapuya, November 29, 1854 Willamette Valley Treaty, January 22, 1855 Treaty with the Molalla, December 21, 1855
Cow Creek Band of Umpqua Tribe of Indians	Cow Creek Band of Umpqua Treaty, September 19, 1853
Confederated Tribes and Bands of the Yakama Nation	Yakama Treaty, June 9, 1855
Nez Perce Tribe	Nez Perce Treaty, June 11, 1855
Confederated Tribes of the Umatilla Indian Reservation	Walla Walla Treaty, June 9, 1855
Confederated Tribes of Warm Springs Reservation of Oregon	Treaty of 1855 (also Treaty with the Tribes of Middle Oregon, June 25, 1855)
Confederated Tribes of Siletz Indians	Rogue River Treaty, September 10, 1853

One area of noticeable overlap is the historical and continued use of Willamette Falls. All of the tribes, with the exception of the Cow Creek Tribe, claim the falls as ceded lands or ancestral territory and currently procure salmon and lamprey from the Willamette River near the falls (CTGR 2022b; CTUIR 2021; CTWS 2021b; Karson Engum 2020; WFT No Date).

According to the U.S. Bureau of Indian Affairs, Division of Land Titles and Records, only the Grand Ronde and Warm Springs Tribes have ITA holdings in the outer reaches of the Willamette River Basin (BIA No Date). The Grand Ronde Tribe has an 11,500-acre reservation in the western extent of the Yamhill River Subbasin (CTGR 2022a). This amount is substantially reduced from the original size of the Grand Ronde Reservation established by Executive Order on June 30, 1857 (61,000 acres) but increased from 9,811 acres that the Tribe got back through the Grand Ronde Restoration Act of November 22, 1983 (CTGR 2022a). As a result of the seven treaties, Grand Ronde Tribal ancestors ceded all of the Willamette Valley and beyond for a substantially reduced reserve of Tribal lands.

On the opposite end of the Willamette River Basin, a small portion of the western boundary of the Warm Springs Reservation overlaps with the eastern tips of the Clackamas and North Santiam River Subbasins. The reservation currently totals 644,000 acres, which is a small fraction of the 10 million acres ceded in 1855. The original treaty incorrectly provided for 464,000 acres, but this was rectified in 1972 to include another 180,000 acres after the resolution of a longstanding boundary dispute.

ITA holdings for the Grand Ronde and Warm Springs Tribes are located outside of the analysis area (i.e., in the Clackamas and Yamhill River Subbasins) or in upper reaches above the WVS (i.e., North Santiam River Subbasin). However, the Grand Ronde Tribe owns off-reservation lands in Polk County, Oregon.

3.24.3 Environmental Consequences

Potential direct, indirect, and climate change effects of the alternatives on tribal resources encompass all resource effects analyzed in the EIS. As such, the degrees of effects are broad, ranging from substantial under some resources and alternatives to minor or no effect under others. These effects are summarized in Section 3.25, Summary of Direct and Indirect Environmental Consequences.

This environmental consequences section summarizes tribal issues related to the alternatives (Table 3.24-2). Consideration of traditional cultural properties and historic properties of religious and cultural significance to Indian tribes are discussed in Section 3.21, Cultural Resources, and Appendix O, Tribal Coordination and Perspectives.

Defining and documenting views of the tribes who have a vested interest in the analysis area and potential impacts from operations and maintenance of the WVS was ongoing throughout EIS development and acquired through tribal engagement. The Grand Ronde Tribe as a Cooperating Agency engaged in cooperator meetings and provided verbal and written comments in their cooperator capacity and through the public comment process. Staff from the Siletz and Warm Springs Tribes attended cooperator meetings and were able to participate in the EIS development process although no written comments have been received from the two Tribes (Section 3.24.2, Affected Environment; Appendix O, Tribal Coordination and Perspectives; Appendix V, Draft EIS Public Comments and Responses). The Yakama Tribe and the Columbia River Inter-Tribal Fish Commission (CRITFC)4, who represents the Nez Perce,

[4] CRITFC is a tribal organization that is wholly owned and governed by the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and Bands of the Yakama Nation. As a tribal organization, CRITFC is subject to a unique blend of policies and laws (https://critfc.org/).

Umatilla, Warm Springs, and Yakama Tribes, provided comments through the public scoping process (Appendix P, Public Scoping Report).

USACE requested a point of contact for potentially affected tribes, and written perspectives on tribal resources and potential impacts from operations and maintenance of the WVS on these resources (Appendix O, Tribal Coordination and Perspectives).

Table 3.24-2. Tribal Issues Identified for Development of the Willamette Valley System Operations and Maintenance Environmental Impact Statement.

Federally Recognized Tribe or Tribal Advocacy Group	Issues and Concerns
Confederated Tribes of the Grand Ronde Community of Oregon	The Grand Ronde Tribe provided comments on June 2, 2020, noting: • The Tribe wishes to be involved in measure and alternative development. • Balance project needs to include operations and structure-based measures, as needed. • Include monitoring, evaluation, and adaptive management programs. • Consider interim measures as well as long-term and no-term measures in analyses. • Analyze measures for salmon and lamprey in the Coast Fork and Long Tom River Subbasins. • Include Long Tom River Subbasin structure removal/modification measures. • Include fish passage measures at Dorena and Cottage Grove Dams. • Use annual drawdowns at all or most reservoirs, where feasible. • Consider Pacific lamprey passage at all dams and reservoirs. • Consider structures at Cougar and Detroit Dams. • Include the Tribe in water quality discussions. • Baseline analyses should be pre-system for all resources that existed before the WVS was constructed. In a November 2, 2022, Tribal Perspectives statement, the Grand Ronde Tribe noted that important Tribal resources include: • Archaeological values. • Historic values. • Aesthetic/visual values.

Federally Recognized Tribe or Tribal Advocacy Group	Issues and Concerns
	• Tribal Cultural Landscapes as defined by the Tribe. • Quality and integrity of water, air, and soil. • All native habitats, regardless of current land ownership or status. • All native species, whether they have any special status under Federal or state law, and regardless of current management responsibility. The Grand Ronde Tribe provided additional comments on February 21, 2023, noting: • Operation of the Willamette River Basin dams has driven the Upper Willamette River (UWR) Chinook salmon and steelhead to the brink of extinction. USACE must act urgently to right this historic wrong. • Preferred Alternative should focus on immediate operational measures to improve volitional juvenile outmigration. • The Final EIS should accurately describe that hydropower from USACE-managed dams is not profitable. • The alternative analyses violate NEPA by failing to evaluate a no-hydropower alternative. • The Final EIS should include robust monitoring and inclusive adaptive management. • The Final EIS must evaluate environmental justice impacts of salmon decline on the Tribe and other Tribal Nations. The Grand Ronde Tribe provided comments on March 21, 2024, noting: • Salmon are an essential part of the cultural and lifeways of the Grand Ronde Tribe. Salmon are our heritage, our identity, and our cultural responsibility. They also noted that cultural resources are important to the Grand Ronde Tribe: • The Grand Ronde Tribe has been in consultation with USACE for development of the WVS program-level National Historic Preservation Action Section 106 programmatic agreement to manage cultural resources.

Federally Recognized Tribe or Tribal Advocacy Group	Issues and Concerns
CRITFC, while not a tribe, advocates for and submitted comments on behalf of the Yakama, Umatilla, Warm Springs, and Nez Perce Tribes	CRITFC provided comments on June 28, 2019, noting concerns with the following: • Tribal fishery of Columbia River and tributaries. • Non-tribal fishery of Columbia River and tributaries. • Hatchery production. • Protection of natural spawning environment. • Protection of downstream and upstream migration through the river. • Pacific lamprey. • Fish and wildlife. • Cumulative impact analyses for the Willamette Basin Water Reallocation Project and WVS EIS. • Water quality. • Climate change. • Adequate flows for fish and wildlife. • Tribal cultural resources. • Hydropower system operations. • Hydropower system structural modifications. • Off-site mitigation. • Reservoir ecology. • Data and metrics used in the EIS analyses.
Confederated Tribes of Siletz Indians	The Siletz Tribes have been invited to consult with USACE on development of the WVS program-level NHPA Section 106 programmatic agreement to manage cultural resources.
Cow Creek Band of Umpqua Tribe of Indians	The Cow Creek Tribe has been invited to consult with USACE on development of the WVS program-level NHPA Section 106 programmatic agreement to manage cultural resources.
Confederated Tribes and Bands of the Yakama Nation	The Yakama Tribe provided comments on April 17, 2019, noting: • Concerns that any proposals developed through any EIS may interfere with Yakama Nation Treaty-reserved rights. • A request for meaningful technical-level engagement with USACE during the NEPA process and development of the EIS. CRITFC provided comments on behalf of the Columbia River Tribes on June 28, 2019.

Federally Recognized Tribe or Tribal Advocacy Group	Issues and Concerns
Nez Perce Tribe	CRITFC provided comments on behalf of the Columbia River Tribes on June 28, 2019.
Confederated Tribes of the Umatilla Indian Reservation	CRITFC provided comments on behalf of the Columbia River Tribes on June 28, 2019.
Confederated Tribes of Warm Springs Reservation of Oregon	CRITFC provided comments on behalf of the Columbia River Tribes on June 28, 2019. The Warm Springs Tribe has been in consultation with USACE on development of the WVS program-level NHPA Section 106 programmatic agreement to manage cultural resources. The Warm Springs Tribe identified the following topics and issues in their usual and accustomed areas (CTWS 2021a): *Fisheries Program* • Upland, riparian, and aquatic habitats for fish. • Natural production of anadromous and resident fish populations. • Enhancing and supplementing Chinook salmon and steelhead trout populations. • Providing support and expertise to agencies that manage fisheries programs. *Conservation Lands Program and the Willamette Wildlife Mitigation Program (ODFW No Date).* • Little Sweden is 183.17 acres of privately-owned Tribal land on the North Santiam River, directly downstream from Big Cliff Reservoir (1 mile west of the dam). The Tribe manages this land for fish and wildlife habitat and for members to hunt, fish, gather forest products, and recreate. This is not an ITA. • Austin Hot Springs is a 151.7-acre privately-owned Tribal property in the Clackamas River drainage. It is not located on the WVS. This is not an ITA. • Red Hills is a privately-owned Tribal property of 278.5 acres of fish and wildlife habitat. Tribal members can hunt, fish, gather forest products, and recreate. This is not an ITA.

Sources: Direct comment on EIS development by tribal and CRITFC representatives, and official websites of tribes and CRITFC.

END REVISED TEXT

US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.25 SUMMARY OF DIRECT AND INDIRECT ENVIRONMENTAL CONSEQUENCES

LIST OF TABLES

Table 1. Santiam River Subbasin Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Detroit Reservoir[1]	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage more than 75% of years during the spring and would very rarely reach the bottom of conservation storage in the fall.	Would reach the top of conservation storage about 75% of years during the spring and would very rarely reach the bottom of conservation storage in the fall.	Same as Alternative 2A.	Would never reach the top of conservation storage during summer and would reach lower minimum elevation 75% of years. Increased winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage about 75% of years during the spring and would very rarely reach the bottom of conservation storage prior to deeper fall reservoir drawdown. Increased winter storage space from deeper fall reservoir drawdown.	Same as Alternative 2A.	Same as Alternative 2A.
Detroit Reservoir/ Big Cliff Reservoir Outflow	Would meet or exceed outflow targets between 1,000 cfs and 1,500 cfs except in fall of very dry years.	Would meet or exceed outflow target of 1,050 cfs in nearly all years.	Would meet or exceed outflow target of between 1,000 cfs and 1,600 cfs in nearly all years.	Same as Alternative 2A.	Would increase spring flow. Would meet outflow target between 1,000 and 1,600 cfs in only 25% of wettest years; minimum flow of about 400 cfs in dry years.	Would meet or exceed outflow target of between 1,000 cfs and 1,600 cfs except in fall of very dry years.	Same as Alternative 2A.	Same as Alternative 2A.
North Santiam River at Mehama	Flow would vary within Biological Opinion targets, falling to about 700 cfs in fall of very dry years.	Steadier flow with Congressionally authorized minimum flow targets, falling to about 950 cfs in fall of very dry years.	Lower varied spring flow across all years. About 1,000 cfs in fall of very dry years.	Same as Alternative 2A.	Higher spring flow. Only wettest years would approach NAA flows in summer with about 400 cfs in fall of very dry years.	Lower varied spring flow and higher summer flow across all years. About 1,000 cfs in fall of very dry years.	Same as Alternative 2A.	Same as Alternative 2A.
Green Peter Reservoir[2]	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage more than 90% of years during the spring and would very rarely reach bottom of conservation storage in the fall.	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior to the deeper fall reservoir drawdown. Would increase winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior to the deeper fall reservoir drawdown. Would increase winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior to the deeper fall reservoir drawdown. Would increase winter storage space from deeper fall reservoir drawdown.	Would never reach the top of conservation storage during summer and would reach lower minimum elevation about 70% of years. Would increase winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage less than 75% of years during the spring and the lower minimum elevation in about 5% of years in late fall.	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior to the deeper fall reservoir drawdown. Would increase winter storage space from deeper fall reservoir drawdown.
Foster Reservoir[3]	Would only vary from rule curve during flood operations.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same No-action Alternative.	Would reach the bottom of conservation storage in summer during average and drier years.	Same No-action Alternative.	Would only vary from rule curve during flood operations.
Green Peter Reservoir / Foster Reservoir Outflow	Would meet or exceed outflow targets between 800 cfs and 1,500 cfs except in summer and fall of very dry years.	Would meet or exceed outflow target of 750 cfs in nearly all years.	Would increase fall flow. Would meet or exceed outflow target of between 1,000 cfs and 1,550 cfs except in fall of very dry years.	Same as Alternative 2A.	Same as Alternative 2A.	Would increase spring flow. Would only meet flow targets in very wet years. Average summer flow about 600 cfs, and dry years minimum flow about 110 cfs.	Would meet or exceed outflow target of between 1,000 cfs and 1,550 cfs except in fall of very dry years.	Same as Alternative 2A.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
South Santiam River at Waterloo	Flow would vary within Biological Opinion targets, falling to about 550 cfs in fall of very dry years.	Steadier flow with Congressionally authorized minimum targets, falling to about 700 cfs in fall of very dry years.	Lower varied spring flow and higher summer flow across all years. About 900 cfs in very dry years. Higher fall flows due to drawdown.	Same as Alternative 2A.	Same as Alternative 2A.	Higher spring flow. Only wettest years would approach NAA flow in summer with minimum of about 100 cfs in dry years.	Lower varied spring flow and higher summer flow across all years. About 900 cfs in very dry years.	Same as Alternative 2A.
Santiam River at Jefferson	Flow would vary within Biological Opinion targets, falling to about 1,200 cfs in summer of very dry years.	Lower, steadier flow across all years in spring and summer and higher flow in fall as reservoirs prepare for flood season. About 1,200 cfs in very dry years.	Lower spring flow in dry years. Higher summer flow across all years and much higher fall flow during Green Peter Reservoir drawdown. About 1,400 cfs in very dry years.	Same as Alternative 2A.	More varied flow from spring to fall. More flow during wet years and less flow during dry years. About 800 cfs in very dry years.	Higher spring flow. More summer flow during wet years and less during dry years. About 700 cfs in very dry years.	Lower spring flow in dry years and higher summer and fall flow across all years. About 1,400 cfs in very dry years.	Lower spring flow in dry years. Higher summer flow across all years and much higher fall flow during Green Peter Reservoir drawdown. About 1,700 cfs in very dry years.

% = percent; cfs = cubic feet per second

[1] Detroit Reservoir top and bottom of conservation storage are elevations 1,563.5 feet and 1,450 feet, respectively.

[2] Green Peter Reservoir top and bottom of conservation storage are elevations 1,010 feet and 922 feet, respectively.

[3] Foster Reservoir top and bottom of conservation storage are elevations 637 feet and 613 feet, respectively.

Table 2. Long Tom River Subbasin Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Fern Ridge Reservoir[1]	Would reach the top of conservation storage about 50% of years during the spring. Fall drawdown to prepare for flood operations.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Long Tom River at Monroe	Would maintain 50 cfs summer target. Winter regulation maximum target of 6,000 cfs.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.

% = percent; cfs = cubic feet per second

[1] Fern Ridge Reservoir top and bottom of conservation storage are elevations 373.5 feet and 353 feet, respectively.

Table 3. McKenzie River Subbasin Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Blue River Reservoir[1]	Would reach the top of conservation storage more than 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage about 95% of years during the spring and would very rarely reach the bottom of conservation storage in the fall.	Would reach the top of conservation storage about 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage about 75% of years during the spring and the bottom of conservation storage more than 5% of years in late fall.	Would reach the top of conservation storage about 75% of years during the spring and would reach lower minimum elevation 5% of years. Increased winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage about 75% of years during the spring and would very rarely reach bottom of conservation prior to fall drawdown. Increased winter storage space from deeper fall reservoir drawdown.	Same as Alternative 2A.	Same as Alternative 2A.
Blue River Reservoir Outflow	Would meet downstream flow targets in nearly all years.	Steadier flow and slightly lower flow in spring of dry years as reservoir fills. Would meet downstream flow targets in nearly all years.	Slightly lower flow in spring of dry years as reservoir fills. Would meet downstream flow targets in nearly all years.	Same as Alternative 2A.	Higher flow in summer due to mainstem Willamette flow targets and would miss downstream flow targets in fall of the driest years.	Higher flow in summer due to mainstem Willamette flow targets. Would meet downstream flow targets in nearly all years.	Same as Alternative 2A.	Same as Alternative 2A.
Cougar Reservoir[2]	Would reach the top of conservation storage about 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage more than 75% of years during the spring and lower minimum elevation about 5% of years in late fall.	Would reach the top of conservation storage less than 75% of years during the spring and lower minimum elevation about 5% of years in late fall.	Would never reach the top of conservation storage during summer and reach very low minimum elevation about 25% of years. Increased winter storage space from deeper fall reservoir drawdown.	Would never reach the top of conservation storage during summer and reach lower minimum elevation about 60% of years. Increased winter storage space from deeper fall reservoir drawdown.	Same as Alternative 2B.	Same as Alternative 2A.	Same as Alternative 2B.
Cougar Reservoir Outflow	Would meet downstream flow targets in nearly all years.	Steadier flow and slightly lower flow in spring of dry years as reservoir fills. Would meet downstream flow targets in nearly all years.	Slightly lower flow in spring of dry years as reservoir fills. Higher summer flow in dry years.	Higher spring flow for spring reservoir drawdown. Would meet downstream targets in about 75% wettest years, with lower flows throughout summer.	Higher spring flow for spring reservoir drawdown. Would meet downstream targets in about 40% wettest years, with lower flows throughout summer.	Same as Alternative 2B.	Same as Alternative 2A.	Same as Alternative 2B.
McKenzie River at Vida	Elevated spring flow due to mainstem Willamette flow targets. Summer/fall flow about 1,500 cfs in very dry years.	Lower spring and higher summer flows. Summer/fall flow about 1,400 cfs in very dry years.	Lower spring flows. Summer/fall flow about 1,700 cfs in very dry years.	Lower spring flow in dry years and lower summer/fall flow in wet years. Summer/fall flow about 1,500 cfs in very dry years.	Lower spring flow in dry years and lower summer/fall flow across all years. Summer/fall flow about 1,400 cfs in very dry years.	Same as Alternative 2B.	Lower spring flows. Summer/fall flow about 1,700 cfs in very dry years.	Lower spring flow in dry years and lower summer/fall flow in wet years. Summer/fall flow about 1,400 cfs in very dry years.

% = percent; cfs = cubic feet per second

[1] Blue River Reservoir top and bottom of conservation storage are elevations 1,350 feet and 1,180 feet, respectively.

[2] Cougar Reservoir top and bottom of conservation storage are elevations 1,690 feet and 1,532 feet, respectively.

Table 4. Middle Fork Willamette River Subbasin Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hills Creek Reservoir[1]	Would reach the top of conservation storage less than 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage more than 75% of years during the spring and lower minimum elevation about 5% of years in late fall.	Would reach the top of conservation storage less than 75% of years during the spring and lower minimum elevation about 10% of years in late fall.	Same as Alternative 2A.	Would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 75% of years in summer/fall, with an average of middle of September.	Would never reach the top of conservation storage during summer and would reach bottom of conservation storage 50% of years.	Same as Alternative 2A.	Would reach the top of conservation storage about 50% of years during the spring and lower minimum elevation about 20% of years in late fall.
Hills Creek Reservoir Outflow	Flow would meet downstream flow targets in nearly all years. Minimum flow about 350 cfs.	Flow higher in spring and summer of average and wetter years. Flow would miss downstream flow target in fall of driest years. Minimum flow about 250 cfs.	Same as Alternative 1.	Same as Alternative 1.	Higher flow in spring/early summer. Flow downstream would be below target for at least 2 months in dry years. Minimum flow about 250 cfs.	Higher spring flow. Flow downstream would be below target for at least 3 months in dry years. At target in all other years. Minimum flow about 220 cfs.	Same as Alternative 1.	Higher flow in spring and summer of average and wetter years. Flow would miss downstream flow target in summer and fall of driest years. Minimum flow about 230 cfs.
Lookout Point Reservoir[2]	Would reach the top of conservation storage about 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage about 75% of years during the spring and lower minimum elevation about 5% of years in late fall.	Same as Alternative 1.	Would reach the top of conservation storage about 75% of years during the spring and lower minimum elevation about 10% of years in late fall.	Would never reach the top of conservation storage and lower minimum elevation 5% of years. Increased winter storage space from deeper fall reservoir drawdown.	Would reach the top of conservation storage more than 75% of years during the spring and lower minimum elevation about 5% of years in summer. Increased winter storage space from deeper fall reservoir drawdown.	Same as Alternative 1.	Same as Alternative 2B.
Lookout Point Reservoir/ Dexter Reservoir Outflow	Would miss downstream flow target in fall of driest years	Lower flow in spring and higher flow in summer/fall. Would miss downstream flow target in fall of driest years.	Minor differences compared to NAA. Would miss downstream flow target in fall of driest years.	Would miss downstream flow target in fall of driest years for longer periods than NAA.	Higher flow in spring and minimum flow in summer across all years. Would miss downstream flow target in fall of driest years.	Higher spring flow. Would miss downstream flow target during late summer and fall.	Minor differences compared to NAA. Would miss downstream flow target in fall of driest years.	Would miss downstream flow target during late summer and fall of driest years.
Fall Creek Reservoir[3]	Would reach the top of conservation storage less than 75% of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown.	Would reach the top of conservation storage about 75% of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Fall Creek Reservoir Outflow	Flow would meet downstream flow targets.	Lower spring flow. Flow would meet downstream flow targets.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Middle Fork Willamette River at Jasper	Elevated spring flow due to mainstem Willamette River flow targets. Fall flow about 1,200 cfs in very dry years.	Lower spring flow in dry years and higher summer/fall flow across all years. Flow about 1,100 cfs in very dry years.	Lower spring flow and higher summer/fall flow in dry years. Flow about 1,500 cfs in very dry years.	Lower spring flow in September of driest years. Higher flow in fall of most years. Flow about 1,300 cfs in very dry years.	Higher spring flows. Summer/fall flow at minimum for 3 months for all years. Flow about 1,100 cfs for 5 months in very dry years.	Lower spring flow in dry years. Flow at 1,100 cfs for 2 months in very dry years.	Same as Alternative 2A.	Lower spring flow, late August and September of driest years. Higher flow in fall of most years. Flow about 1,100 cfs in very dry years.

% = percent; cfs = cubic feet per second

[1] Hills Creek Reservoir top and bottom of conservation storage are elevations 1,541 feet and 1,448 feet, respectively.

[2] Lookout Point Reservoir top and bottom of conservation storage are elevations 926 feet and 825 feet, respectively.

[3] Fall Creek Reservoir top and bottom of conservation storage are elevations 830 feet and 728 feet, respectively.

Table 5. Coast Fork Willamette River Subbasin Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Dorena Reservoir[1]	Would reach the top of conservation storage about 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage less than 75% of years during the spring and would very rarely reach lower minimum elevation.	Would reach the top of conservation storage more than 50% of years and would very rarely reach the bottom of conservation storage.	Same as Alternative 2A.	Would reach the top of conservation storage more than 50% of years during the spring and lower minimum elevation about 5% of years in late fall.	Would reach the top of conservation storage more than 50% of years during the spring and lower minimum elevation about 25% of years in late fall.	Same as Alternative 3B.	Same as No-action Alternative.
Dorena Reservoir Outflow	Would maintain minimum flows except in fall of driest years.	Would maintain minimum flows in nearly all years.	Same as No-action Alternative.	Same as No-action Alternative.	Same as described under the NAA.	Would maintain minimum flows except in fall of dry years.	Same as Alternative 1.	Same as No-action Alternative.
Cottage Grove Reservoir[2]	Would reach the top of conservation storage less than 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall.	Would reach the top of conservation storage more than 50% of years during the spring and would very rarely reach lower minimum elevation.	Would reach the top of conservation storage about 50% of years during the spring and would very rarely reach the bottom of conservation storage.	Same as Alternative 2A.	Would reach the top of conservation storage more than 50% of years during the spring and lower minimum elevation in more than 5% of years during fall.	Would reach the top of conservation storage about 50% of years during the spring and lower minimum elevation in about 25% of years during fall.	Same as Alternative 3B.	Same as No-action Alternative.
Cottage Grove Reservoir Outflow	Would maintain minimum flows except in fall of driest years.	Would maintain minimum flows in nearly all years.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Coast Fork Willamette River at Goshen	Elevated spring flow due to mainstem Willamette River flow targets. Low flow in fall about 80 cfs in very dry years.	Lower spring and higher summer flow in dry years. Low flow in fall about 150 cfs in very dry years.	Lower spring flow in dry years. Low flow in fall about 80 cfs in very dry years.	Same as Alternative 2A.	Lower spring and higher summer flow in dry years. Low flow in fall about 90 cfs in very dry years.	Lower spring flow in dry years. Low flow in fall about 90 cfs in very dry years.	Lower spring flow in dry years. Low flow in fall about 100 cfs in very dry years.	Same as Alternative 2A.

% = percent; cfs = cubic feet per second

[1] Dorena Reservoir top and bottom of conservation storage are elevations 832 feet and 771 feet, respectively.

[2] Cottage Grove Reservoir top and bottom of conservation storage are elevations 790 feet and 750 feet, respectively.

Table 6. Mainstem Willamette River Summary of Hydrologic Processes Environmental Consequences as Compared to the No-action Alternative.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Willamette River at Harrisburg	Elevated spring flow due to downstream flow targets. Low flow about 3,000 cfs around October in very dry years.	Lower spring flow in dry years and higher summer flow. Low flow about 3,000 cfs around October in very dry years.	Lower spring flow in dry years. Less variation in summer flow. Low flow about 3,700 cfs around October in very dry years.	Lower spring flow in dry years. Less variation in summer flow. Low flow about 3,300 cfs around October in very dry years.	Increased spring flow variation. Lower summer flow across all years. Low flow about 2,800 cfs around August in very dry years.	Lower spring flow in dry years. Less variation in summer flow. Low flow about 2,900 cfs around September in very dry years.	Same as Alternative 2A.	Lower spring flow in dry years. Less variation in summer flow. Low flow about 2,900 cfs around October in very dry years.
Willamette River at Albany, Oregon	Elevated spring flow in dry years due to downstream flow target. Would miss baseline[1] flow target from middle of summer to fall in driest years. Low flow about 3,200 cfs around August in very dry years.	Lower spring flow in dry years. Would miss flow target in fall of driest years. Low flow about 3,000 cfs around October in very dry years.	Lower spring flow in dry years. Somewhat lower summer flow, while meeting flow target in nearly all years. Low flow about 4,000 cfs around October in very dry years.	Lower spring flow in dry years. Somewhat lower summer flow and would miss flow target in fall of driest years. Low flow about 4,000 cfs in very dry years.	Increased spring flow variation. Much lower summer flow. Would miss flow target in about 80% of years. Typical year would miss target for about 2 months. Low flow about 3,000 cfs around September in very dry years.	Increased spring flow variation. Would miss baseline[1] flow target from August to October in driest years. Low flow about 3,200 cfs around October in very dry years.	Lower spring flow in dry years. Somewhat lower summer flow and would meet flow target in nearly all years. Low flow about 3,800 cfs around October in very dry years.	Lower spring flow in dry years. Somewhat lower summer flow and would miss flow target in late August through October of driest years. Low flow about 3,300 cfs in fall in very dry years.
Willamette River at Salem, **Salem, Oregon**	Spring flow below baseline[1] target more than 25% of years. Summer flow below baseline[1] target in 5% of years for about 4 months. Low flow about 4,800 cfs around August in very dry years.	Lower spring flow in dry years. Higher summer flow across all years. Flow would miss lower target in October of driest years. Low flow about 5,500 cfs around October in very dry years.	Lower spring flow would meet lower seasonal target. Higher summer flow and elevated fall flow from Green Peter Reservoir deeper fall drawdown. Low flow about 6,200 cfs around August in very dry years.	Lower spring flow would meet lower seasonal target. Higher summer flow and elevated fall flow from Green Peter Reservoir deeper fall drawdown. Low flow about 6,000 cfs around August in very dry years.	Lower spring flow would meet lower seasonal target. Lower summer flow misses lower target in August of driest years. Low flow about 4,000 cfs around August in very dry years.	Lower spring flow would meet lower seasonal target. Lower summer flow misses lower target very rarely in August. Low flow about 4,500 cfs around August in very dry years.	Lower spring flow would meet lower seasonal target. Higher summer and fall flow in dry years. Low flow about 6,100 cfs around August in very dry years.	Lower spring flow would meet lower seasonal target. Higher summer flow and elevated fall flow from Green Peter Reservoir deeper fall drawdown. Low flow about 5,900 cfs around August in very dry years.

% = percent; cfs = cubic feet per second

[1] "Baseline" refers to the typical flow target for a location, which can be modified by the WATER forum during seasonal operations.

Table 7. Summary of Effects on Geologic Resources as Compared to the No-action Alternative[1,2].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Cottage Grove (Coast Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Dorena (Coast Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Fern Ridge (Long Tom River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Blue River (McKenzie River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate	Same as No-action Alternative	Same as No-action Alternative
Cougar (McKenzie River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	• Landslides Negligible • Removal Moderate	• Landslides Moderate • Removal Moderate	• Landslides Moderate • Removal Moderate	• Landslides Moderate • Removal Moderate	• Landslides Negligible • Removal Moderate	• Landslides Moderate • Removal Moderate
Dexter (Middle Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Fall Creek (Middle Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Hills Creek (Middle Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	• Landslides Moderate • Removal Moderate	• Landslides Moderate • Removal Moderate	• Landslides Negligible • Removal Moderate	Same as No-action Alternative
Lookout Point (Middle Fork Willamette River Subbasin)	• Landslides Negligible • Removal None	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate	• Landslides Moderate • Removal None	• Landslides Moderate • Removal None	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate
Big Cliff (North Santiam River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Detroit (North Santiam River Subbasin)	• Landslides Negligible • Removal None	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate	• Landslides Moderate • Removal None	• Landslides Moderate • Removal None	• Landslides Negligible • Removal Moderate	• Landslides Negligible • Removal Moderate
Foster (South Santiam River Subbasin)	• Landslides Negligible • Removal None	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Green Peter (South Santiam River Subbasin)	• Landslides Negligible • Removal None	• Landslides Negligible • Removal Moderate	• Landslides Minor • Removal Moderate	• Landslides Minor • Removal Moderate	• Landslides Minor • Removal Moderate	• Landslides Minor • Removal Moderate	Same as NAA	• Landslides Minor • Removal Moderate
Duration	• Long-term for landslide events • Permanent for removal of geologic material	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative

[1] Degree of landslide effects describes risk of landslide activation.

[2] The extent of effects would be local under all alternatives.

Table 8. Summary of Effects to Water Quality in the North Santiam River Subbasin as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Detroit and Big Cliff Reservoirs	**Temp –** Moderate adverse effect. **TDG –** Moderate adverse effect. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Substantially less adverse effects. **TDG –** Substantially less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effects. **TDG –** Substantially less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effects. **TDG –** Substantially less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Moderate increase to adverse effects. **TDG –** Substantial increase of adverse effects. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more Adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Substantial increase of adverse effects. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more Adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Substantially less adverse effects. **TDG –** Substantially less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effects. **TDG –** Substantially less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 9. Summary of Effects to Water Quality in the South Santiam River Subbasin as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Green Peter and Foster Reservoirs	**Temp –** Moderate adverse effect. **TDG –** Slight adverse effect. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Slightly less adverse effect. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Substantially more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Substantially more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Substantially more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Slightly more adverse effects. **TDG –** Moderately more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Slightly less adverse effects downstream of Foster Dam. Moderately more adverse below Green Peter Dam. **Turbidity –** Same as the No-action Alternative. **HABs, Mercury –** Slightly more adverse effect.	**Temp –** Slightly less adverse effects. **TDG –** Substantially more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 10. Summary of Effects to Water Quality in the McKenzie River Subbasin as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Cougar and Blue River Reservoirs	**Temp –** Slight adverse effect. **TDG –** Moderate adverse effect. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Slightly less adverse effect. **TDG –** Slightly less adverse effect. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effect. **Mercury –** Slightly more adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effect. **Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effect. TDG – Moderately less adverse effect. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more adverse effects. **Mercury –** Moderately more adverse effects.	**Temp –** Slightly more adverse effect. **TDG –** Slightly more adverse effect. **Turbidity –** Slightly more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effect. **TDG –** Moderately less adverse effect. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more adverse effects. **Mercury –** Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Moderately less adverse effect. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effect. **Mercury –** Slightly more adverse effect.	**Temp –** Substantially less adverse effect. **TDG –** Moderately less adverse effect. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more adverse effects. **Mercury –** Moderately more adverse effects.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 11. Summary of Effects to Water Quality in the Middle Fork Willamette River Subbasin as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hills Creek Reservoir	**Temp –** Moderate adverse effect. **TDG –** Slight adverse effect. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight Adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Same as the No-action Alternative. **TDG** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Moderately less adverse effect. **TDG –** Slightly less adverse effects. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Slightly less adverse effects. **TDG –** Same as the No-action Alternative. **Turbidity –** Substantially more adverse effects. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effect.	**Temp –** Moderately less adverse effect. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Lookout Point and Dexter Reservoirs	**Temp –** Moderate adverse effect. **TDG –** Slight adverse effect. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –S**imilar to the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp – S**imilar to the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp – S**imilar to the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Slightly less adverse effect. **TDG –** Moderately more adverse effect. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effects. **Mercury –** Moderately more adverse effects.	**Temp –** Slightly less adverse effects. **TDG –** Moderately more adverse effects below Dexter Dam. **Turbidity –** Substantially more adverse effect. **HABs –** Moderately more adverse effect. **Mercury –** Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Slightly less adverse effect. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.
Fall Creek Reservoir	**Temp –** Moderate Adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight Adverse effect. **Mercury –** Moderate adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HAB –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity –** Same as the No-action Alternative. **HABs –** Slightly more adverse effects. **Mercury –** Slightly more adverse effects.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms, N/A = Not Applicable

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 12. Summary of Effects to Water Quality in the Coast Fork Willamette River and Long Tom River Subbasins as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Dorena Reservoir	**Temp –** Moderate adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Moderate adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.
Cottage Grove Reservoir	**Temp –** Moderate adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Moderate adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.
Fern Ridge Reservoir	**Temp –** Moderate adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Moderate adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms, N/A = Not Applicable

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 13. Summary of Effects to Water Quality in the Mainstem Willamette River as Compared to the No-action Alternative[1].

Location	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Willamette River at Albany, Oregon	**Temp –** Slight adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Slightly more adverse effects.
Willamette River at Salem, Oregon	**Temp –** Slight to moderate adverse effect. **TDG –** N/A. **Turbidity –** Adverse and beneficial effects. **HABs –** Slight adverse effect. **Mercury –** Slight adverse effect.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Slightly more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –**Moderately more adverse effects.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Same as the No-action Alternative.	**Temp –** Same as the No-action Alternative. **TDG –** Same as the No-action Alternative. **Turbidity, HABs, Mercury –** Slightly more adverse effects.

Temp = temperature, TDG = total dissolved gas, HABs = harmful algal blooms, N/A = Not Applicable

[1] Effects under all water quality parameters would occur seasonally/in the short term; however, overall effects would occur over the long term during the 30-year implementation timeframe.

Table 14. Summary of Effects to Vegetation as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Reservoir-adjacent Vegetation	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive -dominated plant communities.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities.
	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season.	Moderate, adverse effects to vegetation during spring refill on new plant establishment.	Moderate, adverse effects to vegetation during spring refill on new plant establishment.	Moderate, adverse effects to vegetation during spring refill on new plant establishment at all reservoirs, except Cougar Reservoir.	Moderate, adverse effects to vegetation during spring refill on new plant establishment at all reservoirs except Cougar, Lookout Point, and Detroit Reservoirs.	Moderate, adverse effects to vegetation during spring refill on new plant establishment at all reservoirs except Cougar, Hills Creek, and Green Peter Reservoirs.	Moderate, adverse effects to vegetation during spring refill on new plant establishment.	Moderate, adverse effects to vegetation during spring refill on new plant establishment at all reservoirs, except Cougar Reservoir.
	Negligible effects to vegetation from induced landslides compared to the NAA.	Negligible effects to vegetation from induced landslides compared to the NAA.	Minor, adverse effects to vegetation because of increased potential for slope failures at Green Peter Reservoir from fall and spring drawdowns for fish passage.	Moderate, adverse effects to vegetation because of increased potential for slope failures at Cougar and Green Peter Reservoirs from fall and spring drawdowns for fish passage.	Moderate, adverse effects to vegetation because of increased potential for slope failures at Cougar, Lookout Point, and Detroit Reservoirs from fall and spring drawdowns for fish passage.	Moderate, adverse effects to vegetation because of increased potential for slope failures at Cougar, Lookout Point, and Detroit Reservoirs from fall and spring drawdowns for fish passage.	Negligible effects to vegetation from induced landslides compared to the NAA.	Moderate, adverse effects to vegetation because of increased potential for slope failures at Cougar and Green Peter Reservoirs from fall and spring drawdowns for fish passage.
	Negligible effects from potential for reservoirs not to refill.	Negligible effects from potential for reservoirs not to refill.	Minor, adverse effects to vegetation if Green Peter Reservoir is unable to refill during the 30-year implementation timeframe.					

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Downstream Stream-adjacent Vegetation	Major, adverse effects to vegetation from limited floodplain connectivity. Negligible effects to vegetation from downstream flow operations.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Minor, beneficial effects to vegetation from higher summer flows. Negligible effects to vegetation from flow differences.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from drawdown-related sediment releases. Minor, beneficial effects to vegetation from higher summer flows. Minor, adverse effects to vegetation from lowered spring flows in dry years.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from drawdown-related sediment releases. Minor, beneficial effects to vegetation from higher summer outflows. Potential for minor, adverse effects to vegetation in dry years from lower spring flows.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from drawdown-related sediment releases. Potential for moderate, adverse effects to vegetation from lowered reservoir elevations in the summer and fall. Minor, beneficial effects to vegetation from spring water releases during dry years.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from drawdown-related sediment releases. Minor, adverse effects to vegetation from lower summer flows.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from flow operations in average years.	Major, adverse effects to vegetation from limited floodplain connectivity. Major, beneficial effects to vegetation from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank. Negligible effects to vegetation from drawdown-related sediment releases. Minor, beneficial effects to vegetation from higher summer flows. Potential for minor, adverse effects to vegetation in dry years from lower spring flows.
Invasive and Noxious Weed Presence	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes.	Major, adverse effects to vegetation from increased potential for invasive establishment compared to NAA from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects to vegetation from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes. Minor, beneficial effects to vegetation from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes. Minor, beneficial effects to vegetation at all reservoirs except, Cougar Reservoir from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes. Minor, beneficial effects to vegetation in all reservoirs, except Cougar, Lookout Point, and Detroit Reservoirs from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes. Minor, beneficial effects to vegetation in all reservoirs, except Hills Creek, Cougar, and Green Peter Reservoirs from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation from increased potential for invasive establishment compared to NAA from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects to vegetation from spring refills controlling invasive species establishment.	Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes. Minor, beneficial effects to vegetation at all reservoirs except Cougar from spring refills controlling invasive species establishment.
Wildfire Recovery and Fine Fuels	Analysis area forests would continue to recover; no effect on establishment of fine fuels in reservoir or downstream areas from USACE operations.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Special-status Plant Species	Minor, adverse effects to vegetation from frequent reservoir water elevation changes for special-status species.	Moderate, adverse effects to special-status species from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species at all reservoirs, except Cougar Reservoir from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species in all reservoirs, except Lookout Point, Cougar, and Detroit Reservoirs from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species in all reservoirs, except Hills Creek, Cougar, and Green Peter Reservoirs from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species from spring refill potential to inhibit species establishment.	Moderate, adverse effects to special-status species at all reservoirs except ,Cougar Reservoir from spring refill potential to inhibit species establishment.
		Minor, adverse effects to special-status species from frequent reservoir water elevation changes.	Minor, adverse effects to habitat from frequent reservoir water elevation changes.	Minor, adverse effects to special-status species from frequent reservoir water elevation changes.	Minor, adverse effects to special-status species from frequent reservoir water elevation changes.	Minor, adverse effects to special-status species from frequent reservoir water elevation changes.	Minor, adverse effects to special-status species from frequent reservoir water elevation changes.	Minor, adverse effects to special-status species from frequent reservoir water elevation changes.
	Negligible effects to special-status species from landslide activity.	Negligible effects to special-status species from landslide activity.	Minor, adverse effects to special-status species from potential plant community burial from landslide activity because of drawdowns at Green Peter Reservoir.	Minor, adverse effects to special-status species from potential plant community burial from landslide activity because of drawdowns at Green Peter and Cougar Reservoirs.	Minor, adverse effects to special-status species from potential plant community burial from landslide activity because of drawdowns at Green Peter, Lookout Point, Detroit, and Cougar Reservoirs.	Minor, adverse effects to special-status species from potential plant community burial from landslide activity as a result of drawdowns at Green Peter, Lookout Point, Detroit, and Cougar Reservoirs.	Negligible effects to special-status species from landslide activity.	Minor, adverse effects to special-status species from potential plant community burial from landslide activity because of drawdowns at Green Peter and Cougar Reservoirs.
		Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.	Major, beneficial effects to habitat from gravel augmentation.
	Negligible effect to wapato.	Moderate, adverse effects to special-status plant species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools**.**	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.	Moderate, adverse effects to special-status species and wapato from use of power and inactive pools.
Ecoregions	Negligible	Major, beneficial effects from gravel augmentation.	Major, beneficial effects from gravel augmentation	Major, beneficial effects from gravel augmentation.	Major, beneficial effects from gravel augmentation.	Major, beneficial effects from gravel augmentation.	Major, beneficial effects from gravel augmentation.	Major, beneficial effects from gravel augmentation.

[1] The duration of all effects would be long-term.

Table 15. Summary of Effects to Wetlands as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Reservoir-adjacent Wetlands	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.	Minor, adverse effects from frequent water level fluctuations allowing for establishment of invasive-dominated plant communities.
	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season at reservoirs where refill is achieved.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season at reservoirs where refill is achieved.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season at reservoirs where refill is achieved.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season.	Minor, beneficial effects to plant growth and biomass accumulation from high reservoir levels during the growing season at reservoirs where refill is achieved.
			Negligible effects from potential for reservoir to not refill.	Moderate, adverse effects to wetlands at Cougar Reservoir if reservoir is not refilled.	Moderate, adverse effects to wetlands at Cougar, Lookout Point, and Detroit Reservoirs if unable to refill.	Moderate, adverse effects to wetlands at Cougar, Hills Creek, and Green Peter Reservoirs if unable to refill.	Negligible effects from potential for reservoir to not refill.	Moderate, adverse effects to wetlands at Cougar Reservoir if reservoir is unable to refill.
	Negligible effects to wetlands from the potential for induced landslides.	Negligible effects to wetlands from the potential for induced landslides.	Minor, adverse effects from the potential for induced landslides at Green Peter Reservoir from fall and spring drawdowns.	Moderate, adverse effects from the potential for induced landslides at Green Peter and Cougar Reservoirs from fall and spring drawdowns.	Moderate, adverse effects from the potential for induced landslides at Green Peter, Lookout Point, Detroit, and Cougar Reservoirs from fall and spring drawdowns.	Moderate, adverse effects from the potential for induced landslides at Green Peter, Lookout Point, Detroit, Hills Creek, and Cougar Reservoirs from fall and spring drawdowns.	Negligible effects to wetlands from the potential for induced landslides.	Moderate, adverse effects from the potential for induced landslides at Green Peter and Cougar Reservoirs from fall and spring drawdowns.
Downstream-adjacent Wetlands	Negligible effects from flow operations.	Negligible effects from flow operations.	Minor, beneficial effects from increased summer flows.	Minor, beneficial effects from increased summer flows.	Moderate, adverse effects from lowered reservoir levels in summer and fall preventing flow operations.	Moderate, adverse effects from lowered reservoir levels in summer and fall preventing flow operations.	Negligible effects from flow operations.	Minor, beneficial effects from increased summer flows.
			Minor, adverse effects from lower spring flows.	Minor, adverse effects from lower spring flows in dry years.	Minor benefit to wetlands from spring water releases during dry years.			
	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.	Major, adverse effects from limited floodplain connectivity.
		Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.	Major, beneficial effects from connectivity improvements from gravel bars. Improved revetments may improve the native riparian seedbank.
			Negligible effects from sediment releases.	Negligible effects from sediment releases.	Negligible effects from sediment releases.	Negligible effects from sediment releases.		Negligible effects from sediment releases.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Invasive and Noxious Weed Presence	Minor, adverse effects in reservoirs from frequent reservoir elevation changes that increases the potential for the establishment of invasive dominated plant communities.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects from spring refills controlling invasive species establishment.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns. Minor beneficial effects from spring refills controlling invasive species establishment. Potential for increased adverse effects because of deep drawdowns at reservoirs.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns Minor, beneficial effects in all reservoirs except Cougar Reservoir from spring refills controlling invasive species establishment. Potential for increased adverse effects because of deep drawdowns at reservoirs.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects in all reservoirs except Cougar, Lookout Point, and Detroit Reservoirs from spring refills controlling invasive species establishment. Potential for increased adverse effects because of deep drawdowns at reservoirs.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects in all reservoirs except Hills Creek, Cougar, and Green Peter Reservoirs from spring refills controlling invasive species establishment. Potential for increased adverse effects because of deep drawdowns at reservoirs.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevation changes and deep drawdowns. Minor, beneficial effects from spring refills controlling invasive species establishment.	Major, adverse effects from increased potential for invasive establishment from frequent reservoir elevations changes and deep drawdowns. Minor, beneficial effects in all reservoirs except Cougar Reservoir from spring refills controlling invasive species establishment. Potential for increased adverse effects because of deep drawdowns at reservoirs.

[1] The duration of all effects would be long term.

Table 16. Summary of Fish and Habitat Effects on Upper Willamette River Chinook Salmon as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Mitigation in All Subbasins	Adverse effects from domestication and genetic introgression, increased competition, disease transfer, increased exploitation of native fish, effects on downstream water quality from effluent. Beneficial effects for sport fishing and harvest opportunities, prey sources for other fish, and increased Chinook salmon spawner abundance.	Same as the No-action Alternative, but with reduced number of hatchery Chinook salmon released upstream; reduced proportion of hatchery origin spawners, and increased risks to bull trout from the rainbow trout hatchery program and sport fishing.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Reservoir/Lake-like Habitat	**North Santiam -** Moderate to substantial, adverse effects on juveniles from reservoir operations due to delayed migration, increased predation, and disease. Beneficial effects on juveniles from high growth rates. **South Santiam –** Same as North Santiam, except at Green Peter Reservoir where Chinook salmon would not occur. **McKenzie –** Same as North Santiam, except at Blue River Reservoir where Chinook salmon would not occur. **Middle Fork –** Same as North Santiam, except at Fall Creek Reservoir where adverse effects would be minor due to annual reservoir drawdowns to streambed. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as the No-action Alternative, but reduced adverse effects from Detroit Reservoir due to improved downstream passage reducing duration juveniles are in Detroit Reservoir. **South Santiam –** Same as North Santiam. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative, but reduced adverse effects from Lookout Point Reservoir due to improved downstream passage reducing duration juveniles are in the reservoir. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Foster Reservoir habitat. Increased adverse effects in Green Peter Reservoir during fall drawdowns. **McKenzie –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Cougar Reservoir. **Middle Fork –** Same as Alternative 1. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as 2A. **McKenzie –** Increased adverse effects within Cougar Reservoir during fall drawdowns. **Middle Fork –** Same as Alternative 1. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Moderate reductions in adverse effects from reservoir habitat due to improved downstream passage reducing duration juveniles are in reservoirs. **South Santiam –** Same as the No-action Alternative at Foster Reservoir. Same as Alternative 2A at Green Peter Reservoir. **McKenzie –** Similar to the No-action Alternative. **Middle Fork –** Same as the No-action Alternative at Fall Creek and Hills Creek Reservoirs. Moderate reductions in adverse effects to from Lookout Point Reservoir due to improved downstream reducing duration juveniles are in the reservoir. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Increased adverse effects within Detroit Reservoir during fall drawdowns. **South Santiam –** Same as the No-action Alternative at Foster Reservoir. Moderate reductions in adverse effects from Green Peter Reservoir due to improved downstream passage reducing duration juveniles are in the reservoir. **McKenzie –** Same as Alternative 2B. **Middle Fork –** Same as the No-action Alternative at Fall Creek and Hills Creek Reservoirs. Increased adverse effects within Lookout Point Reservoir during fall drawdowns. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as the No-action Alternative, but improved downstream passage reducing adverse effects from Foster Reservoir. **McKenzie –** Same as Alternative 1. **Middle Fork –** Same as the No-action Alternative, but improved downstream passage reducing adverse effects from Lookout Point and Hills Creek Reservoirs. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Cougar Reservoir. **Middle Fork –** Same as Alternative 3B. **Coast Fork –** N/A **Long Tom –** N/A

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Riverine Habitat	**North Santiam –** Substantial, adverse effects in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Beneficial effects from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons. Adverse effects from TDG below dams. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to the No-action Alternative with slight to moderate improvements during low flow seasons from flow augmentation from minimum flow targets. Moderate increased improvements from temperature management and reduced TDG. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**North Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **South Santiam –** Similar to North Santiam with increased adverse effects on water quality below dams due to Green Peter Reservoir drawdown in fall. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but with slight to moderate reductions in habitat due to lower stream flows in summer, slight increased benefits from water temperatures, and increased adverse effects (moderate in first few years, slight in later years) from turbidity below Cougar Dam. **Middle Fork –** Same as Alternative 2A. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A, but with increased adverse effects on water quality and habitat availability below dams due to Detroit Reservoir drawdown in spring and fall. **South Santiam –** Same as Alternative 2A. **McKenzie –** Similar to the No-action Alternative below Cougar Dam with slight reductions in habitat availability. Increased adverse effects on water quality due to Blue River Reservoir drawdown in fall. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Lookout Point Reservoir drawdown in spring and fall. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A in spring and summer. Increased adverse effects from water quality in fall below dams due to Detroit Reservoir drawdown. **South Santiam –** Increased adverse effects on water quality and habitat availability below dams due to Green Peter Reservoir drawdown in spring and fall. **McKenzie –** Same as Alternative 3B. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Hills Creek Reservoir drawdown in spring and fall and Lookout Point Reservoir drawdown in fall. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**Interim Operations** **North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but reduced adverse effects from reservoir habitat due to improved downstream passage reducing duration juveniles are in Cougar Reservoir. **Middle Fork –** Same as Alternative 3B. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.
Dam Passage Conditions	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor downstream passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as North Santiam from upstream passage effects. Moderate, adverse effects due to poor passage conditions at Foster Dam.	**North Santiam –** Slight, adverse effects from upstream and downstream passage at Detroit and Big Cliff Dams. **South Santiam –** Slight, adverse effects from upstream, and downstream passage at Green Peter Dam. Negligible to slight, adverse effects at Foster Dam. **McKenzie –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream passage at Foster and Green Peter Dams. Slight, adverse effects at Foster Dam from downstream passage. Moderate, adverse effects at Green Peter Dam from downstream passage.	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as Alternative 2A. **McKenzie –** Slight, adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam. **Middle Fork –** Same as Alternative 2A at Dexter and Lookout Point Dams. Same as the No-action Alternative at Fall Creek and Hills Creek Dams.	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above Detroit and Big Cliff Dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as Alternative 2A at Green Peter Dam. Same as the No-action Alternative at Foster Dam.	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as Alternative 2A at Green Peter Dam. Same as the No-action Alternative at Foster Dam.	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream and downstream passage at Foster Dam Same as the No-action Alternative at Green Peter Dam. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A at Fall Creek, Lookout Point, Dexter, and Hills Creek Dams. **Coast Fork –** N/A **Long Tom –** N/A	**Interim Operations** **North Santiam –** Same as Alternative 3A. **South Santiam –** Same as Alternative 3A. **McKenzie –** Same as the No-action Alternative with slight trend toward beneficial effects from downstream passage due to regulating outlet improvements. **Middle Fork –** Same as the No-action Alternative from upstream passage. Same as Alternative 3A from downstream passage.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
	McKenzie - Same as North Santiam from upstream and downstream passage at Cougar Dam. **Middle Fork –** Slight, adverse effects from collection and upstream transport of adults above Dexter and Lookout Point Dams. Moderate, adverse effects above Hills Creek Dam due to transport distance from Dexter Adult Fish Facility. Slight to moderate, adverse effects from upstream and downstream passage at Fall Creek Dam. **Coast Fork –** N/A **Long Tom –** N/A	**Middle Fork –** Slight, adverse effects from upstream and downstream passage at Fall Creek, Dexter, and Lookout Point Dams. Same as the No-action Alternative at Fall Creek and Hills Creek Dams. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**McKenzie –** Slight, adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam. **Middle Fork –**Slight, adverse effects from upstream passage above dams. Slight, adverse effects from downstream passage at Dexter and Lookout Point Dams. Same as the No-action Alternative from downstream passage at Hills Creek and Fall Creek Dams. **Coast Fork –** N/A **Long Tom –** N/A	**Coast Fork –** N/A **Long Tom –** N/A	**McKenzie –** Similar to the No-action Alternative at Cougar Dam, but adverse effects trending toward beneficial. slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Slight, adverse effects from upstream passage above dams. Slight, adverse effects from downstream passage at Fall Creek, Dexter, Lookout Point, and Hills Creek Dams. **Coast Fork –** N/A **Long Tom –** N/A	**McKenzie –** Same as Alternative 2B at Cougar Dam. Slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** N/A **Long Tom –** N/A		**Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.
Population Performance	**North Santiam –** Substantial, adverse effects. **South Santiam –** Moderate to substantial, adverse effects. **McKenzie –** Substantial, adverse effects. **Middle Fork –** Substantial, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Slight, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** Substantial, adverse effects. **Middle Fork –** Moderate to substantial, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Sight, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** Slight, adverse effects. **Middle Fork –** Moderate, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Slight, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** Moderate, adverse effects. **Middle Fork –** Moderate, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Moderate, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** Moderate, adverse effects. **Middle Fork –** Moderate to substantial, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Moderate, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** Moderate, adverse effects. **Middle Fork –** Moderate to substantial, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**North Santiam –** Slight, adverse effects. **South Santiam –** Moderate to substantial, adverse effects. **McKenzie –** Slight, adverse effects. **Middle Fork –** Moderate, adverse effects. **Coast Fork –** N/A **Long Tom -** N/A	**Interim Operations** Same as Alternative 3A. **Long-term Operations** Same as Alternative 2B.

N/A = Not Applicable. There are no UWR Chinook salmon populations above dams in these subbasins.

North Santiam = North Fork Santiam River Subbasin, South Santiam = South Fork Santiam River Subbasin, McKenzie = McKenzie River Subbasin, Middle Fork = Middle Fork Willamette River Subbasin, Coast Fork = Coast Fork Willamette River Subbasin, Long Tom = Long Tom River Subbasin

[1] All effects would occur or reoccur over the 30-year implementation timeframe.

Table 17. Summary of Fish and Habitat Effects on Upper Willamette River Steelhead as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Mitigation in All Subbasins	Adverse effects from domestication and genetic introgression, increased competition, disease transfer, increased exploitation of native fish, effects on downstream water quality from effluent. Beneficial effects for sport fishing and harvest opportunities, prey sources for other fish, and increased steelhead spawner abundance.	Same as the No-action Alternative, but with adverse effects trending toward beneficial due to increased abundance of UWR steelhead.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Reservoir/Lake-like Habitat	**North Santiam -** Moderate to substantial, adverse effects on juveniles from reservoir operations due to delayed migration, increased predation, and disease. Beneficial effects on juveniles from high growth rates. **South Santiam –** Same as North Santiam, except at Green Peter Reservoir where UWR steelhead would not occur. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Detroit Reservoir. **South Santiam –** Same as North Santiam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Foster Reservoir. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as Alternative 2A. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Moderate reductions in adverse effects due to improved downstream passage reducing duration juveniles in reservoirs. **South Santiam –** Same as the No-action Alternative at Foster Reservoir. Same as Alternative 2A at Green Peter Reservoir. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Increased adverse effects within Detroit Reservoir during fall drawdowns. **South Santiam –** Same as the No-action Alternative at Foster Reservoir. Moderate reductions in adverse effects due to improved downstream passage reducing duration juveniles are in Green Peter Reservoir. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as the No-action Alternative, but improved downstream passage reducing adverse effects from Foster Reservoir. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** N/A **Middle Fork –** Same as Alternative 3B. **Coast Fork –** N/A **Long Tom –** N/A

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Riverine Habitat	**North Santiam –** Substantial, adverse effects in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Beneficial effects from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons. Adverse effects from TDG below dams. **South Santiam –** Same as the North Santiam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to the No-action Alternative with slight to moderate benefits during low flow seasons from flow augmentation due to change in minimum flow targets, moderate increased benefits from temperature management, and reduced TDG. **South Santiam –** Same as the North Santiam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. South Santiam – Similar to North Santiam with increased adverse effects on water quality below dams due to Green Peter Reservoir drawdown in fall. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Same as Alternative 2A. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A, but with increased adverse effects on water quality and habitat availability below dams due to Detroit Reservoir drawdown in spring and fall. **South Santiam –** Same as Alternative 2A. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A in spring and summer. Increased adverse effects from water quality in fall below dams due to Detroit Reservoir drawdown. **South Santiam –** Increased adverse effects on water quality and habitat availability below dams due to Green Peter Reservoir drawdown in spring and fall. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**Interim Operations** **North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but reduced adverse effects from reservoir habitat due to improved downstream passage reducing duration juveniles are in Cougar Reservoir. **Middle Fork –** Same as Alternative 3B. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.
Dam Passage Conditions	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor downstream passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Moderate, adverse effects due to poor passage conditions at Foster Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Slight, adverse effects from upstream and downstream passage at Detroit and Big Cliff Dams. **South Santiam –** Slight, adverse effects from upstream and downstream passage at Green Peter Dam. Negligible to slight adverse effects at Foster Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream passage at Foster and Green Peter Dams. Slight, adverse effects at Foster Dam from upstream passage. Moderate, adverse effects from downstream passage at Green Peter Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1 **South Santiam –** Same as Alternative 2A **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above Detroit and Big Cliff Dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as Alternative 2A at Green Peter Dam Same as the No-action Alternative at Foster Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as Alternative 2A at Green Peter Dam. Same as the No-action Alternative at Foster Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream and downstream passage at Foster Dam. Same as the No-action Alternative at Green Peter Dam. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**Interim Operations** **North Santiam –** Same as Alternative 3A. **South Santiam –** Same as Alternative 3A. **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative from upstream passage. Same as Alternative 3A from downstream passage. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Population Performance	**North Santiam –** Substantial, adverse effects. **South Santiam –** Moderate to substantial, adverse effects. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Slight, adverse effects. **South Santiam –** Moderate, adverse effects. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as Alternative 1. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as Alternative 1. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Moderate, adverse effects. **South Santiam –** Same as Alternative 1. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Moderate, adverse effects. **South Santiam –** Same as Alternative 1. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as the No-action Alternative. **McKenzie –** N/A **Middle Fork –** N/A **Coast Fork –** N/A **Long Tom –** N/A	**Interim Operations** Same as Alternative 3A. **Long-term Operations** Same as Alternative 2B.

N/A = Not Applicable. There are no steelhead populations in these subbasins.

North Santiam = North Fork Santiam River Subbasin, South Santiam = South Fork Santiam River Subbasin, McKenzie = McKenzie River Subbasin, Middle Fork = Middle Fork Willamette River Subbasin, Coast Fork = Coast Fork Willamette River Subbasin, Long Tom = Long Tom River Subbasin

[1] All effects would occur or reoccur over the 30-year implementation timeframe.

Table 18. Summary of Fish and Habitat Effects on Bull Trout as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Mitigation in All Subbasins	Adverse effects from sport fishing, habitat competition, and effects on downstream water quality from effluent. Beneficial effects from increased forage where hatchery trout releases overlap with bull trout distributions.	Same as the No-action Alternative, but with increased risks to bull trout from the rainbow trout hatchery program and sport fishing below dams due to improved passage conditions at dams in the North Santiam River Subbasin.	Same as the No-action Alternative, but with increased risks to bull trout from the rainbow trout hatchery program and sport fishing below dams due to improved passage conditions at dams in the North Santiam River and McKenzie River Subbasins.	Same as Alternative 2A.	Same as Alternative 1.	Same as Alternative 2A.	Same as the No-action Alternative, but with increased risks to bull trout from the rainbow trout hatchery program and sport fishing below dams due to improved passage conditions at dams in the North Santiam River and McKenzie River, and Middle Fork Willamette River Subbasins.	Same as Alternative 1.
Reservoir/Lake-like Habitat	**North Santiam -** Substantial, beneficial effects due to feeding and growth opportunities in reservoirs. **South Santiam –** N/A **McKenzie –** Substantial, beneficial effects due to feeding and growth opportunities in reservoirs.	**North Santiam –** Same as the No-action Alternative. **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as the No-action Alternative. **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as the No-action Alternative. **South Santiam –** N/A **McKenzie –** Substantial, adverse effects on habitat availability due to spring and fall reservoir drawdowns. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Moderate to substantial, adverse effects on habitat availability due to spring and fall reservoir drawdowns. **South Santiam –** N/A **McKenzie –** Similar to the No-action Alternative.	**North Santiam –** Moderate, adverse effects on habitat availability due to fall reservoir drawdowns. **South Santiam –** N/A **McKenzie –** Same as Alternative 2B. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as the No-action Alternative. **South Santiam –** N/A **McKenzie –** Same as Alternative 1. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Same as Alternative 3A. **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** N/A **Long Tom –** N/A

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
	Middle Fork – Substantial, beneficial effects due to feeding and growth opportunities in reservoirs. **Coast Fork –** N/A **Long Tom –** N/A				**Middle Fork –** Moderate, adverse effects on habitat availability due to Hills Creek Reservoir drawdown in fall. **Coast Fork –** N/A **Long Tom –** N/A			
Riverine Habitat	**North Santiam –** Substantial, adverse effects in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Beneficial effects from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons. Adverse effects from TDG below dams. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to the No-action Alternative with slight to moderate benefits during low flow seasons from flow augmentation due to minimum flow targets, moderate increased benefits from temperature management, and reduced TDG. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**North Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **South Santiam –** Similar to North Santiam effects, but increased, adverse effects on water quality below dams due to Green Peter Reservoir drawdown in fall. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but with slight to moderate reductions in habitat due to lower stream flows in summer, slight increased benefits from water temperatures, and increased adverse effects from turbidity below Cougar Dam (moderate in first few years, slight in later years). **Middle Fork –** Same as Alternative 2A. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A, but with increased adverse effects on water quality and habitat availability below dams due to Detroit Reservoir drawdown in spring and fall. **South Santiam –** Same as Alternative 2A. **McKenzie –** Similar to the No-action Alternative below Cougar Dam with slight reductions in habitat availability. Increased adverse effects on water quality due to Blue River Reservoir drawdown in fall. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Lookout Point Reservoir drawdown in spring and fall. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A in spring and summer. Increased adverse effects from water quality in fall below dams due to Detroit Reservoir drawdown. **South Santiam –** Increased adverse effects on water quality and habitat availability below dams due to Green Peter Reservoir drawdown in spring and fall. **McKenzie –** Same as Alternative 3B. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Hills Creek Reservoir drawdown in spring and fall and Lookout Point Reservoir drawdown in fall. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**Interim Operations** **North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but reduced adverse effects due to improved downstream passage reducing duration juveniles are in Cougar Reservoir. **Middle Fork –** Same as Alternative 3B. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.
Dam Passage Conditions	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** N/A	**North Santiam –** Slight, adverse effects from upstream and downstream passage at Detroit and Big Cliff Dams. **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 1. **South Santiam –** N/A **McKenzie –** Slight, adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam.	**North Santiam –** Same as Alternative 1. **South Santiam –** N/A **McKenzie –** Slight, adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam.	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above Detroit and Big Cliff Dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** N/A	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Moderate, adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** N/A	**North Santiam –** Same as Alternative 1. **South Santiam –** N/A **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A at Fall Creek, Lookout Point, Dexter, and Hills Creek Dams. **Coast Fork –** N/A	**Interim Operations** **North Santiam –** Same as Alternative 3A. **South Santiam –** Same as Alternative 3A.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
	McKenzie – Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor passage conditions at Cougar Dam. **Middle Fork –** Slight, adverse effects from collection and upstream transport of adults above Dexter and Lookout Point Dams. Moderate to substantial, adverse effects from upstream passage conditions at Hills Creek Dam due to use of traps and angling for collection. Substantial, adverse effects due to poor downstream passage conditions at Hills Creek Dam. **Coast Fork –** N/A **Long Tom –** N/A	**Middle Fork –** Same as the No-action Alternative at Hills Creek Dam. Slight, adverse effects from upstream and downstream passage at Dexter and Lookout Point Dams. **Coast Fork –** N/A **Long Tom –** N/A	**Middle Fork –** Slight, adverse effects from upstream passage above dams. Same as the No-action Alternative from downstream passage at Hills Creek Dam. Slight, adverse effects from downstream passage at Dexter and Lookout Point Dams. **Coast Fork –** N/A **Long Tom –** N/A	**Middle Fork –** Same as Alternative 2A at Dexter and Lookout Point Dams. Same as the No-action Alternative at Hills Creek Dam. **Coast Fork –** N/A **Long Tom –** N/A	**McKenzie –** Similar to the No-action Alternative at Cougar Dam, but adverse effects trending toward more beneficial. Slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Slight, adverse effects from upstream passage above dams. Slight, adverse effects from downstream passage at Fall Creek, Dexter, Lookout Point, and Hills Creek Dams. **Coast Fork –** N/A **Long Tom –** N/A	**McKenzie –** Same as Alternative 2B at Cougar Dam. Slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** N/A **Long Tom –** N/A	**Long Tom –** N/A	**McKenzie –** Same as the No-action Alternative with slight trend toward beneficial effects from downstream passage due to regulating outlet improvements. **Middle Fork –** Same as the No-action Alternative from upstream passage. Same as Alternative 3A from downstream passage. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 2B.

N/A = Not Applicable. Bull trout populations do not occur in these subbasins.

North Santiam = North Fork Santiam River Subbasin, South Santiam = South Fork Santiam River Subbasin, McKenzie = McKenzie River Subbasin, Middle Fork = Middle Fork Willamette River Subbasin, Coast Fork = Coast Fork Willamette River Subbasin, Long Tom = Long Tom River Subbasin

[1] All effects would occur or reoccur over the 30-year implementation timeframe.

Table 19. Summary of Fish and Habitat Effects on Pacific Lamprey as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Mitigation in All Subbasins	Slight, adverse effects from predation and effects on downstream water quality from effluent.	Same as the No-action Alternative.	Same as the No-action Alternative.	Same as the No-action Alternative.	Same as the No-action Alternative.	Same as the No-action Alternative.	Same as the No-action Alternative.	Same as the No-action Alternative.
Reservoir/Lake-like Habitat	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Moderate, adverse effects due to Fall Creek Reservoir drawdowns in fall. Lamprey are not above other Middle Fork Willamette River Subbasin dams. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A
Riverine Habitat	**North Santiam –** Substantial, adverse effects in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Beneficial effects from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons. Adverse effects from TDG below dams. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as the North Santiam. **Long Tom –** Same as the North Santiam.	**North Santiam –** Similar to the No-action Alternative with slight to moderate benefits during low flow seasons from flow augmentation due to minimum flow targets. Moderate increased benefits from temperature management and reduced TDG. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Beneficial effects from increased access upstream for spawning and rearing due to removal of drop structures.	**North Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach and life stage. **South Santiam –** Similar to North Santiam with increased adverse effects on water quality below dams due to Green Peter Reservoir drawdown in fall due to turbidity (moderate in first few years, slight in later years). **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but with slight to moderate reductions in habitat due to lower stream flows in summer. Slight increased benefits from water temperatures. Increased adverse effects from turbidity below Cougar Dam (moderate in first few years, slight in later years). **Middle Fork –** Same as Alternative 2A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A, but with increased adverse effects on water quality and habitat availability below dams due to Detroit Reservoir drawdown in spring and fall. **South Santiam –** Same as Alternative 2A. **McKenzie –** Similar to the No-action Alternative below Cougar Dam with slight reductions in habitat availability. Increased adverse effects on water quality due to Blue River Reservoir drawdown in fall. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Lookout Point Reservoir drawdown in spring and fall. **Coast Fork –** N/A	**North Santiam** – Similar to Alternative 2A in spring and summer. Increased adverse effects from water quality in fall below dams due to Detroit Reservoir drawdown. **South Santiam –** Increased adverse effects on water quality and habitat availability below dams due to Green Peter Reservoir drawdown in spring and fall. **McKenzie –** Same as Alternative 2B. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Hills Creek Reservoir drawdown in spring and fall and Lookout Point Reservoir drawdown in fall. **Coast Fork –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach, species, and life stage. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as Alternative 1.	**Interim Operations** **North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as 2b. **Middle Fork –** Same as Alternative 3B **Coast Fork –** N/A **Long Tom –** Same as the No-action Alternative. **Long-term Operations** Same as Alternative 2B.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
					Long Tom – Same as the No-action Alternative.	**Long Tom –** Same as the No-action Alternative.		
Dam Passage Conditions	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Moderate, adverse effects due to Fall Creek Reservoir drawdowns in fall. **Coast Fork –** N/A **Long Tom –** Adverse effects on upstream passage of lamprey at drop structures. Slight, adverse effects on downstream passage of lamprey at drop structures.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Beneficial effects from increased access upstream for spawning and rearing due to removal of drop structures.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Same as the No-action Alternative.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Same as the No-action Alternative.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Same as the No-action Alternative.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Same as the No-action Alternative.	**North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** Same as Alternative 1	**Interim Operations** **North Santiam –** N/A **South Santiam –** N/A **McKenzie –** N/A **Middle Fork –**Same as the No-action Alternative. **Coast Fork –** N/A **Long Tom –** N/A **Long-term Operations** Same as Alternative 1.

N/A = Not Applicable. Lamprey do not occur above dams.

North Santiam = North Fork Santiam River Subbasin, South Santiam = South Fork Santiam River Subbasin, McKenzie = McKenzie River Subbasin, Middle Fork = Middle Fork Willamette River Subbasin, Coast Fork = Coast Fork Willamette River Subbasin, Long Tom = Long Tom River Subbasin

[1] All effects would occur or reoccur over the 30-year implementation timeframe.

Table 20. Summary of Fish and Habitat Effects on Resident Fish and Gamefish as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Mitigation in All Subbasins	Adverse effects from sport fishing, habitat competition, and effects on downstream water quality from effluent. Beneficial effects from increased forage for some species and life stages.	Same as the No-action Alternative, but with increased risks from the rainbow trout hatchery program and sport fishing below dams due to increased movement of resident fish below dams with improved passage conditions in North Santiam River, South Santiam River, and Middle Fork Willamette River Subbasins.	Same as the No-action Alternative, but with increased risks from the rainbow trout hatchery program and sport fishing below dams due to increased movement of resident fish below dams with improved passage conditions in North Santiam River, South Santiam River, McKenzie, and Middle Fork Willamette River Subbasins.	Same as Alternative 2A.	Same as Alternative 1.	Same as Alternative 2A.	Same as Alternative 2A.	Same as Alternative 1.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Reservoir/Lake-like Habitat	**North Santiam –** Substantial, beneficial effects due to feeding and growth opportunities in reservoirs. **South Santiam –** Same as North Santiam. **McKenzie –** Same as North Santiam. **Middle Fork –** Same as North Santiam. **Coast Fork –** Same as North Santiam. **Long Tom –** Same as North Santiam. **Gamefish in all Subbasins[2]** Adverse effects to sport fishing opportunities moderated by stocking of rainbow trout and kokanee as determined by ODFW.	**North Santiam –** Same as the No-action Alternative. **South Santiam –** Same as the No-action Alternative. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as the No-action Alternative.	**North Santiam –** Same as the No-action Alternative. **South Santiam –** Moderate, adverse effects on habitat availability and entrainment of fish due to Green Peter Reservoir drawdown in fall. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Adverse effects to sport fishing opportunities moderated by stocking of rainbow trout and kokanee as determined by ODFW. However, deep drawdowns at Green Peter Reservoir would reduce stocking benefits.	**North Santiam –** Same as the No-action Alternative. **South Santiam –** Same as Alternative 2A. **McKenzie –** Substantial, adverse effects on habitat availability and entrainment of fish due to Cougar Reservoir spring and fall drawdowns. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as the Alternative 2A. Deep drawdowns at Cougar Reservoir would also reduce stocking benefits.	**North Santiam –** Substantial, adverse effects on habitat availability and entrainment of fish due to spring and fall reservoir drawdowns. **South Santiam –** Same as Alternative 2A. **McKenzie –** Similar to the No-action Alternative. **Middle Fork –** Substantial, adverse effects on habitat availability and entrainment of fish due to Lookout Point Reservoir spring and fall drawdowns. Moderate, adverse effects on habitat availability and entrainment of fish due to Hills Creek Reservoir and Fall Creek Reservoir drawdowns in fall. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as the Alternative 2A. Deep drawdowns at Detroit, Blue River, Lookout Point, and Hills Creek Reservoirs would also reduce stocking benefits.	**North Santiam –** Moderate, adverse effects on habitat availability and entrainment of fish due to fall reservoir drawdowns. **South Santiam –** Substantial, adverse effects on habitat availability and entrainment of fish due Green Peter Reservoir drawdowns in spring and fall. **McKenzie –** Same as Alternative 2B. **Middle Fork –** Substantial, adverse effects on habitat availability and entrainment of fish due to Hills Creek Reservoir spring and fall drawdowns. Moderate, adverse effects on habitat availability and entrainment of fish due to Lookout Point Reservoir and Fall Creek Reservoir drawdowns in fall. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as Alternative 3A. Deep drawdowns at Cougar Reservoir would also reduce stocking benefits.	**North Santiam –** Same as the No-action Alternative. **South Santiam –** Same as the No-action Alternative. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 3A. **South Santiam –** Same as the No-action Alternative. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Gamefish in all Subbasins** Same as the No-action Alternative. Deep drawdowns would also reduce stocking benefits where stocking occurs throughout all subbasins.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Riverine Habitat	**North Santiam –** Substantial, adverse effects in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Beneficial effects from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons. Adverse effects from TDG below dams. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as North Santiam. **Long Tom –** Same as North Santiam.	**North Santiam –** Similar to the No-action Alternative with slight to moderate benefits during low flow seasons from flow augmentation due to minimum flow targets. Moderate increased benefits from temperature management and reduced TDG. **South Santiam –** Same as the North Santiam. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**North Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach, species, and life stage. **South Santiam –** Similar to North Santiam with increased adverse effects on water quality below dams due to Green Peter Reservoir drawdown in fall. **McKenzie –** Same as the North Santiam. **Middle Fork –** Same as the North Santiam. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as the No-action Alternative, but with slight to moderate reductions in habitat due to lower stream flows in summer. Slight increased benefits from water temperatures. Increased adverse effects from turbidity below Cougar Dam (moderate in first few years, slight in later years). **Middle Fork –** Same as Alternative 2A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A, but with increased adverse effects on habitat available and water quality below dams due to Detroit Reservoir drawdown in spring and fall. **South Santiam –** Same as Alternative 2A. **McKenzie –** Similar to the No-action Alternative below Cougar Dam with slight reductions in habitat availability. Increased adverse effects on water quality due to Blue River Reservoir drawdown in fall. **Middle Fork –** Increased adverse effects water quality and habitat availability due to Lookout Point Reservoir drawdown in spring and fall. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A in spring and summer. Increased adverse effects from water quality in fall below dams due to Detroit Reservoir drawdown. **South Santiam –** Increased adverse effects on water quality and habitat availability below dams due to Green Peter Reservoir drawdown in spring and fall. **McKenzie –** Same as Alternative 3B. **Middle Fork –** Increased adverse effects on water quality and habitat availability due to Hills Creek Reservoir drawdown in spring and fall and Lookout Point Reservoir drawdown in fall. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Similar to Alternative 2A. **South Santiam –** Similar to the No-action Alternative, but slight differences in benefits during spring and low flow seasons depending on reach, species, and life stage. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Beneficial effects from increased rearing due to improved habitat access with removal of drop structures.	**Interim Operations** **North Santiam –** Same as Alternative 3B. **South Santiam –** Same as Alternative 2A. **McKenzie –** Same as Alternative 2B. **Middle Fork –** Same as Alternative 3B. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Long-term Operations** Same as Alternative 2B.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Dam Passage Conditions	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor downstream passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as North Santiam. **McKenzie –** Slight, adverse effects from collection and upstream transport of adults above dams. Substantial, adverse effects due to poor passage conditions at Cougar Dam. **Middle Fork –** Slight, adverse effects from collection and upstream transport of adults above Dexter and Lookout Point Dams. Moderate to substantial, adverse effects from upstream passage conditions at Hills Creek Dam due to use of traps and angling for collection. Substantial, adverse effects due to poor passage conditions at Hills Creek Dam. **Coast Fork –** Substantial, adverse due to upstream and downstream passage conditions. **Long Tom –** Substantial, adverse due to upstream and downstream passage conditions.	**North Santiam –** Slight, adverse effects from upstream and downstream passage at Detroit and Big Cliff Dams. **South Santiam –** Slight, adverse effects from upstream, and downstream passage at Green Peter Dam. Negligible to slight, adverse effects at Foster Dam. **McKenzie –** Same as the No-action Alternative. **Middle Fork –** Same as the No-action Alternative at Hills Creek Dam. Slight, adverse effects from upstream and downstream passage at Dexter and Lookout Point Dams. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream passage at Foster and Green Peter Dams. Slight, adverse effects at Foster Dam from downstream passage. Moderate, adverse effects at Green Peter Dam from downstream passage. **McKenzie –** Slight adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam. **Middle Fork –** Slight, adverse effects from upstream passage above dams. Same as the No-action Alternative from downstream passage at Hills Creek Dam. Slight, adverse effects from downstream passage at Dexter and Lookout Point Dams. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 1. **South Santiam –** Same as Alternative 2A. **McKenzie –** Slight, adverse effects from upstream and downstream passage at Cougar Dam. Same as the No-action Alternative at Blue River Dam. **Middle Fork –** Same as Alternative 2A at Dexter and Lookout Point Dams. Same as the No-action Alternative at Hills Creek Dam. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Slight, adverse effects from collection and upstream transport of adults above Detroit and Big Cliff Dams. Moderate adverse effects due to poor passage conditions at Detroit and Big Cliff Dams. **South Santiam –** Same as Alternative 2A at Green Peter Dam. Same as the No-action Alternative at Foster Dam. **McKenzie –** Similar to the No-action Alternative at Cougar Dam, but adverse effects trending toward beneficial. Slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Slight, adverse effects from upstream passage above dams. Slight, adverse effects from downstream passage at Fall Creek, Dexter, Lookout Point, and Hills Creek Dams. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 3A. **South Santiam –** Same as Alternative 2A at Green Peter Dam. Same as the No-action Alternative at Foster Dam **McKenzie –** Same as Alternative 2B at Cougar Dam. Slight to moderate, adverse effects from downstream passage at Blue River Dam. **Middle Fork –** Same as Alternative 3A. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**North Santiam –** Same as Alternative 1. **South Santiam –** Slight, adverse effects from upstream and downstream passage at Foster Dam Same as the No-action Alternative at Green Peter Dam. **McKenzie –** Same as Alternative 2A. **Middle Fork –** Same as Alternative 2A at Fall Creek, Lookout Point, Dexter, and Hills Creek Dams. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative.	**Interim Operations** **North Santiam –** Same as Alternative 3A. **South Santiam –** Same as Alternative 3A. **McKenzie –** Same as the No-action Alternative with slight trend toward beneficial from downstream passage due to regulating outlet improvements. **Middle Fork –** Same as the No-action Alternative from upstream passage. Same as Alternative 3A from downstream passage. **Coast Fork –** Same as the No-action Alternative. **Long Tom –** Same as the No-action Alternative. **Long-term Operations** Same as Alternative 2B.

North Santiam = North Fork Santiam River Subbasin, South Santiam = South Fork Santiam River Subbasin, McKenzie = McKenzie River Subbasin, Middle Fork = Middle Fork Willamette River Subbasin, Coast Fork = Coast Fork Willamette River Subbasin, Long Tom = Long Tom River Subbasin, ODFW = Oregon Department of Fish and Wildlife

[1] All effects would occur or reoccur over the 30-year implementation timeframe.

[2] Gamefish stocking in all reservoirs is managed by ODFW and may or may not occur throughout all subbasins during the 30-year implementation timeframe.

Table 21. Summary of Effects to Wildlife and Habitat as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Construction	Minor, adverse	Minor, adverse	Minor, adverse	Minor, adverse	Minor, adverse	Minor, adverse	Minor, adverse	Minor, adverse
Summer Water Surface Elevations	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species.	Moderate, beneficial due to sustained water source , supports the presence of aquatic prey species. Minor, adverse effects to northwestern pond turtle as nests may be inundated by high surface elevations.	Moderate, beneficial due to a sustained water source, supports the presence of aquatic prey species.	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species.	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species.	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species.	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species. Minor adverse effect to northwestern pond turtle as nests may be inundated by high surface elevations.	Moderate, beneficial due to sustained water source, supports the presence of aquatic prey species.
Winter Water Surface Elevations	Minor, adverse from increased distance from sheltering/foraging habitats to the water's edge requiring some species to travel longer distances for water.	Minor, adverse from increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water.	Moderate, adverse due to the additional deep drawdown at Green Peter and increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water. Moderate, adverse from dramatic changes in reservoir elevations over the year causing wetting/drying cycles for reservoir-adjacent habitats.	Moderate, adverse due to additional deep drawdown at Cougar and from increased distance from sheltering/ foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water.	Moderate, adverse due to additional deep drawdown at multiple reservoirs and increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water, which would have lasting generational impacts on wildlife populations.	Moderate, adverse due to the additional deep drawdown at multiple reservoirs and increased distance from sheltering/ foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water, which would have lasting generational impacts on wildlife populations.	Minor, adverse from increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water.	Moderate, adverse due to the additional deep drawdown at Green Peter and increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water. Moderate, adverse from dramatic changes in reservoir elevations over the year causing wetting/drying cycles for reservoir-adjacent habitats.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Downstream Habitat	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, beneficial to riparian wildlife habitat from increased summer flows. No gravel augmentation or revetment improvements, so no benefits. No effect to northwestern pond turtle downstream habitat from gravel augmentation. No effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, beneficial due to maintained instream flows. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse effects to northwestern pond turtle downstream habitat from gravel augmentation. No effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, channel alteration, and migration limitations. Minor, adverse from spring drawdown and associated high flows/sediment releases dislodging amphibian egg masses and burying mussel beds and aquatic invertebrates. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. Minor, beneficial effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, channel alteration, and migration limitations. Minor, adverse from spring drawdown and associated high flows/sediment releases dislodging amphibian egg masses and burying mussel beds and aquatic invertebrates Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. Minor, beneficial effects to prey and foraging availability from fish passage measures	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, benefits from increased flows downstream. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. No effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations and revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, benefits from increased flows downstream. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. No effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, beneficial due to maintained instream flows. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. No effects to prey and foraging availability from fish passage measures.	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Minor, adverse from spring drawdown and associated high flows and sediment releases dislodging amphibian egg masses and burying mussel beds and aquatic invertebrates. Minor, beneficial effects to habitat connectivity and quality due to gravel augmentation and revetment improvements. Minor, adverse to northwestern pond turtle downstream habitat from gravel augmentation. Minor, beneficial effects to prey and foraging availability from fish passage measures.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
ESA Threatened and Endangered Species	Negligible, adverse effects to Southern Resident killer whales from adverse effects to prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Minor benefits to northwestern pond turtles in summer with high water levels. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Minor benefits to northwestern pond turtles in summer with high water levels. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Minor benefits to northwestern pond turtles in summer with high water levels. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Minor benefits to northwestern pond turtles in summer with high water levels. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from multiple deep drawdowns resulting in lowered winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Spring deep drawdowns may negatively affect turtles by increasing the return distance to aquatic habitat. Minor, adverse effects from early drawdowns may reduce habitat availability and increase resource competition. Turtles that overwinter in reservoir bed may have to move to follow the drawdown resulting in greater energy expenditures. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from multiple deep drawdowns resulting in lowered winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Spring deep drawdowns may negatively affect turtles by increasing the return distance to aquatic habitat. Minor, adverse effects from early drawdowns may reduce habitat availability and increase resource competition. Turtles that overwinter in reservoir bed may have to move to follow the drawdown resulting in greater energy expenditures. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. Minor benefits to northwestern pond turtles in summer with high water levels. No effect to northern spotted owl or streaked horned lark.	Negligible, adverse effects to Southern Resident killer whales from adverse effects to their prey. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources. No effect to northern spotted owl or streaked horned lark.

[1] The extent of all effects would be long term.

Table 22. Summary of Effects on Air Quality and Compliance with Federal and State Regulations as Compared to the No-action Alternative.

Degree of Adverse or Beneficial Effect and Extent	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Short-term Duration								
Degree	• None	• Minor adverse.	• None	• None	• None	• None	• Minor adverse.	• None
Extent	• None	• Small (Fern Ridge Dam)	• None	• None	• None	• None	• Small (Fern Ridge Dam)	• None
Medium-term Duration								
Degree	• Minor adverse	• Minor adverse.	• Minor adverse.	• Minor adverse.	• Minor adverse.	• Minor adverse.	• Minor adverse.	• Minor adverse.
Extent	• Small	• Small (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam).	• Small (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam).	• Small (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam).	• Small (Blue River Dam, Green Peter Dam, Hills Creek Dam).	• Small (Blue River Dam, Green Peter Dam, Hills Creek Dam).	• Small (Detroit Dam, Lookout Point Dam, Hills Creek Dam, Foster Dam, Cougar Dam).	• Small (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam).
Long-term Duration (Permanent, Intermittent, and/or Recurring)								
Degree	• Negligible adverse. • Minor adverse for climate change effects.	• Minor adverse; minor beneficial. • Minor adverse for climate change effects.	• Minor adverse. • Minor adverse for climate change effects.	• Minor adverse. • Minor adverse for climate change effects.	• Minor adverse. • Minor adverse for climate change effects.	• Minor adverse. • Minor adverse for climate change effects.	• Minor adverse; minor beneficial. • Minor adverse for climate change effects.	• Minor adverse. • Minor adverse for climate change effects.
Extent	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Small (Fern Ridge Dam) • Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Small (Fern Ridge Dam) • Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).	• Large (Detroit Dam, Green Peter Dam, Lookout Point Dam, Foster Dam, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Big Cliff Dam, Dexter Dam, Blue River Dam).

Table 23. Summary of Effects on Greenhouse Gas Emissions as Compared to the No-action Alternative.

Degree of Adverse or Beneficial Effect and Extent	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
	Short-term Duration							
Degree	• Negligible adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.	• Minor adverse. • Moderate to substantial adverse for climate change effects.
Extent	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)
	Medium-term Duration							
Degree	• Slightly adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.	• Slight to moderate adverse.
Extent	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)
	Long-term Duration (Permanent, Intermittent, and/or Recurring)							
Degree	• Moderate to substantial adverse. • Moderate to substantial adverse for climate change effects.	• Slight to moderate beneficial. • Moderate to substantial adverse for climate change effects.	• Slight to moderate adverse. • Moderate to substantial adverse for climate change effects.	• Slight to moderate adverse. • Moderate to substantial adverse for climate change effects.	• Moderate to substantial adverse. • Moderate to substantial adverse for climate change effects.	• Moderate to substantial adverse. • Moderate to substantial adverse for climate change effects.	• Slightly beneficial. • Moderate to substantial adverse for climate change effects.	• Slight to moderate adverse. • Moderate to substantial adverse for climate change effects.
Extent	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)	• Large (state or beyond)

Table 24. Summary of Socioeconomic Effects on Metropolitan Statistical Area Communities as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Arts, Entertainment, and Recreation Industry Employment	Negligible, direct, beneficial effect to any employment industry. Employment opportunities would not be a substantial contributor to MSA industry employment rates at the local, regional, or statewide levels.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Housing	None	None	None	None	None	None	None	None
Labor Force and Unemployment	Minor, beneficial effects	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Recreation Industry	No measurable adverse or beneficial effect	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Federal Spending for Construction	No benefit	Second most beneficial	Third most beneficial	Fourth most beneficial	Fifth most beneficial	Sixth most beneficial	Most beneficial	Fourth most beneficial

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Federal Spending for Operations and Maintenance	Slight, beneficial	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Recreation-related Revenue and Employment Earnings at the Local, Reservoir Level	Substantial, beneficial	Same as NAA with slight increases in benefits, except a slight decrease in benefits to Eugene MSA communities localized to Lookout Point Reservoir in late summer.	Same as NAA with slight increases in benefits, except a slight decrease in benefits to Salem MSA communities localized to Green Peter Reservoir in late summer.	Same as NAA, except a substantial adverse effect to Eugene MSA communities localized to Cougar Reservoir.	Substantial, adverse effect to Salem and Eugene MSA communities localized to Detroit, Cougar, and Lookout Point Reservoirs.	Substantial, adverse effect to Eugene MSA communities localized to Cougar, Green Peter, and Hills Creek Reservoirs. Substantial, adverse effects to communities localized to Detroit, Blue River, and Lookout Point Reservoirs in late summer, depending on the amount of precipitation during the summer and timing of drawdown initiation at each reservoir.	Same as NAA with negligible decreases in benefits to Salem MSA communities localized to Detroit Reservoir and slight decreases in benefits to Albany MSA communities localized to Green Peter Reservoir.	Same as NAA with negligible decreases in benefits to Albany MSA communities localized to Green Peter Reservoir and slight decreases in benefits to Salem MSA communities localized to Detroit Reservoir.
Economic Relationship with Communities	Beneficial	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative with slightly fewer benefits.	Substantial, adverse	Substantial, adverse	Same as No-action Alternative.	Same as No-action Alternative with slightly fewer benefits.

[1] All effects would occur or reoccur over the 30-year implementation timeframe (i.e., long term).

Table 25. Summary of Effects to Regional Power System Generation and Transmission as Compared to the No-action Alternative.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5	Interim Operations
Regional Power System Reliability Impacts	Long-term, slight, beneficial.	Same as No-action Alternative, but more beneficial from slight, additional power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but less beneficial from substantially less power generation.	Same as No-action Alternative, but less beneficial from substantially less power generation.	Same as No-action Alternative, but more beneficial from slightly more power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but medium term and less beneficial from less power generation and shorter term.
Willamette Valley System Dam Generation Impacts	Long-term, substantial, beneficial.	Same as No-action Alternative, but more beneficial from slightly more additional power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but less beneficial from a 50 percent power generation decrease.	Same as No-action Alternative, but less beneficial from a 50 percent power generation decrease.	Same as No-action Alternative with negligible changes to power generation.	Same as No-action Alternative, but less beneficial from slightly less power generation.	Same as No-action Alternative, but less beneficial from moderately less power generation. Interim Operations implementation would be shorter than an alternative implementation but may extend for nearly the full 30-year implementation timeframe.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5	Interim Operations
Transmission System Impacts	Long-term, slight, adverse. Power generated at Hills Creek and Cougar Dams would continue to be able to operate islanded (isolated) as needed and to provide power to the Oakridge and Blue River communities during outage, respectively.	Long-term, slight, adverse. Islanding during power outages would be the same as the No-action Alternative.	Long-term, moderate, adverse. Islanding during power outages would be the same as the No-action Alternative.	Long-term, moderate, adverse. Islanding during power outages from Hills Creek Dam would be the same as the No-action Alternative. Deep fall and spring drawdowns at Cougar Reservoir would likely compromise the ability to provide power to the community of Blue River, which would be a substantial, adverse effect to the community.	Long-term, moderate, adverse. Substantial, adverse community effects because operations at Hills Creek and Cougar Dams would not be able to continue to operate islanded (isolated).	Long-term, moderate, adverse. Substantial, adverse community effects because operations at Hills Creek and Cougar Dams would not be able to continue to operate islanded (isolated).	Long-term, slight, adverse. Islanding during power outages would be the same as the No-action Alternative.	Long-term, moderate, adverse. Islanding during power outages from Hills Creek Dam would be the same as the No-action Alternative. Deep fall and spring drawdowns at Cougar Reservoir and limited ability to manage Cougar Dam for power generation would likely compromise the ability to provide power to the community of Blue River, which would be a substantial adverse effect to the community.	Medium-term, moderate, adverse. Islanding during power outages from Hills Creek Dam would be the same as the No-action Alternative. Deep fall and spring drawdowns at Cougar Reservoir would likely compromise the ability to provide power to the community of Blue River, which would be a substantial, adverse effect to the community.
Economic Viability of Power Generation Impacts	Long-term, slight, beneficial.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Long-term, substantial, adverse.	Medium-term, substantial, adverse.

Table 26. Summary of Effects on Water Supply and to Water Users Dependent on Stored Water and River Flows as Compared to the No-action Alternative[1,2].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5	Interim Operations
System-wide Stored Water[1]	Substantially beneficial except during dry years or when reductions are needed to meet flow targets.	Substantially beneficial except during dry years or when reductions are needed to meet flow targets.	Substantially beneficial except during dry years or when reductions are needed to meet flow targets.	Moderately beneficial except during dry years or when reductions are needed to meet flow targets.	Substantially adverse	Substantially adverse	Substantially beneficial except during dry years or when reductions are needed to meet flow targets.	Moderately beneficial except during dry years or when reductions are needed to meet flow targets.	Slightly beneficial except during dry years or when reductions are needed to meet flow targets.
North Santiam River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Adverse	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
South Santiam River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Adverse	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
Santiam River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
Long Tom River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
McKenzie River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
Middle Fork Willamette River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
Coast Fork Willamette River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.
Mainstem Willamette River Flow	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.	Beneficial except during dry years.

[1] Although model results indicate an increase or decrease to June 1 in stored water volumes, the actual effects to specific stored water users are unknown because the annual management process in dry years has not been established as required by the Willamette Basin Review Feasibility Study Biological Opinion (NMFS 2019b) RPA.

[2] Effect summaries include both direct effects on water supply and indirect effects on water users.

Table 27. Summary of Effects on Recreation Opportunities as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Water-based Opportunities	Substantial, beneficial. Potential direct, moderate to substantial, adverse effects during the latter portion of the recreation season in summer to some analysis area reservoirs depending on the amount of precipitation and timing of the drawdowns.	Same as the No-action Alternative at most reservoirs. Direct, slight, increased benefits at Detroit, Green Peter, Cougar, Hills Creek, Dorena, and Cottage Grove Reservoirs from earlier spring refill.	Same as No-action Alternative.	Same as the No-action Alternative at most reservoirs. Direct, substantial, adverse effects at Cougar Reservoir with slight to moderate, adverse effects on other analysis area reservoirs due to displaced visitor use.	Same as the No-action Alternative at some reservoirs. Direct, substantial, adverse effects at Lookout Point, Cougar, and Detroit Reservoirs with substantial adverse effects on other analysis area reservoirs due to displaced visitor use. Potential direct, substantial, adverse effects during the latter portion of the recreation season in late summer at Hills Creek, Blue River, and Green Peter Reservoirs.	Same as the No-action Alternative at some reservoirs. Direct, substantial, adverse effects at Green Peter, Hills Creek, and Cougar Reservoirs with substantial, adverse effects on other analysis area reservoirs due to displaced visitor use. Potential direct, substantial, adverse effects during the latter portion of the recreation season in late summer at Lookout Point, Detroit, and Blue River Reservoirs.	Same as No-action Alternative.	Same as Alternative 2B.
Land-based Opportunities	Substantial, beneficial because no change in land-based recreation opportunities.	Same as No-action Alternative.	Same as No-action Alternative.	Same as the No-action Alternative at most reservoirs. Reduced incentive to use facilities at Cougar Reservoir from lack of water-based opportunities.	Same as the No-action Alternative at some reservoirs. Reduced incentive to use facilities at Cougar, Detroit, and Lookout Point Reservoirs from lack of water-based opportunities.	Same as the No-action Alternative at some reservoirs. Reduced incentive to use facilities at Cougar, Green Peter, and Hills Creek Reservoirs from lack of water-based opportunities.	Same as No-action Alternative.	Same as Alternative 2B.
Recreation Site Management	Substantially beneficial. Potential indirect, moderate to substantial, adverse effects on management during the latter portion of the recreation season in late summer at some analysis area reservoirs depending on the amount of precipitation and timing of the drawdowns due to visitor displacement.	Same as the No-action Alternative at most reservoirs. Potential indirect, adverse impacts on management at Detroit, Green Peter, Cougar, Hills Creek, Dorena, and Cottage Grove Reservoirs due to increased visitor use.	Same as No-action Alternative.	Same as the No-action Alternative at most reservoirs. Indirect, adverse effects at Cougar Reservoir from management requirements. Potential indirect, adverse impacts on management at nearby reservoirs from displaced visitors and related management requirements.	Same as the No-action Alternative at some reservoirs. Indirect, adverse effects at Cougar, Detroit, and Lookout Point Reservoirs from management requirements. Potential indirect, moderate, adverse effects on management during the latter portion of the recreation season at Hills Creek, Green Peter, and Blue River Reservoirs from displaced, late summer visitor use.	Same as the No-action Alternative at some reservoirs. Indirect, adverse, substantial impacts at Green Peter, Hills Creek, and Cougar Reservoirs from management requirements. Potential indirect, moderate, adverse effects on management during the latter portion of the recreation season at Lookout Point, Detroit, and Blue River Reservoirs from late summer visitor use.	Same as No-action Alternative.	Same as Alternative 2B.

[1] Effects would occur annually during the peak recreation season May 15 to September 15. Some effects may occur into late summer past the peak recreation season as identified.

Table 28. Summary of Effects from Hazardous Materials Use on Natural Resources and the Public as Compared to the No-action Alternative[1].

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Hatchery Chemicals	Negligible adverse, localized, long-term	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Hatchery Pesticides	Minor adverse, localized, long-term	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Construction, Demolition, Maintenance	Negligible to minor adverse, localized, short- to medium-term (however, construction, etc. would continue for 30-year implementation timeframe)	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Oil Spills	Minor adverse, localized, short- to medium-term; Region-wide, long-term as dams continue to discharge oil over the 30-year implementation timeframe	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative

[1] Extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the lesser beneficial effect does not occur at that reservoir. This follows the approach to present the most conservative degree of potential effects in this summary instead of omitting reservoirs where less severe or more beneficial effects would occur.

Table 29. Summary of Effects to Public Health and Safety from Hazardous, Toxic, and Radioactive Waste.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Waste Generation from Operations and Maintenance	Negligible to minor adverse, long-term, regional in extent	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Waste from Legacy Contamination	Minor to moderate adverse, long-term, regional in extent	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative
Risk from Sites on National Priorities List	Negligible to minor adverse, long-term, regional in extent	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative	Same as No-action Alternative

Table 30. Summary of Effects to Public Health and Safety from Effects to Drinking Water[1].

Effect Category[2]	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Water Quality	**Turbidity –** Adverse, but benefits from sediment trapped at all reservoirs during high-flow events. Minor, short-term, adverse below Fall Creek Reservoir.	**Turbidity –** Same as No-action Alternative.	**Turbidity –** Same as No-action Alternative but substantially more adverse below Foster Reservoir.	**Turbidity –** Same as No-action Alternative but substantially more adverse below Foster and Cougar Reservoirs.	**Turbidity –** Same as No-action Alternative below Hills Creek Reservoir. Slightly more adverse below Cougar Reservoir. Substantially more adverse below Dexter, Foster, and Big Cliff Reservoirs.	**Turbidity –** Substantially more adverse below Hills Creek, Dexter, Cougar, Foster, and Big Cliff Reservoirs.	**Turbidity –** Same as No-action Alternative.	**Turbidity –** Same as No-action Alternative but substantially more adverse below Foster and Cougar Reservoirs.
	Harmful Algal Blooms – Slightly adverse.	**Harmful Algal Blooms –** Slightly more adverse.	**Harmful Algal Blooms –** Slightly more adverse. Moderately more adverse in Foster Reservoir.	**Harmful Algal Blooms –** Slightly more adverse. Moderately more adverse in Foster and Cougar Reservoirs.	**Harmful Algal Blooms –** Moderately more adverse, but slightly more adverse in Hills Creek Reservoir.	**Harmful Algal Blooms –** Moderately more adverse below the same reservoirs as for turbidity.	**Harmful Algal Blooms –** Slightly more adverse.	**Harmful Algal Blooms –** Slightly more adverse. Moderately more adverse in Foster and Cougar Reservoirs.
Water Supply	**Groundwater –** No effect.	**Groundwater –** Same as No-action Alternative.	**Groundwater –** Same as No-action Alternative.	**Groundwater –** Same as No-action Alternative.	**Groundwater** Same as No-action Alternative.	**Groundwater –** Same as No-action Alternative.	**Groundwater –** Same as No-action Alternative.	**Groundwater –** Same as No-action Alternative.
	Stored Water – Substantial beneficial.	**Stored Water –** Same as No-action Alternative.	**Stored Water –** Same as No-action Alternative.	**Stored Water –** Slightly less beneficial than under the No-action Alternative.	**Stored Water** Substantial, adverse.	**Stored Water –** Substantial adverse.	**Stored Water –** Same as No-action Alternative.	**Stored Water –** Slightly less beneficial than under the No-action Alternative.
	River Flow – Beneficial but not all uses satisfied in all years.	**River Flow –** Same as No-action Alternative.	**River Flow –** Same as No-action Alternative.	**River Flow –** Same as No-action Alternative.	**River Flow** Same as No-action Alternative except adverse effects below Detroit Reservoir.	**River Flow –** Same as No-action Alternative except adverse effects below Green Peter Reservoir.	**River Flow –** Same as No-action Alternative.	**River Flow –** Same as No-action Alternative.

[1] All effects would be long term, occurring or reoccurring over the 30-year implementation timeframe.

[2] See Figures 3.5-59 through 3.5-63 in Section 3.5, Water Quality.

Table 31. Summary of Effects to Cultural Resources as Compared to the No-action Alternative.

Effect Category	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Annual draft and fill that would erode physical integrity of archaeological sites in reservoirs and expose them to unauthorized collection by the public.	Major, adverse effects at all reservoirs, except Big Cliff and Dexter Reservoirs.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.
Deep drawdowns that would increase erosion and exposure of archaeological sites in reservoirs.	Major, adverse effect at Fall Creek Reservoir.	Same as No-action Alternative.	Same as No-action Alternative.	Same as No-action Alternative.	Major, adverse effects at Lookout Point, Fall Creek, Hills Creek, Cougar, Blue River, Green Peter, Detroit Reservoirs.	Major, adverse effects at Lookout Point, Fall Creek, Hills Creek, Cougar, Blue River, Green Peter, Detroit Reservoirs.	Same as No-action Alternative.	Major adverse effects at Fall Creek, Cougar, Green Peter Reservoirs.
Modify existing or build new structures that would change the aesthetic of a resource type or historic district.	None	Moderate to major, adverse effects at Fern Ridge, Dexter, Lookout Point, Foster Green Peter Detroit Reservoirs.	Moderate to major, adverse effects at Dexter, Lookout Point, Cougar Foster, Green Peter, Detroit Reservoirs.	Moderate to major, adverse effects at Dexter, Lookout Point, Cougar Foster, Green Peter, Detroit Reservoirs.	Moderate to major, adverse effects at Hills Creek, Cougar, Blue River, Green Peter Reservoirs.	Moderate to major, adverse effects at Hills Creek, Cougar, Blue River, Green Peter Reservoirs.	Moderate to major, adverse effects at Dexter, Lookout Point, Hills Creek, Cougar Foster, Big Cliff Detroit Reservoirs.	Moderate to major, adverse effects at Dexter, Lookout Point, Cougar, Foster, Green Peter, Detroit Reservoirs.

Table 32. Summary of Effects on Visual Resources as Compared to the No-action Alternative[1].

Degree of Adverse or Beneficial Effect and Extent	No-action Alternative	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3A	Alternative 3B	Alternative 4	Alternative 5
Short-term Duration								
Degree	Negligible to major adverse	Moderate to major adverse	Moderate to major adverse	Moderate to major adverse	Moderate to major adverse	Moderate to major adverse	Moderate to major adverse	Moderate to major adverse
Extent	• Large for drawdowns (Fall Creek Dam) • Small to large depending on exterior maintenance activity	• Large (Foster Dam, Fall Creek Dam) • Same as the No-action Alternative for exterior maintenance	• Large (Foster Dam, Green Peter Dam, Fall Creek Dam) • Same as the No-action Alternative for exterior maintenance	• Small (Cougar Dam) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam) • Same as the No-action Alternative for exterior maintenance	• Small (Hills Creek Dam, Cougar Dam, Blue River Dam) • Medium (Lookout Point) • Large (Green Peter Dam, Fall Creek Dam, Detroit Dam) • Same as the No-action Alternative for exterior maintenance	• Small (Hills Creek Dam, Cougar Dam, Blue River Dam) • Medium (Lookout Point) • Large (Green Peter Dam, Fall Creek Dam, Detroit Dam) • Same as the No-action Alternative for exterior maintenance	• Large (Foster Dam, Fall Creek Dam) • Same as the No-action Alternative for exterior maintenance	• Small (Cougar Dam) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam) • Same as the No-action Alternative for exterior maintenance
Medium-term Duration								
Degree	None	Minor adverse	Minor adverse	Minor adverse	Minor adverse	Minor adverse	Minor adverse	Minor adverse
Extent	None	• Medium (Lookout Point) • Large (Detroit Dam, Green Peter Dam)	• Small (Cougar Dam) • Medium (Lookout Point) • Large (Detroit Dam, Green Peter Dam)	• Medium (Lookout Point) • Large (Detroit Dam, Green Peter Dam)	• Small (Blue River Dam, Hills Creek Dam) • Large (Green Peter Dam)	• Small (Blue River Dam, Hills Creek Dam) • Large (Green Peter Dam)	• Small (Hills Creek Dam, Cougar Dam) • Medium (Lookout Point) • Large (Detroit Dam, Dexter Dam)	• Medium (Lookout Point) • Large (Detroit Dam, Green Peter Dam)
	Long-term Duration (Permanent, Intermittent, and/or Recurring)							
Degree	Moderate adverse	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial	Moderate adverse; minor beneficial
Extent	• Large (Fall Creek Dam)	• Medium (Lookout Point) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam, Detroit Dam)	• Small (Cougar Dam) • Medium (Lookout Point) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam, Detroit Dam)	• Small (Cougar Dam) • Medium (Lookout Point) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam, Detroit Dam)	• Small (Hills Creek Dam, Cougar Dam, Blue River Dam) • Medium (Lookout Point) • Large (Green Peter Dam, Fall Creek Dam, Detroit Dam)	• Small (Hills Creek Dam, Cougar Dam, Blue River Dam) • Medium (Lookout Point) • Large (Green Peter Dam, Fall Creek Dam, Detroit Dam)	• Small (Hills Creek Dam, Cougar Dam) • Medium (Lookout Point) • Large (Foster Dam, Dexter Dam, Fall Creek Dam, Detroit Dam)	• Small (Cougar Dam) • Medium (Lookout Point) • Large (Foster Dam, Green Peter Dam, Fall Creek Dam, Detroit Dam)
Duration Type	Recurring for drawdowns and maintenance, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.	Permanent and/or recurring, but not permanent for maintenance activities.

[1] Note a range of effects may occur under each alternative, reflecting maintenance activities and drawdowns. Where a range of potential effects would occur, the most severe magnitude of adverse effects and the least magnitude of beneficial effects for each alternative is listed to present the most conservative range of potential effects. The extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the least beneficial effect does not occur at that reservoir.

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WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

SECTION 3.26 UNAVOIDABLE ADVERSE EFFECTS

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3.26 Unavoidable Adverse Effects

IDENTIFICATION OF UNAVOIDABLE ADVERSE EFFECTS UNDER THE NO-ACTION AND PREFERRED ALTERNATIVES HAVE BEEN REVISED IN ITS ENTIRETY FROM THE DEIS

3.26.1 Introduction

Council on Environmental Quality regulations require that agencies disclose any adverse environmental effects that cannot be avoided if the action is implemented (40 CRF 1502.16)[1]. Potential unavoidable adverse effects are described under the No-action Alternative (NAA) and the Preferred Alternative (Alternative 5) (Table 3.26-1 through Table 3.26-3). Site-specific information associated with alternative implementation will provide additional analyses regarding unavoidable adverse effects targeting specific resources at the time of implementation.

3.26.2 Unavoidable Adverse Effects

Anticipated effects under any alternative would result from operational changes that disrupt the human environment. Operations would continue to result in adverse effects to some resources under the NAA.

Operations modified from the NAA under any alternative to affect water levels would result in some degree of unavoidable, adverse effect as compared to adverse effects or non-adverse effects under the NAA. Adverse effects and degree of affect would vary by alternative and are described in Chapter 3, Affected Environment and Environmental Consequences.

[1] When this EIS was initiated, the Council on Environmental Quality (CEQ) was in the process of revising NEPA regulations. Consequently, USACE noticed the public that the EIS complies with the 1978 CEQ NEPA implementing regulations as amended. Additionally, the EIS follows the most current CEQ guidance on use of programmatic NEPA reviews, December 18, 2014.

Table 3.26-1. Summary of Unavoidable Adverse Effects under the Preferred Alternative as Compared to the No-action Alternative (table continued below).

Alternative	Hydrologic Processes	Geology and Soils	Water Quality	Vegetation and Wetlands	Fish and Aquatic Habitat	Wildlife and Habitat	Air Quality and Greenhouse Gases	Socioeconomics
No-action	Detroit and Green Peter Reservoir operations would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall. Operations at Foster Reservoir would vary from rule curve during flood operations. Flow would vary within Biological Opinion targets, falling to about 700 cfs in fall of very dry years in the North Santiam River at Mehama.	No unavoidable, adverse effects from landslide risk or debris removal.	Slight to moderate, adverse temperature effects across monitored subbasins. Slight to moderate, adverse TDG effects across monitored locations. Adverse (and beneficial) effects from turbidity across monitored locations, except slightly adverse at Salem. Slightly adverse effects from harmful algal blooms at all monitored locations. Slightly adverse effects from mercury at all monitored locations.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities. Major, adverse effects to vegetation and wetlands from limited floodplain connectivity. Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes.	Major, adverse effects from upstream and downstream fish passage. Adverse effects on downstream flow and water quality (see Water Quality, above). Degree of adversity would vary by season and subbasin. Major, adverse effects from decreased materials transport in combination with land use practices, degrading downstream habitat. Moderate to major, adverse effects from bank protection structures and flow operations, preventing downstream habitat connectivity and peak flows. Major, adverse effects within reservoirs on competition, predation, and delayed migration. Adverse effects from hatcheries resulting in domestication and genetic introgression, increased competition, disease transfer, increased exploitation of native fish, effects on downstream water quality from effluent.	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources.	Minor, adverse effects on air quality localized to dams in the medium term from operations. Minor, adverse effects on air quality at a large scale from climate change-related operational effects. Moderate to substantial adverse effects from greenhouse gas emissions related to climate change effects in the long term.	No unavoidable, adverse effects from socioeconomic conditions.

Alternative	Hydrologic Processes	Geology and Soils	Water Quality	Vegetation and Wetlands	Fish and Aquatic Habitat	Wildlife and Habitat	Air Quality and Greenhouse Gases	Socioeconomics
Alternative 5	Detroit Reservoir operations would reach the top of conservation storage about 75% of years during the spring and would very rarely reach the bottom of conservation storage in the fall. Green Peter Reservoir operations would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior to the deeper fall reservoir drawdown. Foster Reservoir Operations same as No-action Alternative. Lower varied spring flow across all years in the North Santiam River at Mehama. About 1,000 cfs in fall of very dry years. Lower spring flow in dry years in the Santiam River at Jefferson.	Moderate, adverse effect of landslide activation risk and debris removal at Cougar Reservoir. Moderate, adverse effect from debris removal at Lookout Point, Detroit, and Green Peter Reservoirs.	Moderate, adverse temperature effects below Hills Creek and Dexter Reservoirs; slightly adverse at Salem. Same as No-action Alternative below Hills Creek and Dexter Reservoirs; substantially more adverse below Foster Reservoir. Substantially more adverse effects from turbidity below Cougar and Foster Reservoirs; slightly more adverse at Salem. Moderately more adverse effects from harmful algal blooms at Cougar and Foster Reservoirs; slightly more adverse at all other monitored locations. Moderately more adverse effects from mercury at Cougar and Foster Reservoirs; slightly more adverse at all other monitored locations.	All unavoidable, adverse effects on vegetation same as No-action Alternative. Moderate, adverse effects to wetlands at Cougar Reservoir if reservoir is unable to refill. Moderate, adverse effects to wetlands from the potential for induced landslides at Green Peter and Cougar Reservoirs from fall and spring drawdowns. Same as No-action Alternative regarding adverse effects on wetlands from floodplain connectivity. Moderate, adverse effects to special-status species and wapato from use of power and inactive pools. Major, adverse effects to wetlands from increased potential for invasive establishment from frequent reservoir elevations changes and deep drawdowns.	Same as No-action Alternative with substantial reductions in adverse effects for fish passage at dams. Same as No-action Alternative with reduced adverse effects from water quality improvements. Same as No-action Alternative with slight reductions in adverse effects in the South Santiam River Subbasin below Green Peter Dam. Same as No-action Alternative regarding bank protection structures. Same as No-action Alternative regarding in-reservoir adverse effects. Same as Same as No-action Alternative with reduced adverse effects from hatchery Chinook salmon program from increased abundance of natural-origin fish.	Same as No-action Alternative regarding adverse effects from flood operations/revetments. Same as No-action Alternative regarding adverse effects to northwestern pond turtles. Moderate, adverse due to the additional deep drawdown at Green Peter and increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water. Moderate, adverse from dramatic changes in reservoir elevations over the year causing wetting/drying cycles for reservoir-adjacent habitats.	All unavoidable, adverse effects same as No-action Alternative.	All unavoidable, adverse effects same as No-action Alternative.

Table 3.26-1. Summary of Unavoidable Adverse Effects under the Preferred Alternative as Compared to the No-action Alternative, Continued.

Alternative	Power Generation and Transmission	Water Supply	Recreation Resources	Hazardous Materials	Hazardous, Toxic, and Radioactive Waste	Drinking Water	Cultural Resources	Visual Resources	Tribal Resources
No-action	Long-term, slight, adverse effects on transmission system reliability.	Adverse in all subbasins and the Mainstem Willamette River during dry years.	Potential direct, moderate to substantial, adverse effects to water-based opportunities during the latter portion of the recreation season in summer to some analysis area reservoirs depending on the amount of precipitation and timing of the drawdowns. Potential indirect, moderate to substantial, adverse effects on management during the latter portion of the recreation season in late summer at some analysis area reservoirs depending on the amount of precipitation and timing of the drawdowns due to visitor displacement.	Minor, adverse, localized effects from use of hatchery pesticides, construction, demolition, maintenance, and oil spills.	Negligible and minor adverse effects from operations and maintenance and risk from sites on the National Priorities List. Regional extent. Minor to moderate adverse effects from waste from legacy contamination. Regional extent.	Not all water uses satisfied by river flow in all years. See also water quality effects summary above.	Major, adverse effects at all reservoirs, except Big Cliff and Dexter Reservoirs from annual draft and fill that would erode physical integrity of archaeological sites in reservoirs and expose them to unauthorized collection by the public. Major, adverse effect at Fall Creek Reservoir from deep drawdowns that would increase erosion and exposure of archaeological sites in reservoirs.	Moderate to major, adverse effects depending on the dam, visitor numbers, and operations. Deep drawdowns with high visitor use would be more adverse than those with low visitor use. Adverse effects would occur in the short and long terms. Recurring for drawdowns and maintenance, but not permanent for maintenance activities.	Potential adverse effects on tribal resources encompass all resource effects analyzed in the EIS. As such, the degrees of effects are broad, ranging from substantial and unavoidable under some resources and alternatives to minor or no effect under others. See all summaries of unavoidable, adverse effects.

Alternative	Power Generation and Transmission	Water Supply	Recreation Resources	Hazardous Materials	Hazardous, Toxic, and Radioactive Waste	Drinking Water	Cultural Resources	Visual Resources	Tribal Resources
Alternative 5	Moderate, adverse effects on transmission system reliability. Islanding during power outages from Hills Creek Dam would be the same as under the NAA. Deep fall and spring drawdowns at Cougar Reservoir and limited ability to manage Cougar Dam for power generation would likely compromise the ability to provide power to the community of Blue River, which would be a substantial adverse effect to the community. Medium-term, substantial, adverse economic viability.	All unavoidable, adverse effects same as No-action Alternative.	Substantial, adverse effects to water-based opportunities at Cougar Reservoir with slight to moderate, adverse effects on other analysis area reservoirs due to displaced visitor use. Indirect, adverse effects at Cougar Reservoir from management requirements. Potential indirect, adverse impacts on management at nearby reservoirs from displaced visitors and related management requirements.	All unavoidable, adverse effects same as No-action Alternative.	All unavoidable, adverse effects same as No-action Alternative.	All unavoidable, adverse effects same as No-action Alternative.	All unavoidable, adverse effects same as No-action Alternative. Major adverse effects at Fall Creek, Cougar, Green Peter Reservoirs from deep drawdowns that would increase erosion and exposure of archaeological sites in reservoirs.	All unavoidable adverse effects same as No-action Alternative.	All unavoidable adverse effects same as No-action Alternative.

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SECTION 3.27 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

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3.27 Relationship between Short-term Uses and Long-term Productivity

THE RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY SECTION HAS BEEN REVISED IN CONTENT AND FORMAT FROM THE DEIS

Summary of changes from the DEIS:

- **This section has been renumbered from DEIS Section 3.26 to FEIS Section 3.27.**
- **Context for an analysis of the relationship between short-term uses of the environment and long-term productivity has been modified for clarity in Section 3.27.1, Introduction. Productivity categories have been identified.**
- **Information has been reorganized for improved flow and explanation. Cross-references have been included.**
- **Additional detail on short-term uses has been provided in newly added Section 3.27.2, Short-term Uses of the Environment under the Alternatives.**
- **Productivity categories from definitions provided in Section 3.27.1, Introduction, have been applied to the alternatives, the Congressionally authorized purposes, and to specific Willamette River Basin resources in newly added Section 3.27.3, Productivity Categories under all Alternatives.**
- **The relationship between these short-term uses and productivity categories are analyzed over the 30-year implementation timeframe in newly added Section 3.27.4, Relationship between Short-term Uses of the Environment and Long-term Productivity under All Alternatives.**
- **Information on climate change has been added.**

THE DEIS HAS BEEN MODIFIED TO REVISE THE FOLLOWING INFORMATION IN THE FEIS

3.27.1 Introduction

Council on Environmental Quality regulations require that agencies disclose the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity (40 CFR 1502.16)[1]. CEQ does not define "productivity." The Oxford dictionary

[1] When this EIS was initiated, CEQ was in the process of revising NEPA regulations. Consequently, USACE noticed the public that the EIS complies with the 1978 CEQ NEPA implementing regulations as amended. Additionally, the EIS follows the most current CEQ guidance on use of programmatic NEPA reviews, December 18, 2014.

defines productivity as "the effectiveness of productive effort measured in output, or in ecological terms, the rate of production of new biomass, and the fertility or capacity of a given habitat or area." These definitions are translated into productivity categories in Section 3.27.3, Productivity Categories under All Alternatives.

An alternative would be implemented for a 30-year timeframe. "Short term" within the 30-year implementation timeframe is subject to interpretation; consequently, a qualitative assessment is provided. Both short- and long-term uses of the environment are acknowledged given the 30-year implementation scope of the Proposed Action (Section 1.4, Geographic and Temporal Scopes).

3.27.2 Short-term Uses of the Environment under the Alternatives

Operations and maintenance under any alternative would result in short-term uses of the environment on an annual basis. For example, annual reservoir operations would result in short-term uses of water managed at various levels.

This short-term use would cause some mix of short-term effects under all alternatives, including soil erosion, dust generation, degradation of water quality, loss of riparian or wetland vegetation, increases in invasive species, disruption of fish and wildlife habitat, disruption of recreational use, degradation of visual quality, and effects to cultural resources. The degree of these effects could vary depending on environmental conditions specific to a given year (e.g., drought) or timing of operation.

Effects from short- or long-term uses of reservoir water through fluctuations could become long-term adverse effects, particularly when combined with climate change-related impacts such as increases in noxious weed growth from conditions more favorable to invasive species.

However, short-term uses could also result in long-term beneficial effects such as the maintenance or increase in hydropower, flood risk management, and flows necessary for fish. In general, the duration of short-term uses would depend on implementation timing of an operational measure during the 30-year timeframe.

3.27.3 Productivity Categories under all Alternatives

3.27.3.1 Effectiveness of Productive Effort Category

The "effectiveness of productive effort" category encompasses the Congressionally authorized purposes through operations and maintenance activities under any alternative (Section 1.10, Congressionally Authorized Purposes). For example, short-term uses of resources to address flood risk management or to provide for fish and wildlife would be operationally productive.

3.27.3.2 Output Productivity Category

Additionally, productivity as applied to the scope of this NEPA review can be exemplified by outputs such as irrigation water or hydropower.

3.27.3.3 Ecological Productivity Category

Finally, ecological productivity consistent with the scope of this NEPA review can be addressed in terms of creating biomass or maintaining or improving the capacity of a given habitat or area.

3.27.4 Relationship between Short-term Uses of the Environment and Long-term Productivity under all Alternatives

The relationship of short-term uses of water necessary for operations of the Willamette Valley System would cause maintenance, enhancement, and decreases of long-term productivity, depending on the category of productivity assessed. Consequently, productivity associated with operations and maintenance would be either adverse or beneficial. Adaptive management applied throughout the 30-year implementation timeframe would foster maintenance or enhancement of long-term productivity categories.

3.27.4.1 Effectiveness of Productive Effort

Operations under all alternatives would meet Congressionally authorized purposes. Consequently, the effectiveness of productive effort exemplified by meeting these purposes would be maintained or enhanced over the 30-year implementation timeframe. For example, if flood risk were to increase, short- or long-term uses of resources implemented to meet risk increases would enhance flood risk management productivity.

Similarly, short- and long-term uses of the environment for WVS operations could have beneficial effects on long-term productivity outputs. For example, water used for the continued availability of power should help maintain the region’s reliability on power productivity.

Decreases in productivity from short-term uses of the environment may also be realized during the 30-year implementation timeframe. For example, dam releases that contribute to downstream flow requirements to operate irrigation pumps could result in long-term agricultural productivity losses (assuming no pump modifications). Losses in recreation-derived income could be realized if short- or long-term water level reductions, possibly in conjunction with climate change-related factors, eliminate income-producing recreation opportunities in the Willamette River Basin under a given alternative.

Short- and long-term uses of resources under all action alternatives intended to benefit anadromous and resident fish should contribute to the enhancement of the “fertility or capacity of a given habitat or area” necessary for ESA-listed species and to the maintenance of other species (i.e., ecological productivity). For example, managing flows for fish and continuation of the Willamette Hatchery Mitigation Program under all alternatives would improve habitat capacity and species productivity, respectively. Improved conditions for anadromous and resident fish and wildlife through the short- and long-term uses of basin resources under the action alternative could improve the long-term productivity of these resources.

Enhancement of fertility or capacity of invasive species habitat or areas could occur from short-term uses of water through reservoir fluctuations, particularly if combined with favorable climate change-related conditions. Increased ecological productivity of invasive plants and animals would, however, have long-term adverse effects within the basin.

END REVISED TEXT

Photo of a painting by Lee Jensen (USACE Media Database).

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SECTION 3.28 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

3.28 Irreversible and Irretrievable Commitments of Resources

THE IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES SECTION HAS BEEN DELETED IN THE FEIS

Summary of changes from the DEIS:

- **Inclusion of this section incorrectly represents Council on Environmental Quality guidance on this matter.**

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SECTION 3.29 INTENTIONAL DESTRUCTIVE ACTS

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3.29 Intentional Destructive Acts

THE INTENTIONAL DESTRUCTIVE ACTS SECTION HAS BEEN REVISED FROM THE DEIS

Summary of changes from the DEIS:

- **This section has been renumbered from DEIS Section 3.28 to FEIS Section 3.29.**
- **An explanation for the purpose of this section is provided in FEIS Section 3.29.1, Introduction.**
- **Information highlights the potential for sabotage or terrorism. Information on vandalism, theft, and burglary are summarized to support sabotage or terrorism potential.**
- **References to the *Tri-Valley Cares v. Dep't of Energy* case (*Tri-Valley Cares v. Dep't of Energy*, 203 Fed.Appx. 105, 107 (9th Cir. 2006)) have been deleted in the FEIS. The section was revised to focus on effects to the human environment as required for disclosure under NEPA rather than responsiveness to case law. This revision provides consistency with the analysis approach throughout the EIS.**
- **Information specific to Bonneville Power Administration facilities has been deleted because this does not pertain to management of the Willamette Valley System.**

THE FOLLOWING TEXT HAS BEEN REVISED FROM THE DEIS

3.29.1 Introduction

This section addresses possible threats and other forms of sabotage to the Willamette Valley System (WVS). The potential for sabotage or terrorism at the 13 dams in the Willamette River Basin can affect the human environment as threats to Federally-managed facilities on national safety.

3.29.2 Terrorism and Sabotage

Terrorism and sabotage are defined similarly and are both carried out in pursuit of political objectives: terrorism is the use of violence and intimidation, while sabotage is the deliberate damage of equipment or structures. Since September 11, 2001, terrorism has been recognized as one of the most critical problems facing United States security.

Terrorism and sabotage have not occurred at USACE-managed facilities within the Willamette River Basin, and none of the alternatives are anticipated to alter this status quo. There was no indication of potential terrorism or sabotage when the alternatives were analyzed.

While possible, expectations of terrorism or sabotage, including locations and degree of effect, would be speculative over the 30-year implementation timeframe. However, consequences from terrorist attacks or sabotage on WVS dams could range from temporary operational shutdown to destruction of a dam, thereby compromising USACE's ability to manage for its authorized purposes and in compliance with the Endangered Species Act. The likelihood of a substantial adverse effect would be low.

3.29.3 Vandalism, Theft, and Burglary

According to data collected between 2016 and 2018, the intentional destructive acts that occur most frequently at USACE-managed facilities within the Willamette River Basin are vandalism, theft, and burglary (Table 3.29-1). The most common intentional destructive act was vandalism, which made up over half of all reported incidents.

Vandalism is the deliberate destruction of property. Theft involves the non-consensual taking of property, whereas burglary involves entering a building with the intent to commit a crime inside. Burglary is often committed with the intent of theft (Mince-Didier 2022).

Table 3.29-1. Intentional Destructive Acts Reported to USACE Within the Willamette River Basin (2016 to 2018).

Incident Type	Number of Incidents	Percent of Total Incidents[1] (%)
Vandalism	102	53
Theft	10	5
Burglary	1	Less than 1
Total	**108**	**56**

Source: USACE 2018e

[1]Other incidents recorded by USACE that are not considered intentional destructive acts include but are not limited to vehicle collisions, illegal dumping, and wildfires.

3.29.4 Summary

USACE does not anticipate threats to the WVS from terrorism or sabotage because such threats have not yet occurred and none of the alternatives would alter this status quo. While threats to WVS infrastructure during the 30-year implementation timeframe cannot be overlooked, details would be speculative. Threats to WVS infrastructure from vandalism would continue to be the most likely form of known infrastructure threat during the 30-year implementation timeframe.

END REVISED TEXT