US Army Corps
of Engineers ®
Portland District

Phase II Report

Willamette Valley Projects Configuration/Operation Plan (COP)

October 2015

Final Report

EXECUTIVE SUMMARY

The Configuration/Operation Plan (COP), Phase II Report, for the Willamette Valley system provides recommendations to address the Reasonable and Prudent Alternative (RPA) contained in the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries or NMFS) 2008 Biological Opinion (BiOp) for the Willamette System (WS) operated and maintained by the US Army Corps of Engineers (USACE or Corps). The RPA listed actions to be implemented to avoid jeopardy to Upper Willamette River (UWR) spring Chinook salmon (*Oncorhynchus tshawytscha*) and UWR winter steelhead (*O. mykiss*) from continued operations and maintenance of the WS. This COP Phase II report was guided by the development of alternatives documented in the 2009 COP Phase I Report.

Although this document does not meet the EC 11-2-208 (dated 31 Mar 2015) definition as a "Decision Document", it is being used to document the long-term plan for implementing the 2008 Willamette Biological Opinion.

BACKGROUND

The WS system consists of 13 multipurpose dams and reservoirs, and approximately 92 miles of riverbank protection projects in the Willamette River Basin in Oregon. Each project contributes to the overall water resources management in the basin which is designed to provide flood risk management, hydropower generation, irrigation, navigation, recreation, fish and wildlife, and improved water quality on the Willamette River and many of its tributaries.

The fish species listed under the Endangered Species Act (ESA) affected by operation of the WS[1] include UWR spring Chinook salmon, UWR winter steelhead, and bull trout (*Salvelinus confluentus,* threatened). The WS primarily affects four of seven Chinook salmon populations in the UWR, located in the North and South Santiam, McKenzie, and Middle Fork subbasins, as well as two of four winter steelhead populations located in the North and South Santiam subbasins (see map). Willamette subbasins not influenced by Corps facilities are not addressed in this document, although it should be noted that these subbasins also have an impact on the overall recovery of these fish.

Historically, annual wild adult spring Chinook salmon abundance in the Willamette Basin may have ranged as high as 300,000. Large declines in abundance were noted before construction of the WS dams and revetments. Intense commercial and sport fisheries, hatcheries, pollution (domestic and industrial), and habitat degradation (including logging) are cited as the most important factors contributing to these declines. Prior to the start of any WS dam construction in subbasins where spring Chinook populations occurred, the count of wild spring Chinook at Willamette Falls was about 55,000 in 1946 and 47,000 in 1947. Runs continued to diminish as WS dams were constructed in the Santiam, McKenzie, and Middle Fork subbasins, to less than 20,000 wild Chinook after 1960. WS dams and revetments were constructed mostly in eastside tributaries of the Willamette Basin during the 1950s and 1960s.

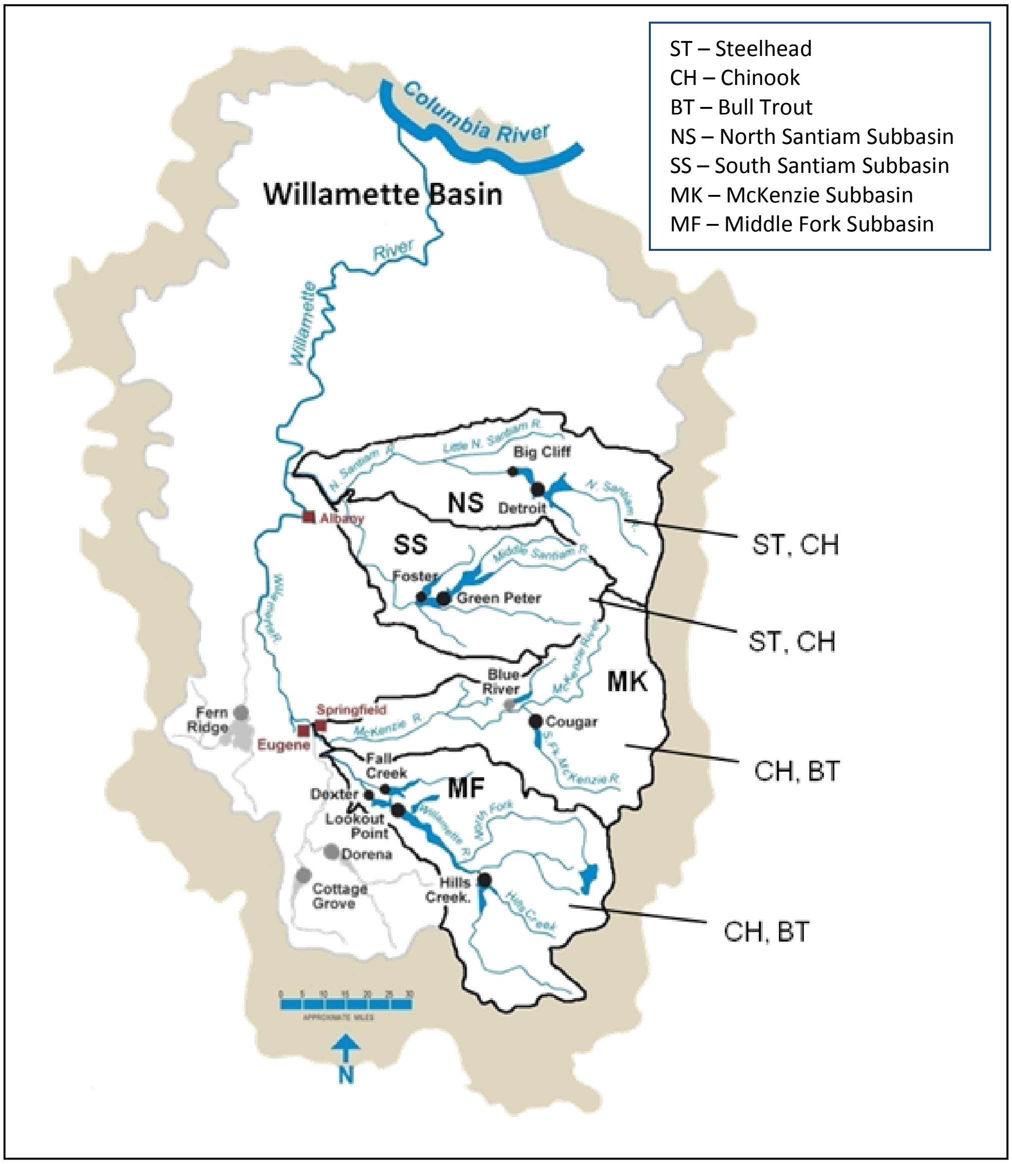
In addition to reducing flooding in the developing Willamette Valley, improving river navigation, and providing hydropower and other benefits, the WS was envisioned to improve water quality by increasing summer flows using WS storage. Water quality in the Willamette River mainstem has since improved; however, dams in the tributaries have blocked access to a majority of spawning habitat for spring Chinook and impacted their production by channelizing the river with revetments, and altering flow,

[1] Oregon chub (*Oregonichthys crameri*) are also affected by the WS but were officially delisted from the ESA in February 2015.

changing sediment dynamics, and impacting water temperature. At the time, state and federal fisheries managers preferred implementation of hatcheries to maintain fish for harvest, as fish passage was deemed infeasible for WS high head dams. Therefore, hatchery production of Chinook salmon, steelhead and trout was increased to mitigate for lost habitat above WS dams. These hatchery practices have impacted the wild productivity and health of spring Chinook in the Willamette Basin.

In recent years, the total abundance of wild spring Chinook migration at Willamette Falls was less than 5,000 annually, while total abundance of hatchery spring Chinook migrating passed Willamette Falls was 28,000 to 65,000.

Map of Corps Impacted Subbasins in the Willamette Basin and Distribution of Listed Fish Species



In 2000, the Corps prepared a Biological Assessment (BA) to meet requirements under Section 7 of the ESA with regard to continued operations and maintenance of the WS. In 2007, a supplemental BA was prepared by the Action Agencies (Corps, Bonneville Power Administration and Bureau of Reclamation), providing an update on the biological information for ESA-listed species, the environmental baseline condition, and analysis of the effects of a revision to the proposed action on spring Chinook and winter steelhead. Based on the Supplemental BA, NOAA Fisheries issued a BiOp in 2008 concluding that spring Chinook and winter steelhead would be jeopardized by continued operation and maintenance of the WS as described in the supplemental BA. A USFWS BiOp, also completed in 2008, concluded bull trout would not be jeopardized by continued WS operations as long as the NOAA Fisheries BiOp RPA was implemented.

A major goal of the RPA is to provide effective fish passage for UWR Chinook and steelhead at select WS dams to re-gain access to upstream historic spawning grounds and increase fish production. An effective fish passage program for Chinook and steelhead requires appropriate flows, water temperatures, and fish passage routes at dams to attract and safely pass upstream-migrating adults and downstream-migrating juveniles.

Several actions have been completed as part of the 2007 BA/2008 RPA implementation, which include construction of three new adult fish facilities (Cougar, Minto and Foster) for collection and transport to upstream habitats, interim operations for downstream fish passage and temperature improvement implemented at several dams, improvements to adult fish release sites at spawning grounds above the dams, and research to fill data gaps supporting alternative selection and design.

Improving downstream juvenile fish passage at high-head dams will be challenging, and this action was only generally described in the RPA. As a result of negotiations between NOAA Fisheries and the Action Agencies, the feasibility, performance criteria, biological benefits, and specific locations of these substantive downstream fish actions were to be investigated, and preferred alternatives presented to NOAA Fisheries using the COP process (RPA 4.13). The Action Agencies harbor sole responsibility for implementation of proposed alternatives to meet BiOp requirements that are determined to be feasible and authorized, while the responsibility for assessing the adequacy of alternatives and system-wide scenarios for avoiding jeopardy to ESA-listed species or adverse modification of critical habitat remains solely the responsibility of NOAA Fisheries and USFWS.

The 2007 BA and 2008 RPA included the following specific priority actions for implementation, unless the COP analysis indicated they were infeasible or identified more cost-effective actions:

- Upstream Passage Improvements (complete Cougar adult trap facility, replace/improve Minto, Foster, Dexter, and Fall Creek adult fish collection facilities).
- Provide Downstream Fish Passage (Cougar, Detroit, and Lookout Point).
- Provide Temperature Control (Detroit).

A visual aid to demonstrate the actions outlined in the RPA that have been, or are in the process of being, implemented by the Action Agencies is the table below. The color coding in the table is green for completed actions, blue for ongoing actions, white for actions not yet implemented or else not applicable.

Overview of Action Agency[3] BiOp Implementation Status (Green are completed actions, Blue are ongoing actions, White are not yet implemented or not applicable)

	North Santiam	South Santiam	McKenzie	Middle Fork	
Adult Upstream Passage	Minto	Foster	Cougar[1]	Dexter	Fall Creek
Juvenile Downstream Passage	Detroit	Spill weir at Foster	Cougar (PFFC)[2]	Hills Creek / Lookout Point	Drawdown of Fall Creek
Downstream Temperature	Detroit (operational)	NA (current operations sufficient)	Temperature Tower operation at Cougar[1]	NA	NA
Habitat	Habitat Technical Team work ongoing – land purchases/habitat restoration funded (BPA)				
Streamflow and Ramping Rates	Targets implemented per NOAA Fisheries 2008 RPA, RM&E ongoing				
Hatchery Reforms	Best practices for adult trap and haul, adjust juvenile release timing, hatchery production reprogramming and reductions				
RM&E	Informing implementation of fish passage solutions and other actions				

[1] Cougar adult trap and temperature tower completed separately from the 2008 BiOp.
[2]Cougar PFFC is the Portable Floating Fish Collector.
[3]The Action Agencies are USACE, BPA, and the BOR

COP CRITERIA AND APPROACH TO EVALUATING ALTERNATIVES

The 2008 RPA for the WS stated that the Action Agencies will evaluate a variety of potential actions intended to benefit ESA-listed fish to avoid jeopardy, and that the biological criteria would be defined as a part of the COP process. The RPA further described that the Action Agencies would then present specific implementation plans to NOAA Fisheries based on the COP, and NOAA would evaluate whether the actions proposed were likely to have the biological results that NOAA relied on in their 2008 BiOp to avoid jeopardy. Thus, biological evaluations in the COP incorporate biological criteria and an analysis approach consistent with that used in biological opinions by NOAA Fisheries

Subbasin alternatives and system-wide scenarios were evaluated in several steps as shown below. A science-based decision framework was applied to organize and assess biological, technical and economic data for the wide range of subbasin alternatives under consideration. This framework aimed to clearly present the tradeoffs associated with different implementation strategies to decision makers. The criteria applied by the Action Agencies determined whether or not the action was: (1) biologically feasible, (2) technically feasible; and (3) cost effective (from the NOAA Fisheries 2008 BiOp). Documenting uncertainty and impacts (both positive and negative) were important aspects of this framework. As new information is learned, refined results can be provided to decision makers.

COP Phase II Steps

STEP	Decision Support Process
Step 1	Define project goals, objectives, and constraints
Step 2	Update Phase I results/supplement with current data
Step 3	Determine range of alternatives to be assessed
Step 4	Conduct detailed biological analyses for baseline and alternatives (review with WATER)
Step 5	Establish subbasin alternatives and system-wide scenarios for assessment (review with WATER)
Step 6	Conduct detailed technical and economic assessments
Step 7	Determine benefits and costs, including uncertainty
Step 8	Determine other impacts, including uncertainty
Step 9	Determine significance of impacts (work with WATER)
Step 10	Compile results based on decision-maker input
Step 11	Presentation/discussion with decision makers – Action Agencies select Preferred Plan
Step 12	Repeat decision process (as new data, new measures, etc. are identified)

Note: WATER is the Willamette Action Team for Ecosystem Restoration

The decision framework applied a range of specific screening criteria and assumptions to assess alternative actions in the COP Phase II analysis. These criteria and assumptions are fully described in Section 2.2, but are briefly summarized below:

1) *Actions will meet dam safety requirements, and not result in a reduction to the Corps flood risk management mission.*

2) *Any above-dam fish reintroduction efforts must reach "replacement."* Upstream fish passage, and in some cases downstream fish passage, were expected to be via trap and haul, (i.e., not volitional fish passage). Fish passage improvements must allow sufficient passage survival so that the above dam sub-population is able to replace itself on average over time (i.e., enough adult progeny must successfully return and be transported above the dam to seed production of the next generation).

3) *Drainages with both Chinook and steelhead are a priority.* Actions which provide benefits for both Chinook salmon and steelhead species are understood to be of greater value than actions that address only one species.

4) *Improvements for more than one population per species needed.* Improvements for at least two populations per species (Chinook or steelhead) are necessary to spread risks for the species relating to environmental variability and catastrophic events.

5) *Biological Criteria – System Viable Salmonid Population (VSP) score $\geq$ 1.6 above 95% confidence interval and two subbasin populations above 2.0.* These fish population-level criteria are outlined in detail in Section 2.2.1.1.

6) *Phased Approach is Preferred.* This is to reduce risks and apply information gained during the design and implementation steps.

7) *Middle Fork investments are most risky (technically and biologically).* Of the subbasins within the Willamette system, the Middle Fork Willamette (with the exception of Fall Creek) poses the

most challenges for reintroducing and establishing a stable population of spring Chinook salmon above the dams. Although Fall Creek is a tributary to the Middle Fork, improvements there were also considered since wild Chinook are established above Fall Creek Dam. See Section 2.2.1.9 for more details.

8) *Actions should be cost-effective, including consideration of hydropower impacts*.

The Viable Salmonid Population (VSP) Analysis Framework was used in the COP II process to assess the biological benefit of individual and combinations of measures for achieving population-level goals. The VSP principles help form an explicit science-based framework to evaluate population extinction risk. The VSP assessment approach provides a comparable framework to that used in the NOAA Fisheries 2008 Biological Opinion and 2011 UWR Recovery Plan, and will also be useful for future ESA consultation for the WS and Willamette recovery planners. Two biological tools, the Species Lifecycle Analysis Module (SLAM) and the Fish Benefits Workbook (FBW), were used to prepare the VSP scores. These tools were parameterized with regional input through the Willamette Action Team for Ecosystem Restoration (WATER).

The Species Lifecycle Analysis Module (SLAM) was developed by the Northwest Fisheries Science Center (NWFSC). Several workshops (eight) were conducted with WATER in 2014 to develop model input assumptions and provide guidance on model results. Model documentation products and results authored by NWFSC (Appendix C) were reviewed by WATER and the Independent Scientific Advisory Board[2] (ISAB).

The Fish Benefits Workbook (FBW) methodology and input parameters were developed collaboratively at WATER Fish Passage Team meetings and multiple regional workshops. The workbook documentation was reviewed by the Region and the model framework, parameters and results were reviewed by the ISAB and WATER (Appendix K). Additionally, model parameter assumptions were provided by WATER and used to test the Fish Benefits Workbook tool.

Cost estimates for design; construction, supervisory and administration costs during construction; and operation and maintenance were developed (Appendix H). All costs were derived using corollary data from similar projects completed recently and scaled up or down to the projected design. Cost information was reviewed by the Cost Engineering Mandatory Center of Expertise (Cost MCX) located in the Walla Walla District.

Multiple non-monetized impacts were captured for a range of alternatives through the technical assessments. Each impact category was considered for how it would impact decision making. To simplify the analysis, only the critical components were captured for decision makers. Forgone hydropower was monetized and used for some cost-effectiveness calculations.

Given the longevity of the alternative assumed (50+ years) and potential impact on the alternatives, the COP PDT considered climate change as a future risk factor and incorporated that understanding into the final evaluation of the alternatives. Likely climate trends were identified from studies of the region chosen as being recent, regional and relevant to the COP alternative evaluations.

[2] The executive summary and full report from the ISAB are available at http://www.nwcouncil.org/fw/isab/.

ANALYSIS

Development of alternatives was guided by actions initially identified in the 2007 BA and 2008 RPA, and worked in collaboration with regional partners. RPA 4.13 identified several actions that the COP used to guide development of specific alternatives documented in the COP Phase I Report. This COP Phase I Report from October 2009 was also used for guidance in developing this report.

Using the above criteria and tools, 102 individual actions were assessed that included a range of downstream passage options (operational and structural), temperature improvements (operational and structural), total dissolved gas improvements and upstream passage improvements. Individual subbasin actions were combined into system alternatives (one subbasin alternative from each of the four subbasins equals a system alternative) and their affect on each Chinook and steelhead population was assessed. A total of 16 system alternatives were identified which met all criteria before cost-effectiveness was considered. The most cost-effective COP alternatives were identified from which a recommended plan was selected.

RECOMMENDATION

The COP Phase II recommendation includes the following actions:

- Downstream fish passage at Detroit through the Selective Withdrawal Structure (SWS), Weir Box, and the Floating Screen Structure (FSS)
- Downstream fish passage improvement at Foster with an upgraded fish weir
- Downstream fish passage at Cougar through the Floating Screen Structure (FSS)
- Upgraded adult fish facility (AFF) at Fall Creek
- Continued deep winter drawdown for downstream fish passage at Fall Creek
- Although the RPA indicates downstream fish passage in the Middle Fork is required, the COP determined that the prudent path forward is continued evaluation of feasibility and review of the need for providing fish passage in the Middle Fork, in consultation with NOAA Fisheries.
- Hatchery fish management changes

This recommendation will provide improvements for spring Chinook salmon in the North Santiam, South Santiam, McKenzie and Fall Creek subbasins. Winter steelhead improvements will be made in the North and South Santiam subbasins. Bull trout benefits are provided with proposed passage improvements in the McKenzie subbasin. Authority for completing these actions has been verified. This authority is summarized in Section 1.1.1. This option has a weighted average VSP score for steelhead and Chinook of 2.0. The system Chinook VSP score improves from 1.6 at Baseline to 2.3. The steelhead VSP for the two subbasins increases from 2.4 up to 3.5. A summary of biological benefits (VSP scores) and cost by feature is provided in the next table.

This package of actions includes construction of a selective withdrawal structure and three downstream fish passage improvement structures to provide effective fish passage to above-dam habitat for three populations of UWR Chinook and two populations of UWR steelhead. The recommendation takes advantage of investments for fish already made by the Corps, and in subbasins where natural production of Chinook salmon and steelhead is already occurring. The new actions are proposed at locations also prioritized in the NOAA Fisheries 2008 RPA, and on a feasible time frame accounting for necessary appropriations, design and construction. Details of this package include design/performance criteria for Cougar downstream passage, to be used to assess the effectiveness of the new facility after construction. The Cougar criteria are expected to be used as the framework for development of similar criteria for other proposed downstream passage actions. The package also includes continued implementation of discharge rates and volumes recommended in the RPA, and hatchery and fisheries management reforms not considered in the RPA outlined below. Although the RPA indicates downstream fish passage in the Middle Fork is required, the COP determined that the prudent path forward is continued evaluation of feasibility and review of the need for providing fish passage in the Middle Fork, in consultation with NOAA Fisheries.

Summary of Biological and Future Cost Information for the Recommended Plan

(Costs do not include the $144.5 MIL From 2008-2014)	VSP Scores (95% confidence)		Total Costs ($MIL)[1] 2015-2033		Forgone Hydropower[4] 2015-2033
	Chinook	Steelhead	Fully Funded Capital Costs[2]	O&M[3]	
NS-DSP-H4-DET Selective Withdrawal Structure with Weir Box and Floating Screen Structure at Detroit	3.9 (3.7)	3.7	$ 314.9	$ 6.8	$ -74
SS-DSP-H2-FOS Upgraded Fish Weir at Foster	1.0 (0.7)	3.3	$ 6.8	$ 0.8	$ 10
MK-DSP-10-CGR Floating Screen Structure at Cougar	3.8 (3.5)	NA	$ 127.5	$ 8.8	$ 2
MF-DSP-01-FAL Deep Winter Drawdown and FAL Adult Collection Facility	0.3 (0.2)[5]	NA	$ 21.1	$ 2.6	$ 0
RM&E Research Monitoring and Evaluation to Support BiOp Implementation	NA	NA	$ 144.9	NA	NA
Willamette System Level	2.3 (2.2)	3.5	$ 615.2	$ 19.0	$ -62

NA = Not applicable

[1] Costs are in 2014 dollars and do not include expended dollars from 2008-2014 ($144.5 MIL). Costs do not include fish passage actions in the Middle Fork subbasin which could be included in the future if determined feasible and necessary. Costs for Middle Fork actions are summarized in Section 3.5.4 (Monetized costs and impacts). Costs shown in this table may differ from the 5-year plan due to further refinements after the cost analyses for the above figures were performed.

[2] Capital costs and RM&E are Columbia River Fish Mitigation (CRFM) appropriated funds from 2015-2033.

[3] O&M costs are Operations and Maintenance appropriated funds estimated over 2015-2033 accounting for inflation assumed at 3.5% with a 50% contingency. Costs shown are for those alternatives comprising Option 1 in Chapter 3.

[4] Forgone Hydropower (2015-2033) is the sum of net energy benefit and net capacity benefit, present valued over 50 years using a 3.75% interest rate. For full derivation of hydropower costs please refer to Appendix G. A negative value represents a gain in hydropower value.

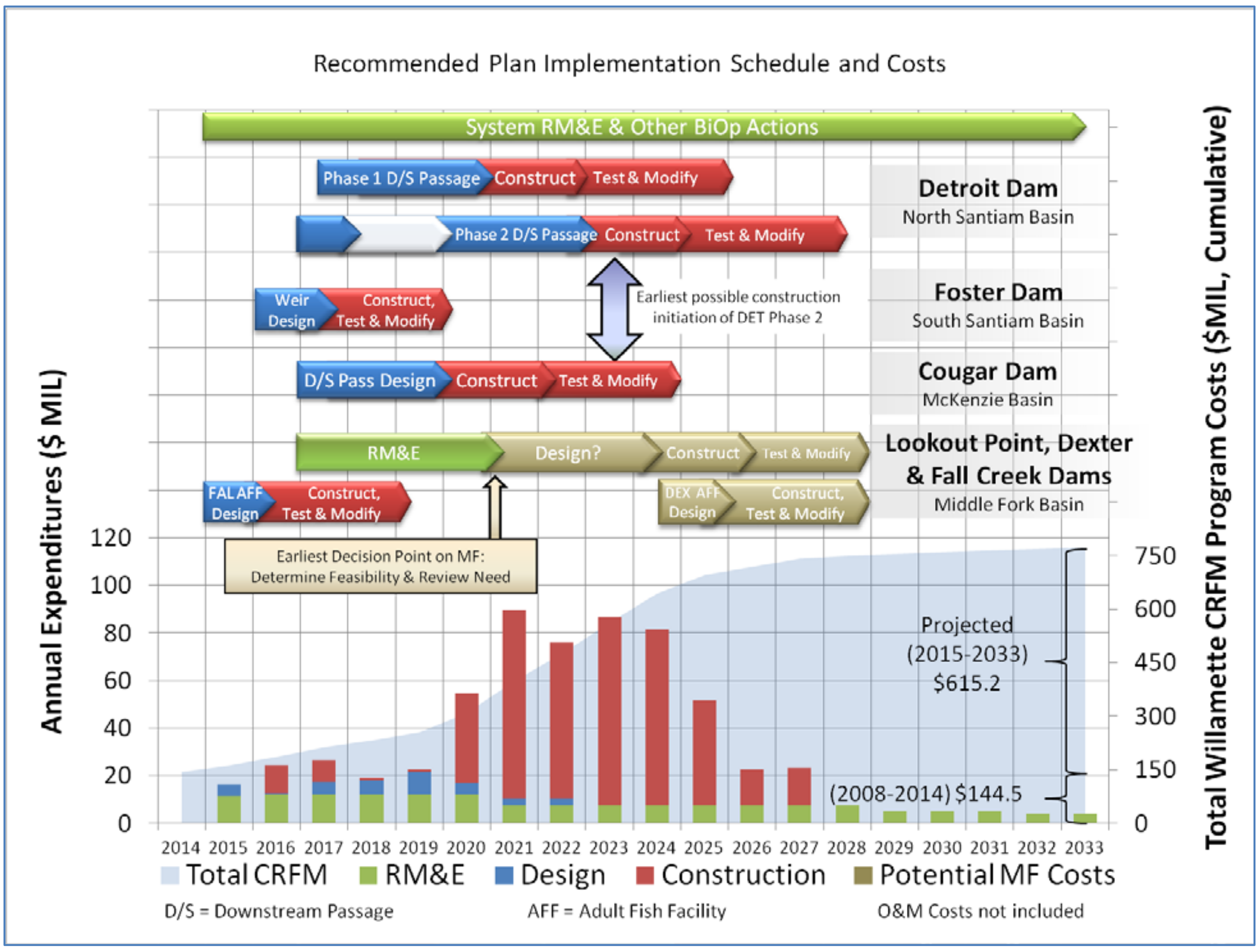
[5] VSP scores are for the entire Middle Fork spring Chinook salmon population (which includes the Fall Creek spring Chinook salmon component population).

Costs associated with BiOp implementation include capital infrastructure, RM&E, O&M and changes to hydropower. From 2008 – 2014, $144.5 MIL has been spent on BiOp implementation using CRFM funds. The table above shows a summary of the remaining fully funded capital costs by project and RM&E for a total of $615.2 MIL through 2033. O&M costs over the same time period equates to $19 MIL, or roughly $1MIL per year. In addition to these costs, changes in dam operations are expected to result in a net increase in hydropower production since the Detroit alternatives result in more water passing through the turbines instead of the spillway.

The fully funded capital costs shown in the table are project estimates as of February 2015. These estimates were based on an assumed timing of project phases between 2015 and 2033. Actual project implementation timing may result in minor cost changes when compared to the COP estimates. These costs reflect the results from the COP analyses developed for this document. A Strategic Implementation Plan (the 5-year plan) for the Willamette summarizing the Corps response to the BiOp was developed after this COP analysis was complete. See the Addendum in Chapter 4 for a detailed description of the minor differences in costs between this report and the 5-Year plan. The annual 5-year planning process will be the venue for budgeting purposes and to document the specific adjustments in costs based on updated design level information.

The next figure graphically displays the proposed implementation schedule for the recommended plan. A rough timeline is shown for each subbasin by structure with representations of design phases shown in blue, and construction with testing and modification phases shown in red. Additionally, the yearly budget assumptions for each phase are plotted, as well as a cumulative total of the CRFM program funds through 2033. This estimate accounts for inflation over time. In addition to the implementation costs, this recommendation will require future funds for O&M in order to keep new features operating properly. The estimated O&M costs associated with the preferred option (as described in Chapter 3) are shown in the table above.

Proposed Implementation Schedule for COP II Recommended Plan



IMPLEMENTATION APPROACH

The results of the COP II assessment identified a suite of actions to address the impacts to ESA-listed fish as a result of the continued operation of the Corps WS dams and support the overall recovery of the fish. The recommended plan was presented to NOAA Fisheries for input, and there is consensus at this time on the proposed major actions at Cougar and Detroit dams. The recommended suite of actions also includes implementing cost-effective measures at Foster Dam, Fall Creek Dam, and RM&E.

As implementation proceeds, RM&E will be used to refine design details of planned actions, confirm their performance, and inform decisions on the need and feasibility of additional actions in the Middle Fork subbasin to meet ESA requirements. Completed actions will be evaluated against performance criteria and adjustments or modifications will be planned and made as needed (see Section 4.1.1).

The plan includes an FY19 review of COP assumptions based on the RM&E completed to that point. The purpose of this review will be to determine if enough information is available to recommend a path forward for approval in FY21. The NMFS 2008 BiOp included RPA actions for both upstream and downstream passage in the Middle Fork Willamette at Dexter and Lookout Point dams, respectively. However, the RPA acknowledged uncertainty in the level of benefits that would be achieved from the specified actions, and in the feasibility of those actions. The Corps' COP analysis contained in this report indicates that an overall level of benefit may be attainable to address the BiOp, and potentially recovery goals, without fish passage and temperature control structures at mainstem Middle Fork dams. This report further concludes that the feasibility of completing effective fish passage at WS dams in the Middle Fork remains uncertain, citing issues created by the number of dams and reservoirs, predation risks, and pre-spawn mortality rates. Therefore, the FY19 COP review and FY21 recommendation will serve as important check-ins with NMFS for further discussions on downstream passage requirements and feasibility in the Middle Fork.

If new information becomes available indicating differences from information relied on in this report, then a re-evaluation of actions will be considered. Depending on the type of new information available and magnitude of difference from the original information relied upon, the COP analysis framework may be re-applied to evaluate actions to achieve an overall level of performance for the collection of fish populations affected by the WS.

It is the intent of the Action Agencies to work closely with stakeholders in the Willamette Basin to ensure other factors impacting the fish are addressed. The following additional actions are recommended for implementation in collaboration with state and federal fishery management agencies (Oregon Department of Fish and Wildlife and NOAA Fisheries).

1) Develop fish management plans for each wild spring Chinook and winter steelhead population affected by the WS which considers: a) near term actions to reduce hatchery effects as fish passage improvements are planned, b) reintroduction strategies to reestablish ESA listed Chinook and steelhead above dams, and c) long-term hatchery program plans following completion of fish passage improvements.
2) Eliminate hatchery summer steelhead production in the South Santiam and the North Santiam sub-basins to reduce impacts to wild winter steelhead.
3) Reduce hatchery Chinook production in the North Santiam and South Santiam to reduce impact to wild spring Chinook and support reintroduction and conservation goals.
4) Reprogram Chinook hatchery production to areas that do not impact wild spring Chinook natural production.

5) Protect reintroduced wild spring Chinook and winter steelhead above and below WS dams, by implementing new fishery regulations and designating critical habitat in the North Santiam above Detroit Dam.
6) Implement alternative mitigation to non-native trout stocking to reduce impacts to wild juvenile spring Chinook salmon, winter steelhead, and native trout where they co-occur.

Any actions taken as a result of the recommended plan described in this report will be carried forward for analysis under the National Environmental Policy Act (NEPA) and other applicable environmental statutes.

This plan will be assessed on an annual basis and validated or adjusted in the out-years. It is anticipated that the refinements and updates will continue to inform decision makers. It is not intended that this COP report will be updated, but the annual assessment will be conducted and documented outside of this report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

AAB	average annual benefit
AAC	average annual cost
aMW	average megawatt
BA	Biological Assessment
BiOp	Biological Opinion
BPA	Bonneville Power Administration
CFR	Code of Federal Regulations
cfs	cubic feet (foot) per second
CI	confidence interval
CO_2	carbon dioxide
COP	Configuration/Operation Plan
Corps	U.S. Army Corps of Engineers
CRFM	Columbia River Fish Mitigation
CWA	Clean Water Act
DDR	design documentation report
DPE	dam passage efficiency
DPS	distinct population segment
EDC	engineering during construction
EDR	engineering documentation report
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FBW	Fish Benefit Workbook
FCRPS	Federal Columbia River Power System
FRM	flood risk management
FSC	floating surface collector
FSO	floating surface outlet
FSS	floating screen structure
FY	fiscal year
HOR	head of reservoir
HYDSIM	Hydro System Simulation (model)
IDC	interest during construction
IRRM	interim risk reduction measures
ISAB	Independent Science Advisory Board
IWR	Institute for Water Resources
M&I	municipal and industrial
MOU	Memorandum of Understanding
MW	megawatt(s)
MWh	megawatt hour

ACRONYMS AND ABBREVIATIONS (continued)

NA	not applicable
NGVD29	National Geodetic Vertical Datum of 1929
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWFSC	Northwest Fisheries Science Center
O&M	operation and maintenance
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OMBIL	Operations and Maintenance Business Information Link
OWRD	Oregon Water Resources Department
P&S	plans and specifications
PDT	Product Delivery Team
PGE	Portland General Electric
pHOS	percent of hatchery origin spawners
pNOB	percent natural origin broodstock
POR	period of record
PSM	pre-spawn mortality
PVA	Power Value Analysis
ResSim	Reservoir System Simulation (model)
RM&E	research, monitoring and evaluation
RO	regulating outlet
RPA	Reasonable and Prudent Alternative
S&A	supervision and administration
SAR	smolt-to-adult return rate
SLAM	Species Life-cycle Analysis Modules
SWS	selective withdrawal structure
TBD	to be determined
TDG	total dissolved gas
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
UWR	Upper Willamette River
VSP	viable salmonid population
WATER	Willamette Action Team for Ecosystem Restoration
WCM	Water Control Manual
WLC-TRT	Willamette/Lower Columbia Technical Recovery Team
WTC	water temperature control
WS	Willamette System

CHAPTER 1. INTRODUCTION

1.1. OVERVIEW

The Willamette System (WS), built and operated by the U.S. Army Corps of Engineers (Corps), consists of 13 multipurpose dams and reservoirs, and approximately 92 miles of riverbank protection projects in the Willamette River Basin in Oregon (Figure 1-1). Each project in the WS contributes to an overall water resources management plan for the basin designed to provide flood risk management (FRM), hydropower generation, irrigation, navigation, recreation, fish and wildlife, and improved water quality on the Willamette River and many of its tributaries.

The Willamette System dams are classified as either storage or re-regulation projects. Storage projects are operated to provide FRM benefits in winter and conservation storage benefits in summer. Some Willamette system storage projects have hydropower units and can be operated as either base-load projects or peaking projects. Base-load projects generally run their turbines around the clock producing electricity evenly across heavy load hours and light load hours. Hills Creek and Cougar dams are base-load projects. Green Peter, Detroit and Lookout Point dams are storage projects that are used for power peaking. Because power-peaking projects have the ability to shape their power operations, re-regulation dams that also generate hydropower are installed downstream to normalize and produce steady downstream flows. Big Cliff, Foster and Dexter are re-regulation dams. Fall Creek, Cottage Grove, Fern Ridge, and Blue River are storage projects without hydropower generation. Dorena has a privately owned hydropower facility that was recently installed, with the Corps maintaining control over project releases for Willamette System operations. The hydropower generated by the Willamette system and marketed by Bonneville Power Administration (BPA) can provide enough power to service about 300,000 homes. The BPA funds the operation and maintenance of the hydropower infrastructure associated with the Willamette dams.

All Willamette system dams have a water control manual (WCM), and those that store water follow a water control diagram (also sometimes called a rule curve) that provides guidance to reservoir regulators on how to manage reservoir storage to meet multiple purposes. In the fall, the storage projects are drafted down to their minimum pool level in preparation for operating to reduce flood risk, which occurs primarily in December and January. The dams are operated as a system, with FRM being their primary purpose, to minimize flooding downstream, including along the mainstem Willamette River in the large population centers at Eugene, Albany, Salem, and Portland. To do this, reservoir inflow is stored during a storm event and released after the downstream river levels have subsided. This operation reduces flooding downstream of the projects in both the regulated tributaries and the mainstem. In total, the dams control flows on six major tributaries affecting approximately 27% of the total geographic area of the basin, and 42% of the upper basin upstream of Salem.

The fish species listed under the Endangered Species Act (ESA) that are affected by operation of the Willamette system include Upper Willamette River (UWR) spring Chinook (*Oncorhynchus tshawytscha*, threatened), UWR winter steelhead (*O. mykiss*, threatened), and bull trout (*Salvelinus confluentus*, threatened). Oregon chub[3] (*Oregonichthys crameri*), recently delisted in 2015), were also assessed in this report. The distribution of each species is shown in Table 1-1. Populations of these ESA-listed fish species have declined as a result of the dams, hatcheries, harvest, habitat degradation, competition with non-native fish, and predation, among other factors.

[3] On February 4, 2014, the U.S. Fish and Wildlife Service (USFWS) announced a proposal to remove the Oregon chub (*Oregonichthys crameri)*, and its critical habitat, from the list of endangered and threatened species. Oregon chub were officially delisted in February 2015.

Figure 1-1. Projects, Fish Facilities and Revetments in the Willamette Valley System

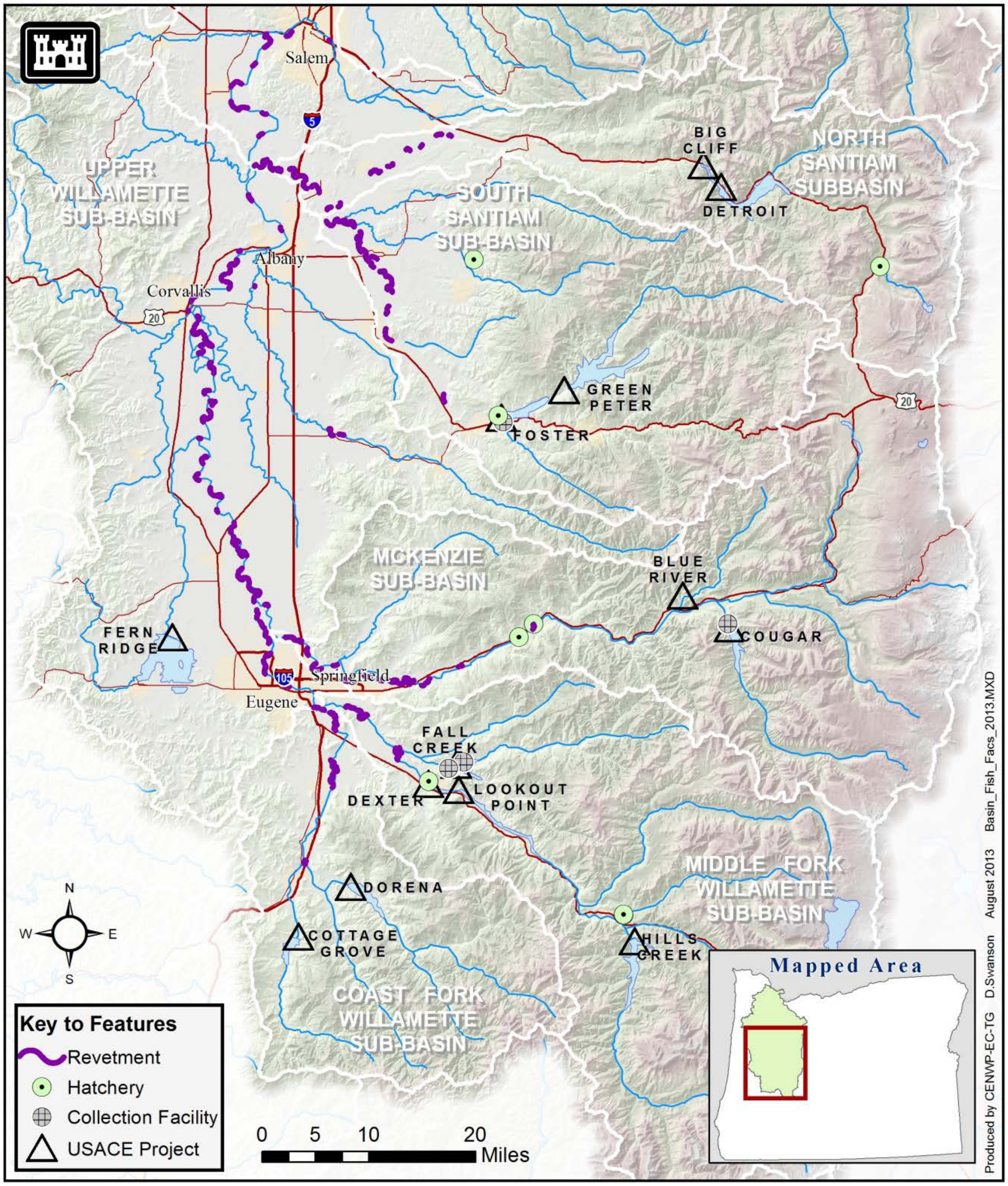


Table 1-1. ESA-listed Fish Presence by Willamette System Subbasin

Subbasin	Willamette System Facilities	Fish Species			
		Spring Chinook	**Winter Steelhead**	**Bull Trout**	**Oregon Chub**[c]
North Santiam	Detroit/Big Cliff	**Present**	**Present**	Absent	**Present**
South Santiam	Green Peter (Middle Santiam) Foster (South Santiam)	**Present**	**Present**	Absent	**Present**
McKenzie	Cougar (South Fork McKenzie) Blue River	**Present**	Absent[b]	**Present**	**Present**
Middle Fork Willamette	Hills Creek/Lookout Point/Dexter	**Present**	Absent[b]	**Present**	**Present**
Fall Creek	Fall Creek	**Present**	Absent[b]	Absent	**Present**
Long Tom	Fern Ridge	Absent[a]	Absent	Absent	Absent
Coast Fork Willamette	Dorena	Absent[a]	Absent	Absent	**Present**
Row River	Cottage Grove	Absent	Absent	Absent	Absent

[a] Juvenile spring Chinook salmon have been documented using lower accessible reaches for winter off-channel use.
[b] Winter steelhead in the McKenzie and Middle Fork Willamette rivers and in Fall Creek are not designated as part of the distinct population segment but may be present in small numbers (source: NMFS 2008).
[c] Oregon chub were officially delisted in February 2015.

Significant declines in abundance of salmon and steelhead in the Willamette were noted before construction of the Corps' dams and revetments in the WS. Historically, for example, annual adult spring Chinook salmon abundance in the Willamette Basin may have ranged as high as 300,000 (Myers et al. 2006). Intense commercial and sport fisheries, hatcheries, pollution (domestic and industrial), and habitat degradation (including logging) are cited as the most important factors contributing to these declines. The count of spring Chinook at Willamette Falls was about 55,000 in 1946, and 47,000 in 1947, and runs diminished rapidly over the next 10 years. Abundance of actual spawning adult Chinook was much lower than numbers observed passing Willamette Falls. Spawning abundance was estimated at about 10,000 in 1947. This loss of adults between Willamette Falls and upstream spawning grounds, before construction of WS dams, can primarily be attributed to harvest, pre-spawn mortality (caused by poor water quality and delay at hatchery racks, or weirs, used to block adult migration for collection of eggs), and brood take for hatcheries.

WS dams and revetments were constructed mostly in eastside tributaries of the Willamette Basin during the 1950s and 1960s. In addition to reducing flooding in the developing Willamette Valley, improving river navigation, and providing hydropower and other benefits, the WS was envisioned to improve water quality by increasing summer flows using WS storage. Water quality in the Willamette River mainstem has since improved, however dams in the tributaries also blocked access to a majority of spawning habitat for spring Chinook, and impacted their production by channelizing the river with revetments, and altered flow, sediment dynamics, and water temperature. At the time, state and federal fisheries managers preferred implementation of hatcheries to maintain fish for harvest, and fish passage was deemed not feasible for several dams. Therefore, hatchery production of Chinook salmon, steelhead and trout was increased to mitigate for lost habitat above WS dams, as funded by the Corps. These hatchery practices have impacted the wild productivity and health of spring Chinook in the Willamette Basin.

Today, the total abundance of wild spring Chinook above Willamette Falls is < 5,000 annually. Winter steelhead and bull trout declines have been of a similar magnitude. Development of the Willamette system dams blocked access to a significant proportion of historical habitat for UWR Chinook and UWR steelhead, and resulted in fragmentation of habitat for bull trout and Oregon chub. The dams degraded downstream habitat by altering seasonal flows and water temperature patterns, and disrupting normal geomorphic processes that are important for fish. Hatchery fish produced to mitigate the loss of wild fish have had a negative effect on the genetic diversity and productivity of wild fish in the basin. All of these factors, as well as the effects of climate change, may continue to affect the ability for these fish species to persist.

In 2008, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) and the U.S. Fish and Wildlife Service (USFWS) each issued a Biological Opinion (BiOp) with regard to continued operations and maintenance of the Willamette system. The NOAA Fisheries BiOp (2008 BiOp) included a Reasonable and Prudent Alternative (RPA) outlining actions to be taken by the Action Agencies[4] to avoid jeopardy of ESA-listed Chinook and steelhead in the Willamette River Basin (NOAA Fisheries 2008). The 2008 BiOp also included the formation of the Willamette Action Team for Ecosystem Restoration (WATER) as the regional group to collaboratively work on BiOp implementation. The WATER group includes federal, state, tribal, municipal, and other stakeholders with interests or management authority in the Willamette River Basin. The USFWS BiOp concluded the proposed action would not jeopardize ESA-listed Oregon Chub or bull trout so long as the 2008 BiOp RPA was implemented.

The 2008 BiOp RPA included measures for fish passage, water temperature, total dissolved gas (TDG), flows, water contracts, habitat and hatcheries. There also were measures for coordination, studies and monitoring related to the substantive measures. More specifically, RPA measure 4.13 required the Action Agencies to carry out a Configuration/Operation Plan (COP), a multi-year, multi-level study process to evaluate a range of potentially beneficial actions for listed fish at Willamette system dams and reservoirs. During the consultation process, the Action Agencies requested that this RPA measure be included in the BiOp in order to provide the information necessary to seek Congressional authorization and or appropriations to complete RPA actions.

Decision-making for all of the final actions and implementation of the actions included must comply with all applicable statutes and regulations. Among those the Action Agencies must consider are the National Environmental Policy Act, Clean Water Act (CWA), and the Northwest Power Planning Act. Although no final determination has been made, it is likely that an Environmental Impact Statement or Supplemental Environmental Impact Statement will be required to implement the preferred plan.

In 2009, the Portland District completed the Reconnaissance Phase (Phase I) of the COP as described in the 2008 BiOp RPA (measure 4.13). The Phase I COP Report identified a range of structural and operational measures to be considered, established preliminary system-wide priorities, and outlined a process to formulate and evaluate alternatives during the COP Phase II effort.

1.1.1. Authority

Part of the COP Phase II effort was to verify that there was authority to design and construct downstream fish passage and temperature management improvements at Corps dams in the WS.

House Resolution Document No. 81-531, Appendix J of the Report of the Division Engineer, prepared by Portland District, provides the Corps with authority to design and construct downstream fish passage and temperature management improvements at sites identified in the COP Phase II recommendation. The House Resolution Document discusses the impact of the comprehensive plan on fish in greater detail and states:

[4] The Action Agencies for the BiOp include the U.S. Army Corps of Engineers, Bonneville Power Administration, and the Bureau of Reclamation.

> At the present time, successful means or devices for passing migratory fish over high dams have not been devised, and the artificial propagation of spring Chinook salmon and steelhead trout has not accomplished the desired results. The proposed reservoirs, drainage projects, and other improvements would have both adverse and beneficial effects on the wildlife of the area. Apparently a need exists for the development, by means of research and experimentation, of facilities for passing anadromous fish over high dams, new hatchery techniques and methods of hatchery operation, and *ways and means to mitigate the losses that might be incurred by fish and wildlife resulting from the proposed plan of improvement*. (H.R. Doc No. 81-531, 1824, emphasis added.)

Fish passage and temperature management are inextricably linked, and therefore temperature management is an important component of mitigating the potential loss of migrating adult and juvenile fish when providing for fish passage. Fish passing both upstream and downstream of dams require both safe and effective methods for surviving passage through the dam and the appropriate water quality to attract them to preferred passage routes. As a result, the COP Phase II recommended plan includes a floating screen structure with associated temperature management at Detroit Dam to provide safe and effective juvenile fish passage and to manage fish habitat conditions downstream for both juvenile and adult fish. (Personal communication with NWP Office of Counsel.)

1.2. BIOLOGICAL OPINION AND IMPLEMENTATION TO DATE

An RPA is an action, identified during formal consultation, that can be carried out consistent with the purpose of the action, is within the scope of the action agency's legal authority, is economically and technologically feasible, and would avoid jeopardy to listed species and the destruction or adverse modification of designated critical habitats (50 CFR 402.02). Implementation of the NOAA Fisheries 2008 Willamette system BiOp RPA has focused on actions such as flow management, upstream fish collection facility improvements, and research to better understand requirements and likely effectiveness of large downstream fish passage and temperature management structures. Initial alternatives evaluations have commenced for effective fish passage improvements at Cougar, Detroit, and Foster. RM&E has commenced in the Middle Fork Willamette, and a High-Head Bypass Team was initiated. Fall Creek and Dexter adult collection facility design work has also been completed. Additionally, the following construction actions have been completed to date:

- Minto adult fish facility.
- Improved adult fish release sites above Corps dams.
- Foster adult fish facility.
- Cougar portable floating fish collector in support of research, monitoring and evaluation (RM&E) for Cougar downstream passage.
- Cougar adult fish facility.

The Fall Creek Water Control Manual is currently being updated to specify a drawdown for a short period each winter, when conditions allow, to pass fish and also to purge predatory fish from the reservoir. This operation was previously considered an interim operation, but will now be part of normal operations.

Endangered Species Act Section 7 consultation for the Willamette system involves many measures that could not be clearly defined at the time the 2008 BiOp RPA was completed, and were awaiting study results and design feasibility analyses before specific decisions could be made. For instance, in the fish passage measures in RPA section 9.4, NOAA Fisheries required that downstream fish passage be carried out by a specific year at three dams; but until field studies were completed and design alternatives analyzed, neither the Action Agencies nor NOAA Fisheries could predict what sort of system or set of operations this would entail. The COP evaluation is an important component of the BiOp and outlines the implementation strategy for these large structures.

1.3. CONFIGURATION/OPERATION PLAN PROCESS

The Corps initiated the COP process in 2008 to calculate the costs of specific projects, their biological benefits, and a reasonable array of potential alternatives to achieve the desired results. The COP is being used by the Action Agencies to identify specific cost-effective feasible actions and implementation plans to be presented to NOAA Fisheries to evaluate whether the actions sufficiently reduce effects of the Willamette system on Chinook and steelhead to address ESA Section 7 requirements (avoidance of jeopardy and destruction or adverse modification of critical habitat). In addition, other studies were undertaken separately from the COP as required or recommended under the BiOps, such as for head of reservoir (HOR) juvenile fish collection.

1.3.1. COP Phase I

In 2009, the Portland District completed the Reconnaissance Phase (Phase I) of the COP as described in the 2008 BiOp RPA (measure 4.13). The Phase I COP Report identified a range of structural and operational measures to be considered, established preliminary system-wide priorities, and outlined a process to formulate and evaluate alternatives during the COP Phase II effort.

1.3.2. COP Phase II

Using the latest biological study results and analysis of feasibility, this Phase II report provides determinations regarding the feasibility of fish passage, water temperature control, and other related structural, operational, or habitat improvement alternatives. It provides specific recommendations for improving biological conditions for ESA-listed anadromous fish species in the Willamette system, includes recommendations for major structural and operational changes, and considers the potential effects of implementing proposed alternative(s) on ESA-listed resident fish (bull trout and Oregon chub). The process used to evaluate subbasin alternatives and system-wide scenarios for biological benefit, technical feasibility and cost-effectiveness was completed in several steps (Table 1-2).

Table 1-2. COP Phase II Steps

STEP	Decision Support Process
Step 1	Define project goals, objectives, and constraints
Step 2	Update Phase I results/supplement with current data
Step 3	Determine range of alternatives to be assessed
Step 4	Conduct detailed biological analyses for baseline and alternatives (review with WATER)
Step 5	Establish subbasin alternatives and system-wide scenarios for assessment (review with WATER)
Step 6	Conduct detailed technical and economic assessments
Step 7	Determine benefits and costs, including uncertainty
Step 8	Determine other impacts, including uncertainty
Step 9	Determine significance of impacts (work with WATER)
Step 10	Compile results based on decision-maker input
Step 11	Presentation/discussion with decision makers – Action Agencies select Preferred Plan
Step 12	Repeat decision process (as new data, new measures, etc. are identified)

To complete the overall COP Phase II assessment, the COP team developed and applied a science-based decision framework to organize and assess biological, technical and economic data for the wide range of subbasin alternatives under consideration. The criteria the Action Agencies applied determined whether or not the action was: (1) biologically feasible, (2) technically feasible; and (3) cost effective (from 2008 BiOp). Documenting uncertainty and impacts (both positive and negative) were important aspects of this framework. The intent was to clearly present to decision makers the tradeoffs associated with different implementation strategies. As new information is learned, refined results can be provided to decision makers.

The decision framework applied a range of screening criteria. Screening criteria include minimum biological thresholds, certainty of actions, and other impacts. Alternatives achieving the criteria were carried forward. Evaluation of impacts and uncertainty were then used to identify preferred actions and implementation strategies. Screening criteria are presented in Section 2.2 and its various sub-sections. Additional discussion and information about how results were compiled for decision makers is presented in Section 2.11.

1.3.3. Coordination, Review and Decision Making

The WATER structure was established as part of the 2008 BiOp RPA to accomplish coordination and includes several technical teams, as well as a Steering Team and a Managers Forum for policy level discussions. The Action Agencies have provided updates to WATER managers that summarized the information for decision-making, what data gaps exist, and the risk and/or uncertainty related to the information to assist in the decision-making process. The WATER managers met as needed based on key decision points included in the 2008 BiOp. The updates contained details on COP alternatives and system-wide scenarios to reflect updates on biological data and engineering feasibility, as well as anticipated biological benefits. The updates and final report serve as a key source of information for WATER coordination, collaboration, and dispute resolution. The typical steps required before finalizing results and reports include:

1. Complete draft document/report.
2. Internal Corps technical and management review.
3. Action Agency review/discussions.
4. WATER review.
5. Action Agencies finalize decisions and document/report (significant unresolved WATER comments will result in Agency Manager input).

Since 2008, separate Corps design teams have initiated work on implementation of the 2008 BiOp, identifying detailed alternatives for Cougar, Lookout Point and Detroit and also follow the above coordination steps. As each design team progresses with their alternative studies, information is exchanged with the COP and through WATER teams, and was incorporated into the COP Phase II analysis.

The RM&E program provides key information for identifying and designing alternatives to address the identified measures in the RPA, and to evaluate their effectiveness once implemented. This information was used to help establish project performance criteria by evaluating the feasibility and biological benefit of specific alternatives. The Action Agencies and WATER conduct annual reviews of the Willamette RM&E program to assess the results from previous years and provide input on RM&E priorities and study approaches on upcoming years. Critical uncertainties requiring RM&E continues to be identified and addressed as the design teams move forward with the alternative studies.

The Action Agencies harbor sole responsibility for implementation of proposed alternatives and system-wide scenarios to meet 2008 BiOp requirements that are determined to be feasible and authorized, while the responsibility for assessing the adequacy of alternatives and system-wide scenarios for avoiding jeopardy to ESA-listed species or adverse modification of critical habitat remains solely the responsibility of NOAA Fisheries and USFWS (the Services). The Services will inform the Action Agencies whether they agree or disagree with the decisions, or if specific decisions are inconsistent with the intent of their respective BiOp. If the Services disagree, the Action Agencies may modify the decisions based on the Services determination, or reinitiate consultation. Decision-making for all of the final actions and implementation of a plan to meet BiOp requirements must comply with all applicable statutes and regulations.

CHAPTER 2. FRAMEWORK FOR EVALUATION

2.1. OVERVIEW

The overall objective for the COP Phase II effort is to develop an implementation strategy to address the 2008 BiOp RPA to avoid jeopardy for ESA-listed fish species in the Willamette Basin, which satisfies completeness, effectiveness, efficiency (cost-effective), and acceptability criteria (Corps 2009). A science-based framework was developed to organize and assess biological, technical and economic data for the wide range of alternatives under consideration for implementation. This framework aims to clearly present the tradeoffs associated with different BiOp implementation strategies to decision makers, be useful throughout the time frame of BiOp implementation, and support future ESA consultations on the Willamette system. Once implementation begins, detailed design work and ongoing RM&E will continue to inform the details of the plan. This information will be critically important in refining designs. It is anticipated the plan can be implemented within the cost estimate developed. Significant cost changes due to this new information would require new authorization. As new information is learned, updated and refined, results will be provided to the decision makers.

To develop the implementation strategy, biological analysis tools were developed and applied to determine the environmental effectiveness of the alternatives. These tools were logical, empirically based, transparent and defensible. The analysis considered all significant costs and other impacts of the alternatives. A process was developed to assist the COP Product Delivery Team (PDT), decision makers and other stakeholders in evaluating individual alternatives and combinations of alternatives within and across the Willamette subbasins. This process incorporated non-monetary benefits, monetary costs, and non-monetary outputs. Criteria, to help assess actions were defined in terms of biological metrics.

This chapter of the COP Phase II report discusses the 12-step process used to evaluate COP Phase II alternatives for biological benefit, technical feasibility and cost-effectiveness. It also describes how the biological, technical, and economic evaluations were conducted for the study.

2.1.1. Baseline Condition

Baseline conditions provided a point of reference for comparison and for weighing potential benefits and impacts. For 2008 BiOp implementation, which is occurring over several years, incremental or yearly changes have and will continue to occur in the Willamette system. Therefore, for the COP Phase II effort, three points of reference were considered in technical evaluations:

- **Pre-BiOp Baseline** – Represents conditions as of the 2007 Supplemental Biological Assessment (BA; Corps et al. 2007). This baseline represents the basin conditions that were in place just prior to the 2008 BiOp being issued.
- **Early Implementation Benchmark** – Represents conditions early in the 2008 BiOp implementation (2009-2010) with some actions well established (including meeting mainstem and tributary flow targets, the construction of the Cougar adult collection facility, completion of the Minto facility, improved flow ramping rates for fish and interim temperature operations at Detroit). These actions are to be carried forward and included as a part of future BiOp implementation and unlikely to revert back to pre-BiOp conditions. This point of reference will be provided in the comparison of results to help differentiate improvements beyond what has already been implemented.
- **Early Implementation with IRRM Benchmark (IRRM Benchmark)** – Represents conditions early in the 2008 BiOp implementation (2009-2010) combined with near-term restrictions from interim risk reduction measures (IRRM) implemented in 2010 as a result of structurally overstressed spillway gates identified during project inspections. For most projects, the IRRMs

relate to restricting use of the gates during high pool levels (caused from large flood events) in the winter months. The one exception is Lookout Point that has a spillway gate restriction year-round (at elevation 915 feet NGVD29[5]). The IRRMs have caused a slight change in project operations; the COP team identified the IRRM Benchmark as another important point of reference when assessing impacts (both positive and negative). This point of reference will be provided in the comparison of results to help differentiate improvements beyond what has already been implemented and will be very similar to the Early Implementation Benchmark and is the basis for comparisons in the cost-effectiveness analysis.

The detailed assumptions for each key point of reference are documented in Appendix A and summarized in Table 2-1.

[5] All elevations in this report are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

2.2. STEP 1: DEFINE PROJECT GOALS, OBJECTIVES, AND CONSTRAINTS

The overarching goal of the COP is to provide the detailed analyses needed to implement RPA measure 4.13 in the NOAA 2008 BiOp, and prepare an implementation plan proposing specific feasible actions, costs, and schedules for addressing the overall 2008 RPA. Corps Planning Guidance requires an upfront examination of project goals, objectives, and constraints. Much of this was done for the COP Phase I effort (Corps 2009), and is expanded upon here for the Phase II effort. The objectives and constraints for the Phase II effort are described below.

The decision framework applied a range of specific screening criteria and assumptions to assess alternative actions in the COP Phase II analysis. These criteria and assumptions are summarized as:

1) *Actions will meet dam safety requirements, and not result in a reduction to the Corps flood risk management mission.* To assess and implement alternatives for BiOp implementation, it was assumed that the selected plan or suite of plans would not result in a reduction to the Corps flood risk management mission. If an alternative resulted in an increase in flood risk or flood impacts as analyzed, it was flagged for further discussion to mitigate flood risk or dam safety concerns. Assessed changes to operational regimes were necessary to meet Corps dam safety requirements.

2) *Any above-dam fish reintroduction efforts must reach "replacement."* Upstream fish passage, and in some cases downstream fish passage, were expected to be via trap and haul, (i.e., not volitional fish passage), fish passage improvements must allow sufficient passage survival so that the above dam sub-population is able to replace itself on average over time (i.e., enough adult progeny must successfully return and be transported above the dam to seed production of the next generation).

3) *Drainages with both Chinook and steelhead are a priority.* Actions which provide benefits for both Chinook salmon and steelhead species are understood to be of greater value than actions that address only one species. Subbasins with both Chinook salmon and steelhead were prioritized higher than those with only one species.

4) *Improvements for more than one population per species needed.* Improvements for at least two populations per species (Chinook or steelhead) are necessary to spread risks for the species relating to environmental variability and catastrophic events.

5) *Biological Criteria - System VSP score ≥ 1.6 above 95% confidence interval and two subbasin populations above 2.0.* Neither the ESA nor regulations have provided a specific metric or criteria in which to determine jeopardy avoidance. After reviewing regional biological opinions and recovery plans for salmon, the COP Product Delivery Team (PDT) assumed measures of extinction risk best relate to species survival, and that a high probability of going extinct over a relatively short time period related to a Viable Salmonid Population (VSP) score less than 1.6 averaged across populations affected by the WS. Because of the uncertainty in VSP scores and in the proposed measures, only alternatives that achieved the VSP criteria with 95% confidence were carried forward.

6) *Phased Approach is Preferred.* To reduce risks and apply information gained during the design and implementation steps, a phased approach was considered where feasible for each alternative. This approach provides important phased prototyping steps to help lower risks and improve chances of reaching biological goals.

7) *Middle Fork investments are most risky (technically and biologically).* Middle Fork subbasin was ranked lowest among other subbasins for improvement by the COP PDT, and solutions which met biological and other criteria were sought which considered improvements in the other three subbasins affected by the WS while maintaining baseline conditions in the Middle Fork (except for Fall Creek tributary of the Middle Fork). If solutions which met biological and other criteria were not available, then this criterion would be reconsidered. Although a tributary to the Middle Fork, improvements in Fall Creek were considered since wild Chinook are established above Fall Creek Dam and abundance has increased in recent years.

8) *Actions should be cost-effective, including consideration of hydropower impacts.* Some alternatives will provide similar levels of benefits, and the least expensive, feasible alternative should be prioritized. Implementation of the RPA will be costly and it must be done in a cost-effective manner. Development of a cost-effective plan, or suite of plans, is an opportunity for the region and nation to improve the probability of long-term survival of ESA-listed species, while using available resources wisely.

The following sub-sections go into each of these criteria and assumptions in more detail, although the order of discussion differs from the numbered items above.

2.2.1. Objectives and Constraints

The fundamental objectives and constraints used to assess alternative actions in the COP Phase II analysis are summarized and described below. The COP results are formulated based on the objectives. Constraints are restrictions that have been placed on the evaluation.

Objectives:

- Biological criteria - system viable salmonid population (VSP) scores ($\geq$ 1.6 above 95% confidence interval (CI) and two subbasin populations $\geq$ 2.0).
- Actions should be cost-effective, including consideration of hydropower impacts.
- Improvements for more than one fish population per species are needed.
- Any above-dam fish reintroduction efforts must reach “replacement.”
- Phased implementation approach is preferred.
- Drainages with both Chinook salmon and steelhead are a priority.

Constraints:

- Actions that will result in a reduction to the Corps FRM mission will be flagged.
- Actions will meet Corps dam safety requirements.
- If improving North Santiam subbasin, need both water temperature and passage measures.
- Middle Fork subbasin investments are the most risky (technically and biologically).

Additional details about each of the objectives and constraints are discussed in sections below.

Table 2-1. Summary of Baseline and Benchmark Assumptions for Willamette Valley Projects

Category	Description	Location	Baseline and Key Benchmark Scenarios		
			Pre-BiOp (2007 Supplemental BA)	**Early BiOp Implementation**	**Early BiOp Implementation with IRRMs**
Project Operations Related to Flow	Ramping Rates	Detroit, Foster, Cougar, Hills Creek, Dexter, Fall Creek	WCM ramping rates	BiOp ramping rates	
	Mainstem Flow Targets	Detroit, Cougar, Hills Creek, Dexter, Fall Creek	State requested mainstem flows	BiOp mainstem flows (same as Pre-BiOp Baseline)	
	Tributary Flow Targets	Detroit, Cougar, Hills Creek, Dexter, Fall Creek	WCM minimum flows	BiOp tributary flows	
	Irrigation	Detroit	Assume 75 cubic feet per second (cfs) in spring-summer		
Passage	Transporting Chinook above Dams	Detroit, Foster, Cougar, Hills Creek, Lookout Point, Fall Creek	Transporting Chinook above project		
		Green Peter, Dexter	Not transporting Chinook above project		
	Transporting Steelhead above Dams	Detroit, Green Peter	Not transporting steelhead above project		
		Foster	Transporting steelhead above Foster		
		Other Projects	Fish not present		
	Adult Fish Facility	Minto, Cougar	Original facility	Facility upgraded	
		Foster, Dexter, Fall Creek	Original facility		
	Interim Downstream Passage	Detroit, Green Peter, Cougar, Hills Creek, Lookout Point	Not operated for downstream passage		
		Foster	Project drafted April-May for fish weir use		
		Fall Creek	Not operated for downstream passage	Reservoir is drawn down in winter to move fish out of reservoir	
	Permanent Downstream Passage	Detroit, Big Cliff, Green Peter, Hills Creek, Lookout Point	Passage limited to turbine, spillway or regulating outlet (RO)		
		Foster	Fish weir in use April-May; otherwise, passage limited to turbine or spillway		
		Cougar	Passage limited to turbine or RO		
		Dexter	Passage limited to turbine or spillway		
		Fall Creek	Passage limited to RO		
Water Quality	Permanent Temperature Control	Detroit, Big Cliff, Foster, Green Peter, Hills Creek, Lookout Point, Fall Creek	No permanent temperature control in place		
		Cougar	Temperature control tower in place		
	Interim Temperature Control	Detroit & Big Cliff	Not operated for temperatures	Operated for interim temp control (blend cold turbine/RO flows with warm spillway flows June-November)	
		Foster & Green Peter, Hills Creek, Lookout Point	Not operated for temperatures		
		Fall Creek	Use fish horns (intakes at various elevations) improves temperatures		
	Total Dissolved Gas Operations	Cougar	Pre-draft by releasing at full load in summer to prevent spill during fall drawdown (for TDG)		
		Detroit, Big Cliff, Foster, Green Peter, Hills Creek, Lookout Point, Dexter	Spread spill across bays to minimize TDG		
		Fall Creek	No operations for TDG		
Dam Safety	Minimum Gate Openings	All Projects	Equipment operated to meet flow needs, not necessarily 2010 guidance	Operated to meet 2010 guidance on minimum gate openings	
	Spillway Gates & Components	Detroit, Cougar, Hills Creek, Fall Creek	Emergency spillway gate – no restrictions		IRRM in place affecting winter pools
		Foster	No restrictions		
		Green Peter	No restrictions		IRRM in place affecting winter pools
		Lookout Point, Dexter, Big Cliff	No restriction		IRRM in place year-round

2.2.1.1. Biological Criteria - System VSP Scores

The ESA provides that a federal agency must "ensure" that its actions are not likely to jeopardize the continued existence of a listed species or adversely modify its critical habitat. Regulations define jeopardy as, ". . . to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both survival and recovery of a listed species in the wild…." In analyzing the effects of an action, consulting agencies must:

- Resolve uncertainty in favor of the species.
- Be "reasonably certain" that any actions or mitigation identified will, in fact, occur.
- Consider impacts on recovery as well as survival.
- Consider impacts on survival and recovery in both the short and long term.

The 2008 RPA for the Willamette system states that the Action Agencies will evaluate a variety of potential actions intended to benefit ESA-listed fish to avoid jeopardy, and that the biological criteria would be defined as a part of the COP process. The RPA further describes that the Action Agencies would then present specific implementation plans to NOAA Fisheries based on results of the COP, and NOAA Fisheries would evaluate whether the actions proposed in the implementation plans were likely to have the biological results that NOAA Fisheries relied on in their BiOp to avoid jeopardy. Therefore, biological evaluations in the COP incorporate biological criteria and an analysis approach consistent with that used by NOAA Fisheries for evaluating the jeopardy standard.

The Viable Salmonid Population (VSP) analysis framework (McElhany et al. 2000) is used by the NOAA Fisheries to help evaluate the status of a species, determine if a federal action will meet the requirements of the ESA, and provide an analytical framework for determining if a RPA is needed (e.g., NOAA Fisheries 2006). For example, the VSP was used in the 2008 BiOp and in the 2011 *Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead* (ODFW and NOAA Fisheries 2011).

For consistency between the 2008 BiOp, the BiOp for the Federal Columbia River Power System (FCRPS; NOAA Fisheries 2014), the UWR Recovery Plan for Chinook and steelhead (ODFW and NOAA Fisheries 2011), and the latest NOAA Fisheries salmon and steelhead status review (Ford et al. 2011), the VSP analysis was used in the COP to assess the biological benefit of individual and combinations of measures for achieving population-level goals. The VSP principles help form an explicit science-based framework to evaluate population extinction risk (NOAA Fisheries 2006). Although the actions assessed in the 2008 BiOp and 2011 UWR Recovery Plan are less specific or different than those evaluated in this report, the VSP assessment approach provides a comparable framework, also useful for future ESA consultation for the Willamette system and to Willamette recovery planners. A summary of the approach is provided in Section 2.5. Additional information is provided in Appendix C.

Specific biological criteria (performance criteria) for proposed actions could not be defined in the 2008 BiOp RPA, in part due to questions on the feasibility and biological benefits of major substantive actions (downstream fish passage in particular). To develop biological criteria to identify and prioritize COP alternatives consistent with avoiding jeopardy, criteria from the following were considered: (a) the FCRPS ESA consultation, (b) other NOAA Fisheries BiOps for salmon and steelhead, (c) the Willamette-Lower Columbia Technical Recovery Team (WLC-TRT; McElhany et al. 2007), and (d) other regional recovery plans.

McElhany and others (2000) assumed that risks to a species may constitute jeopardy if the risks pose threats to short- or long-term species survival, further stating that some jeopardy evaluations have made use of “critical” thresholds that trigger strong management actions if exceeded (where, in most cases, a “critical” status means that a population has a non-negligible probability of going extinct over a relatively short time period (e.g., 10 years).

The FCRPS ESA consultation represents the largest effort to date for a federal action to reduce effects on listed salmonids and avoid jeopardy. Section 2.1.1.4 of the 2008 FCRPS BiOp describes metrics and the analytical approach to evaluate the jeopardy standard. The 2008 FCRPS BiOp evaluated the effects of the RPA relevant to the survival and recovery prongs of the jeopardy standard in a manner consistent with recovery planning criteria and analyses, first at the individual population level, second at the major population group level, and finally reaching conclusions at the species level [evolutionarily significant unit (ESU) or distinct population segment (DPS)]. To complete the 2008 FCRPS BiOp, NOAA Fisheries completed a forward looking evaluation of the listed species and critical habitat, considering ongoing and future effects of the environmental baseline and activities with cumulative effects:

> “The focus of the analysis is on the resulting survival and recovery potential. In particular, NOAA Fisheries identifies the factors limiting improvement in the species’ status toward recovery and assesses whether such limiting factors (considering both biological and listing factor criteria) will be lessened or eliminated. The listed species must have a high probability of continued survival (NOAA 2007b).”
>
> “An adequate potential for recovery is evident when the listed species is on a trend toward eventual recovery. The adequacy of the recovery potential is sensitive to the present obstacles for planning or achieving recovery, as well as to the extent of influence the agency’s actions can have on recovery potential considering the action’s duration and magnitude of adverse effects on the listed species. Thus, in some clearly articulated circumstances, a resulting recovery potential will be adequate where limiting factors are reduced or protective mechanisms are implemented, as with safety net hatcheries, to position the species for eventual progress to recovery.”

The 24-year extinction risk was considered in the FCRPS BiOp as indicative of the survival prong of the jeopardy standard. Three productivity estimates, along with other relevant information such as abundance data, informed the recovery prong of the jeopardy standard:

1. 24-year extinction risk.
2. Average returns-per-spawner productivity.
3. Median population growth rate.
4. Abundance trends.

Each of the productivity metrics provides a complementary but slightly different view of the same underlying population processes.

Considering the 0-4 persistence risk categories presented by McElhany and others (2000), the COP team assumed that a high probability of going extinct over a relatively short time period related to a VSP score of 1.6 averaged across populations affected by the Willamette system. This VSP score represented the mid-point between a high risk of extinction and the UWR recovery criteria for the ESU (a VSP score of 2.25). The system VSP score is an average across all four Willamette system subbasins so some subbasin populations could be higher than 1.6 and others lower. Looking at the system score provides a comparison across the multiple Chinook and steelhead populations affected by the Willamette system not just on individual subbasin populations and therefore, comparable to how NOAA Fisheries evaluates jeopardy at the multiple population group and ESU levels, and comparable to recovery plan criteria.

Because of the uncertainty in VSP scores and reducing extinction risk for each population from proposed measures, the COP VSP criteria only carried forward alternatives which achieved or exceeded the 1.6 system VSP criteria with 95% confidence. Ranges, instead of point values, were developed given the uncertainty in the current understanding of Willamette system affects and uncertainty in the expected benefits of each identified measure. Uncertainty information was provided by the Northwest Fisheries Science Center (NWFSC) for each alternative analyzed in the Species Life-cycle Analysis Modules (SLAM), using the stochastic output of the model. The uncertainty information was included in the COP analysis to help capture risk associated with implementing an action. The methodology to capture uncertainty is documented in Appendix C.

By evaluating the extinction risk score for each individual alternative and combination of alternatives, the VSP analysis allowed the Corps to prepare a strategy to meet the defined criteria for each population and the Willamette system. The COP team used these system VSP scores to assess cost-effective combinations of actions to achieve the average 1.6 scores across populations with 95% CI (and achieve the other criteria as well); therefore, some individual population scores would be greater or less than 1.6 for some combinations that achieve the average criterion.

2.2.1.2. Cost Effective Actions

Implementation of the 2008 BiOp RPA will be costly and it must be done in a cost-effective manner. Implementing actions may involve tradeoffs with other project benefits. Foregoing project benefits is an "opportunity cost" to the nation and must be considered. Additionally, some actions may improve project benefits. Establishing a process to quantify changes to other project purposes, as well as benefits to ESA-listed fish species, allows for informed decision making. Implementing actions, with careful consideration of both the benefits and all the costs to implement the actions, will avoid a situation where the species remain in jeopardy and/or resources are not used efficiently and effectively. Development of a cost-effective plan, or suite of plans, is an opportunity for the region and nation to improve the probability of long-term survival of listed species, while using available resources wisely.

Detailed cost estimates prepared for the recommended COP alternative will also serve as the basis for increasing the congressionally authorized budget cap for the Columbia River Fish Mitigation (CRFM) Program. It was originally estimated that up to $300 million of the CRFM program would be needed for Willamette BiOp implementation. Funds spent from fiscal year (FY) 2008 to 2014 totaled approximately $144.5 million. Providing a biologically based, technically feasible and cost-effective recommendation to implement the Willamette system BiOp will support the request for a CRFM budget increase.

There are many combinations of alternatives that could meet biological and technical criteria but vary widely in cost. If there is a less expensive alternative that would provide similar benefits, it should be considered. Cost information has several facets including the types of funding required (CRFM or operations and maintenance), which must be budgeted. Forgone hydropower impacts must also be considered.

2.2.1.3. Improve More than One Fish Population per Species

Some system alternatives focused on improvements in a single subbasin, which did little to minimize the risk of extinction (or benefits) for steelhead and Chinook within the Willamette system. The COP team focused on alternatives that spread benefits to multiple basins and species. A criteria requiring improvements for Chinook or steelhead in at least two subbasins was established.

2.2.1.4. Above-dam Fish Reintroductions Must Reach Replacement

The fish passage improvements must allow sufficient passage survival so that the above dam sub-population must be able to replace itself (i.e., enough adults must successfully return from the ocean and pass upstream of the dam to seed production of the next generation). In order to evaluate what level of improvement in fish passage survival was needed to establish a self-sustaining sub-population of Chinook or steelhead above a given dam, predicted adult abundance estimates were used to evaluate if replacement was likely to be achieved with each proposed alternative. Fish passage alternatives that met replacement criteria were carried forward for further consideration. The specific criteria used in the "replacement analysis" are presented in Section 2.5.2. Results of the replacement analysis are included in Chapter 3.

2.2.1.5. Phased Implementation Approach

To reduce risks and adapt approaches as information is gained during the design and implementation steps, a phased approach was considered for many alternatives. For example, to engineer a solution for juvenile fish passage and temperature control at Detroit, a phased approach was used for alternative NS-DSP-H4-DET [Selective Withdrawal Structure (SWS) with Weir Box and Floating Screen Structure (FSS)]. The SWS would be designed and constructed initially with a weir box for fish passage. If the weir box did not meet biological requirements, then a FSS would be added using information collected on the weir box during testing. This approach provides important phased prototyping steps to help lower risks of technical failure and improve chances of reaching biological goals in a cost effective manner. Cost estimates were included for all phases to accurately account for total implementation costs.

2.2.1.6. Multi-species Benefits

It is assumed that improvements for both Chinook and steelhead populations are needed to address the 2008 BiOp for the Willamette system. Actions which provide benefits for both species are more efficient than actions that address only one species. A weighted system VSP was used to incorporate steelhead and Chinook biological results. The weighted VSP was calculated using an average of two species within four subbasins (so essentially eight populations assuming a zero VSP for steelhead in the McKenzie and Middle Fork subbasins). This allowed benefits for Chinook and steelhead to be considered in the cost-effective analysis simultaneously, and effectively prioritize actions in the North Santiam and South Santiam subbasins, which have both Chinook and steelhead, over actions in the McKenzie and Middle Fork subbasins.

2.2.1.7. Flood Risk Management and Dam Safety Requirements

In order to assess and implement alternatives for 2008 BiOp implementation, effects on FRM were assessed. House Document 531 specifies that flood control is the primary purpose of the Willamette Valley system. As such, FRM impacts were considered in a manner that weighed the nature and magnitude of potential FRM impacts relative to any advantages provided by the alternatives. Additionally in the Corps Supplemental BA (USACE 2007) the Corps recognized that implementing the actions for listed species would be done "consistent with flood damage reduction and public safety requirements". If an alternative was suspected to increase flood risk or flood impacts, it was flagged for additional technical analysis (see Section 2.7.4). Specifically, the Hydrologic Engineering Center's Reservoir System Simulation model (ResSim) was used to test for impacts to downstream control points as compared to the Early Implementation Benchmark. If either the duration a control point exceeded a threshold or the magnitude of the peak flow was higher under the alternative being simulated, then the alternative was flagged for possible mitigation costs or acceptability. If the alternative increased flood risk and the biological benefits were not anticipated to be high, it was dropped for further consideration.

When assessing changes to operational regimes, it was required that the Corps dam safety requirements were met (see Section 2.7.6). Modifications to alternatives to comply with dam safety requirements were typically reflected as changes to the cost estimates. Additional details on FRM and dam safety assessments are included in Appendix J.

2.2.1.8. Temperature and Passage in North Santiam Subbasin

Improving habitat access for Chinook and steelhead above Willamette dams in the North Santiam is critical for establishing self-sustaining populations of spring Chinook and steelhead. Fish habitat downstream of the Big Cliff and Detroit dams is of lesser quality and is likely insufficient to support self-sustaining Chinook and steelhead populations alone. The majority of historic production for Chinook and steelhead in the North Santiam occurred above Big Cliff and Detroit dams. Below the dams, the subbasin is presently shared with massive Chinook and steelhead hatchery programs that reduce natural productivity.

A new adult fish facility completed at the Minto hatchery in 2012 provides for upstream trap and haul of fish above Detroit Dam. Effective fish passage is dependent on the ability to attract upstream migrating adult Chinook into trapping facilities at Minto, where they are then transported above Detroit Dam to spawn. Water temperatures discharged from Big Cliff Dam can substantially delay adult spring Chinook migration timing and affect egg incubation survival and fry emergence timing below the dam. Before interim temperature operations, adult Chinook upstream migration was delayed and fry emerged from redds below Big Cliff Dam earlier than normal.

Therefore, a criterion was established that both fish passage and water temperature improvements are needed, since achieving benefits of improved passage at Big Cliff and Detroit dams depends on adult Chinook successfully migrating upstream, and production below the dam depends on temperature discharges from Big Cliff Dam. Providing water temperatures within ranges adequate for Chinook will aid migration timing and improve survival of incubating eggs and fry below Big Cliff Dam. Assessment of this criterion is documented in Section 3.2.2.1.

The operation of the Willamette dams in the Middle Fork Willamette subbasin also impact water temperature needs for Chinook salmon; however, actions in the Middle Fork have a high uncertainty and the special criteria described above for the North Santiam was not applied (see Section 2.2.1.9).

2.2.1.9. High Uncertainty in the Middle Fork Subbasin

Of the subbasins within the Willamette system, the Middle Fork Willamette (with the exception of Fall Creek) poses the most challenges for reintroducing and establishing a stable population of spring Chinook salmon above the dams. This subbasin has the most dams and reservoirs in series (Hills Creek, Lookout Point and Dexter), which subdivide the spawning and rearing habitat for spring Chinook and present multiple large passage barriers. In addition, Lookout Point and Dexter reservoirs are inhabited by several species of fish known to prey on juvenile Chinook, including large populations of northern pikeminnow (e.g., Monzyk et al. 2014). These two contiguous reservoirs (subdivided by Lookout Point Dam) have a combined length of over 20 linear miles at full pool, creating challenging conditions for downstream migrating juvenile Chinook.

Successful reintroduction of adult Chinook upstream of Lookout Point Dam and/or Hills Creek Dam is also complicated by having to trap adults below Dexter Dam, located downstream of the historic spring Chinook holding and spawning habitat, where water temperatures are warmer and little adult holding habitat is available. Warmer waters and poor holding conditions contribute to pre-spawn mortality (PSM), and spring Chinook in the Middle Fork subbasin have exhibited extremely high PSM (>90%) in some years (ODFW and NOAA 2011; NWFSC 2015 attached as Appendix C). If PSM cannot be controlled and reduced, re-establishing Chinook salmon in the Middle Fork subbasin will not be possible.

2.2.2. Applied Tool Validation/Certification

As part of the USACE planning guidance, EC 1105-2-412 requires the use of certified or approved models for all planning activities. Models are defined as including any models and analytical tools used to evaluate potential effects of alternatives and to support decision-making. The Willamette BiOp Configuration Operation Plan (COP) Review Plan Amendment approved by NWD on 05 Feb 2015, specifies the process for COP Tool/Model Review: Approved Corps planning tools, such as Institute of Water Resources Planning Suite (IWR-Plan), will be documented as part of the ATR process, and COP biological tools will undergo independent technical assessment using the Independent Science Advisory Board (ISAB) associated with the Northwest Power and Conservation Council.

Several tools were used in the COP analysis. The following is a summary of these tools and how they were used or validated for use. More detailed information on these tools is discussed in Chapter 2 and documented in Appendices.

- IWR-Plan 2.0.6.0 is currently a USACE certified planning model (certified 22 Sep 2010). This tool was used to evaluate cost-effectiveness of alternatives.
- SLAM, VSP and Fish Benefits Workbook (FBW) were not formally certified but were validated using the Independent Science Advisory Board (ISAB). These biological evaluation tools were verified similarly to the process that has been used for the Northwestern Division, Columbia River Basin BiOp actions over the last 20 years. The biological tools went under independent technical review through the ISAB. A NWD/NWP agreement was reached in August 2013 during an in-progress review meeting that biological tools used in the COP would be reviewed using the ISAB that is associated with the Northwest Power and Conservation Council. This approach was included in the 2015 Review Plan. The rationale for this approach, rather than through the PCX, is that the existing ISAB review panel includes the needed biological expertise on these tools and has been working with similar tools on the Columbia. These biological tools/approaches were developed by the NOAA NMFS Science Center over many years and as part of that development were put through extensive peer review. The ISAB review verified that these tools have been properly applied to the Willamette BiOp.

  (Background on the ISAB: In 1998 US Congress Senate-House conference report for the FY 1999 Energy and Water Development Appropriations bill, identified the Northwest Power and Conservation Council's Independent Study Review Panel reviews as an appropriate means for the USACE to have completed independent assessment of study designs, methods and goals to implement regional BiOps. This is especially critical as the data produced are used to support BiOp RPA's implementation. Additional details on the review are included in Section 2.5.4).
- HEC-ResSim, a USACE certified engineering model. This tool was used to analyze system impacts to modified project operations and to quantify impacts to recreation, FRM, water quality and downstream flows. This model's application was reviewed for the Operational Measures

Evaluation Team (OMET) report (USACE 2014). The COP team utilized the ResSim results from the OMET report.

2.3. STEP 2: UPDATE PHASE I RESULTS

A preliminary re-analysis of the COP Phase I measures was completed early in the COP Phase II effort to identify measures to carry forward as alternatives for detailed biological, technical and economic analyses. Each Phase I measure was qualitatively assessed by the PDT for several biological categories. Each category was given a score between 1 and 5, with 1 indicating the measure was worse for ESA-listed species, 3 indicating no change (for most categories), and 5 indicating the measures provided significant biological benefit. To help ensure scoring was applied consistently, a pre-defined question was used for each category, and each value was discussed by the team.

A matrix was developed for each subbasin – North Santiam, South Santiam, McKenzie and Middle Fork Willamette. No actions were proposed for the Coast Fork and Long Tom subbasins. The resulting matrix for each subbasin documented assumptions and captured key interactions between biological categories. The results were then examined on a broad scale (i.e., reconnaissance level) for technical feasibility. The PDT also reviewed the ranked list to consider redundancy of actions, incorporate new knowledge gained through on-going RM&E activities, and consider regional priorities. The end product was a refined list of alternatives by subbasin to be carried forward for detailed assessment in the COP II effort. The measures found not to be technically feasible, and/or that appeared not to provide sufficient biological benefits, were flagged and not carried forward for detailed analysis.

Two points of reference were scored for comparison to the proposed measures: the pre-BiOp baseline and Early Implementation benchmark. For the purpose of the analysis the team assumed that Early Implementation benchmark score would be essentially the same as the IRRM benchmark score due to the limited changes in spillway gate modifications and the inability to capture fine detail in this broad qualitative assessment. Appendix B documents the assumptions used to populate each subbasin matrix and contains the final matrix for each subbasin.

2.4. STEP 3: DETERMINE RANGE OF ALTERNATIVES FOR ASSESSMENT

The PDT reviewed the matrix results from Step 2 and updated priorities or verified that matrix results were consistent with current subbasin knowledge, regional priorities and RPA requirements. Priorities were adjusted based on biological and technical considerations documented in Appendix B, and included complexity, redundancy, cost and uncertainty. Only a few measures were flagged as being not technically feasible; these measures were not carried forward as alternatives for detailed biological or technical assessment. For example, fish ladders were considered not technically feasible to achieve upstream fish passage due to associated risks such as temperature issues, head differential, forebay fluctuation, and real estate limitations at the associated Willamette dams.

Other measures were handled by separate groups outside of the COP or design teams (e.g., the Forest Service is currently conducting habitat improvement actions above several Willamette projects). Since these actions are being carried forward outside of the COP effort, they were not assessed in Phase II. The COP recognizes these other actions would contribute towards meeting recovery goals.

2.5. STEP 4: CONDUCT DETAILED BIOLOGICAL ANALYSES

2.5.1. Spring Chinook and Winter Steelhead

A VSP analysis, supported with a life-cycle model and a juvenile fish dam passage model, was used to assess the biological benefits of alternative actions for each Chinook and steelhead population affected by the Willamette system. The rationale for using VSP and descriptions of biological screen criteria are provided in Section 2.2.1.1. The VSP analysis and life-cycle modeling for each Chinook and steelhead population were led by the NWFSC, with parameter development supported with regional input from WATER. The juvenile fish dam passage modeling was completed by the Corps, with parameter development also supported with regional input from WATER. The relationship between the three biological analysis tools and their primary purpose is described in Figure 2-1.

The VSP analysis focused on four biological attributes of viable populations identified by McElhany and others (2000): abundance, productivity, diversity, and spatial structure. Scores for each Chinook and steelhead population affected by the Willamette system were computed.

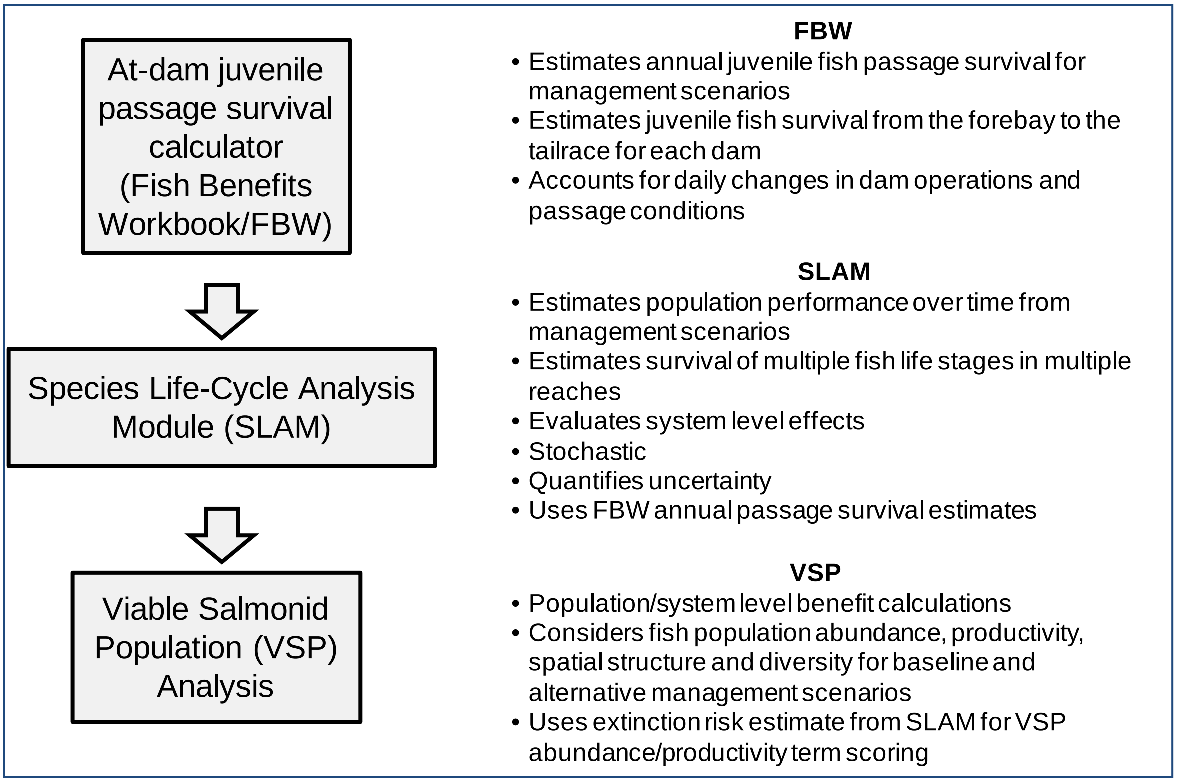
Population persistence (VSP) scoring is based on the contribution of each population attribute toward population persistence (1 – extinction risk). The actual score is a non-linear categorical representation of the probability of population persistence (McElhany et al. 2007).

The VSP score:

$$VSP = \frac{4(Population\_Persistence) + Diversity + Spatial\_Structure}{6}$$

The SLAM model was used to estimate the population persistence term using the quasi extinction risk (all natural origin spawners) option in the SLAM model.

Figure 2-1. Biological Benefit Analysis Tools



For VSP scoring of the diversity term, both direct measures of life history traits and genetic variation and indirect measures were included. The VSP scoring for life history traits (specifically juvenile life history traits) focuses on whether multiple strategies are available in significant proportions, enough so that the population could respond to short-term and long-term environmental changes without suffering a severe decline in population abundance. Scores were computed annually and averaged across the SLAM time series. For each year, deductions would be applied against the possible score of 4 when any juvenile life history segment fell below one of the critical values, any deductions that resulted in scores of less than zero would be considered zero.

The juvenile fish dam passage modeling, or the FBW, was used to estimate annual juvenile fish passage survival for alternatives (operational, structural, and combinations). The FBW calculated passage survival was input into the SLAM model as a parameter and included in the subbasin VSP estimate for a specific alternative. The workbooks allow for testing of operational and structural downstream fish passage improvements as standalone or combined improvements. The FBW analysis estimated project survival from a given Willamette system dam forebay to tailrace for three individual life history types of juvenile Chinook and steelhead (fry, sub-yearling, and yearling) under existing and alternative reservoir, discharge, and passage route conditions. Additionally, project specific passage information, including life history divisions (portions of population passing at each life stage), life history timing, passage route efficiency, and passage route survival calculations were included. FBW development was coordinated with regional representatives to ensure the best available data was used, and was also coordinated with SLAM and VSP to ensure consistency and compatibility between models. Details on the FBW tool are included in Appendix K.

Hatchery fish affect natural population diversity largely through the process of domestication and the introgression of non-adapted hatchery transplants. In general, the VSP diversity scoring regarding hatchery affects relies on the proportion of natural influence, or the relationship between the percent of hatchery-origin spawners (pHOS) and the percent natural-origin broodstock (pNOB) in the hatchery to determine the rate of domestication. The greater the proportion of natural-origin fish utilized as broodstock in the hatchery the slower the rate of hatchery domestication for the broodstock overall. Similarly, lowering the proportion of hatchery-origin fish that spawn in the wild decreases the frequency of "domesticated" genes entering the natural population's gene pool.

Additionally, hatchery propagation may produce non-genetic effects on the expression of life history traits via non-natural rearing regimes (i.e., non-natural size and time of release), although the long-term consequences of these practices on diversity are not well understood. Issues related to competition, predation, or disease transmittal by hatchery-origin fish are indirectly included in life-stage specific survivals in the SLAM model. Appendix C contains a detailed discussion of how hatchery impacts are captured in the SLAM model.

Spatial structure was assessed based on the application of basic principles developed by WLC-TRT (McElhany et al. 2007). The quantitative metrics used address two of the key spatial structure issues: (1) total quantity of available habitat, and (2) spatial distribution of accessible habitat. In addition, quantitative scores were adjusted based on qualitative considerations including habitat quality and life-stage specific spatial distribution. The WLC-TRT spatial structure evaluations were primarily based on the evaluation of maps of accessible habitat developed in the *Atlas of Salmon and Steelhead Habitat in the Oregon Lower Columbia and Willamette Basins* (Maher et al. 2005). The maps likely overestimate current and historical use, perhaps substantially. In addition, the maps only address adult accessibility; they do not describe life stage specific habitat spatial distribution, such as the arrangement of habitat for juvenile rearing. Despite these caveats, the maps can provide useful information and as they were developed using a consistent protocol comparing current and historical potential distribution for an entire ESU/DPS. However, the analysis does not rely solely on these maps and incorporates additional information in the final spatial structure evaluations.

The biological benefit of high ranking alternatives identified in the preliminary evaluation matrix was evaluated using the population persistence category scale shown in Table 2-2.

Table 2-2. Population Persistence Categories

Population Persistence Category	Probability of Population Persistence in 100 years	Probability of Population Extinction in 100 years	Description
0	0-40%	60%-100%	Either extinct or very high risk of extinction
1	40%-75%	25%-60%	Relatively high risk of extinction in 100 years
2	75%-95%	5%-25%	Moderate risk of extinction in 100 years
3	95%-99%	1%-5%	Low ("negligible") risk of extinction in 100 years (viable salmonid population)
4	>99%	<1%	Very low risk of extinction in 100 years

From Table 1 in McElhany and others (2007).

2.5.2. Replacement Analysis

An analysis was conducted using output from SLAM to estimate whether or not a population could successfully replace itself under the assumed fish passage alternatives. The SLAM output provided estimates of hatchery origin spawners and natural origin spawners for each year from 1-105 in the simulation. For the above dam population component, the replacement ratio was computed for each year using the current natural origin spawners (spawning adults) divided by the (natural origin + hatchery origin spawners) from 4 years prior (their parents). The 5-year running average was also computed to look at the replacement from the cohort perspective. To verify whether or not an alternative resulted in population replacement above a dam, multiple aspects were checked including:

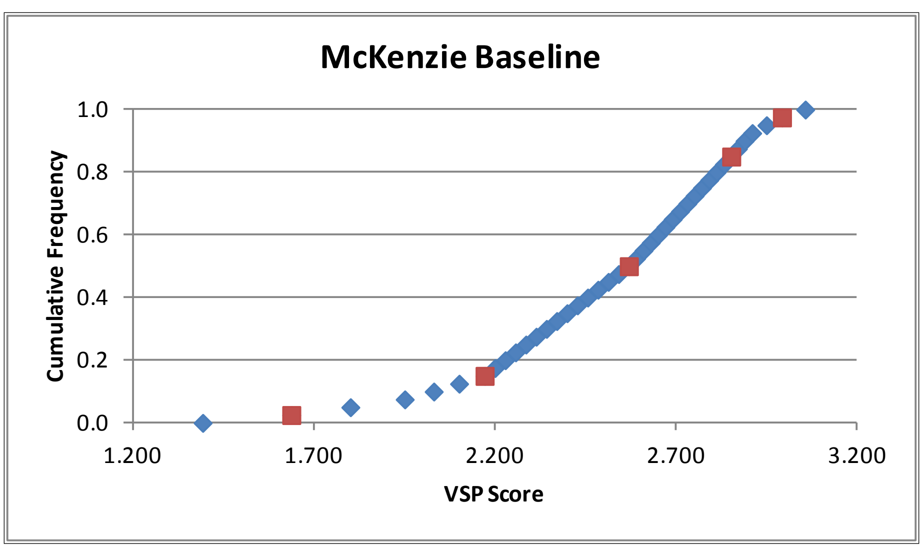
- The average replacement ratio - above 90% (meets replacement) and above 85% (nearly meets replacement).
- The percent of time the 5-year running average was above 95% - more than 70% of the time (meets replacement) and more than 60% of the time (nearly meets replacement).

Results of the replacement analysis are included in Chapter 3.

2.5.3. Biological Uncertainty for System Alternatives

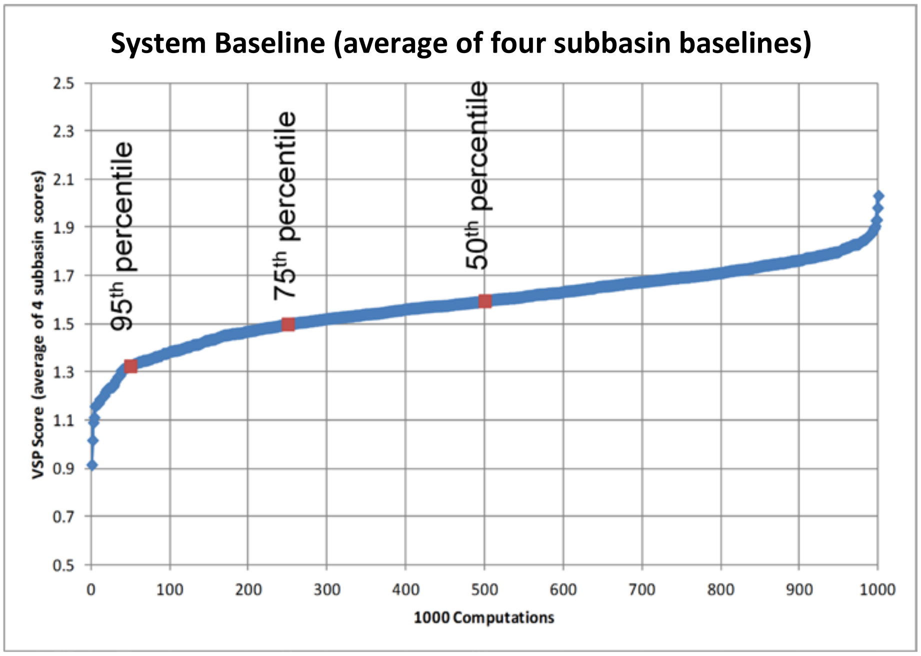
The SLAM model produced stochastic results which captured uncertainty for individual subbasin actions. The COP system alternatives were combinations of the individual subbasin actions. To estimate uncertainty for the system alternatives, the NWFSC provided key summary statistics for each of the simulated alternatives, including the probability exceedance VSP values at 0.025, 0.16, 0.50, 0.84 and 0.975. These were then used to estimate a cumulative frequency curve for each alternative (Figure 2-2). To estimate system alternative uncertainty, a Monte Carlo approach was used with 1000 random samples taken from the cumulative frequency curves for the subbasin alternatives and 1000 averages were computed. Statistics were than computed from the 1000 runs to estimate the 95% CI for the system alternatives (Figure 2-3). In the example shown, the median VSP is 1.6 and the 95th percentile is 1.3.

Figure 2-2. Cumulative Frequency Example for Estimating Uncertainty for a Subbasin Alternative



Cum Freq	VSP Score
0.025	1.64
0.16	2.17
0.50	2.57
0.84	2.85
0.975	2.99

Figure 2-3. Exceedance Graph for 1000 Samples of System Alternative VSP Scores



2.5.4. Regional Input and Technical Review of Analysis Approach for Chinook/Steelhead

Inputs for the FBW and SLAM analyses were discussed regionally with WATER to verify assumptions and expand professional opinions. A series of workshops were held in 2014 with the NWFSC to explore specific parameters and review results. Parameters that lacked empirical data were primarily discussed to ensure a range of appropriate values were assessed during the sensitivity analyses for FBW (Alden BioAnalysts Inc 2014) and SLAM (Appendix C). Additionally, interim products or model results were available to WATER for review. This process helped provide transparency to the tools as well as improve the product with regional experts providing information.

The FBW models, SLAM models, and VSP analysis were reviewed by the Independent Science Advisory Board (ISAB)[6] after parameterization and review by WATER (i.e., regional stakeholders). The ISAB review concluded that the approach for estimating VSP scores, based on outputs from the FBW and VSP life-cycle models, was conceptually and technically valid; however, the Board recommended that VSP scores from the existing life-cycle model should be considered highly uncertain given limitations on the quality of data currently available. Because quantitative outputs from the existing models may be unreliable to differentiate among the options, the ISAB recommended that additional steps should be considered to support decision making in the near term. Weighting factors, including for expected survival benefits and other considerations, were recommended as useful approaches for ranking the alternatives under review. In addition, incremental implementation of some alternatives (i.e., where feasible) was recommended, provided the decision-making process remains flexible and monitoring is adequate to evaluate early results.

[6] The executive summary and full report from the ISAB are available at http://www.nwcouncil.org/fw/isab/.

The COP implemented these recommendations by including weighting factors among the alternatives assessment criteria, considerations of certainty of achieving benefits of the actions, and considered performance of existing fish facilities. The COP implementation plan also discusses an incremental and adaptable implementation approach (see Chapter 4).

2.5.5. Performance of Existing Surface Collection Facilities for Juvenile Fish

Improving downstream fish passage conditions at Willamette system dams is a major action evaluated in the COP. To support fish passage alternative development and comparison, the following information was relied on to estimate expected performance of proposed alternatives:

1. Surface Bypass Program Comprehensive Review Report (ENSR/AECOM 2007)
2. Willamette River Fish Benefit Workbook Parameterization; Chinook (Alden, 2014)
3. Willamette River Fish Benefit Workbook Parameterization; Steelhead (Alden, 2014).
4. Development of New Information to Inform Fish Passage Decisions at the Yale and Merwin Hydro Projects on the Lewis River (Al-Chokhachy 2013)
5. Personal communications with project operators and biologists

Johnson and Dauble (2006) found fish collection efficiency averaged 53%, based on available data reviewed of 69 surface flow outlets. However, it is difficult to compare performance among surface flow outlets, and specifically surface collectors, since evaluation approaches are not standardized in the region, including if/how downstream passage efficiency (DPE) is measured which is a primary metric used in the COP biological evaluation.

Four recent state-of-the-art juvenile fish collection facilities recently implemented at dams in the Pacific Northwest are the: floating surface collector (FSC) at Swift Dam, Lewis River, Washington (operational in 2012); River Mill Dam surface collector, Clackamas River, Oregon (operational in 2012); floating screen structure (FSS) at Round Butte Dam, Deschutes River, Oregon (operational in 2009); and the FSC at Upper Baker Dam, Baker River, Washington (operational 2008). Information and images of these structures are provided in Appendix H. Among these four examples, conditions at Swift Dam and reservoir are arguably the most similar to conditions at Willamette system dams, having a wide and deep forebay with annual fluctuations of 50 feet or greater.

Available mean estimates of passage survival for the recent juvenile fish collection facilities listed above are summarized in Table 2-3. Passage survival was high for both Chinook and rainbow trout/steelhead collected at the Swift, River Mill, and Round Butte juvenile facilities (98-100%). These results are consistent with observations at other projects. Survival rates estimates for several other facilities, summarized by ENSR and AECOM (2007), were generally above 90%, and many of those above 95%.

Table 2-3. Mean Estimates of Collection Efficiency for Facilities Operating in Conditions Comparable to Willamette System Dams

River	Facility	Type	Species	Collection Efficiency (%)	Passage Survival (%)
Lewis	Swift	Forebay collector - Surface collector	Chinook[1]	<5	
			coho[1]	20-25	
Deschutes	Pelton Round Butte	Forebay collector	Chinook[3]	40-62	98
			steelhead[3]	22-48	98
Baker	Lower Baker	Forebay collector -Gulper	coho[2]	23.7	
	Upper Baker	Forebay collector - Gulper	coho[2]	53.9	100
		Forebay collector - Surface collector/ enhanced gulper	coho[2]	91.4	
Clackamas	River Mill Dam	Forebay collector - Surface collector	Chinook[4]	98	100
			steelhead[4]	96	100

[1] Data from personal communication, Chris Karchesky, PacifiCorp, October 2014.
[2] Data as summarized in Al-Chokhachy (2013).
[3] Data from personal communication, James Bartlett, Portland General Electric (PGE), January 2015.
[4] Data from PGE (2013).
Individual studies are available in Appendix Table 2 of Al-Chokhachy (2013).

Collection efficiencies summarized for these recently constructed facilities (Table 2-3) were not measured using a standardized approach and therefore direct comparison among these should not be made. Collection efficiency ranged widely from less than 5% to 91.4% for the collectors and species as listed. For fish species targeted for passage at Willamette system dams (Chinook and rainbow trout/steelhead), collection efficiency ranged from less than 5% to 62% (Swift and Round Butte facilities), and was 95% and 98% at River Mill Dam for steelhead and Chinook, respectively. Conditions at River Mill Dam are probably most conducive to juvenile fish collection compared to the others listed and compared with Willamette system dams. River Mill Dam has a relatively narrow reservoir and forebay, a stable reservoir elevation, and run-of-river operation with water travel time less than 1 day (personal communication, Nick Ackerman, January 2015). Preliminary studies at Swift indicate fish are successfully transitioning through the reservoir and making it to the forebay; however, only a small portion are finding the entrance of the FSC likely due to problems with the barrier nets (personal communication, Chris Karchesky, PacifiCorp, October 2014). At Round Butte, a range of factors may be influencing collection efficiency, including daily variation in water intake, forebay temperature variability, predation and disease (personal communication, James Bartlett, PGE, January 2015).

In comparison to the facilities listed in Table 2-3, Willamette System dams targeted for surface collection facilities (Cougar, Detroit, and Lookout Point) have added complexity when considering likely performance of proposed fish surface collectors, in particular having annual reservoir fluctuation greater than 150 feet. This factor complicates fish collection in several ways, including: forebay conditions (e.g. hydraulics, temperatures) will change through the year with water elevation influencing collection efficiency; lifting juvenile fish from the collector up 150 feet for truck transport is unprecedented and could be impacted by wind, waves, snow, ice, etc, and will be difficult to extract or extrapolate from existing facilities in the region. These and other factors add uncertainty when attempting to estimate performance of proposed surface collection systems at Willamette dams, and suggest surface collector performance at Willamette dams may be lower than observed at other locations in the region. However, direct evidence from studies in the Willamette at Cougar and Detroit indicate collection and dam passage efficiency (DPE) for the proposed FSS facilities could be 70% or greater. Studies by USGS indicate a

DPE of approximately 70% and 60% for the spillway when operating with free flow for Chinook and steelhead juveniles, respectively (Beeman et al. 2013). An FSS would operate in a similar fashion as a spillway with free flow, providing surface attraction for juvenile fish, assuming similar flow volumes. At Cougar, over 90% of JSATS tagged juvenile Chinook enter the relatively small confined area of the cul de sac region of the forebay (Beeman et al. 2014), where the proposed FSS would be located, suggesting most will locate a surface collection facility; assuming this facility would provide the only flow outlet during times when most juvenile Chinook will attempt passage during spring and fall.

2.5.6. Oregon Chub and Bull Trout

Affects of each alternative on bull trout or Oregon chub populations were qualitatively evaluated; assumptions are documented in Appendix D. If negative impacts were expected, they were flagged for consideration by decision makers. No alternative will be carried forward that negatively impacts bull trout or Oregon chub without consideration of the impacts.

Bull trout are currently found in the Middle Fork Willamette and South Fork McKenzie subbasins. Actions contemplated at Cougar Dam (South Fork McKenzie) and Hills Creek, Lookout Point, and Dexter dams (Middle Fork Willamette) may affect bull trout. Primary concerns at these projects include habitat and population connectivity (including downstream and upstream passage) and reservoir use for rearing and foraging. Dam passage mortality and efficiency will be different for bull trout than for spring Chinook due to fish size, swimming behavior and performance, and timing of passage. Additionally, bull trout in the reservoir may not be seeking a downstream passage route, but may be using the reservoir habitat to forage and rear. Although genetic interchange between the sub-populations is biologically beneficial, the potential negative influence of passage on sub-population abundance must also be considered (e.g., downstream habitat quality and availability). If survival is estimated low for downstream migrants, other mechanisms for population (genetic) intermixing should be considered (e.g., periodic trap and haul among populations). Secondary benefits for bull trout relating to reintroducing Chinook upstream of Cougar and Hills Creek dams include increased forage opportunities (Chinook juveniles), as well as general benefits related to nutrient delivery from adult Chinook carcasses.

Oregon chub are found in the Middle Fork Willamette, McKenzie, and North and South Santiam subbasins. On February 18, 2015, the USFWS announced the removal of the Oregon chub, and its critical habitat, from the list of Endangered and Threatened Species, and the Oregon chub became the first fish ever to be delisted due to recovery. Populations are found in the mainstem North and South Santiam, Middle Fork Willamette and McKenzie rivers in off-channel and backwater areas. These populations can be influenced by flow releases at the associated Willamette system dams. Both water levels and stream temperatures affect spawning potential and ultimately recruitment of this species. Other populations are found in isolated ponds. Some of these ponded habitats are hydraulically connected to Willamette system reservoirs and are influenced by operations; these include populations found adjacent to Dexter and Lookout Point reservoirs. Oregon chub found in Fall Creek Pond, Foster Pullout Pond and the newly formed population in Hills Creek Pond are isolated from changes in reservoir elevations. Use of the spillway at Fall Creek would directly impact the Fall Creek Pond population, but its use is only for emergency events.

The Corps used the ResSim to model various reservoir operation alternatives. Impacts (both positive and negative) to Oregon chub were assessed through post-processing of the ResSim modeling results. Elevations were identified that affect the quantity and quality of habitat that would be used in the post-processing evaluation. Critical elevations were estimated for ponds that were hydraulically connected to Willamette system reservoirs where specific Oregon chub populations exist to assess potential impacts (Bangs et al. 2010). On-going RM&E studies are assessing the influence of reservoir operations on chub populations located below the dams. Although no clear relationship is known at this time, changes in target minimum flows and temperature control operations being contemplated in the COP Phase II effort may affect these populations. Any alternative identified as impacting lake populations through modifications to reservoir elevations, or actions that modify existing target instream flows or thermal conditions below the dams, will be coordinated with USFWS. Although the Oregon chub was delisted early in 2015, the Corps will continue to monitor chub through the 5-year monitoring period that is required through delisting.

2.6. STEP 5: ESTABLISH SUBBASIN ALTERNATIVES AND SYSTEM-WIDE SCENARIOS FOR ASSESSMENT

Viable salmonid population scores were developed to compare biological benefits for a range of alternatives within each subbasin. Chinook and steelhead VSP scores for each population were then used to evaluate scenarios to functionally achieve a desired status for the population and system-wide (group of populations affected by the WS) levels. Scenarios involved one or more specific alternatives. Alternatives varied by subbasin and are discussed further in Chapter 3 and Appendix D.

Individual alternatives were initially assessed for biological benefit. Sensitivity analyses were completed using SLAM to evaluate how biological benefit could vary under different assumptions. This analysis helped confirm which alternatives provided significant biological benefit (i.e., result in an increase in VSP score), required additional analysis or field verification of assumptions, or could be de-prioritized due to low biological benefit.

Since achieving system-wide biological goals can consist of different combinations of populations at different risk levels, population scores were combined to generate system-wide VSP scores for combinations of alternatives. The system-wide VSP score was computed based on an average of the individual subbasin scores. Cost-effectiveness analysis was conducted for individual alternatives and combinations of alternatives to achieve system-wide level performance and meet COP criteria and assumptions (see Section 2.2.1). In addition, detailed technical assessments and cost information were applied to the final set of alternatives by subbasin. At this point, the biological benefits, costs, other impacts, and uncertainty were captured and results are presented in Chapter 3.

Within a subbasin, the general types of alternatives included downstream passage, upstream passage, TDG, temperature and adult collection facilities. When combining alternatives, it was generally assumed that multiple alternatives from within the general types of alternative would not be combined (i.e., a downstream passage option with high benefit and one with moderate benefit would not be evaluated in combination) unless there was uncertainty in a benefit. In some cases multiple downstream passage options were combined in order to allow for a phased approach to buy down risk. These were typically developed as new alternatives or combinations.

2.7. STEP 6: CONDUCT DETAILED TECHNICAL AND ECONOMIC ASSESSMENTS

Several technical and economic aspects were addressed under the COP II effort including FRM, dam safety, constructability and implementation timing. Technical assessments included detailed reservoir system modeling, temperature modeling, more comprehensive engineering documentation report (EDR) assessments performed by separate design teams, and assessments for constructability and implementation timing. The model outputs were post-processed to capture impacts. Dam safety requirements were built into the model framework to ensure that alternatives complied with minimum gate openings, spillway restrictions and ramp rates for human health and safety. Technical information incorporated from the design teams included the quantification of costs and non-monetary impacts (both positive and negative). The processes used for assessing impacts to technical aspects are summarized in the following subsections. More detailed information can be found in Appendix J.

2.7.1. System Reservoir Modeling

Reservoir modeling of the Willamette System was conducted to determine the operational feasibility of alternatives and assess project and system-wide impacts (both positive and negative) of alternatives. The ResSim model of the Willamette system was set up to run a 74-year period of record (POR, water years 1936-2008) with a daily time-step. Results for ResSim modeling were compared to the IRRM Benchmark in order to differentiate improvements beyond what has already been implemented in the Willamette system. By running the analyses for the IRRM Benchmark and comparing the same calculations to proposed regulation changes, differences could be highlighted to assess impacts.

2.7.2. Water Temperature and Total Dissolved Gas

The CE-QUAL-W2 model is a two-dimensional (longitudinal and vertical) water quality and hydrodynamic application for rivers, estuaries, lakes, reservoirs and river basin systems. It models basic reservoir and river processes such as temperature stratification, and nutrient and algae relationships. CE-QUAL-W2 modeling was used to assess the COP water temperature improvement and downstream fish passage alternatives. In addition, the results of temperature modeling were input into the SLAM model as a mortality factor used in the calculation to estimate abundance/ productivity in each subbasin. The temperature modeling results were also used to quantify exceedances to the CWA and State of Oregon standards for informational purposes and management decision-making. The CE-QUAL W2 model will be used to assist with the specific design of alternatives carried forward for final design.

2.7.2.1. Water Temperature

To date, changes to water temperature have been assessed both quantitatively and qualitatively by extrapolating results from CE-QUAL-W2 simulations and RM&E studies, and by using best professional judgment to rank a proposed alternative's effect on the ability to manage the temperature of water released from the dam. Instead of basing the assessment value on a specific number of days' improvement or impairment, the score was based on whether or not the project would be able to maintain (or achieve if not already being accomplished) either operational or structural temperature management. Thus, if an alternative altered the elevation of the reservoir and limited the use of surface and/or deep dam outlets, the measure was considered to have an impact on temperature. Values for this impact were assigned as follows:

- 1 = High Impact. The alternative impacted the ability of the project to perform water temperature operations for a significant portion of the year (limited to the time period when temperature control is needed).
- 2 = Moderate Impact. The alternative had some impact but the project could still provide some temperature control.
- 3 = No to Low Impact/Benefit. The alternative had no to insignificant impacts or benefits to temperature management options.
- 4 = Moderate Benefit. The alternative improved the ability of the project to modify temperatures to more closely match historical background temperatures.
- 5 = High Benefit. The alternative would improve temperatures to near historical levels.

2.7.2.2. Total Dissolved Gas

Total dissolved gas production was estimated below each project using ResSim output data for total spillway and/or regulating outlet discharge. Increased flow over the spillway was assumed to produce TDG in excess of state water quality standards, whereas flow through the turbines was assumed to be in compliance with water quality standards. The current estimates were calculated using ResSim outflows and TDG production curves based on available TDG data. The Corps compared the number of days at the 50% non-exceedance interval between the IRRM Benchmark and the simulation runs to determine if a proposed alternative would have an effect on TDG levels. Although there is a standard for TDG throughout the year, the standard is in place to protect aquatic species. Therefore, the TDG assessment was focused on the end of the incubation and beginning of the rearing season when sac-fry are present. This salmonid life stage is most sensitive to elevated TDG levels. Values for the TDG impact were assigned as follows:

- 1 = High Impact. The alternative significantly increased the numbers of days above 110% saturation during the critical time periods.
- 2 = Moderate Impact. The alternative increased the number of days above 110% saturation, but not significantly.
- 3 = No to Low Impact/Benefit. The alternative increased or decreased the number of days above 110% saturation but either did so by only a day or two in any given month or did so when higher gas levels are not a concern.
- 4 = Moderate Benefit. The alternative decreased the number of days above 110% saturation, but not significantly.
- 5 = High Benefit. The alternative significantly decreased the numbers of days above 110% saturation during the critical time periods.

In addition to comparing the number of days change between the IRRM Benchmark and the simulation runs, the Corps took into consideration the downstream river characteristics below each Willamette system dam. Most dams are located in high gradient systems that naturally degas quickly. Therefore, an alternative may only present a small or insignificant impact depending on the dam, river, and time of year the alternative would be implemented.

2.7.2.3. Clean Water Act Impacts

If CWA impacts were identified for COP II alternatives, then those alternatives were flagged for additional coordination with Oregon Department of Environmental Quality (ODEQ). At this time, the process for approval of interim and permanent operational and/or structural changes at Willamette dams has not been fully established by the Corps and ODEQ when water quality standards are not met.

Since the release of the 2008 BiOp, approval from ODEQ to conduct RM&E or interim operational actions has been done on a case-by case basis. The Corps and ODEQ are currently working on a more streamlined Memorandum of Understanding (MOU) that would provide assurance for the ODEQ and for the Corps to move forward with temporary and permanent changes at the Willamette projects. This MOU would describe the process in which the Corps and ODEQ would work together to coordinate possible CWA violations to protect ESA-listed fish. The agencies would identify avenues for documenting regional support of experimental/interim and permanent changes at the Willamette projects that may cause violations in water quality standards, but also support intent of the total maximum daily loads and provide a benefit to fish. Options that concurrently address temporary and permanent operations, provide for third party protection, and eliminate case-by-case approval would be preferred. Steps include:

- ODEQ review of options for regional staff to implement.
- Interagency discussion with Corps on options.
- Interagency meeting to propose options.
- Develop and draft mutually accepted options.

It will ultimately be up to regional policy makers to decide how to evaluate any alternatives that would significantly impact the Corps ability to comply with CWA requirements.

2.7.3. Climate Change as a Factor of Future Risk

The proposed alternatives may be influenced by future changes in temperature, as well as to streamflow timing and volume, relating to climate. Additionally, these types of changes are likely to occur over the proposed project life cycle, for example into the 2040s, the 2060s and beyond with a 50-year planning horizon. Given the longevity of the life cycles and potential impact on the alternatives, the COP PDT considered climate change as a future risk factor and incorporated that understanding into the final evaluation of the alternatives, primarily within the North Santiam subbasin. Likely climate trends were identified from studies of the region chosen by the PDT as being recent, regional and relevant to the COP alternative evaluations. The review of existing climate change reports and associated data was then factored into the evaluations, albeit qualitatively. A summary list of past work utilized by the COP PDT to help identify climate change trends and potential impacts on the proposed alternatives is shown below.

- Doppelt, B. and others, 2009. Preparing for Climate Change in the Upper Willamette River Basin of Western Oregon. Co-Beneficial Planning for Communities and Ecosystems. Climate Leadership Initiative, University of Oregon and National Center for Conservation Science and Policy.
- Vynne, S. and others, 2011. Building Climate Resiliency in the Lower Willamette Region of Western Oregon. Climate Leadership Initiative, a program of The Resource Innovation Group.
- Dalton, M.M. and others, 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities.

- Hamlet, A.F. and others, 2009. Final Report for the Columbia Basin Climate Change Scenarios Project. Climate Impacts Group, University of Washington. The project created useful site specific climate change data that can be found at http://warm.atmos.washington.edu/2860/products/sites/.

The primary source of information used by the PDT, which was most relevant to COP sites, was derived from the work performed by the University of Washington, Climate Impacts Group (Hamlet et al. 2009). Other sources cited provided recent and regional specific climate change information that helped to frame the climate change trends of interest. These reports were generally prepared as a response to regional interest and concern of how climate change could affect the Pacific Northwest and Willamette Valley in the near term and out to 2100. The reports used projections from the International Panel on Climate Change which had then been downscaled to a temporal, and spatially useful, scale. The reports used by the PDT for climate change were authored by regional recognized authorities on the topic, for example, the University of Washington and Oregon State University, Oregon Climate Change Research Institute.

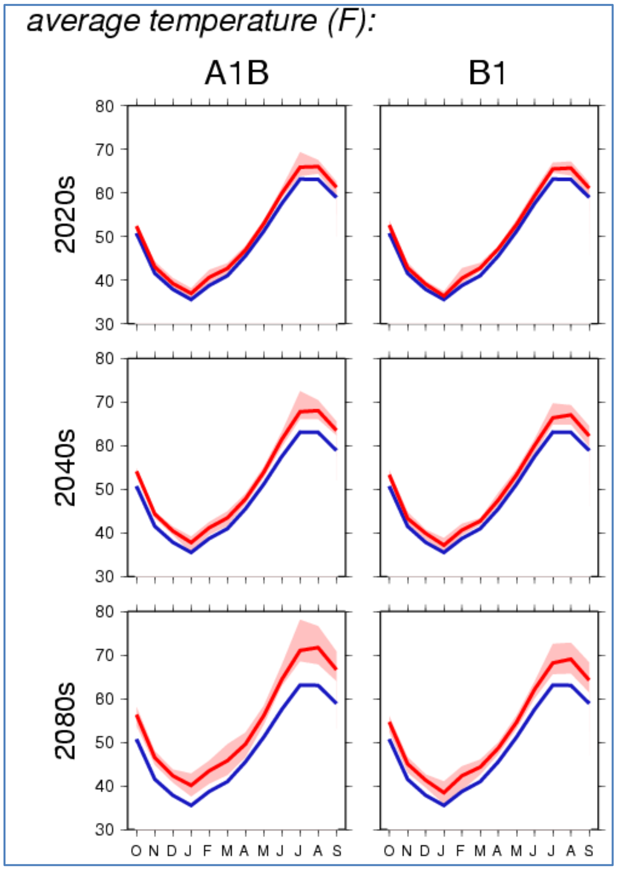
The COP analyses used the most recent downscaled climate change model data, the Coupled Model Intercomparison Project Phase 3 created by World Climate Research Program and the Working Group on Coupled Modeling in 2007 (http://cmip-pcmdi.llnl.gov/). The group provides coordination for various climate change modeling and a framework for comparing these climate change models and their results. The A1B greenhouse gas emission scenario was also used for the COP studies. The A1B scenario has been used as the greenhouse gas scenario for many projects and studies in the Pacific Northwest and by the Corps in recent climate change studies. This scenario is a 'business as usual' attitude and was deemed a reference point for relative trend comparisons.

2.7.3.1. Warming Temperatures

Regional climate studies have all identified future warming as being highly probable for the Pacific Northwest. The Upper (Doppelt et al. 2009) and Lower (Vynne et al. 2011) Willamette Valley studies presented warming estimates that were typical of other studies. The reports found that the temperatures in the valley could increase about 2°F to 4°F (average annual) by the 2040s. Seasonal variation was expected to be more extreme for the summer, for example being 10°F to 15°F higher but 3°F to 5°F warmer in the winter by the 2040s. The more recent report by Dalton and others (2013) utilized the more recent Coupled Model Intercomparison Project Phase 5 data. This report also identified future (2040 through 2070) annual warming of 2°F to 8.5°F as predicted by all models evaluated. Increased warming differences were noted for the summer, 3.4°F to 9.4°F (i.e., for the most aggressive CO_2 emission case, termed RCP 8.5). The study summary identified a trending of increased heat extremes and consequent decrease in cold extremes.

The University of Washington Climate Impact Group work (Hamlet et al. 2009) also identified similar climate trends and proved useful for identification of climate change variables for individual locations in the Willamette basin. Figure 2-4 is from this report and is site specific data. The figure graphically shows the overall warming of temperatures in the region and into the future for the Willamette River at Salem. The site also corresponds to U.S. Geological Survey gage #14191000. The red shading equals the future projected range, the red line represents future projected mean annual temperatures and the blue line equals the historical mean.

Figure 2-4. Overall Warming Through Time in the Willamette Basin



Source: http://warm.atmos.washington.edu/2860/products/sites/?site=4049

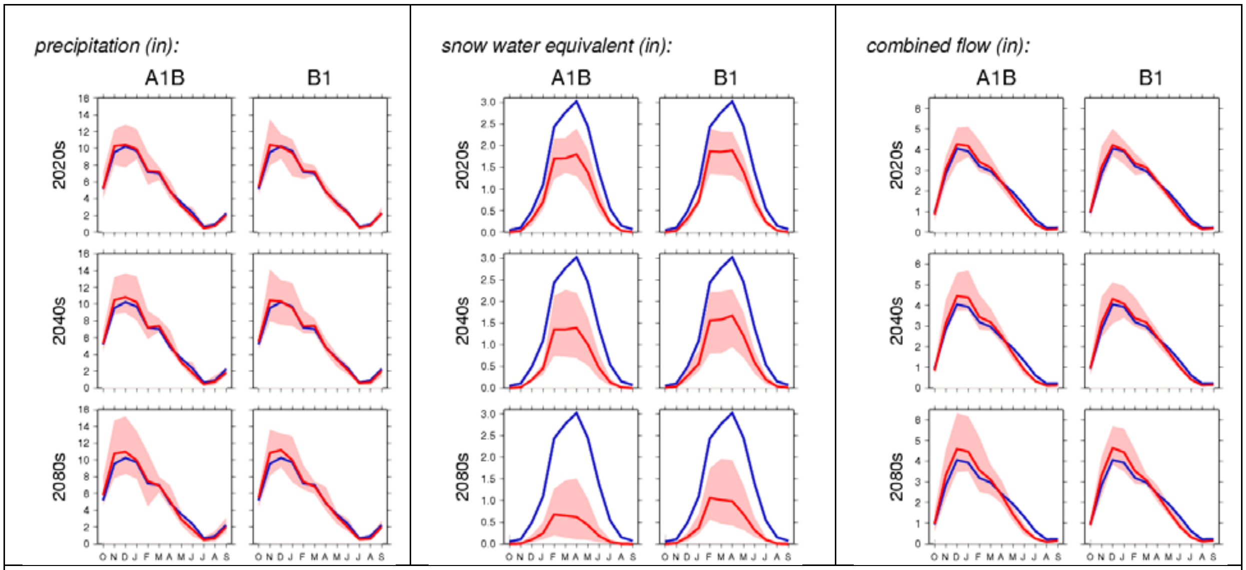
Overall, the climate studies identified by the COP PDT are unanimous in their predictions of future warming. Given this certainty, the PDT took the approach that temperature improvement alternatives should consider that the future will likely be a warmer place and considered alternatives in this light.

Another aspect of the climate change picture is that precise predictions are not possible. Therefore, to specifically plan and 'design' to a unique climate regime was deemed inadvisable. The approach taken by the COP PDT emphasized a qualitative approach be taken for addressing climate change as part of alternative formulation. Knowledge of likely warming, based on the best available science, emphasized that the alternatives should incorporate functionality that increased flexible response and were amenable to adaptive change over the life cycle of the project. Alternatives like this tend to be more expensive; however, future climate change argues for buying the additional functionality. The results of the temperature assessment considering climate change in the North Santiam are included in Section 3.2.2.3.

2.7.3.2. Hydrology Changes

As a result of warming temperatures, snowpack in the Willamette Basin is projected to decline significantly in the future (2040 to 2100). This will be experienced most in areas where current average winter temperatures hover around the freezing mark; therefore, slight increases in average temperature would tip the balance from snowpack accumulation to snowpack loss. Snow pack is projected to decrease within the Willamette Basin by approximately 71% (2040s) to 86% (2080s), based on University of Washington Climate Impact Group modeling. Although the Willamette tributaries are primarily rain driven and originate on the western slope of the Cascades, the simulated data does show a marked decrease in the little snow-water equivalent currently in the basins (Figure 2-5). Within the figure, red shading is the range of 10 global climate model forecasts.

Figure 2-5. Key Hydrology Parameter Trends Predicted within the Willamette Valley



Red shading equals future projected range; red line equals future projected mean; blue equals historical mean.
Source: University of Washington Climate Impact Group modeling.

Flow timing (hydrograph shift) within the basin is also likely to change but the final effects on the lower reaches are difficult to estimate due to the current hydro-regulation on the Willamette River. Flow hydrographs shown in Figure 2-5 are unregulated unless otherwise specified. In addition to flow changes, the figure shows precipitation and snow-water equivalent. The Upper (Doppelt et al. 2009) and Lower (Vynne et al. 2011) Willamette studies reported generally drier summers and wetter winters. The overall annual precipitation amounts were proportional to observed historic amounts.

The distribution of precipitation over the year is likely to result in drier summer and wetter winters. Consequently, streamflow timing was also predicted to trend to higher winter and lower summer base flows. Individual sites in the Willamette may vary somewhat such as the North and South Santiam subbasins. The North Santiam is higher in elevation and currently has a snowmelt during the late spring as compared to the South Santiam.

The future runoff trends are more similar due to projected warming. The 2040s data was the primary future period evaluated by the PDT. Within this time frame, the future trends become more distinct. The further out the future projects are, the more pronounced the trends will be. A sample of the hydrologic climate change parameters are shown in Figure 2-5. They indicate general trends at other sites in the basin. The figure shows mean annual and seasonal variation. For example, May to October runoff is approximately 70% of normal and 10% higher for November through April. The figure graphically shows these trends.

Ultimately, future streamflow changes appear to have the most important potential impacts. There are obvious implications of lower streamflows during the late spring through fall; increased mortality due to higher temperatures, lower base flows reducing habitat, and increasing overall physiological stress to salmonid fish. Projected increases in winter runoff may also affect floodplain morphology and habitat having implications for salmonid juvenile refugia, etc. These and other changes again support the importance of flexible, resilient and robust alternatives.

2.7.4. Flood Risk Management

Flood risk management is one of the primary authorizations of the Willamette system. Potential changes to FRM could occur if potential alternatives to address the ESA modify project flows, modify the timing of flows, or require pool levels higher than a project's water control diagram. Thus, if results of reservoir modeling for a potential alternative showed a change from IRRM Benchmark operations that negatively impacted FRM, then that would result in flagging a measure for further consideration of possible mitigation costs or acceptability.

Flood risk management analyses were conducted using the results of reservoir simulation modeling and regulation expertise. Measures were modeled using ResSim. The results of these model runs were compared to the results of the IRRM Benchmark to identify changes to FRM operations. Within the ResSim model, downstream control point rules were in place specifying regulation goals for key gage locations called control points. The Willamette projects operated to meet FRM goals at these control points individually and as a system. Therefore, when one project was modified in an operational scenario, another project was adjusted to try to meet the specified control point goal. With other projects able to compensate partially for a change in one project's operation, the impact to flooding was assessed at the control point (i.e., was the system able to maintain flows at a control point below key thresholds). The FRM impact assessment procedure is shown below.

1. Compare the number of occurrences that a control point flow is above the regulation goal under the operational scenario to the IRRM Benchmark (see Table J-3 in Appendix J for benchmark values).
    a. The ResSim period of record output was post-processed to count the number of days the regulation goals were exceeded each year and statistics were computed on these counts.
    b. Compare the 5% exceedance counts. The 5% exceedance was selected because it represents a relatively infrequent occurrence. The 5% exceedance count is the value, in number of days (or more) a year, that the control point flow exceeded the regulation goal for 5% of the years in the POR (4 years of the 73-year POR). These 4 years may have more days above the regulation goal than reported in the 5% exceedance count.
    c. The 5% exceedance should incorporate most of the large flow events. There may be occasion to use the 1% exceedance values.
2. Compare the 5% exceedance peak flow under the operational scenario to the IRRM Benchmark.
    a. The 5% exceedance should incorporate most of the large flow events. There may be occasion to use the 1% exceedance peak flows.
    b. The ResSim flows are also daily peaks and do not truly represent the instantaneous peak of the flood event. Because both simulations under comparison (the Early Implementation with IRRM Benchmark and the operational alternative) were using a daily peak, the focus will be was on differences between them.

c. Because there was both model error and potentially gage error, a difference of 5% in the peak flows was considered no change.

3. If either the duration a control point exceeded the regulation goal or the magnitude of the peak flow were higher under the alternative being simulated than the IRRM Benchmark, then the alternative was flagged for further consideration of possible mitigation costs or acceptability.
4. If there was strong biological support for retaining an alternative that was flagged for consideration, then a more detailed analysis would need to be conducted with individual flood events on an hourly time step.

2.7.5. Tributary and Mainstem Flows

An assessment was conducted to capture impacts to meeting minimum tributary and mainstem flow targets using the ResSim modeling and regulation expertise. The results of alternatives modeled in ResSim were compared to the results of the IRRM Benchmark to identify changes to meeting the tributary and mainstem flow targets specified in the 2008 BiOp.

The tributary flow assessment was focused on the incubation season as this was the most critical season biologically for fish. The mainstem flow assessment focused on the mainstem control point below the impacted reservoir. For example, if the measure looked at a deep drawdown at Detroit, only impacts to Salem on the mainstem were considered. In another example, both impacts to Salem and Albany would be considered in an alternative that affects Cougar reservoir.

The mainstem flow targets, as defined in the 2008 BiOp, are listed in Table 2-4, and tributary flow targets in Table 2-5. In dry water years, flows are adaptively managed to balance competing water needs and may be less than the full BiOp flow targets. Within ResSim, the adaptive management approach was applied through the year classification (abundant, adequate, insufficient and deficit), as well as through reduced targets when the pool was drafted too low. The 2008 BiOp and Appendix B of the Willamette Supplemental BA (Corps et al. 2007) define abundant, adequate, insufficient, and deficit water years and also describes how flow objectives can be decreased in deficit water years.

Table 2-4. Mainstem Flow Targets for Abundant and Adequate Years

Time Period	7-Day Moving Average[1] Minimum Flow at Salem (cfs)	Instantaneous Minimum Flow at Salem (cfs)	Minimum Flow at Albany (cfs)
April 1-30	17,800	14,300	---
May 1-31	15,000	12,000	---
June 1-15	13,000	10,500	4,500
June 16-30	8,700	7,000	4,500
July 1-31	---	6,000	4,500
August 1-15	---	6,000	5,000
August 16-31	---	6,500	5,000
September 1-30	---	7,000	5,000
October 1-31	---	7,000	5,000

The 2008 BiOp, Appendix D, defined abundant, adequate, insufficient, and deficit water years and also described how flow objectives could be decreased in deficit water years. These guidelines were represented in the ResSim simulations.
[1] An average of the mean daily flows in cubic feet per second (cfs) observed over the prior 7-day period.

Table 2-5. Tributary Downstream Flow Targets

Location	Period	Flow Target	Purpose
Cottage Grove	01 July - 31 January	50 cfs min	Instream
	01 February - 30 June	75 cfs min	Instream
Dorena	01 July - 31 January	100 cfs min	Instream
	01 February - 30 June	190 cfs min	Instream
Hills Creek	01 September - 31 January	400 cfs min	Migration & Rearing
	01 February - 31 August	400 cfs min	Rearing
Fall Creek	01 - 15 October	200 cfs min	Chinook Spawning
	16 October - 31 January	50 cfs min	Chinook Incubation
	01 February - 31 March	50 cfs min	Rearing
	01 April - 31 May	80 cfs min	Rearing
	01 - 30 June	80 cfs min	Migration & Rearing
	01 July - 31 August	80 cfs min	Rearing
	01 - 30 September	200 cfs min/400 max	Chinook Spawning
Dexter	01 October- 31 January	1200 cfs min	Chinook Spawning
	01 February - 31 August	1200 cfs min	Rearing
	01 - 30 September	1200 cfs min/3500 max	Chinook Spawning
Blue River	01 September - 15 October	50 cfs min	Chinook Spawning
	16 October - 31 January	50 cfs min	Chinook Incubation
	01 February - 31 August	50 cfs min	Rearing
Cougar	01 - 15 October	300 cfs min	Chinook Spawning
	16 October - 31 January	300 cfs min	Chinook Incubation
	01 February - 31 May	300 cfs min	Rearing
	01 June - 30 June	400 cfs min	Migration & Rearing
	01 July - 31 August	300 cfs min	Rearing
	01 - 30 September	300 cfs min/580 max	Chinook Spawning
Fern Ridge	01 July - 31 January	30 cfs min	Irrigation
	01 February - 30 June	50 cfs min	Irrigation
Foster	01 - 15 October	1500 cfs min	Chinook Spawning
	16 October - 31 January	1100 cfs min	Chinook Incubation
	01 February - 15 March	800 cfs min	Rearing
	16 March - 15 May	1500 cfs min/3000 max	Steelhead Spawning
	16 May - 30 June	1100 cfs min	Steelhead Incubation
	01 July - 31 August	800 cfs min	Steelhead Rearing
	01 - 30 September	1500 cfs min/3000 max	Chinook Spawning
Big Cliff	01 - 15 October	1500 cfs min	Chinook Spawning
	16 October - 31 January	1200 cfs min	Chinook Incubation
	01 February - 15 March	1000 cfs min	Migration & Rearing
	16 March - 31 May	1500 cfs min	Steelhead Spawning
	01 June - 15 July	1200 cfs min	Steelhead Incubation
	16 July - 31 August	1000 cfs min	Steelhead Rearing
	01 - 30 September	1500 cfs min/3000 max	Chinook Spawning
	16 March - 15 May	3000 cfs max	Steelhead Spawning

Each alternative was assessed for impacts to tributary and mainstem flows and given a rating from 1 to 5. The following logic was applied to produce the rating scores using the 5% exceedance value for impacts and effects.

For tributary flow targets:

- 1 = High Impact. If the modeled project's outflow during the incubation period was less than the IRRM Benchmark for more than 3 consecutive days, then there would be a high impact.
- 2 = Moderate Impact. If incubation flow is less than the benchmark for 3 days or less, then there would be a moderate impact since the eggs may be able to survive.
- 3 = No to Low Impact/Benefit. If incubation flow is met during all periods as compared to the benchmark, then there would be no impact as long as the spawning and rearing flows were also met as many days as the benchmark.
- 4 = Moderate Benefit. If incubation flow is exceeded by up to 3 days more than the benchmark, then there would be a moderate benefit as long as the spawning and rearing flows also met or exceeded the benchmark.
- 5 = High Benefit. If incubation flow is exceeded more than 3 days above the benchmark, then there would be a high benefit as long as spawning and rearing flows also met or exceeded the benchmark.

For mainstem flow targets:

- 1 = High Impact. If mainstem flow targets were less than the benchmark 3 or more consecutive days, then there would be a high impact.
- 2 = Moderate Impact. If mainstem flow targets were less than the benchmark for 1 or 2 days, then there would be a moderate impact.
- 3 = No to Low Impact/Benefit. If mainstem flow targets were not met the same number of days as the benchmark, then there would be no impact.
- 4 = Moderate Benefit. If mainstem flow targets were exceeded by 1 or 2 days more than the benchmark, then there would be a moderate benefit.
- 5 = High Benefit. If mainstem flow targets were exceeded by 3 days or more above the benchmark, there is a high benefit as long as spawning and rearing flows also meet or exceed the benchmark.

2.7.6. Dam Safety Considerations

There are concerns and limitations with the existing equipment at each Willamette system dam that must be considered with regard to operations and dam safety. Impacts to dam safety were not assessed as a standalone technical assessment by the COP team, but will be addressed during the work of the specific design teams (i.e., the teams will not design a structure that does not meet dam safety standards). In addition, dam safety requirements, such as the restrictions to spillway gate operations and minimum and maximum gate openings, were incorporated into the operational alternative evaluations through ResSim to ensure that alternatives carried forward comply with dam safety requirements (dam safety assumptions made by project can be found in Appendix A). Alternatives not meeting dam safety requirements were not included in design team recommendations or brought forward for inclusion as alternatives for final design. Design teams will explore dam safety implications in more detail for those alternatives carried forward for final design. A Potential Failure Modes Analysis (ER 1110-2-1156 Appendix K) will be required to ensure that any dam modifications do not increase the overall incremental risk of the project to be greater than tolerable guidelines. The USACE Risk Management Center may have involvement if significant modifications are required. This will be determined by the Portland District Dam Safety Officer.

2.7.7. Monetized Costs and Impacts

Monetized costs include construction costs, operation and maintenance (O&M) costs, and hydropower losses. Costs are present valued to the base year (2014) and annual average costs are computed over the period of analysis (2014 through 2062). The Corps' current discount rate is used (3.375% in FY 2015). A table of cost assumptions is included in Appendix H. Methodologies to compute the monetized costs are summarized in the following subsections.

2.7.7.1. Construction

Construction costs were estimated for all COP II alternatives. Operational measures may not have significant capital costs although there may be capital costs for control and measuring equipment and possibly structural features necessary for implementation of a given operational measure. To the extent capital investments are made, these costs were captured in an engineering cost estimate.

Reconnaissance-level cost estimates (Class 4 estimate) have been prepared for the alternatives described in the COP Phase II effort. The primary cost estimating method used for projects with definition at 0-2% is comparative cost estimating. With this method, the cost engineer finds projects that are similar in nature and scope, are complete, preferably built in the same region, and are as recent as possible. Similar project costs are adjusted based on the professional judgment of the cost engineer to compensate for differences between the previous project and the proposed project. Adjustments account for inflation, scale, site conditions, remote locations, local labor wage rates, maintaining existing operations, and any other inconsistencies between the two projects. Class 4 estimates are ideally presented in a range with a high and low estimate. More detailed information can be found in Appendix H.

2.7.7.2. Operation, Maintenance and Replacement

Operations, maintenance and replacement costs are monetized and include standard O&M and hatchery O&M costs. The Corps experienced a decrease in the annual O&M budget for the past several years. Capturing these costs is important for future budget planning, and O&M and replacement costs will be a consideration in the final recommendations.

Standard O&M

All measures may involve higher future O&M costs than incurred under the without-project condition, including new facilities or implementation of operational alternatives. The O&M costs for all alternatives, including the without-project condition, were estimated. These future costs were present valued to the point in time when the project becomes operational. The increment in O&M costs above the without-project condition was relevant in the economic evaluation of the alternatives.

Hatchery and Fish Facility Operating Costs

The Corps mitigates for WS impacts by funding hatcheries. Hatchery spring Chinook are also now being used to reintroduce wild spring Chinook above some WS dams. As effective fish passage is provided at WS dams, it is expected that hatchery spring Chinook will be reduced or phased out as wild returns increase, and hatchery production in general will be reduced since access to historic habitat will be achieved.

Reducing hatchery production could have multiple benefits for wild fish, both before fish passage at WS dams is established and after. A primary pathway for these effects is at the adult spawning stage. Alternatives that reduce hatchery production to reduce the proportion of hatchery origin spawners (pHOS) in a subbasin may decrease costs (i.e., provide a cost benefit) and produce a biological benefit.

Cost savings (reductions in future O&M costs) were presented for each hatchery/fish facility and subbasin for juvenile fish production levels to attain a more desirable level of pHOS reflected in adult returns (10%: high improvement; 50% reduction: moderate improvement). Various pHOS scenarios were presented for each subbasin, where pHOS is 10% (high improvement) and a 50% reduction (moderate improvement) below projects along with corresponding cost savings.

Estimates of production levels to attain pHOS reductions were generated using data provided by the ODFW for adult returns, smolt-to-adult return rates (SAR), straying, and spawning of hatchery and naturally produced fish. Smolt-to-adult return rates were used to estimate hatchery adult returns over a range of juvenile fish production levels at hatcheries. Stray and spawning proportions were then used to estimate the number hatchery fish on spawning grounds in comparison to natural adult fish spawners to estimate pHOS. Cost savings estimates were generated by estimating the change or decrease in the budget for hatchery juvenile production levels that corresponded to resultant pHOS levels of zero and less than 10%.

2.7.7.3. Hydropower

For the COP II effort, hydropower impacts were jointly estimated by the Corps and BPA. To the extent power production in the Willamette Valley is already optimized as part of the federal power system, any change in operations resulting from the alternatives being evaluated may entail non-optimal power production. If an alternative was found to reduce the social value of hydropower production, then an estimate was made of the losses in monetary terms. Bonneville Power Administration staff was responsible for making an estimate of these losses. The monetary loss estimate used the same underlying parameters and assumptions (discount rate, planning horizon, constant price levels) as the rest of the analysis. The hydropower losses were present valued to a common point in time for each operational alternative. Additional discussion on the process used to estimate hydropower impacts can be found in Appendix G.

The BPA used the Hydro System Simulation (HYDSIM) model, in conjunction with the ResSim model, to estimate hydropower impacts. The HYDSIM model simulates power production for the month-to-month operation of the Pacific Northwest hydropower system. The HYDSIM model was used by BPA to post-process the ResSim modeling to capture hydropower impacts. Additional discussion of the modeling used is located in Appendix G. The lost average megawatts (aMW) of generation was combined with forecast market price estimates to estimate the lost hydropower by alternative. The lost aMW was also used as input for the power value analysis, discussed below.

A power value analysis (PVA) was used by BPA to evaluate the financial impact of each COP II alternative or combination of alternatives. Preliminary PVA analysis by BPA indicates that the Power Value will likely be negative. The PVA quantified the costs and benefits of hydropower operations at each Corps Willamette power plant over a 20-year time horizon, given a set of assumptions about future investment and further operational restrictions at the facilities. Only the costs and benefits associated with hydropower production were captured in the PVA. Monetized impacts of each COP Phase II alternative were then compared to a baseline value in order to calculate the economic effect and the carbon dioxide emission rates for replacement generation for lost hydropower.

2.7.8. Non-monetized Impacts

For the COP II analysis, impacts could not be monetized for constructability, implementation timing, recreation losses, municipal and industrial (M&I) water supply, and irrigation. Methodologies to compute the non-monetized impacts for these categories are summarized in the following subsections.

2.7.8.1. Constructability

The constructability of an alternative refers to the complexity and level of difficultly involved with the design and construction. The following categories were used to assess the COP II alternatives using a rating from 1-3 as discussed below.

- 1 = High Impact. This rating would be for alternatives that are complex and difficult to design and construct, such as downstream passage and temperature control alternatives. The engineering effort often requires specialists. Construction would be complicated. For example, PGE completed an SWS for both downstream fish passage and temperature control at Round Butte Dam in 2010 (see Appendix H). They elected to use the "early contractor involvement" contracting method for the SWS to bring the construction contractor in with the design team to advise and assure that the structure could actually be built. Contractors must be highly qualified to construct these types of structures. Structures in this category are often built on top of the dam where there is very little staging area.
- 2 = Medium Impact. This rating would be for alternatives that require a multi-disciplined engineering effort and could be challenging to construct. As an example, upstream fish passage structures are relatively complex, but are generally considered constructible. Upstream passage bid packages include several hundred plan sheets and very detailed specifications. Contractors must be highly qualified to construct these types of structures. Selection of a contractor based on low bid alone would result in unacceptable risk.
- 3 = No to Low Impact. This rating would be for alternatives that are relatively easy to design and construct. Engineering may be required by one or two disciplines and most minimally qualified contractors could build these types of structures. For example, adult fish release sites would be simple in terms of constructability, as would be many types of repairs (gate, regulating outlet (RO) conduit, mechanical, and general erosion).

2.7.8.2. Implementation Timing

Implementation timing refers to the amount of time needed to carry out an alternative and is directly related to constructability and complexity. Implementation time could impact immediate biological needs. The following categories were used to assess the COP II alternatives using a rating from 1-3 as discussed below.

- 1 = High Impact. This rating would be for alternatives taking more than 7 years to implement. For example, downstream fish passage structures require several years of biological study to reduce biological performance risk, in addition to design and construction. The Baker Lake FSC was implemented in 8.5 years and the Round Butte SWS took 13 years (see Appendix H). Even low-head downstream passage structures can take several years to implement. The Rocky Reach corner collector took 9.5 years and the Bonneville corner collector took 12 years to implement.

- 2 = Medium Impact. This rating would be for alternatives taking between 4 and 7 years to implement. For example, upstream passage structures typically take 4 to 5 years to implement. This time frame would allow 1 year for the EDR, 1 year for the Design Documentation Report (DDR), 1 year for plans and specifications (P&S), and 1-2 years for construction.
- 3 = No to Low Impact. This rating would be for alternatives taking less than 4 years to implement. For example, the adult fish release sites could be implemented in 2 years; 1 year to determine the location and 1 year to engineer and construct (if located on Corps property). If located on Forest Service land or private property, an additional year would be required to coordinate the environmental and real estate clearances.

2.7.8.3. Reservoir Recreation

A recreation impact assessment was conducted for each Willamette project where COP II alternatives were likely to affect recreation visitation and use. The recreation analysis focused on describing the recreational opportunities at the affected reservoirs, collecting the best available information on current and past recreation demand (visitation) at these lakes, and assessing the impact of operational alternatives on recreation facilities, principally boat ramps. The process used for assessing recreation opportunities, recreation demand, and recreation impacts is summarized below. Detailed information on the reservoir recreation impact analysis can be found Appendix E.

- **Profile Recreation Activities and Recreation Setting**. This task provided a profile of recreation opportunities at the specified project.
- **Assess Recreation Demand**. Recreation demand (visitation) and important variables affecting demand were collected and displayed for three cases: current, historical, and prospective.
- **Determine Impact of Alternatives on Reservoir Levels and Access**. The principal effect of the COP II alternatives on recreation usage was presumed to be changes in reservoir levels. Simulation analysis using the ResSim model and post-processing of results provided average reservoir elevations by month and annually for each relevant alternative.

The recreation analysis computed the change in the number of days that lake elevation was below ramp toe elevation for the with-project alternative and the IRRM Benchmark. The difference between the two provided a quantitative estimate of potential impacts of an alternative on water-based recreation at the given project. One difficulty with this approach was that most lakes have more than one ramp at different elevations. In such cases, the score assigned usually reflected the most severely impacted ramp but analyst judgment of the overall effect on ramp services became part of the scoring process. Because an operational change at one Willamette project can affect reservoir elevations at other projects, the same calculations will be made for all projects, not just for the project in question.

The data on differences in boat ramp in-service days was combined with information about the seasonal timing of reservoir elevation changes, seasonal patterns of visitation, and total visitation to yield a qualitative assessment of recreation impacts. The method used for combining boat ramp out-of-service information with visitation and seasonality was to develop indexes for each factor. The standards for assigning values to each index are shown in Table 2-6. For the factor addressing the number of additional days that pool was below the boat ramp, a negative quantity occurred when fewer days of outage were experienced. These cases were assigned negative index value. In most cases, however, the alternatives resulted in more out-of-service days and the quantity and index value were positive. For reservoirs with multiple boat ramps, the assignment of index scores included an element of analyst judgment.

Table 2-6. Evaluation Criteria and Standards

Factor and Standard	Index Value	Comments
Additional days pool is below ramp toe		
Less than -30	-3	
-30 to -16	-2	
-15 to -5	-1	
Between -5 and 5	0	Applies to cases where additional out-of-service days occur when facility is normally closed by management.
5 to 15	1	
16 to 30	2	
>30	3	
Annual visitation		Based on OMBIL/state data where applicable for fiscal year (FY) 2010
<100,000	1	HCR, LOP, CGR
100,000 to 300,000	2	GPR, FAL
>300,000	3	DET, FOS
Seasons of Impacts		
Winter	1	
Spring	2	
Summer	3	
Fall	1	

Key: OMBIL = Operations and Maintenance Business Information Link, HCR = Hills Creek, LOP = Lookout Point, CGR = Cougar, GPR = Green Peter, FAL = Fall Creek, DET = Detroit, FOS = Foster

The final step was to combine the three index values for each alternative into a single index value. The method used in the analysis was to calculate the product of the three indices. This multiplicative model produced possible results that varied between zero (no significant recreation impact at the reservoir in question) to 27 for severe boat ramp impacts during summer at a high visitation project and -27 for large increases in the number of in-service days during the summer at a high visitation project. The calculated overall index was useful as a quick guide to the severity of recreation impacts. For example, if the index is 10 for Alternative A and 20 for Alternative B, one could state with some confidence that the recreation impacts of Alternative B are more severe than for Alternative A. However, it would not be appropriate to state that the effects are twice as severe for Alternative B as for Alternative A. Since the evaluation matrix used to compare alternatives used a 5-point scale, it was necessary to convert the reservoir impact score (-27 to 27) to a 5-point scale shown in Table 2-7.

Table 2-7. COP Reservoir Recreation Conversion Standards

Index of Recreation Impact	COP Matrix Score	Description
-27 to- 18	5	High positive impact
-17 to -6	4	Moderate positive impact
-5 to 5	3	Low impact
6 to 17	2	Moderate negative impact
18 to 27	1	High negative impact

For several reasons, it was not possible to translate the above impacts into changes in future expected visitation for each alternative. The quality of historic visitation data is very limited and there are almost no data on visitation by activity. Time and resource constraints also limited the ability to perform such an analysis. Finally, there are so many alternatives being examined that a simple and pragmatic method of assessing impacts on recreation demand was needed. The method outlined above seemed easily manageable.

Regional economic development and other social effects will be assessed for any alternative that is carried forward for final design, if the alternative would be expected to have significant recreation impacts and would likely significantly impact local communities and counties.

2.7.8.4. Downstream Recreation

Two major components of downstream recreation identified and assessed included downstream boating and fishing activities that may be impacted or receive benefits as COP II alternatives are implemented. The areas assessed were located downstream of the following projects: North Santiam River below Detroit/Big Cliff, South Santiam River below Foster/Green Peter, McKenzie River below Cougar, and the Middle fork Willamette below Hills Creek/Fall Creek/Lookout Point/Dexter. The process used for assessing downstream recreation impacts is summarized below. Detailed information for the downstream recreation analysis can be found Appendix F.

Downstream Fishing

Effects of the COP II alternatives to downstream fishing were ranked on a scale from 1-5: 1 = high impact; 2 = moderate impact; 3 = no to low impact/benefit; 4 = moderate benefit; 5 = high benefit). There was much uncertainty regarding the effects of the various alternatives on fish; thus, also on downstream fisheries. Therefore, it was assumed that project operations designed to enhance downstream fish passage or conditions for fish would ultimately have a positive effect to the fish population resulting in an increased number of returning adult salmon that would be available for harvest. Fish harvest and angler trips are highly correlated with adult fish returns.

Flow also was considered when assessing impacts to downstream fishing. If an alternative increased the frequency flows over bank full, there could be an impact to downstream fishing. Since Willamette system dams are primarily used for flood risk management, it was assumed that the alternatives would not increase the frequency that flows would be above bank full. Further, there is the option of fishing from a boat. There are potential unintended consequences (e.g., increased gas, sediment deposition) for alternatives that enhance downstream passage, which could decrease the alternatives' benefit; however, the result and extent to fish survival and impact on fishing is unknown. For example, a slight increase in turbidity could improve fishing, whereas a significant increase could impact fishing. Alternatives that reduce hatchery fish production or limit straying to decrease impacts to naturally produced salmonid populations were considered an impact to the fishery (1-2 = moderate to high impact). Although reducing impacts from hatchery fish may benefit natural fish populations, a reduction could have substantial impacts to the downstream fishery until an increase in natural fish populations is observed.

Downstream Boating

Because of time and budget constraints, some assumptions were made in order to eliminate variables in the recreation analysis. These assumptions are discussed below.

- Boat ramps and put-in/take-out sites are usable year round and in any flow.
- All seasons are equal for recreation.

- Downstream boating most affected by flow changes would be non-motorized (kayaks, canoes, drift boats, etc.), as motorized boats operate in lower sections of the rivers with more depth and change in flow has a smaller impact.
- Flow ranges found in *Soggy Sneakers: A Paddler's Guide to Oregon Rivers* (P. Giordano 2004) provide a good estimate for general recreation use. Flows presented were as follows: McKenzie River at 2,000-900 cfs, North Santiam River at 3,000-1,000 cfs, South Santiam River at 3,000-900 cfs, and Middle Fork Willamette River at 3,000-1,000 cfs.

Flow tables for the McKenzie, North and South Santiam, and Middle Fork Willamette were generated for each operational alternative using ResSim. The flows were measured downstream of each Willamette project at their respective control points, and listed for each day of the year from 1936 to 2008 and from October 1 to December 31, 1935. Control points used included McKenzie at Vida, North Santiam at Mehama, South Santiam at Waterloo, and Middle Fork Willamette at Jasper.

To compare baseline data to the simulated model output for each alternative, an algorithm was used to tally the number of days outside the ideal flow range on each river for every simulated year from 1935. Then the average number of days outside of the flow range was calculated for each river and added together to get the total number of days outside of the flow range per alternative. The baseline days outside of the flow range were subtracted from the alternative days, resulting in a "difference-from-baseline" number. This resulting number was positive, negative or zero. A zero represents "no change," a positive number represents an increase in the amount of days discharge is outside of the flow ranges, while a negative number represents a decrease in days outside of flow ranges, the latter being preferred for boating recreation on rivers downstream of the Willamette projects.

To assign ranks of 1 through 5, the following scale was used:

- 1 = High Impact. ≤ -76 days
- 2 = Moderate Impact. ≥ -75 and ≤ -26 days
- 3 = No to Low Impact/Benefit. ≥ -25 and ≤ 25 days
- 4 = Moderate Benefit. ≥ 26 and ≤ 75 days
- 5 = High Benefit. ≤ 76 days

The difference-from-baseline numbers were applied to the scale and an output of ranks for each measure was obtained. Since downstream river recreation combines boating and fishing activities, and because the index values for each were both derived by different means, both fishing and boating were assumed to have equal weight when combining index values into a single value. To get a single index value for downstream river recreation, the boating and fishing index values were averaged and rounded down to the nearest whole number to give the actual downstream river recreation index value for each alternative.

2.7.8.5. Water Supply

At this time, assessing the effects of the COP II alternatives to water supply is complicated due to a number of factors including potential changes to the minimum BiOp flow targets as a result of knowledge gained from instream flows studies, and the reliability of future irrigation and M&I water supply demand estimates. Future water supply demand estimates are available from the Willamette Basin Reservoir Study Interim Report, 2000; these estimates will be updated or confirmed through the Willamette Basin Review Feasibility Study and not the COP II effort. For the COP II effort, the method for analyzing impacts to water supply was to take both a qualitative and quantitative approach, wherever possible. The analysis consisted of evaluating impacts to water supply based on current demand and future estimated demand in the year 2050. These two levels of demand provided a bookend look at impacts. Future demand estimates were taken from studies conducted in the 1990s and likely outdated. Therefore, if the actual water supply demands change, then the impacts to water supply may also change.

The Corps analyzed impacts to water supply using ResSim modeling and professional judgment. For the assessments, modeled daily period of record reservoir releases and flows at downstream control points were compared to baseline period of record results to identify changes to operations and storage. Due to current restrictions on reservoir elevations as a result of the IRRMs, the analysis differs slightly when evaluating impacts to current water supply demand and the estimated future water supply demand, as discussed below. While reservoir operations may change by the year 2050 due to BiOp implementation or other factors, assumptions cannot be made at this time as to what these changes might be.

Current Demand Analysis

To date, very little of the total conservation storage in the Willamette reservoirs has been purchased for irrigation and no storage has been purchased for M&I water supply. As of 2014, the total storage under contract for irrigation in the Willamette projects is 72,375 acre-feet, or about 4.5% of the total joint-use conservation storage. A summary of the location of existing irrigation contracts, by reach, was supplied by the Bureau of Reclamation. There are a number of irrigation contracts in subbasins where additional stored water is not released on top of the 2008 BiOp minimum flow targets to satisfy the contracts (e.g., Middle Fork Willamette subbasin). These contracts are satisfied by flow released to meet the 2008 BiOp minimum flows. This is supported by the 2008 BiOp (Section 2.9, page 2-56), “At the current low level of use for water service contracts, the Corps does not make special adjustments, such as increasing flow releases, to meet contract requirements. The Corps does not propose to make special flow adjustments at its dams to supply the total water marketing program of 95,000 acre-feet during the term of this action.”

While there are no agreements for M&I storage in the Willamette reservoirs, there are water supply intakes in both Dexter and Foster reservoirs. The water rights for these intakes pre-date the dams and supply live flow, not stored water. The amount of water withdrawn is small, but the Corps does need to ensure that these two reservoirs are not drawn down below the level of these intakes.

The current demand analysis procedure for water supply was as follows:

1. Compare the number of occurrences that tributary and mainstem BiOp flow targets would not be met for each alternative to the IRRM Benchmark using the modeled 5% exceedance counts. The 5% exceedance was selected because it represents a relatively infrequent occurrence and should incorporate most of the dry periods (the assumption is that if BiOp targets are not met, then current irrigation demand would not be met).
2. Compare the 5% exceedance elevations at Foster for each alternative to the IRRM Benchmark elevations to evaluate impacts to the water supply intakes (note that the Dexter pool is quite small as compared to Foster and it was assumed that Lookout Point could be managed to keep Dexter above the water supply intake so this impact was not evaluated using ResSim).
3. If the number of occurrences that tributary or mainstem flow targets would not be met was higher for the alternative than for the IRRM Benchmark, then the alternative was considered to have moderate to significant water supply impacts. The severity of impacts was based on the number of occurrences and best professional judgment.
4. If model results showed that the water supply intakes would be dewatered more often for the alternative than for the IRRM Benchmark, then the alternative was considered to have moderate

to significant water supply impacts. The severity of impacts was based on the number of occurrences and best professional judgment.

Future Demand Analysis

As part of the Willamette Basin Reservoir Study Interim Report, 2000, the Oregon Water Resources Department, based on the 1994 Oregon Department of Agriculture Reservation Request, projected future irrigation acreage and water-use in the Willamette Basin. The 2020 and 2050 estimated irrigation demands were 95,388 and 550,160 acre-feet of water from Corps' reservoirs, respectively, or more than 33% of the joint-use storage. Since this estimate was issued, land use in the Willamette Valley has changed. Urban development has reduced the need for irrigation water and increased the need for M&I water supply. Updated estimates of irrigation demand have not been developed to date.

Population growth is expected to increase future demands for M&I water supply. As part of the Willamette Basin Review Feasibility Study, municipalities in the basin conducted studies to determine their future water supply needs to the year 2050 and possible water sources to meet those needs. The comprehensive studies covered 128 municipalities (86 cities and 42 water districts) in 9 counties. The 2020 and 2050 water supply demand estimates developed for the study were about 103,000 and 208,000 acre-feet of storage, respectively, or about 13% of the joint-use storage. The estimated future demands were outlined by control point in the Corps Willamette River Basin Reservoir Study Interim Report, 2000.

Although the Willamette Basin Review Feasibility Study is entering a new phase of effort in late FY 2015, the best information available to the Corps at the time of the COP Phase II analyses was to obtain verbal confirmation from water supply stakeholders that the above values for irrigation and M&I demands were the latest information. This confirmation was obtained in February 2012. The new phase of the feasibility study will incorporate new values for future 2050 irrigation and M&I demands for the basin under a Task Order that is not yet complete.

A qualitative approach was used in the COP II effort to determine the impacts to meeting future water supply. Individual project and system storage values under the COP II alternatives were assessed to determine if enough stored water would be available to meet the future estimated demand, and the resulting impact was given a rating from 1 to 5:

- 1 = High Impact,
- 2 = Moderate Impact,
- 3 = No to Low Impact/Benefit,
- 4 = Moderate Benefit, and
- 5 = High Benefit.

For example, if a proposed alternative aims to operate a large storage project as run-of-river (i.e., no water stored for conservation purposes) in a subbasin with future water supply demand, then the impact to future water supply demand would be considered high (1).

2.8. Step 7: Determine Benefits and Costs

In addition to organizing and presenting information for decision makers, a cost-effectiveness analysis was applied. This step describes how the structural and operational alternatives were evaluated. Cost-effectiveness evaluation includes comparison of the benefits of the alternatives to their costs. The benefits are in non-monetary terms. The costs are a mix of monetary costs and non-monetary impacts. The analysis attempted to identify alternatives that met the biological criteria while minimizing costs and negative impacts.

Before conducting the larger economic analysis, the scope of the analysis was determined. Table 2-8 presents many of the key questions and decisions about the scope of the economic analysis.

Table 2-8. Key Questions and Decisions for the Economic Analysis

Question	Decision
What is the objective of the economic analysis?	To determine which fish recovery structural and operational alternatives and combinations of alternatives minimize costs and impacts for a given level of output.
What is the completion date for the study?	2064
What is the planning area?	Although alternatives are restricted to four subbasins, the planning area is the entire Willamette Basin because it acts as a system. In some cases (e.g., hydropower analysis), the analysis implicitly extends beyond the basin.
What is the base year?	Date when the first project is complete and delivering outputs (2015).
What is the planning horizon?	50 years from the base year.
What is the discount rate?	The Corps' real discount rate will be used in future valuing and present valuing. The Corps sets this rate annually. In FY 2015, it is 3.375 percent.
What level of collaboration will there be?	Most of the study will be conducted by the Portland District. Certain economic cost and loss studies will involve other agencies.
What level of analysis will be conducted?	Most of the economic analysis will be done by local staff and use available information with no original data collection (Level I). For some tasks, there will be elements of Level II analysis where small teams of experts collaborate.
What are the key economic cost categories?	Construction costs, O&M costs, hydropower impacts, recreation impacts. M&I water supply markets will be investigated to determine if there are impacts.
Are there important constraints or assumptions that should be considered?	It is assumed that no alternatives will be analyzed and recommended if it is determined that flood risk management is significantly reduced with the alternative in place. Thus, there will be no flood damage impact studies. Fishery benefits will not be monetized.

2.8.1. Comparison of Benefits and Costs

2.8.1.1. Benefits

Benefits were measured using biological benefit analyses results in terms of VSP score. Because benefits are not in dollar terms, a cost-benefit analysis was not provided. In lieu of a cost-benefit analysis, a cost-effectiveness analysis was conducted to compare costs and outputs of the alternative combinations for the system. The Institute for Water Resources Planning Suite software was used. Benefits for all alternatives were considered over the same 50-year period of analysis in accordance with Engineer Regulation 1105-

2-100, pages D-30 and D-31. Because some alternatives are assumed to be implemented after the base year, those measures have fewer than 50 years of benefits. Benefits were averaged over the 50 year period with zero increment in benefits for the years prior to measure implementation and full VSP score after implementation.

2.8.1.2. Costs

The costs of alternatives or combinations of alternatives were in monetary terms. Project first costs including design, construction, supervision and administration, engineering during construction, and O&M costs were in monetary terms at a fixed price level (2014 dollars). If construction extended over a multiple-year period, interest during construction was calculated and added. The costs were present valued to the base year. The O&M costs were estimated over the project life and present-valued back to the base year. The average annual equivalent values were shown for these costs. The period of analysis was the same for all alternatives, 2015 through 2064 where 2015 was the base year.

Opportunity costs such as forgone hydropower and recreation losses were assessed for alternatives in comparison to the without-project condition, with hydropower in dollar terms and recreation impacts in non-monetary terms. Hydropower impacts were considered with stakeholder input from BPA, primarily as a threshold limit. Recreation impacts were not included in the total costs for the cost-effectiveness analysis but were represented as other impacts for consideration.

The non-monetary fish benefits of each measure were weighed against the costs of the measures. The analysis generally followed cost-effective analysis procedures laid out in *Cost Effectiveness Analysis for Environmental Planning: Nine Easy Steps* (Corps 1994). Cost effectiveness analysis identifies projects that minimize cost for a given level of output or maximize output for a given cost. Also, the focus was on monetized costs—construction, O&M and hydropower impacts. The main analysis steps include:

- Display outputs and costs.
- Identify combinable alternatives. Analyze the alternatives to separate those that can be implemented together from those that cannot be implemented together.
- Calculate outputs and costs of combinations. The VSP model will generate combined VSP scores; it may be possible to incorporate a cost database in the VSP computer spreadsheet. The spreadsheet would list and plot outputs and monetary costs for all alternatives and combinations.
- Eliminate economically inefficient solutions. Re-order the list in ascending order and identify the least cost solution for each level of output, dropping the inefficient cases.
- Eliminate ineffective solutions. Conduct a pair-wise comparison of remaining outputs and monetary costs to identify and delete those solutions that will produce less output at equal or greater costs than subsequently ranked solutions.
- Calculate Average Costs. Divide cost by output to find average total cost and display output, total cost, and average cost for cost-effective solutions.
- Calculate cost-effectiveness as average cost per unit of output in $ MIL/VSP improvement for summary tables

The procedure above identified cost-effective alternatives at the system level. Non-monetary impacts were not considered in the cost-effectiveness analysis, but were represented in the summary tables.

2.8.2. Cost-Effectiveness within the Results Summary Tables

Within the results summaries, the cost-effectiveness was represented as the average cost per unit of output. Total life-cycle costs were the sum total of design and construction costs, the present value of 50-year life-cycle O&M costs, measurement and evaluation costs, and replacement costs (in current-year dollars) for each measure. Cost-effectiveness is a quantitative way to evaluate which alternatives have a better “bang for the buck” or a better opportunity for biological benefit for a lower amount of investment. The lower the cost per VSP, the more “bang for the buck” was anticipated. The total VSP score (not the difference) was also captured in summary tables to determine if subbasin and system goals were reached. The cost-effectiveness was computed initially on individual subbasin measures to determine those measures producing a biological output with the least amount of investment. Combinations were included in the cost-effectiveness analysis once the initial assessment had been completed.

Cost-effectiveness results were color-coded (red, yellow, green) in the results summary tables for visual comparison of the cost-effectiveness ratios. Red indicated very high costs per unit of output (greater than 250), green represented costs per unit of output that were less than 150, and yellow indicated values in between 150 and 250. At this point, some alternatives were de-prioritized if their cost-effectiveness was low. If a measure did not show a significant biological benefit, it was not carried forward for further consideration. Final subbasin cost-effectiveness results are included in Appendix D.

When considering system alternatives, the cost information was totaled to represent the total BiOp implementation costs for the CRFM Program for decision making by Corps management. Costs included the funds spent to date through FY 2014 ($144.5 million) as well as future RM&E and commitment ($144.9 million). Future commitments included Foster adult facility and testing of the portable floating fish collector at Cougar. The O&M costs were kept separate but carried forward for comparison and consideration. A total Action Agency cost was also considered to include Corps costs (CRFM and O&M) with lost hydropower.

2.9. STEP 8: DETERMINE OTHER IMPACTS

Multiple non-monetized impacts were captured for a range of alternatives through the technical assessments. For summarizing results, each impact category was considered for how it would impact decision making. To simplify the analysis, only the critical components were captured for decision makers. Forgone hydropower was monetized and used for some cost-effectiveness calculations. As it was not an out-of-pocket cost, it was also captured as an impact. Each impact category and the rationale for inclusion in the decision framework are shown in Table 2-9.

Table 2-9. Other Impacts Used in Results Summaries

Non-Monetized Impact Category	Included in Results Summaries?	Rationale
Flood Risk Management	Yes	Because FRM is the primary purpose of the Willamette system, this category was used as an initial screening of alternatives. Any alternative that had an impact on FRM was flagged for additional considerations.
Meeting Downstream Tributary Flows	No	Downstream tributary and mainstem flow targets were specified in the BiOp. A severe impact to flows would involve exploring tradeoffs between the proposed alternatives' biological benefit and the impact to tributary or mainstem flows. Also, the tributary flows were used in the SLAM model and would reflect a decrease in biological benefit for a measure, so this is captured in the 'opportunity' portion of the decision framework.
Meeting Mainstem Flows	No	
Hydropower	Yes	A threshold of $70,000,000 (present value) was used to indicate if there was a hydropower impact or not.
Reservoir Recreation	Yes	Only alternatives with a rank of 1 (high negative impact) were flagged as having an impact on reservoir recreation.
River Recreation	Yes	Only alternatives with a rank of 1 (high negative impact) were flagged as having an impact on downstream recreation.
Water Supply	Yes	Only alternatives with a rank of 1 (high negative impact) were flagged as having an impact on water supply.
Constructability	No	Constructability and implementation timing are captured in the cost information and related uncertainty (more complex solutions result in higher costs) and does not need to be considered separately in decision making.
Implementation Timing	No	
CWA Impacts from TDG	No	TDG and temperature impacts were reflected in the biological tools (SLAM) as a mortality function so this is captured in the 'opportunity' portion of the decision framework. Any impacts would be coordinated with ODEQ.
Temperature Impacts	No	

2.10. STEP 9: DETERMINE SIGNIFICANCE OF IMPACTS

If other impacts were identified for the alternatives carried forward for final analysis, they were shared and discussed with regional partners in WATER. Discussions occurred to assess the significance of the other impacts. Since the primary impacts were forgone hydropower, BPA was primarily coordinated with. Establishing the significance of these impacts provided important context for scenarios and helped with the evaluation of alternatives.

2.11. STEPS 10 AND 11: COMPILE RESULTS AND PRESENT TO DECISION MAKERS

Biological benefits, cost-effectiveness and impacts were summarized for decision makers for discussion and decision making. There is no current mathematical algorithm defined to compute a final prioritization. The COP Phase II analysis used the cost-effectiveness of subbasin alternatives to evaluate those that produce biological benefits to achieve population performance and their costs. Other impacts were also considered for each alternative. At the system-wide level, a similar approach was taken to assess scenarios that achieve the system-wide performance. In step 10, information was sorted by subbasin and across the Willamette Basin as a whole to show those alternatives or combination of alternatives that met COP criteria in a cost-effective manner. Results are included in Chapter 3.

Step 11 also entails a final review of risks where decision makers have an opportunity to decide to not complete the project based on presented risk and benefits. The process informs management of the risks resulting from implementation of alternatives. This step allows for any additional issues not considered in the analysis to be presented and potentially integrated in the final decision. The intention is for decision makers to have a framework to choose to reject, reduce, transfer, avoid, or except an unfavorable output from other steps in the process.

2.11.1. Presenting Results

The Phase II COP recommendations are intended to provide decision makers with the information necessary to make prudent decisions regarding the implementation of the 2008 BiOp. For a given subbasin alternative (individual or in combination), the VSP score, the cost-effectiveness and the other impacts and their significance was summarized in the results summary tables. Decision makers can easily see a large amount of information in a succinct table. Color coding was used to provide visual cues.

Table 2-10 shows an example of how the COP information is presented in Chapter 3 for a subbasin level analysis. In the example, there is a range of alternatives with several pieces of information summarized. In column 2, the subbasin Chinook VSP score is presented (steelhead VSP estimates are also provided for the North and South Santiam subbasins). The cost-effectiveness (column 16) uses the difference between the baseline and the estimated VSP score as well as the total life-cycle cost (column 10). The lower the number, the lower the cost for VSP improvement. Other costs are also represented in columns (7 to 10). These are color coded with green representing a higher "bang for the buck" and red representing the lowest (or none). Confidence is summarized in columns 3 and 6 with confidence level represented as H (high), M (medium) or L (low). Alternatives with high negative impacts were flagged as Y (yes) or N (no) in columns 11 to 15. "Stakeholder impacts" are summarized in column 17 to provide an indication to decision makers which measures may have high negative impacts to stakeholders.

Table 2-10. Example of Results Summary

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Alternative	**Chinook VSP Score**	**Anadromous Fish Confidence Level**	**Chub Benefits**	**Bull Trout Benefits**	**Resident Fish Confidence Level**	**Project First Costs (Total CRFM) ($ MIL)**	**Additional O&M (PV) ($ MIL)**	**Lost Hydropower ($ MIL)**	**Total Life Cycle (Project First Costs + O&M**	**Negative Chub or Bull Trout Impacts (Y/N)**	**Flood Risk Management (Y/N)**	**Total Recreation Impact (Y/N)**	**Water Supply Impact (Y/N)**	**Hydropower Impact (Y/N)**	**Cost Effectiveness (cost per unit of output)**	**Stakeholder Impacts (H-M-L)**
Alt 1	3.6	L	Neg	Na	M	97.0	10.0	0	107.0	Y	N	Y	N	N	**133**	**H**
Alt 2	3.4	M	Pos	Na	M	111.3	12.3	5	123.3	N	N	N	N	N	**205**	**L**
Alt 3	3.4	H	Pos	Pos	H	100.0	33.8	8	133.8	N	N	N	N	N	**223**	**L**
Alt 4	3.0	M	none	Neg	M	106.7	2.0	120	108.7	Y	N	N	N	Y	**594**	**H**
Alt 5	3.0	M	Pos	Pos	M	117.1	1.2	75	119.3	N	N	N	N	Y	**597**	**M**
Alt 6	2.8	L	Pos	None	L	5.4	0.7	6	6.1	N	N	Y	Y	N	**-**	**M**
Alt 7	2.8	L	None	None	L	5.4	0.7	72	6.1	N	N	N	N	Y	**-**	**M**
Baseline	2.8															

Based on this example, Alternative 1, 2 and 3 would be looked at as the top ranking alternatives. Alternative 1 has the highest biological benefit and the highest cost-effectiveness. It also has a lower level of confidence and higher significance of impacts as compared to Alternative 2 and 3. The COP team could recommend Alternative 1 because the "opportunity score" is higher and has a lower cost than the less biologically effective options, Alternative 2 and 3. Decision makers would need to provide some feedback to the team on whether or not the low confidence or high stakeholder impacts were acceptable. There also may be some options to reduce the risk to affected stakeholders, thereby making Alternative 1 the logical choice. Conversely, Alternative 2 and 3 appear to be less risky (although they have higher costs) and decision makers may want to discuss the merits of those alternatives over the higher impacts of Alternative 1. Alternatives 6 and 7 appear to provide no measureable benefit and would be de-prioritized for further consideration.

Once the information is collated, discussion and coordination with the region through WATER would ensue. Once subbasin information is prepared, system-wide analyses can be summarized using the average VSP estimated for the four major subbasins and total costs for a wide variety of combinations.

2.11.2. Managing Risk

The prioritization process involves evaluating the risks resulting from implementation of the COP alternatives. The intention when summarizing results is for the decision makers to have sufficient information and a built-in framework to make decisions on whether to reduce, transfer, avoid, or accept an unfavorable output. These potential reactions are summarized below.

- Reduce – decrease the severity of impact or reduce the likelihood of negative impact occurring.
- Transfer – shift or share all or part of the anticipated negative impacts.
- Avoid – choosing not to pursue an action that carries unacceptable impacts.
- Accept – proceed with the contemplated action.

For example, consider two potential COP alternatives. Alternative 1 has excellent cost-effectiveness and minimal uncertainty; however, a stakeholder has concerns with the project (stakeholder impact “high”). Alternative 2 also is cost-effective and has minimal uncertainty and in addition no appreciable stakeholder objections (e.g. stakeholder impact “low”). The “stakeholder impact” score of “high” would prioritize Alternative 1 lower than Alternative 2. However, if after considering all alternatives and all factors, it is decided that it is absolutely essential to perform Alternative 1 regardless of the high “stakeholder impact” score, then the decision makers could *accept* the higher risk and prioritize the project for execution without attempting to modify likelihood or severity of the negative impact. They may also attempt to *reduce* the severity or likelihood of the high negative impact by accompanying implementation with offsetting benefits, additional communications, or other methods.

2.11.3. Coordination with WATER

The structure of WATER provides a venue to allow for regional input on Action Agency decisions, and to provide a forum to address and elevate disagreements. The WATER managers meet as needed based on key decision points included in the 2008 BiOp. These meetings included presentations and discussions of details on COP alternatives and system-wide scenarios to reflect updates on biological data and engineering feasibility, as well as anticipated biological benefits. These updates served as a key source of information for WATER manager coordination, collaboration, dispute resolution, and decision-making. Technical meetings with WATER were also completed to obtain input on what alternatives should be analyzed, and on estimates of benefits, costs and feasibility of the alternatives analyzed.

2.11.4. NEPA and Associated Compliance

Decision-making for and implementation of the final actions must comply with all applicable statutes and regulations, including National Environmental Policy Act (NEPA) and associated environmental compliance requirements. Typically, the NEPA process consists of an evaluation of the environmental effects of a federal undertaking. It is anticipated that a programmatic Environmental Impact Statement (EIS) will be prepared using a phased approach incorporating any operational changes since the 1980 EIS, and incorporating actions proposed to address NMFS Biological Opinion. This document will:

- Set the broad view of impacts and benefits for current Willamette system operations.
- Support implementation of all authorized purposes.
- Evaluate and integrate BiOp actions and incorporate previous completed relevant NEPA documents and analyses.
- Provide support for tiering subsequent NEPA reviews of future actions.

However, if the timing of the anticipated programmatic EIS does not align with the recommended plan’s projected timelines, the recommended plan will undergo a separate NEPA analysis.

2.12. STEP 12: REPEAT DECISION PROCESS

The COP team's development of the 12 steps allows the evaluation process to be repeated and updated as new information is obtained. Work within the Willamette system is on-going through various design PDTs and RM&E efforts. As new information is available, the process can be updated. If information indicates a chosen alternative is feasible, or a more cost-effective alternative is available alternatives can be reassessed. Step 12 provides the opportunity to reevaluate options and choices during the implementation of the 2008 BiOp.

CHAPTER 3. BASELINE CONDITIONS AND ALTERNATIVES EVALUATION RESULTS

3.1. OVERVIEW

This chapter describes the COP II alternatives and combined alternatives considered for each Willamette system subbasin. It provides a summary of the results from the biological and technical assessments (monetized and non-monetized) described in Chapter 2. Appendix D contains a detailed discussion of the subbasin alternatives and results (values) from the biological and technical assessments (anadromous and resident fish benefits; flood risk management; tributary/mainstem flows; water supply; constructability and implementation timing). Reservoir and downstream recreation impact results (values) are discussed in Appendix E and F, respectively. Hydropower impacts are discussed in Appendix G, and cost details are presented in Appendix H. This chapter also describes the development of system-wide scenarios and their assessment using cost-effectiveness analysis, and risk and uncertainty.

The 2008 BiOp, the UWR Recovery Plan for Chinook and Steelhead (ODFW and NOAA Fisheries 2011), and Appendix C of this report (prepared by the NWFSC) summarize the current status and limiting factors for ESA listed fish affected by the Willamette system. For context, subbasin overview sections below provide a brief summary of historic and current fish habitat above Corps dams, fish disposition above Corps dams (i.e., are they currently transported upstream) and current abundance status. See the above mentioned reports and Appendix C for more detailed information.

The Willamette system primarily affects four of seven Chinook salmon populations in the UWR, located in the North and South Santiam, McKenzie, and Middle Fork subbasins, and two of four winter steelhead populations in the UWR located in the North and South Santiam subbasins. Table 3-1 indicates extinction risk for UWR spring Chinook and winter steelhead populations. Since 2008, the status of Chinook in the Santiam appears to have improved, but has declined in the McKenzie; extinction risk for the two steelhead populations affected by the Willamette system has declined.

Table 3-1. Extinction Risk Status of UWR Spring Chinook and Winter Steelhead Populations

Subbasin	Spring Chinook		Winter Steelhead	
	Pre-BiOp Status[2]	Current Status[2,3]	Pre-BiOp Status[2]	Current Status[3]
Clackamas	Moderate	Moderate	NA	NA
Molalla	Very High	Very High	Low	Not Evaluated
North Santiam[1]	Very High	Moderate	Low	Moderate
South Santiam	Very High	High	Low	Moderate
Calapooia	Very High	Very High	Moderate	Not Evaluated
McKenzie	Low	Moderate	NA	NA
Middle Fork	Very High	Very High	NA	NA

[1] Subbasins in bold are directly affected by the Willamette system.
[2] Recovery Plan for Chinook and Steelhead (ODFW and NOAA Fisheries, 2011).
[3] Recent extinction risk status taken from NWFSC COP modeling (NWFSC 2014 attached as Appendix C).

The Willamette system BA/BiOp RPA included the following specific major priority actions for implementation to avoid jeopardizing UWR spring Chinook and winter steelhead:

- Upstream passage improvements (complete Cougar adult trap facility, replace /improve Minto, Foster, Dexter, and Fall Creek adult fish collection facilities) .
- Provide downstream fish passage (Cougar, Detroit, and Lookout Point).
- Provide temperature control (Detroit).

Since 2008, actions completed as part of the Willamette system BA/BiOp RPA implementation include three new adult fish facilities (Cougar, Minto and Foster), operations for downstream fish passage and temperature management, flow management, and research to fill data gaps supporting alternative selection and design.

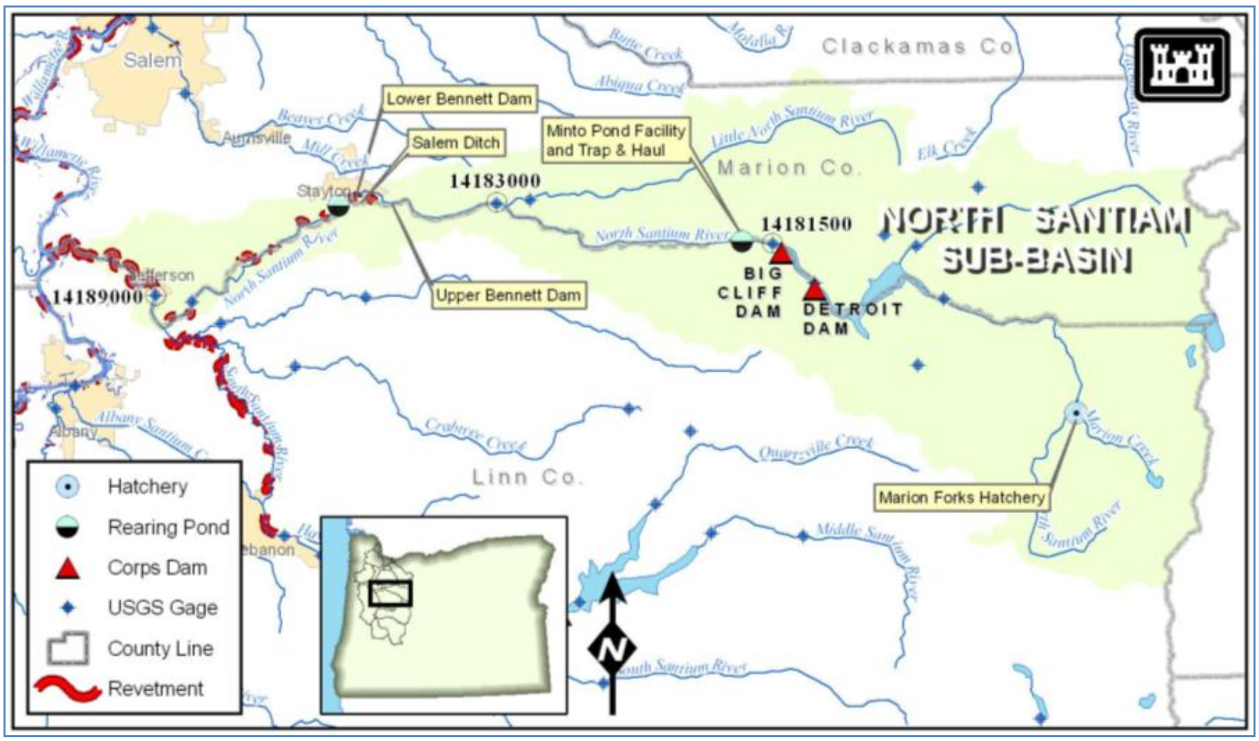
Since 2008, the Corps has reviewed authorities and validated that the Corps has the authority to execute all of the BiOp RPA measures.

3.2. North Santiam Subbasin

3.2.1. Subbasin Overview

The North Santiam subbasin drains about 760 square miles. Detroit and Big Cliff are two of the 13 multi-purpose projects operated by the Corps in the Willamette Valley in Oregon. Located in Marion County in the rugged mountain forests below Mt. Jefferson, the two dams store the waters of the North Santiam River (Figure 3-1). Construction of Detroit and Big Cliff was completed in 1953, and these projects form a complete barrier to upstream fish passage. A new adult fish collection facility was completed at Minto Dam in 2012, located approximately 5 miles below Big Cliff Dam. To migrate downstream, fish must pass through the spillway, regulating outlets or turbines. Downstream fish passage survival and passage efficiency conditions are summarized in Appendix K.

Figure 3-1. North Santiam Subbasin



3.2.1.1. Winter Steelhead

The NWFSC reviewed information on winter steelhead capacity and production (see Appendix C). The following is an excerpt from their documentation:

> Native winter-run historically spawned throughout the North Santiam Basin. Surveys done in 1940 estimated that the run of steelhead was at least 2,000 fish (Parkhurst et al. 1950). Parkhurst et al. (1950) also reported that large spawning aggregations existed in the Breitenbush, Little North Santiam, and Marion Fork rivers. The Oregon Fish Commission

(OFC) hatchery rack was located near Jefferson, below the confluence of the North Santiam and Breitenbush Rivers and below most of the natural-spawning areas, except for the Little North Santiam River (Wallis 1963a). In 1930, 2.8 million eggs were collected, corresponding to 686 females at 4,170 eggs/female (Wallis 1963a). On average 1,000 steelhead adults were collected at Minto Dam from 1952 to 1959 (Wevers et al. 1992). Additionally, from 1959 to 1964 counts of steelhead at Elkhorn Falls, Little North Fork Santiam averaged 120 adults. Recent estimates of escapement to the North Santiam River developed by proportional distribution of Willamette Falls counts based on index redd counts fluctuate between 2000 and 4000 winter-run steelhead adults.

Currently, no production of winter steelhead occurs above Detroit Dam. McElhany and others (2007) provided a current geometric mean of short-term abundance of 2,109 adults based on 1990-2005 data for the North Santiam. Since this estimate, the adult abundance trends for winter steelhead in the Willamette Basin in general have been declining based on Willamette Falls fish ladder counts published by ODFW. The majority of winter steelhead passing above Willamette Falls originates from the North Santiam.

3.2.1.2. Spring Chinook

Mattson (1948) estimated that 71% of the North Santiam Spring Chinook production originated in areas now currently blocked by Detroit Dam. Based on habitat loss with the construction of the Big Cliff and Detroit dams (including the reservoir pools) and habitat loss and degradation below the dams, current spawner (egg) capacity is estimated at approximately 11,500 adult spawners (assuming 2,250 eggs per adult), with 72% of that capacity (for 8,100 adults) above Detroit Reservoir (Appendix C). Current downstream fish passage conditions are summarized in Appendix K.

Downstream of Big Cliff and Detroit dams, Chinook spawning and productivity are affected by flow management, TDG and temperature effects of dam operations, effects of Corps-funded Chinook mitigation hatchery releases (competition and genetic effects for wild Chinook), fishing, and agricultural and other land use impacts, among other effects. Since 2007, changes in dam operations have increased summer temperatures and decreased fall temperatures (during reservoir drawdown for FRM) resulting in improved adult migration timing in summer, and better incubation conditions in the fall below Big Cliff. However, when drier conditions occur in the future or equipment maintenance requires operational changes, the ability to manage temperature below Big Cliff will be impacted. The new adult fish facility at Minto is expected to reduce PSM for transported adult Chinook and pHOS below Minto.

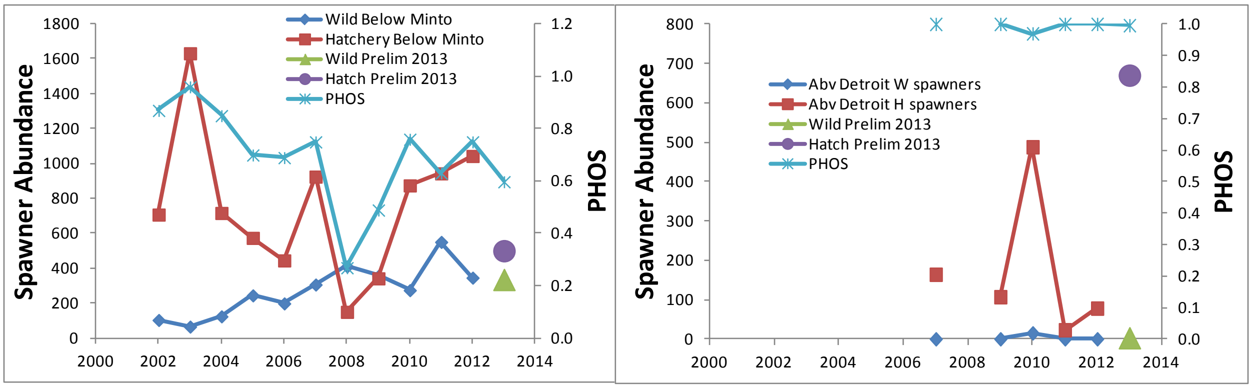
Hatchery-origin spring Chinook are currently outplanted above Detroit Dam in the North Santiam and Breitenbush rivers. Adult counts at the Minto trap 2002-2007 and Bennett Dam counts 2001-2005, indicated less than 500 naturally produced Chinook adults return to the North Santiam River annually.

In recent years, abundance of naturally produced Chinook adult returns has increased. It appears spill operations since 2009 has increased the number of juveniles effectively passing Detroit and Big Cliff dams, resulting in increased adult returns. Genetic pedigree analysis of returning adult Chinook salmon to Minto trap found that most NOR salmon sampled in 2013 (59%) and 2014 (66%) were progeny of outplanted salmon (O'Malley et al. 2015a). This analysis also estimated, for salmon outplanted above Detroit Dam in 2009, that female fitness was ~5× (2.72:0.52 progeny) that of males cohort replacement rate was 1.07 as estimated from female replacement.

The increase in adult abundance in the North Santiam in recent years, and replacement rate >1, is likely due to surface spill operations which are only possible in average to wet year conditions. In dry years, like 2015, no surface spill occurred and fewer juvenile likely passed downstream of Detroit Dam.

Moreover, the effective population size of Chinook, as measured from genetic pedigree analysis, is small and therefore the population is at risk of inbreeding effects unless the population increases.
In Figure 3.2, for below Big Cliff Dam, pHOS has ranged from about 60-80%, and is currently 100% above Detroit Dam since only hatchery fish are currently being transported upstream.

Figure 3-2. North Santiam Subbasin Adult Spring Chinook Abundance and Proportion of Hatchery Origin Spawners Above and Below Detroit/Big Cliff Dams



Unpublished data provided by C. Sharpe, ODFW, 10/6/2014. Note very heavy rain event at peak spawning in 2013, and carcass recoveries and redd counts might have been affected.

3.2.1.3. Bull Trout

Bull trout were historically distributed in the North Santiam subbasin but are no longer present. Bull trout were last observed in the North Santiam in 1945 (USFWS 2008). Construction of Detroit and Big Cliff dams eliminated the possibility of bull trout naturally re-colonizing areas upstream of the projects.

3.2.1.4. Oregon Chub

Scheerer and others (2007) documents that there are Oregon chub populations at five sites on the North Santiam (Geren Island, Stayton Public Works pond, Green's Bridge backwater, Pioneer Park, and Gray slough), and at two sites on the mainstem Santiam (Santiam Interstate 5 side channels, Santiam conservation easement).

3.2.2. Alternatives

Table 3.2 lists the COP II alternatives considered for the North Santiam subbasin and indicates whether the alternative was carried forward for final analysis (shaded in blue). The results of the detailed biological analyses are summarized in Section 3.2.2.1. A summary table was prepared to compile the results from the biological and technical assessments for the North Santiam alternatives. A description of the two alternatives being carried forward for final analysis follows (note that baseline conditions are described in Chapter 2 and in detail in Appendix A). Detailed information about all the alternatives is included in Appendix D.

Table 3-2. North Santiam Subbasin COP II Alternatives

Alternative ID	Description	Carry Forward for Final Analysis?
NS-Baseline	North Santiam Baseline	Yes
NS-COMBO-1	Downstream Passage Improvement with Temperature Benefits – Floating Surface Outlet (FSO) with Floating Surface Collector (FSC)	Yes
NS-DSP-H4-DET	Downstream Passage Improvement with Temperature Benefits - Selective Withdrawal Structure (SWS) and Weir Box with Floating Screen Structure (FSS)	Yes
NS-DSP-01-DET	Operational – Detroit Deep Drawdown to El. 1370 feet with RO Priority	No
NS-DSP-03-DET	Operational – Delay Drawdown of Detroit Reservoir and Lower Minimum Outflows	No
NS-DSP-04-DET	Operational – Detroit RO Priority in Winter	No
NS-DSP-06-DET	Operational - Delay Detroit Refill/Deeper Drawdown to El. 1370 feet and RO Priority	No
NS-DSP-07-DET	Operational – Detroit at Minimum Conservation Pool Year-round	No
NS-DSP-08-DET	Operational – Detroit Run of River	No
NS-DSP-01-BCL	Operational - Operate Big Cliff Powerhouse Within 1% Peak Efficiency	No
NS-DSP-H1-DET	Downstream Passage– Floating Surface Collector	Not as standalone measure, included in NS-COMBO-1
NS-DSP-H2-DET	Downstream Passage Improvement with Temperature Benefits - FSO	Not as standalone measure, included in NS-COMBO-1
NS-DSP-H3-DET	Selective Withdrawal Structure with Weir Box (formerly NS-TMP-H1-DET) - Temperature Control Improvement – High Improvement)	Not as standalone measure, included in NS-DSP-H4-DET
NS-HOR-01-DET	HOR Structure on North Fork Santiam only	No
NS-HOR-02-DET	HOR on North Fork Santiam and Breitenbush	No
NS-TMP-01-DET	Operational - Surcharge Detroit Reservoir in Conservation Season	No
NS-TDG-H1-BCL	TDG – Structural Improvement	No
NS-TDG-H2-BCL	TDG – Operational Improvement	No
NS-HAB-01-DET	Operational – Detroit Storage to Meet Mainstem Flow Targets – Salem Minimums	No

3.2.2.1. Biological Assessment of Alternatives

Some of the alternatives shown in Table 3-2 were assessed using the biological tools described in Chapter 2. Details on the FBW results are discussed in Appendix K. Details on the SLAM modeling and VSP analysis are included in Appendix C. Summaries of the FBW scores are shown in Figure 3-3 for Chinook and Figure 3-4 for steelhead. Measures carried forward for final evaluation are highlighted with red circles. Dam passage survival [concrete survival multiplied by dam passage efficiency (DPE)] for all three life stages (fry, subyearlings and yearlings) were averaged and are shown on the graph.

A wide range of alternatives were compared with the Chinook FBW tool. Some sensitivity runs were conducted to test different assumptions for DPE, route effectiveness, and Big Cliff mortality, as well as fish timing or variations in the size of the structure. As seen in the figure, several baseline runs were tested (Ch NS 1, Ch NS 1a, Ch NS 1 ops and Ch NS 1t) as the FBW parameters were dialed in. Results for each of the runs are included in Appendix K. Multiple FBW runs were also done for the SWS, SWS-FSS and FSC alternatives.

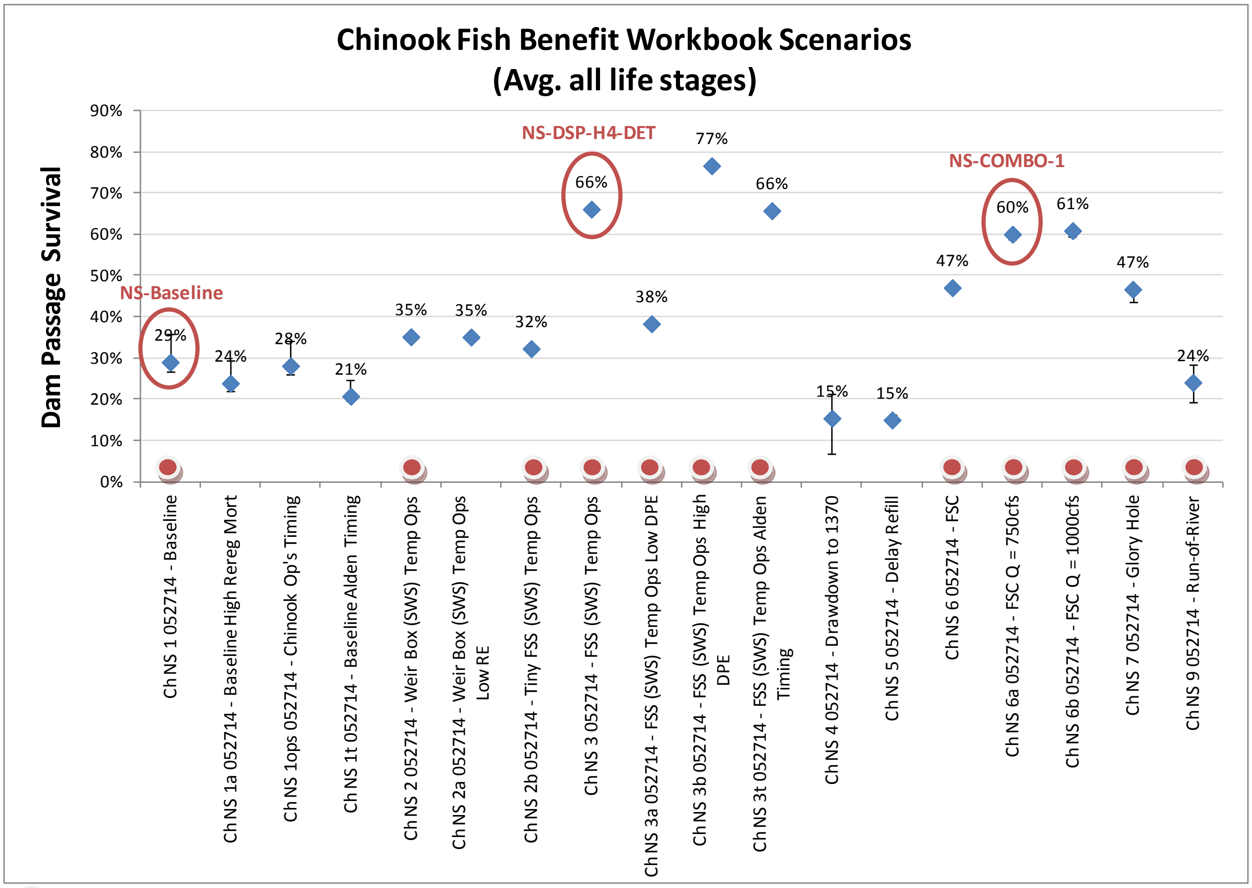
Some of the FBW runs were then sent to SLAM to test the benefit for the subbasin population. In general, if the FBW results were similar or lower than the baseline score, they were not sent to the SLAM model. The operational measures [NS-DSP-01-DET (Ch NS 4 – Drawdown to 1370), NS-DSP-06-DET (Ch NS 5 – Delay Refill) and NS-DSP-08-DET (Ch NS 9 - Run-of-River)] performed similar or less than the Baseline runs, and only the run-of-river option, which performed best out of the operational alternatives, was sent to SLAM. Runs that were sent to SLAM are identified in the figure. Final North Santiam alternatives are highlighted with red circles.

Another version of the FBW spreadsheet was used to estimate benefits for steelhead (Figure 3-4). Since several FBW runs had been completed for Chinook, only a subset was run in the steelhead version. The COP team needed to verify that actions that benefited Chinook also benefited steelhead. Both of the final alternatives showed higher dam passage rates for both species than baseline.

The measures appearing to have the most biological benefit out of the FBW were sent to SLAM to be assessed at the subbasin level. North Santiam results for SLAM are shown in Figure 3-5 and Figure 3-6. Measures carried forward for final evaluation are highlighted with text in bold and boxed in red. A replacement analysis was done using the time-series information generated by SLAM. The statistics were checked to see if, on average, the number of adult offspring replaced their parents. Additionally, checks were made to verify that most of the individual years met replacement. The results of the replacement analysis are shown in Table 3-3 and Table 3-4.

For Chinook, the replacement analysis shows that the SWS-FSS met replacement criteria. The FSC nearly met criteria for Chinook and did meet criteria for steelhead. The FSO did not meet replacement for Chinook, but nearly met replacement for steelhead (it did not meet all criteria, 67% of the time the smolt/adult ratio was greater than 95%). Because the FSO also had the side benefit of providing temperature benefits through surface spill, it was combined with the FSC in NS-COMBO-1. The new combination would allow for a phased implementation approach and would improve fish benefits with more certainty. The SWS with weir box did not meet replacement, but could be used in a phased approach (i.e., implement the weir box first, then if benefits are insufficient after testing and modification, implement a different passage improvement). The technical design teams also saw the value of the weir box for helping inform final design of a larger structure. To help buy-down technical risk, the SWS with weir box was added to the SWS-FSS as a phased approach. The operational passage option of operating at run of river also did not meet replacement.

Figure 3-3. Fish Benefits Workbook for Chinook in North Santiam Subbasin

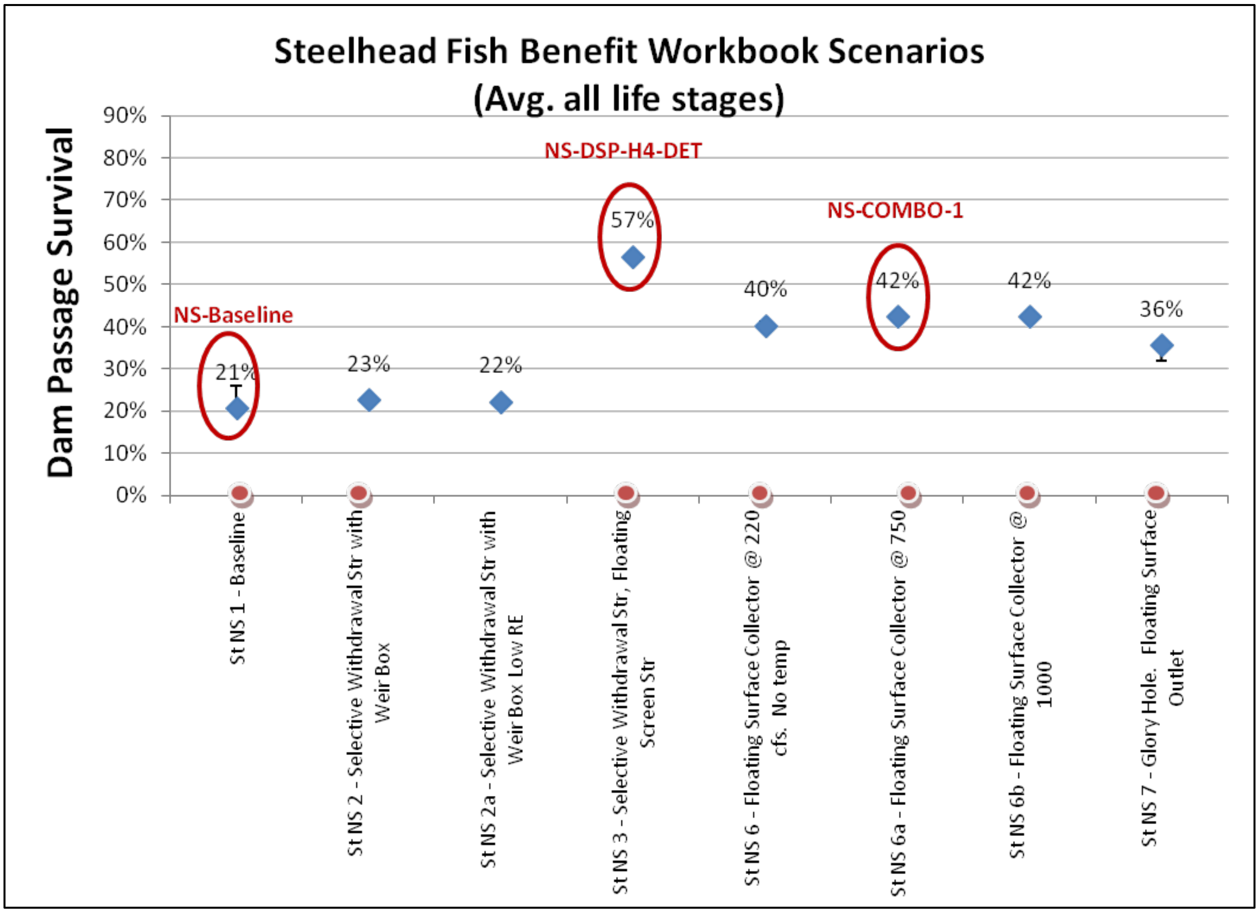


Identifies alternatives that were sent to SLAM

Key: (Red highlighted cases are carried forward for final analyses.)

NS-Baseline	=	Ch NS 1 052714 – Baseline	(Final Parameters)
NS-Baseline	=	Ch NS 1a 052714 – Baseline High Rereg Mort	(Test Parameters)
NS-Baseline	=	Ch NS 1ops 052714 – Chinook Op's Timing	(Test Parameters)
NS-Baseline	=	Ch NS 1t 052714 – Baseline Alden Timing	(Test Parameters)
NS-DSP-H3-DET	=	Ch NS 2 052714 – Weir Box (SWS) Temp Ops	(Test Parameters)
NS-DSP-H3-DET	=	Ch NS 2a 052714 – Weir Box (SWS) Temp Ops Low RE	(Test Parameters)
NS-DSP-H3-DET	=	Ch NS 2b 052714 – Tiny FSS (SWS) Temp Ops	(Test Parameters)
NS-DSP-H4-DET	=	Ch NS 3 052714 – FSS (SWS) Temp Ops	(Final Parameters)
NS-DSP-H4-DET	=	Ch NS 3a 052714 – FSS (SWS) Temp Ops Low DPE	(Test Parameters)
NS-DSP-H4-DET	=	Ch NS 3b 052714 – FSS (SWS) Temp Ops High DPE	(Test Parameters)
NS-DSP-H4-DET	=	Ch NS 3t 052714 – FSS (SWS) Temp Ops Alden Timing	(Test Parameters)
NS-DSP-01-DET	=	Ch NS 4 052714 – Drawdown to 1370	(Operational Run)
NS-DSP-06-DET	=	Ch NS 5 052714 – Delay Refill	(Operational Run)
NS-COMBO-1	=	Ch NS 6 052714 – FSC	(Pump Flow Test)
NS-COMBO-1	=	Ch NS 6a 052714 – FSC Q = 750cfs	(Final Flow)
NS-COMBO-1	=	Ch NS 6b 052714 – FSC Q = 1000cfs	(Pump Flow Test)
NS-DSP-H3-DET	=	Ch NS 7 052714 – Glory Hole	(Operational Run)
NS-DSP-01-DET	=	Ch NS 9 052714 – Run-of-River	(Operational Run)

Figure 3-4. Fish Benefits Workbook Results for Steelhead in North Santiam Subbasin

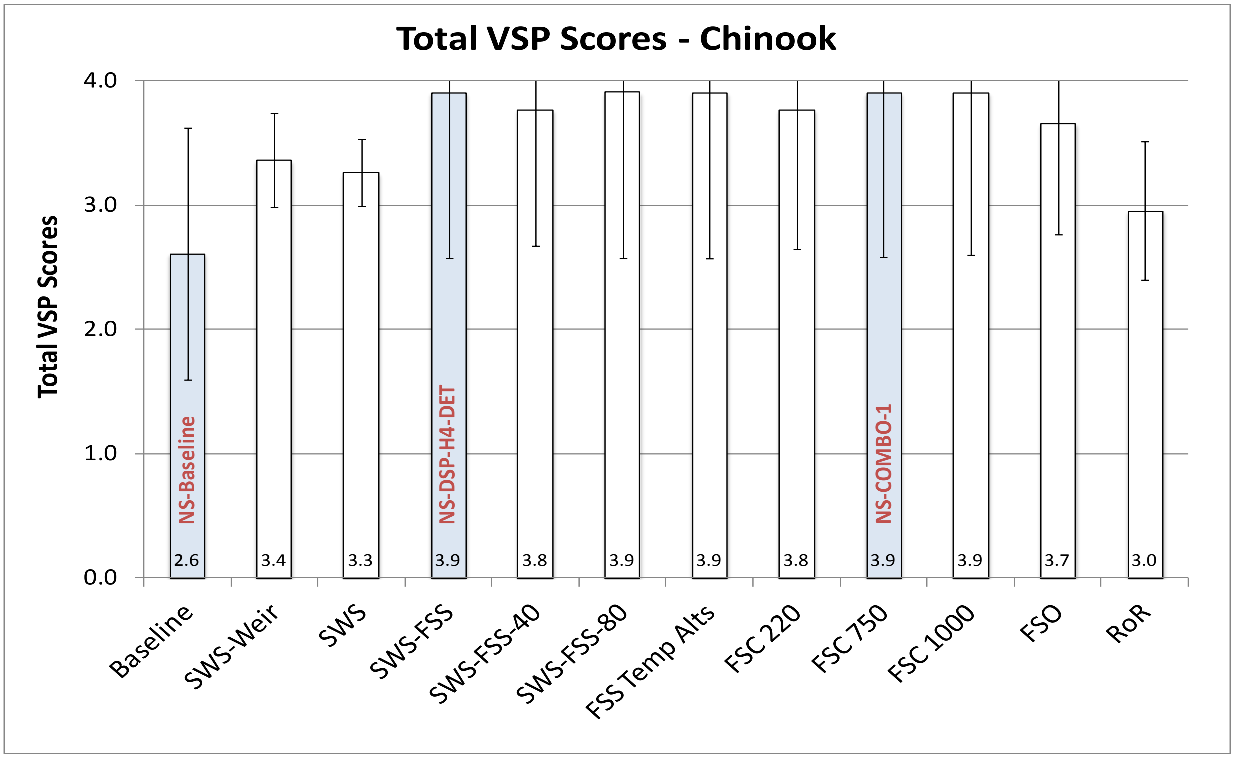


Identifies alternatives that were sent to SLAM.

Key: (Red highlighted cases are carried forward for final analyses.)

NS-Baseline	=	St NS 1 052714 – Baseline	(Final Parameters)
NS-DSP-H3-DET	=	St NS 2 052714 – Weir Box (SWS) Temp Ops	(Test Parameters)
NS-DSP-H3-DET	=	St NS 2a 052714 – Weir Box (SWS) Temp Ops Low RE	(Test Parameters)
NS-DSP-H4-DET	=	St NS 3 052714 – FSS (SWS) Temp Ops	(Final Parameters)
NS-COMBO-1	=	St NS 6 052714 – FSC	(Pump Flow Test)
NS-COMBO-1	=	St NS 6a 052714 – FSC Q = 750cfs	(Final Pump Flow)
NS-COMBO-1	=	St NS 6b 052714 – FSC Q = 1000cfs	(Pump Flow Test)
NS-DSP-H3-DET	=	St NS 7 052714 – Glory Hole	(Operational Run)

Figure 3-5. SLAM Results for Chinook in the North Santiam Subbasin

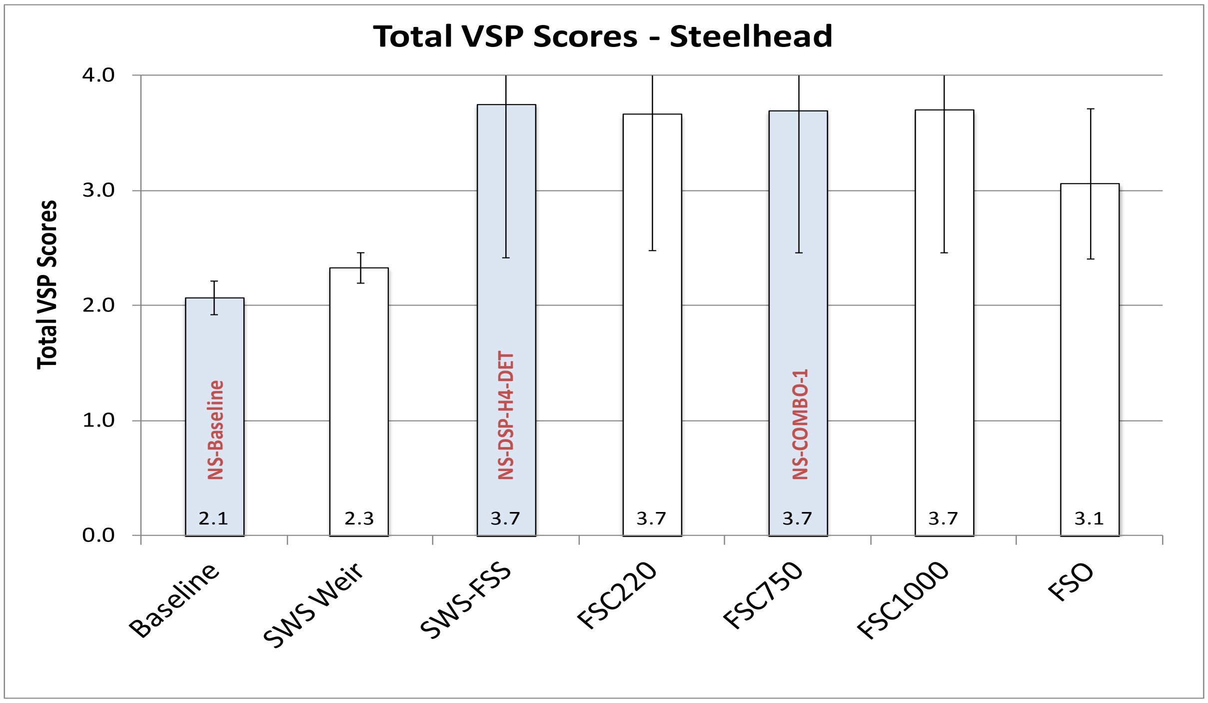


Highlighted alternatives were included in the final system analysis.

Key: (Red highlighted cases are carried forward for final analyses.)

NS-Baseline	=	Ch NS 1 052714 – Baseline	SLAM: Baseline
NS-DSP-H3-DET	=	Ch NS 2 052714 – Weir Box (SWS) Temp Ops	SLAM: SWS-Weir
NS-DSP-H3-DET	=	Ch NS 2b 052714 – Tiny FSS (SWS) Temp Ops	SLAM: SWS
NS-DSP-H4-DET	=	Ch NS 3 052714 – FSS (SWS) Temp Ops	SLAM: SWS-FSS
NS-DSP-H4-DET	=	Ch NS 3a 052714 – FSS (SWS) Temp Ops Low DPE	SLAM: SWS-FSS-40
NS-DSP-H4-DET	=	Ch NS 3b 052714 – FSS (SWS) Temp Ops High DPE	SLAM: SWS-FSS-80
NS-DSP-H4-DET	=	Ch NS 3t 052714 – FSS (SWS) Temp Ops Alden Timing	SLAM: FSS Temp Alts
NS-COMBO-1	=	Ch NS 6 052714 – FSC	SLAM: FSC 220
NS-COMBO-1	=	Ch NS 6a 052714 – FSC Q = 750cfs	SLAM: FSC 750
NS-COMBO-1	=	Ch NS 6b 052714 – FSC Q = 1000cfs	SLAM: FSC 1000
NS-DSP-H3-DET	=	Ch NS 7 052714 – Glory Hole	SLAM: FSO
NS-DSP-01-DET	=	Ch NS 9 052714 – Run-of-River	SLAM: RoR

Figure 3-6. SLAM Results for Steelhead in North Santiam Subbasin



Highlighted alternatives were included in the final system analysis.

Key: (Red highlighted cases are carried forward for final analyses.)

NS-Baseline	=	FBW: St NS 1 052714 – Baseline	SLAM: Baseline
NS-DSP-H3-DET	=	FBW: St NS 2 052714 – Weir Box (SWS) Temp Ops	SLAM: SWS Weir
NS-DSP-H4-DET	=	FBW: St NS 3 052714 – FSS (SWS) Temp Ops	SLAM: SWS-FSS
NS-COMBO-1	=	FBW: St NS 6 052714 – FSC	SLAM: FSC220
NS-COMBO-1	=	FBW: St NS 6a 052714 – FSC Q = 750cfs	SLAM: FSC750
NS-COMBO-1	=	FBW: St NS 6b 052714 – FSC Q = 1000cfs	SLAM: FSC1000
NS-DSP-H3-DET	=	FBW: St NS 7 052714 – Glory Hole	SLAM: FSO

Table 3-3. Summary of Replacement Analysis from SLAM results for North Santiam Chinook

	AVE.	Count > 1	Median	Percent Time >1	Percent Time >.95	Ave of Running Ave	Replacement Status
Baseline	**48%**	**0**	**49%**	**0%**	**0%**	**47%**	**Does not meet**
SWS-Weir	71%	0	71%	0%	0%	68%	Does not meet
SWS	65%	0	66%	0%	0%	63%	Does not meet
SWS-FSS	**100%**	**50**	**100%**	**50%**	**73%**	**96%**	**Meets Replacement Criteria**
SWS-FSS-40	87%	0	87%	0%	1%	83%	Does not meet
SWS-FSS-80	102%	56	101%	56%	75%	98%	Meets Replacement Criteria
FSS Temp Alts	100%	46	99%	46%	74%	96%	Meets Replacement Criteria
FSC 220	87%	0	87%		3%	84%	Does not meet
FSC 750	**97%**	**41**	**99%**	**41%**	**64%**	**94%**	**Nearly Meets Replacement Criteria**
FSC 1000	98%	29	98%	29%	67%	94%	Nearly Meets Replacement Criteria
FSO	82%	0	83%	0%	0%	79%	Does not meet
RoR	58%	0	59%	0%	0%	56%	Does not meet

See Section 2.5.2 for Replacement Criteria. Dark green meets criteria, light green nearly meets criteria, and white does not meet criteria. Bold text and boxed red cases were carried forward for final analyses.

Table 3-4. Summary of Replacement Analysis from SLAM results for North Santiam Steelhead

	AVER	Count > 1	Median	Percent Time >1	Percent Time >.95	Ave of Running Ave	Replacement Status
Baseline	**Went to 0**	**0**	**Na**	**0%**	**0%**	**Na**	**Does not meet**
SWS Weir	Went to 0	0	Na	0%	0%	Na	Does not meet
SWS-FSS	**105%**	**72**	**102%**	**72%**	**93%**	**101%**	**Meets Replacement Criteria**
FSC220	103%	78	102%	78%	93%	99%	Meets Replacement Criteria
FSC750	**103%**	**74**	**102%**	**75%**	**93%**	**99%**	**Meets Replacement Criteria**
FSC1000	103%	78	102%	79%	93%	99%	Meets Replacement Criteria
FSO	101%	44	99%	44%	67%	97%	Nearly Meets Replacement Criteria

See Section 2.5.2 for Replacement Criteria. Dark green meets criteria, light green nearly meets criteria, and white does not meet criteria. Bold text and boxed red cases were carried forward for final analyses.

Key: (Red highlighted cases are carried forward for final analyses.)

Alternative ID		**SLAM Run ID**
NS-Baseline	=	SLAM: Baseline
NS-COMBO-1	=	SLAM: FSC750
NS-DSP-H4-DET	=	SLAM: SWS-FSS

3.2.2.2. North Santiam Temperature and Fish Passage Comparison

Several options were investigated for temperature and downstream passage at Detroit. Options were compared and evaluated looking at biological criteria (does the measure meet replacement, minimize adult migration delay and incubation impacts), key risk factors (is the measure resilient to climate change and redundancy during equipment failure), and an assessment of whether or not the measure allowed flexibility to meet other project missions. Each option was assessed and results are summarized in Table 3-5. The assessments shown in Table 3-5 were qualitative in nature and reflect best professional judgment (with the exception of meeting replacement criteria, which was evaluated quantitatively; see Table 3-3 and Table 3-4). The COP PDT summarized this information to help assess risk and develop a recommendation of alternatives for final analysis. Risks from climate change are discussed in Section 3.2.2.3.

Table 3-5. Summary of Temperature and Fish Passage Option Comparison for Detroit

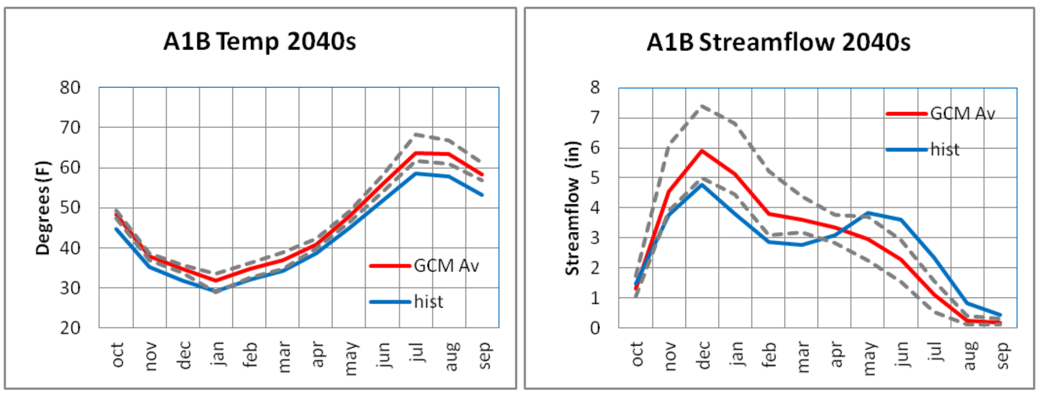
	Population-Specific Biological Criteria			Risk Factors		Overall	Other Considerations
Detroit Dam Options	**Meets Replace-ment?**	**Probability Measure Minimizes Delay**	**Probability Measure Minimizes Below Dam Incubation Impacts**	**Probability Measure is Resilient to Climate Change**	**Probability Measure Can Meet Temps if Equipment Fails**	**Probability of Biological Success (used lowest of all ranks)**	**Probability Measure Provides Flexibility to Meet Missions**
FSC w/o Temp Ops	Likely	Low	Low	Low	Na	Low	Low
SWS	No	High	High	High	High	Low	High
FSO	No	Mod-High	Mod-High	Mod-High	Mod	Low	Mod
SWS-Weir Box	No	High	High	High	High	Low	High
FSC + Temp Ops	Likely	Mod	Low-Mod	Low-Mod	Low	Low-Mod	Low
FSO-FSC	Likely	Mod-High	Mod-High	Mod-High	Mod	Mod-High	Mod
SWS-FSS	Yes	High	High	High	High	High	High

As seen in Table 3-5, the Detroit option that provides the highest biological benefits, redundancy and flexibility is the SWS-FSS. The FSO-FSC would result in moderate to high biological benefits (this option would provide a small surface spill option below spillway crest, but the full flexibility of the SWS would not be there). There is a moderate probability that temperatures could be met if there were equipment failures and a moderate probability that other missions could be met (primary impact to hydropower). The FSC with temperature operations would likely meet replacement and would provide a low to moderate probability that biological criteria could be met (could meet temperature goals in most years but not in driest 20%). This option had a low probability of being able to meet temperature goals if there was an equipment failure. This assessment indicated that the SWS-FSS had the least risk. The FSO-FSC has some risk associated with the measure, while the FSC with (and without) temperature operations were the most risky. The SWS, FSO and SWS-weir box did not meet replacement – a final COP screening criteria.

3.2.2.3. North Santiam Climate Change Trends and Impacts

The North Santiam project alternatives would likely be highly affected by projected warmer temperatures as well as reduced summer base streamflows as a result of climate change; therefore, climate change impacts were mostly considered within the North Santiam subbasin. Data from the University of Washington, Climate Impacts Group was used to identify these trends more specifically within the Willamette subbasins. Figure 3-7 shows the temperature and streamflow changes for the North Santiam. The graphs summarize the future projections for the 2040s. The future and historic comparison time series (in blue) is based on a historic period run for the years 1915 through 2006. The climate change data is based on the A1B emission scenario, as simulated using 10 select global climate models. The A1B scenario was used as the greenhouse gas scenario. The grey dotted line indicates maximum and minimum projections for the 10 climate change models selected by the Climate Impact Group used to run the A1B CO_2 emission future scenario. The combined monthly average total runoff is in terms of inches spread over the entire basin. This was a legacy convention from the original modeling. The graphs are useful for showing the trend in overall streamflow change in the 2040s or for longer time frames.

Figure 3-7. North Santiam Future Temperature and Streamflow Trends



Derived from University of Washington, Climate Impact Group data for Detroit reservoir, just below Boulder Creek.

These graphs show temperature warming and flow declines during the summer months in particular. The warmer months of June through Septembers may be of particular concern due to potential adverse impacts on delaying adult salmonid migration and increasing prespawning mortality. The model results show mean annual temperatures increasing 3.4°F. For the temperature critical months, June through September, the average temperature increase was 4.5°F for the 2040s time frame. Temperatures represent ambient air but are a potential proxy for potential increased water temperatures.

Lower base flows are also expected to occur during future late spring through the summer period. In light of hotter summers, reduced base flow to ameliorate higher temperatures could exacerbate the adverse impacts to fish. Higher temperatures will affect adult migration mortality rates as well as spawning success.

Projected climate changes emphasize the importance of alternatives with greater flexibility to cope with more extreme future conditions. Streamflows are shown to increase in wintertime, starting in October and November. Runoff reduction was more pronounced compared to the baseline which shows an increase in runoff due to snow melt, occurring in May through June. In the future condition, spring melt disappears.

The COP PDT considered climate effects for at the site level with available data. The data available emphasizes that warmer seasonal temperatures and less base flow in the critical summer months are likely. This prompted the COP PDT to put increased value on alternatives that possessed better resilience to climate change. Of the alternatives evaluated in Section 3.2.2.2, the FSC with and without temperature operations (FSC w/o temp ops and FSC + temp ops) had the lowest confidence of being resilient to climate change. This is primarily due to the expected rise in temperatures and the decrease in streamflow, which could limit the ability to refill above the spillway crest. If the pool is below spillway crest, no temperature operations can be provided. The FSO and FSO-FSC had moderate to high resiliency because a surface spill could be provided with the FSO below spillway crest. The SWS options (SWS, SWS-weir box and SWS-FSS) provided the highest resiliency to climate change as they allowed for the most flexibility in pulling water from any reservoir elevation.

3.2.2.4. Non-Monetized Impacts

Table 3-6 summarizes the non-monetized impacts of all the assessed measures, regardless of whether or not they were carried forward for final analysis. Impacts were given a numerical value between 1 and 5 to indicate high negative impact (1) up to a high benefit (5). Biological benefits are also summarized including impacts to residential fish, Oregon chub.

Table 3-6. Summary of Results for North Santiam Subbasin Alternatives

Alternative ID and Description (**Bold denotes alternatives carried forward for final analysis**)	**Anadromous Fish**					**Resident Fish**		**Flood Risk Management**					**Water Supply-M&I and Irrigation**					
	FBW Average score [%]		**VSP Score**		**Confidence Level**	**Impact**	**Confidence Level**		**Meeting Downstream Tributary Flows**	**Meeting Mainstem Flows**	**Reservoir Recreation**	**River Recreation**			**Constructability**	**Implementation Timing**	**Clean Water Act (TDG)**	**Temperature**
	Steelhead	**Chinook**	**Steelhead**	**Chinook**		**Oregon Chub**		**Yes/No Impact**	1=High Negative Impact; 2=Moderate Negative Impact; 3= Low to No Negative/Positive Impact; 4=Moderate Positive Impact; 5=High Positive Impact				**Current Demand**	**Future (2050) Demand**				
NS- Baseline	21	29	2.1	2.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NS-COMBO-1: Downstream Passage Imp. w/ Temperature Benefits – FSO with FSC	FSO-36 FSC-42	FSO-47 FSC-60	3.1 FSO 3.7 FSC	3.7 FSO 3.9 FSC	M	P	H	N	3	3	3	3	3	3	1	1	3	4
NS-DSP-H4-DET: Downstream Passage Imp. with Temperature Benefits - SWS with FSS	57	66	3.7	3.9	H	P	M	N	3	3	3	3	3	3	1	1	3	5
NS-DSP-01-DET: Operational-Detroit Deep Drawdown to El. 1370 ft with RO Priority	NM	15	NM	NM	NA	U	M	N	1	1	1	2	2	2	3	3	3	2
NS-DSP-03-DET: Operational-Delay Detroit Res. Drawdown and Lower Minimum Outflows	--	--	--	--	--	--	--	Y	--	--	--	--	--	--	--	--	--	--
NS-DSP-04-DET: Operational-Detroit RO Priority in Winter	Not fully assessed - salmonids would have to sound much too deep to find ROs																	
NS-DSP-06-DET: Operational-Delay Detroit Refill/Deeper Drawdown to El. 1370 ft/RO Priority	NM	15	NM	NM	NA	N	H	N	1	1	1	2	1	1	3	3	3	1
NS-DSP-07-DET: Operational-Detroit at Minimum Conservation Pool Year-round		Not fully assessed because salmonids would need to sound much too deep to find ROs and negative impacts to downstream water temperatures.																
NS-DSP-08-DET: Detroit Run-of-River	NM	24	NM	3.0	--	N	M	N	1	1	1	2	1	1	3	3	3	2
NS-DSP-01-BCL: Operational-Operate Big Cliff Powerhouse within 1% Peak Efficiency	Not fully assessed - limited flexibility of Big Cliff's single turbine and impacts to spawning steelhead and Chinook.																	

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact); Color coding = Red (high/moderate negative impact), Green (high/moderate positive impact).

Table 3-6 (continued). Summary of Results for North Santiam Subbasin Alternatives

Alternative ID and Description	Anadromous Fish					Resident Fish		Flood Risk Management	Meeting Downstream Tributary Flows	Meeting Mainstem Flows	Reservoir Recreation	River Recreation	Water Supply - M&I and Irrigation		Constructability	Implementation Timing	Clean Water Act (TDG)	Temperature
	FBW Average score [%]		VSP Score		Confidence Level	Impact	Confidence Level	Yes/No Impact	1=High Negative Impact; 2=Moderate Negative Impact; 3= Low to No Negative/Positive Impact; 4=Moderate Positive Impact; 5=High Positive Impact				Current Demand	Future (2050) Demand				
	Steelhead	Chinook	Steelhead	Chinook		Oregon Chub												
NS-DSP-H1-DET: Downstream Passage - FSC	40	47	NM	NM	H	0	H	N	3	3	3	3	3	3	1	1	3	3
NS-DSP-H2-DET: Downstream Passage Improvement with Temperature Benefits - FSO	36	47	3.7	3.1	L	P	M	N	3	3	3	-	3	3	2	1	3	4
NS-DSP-H3-DET: SWS with Weir Box - Temperature Control Improvement – High Improvement)	23	35	3.4	2.3	H	P	M	N	3	3	3	-	3	3	1	1	3	5
NS-HOR-01-DET: HOR on North Fork Santiam Only	NM	NM	NM	NM	L	0	H	N	3	3	3	3	3	3	1	1	3	3
NS-HOR-02-DET: HOR on North Fork Santiam and Breitenbush	NM	NM	NM	NM	L	0	H	N	3	3	3	3	3	3	1	1	3	3
NS-TMP-01-DET: Operational-Surcharge Detroit Reservoir in Conservation Season	--	--	--	--	--	--	--	Y	--	--	--	--	--	--	--	--	--	--
NS-TDG-H1-BCL: TDG Improvement-Structural Improvement	NM	NM	NM	NM	H	0	H	N	3	3	3	3	3	3	2	2	5	3
NS-TDG-H2-BCL: TDG - Operational Improvement	NM	NM	NM	NM	M	0	H	N	4	3	1	-	3	3	3	3	4	1
NS-HAB-01-DET: Operational-Detroit Storage to Meet Mainstem Flow Targets - Salem Minimums	NM	NM	NM	NM	--	N	M	--	--	--	--	--	--	--	--	--	--	--

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact); Color coding = Red (high/moderate negative impact), Green (high/moderate positive impact).

3.2.3. North Santiam Alternatives Carried Forward for Final System Analysis

Two alternatives (NS-COMBO-1 and NS-DSP-H4-DET) met replacement criteria and were carried forward for inclusion in the system analysis. These alternatives are described below, and compared to baseline conditions. More detailed information is included in Appendix D.

3.2.3.1. NS-COMBO 1: Downstream Passage Improvement with Temperature Benefits – Floating Surface Outlet with Floating Surface Collector

This alternative provides temperature benefits below Big Cliff Dam, and downstream fish passage benefits in the North Santiam for fish migrating past Detroit Dam. The downstream fish passage component nearly met replacement. The alternative includes a hybrid solution for downstream fish passage and water temperature management. A FSO similar to a glory-hole spillway structure would be constructed to provide a surface outlet when the reservoir is drawn down below spillway crest (Figure 3-8). Detroit Dam would be operated for water temperature management and the spillway would be used until the reservoir is drawn down below spillway crest. At that time, the FSO would be used to continue the discharge of surface water for improved downstream temperature management and fish passage. If the FSO is unable to attract and safely pass enough fish, a FSC would be added (Figure 3-9).

Figure 3-8. Floating Surface Outlet for NS-COMBO-1

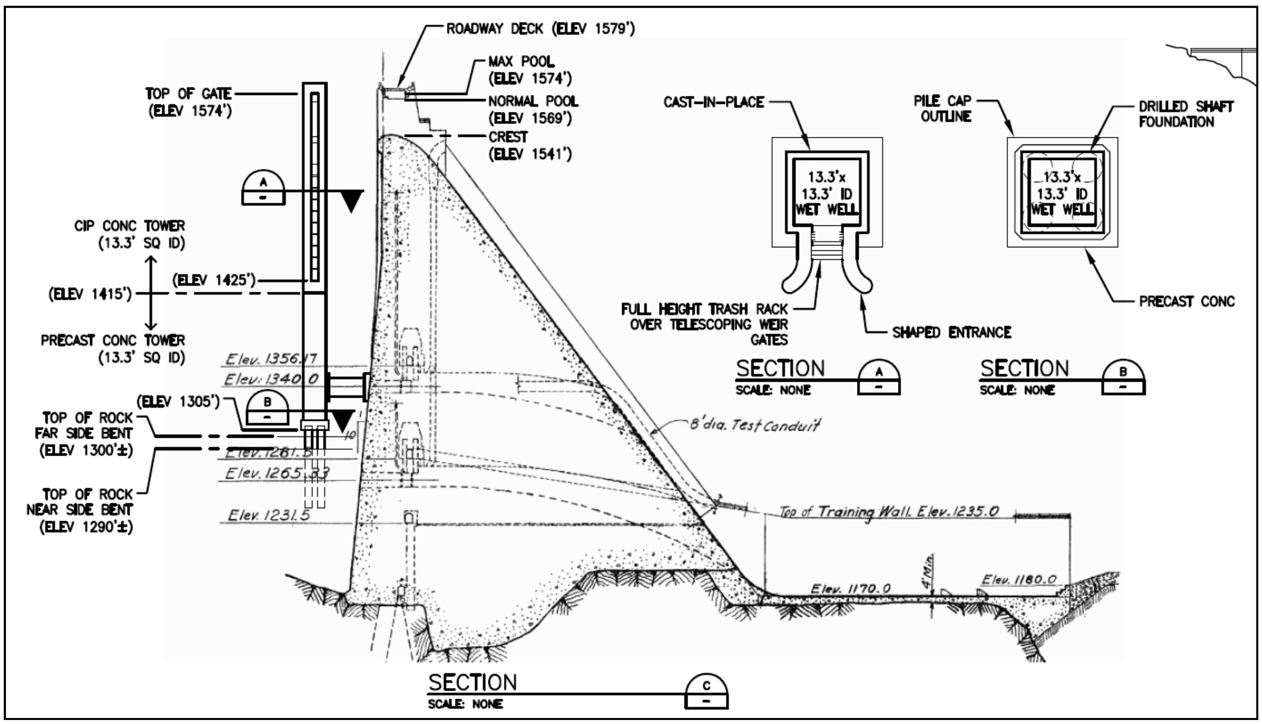
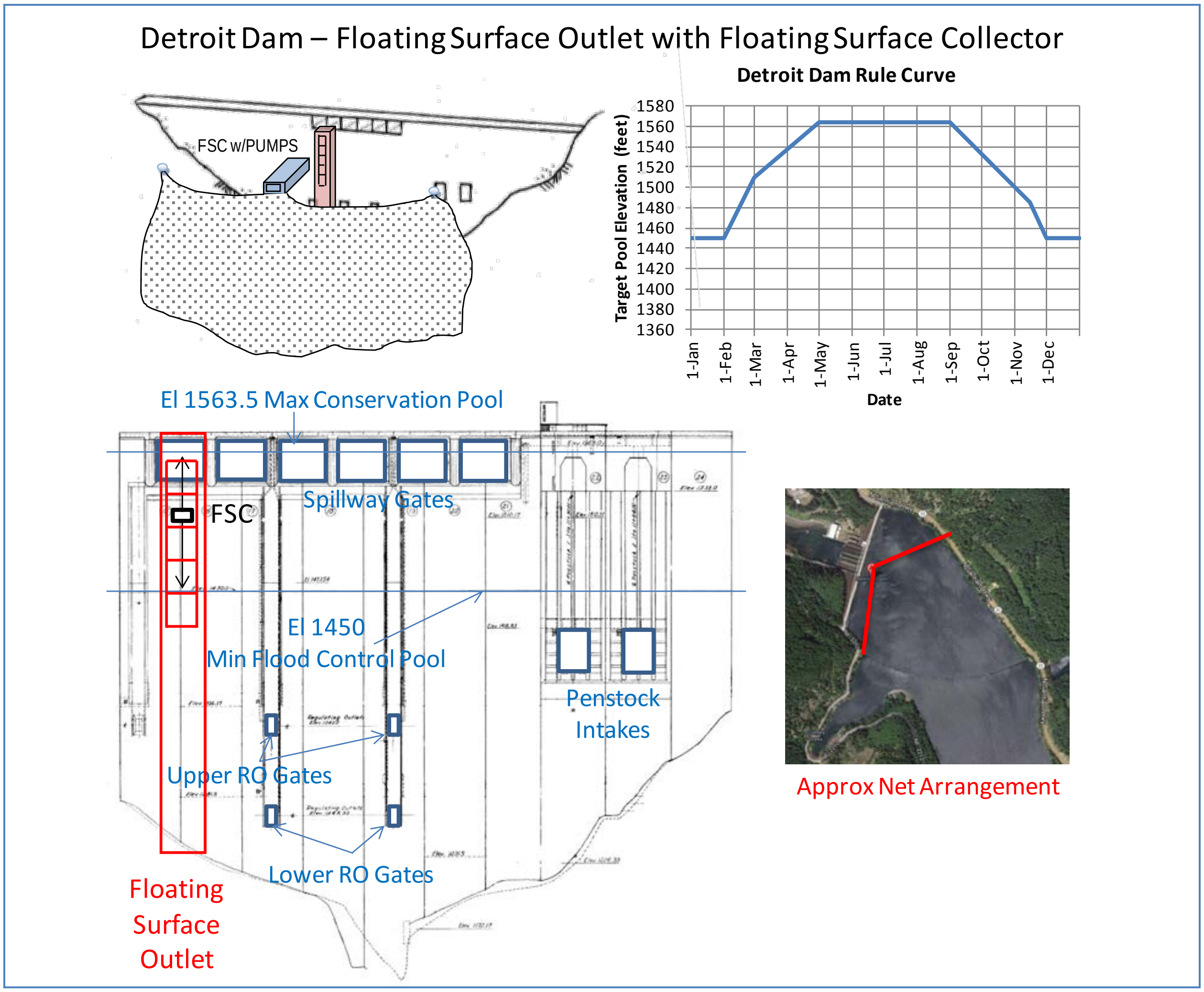


Figure 3-9. Floating Surface Outlet with Floating Surface Collector for NS-COMBO-1



The conceptual designs include installation of a FSC with fully exclusionary guide nets that operate year-round and over the entire forebay range. Captured fish would need to be kept in an attached live box before being transported. Once collected, juvenile fish would either be transported via truck around the dam(s) to a downstream release site, or diverted to a dam bypass system for release downstream of the dam(s).

Downstream fish passage survival is estimated to improve from 29% to 62% for Chinook, and 21% to 41% for steelhead, and population viability is expected to improve from a VSP of 2.6 to 3.9 for Chinook, and 2.1 to 3.7 for steelhead with completion of this alternative via the FSO or FSC, if needed. Fish production below the dam(s) would be as good or better as the current level of production provided by the ongoing interim water temperature control measures. Operations and maintenance of nets to help guide fish to the collector entrance will be complicated by annual flood risk reduction operations requiring water levels to fluctuate over 75 feet. Such water level fluctuations in concert with harsh environmental conditions will increase risk associated with net damage and debris loads experienced by the facility.

Upstream fish passage has already been established with a new fish facility at Minto, allowing trap and haul of Chinook and steelhead adults. The new facility is expected to decrease PSM in Chinook, and could also reduce pHOS below the dams by improving collection of hatchery origin adults.

Constructability and implementation timing impacts would be high because downstream passage structures are complex and require rigorous engineering and design. This alternative should not affect flows or reservoir elevations and would likely have little to no effect on TDG levels, or reservoir/downstream recreation. Downstream water temperature management would improve over baseline since surface water would continue to be discharged downstream even after the reservoir is drawn down below spillway crest, thus providing extended temperature control. There should be no changes from baseline for the other non-monetized impact categories.

Biological Modeling Assumptions: This alternative is predicted to result in self-sustaining populations of spring Chinook and winter steelhead above Detroit Dam, based on the improvements assumed for downstream fish passage. However, it is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival).

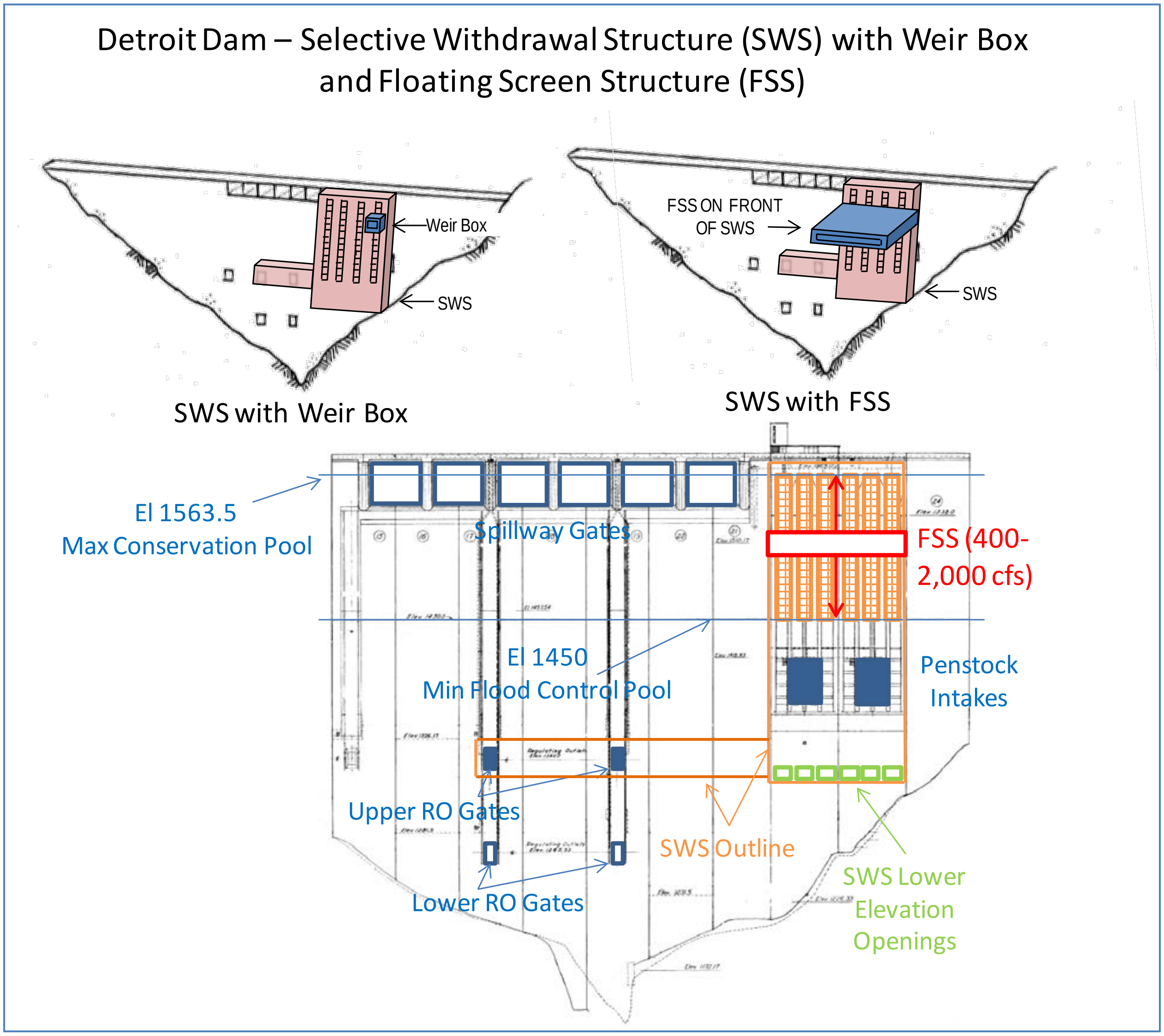
Information on Chinook juvenile survival while rearing within and migrating through Detroit reservoir is limited. Most Chinook enter the reservoir from upstream as fry (< 50 millimeters in length). Survival of fry could be low based on rates documented for other projects in the literature reviewed (Appendix C). Most steelhead/rainbow enter the reservoir as parr (> 50 millimeters). There is the propensity for a portion to residualize in the reservoir due to the life history of this species. This may explain the lower DPE observed for steelhead compared to Chinook (and other species) for recently constructed juvenile fish surface collectors (see Section 2.5.5). The benefits assumed in this analysis reflect a low reservoir survival assumption for both juvenile Chinook and steelhead.

The FSC at Detroit is assumed to increase overall Chinook DPE from 55% to 69% based on professional opinion. Authors assume the FSC will result in improved DPE values equivalent to those estimated for the FSS (Section 3.2.3.2), and it is assumed DPE will remain constant regardless of reservoir elevation, temperature, or timing based on professional opinion since the structure will fluctuate with the pool and remain as a surface outlet. Achieving assumptions for fish downstream DPE (i.e., collection efficiency) into the proposed FSO-FSC will be challenging, given collection rates observed at similar existing facilities has ranged from less than 5% to 62% (see Section 2.5.5). Studies of acoustically tagged juvenile Chinook and steelhead indicate they are attracted to surface spill when it occurs at Detroit Dam, indicating they would likely be attracted to an FSO-FSC once in the zone of influence. Detroit reservoir forebay is relatively wide, similar to Swift reservoir on the Lewis River. The DPE into the new Swift FSC was low for Chinook during the first year of testing (2013) but is expected to improve with changes to the barrier netting (see Section 2.5.5). As such, achieving passage survival assumptions from point of entry to exit (or release) with this alternative is likely when considering survival rates observed at similar existing facilities. The FSC is assumed to have a route specific passage survival greater than 98% if NOAA design principles are applied based on similar structures in the northwest (see section 2.5.5). For FBW/SLAM/VSP sensitivity analysis, DPE was ranged from 62.9% to 74.4% in original Alden sensitivity tests for FSS. Downstream passage survival ranged from 68% to 88%.

3.2.3.2. NS-DSP-H4-DET: Downstream Passage with Temperature Benefits – Selective Withdrawal Structure with Weir Box and Floating Screen Structure

This alternative provides temperature and fish passage benefits in the North Santiam. The downstream fish passage component also met replacement. This alternative involves the construction of an SWS for temperature control and installing a guide or track to allow a FSS to travel up and down along the upstream face of the SWS as the reservoir elevation changes (Figure 3-10). The SWS would be designed and constructed initially with a weir box for fish passage. If the weir box did not meet biological requirements, then a FSS would be added using information collected on the weir box during testing.

Figure 3-10. SWS with Weir Box and FSS for NS-DSP-H4-DET



In Phase I, water flow entering the SWS would pass shaped telescoping weirs that provide for a gradual acceleration of water flow that has reached a capture velocity when entering into the SWS wet well. Attached and floating in front of one of the telescoping weirs will be a surface outlet with roughly 100 cfs of attraction flow to the weir box that would be used to collect fish entering the SWS wet well. That is, fish that entered the wet well would be guided by surface flow in the wet well to pass a weir and into a collection box.

In Phase II, if necessary, water flow entering the FSS would be passed through a v-screen with fish and a small percentage of the flow bypassing the screens through a bypass conduit at the downstream end of the screens. Based on preliminary temperature modeling, it is estimated that the FSS would handle surface flow ranging from 400 cfs up to 2,000 cfs. Captured fish would be kept in an attached live box before being transported. The most likely forms of transportation would be by truck or by a pipeline downstream of the dam(s). Once collected, juvenile fish could be transported around the dam(s) to a downstream release site, or transported to a dam bypass system. The FSS would screen fish from the surface and once collected, the fish would be transported downstream via truck. This alternative would include a SWS with a common wet well that covers the penstock intakes, telescoping weirs for warm surface water and lower fixed elevation openings for cooler water. A conduit would be provided to route temperature flow through the upper ROs.

Constructability and implementation timing impacts would be high because downstream passage structures are complex and require rigorous engineering and design. The structure would not impact reservoir elevations or outflows. It would replace the temperature operations currently in place, sending more water through the powerhouse than through the ROs, resulting in a slight improvement to TDG levels. A structural improvement would provide the most flexibility and would be least dependant on the functionality of existing dam outlets, so would be expected to greatly improve downstream water temperatures in North Santiam River. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, downstream fish passage survival is expected to improve from 29% to 66% for Chinook, and 21% to 57% for steelhead, and population viability is expected to improve from a VSP of 2.6 to 3.9 for Chinook, and 2.1 to 3.7 for steelhead.

Biological Modeling Assumptions: This alternative would result in self-sustaining populations of spring Chinook and winter steelhead above Detroit Dam based on the improvements assumed for downstream fish passage. As for the FSO-FSC alternative, it is important to recognize the same uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival).

Reservoir survival and passage survival through the FSS would have similar considerations as discussed for the FSO-FSC in Section 3.2.3.1. The FSS at Detroit is assumed to increase overall Chinook DPE from 55% to 69% based on professional opinion. Authors assume the FSS will result in improved DPE values equivalent to spillway operations, and it is assumed DPE will remain constant regardless of reservoir elevation, temperature, or timing based on professional opinion since the structure will fluctuate with the pool and remain as a surface outlet (Alden BioAnalysts Inc 2014). Regarding DPE, the FSS is expected to be higher than for the FSO-FSC. The FSS should have a larger zone of influence with its larger flow capacity. The FSS also provides a single point of water discharge, further helping to attract fish to the facility, similar to the Round Butte surface collector (see Section 2.5.5). The DPE for the Round Butte collector has ranged from 20% to 60%. The DPE for the Detroit FSS could be better than observed for Round Butte since the forebay conditions are not complicated by variable temperatures entering from the two arms of Lake Billy Chinook. The FSS is assumed to have a passage survival greater than 98% if NOAA design principles are applied, based on similar structures in the Northwest (see section 2.5.5).

For FBW/SLAM/VSP sensitivity analysis, DPE was ranged from 62.9% to 74.4% in original Alden sensitivity tests and from 40% to 80% upon discussions with the region. Downstream passage survival ranged from 47% to 96%.

3.2.4. Monetized Costs and Impacts

Several facets of the alternative costs were estimated. Those included CRFM costs such as design, construction, engineering during construction (EDC) and supervision and administrative (S&A), project first costs, and O&M, as well as a total life-cycle cost (low, most likely and high). Additionally, forgone hydropower was estimated to assess impacts to other project purposes. A contingency factor (up to 50%) was included for all CRFM and O&M costs and costs with contingency are represented in Table 3-7.

Table 3-7. Summary of Monetized Costs and Impacts for North Santiam Alternatives

Alternative ID and Description	US $1,000,000 (present value, 50-year life, 2014 dollars) with 50% Cost Contingency[1]									
	Design	Con-struc-tion	EDC + S&A Cost	Project First Cost (CRFM)	Annual O&M Cost	PV:O&M Cost @ 4%	Life-cycle Low	Life-cycle[2,4] Most Likely	Life-cycle High	Lost Hydro-power[3]
NS- Baseline	--	--	--	--	--	--	--	--	--	--
NS-COMBO-1: Downstream Passage Imp. w/ Temperature Benefits – FSO with FSC	38	98	20	155	2	32	140	187	326	48
NS-DSP-H4-DET: Downstream Passage Imp. with Temperature Benefits - SWS with FSS	53	165	33	251	1	12	203	263	471	-74

[1] No contingency assumed for lost hydropower.
[2] Life-cycle costs include project first costs plus the present value of O&M.
[3] A negative value means more hydropower is produced than in the NS-Baseline, a positive means less hydropower is produced than the NS-Baseline.
[4] The costs above were developed during early alternative evaluations within sub-basins. The alternatives carried forward into the recommended option have updated cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

3.2.5. North Santiam Results Summary

The COP team summarized all the biological, technical and economic information for a range of alternatives (Table 3-8). Cost-effectiveness is estimated for both alternatives, NS-DSP-H4-DET and NS-COMBO-1 using the average VSP increase and the CRFM cost information. Considering only the project first costs the NS-COMBO-1 alternative is more cost-effective, however with the large forgone hydropower considered NS-DSP-H4-DET is more cost-effective than NS-COMBO-1. There is also a higher biological confidence in achieving the estimated benefits for NS-DSP-H4-DET compared to NS-COMBO-1. This is primarily due to the greater uncertainty in fish collection efficiency and passage survival for juvenile fish under the NS-COMBO-1, which diverts a portion of the total outflow from the reservoir through a floating outlet while the turbines or ROs divert the remaining outflow to meet mission objectives for hydropower, instream flows, temperature management, etc. In comparison, the NS-DSP-H4-DET alternative diverts all flows through a common surface outlet, thereby providing relatively improved fish attraction and collection efficiency conditions. Both alternatives provide chub benefits, and allow spring and summer reservoir levels to be maintained for recreation.

The NS-Baseline assumes the continuation of surface spill in the summer to improve downstream temperatures. Thus the NS-Baseline produces less hydropower as compared to a no-spill, or turbine priority, operation. Since the baseline is the point of reference for comparing alternatives, the NS-Baseline hydropower was reflected as $0. The NS-DSP-H4-DET option actually produces more hydropower than the NS-Baseline since there would not be any more spill and results in $74 MIL more hydropower production. NS-COMBO-1 has additional hydropower losses over the baseline with $48 MIL additional losses above baseline.

Table 3-8. Results Summary for North Santiam Alternatives

Standard Project Information		Opportunity (Biological Benefits)						Investment (Costs)[1,3]				Impacts					Results	
		anadromous fish				resident fish												
		VSP Score																
COP Measure Number	**Measure Name Description**	Average VSP (Ch,St)	Steelhead Population	Chinook Population	confidence level	chub	confidence level	Project First Costs (Total CRFM) ($ MIL)	Additional O&M (PV) ($ MIL)	Lost Hydropower ($ MIL)[2]	Total Life Cycle (Project First Costs + O&M) in $ MIL	Chub or Bull Trout Impacts? (Y/N)	Flood Risk Management Impact (Y/N)	Total Recreation Impact (Y/N)	Water Supply Impact (Y/N)	Hydropower Impacts (Y/N)	Cost Effectiveness (Project Lifecycle Cost over Change in Average VSP)	Projected Stakeholder Impact
NS-Baseline	North Santiam Baseline	2.3	2.1	2.6														
NS-DSP-H4-DET	Selective Withdrawal Structure with Weir Box and Floating Screen Structure (Phased)	3.8	3.7	3.9	H	P	H	251	12	-74	263	N	N	N	N	N	176	N
NS-COMBO-1	Floating Surface Outlet + Floating Surface Collector (Phased)	3.8	3.7	3.9	M	P	M	155	32	48	187	N	N	N	N	Y	127	Maybe

[1] US $1,000,000 (present value, 50-year life, 2014 dollars) with 50% Cost Contingency (except hydropower)

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact)

[2] A negative value indicates a reduction in lost hydropower, this can also be stated as the alternative produces more hydropower than NS-Baseline

[3] The costs above were developed during early alternative evaluations within sub-basins. The alternatives carried forward into the recommended option have updated cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

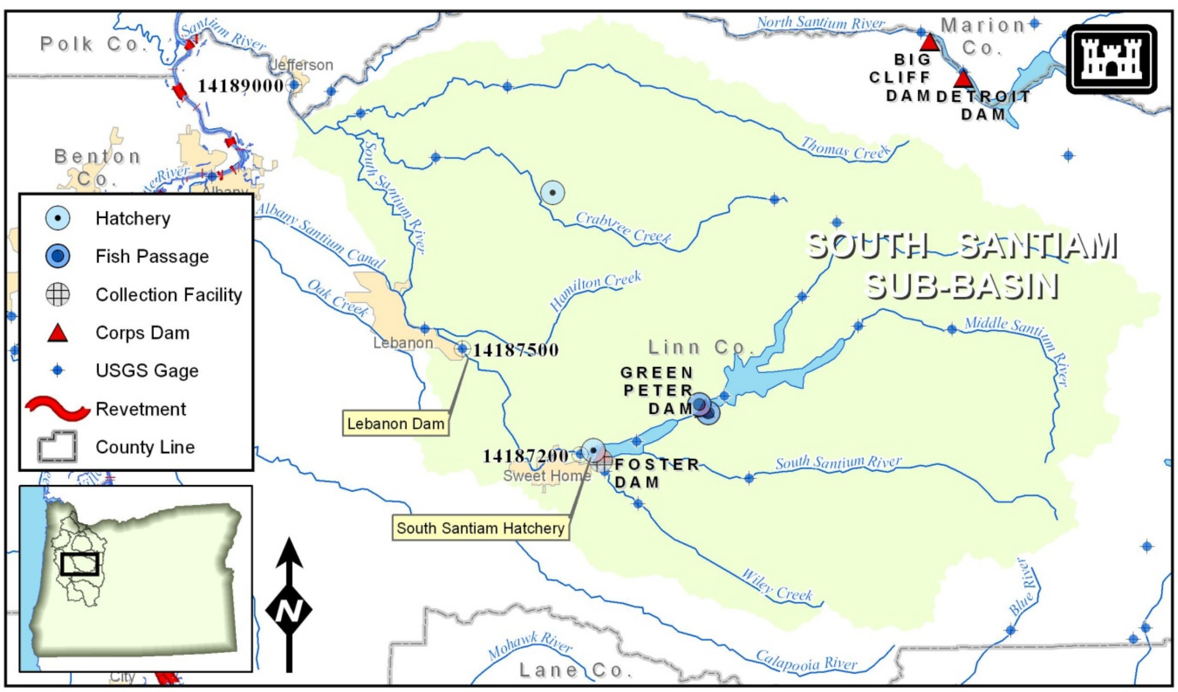
3.3. SOUTH SANTIAM SUBBASIN

3.3.1. Subbasin Overview

The South Santiam River is about 63 miles long and drains an area of about 1,000 square miles (Figure 3-11). The construction of the two Corps dams, Green Peter and Foster, began in 1961 and was completed in 1967. A third dam was planned but never constructed. The 8-foot-tall Lebanon Diversion Dam is located at river mile 21 downstream from Foster Dam and is owned by the City of Albany. Lebanon Dam was outfitted with new fish ladders and a screened diversion intake in 2005-2006.

Spring Chinook, winter steelhead and Oregon chub are present in the South Santiam subbasin. Upstream passage is provided above Foster Dam for natural origin (unmarked) spring Chinook and winter steelhead through trap and haul on the South Santiam River. Juvenile downstream passage at Foster Dam occurs through a spill weir for fish passage, spillway, or turbine passage. Steelhead and Chinook were previously transported and volitionally spawned above Green Peter and Foster dams. Although downstream passage at Green Peter Dam using the historic fish collection system appeared effective for juvenile spring Chinook, few juvenile winter steelhead were collected (Corps 1995). Passage Green Peter was abandoned about 1980 after fish collection efficiency for adult Chinook, and both adult and juvenile winter steelhead, was found to be inadequate (Corps 1995). Foster Dam downstream fish passage conditions (survival rates and passage efficiency) are summarized in Appendix K. A new adult fish facility at Foster was completed in 2014.

Figure 3-11. South Santiam Subbasin



3.3.1.1. Winter Steelhead

The NWFSC recently reviewed information on winter steelhead capacity and production. The following is an excerpt from their report (see Appendix C).

> Parkhurst et al. (1950) estimated that there was spawning habitat available for 20,000 spawners in the South Fork Santiam River above Lebanon. Stream surveys in the 1940s noted that water conditions (due in part of pulp mill effluent[7]) and diversions likely limited the number of fish that were able to access upstream portions of the basin. Steelhead runs were reported in Thomas and Crabtree Creeks, the Middle Santiam River and Quartzville Creek (Parkhurst et al. 1950). Wade et al. (1987) reported that in 1971 the wild winter steelhead count at Foster Dam was 4,254 fish (approximately one-quarter of the Willamette Falls count for that year).
>
> Fulton (1970) identified the South Santiam River as an important steelhead producer with good to excellent spawning and rearing areas.
>
> Wade et al. (1987) suggest that prior to the construction of Foster Dam, two-thirds of the steelhead passing the Foster Dam site were destined for the Middle Fork Santiam River to areas now above Green Peter Dam. On average, 2,600 steelhead passed the Foster Dam site prior to 1966. With the cessation of fish passage over Green Peter Dam in about 1980, spawning is currently limited to the mainstem South Santiam, and Thomas, Crabtree, and Wiley Creeks.

After Foster and Green Peter dams were constructed, Buchanan and others (1993) estimated that 2,600 winter steelhead spawned in the entire South Santiam River basin, including the upper mainstem above the dams and in Thomas, Crabtree, McDowell, Wiley, Canyon, Moose, and Soda Fork creeks (NOAA Fisheries 2008). Abundance estimates provided by ODFW through spawning surveys and dam counts from 2000-2006 averaged 1,953 adults for the South Santiam River (NOAA Fisheries 2008).

In recent years, adult winter steelhead abundance has trended downward for the Willamette Basin based on counts at Willamette Falls fish ladder published by ODFW.

3.3.1.2. Spring Chinook

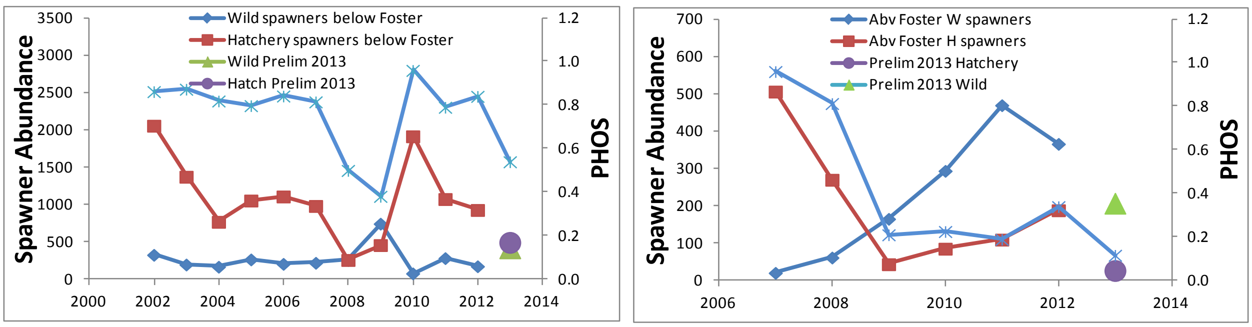
Historically abundant, high quality spring Chinook spawning habitat in the Santiam subbasin is evident through Mattson's (1948) account of the spring Chinook returns to the South Santiam River, representing 35% of the total escapement above Willamette Falls that year (Mattson 1948). Based on habitat loss with the construction of the Foster and Green Peter dams (including the reservoir pools) and habitat loss and degradation below the dams, current spawner (egg) capacity was estimated at approximately 8,289 adult spawners (assuming 2,250 eggs per adult), with 38% and 35% of the capacity above Foster and Green Peter reservoirs, respectively (see Appendix C).

Recent monitoring results indicate natural origin Chinook returns average about 600-700 adults (Figure 3-12). Natural production below Foster Dam may be effected by competition and genetic effects from hatchery Chinook released as part of Corps funded mitigation for the dams, fishing, and habitat degradation associated with land use impacts. The pHOS below Foster Dam has ranged 55% to 85%

[7] Parkhurst et al (1950) noted that where the pulp mill effluent reentered the South Santiam River, they were unable to detect any dissolved oxygen.

between 2011 and 2013. Only unmarked Chinook are transported above Foster Dam, and no Chinook are transported above Green Peter Dam. The new Foster adult fish facility is expected to reduce PSM for collected and transported Chinook and pHOS below Foster Dam. Genetic pedigree analysis indicates that the cohort replacement rate for reintroduced salmon above Foster Dam in 2009 was 1.56 and 1.55 as estimated from female-only and overall replacement, respectively (O'Malley et al. 2015b). These results indicate that replacement of reintroduced salmon was exceeded by ~50% through offspring recruitment. However, the pedigree analysis also indicated the effective number of breeders detected among reintroduced salmon in 2009 was small, estimated at 118.1 individuals in comparison to the census size of 412 reintroduced salmon.

Figure 3-12. South Santiam Subbasin Adult Spring Chinook Abundance and Proportion of Hatchery Origin Spawners Above and Below Foster Dam



Unpublished data provided by C. Sharpe, ODFW, 10/6/2014. Note: very heavy rain event at peak spawning in 2013 and carcass recoveries/redd counts might have been affected.

3.3.1.3. Bull Trout

Bull trout were historically distributed in the South Santiam subbasin but are no longer present. Bull trout were last observed in the South Santiam in 1953 (USFWS 2008). Construction of Green Peter and Foster dams eliminated the possibility of bull trout naturally re-colonizing areas upstream of the projects. The South Santiam or its tributaries are not designated as critical habitat.

3.3.1.4. Oregon Chub

Scheerer and others (2007) documents that there is currently Oregon chub populations at one site on the South Santiam (Foster Pullout pond) and at two sites on the mainstem Santiam (Santiam Interstate 5 side channels, Santiam conservation easement).

3.3.2. Alternatives

Table 3-9 lists the COP II alternatives considered for the South Santiam subbasin and indicates whether the alternative was carried forward for final analysis (shaded in blue). The results of the detailed biological analyses are summarized in Section 3.3.2.1. A summary table (Table 3-14) was prepared to compile the results from the biological and technical assessments for the alternatives. A description of the six alternatives being carried forward for final analysis follows the table. Baseline conditions are described in Appendix A. Note that bull trout are currently not present in the South Santiam subbasin. Detailed information about all the alternatives is included in Appendix D.

Table 3-9. South Santiam Subbasin Alternatives

Alternative ID	Description	Carry Forward for Final Analysis?
SS-Baseline	South Santiam Baseline	Yes
SS-DSP-H1-GPR	Downstream Passage – Floating Surface Collector (FSC)	Yes
SS-DSP-H2-GPR	Downstream Passage Improvement with Temperature Benefits – Selective Withdrawal Structure (SWS) with Floating Screen Structure (FSS)	Yes
SS-DSP-H2-FOS	Upgrade Fish Weir for Year Round Use	Yes
SS-DSP-H3-FOS	Upgrade to Fish Friendly Turbines	Yes
SS-HOR-02-GPR	Head of Reservoir (HOR) Collection in Tributary	Yes
SS-COMBO-2	Fish Friendly Turbines and Green Peter SWS with FSS (SS-DSP-H3-FOS & SS-DSP-H2-GPR)	Yes
SS-DSP-03-GPR	Operational – Delay Refill of Green Peter/RO Priority	No
SS-DSP-H3-GPR	Downstream Passage Improvement – Fish Horn Rehabilitation	No
SS-DSP-03-FOS	Operational – Operate Foster Fish Weir Year-round	No
SS-DSP-05-FOS	Operational – Provide Minimum Gate Opening Spill Winter-Spring to Pass Fish	No
SS-DSP-H1-FOS	Downstream Passage – Floating Surface Collector	No
SS-HOR-01-GPR	HOR in Reservoir	No
SS-TMP-M1-GPR	Temperature Control Improvement – Moderate Improvement	No
SS-TMP-H1-GPR	Temperature Control Improvement – SWS	Not as standalone measure, included in SS-COMBO-2 and SS-DSP-H2-GPR
SS-DSP-02-GPR	Operational – Green Peter RO Priority in Winter	No
SS-DSP-01-FOS	Operational – Extend Operation of Foster Fish Weir by Delayed Refill	No
SS-DSP-02-FOS	Operational – Continuous Operation of Foster Fish Weir	No
SS-DSP-04-FOS	Operational – Operate Foster Powerhouse Within 1% Peak Efficiency	No
SS-HOR-01-FOS	HOR in Tributary	No
SS-TDG-M1-GPR	TDG Improvement – Operational Improvement	No
SS-TMP-M1-FOS	Temperature Control – Moderate Improvement	No
SS-TMP-H1-FOS	Temperature Control Improvement – High improvement	No
SS-TDG-H1-FOS	TDG Improvement – Structural Improvement	No
SS-COMBO-1	Foster Weir Redesign and Green Peter Fish Horn Rehab (SS-DSP-H2-FOS & SS-DSP-H3-GPR)	No
SS-COMBO-3	Foster Fish Friendly Turbines and Green Peter SWS (SS-DSP-H3-FOS & SS-TMP-H1-GPR)	No

3.3.2.1. Biological Assessment of Alternatives

Several alternatives were assessed using the biological tools described in Chapter 2. Details on the FBW results are discussed in Appendix K. Details on the SLAM modeling and VSP analysis are included in Appendix C. Summaries of the FBW scores are shown in Figure 3-13 to Figure 3-16. Measures carried forward for final evaluation are highlighted. Dam passage survival (concrete survival multiplied by dam passage efficiency) for all three life stages were averaged and are shown on the graph.

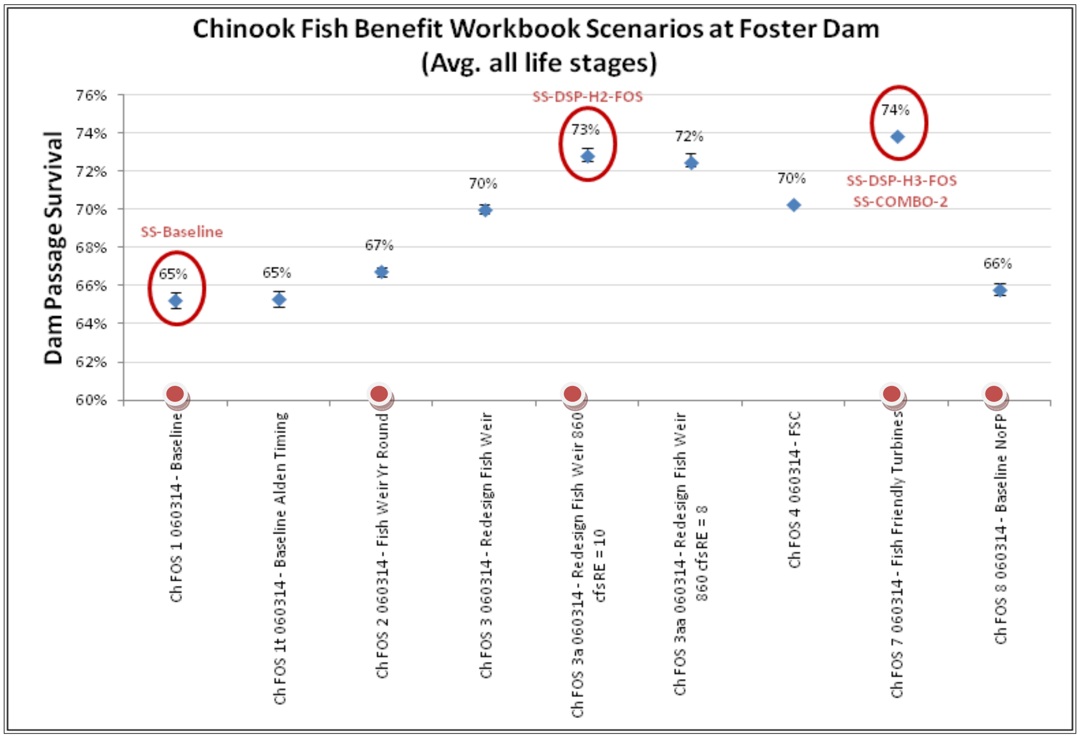
A range of alternatives were compared with the Chinook FBW tool. Some sensitivity runs were conducted to test different assumptions for RE and fish timing. Multiple fish weir options were tested at Foster (see alternative runs Ch SS 2, Ch SS 3, Ch SS 3a and Ch SS 3aa). Results for each of the runs are included in Appendix K. The FBW runs were prepared for Green Peter and for Foster dams.

Another version of the FBW spreadsheet was used to estimate benefits for steelhead. Since several FBW runs had been completed for Chinook, only a subset was ran in the steelhead version. The COP team needed to verify that actions that benefited Chinook also benefited steelhead. All of the final alternatives showed higher dam passage rates for both species than baseline. The measures that appeared to have the most biological benefit from FBW were sent to SLAM to be assessed at the subbasin level. In general, if the FBW results were similar or lower than the baseline score, they were not sent to the SLAM model. Runs that were sent to SLAM are identified in the FBW figures. Final South Santiam alternatives are highlighted with red circles.

South Santiam results for SLAM are shown in Figure 3-17 and Figure 3-18. Measures carried forward for final evaluation are highlighted. A replacement analysis was done using the time series information generated by SLAM for downstream fish passage alternatives. The statistics were checked to see if, on average, the number of adult offspring replaced their parents. Additionally checks were made to verify that most of the individual years met replacement. For dams in series, the replacement for each above dam reach was checked. The results of the replacement analysis by reach are shown in Table 3-10 and Table 3-11. A composite summary for all reaches is shown in Table 3-12 and Table 3-13 and serves as the final replacement analysis for the South Santiam alternatives.

For Chinook and steelhead, the replacement analysis shows that the SWS-FSS at Green Peter met replacement criteria. The FSC, Foster fish weir, and fish friendly turbines also met replacement for both species. Making improvements to the existing Green Peter fish horns, the Green Peter SWS and HOR options did not meet replacement.

Figure 3-13. Fish Benefits Workbook Results for Chinook at Foster Dam

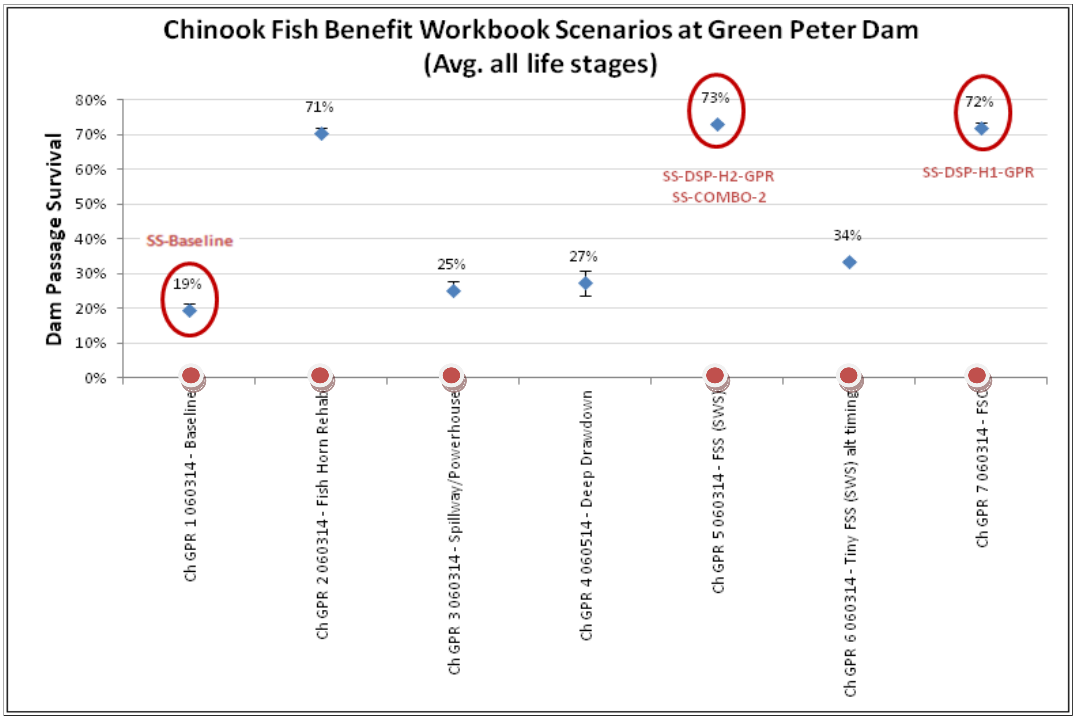


Identifies alternatives that were sent to SLAM.

Key: (Red highlighted cases are carried forward for final analyses.)

SS-Baseline	=	Ch FOS 1 060314 – Baseline	(Final Parameters)
SS-Baseline	=	Ch FOS 1t 060314 – Baseline Alden Timing	(Test Parameters)
SS-DSP-03-FOS	=	Ch FOS 2 060314 – Fish Weir Yr Round	(Operational Run)
SS-DSP-H2-FOS	=	Ch FOS 3 060314 – Redesign Fish Weir	(Flow Test)
SS-DSP-H2-FOS	=	Ch FOS 3a 060314 – Redesign Fish Weir 860 cfs RE = 10	(Final Flow)
SS-DSP-H2-FOS	=	Ch FOS 3a 060314 – Redesign Fish Weir 860 cfs RE = 8	(Flow Test)
SS-DSP-H1-FOS	=	Ch FOS 4 060314 - FSC	(Final Parameters)
SS-DSP-H3-FOS and SS-COMBO-2	=	Ch FOS 7 060314 – Fish Friendly Turbines	(Operational Run)
SS-DSP-05-FOS	=	Ch FOS 8 060314 – Baseline noFP	(Operational Run)

Figure 3-14. Fish Benefits Workbook Results for Chinook at Green Peter Dam



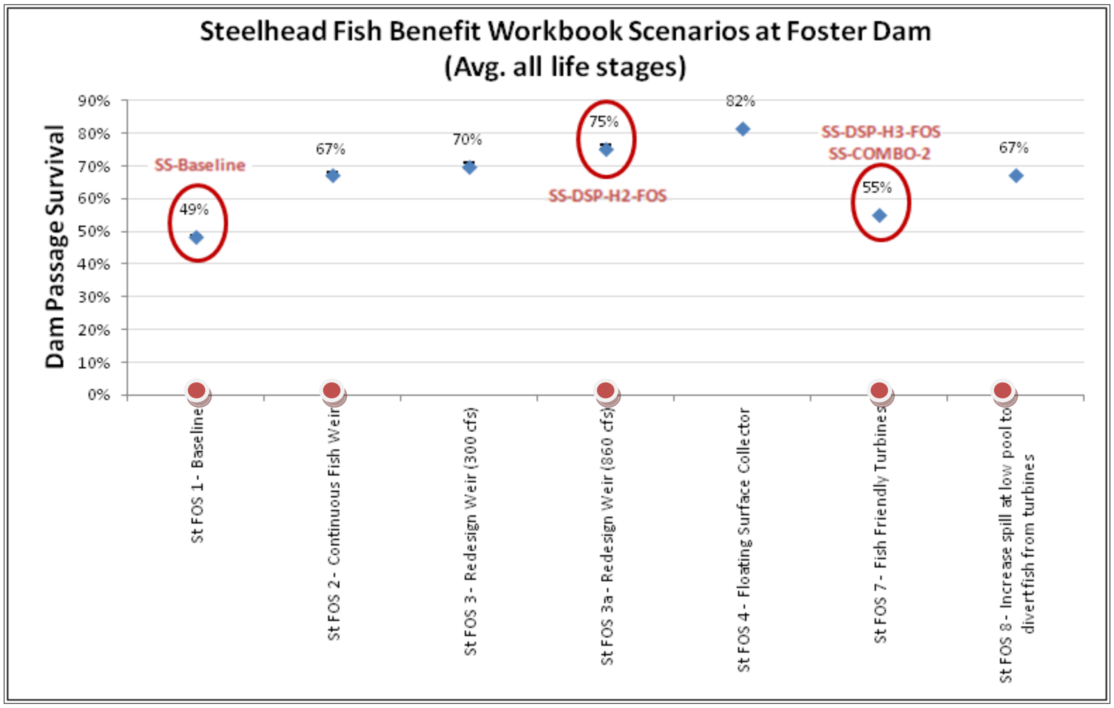
Identifies alternatives that were sent to SLAM

Key: (Red highlighted cases are carried forward for final analyses.)

SS-Baseline	=	Ch GPR 1 060314 – Baseline	(Final Parameters)
SS-DSP-H3-GPR	=	Ch GPR 2 060314 – Fish Horn Rehab	(Pump Flow 200 cfs)
SS-TMP-M1-GPR	=	Ch GPR 3 060314 – Spillway/Powerhouse	(Operational Run)
SS-DSP-03-GPR	=	Ch GPR 4 060514 – Deep Drawdown	(Operational Run)
SS-DSP-H2-GPR and SS-COMBO-2	=	Ch GPR 5 060314 – FSS (SWS)	(New Structures)
SS-TMP-H1-GPR	=	Ch GPR 6 060314 – Tiny FSS (SWS) alt timing	(Structural run)
SS-DSP-H1-GPR	=	Ch GPR 7 060314 – FSC	(New Structures)

Note that the Head or Reservoir alternatives for Green Peter, SS-HOR-01-GPR and SS-HOR-02-GPR, are not plotted in the above Dam Passage Survival graphs, although they are still evaluated in the FBW and passed to SLAM for analysis.

Figure 3-15. Fish Benefits Workbook Results for Steelhead at Foster Dam

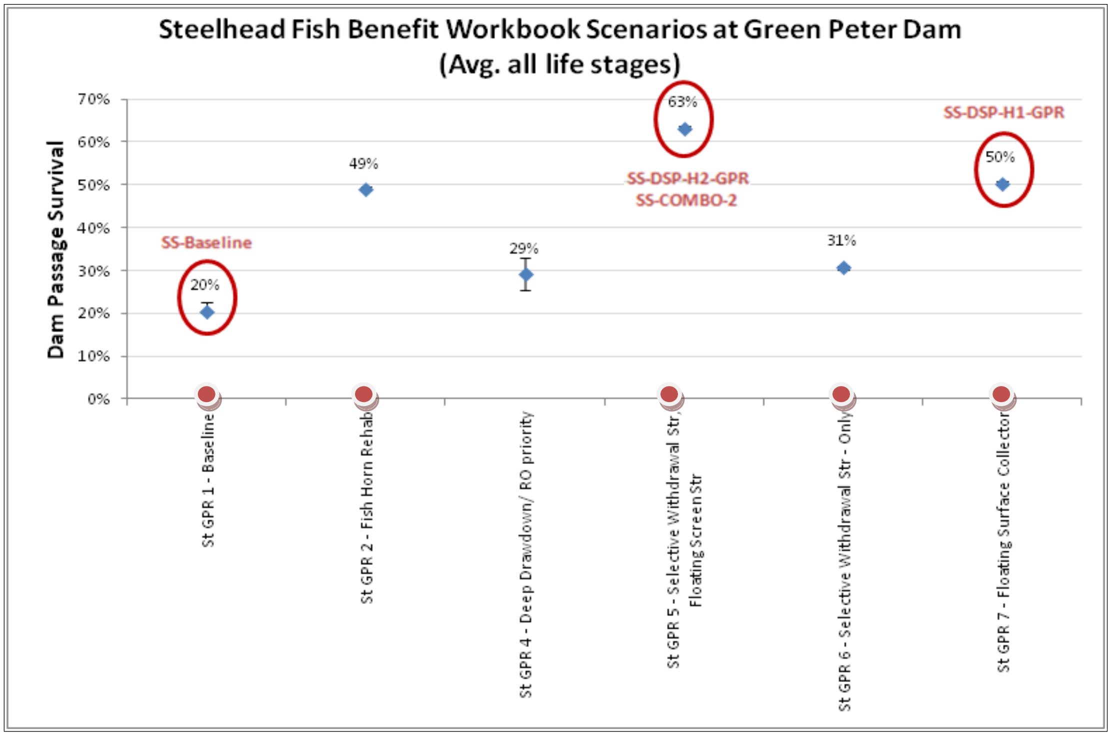


Identifies alternatives that were sent to SLAM

Key: (Red highlighted cases are carried forward for final analyses.)

SS-Baseline	=	St FOS 1 – SS-Baseline	(Final Parameters)
SS-DSP-H2-FOS	=	St FOS 2 - Continuous Fish Weir	(Final Parameters)
SS-DSP-H2-FOS	=	St FOS 3 – Redesign Fish Weir (300 cfs)	(Flow 300 cfs)
SS-DSP-H2-FOS	=	St FOS 3a – Redesign Fish Weir (860 cfs)	(Flow 860 cfs)
SS-DSP-H1-FOS	=	St FOS 4 – Floating Surface Collector	(Structural Alternative)
SS-DSP-H3-FOS and SS-COMBO-2	=	St FOS 7 – Fish Friendly Turbines	(Final Parameters)
SS-DSP-05-FOS	=	St FOS 8 – Increase spill at low pool to divert fish from turbines	(Operational)

Figure 3-16. Fish Benefits Workbook Results for Steelhead at Green Peter Dam



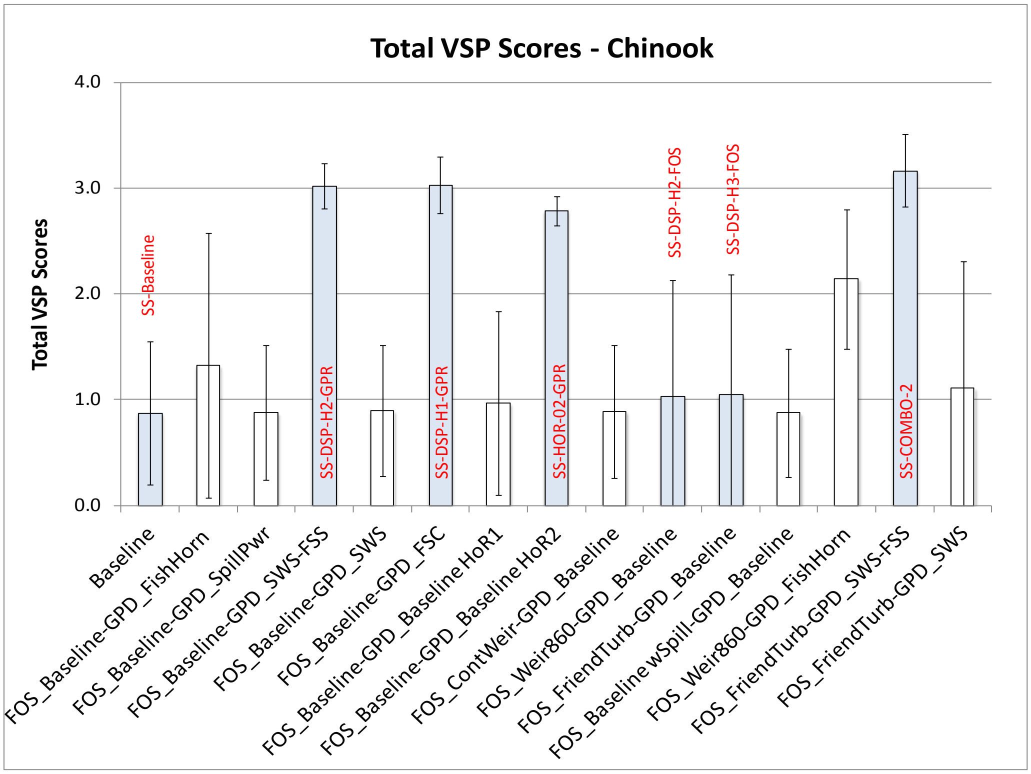
Identifies alternatives that were sent to SLAM

Key: (Red highlighted cases are carried forward for final analyses.)

SS-Baseline	=	St GPR 1 – SS-Baseline	(Final Parameters)
SS-DSP-H3-GPR	=	St GPR 2 – Fish Horn Rehab	(Structural Alternative)
SS-DSP-03-GPR	=	St GPR 4 – Deep Drawdown/RO priority	(Operational Alternative)
SS-DSP-H2-GPR	=	St GPR 5 – Selective Withdrawal Str. Floating Screen Str	(Structural Alternative)
SS-DSP-H2-GPR	=	St GPR 6 – Selective Withdrawal Str. - Only	(Structural Alternative)
SS-DSP-H1-GPR	=	St GPR 7 – Floating Surface Collector	(Structural Alternative)

Note that the Head or Reservoir alternatives for Green Peter, SS-HOR-01-GPR and SS-HOR-02-GPR, are not plotted in the above Dam Passage Survival graphs, although they are still evaluated in the FBW and passed to SLAM for analysis.

Figure 3-17. SLAM Results for Chinook in the South Santiam Subbasin

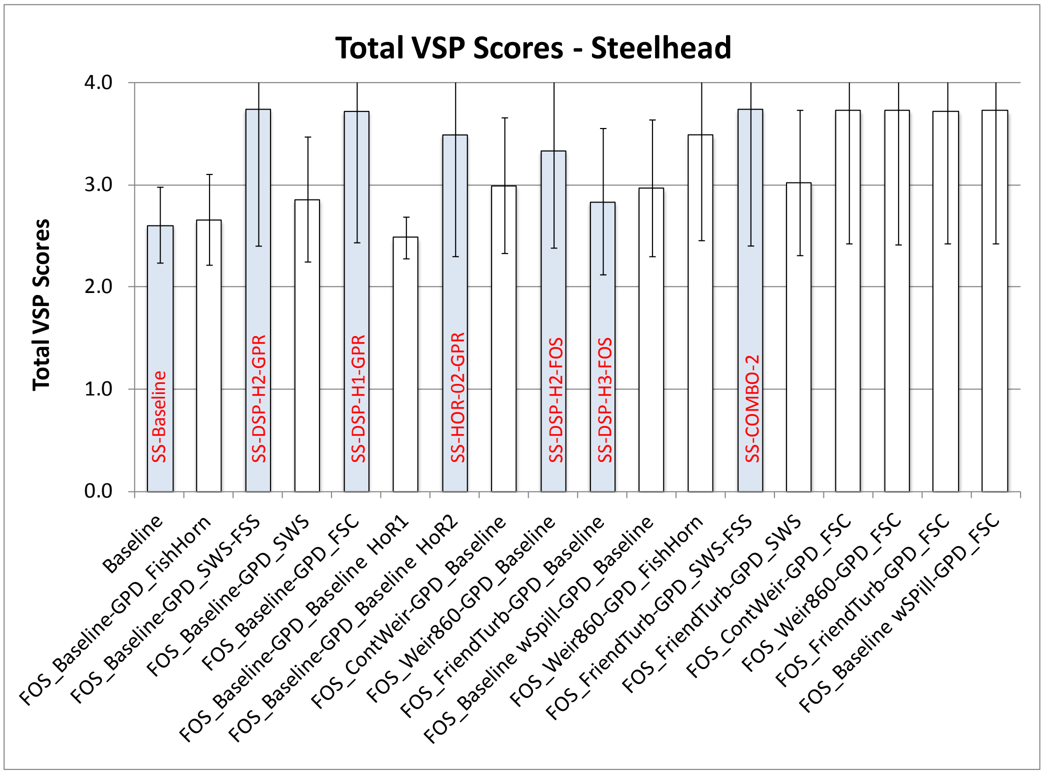


Highlighted alternatives were included in the final system analysis.

Key: (Red highlighted cases are carried forward for final analyses.)

SS-Baseline	=	FBW: Ch FOS 1 and Ch GPR 1	SLAM: Baseline
SS-DSP-H3-GPR	=	FBW: Ch FOS 1 and Ch GPR 2	SLAM: FOS_Baseline-GPD_FishHorn
SS-TMP-M1-GPR	=	FBW: Ch FOS 1 and Ch GPR 3	SLAM: FOS_Baseline-GPD_SpillPwr
SS-DSP-H2-GPR	=	FBW: Ch FOS 1 and Ch GPR 5	SLAM: FOS_Baseline-GPD_SWS-FSS
SS-TMP-H1-GPR	=	FBW: Ch FOS 1 and Ch GPR 6	SLAM: FOS_Baseline-GPD_SWS
SS-DSP-H1-GPR	=	FBW: Ch FOS 1 and Ch GPR 7	SLAM: FOS_Baseline-GPD_FSC
SS-HOR-01GPR	=	FBW: Ch FOS 1 and Ch GPR 1 (Test Par.)	SLAM: FOS-Basline-GPD_BaselineHoR1
SS-HOR-02-GPR	=	FBW: Ch FOS 1 and Ch GPR 1 (Final Par.)	SLAM: FOS-Basline-GPD_BaselineHoR2
SS-DSP-03-FOS	=	FBW: Ch FOS 2 and Ch GPR 1	SLAM: FOS_ContWeir-GPD_Baseline
SS-DSP-H2-FOS	=	FBW: Ch FOS 3a and Ch GPR 1	SLAM: FOS_Weir860-GPD_Baseline
SS-DSP-H3-FOS	=	FBW: Ch FOS 7 and Ch GPR 1	SLAM: FOS_FriendTurb-GPD_Baseline
SS-DSP-05-FOS	=	FBW: Ch FOS 8 and Ch GPR 1	SLAM: FOS_BaselinewSpill-GPD_Baseline
SS-COMBO-1	=	FBW: Ch FOS 3a and Ch GPR 2	SLAM: FOS_Weir860-GPD_FishHorn
SS-COMBO-2	=	FBW: Ch FOS 7 – and Ch GPR 5	SLAM: FOS_FriendTurb-GPD_SWS-FSS
SS-COMBO-3	=	FBW: Ch FOS 7 – and Ch GPR 6	SLAM: FOS_FriendTurb-GPD_SWS

Figure 3-18. SLAM Results for Steelhead in the South Santiam Subbasin



Highlighted alternatives were included in the final system analysis.

Key: (Red highlighted cases are carried forward for final analyses.)

SS-Baseline	=	FBW: St FOS 1 and St GPR 1	SLAM: Baseline
SS-DSP-H3-GPR	=	FBW: St FOS 1 and St GPR 2	SLAM: FOS_Baseline-GPD_FishHorn
SS-DSP-H2-GPR	=	FBW: St FOS 1 and St GPR 5	SLAM: FOS_Baseline-GPD_SWS-FSS
SS-DSP-H2-GPR	=	FBW: St FOS 1 and St GPR 6	SLAM: FOS_Baseline-GPD_SWS
SS-DSP-H1-GPR	=	FBW: St FOS 1 and St GPR 7	SLAM: FOS_Baseline-GPD_FSC
SS-HOR-01GPR	=	FBW: Baseline Flows (HOR1 Parameters)	SLAM: FOS-Basline-GPD_BaselineHoR1
SS-HOR-02-GPR	=	FBW: Baseline Flows (HOR2 Parameters)	SLAM: FOS-Basline-GPD_BaselineHoR2
SS-DSP-H2-FOS	=	FBW: St FOS 2 and St GPR 1	SLAM: FOS_ContWeir-GPD_Baseline
SS-DSP-H2-FOS	=	FBW: St FOS 3a and St GPR 1	SLAM: FOS_Weir860-GPD_Baseline
SS-DSP-H3-FOS	=	FBW: St FOS 7 and St GPR 1	SLAM: FOS_FriendTurb-GPD_Baseline
SS-DSP-05-FOS	=	FBW: St FOS 8 and St GPR 1	SLAM: FOS_Baseline wSpill-GPD_Baseline
SS-COMBO-1	=	FBW: St FOS 3a and St GPR 2	SLAM: FOS_Weir860-GPD_FishHorn
SS-COMBO-2	=	FBW: St FOS 7 and St GPR 5	SLAM: FOS_FriendTurb-GPD_SWS-FSS
SS-COMBO-3	=	FBW: St FOS 7 and St GPR 6	SLAM: FOS_FriendTurb-GPD_SWS
N/A	=	FBW: St FOS 2 and St GPR 7	SLAM: FOS_ContWeir-GPD_FSC
N/A	=	FBW: St FOS 3a and St GPR 7	SLAM: FOS_Weir860-GPD_FSC
N/A	=	FBW: St FOS 7 and St GPR 7	SLAM: FOS_FriendTurb-GPD_FSC
N/A	=	FBW: St FOS 8 and St GPR 7	SLAM: FOS_Baseline wSpill -GPD_FSC

Table 3-10. Summary of Replacement Analysis for South Santiam Chinook

Reach	SLAM Alternative	AVER	Count > 1	Median	Percent Time >1	Percent Time >.95	Ave of Running Ave	Replacement Status
Above Foster - Below Green Peter	Baseline	100%	48	99%	48%	61%	97%	Nearly meets replacement criteria
	FOS_Baseline-GPD_FishHorn	102%	53	101%	53%	66%	99%	Nearly meets replacement criteria
	FOS_Baseline-GPD_SpillPwr	100%	46	99%	46%	60%	97%	Does not meet
	FOS_Baseline-GPD_SWS-FSS	104%	61	104%	60%	70%	100%	Meets replacement criteria
	FOS_Baseline-GPD_SWS	100%	49	100%	48%	59%	97%	Does not meet
	FOS_Baseline-GPD_FSC	105%	59	103%	58%	70%	101%	Meets replacement criteria
	FOS_Baseline-GPD_Baseline HoR1	100%	52	101%	51%	61%	98%	Nearly meets replacement criteria
	FOS_Baseline-GPD_Baseline HoR2	103%	59	102%	58%	69%	100%	Nearly meets replacement criteria
	FOS_ContWeir-GPD_Baseline	101%	49	99%	49%	64%	98%	Nearly meets replacement criteria
	FOS_Weir860-GPD_Baseline	105%	68	104%	67%	84%	102%	Meets replacement criteria
	FOS_FriendTurb-GPD_Baseline	105%	68	104%	67%	82%	102%	Meets replacement criteria
	FOS_Baseline wSpill-GPD_Baseline	100%	49	100%	49%	60%	97%	Does not meet
	FOS_Weir860-GPD_FishHorn	106%	63	104%	63%	79%	103%	Meets replacement criteria
	FOS_FriendTurb-GPD_SWS-FSS	106%	66	106%	65%	76%	103%	Meets replacement criteria
	FOS_FriendTurb-GPD_SWS	105%	68	104%	67%	84%	102%	Meets replacement criteria
Above Green Peter	Baseline	7%	0	7%	0%	0%	7%	Does not meet
	FOS_Baseline-GPD_FishHorn	67%	0	67%	0%	0%	65%	Does not meet
	FOS_Baseline-GPD_SpillPwr	11%	0	11%	0%	0%	11%	Does not meet
	FOS_Baseline-GPD_SWS-FSS	103%	64	103%	63%	83%	100%	Meets replacement criteria
	FOS_Baseline-GPD_SWS	17%	0	17%	0%	0%	17%	Does not meet
	FOS_Baseline-GPD_FSC	103%	61	104%	60%	79%	100%	Meets replacement criteria
	FOS_Baseline-GPD_Baseline HoR1	28%	0	28%	0%	0%	27%	Does not meet
	FOS_Baseline-GPD_Baseline HoR2	101%	53	101%	53%	77%	98%	Meets replacement criteria
	FOS_ContWeir-GPD_Baseline	8%	0	8%	0%	0%	8%	Does not meet
	FOS_Weir860-GPD_Baseline	9%	0	9%	0%	0%	9%	Does not meet
	FOS_FriendTurb-GPD_Baseline	9%	0	9%	0%	0%	9%	Does not meet
	FOS_Baseline wSpill-GPD_Baseline	7%	0	7%	0%	0%	7%	Does not meet
	FOS_Weir860-GPD_FishHorn	78%	0	78%	0%	1%	76%	Does not meet
	FOS_FriendTurb-GPD_SWS-FSS	103%	63	103%	63%	81%	100%	Meets replacement criteria
	FOS_FriendTurb-GPD_SWS	23%	0	23%	0%	0%	23%	Does not meet

See Section 2.5.2 for Replacement Criteria. Dark green meets criteria, light green nearly meets criteria, and white does not meet criteria

Table 3-11. Summary of Replacement Analysis for South Santiam Steelhead

		AVER	Count > 1	Median	Percent Time >1	Percent Time >.95	Ave of Running Ave	Replacement Status
Above FOS - Below GPR	Baseline	99%	52	100%	52%	82%	96%	Meets replacement criteria
	FOS_Baseline-GPD_FishHorn	99%	40	99%	40%	83%	96%	Meets replacement criteria
	FOS_Baseline-GPD_SWS-FSS	99%	49	99%	49%	63%	96%	Nearly meets replacement criteria
	FOS_Baseline-GPD_SWS	100%	61	101%	60%	82%	97%	Meets replacement criteria
	FOS_Baseline-GPD_FSC	99%	46	99%	46%	70%	96%	Meets replacement criteria
	FOS_Baseline-GPD_Baseline HoR1	99%	51	100%	51%	84%	96%	Meets replacement criteria
	FOS_Baseline-GPD_Baseline HoR2	99%	46	99%	45%	71%	96%	Meets replacement criteria
	FOS_ContWeir-GPD_Baseline	101%	70	102%	70%	88%	98%	Meets replacement criteria
	FOS_Weir860-GPD_Baseline	102%	73	102%	72%	87%	99%	Meets replacement criteria
	FOS_FriendTurb-GPD_Baseline	100%	58	101%	57%	88%	98%	Meets replacement criteria
	FOS_Baseline wSpill-GPD_Baseline	101%	59	101%	59%	86%	98%	Meets replacement criteria
	FOS_Weir860-GPD_FishHorn	102%	69	102%	69%	88%	99%	Meets replacement criteria
	FOS_FriendTurb-GPD_SWS-FSS	102%	64	103%	63%	80%	99%	Meets replacement criteria
	FOS_FriendTurb-GPD_SWS	102%	63	101%	62%	88%	98%	Meets replacement criteria
	FOS_ContWeir-GPD_FSC	102%	68	102%	68%	86%	99%	Meets replacement criteria
	FOS_Weir860-GPD_FSC	103%	74	103%	73%	86%	100%	Meets replacement criteria
	FOS_FriendTurb-GPD_FSC	102%	62	102%	61%	82%	98%	Meets replacement criteria
	FOS_Baseline wSpill-GPD_FSC	102%	71	103%	71%	86%	99%	Meets replacement criteria
Above GPR	Baseline		0		0%	0%		Does not meet
	FOS_Baseline-GPD_FishHorn		0		0%	0%		Does not meet
	FOS_Baseline-GPD_SWS-FSS	103%	64	101%	64%	91%	100%	Meets replacement criteria
	FOS_Baseline-GPD_SWS	93%	9	92%	9%	32%	90%	Does not meet
	FOS_Baseline-GPD_FSC	103%	64	101%	64%	91%	99%	Meets replacement criteria
	FOS_Baseline-GPD_Baseline HoR1		0		0%	0%		Does not meet
	FOS_Baseline-GPD_Baseline HoR2	101%	59	101%	58%	90%	98%	Meets replacement criteria
	FOS_ContWeir-GPD_Baseline		0		0%	0%		Does not meet
	FOS_Weir860-GPD_Baseline		0		0%	0%		Does not meet
	FOS_FriendTurb-GPD_Baseline		0		0%	0%		Does not meet
	FOS_Baseline wSpill-GPD_Baseline		0		0%	0%		Does not meet
	FOS_Weir860-GPD_FishHorn	97%	33	96%	33%	54%	94%	Does not meet
	FOS_FriendTurb-GPD_SWS-FSS	103%	66	101%	65%	91%	100%	Meets replacement criteria
	FOS_FriendTurb-GPD_SWS	93%	9	93%	9%	27%	90%	Does not meet
	FOS_ContWeir-GPD_FSC	103%	64	101%	64%	91%	100%	Meets replacement criteria
	FOS_Weir860-GPD_FSC	103%	65	102%	65%	91%	100%	Meets replacement criteria
	FOS_FriendTurb-GPD_FSC	103%	64	102%	64%	91%	100%	Meets replacement criteria
	FOS_Baseline wSpill-GPD_FSC	103%	67	101%	67%	91%	100%	Meets replacement criteria

See Section 2.5.2 for Replacement Criteria. Dark green meets criteria, light green nearly meets criteria, and white does not meet criteria

Table 3-12. Composite Summary of Replacement Analysis for South Santiam Chinook

	Above FOS Below GPR	Above GPR
Baseline	**Nearly**	**No**
FOS_Baseline-GPD_FishHorn	Nearly	No
FOS_Baseline-GPD_SpillPwr	No	No
FOS_Baseline-GPD_SWS-FSS	**Meets**	**Meets**
FOS_Baseline-GPD_SWS	No	No
FOS_Baseline-GPD_FSC	**Meets**	**Meets**
FOS_Baseline-GPD_Baseline HoR1	Nearly	No
FOS_Baseline-GPD_Baseline HoR2	**Nearly**	**Meets**
FOS_ContWeir-GPD_Baseline	Nearly	No Change
FOS_Weir860-GPD_Baseline	**Meets**	No Change
FOS_FriendTurb-GPD_Baseline	**Meets**	No Change
FOS_Baseline wSpill-GPD_Baseline	No	No Change
FOS_Weir860-GPD_FishHorn	Meets	No
FOS_FriendTurb-GPD_SWS-FSS	**Meets**	**Meets**
FOS_FriendTurb-GPD_SWS	Meets	No

See Section 2.5.2 for Replacement Criteria. Dark green meets criteria, light green nearly meets criteria, and white does not meet criteria. Bold text and boxed red cases were carried forward for final analyses. "No Change" means Green Peter at baseline.

Table 3-13. Composite Summary of Replacement Analysis for South Santiam Steelhead

	Above FOS - Below GPR	Above GPR
Baseline	Meets	No
FOS_Baseline-GPD_FishHorn	Meets	No
FOS_Baseline-GPD_SWS-FSS	**Nearly**	**Meets**
FOS_Baseline-GPD_SWS	Meets	No
FOS_Baseline-GPD_FSC	**Meets**	**Meets**
FOS_Baseline-GPD_Baseline HoR1	Meets	No
FOS_Baseline-GPD_Baseline HoR2	**Meets**	**Meets**
FOS_ContWeir-GPD_Baseline	Meets	No Change
FOS_Weir860-GPD_Baseline	**Meets**	**No Change**
FOS_FriendTurb-GPD_Baseline	**Meets**	**No Change**
FOS_Baseline wSpill-GPD_Baseline	Meets	No Change
FOS_Weir860-GPD_FishHorn	Meets	No
FOS_FriendTurb-GPD_SWS-FSS	**Meets**	**Meets**
FOS_FriendTurb-GPD_SWS	Meets	No
FOS_ContWeir-GPD_FSC	Meets	Meets
FOS_Weir860-GPD_FSC	Meets	Meets
FOS_FriendTurb-GPD_FSC	Meets	Meets
FOS_Baseline wSpill-GPD_FSC	Meets	Meets

See Section 2.5.2 for Replacement Criteria. Dark green meets criteria, light green nearly meets criteria, and white does not meet criteria. Bold text and boxed red cases were carried forward for final analyses. "No Change" means Green Peter at baseline.

Key: (Red highlighted cases are carried forward for final analyses.)

Alternative ID		**SLAM Run ID**
SS-Baseline	=	SLAM: Baseline
SS-DSP-H2-GPR	=	SLAM: FOS_Baseline-GPD_SWS-FSS
SS-DSP-H1-GPR	=	SLAM: FOS_Baseline-GPD_FSC
SS-HOR-02-GPR	=	SLAM: FOS_Baseline-GPD_Baseline HoR2
SS-DSP-H2-FOS	=	SLAM: FOS_Weir860-GPD_Baseline
SS-DSP-H3-FOS	=	SLAM: FOS_FriendTurb-GPD_Baseline
SS-COMBO-2	=	SLAM: FOS_FriendTurb-GPD_SWS-FSS

3.3.2.2. Non-Monetized Impacts

Table 3-14 summarizes the non-monetized impacts of all the assessed measures, regardless of whether or not they were carried forward for final analysis. Impacts were given a numerical value between 1 and 5 to indicate high negative impact (1) up to a high benefit (5). Biological benefits are also summarized including impacts to residential fish, Oregon chub.

3.3.3. South Santiam Alternatives Carried Forward for Final System Analysis

In addition to the SS-Baseline, six alternatives (SS-DSP-H1-GPR, SS-DSP-H2-GPR, SS-DSP-H2-FOS, SS-DSP-H3-FOS, SS-HOR-02-GPR and SS-COMBO-2) met replacement criteria and were carried forward for inclusion in the system analysis. These alternatives are described below with more detailed information included in Appendix D.

3.3.3.1. SS-DSP-H1-GPR: Downstream Passage, Floating Surface Collector

This alternative was carried forward for final analysis as it provided passage benefits in the South Santiam that met replacement. This alternative involves a FSC consisting of a floating barge structure with an attraction flow, dewatering v-screens, pump system to return flow to the reservoir, and fish transfer to a downstream passage system (Figure 3-19). Typically, a FSC has guidance nets that increase the collection efficiency. If nets are required, they could be installed at partial depth (assumed to be 75-feet deep) or full depth depending on the collection efficiency required for the FSC. The FSC would be moored to a tower or moored with multiple lines from anchor points, requiring an active positioning system to maintain the location of the FSC as the reservoir level fluctuates. The FSC could be moored in a location where a guide net extending from the shoreline to the FSC to provide fish guidance and could be deployed in an adaptive management approach. Initially, the FSC could be deployed with no net or a partial depth guide net (~75-feet deep) to determine whether satisfactory biological performance were met without a full depth guide net. If additional guidance is needed, a full depth guide net would be deployed. For the system analysis this alternative also assumed that a Foster fish weir would be implemented (SS-DSP-FOS-H2) and those costs were included in the summary tables.

Table 3-14. Summary of Results for South Santiam Subbasin Alternatives

Alternative ID and Description (Bold denotes alternatives carried forward for final analysis)	Anadromous Fish					Resident Fish		Flood Risk Management	Meeting Downstream Tributary Flows	Meeting Mainstem Flows	Reservoir Recreation	River Recreation	Water Supply-M&I and Irrigation		Constructability	Implementation Timing	Clean Water Act (TDG)	Temperature
	FBW Average score [%]		VSP Score		Confidence Level	Impact	Confidence Level											
	Steelhead	Chinook	Steelhead	Chinook		Oregon Chub		Yes/No Impact					Current Demand	Future (2050) Demand				
									1=High Negative Impact; 2=Moderate Negative Impact; 3= Low to No Negative/Positive Impact; 4=Moderate Positive Impact; 5=High Positive Impact									
SS-Baseline	FOS-49 GPR-20	FOS-65 GPR-19	2.6	0.9	M	--	--	--	--	--	--		--	--	--	--	--	--
SS-DSP-H1-GPR: Downstream Passage-FSC	50	72	3.7	3.0	M	0	H	N	3	3	3	3	3	3	1	1	3	3
SS-DSP-H2-GPR: Downstream Passage w/ Temperature-SWS w/FSS	63	73	3.7	3.0	H	P	H	N	3	3	3	3	3	3	1	1	3	5
SS-DSP-H2-FOS: Upgrade Fish Weir for Year Round Use	75	73	3.3	1.0	H	0	H	N	2	3	3	3	3	3	3	3	3	3
SS-DSP-H3-FOS: Upgrade to Fish Friendly Turbines	55	74	2.8	1.1	M	0	H	N	3	3	3	3	3	3	3	3	3	3
SS-HOR-02-GPR: HOR Collector Trib.	--	--	2.5-3.5	1.0-2.8	L	0	H	N	3	3	3	3	3	3	1	1	3	3
SS-COMBO-2: Foster Fish Friendly Turbines/Green Peter SWS with FSS (SS-DSP-H3-FOS + SS-DSP-H2-GPR)	FOS-55 GPR-63	FOS-74 GPR-73	3.7	3.2	H	P	H	N	3	3	3	3	3	3	1	1	3	5
SS-DSP-03-GPR: Operational-Delay Refill of GPR/RO Priority	29	27	NM	NM	--	0	H	N	1	1	1	3	1	1	3	3	3	1
SS-DSP-H3-GPR: Downstream Passage-Fish Horn Rehabilitation	49	71	2.7	1.3	--	Not fully assessed - did not meet replacement for Chinook when modeled												
SS-DSP-03-FOS: Operational-Operate Foster Fish Weir Year-round	67	67	3.0	0.9	--	0	H	N	2	3	3	3	3	3	3	3	3	3
SS-DSP-05-FOS: Operational-Minimum Gate Opening Spill Winter-Spring	67	72	3.0	0.9	--	Not fully assessed – did not meet replacement for Chinook when modeled												
SS-DSP-H1-FOS: D/S Passage-FSC	82	70	NM	NM	--	0	H	N	3	3	3	3	3	3	1	1	3	3
SS-HOR-01-GPR: HOR in Reservoir	NM	NM	NM	NM	--	0	H	N	3	3	3	3	3	3	1	1	3	3
SS-TMP-M1-GPR: Temperature Control Improvement – Moderate Improvement	NM	25	NM	NM	--	P	M	N	3	3	3	3	3	3	3	3	3	4

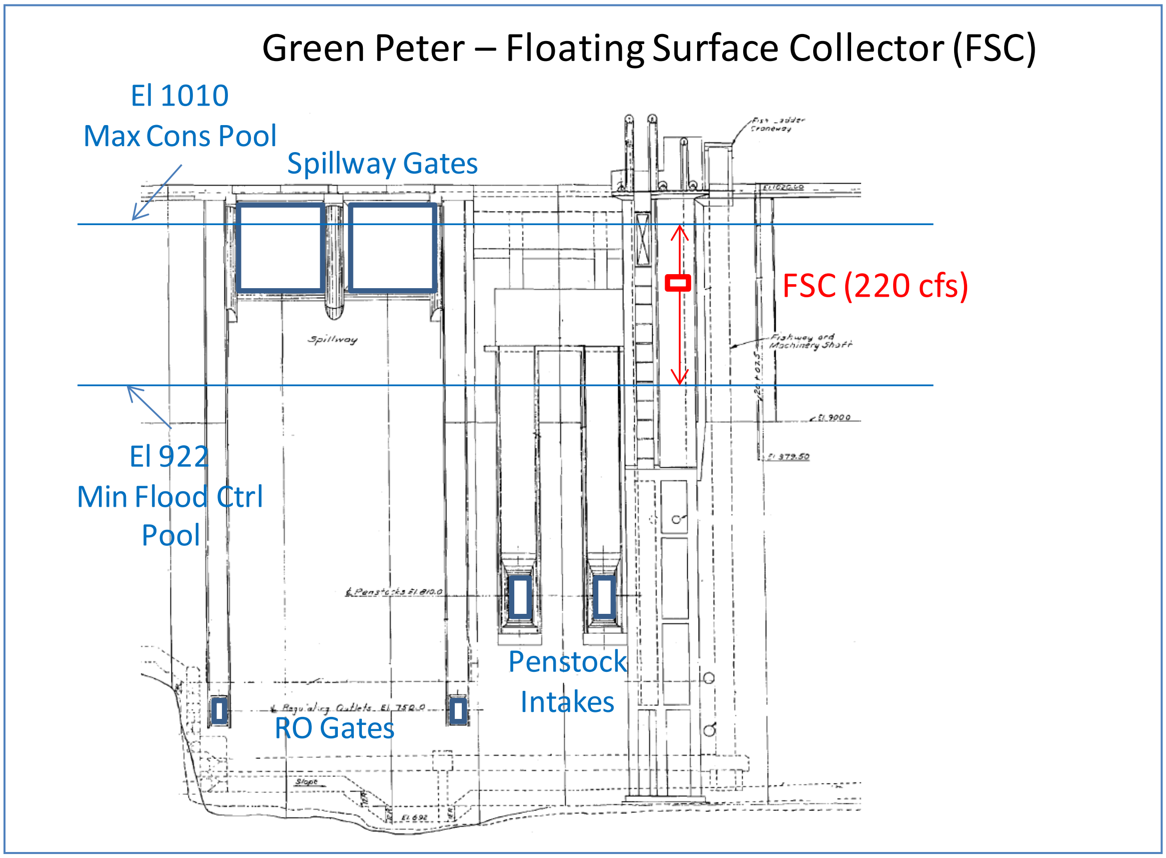
Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact); Color coding = Red (high/moderate negative impact), Green (high/moderate positive impact).

Table 3-14 (continued). Summary of Results for South Santiam Subbasin Alternatives

Alternative ID and Description	Anadromous Fish					Resident Fish		Flood Risk Management	Meeting Downstream Tributary Flows	Meeting Mainstem Flows	Reservoir Recreation	River Recreation	Water Supply - M&I and Irrigation		Constructability	Implementation Timing	Clean Water Act (TDG)t	Temperature
	FBW Average score [%]		VSP Score		Confidence Level	Impact	Confidence Level											
	Steelhead	Chinook	Steelhead	Chinook		Oregon Chub		Yes/No Impact	1=High Negative Impact; 2=Moderate Negative Impact; 3= Low to No Negative/Positive Impact; 4=Moderate Positive Impact; 5=High Positive Impact				Current Demand	Future (2050) Demand				
SS-TMP-H1-GPR: Temperature Control Improvement - SWS	31	34	2.9	0.9	--	P	M	N	3	3	3	3	3	3	1	1	3	5
SS-DSP-02-GPR: Operational-Green Peter RO Priority in Winter	Not fully assessed – anticipated low biological benefits																	
SS-DSP-01-FOS: Operational-Extend Op. Foster Fish Weir by Delayed Refill	Not fully assessed – anticipated low biological benefits																	
SS-DSP-02-FOS: Operational-Continuous Op. of Foster Fish Weir	Not fully assessed – anticipated low biological benefits																	
SS-DSP-04-FOS: Operational-Operate Foster Powerhouse within 1% Peak Efficiency	Not fully assessed – anticipated low biological benefits																	
SS-HOR-01-FOS: HOR in Trib.	Not fully assessed – high costs in relation to low biological benefits																	
SS-TDG-M1-GPR: TDG Improvement-Op. Improvement	Not fully assessed – would provide only limited TDG benefit																	
SS-TMP-M1-FOS: Temperature Control-Moderate Improvement	Not fully assessed – water temperature management at Foster may not be necessary																	
SS-TMP-H1-FOS: Temperature Control Improvement-High Imp.	Not fully assessed – water temperature management at Foster may not be necessary																	
SS-TDG-H1-FOS: TDG Improvement-Structural Imp.	Not fully assessed - limited biological benefit since TDG in subbasin is not a major factor on survival																	
SS-COMBO-1: Foster Weir Redesign/GPR Fish Horn Rehab (SS-DSP-H2-FOS & SS-DSP-H3-GPR)	FOS-75 GPR-49	FOS-73 GPR-71	3.5	2.1	--	Not fully assessed – only minor biological benefit shown in SLAM modeling												
SS-COMBO-3: Foster Fish Friendly Turbines/GPR SWS (SS-DSP-H3-FOS and SS-TMP-H1-GPR)	NM	NM	3.0	1.1	--	Not fully assessed - only minor biological benefit shown in SLAM modeling												

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact); Color coding = Red (high/moderate negative impact), Green (high/moderate positive impact).

Figure 3-19. Overview of SS-DSP-H1-GPR



Design requirements would determine if the full-depth guide net would need to be removed or dropped at lower pool elevations to prevent approach velocities on the net from exceeding 0.1 feet per second. In addition, a full-depth guide net would need to accommodate reservoir fluctuation by lying down on a grubbed reservoir bottom area, rolling up, or folding on itself to eliminate net bagging at low pool elevations. The attraction flow for the FSC will need to be determined to provide effective attraction relative to the ambient flow conditions for flows from 627 cfs to 9,079 cfs (95% to 5% exceedance outflow) and will likely depend on the FSC location and project operations (surface flow vs. bottom withdrawal). The FSC entrance for 220 cfs would be on the order of 10-feet wide by 6-feet deep, with an entrance velocity of approximately 3.7 feet per second. Flow entering the FSC would be dewatered through a primary v-screen on the order of 40 feet long, and secondary screens (~12-feet long), and returned to the reservoir. Consideration must be given to the impacts of pump discharge on surface flow patterns and attraction. Approach velocities through the primary and secondary screens will be balanced using a baffle system on the downstream face of the screens. Fish entering the FSC will pass along to a collection channel in a bypass flow of approximately 12 cfs for transport to a safe release location in the Foster Dam tailrace or beyond. It was assumed that an "at-dam" passage improvement would not impact reservoir elevations or project outflows.

Constructability and implementation timing impacts would be high because downstream passage structures are complex and require rigorous engineering and design. This alternative would not impact reservoir elevations or outflows, so would not affect TDG or water temperatures. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, downstream fish passage survival at Green Peter Dam is expected to improve from 19% to 72% for Chinook, and 20% to 50% for steelhead, and population viability is expected to improve from a VSP of 0.9 to 3.0 for Chinook, and from 2.6 to 3.7 for steelhead in the South Santiam.

Biological Modeling Assumptions: This alternative would enhance the existing populations of spring Chinook and winter steelhead and is estimated to provide sufficient survival improvements to establish self-sustaining sub-populations above Green Peter Dam, based on the improvements assumed for downstream fish passage. However it is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival). These uncertainties would be similar for those discussed for Detroit Dam FSO-FSC (Section 3.1.2.2). However, performance of the previously operated Green Peter juvenile fish collection system (fish horn) should also be considered. Collection efficiency of the Green Peter fish horn in the early years of operation for Chinook was greater than 80% and less than 57% for steelhead; however, it declined possibly in part due to increased predation as the fish community in the reservoir changed over time (Corps 1995). One major difference in the proposed FSC in comparison to the decommissioned fish horn is that the FSC and its entrance would be out in the forebay instead of flush with the face of the dam, which could make it more difficult for fish to find the entrance thereby decreasing the collection efficiency.

The FSC at Green Peter is assumed to increase overall Chinook DPE from 39% to 81% based on professional opinion. Authors assume the FSC will result in improved DPE values equivalent to levels seen at the fish horns in Wagner and Ingram data (Alden BioAnalysts Inc 2014), and it is assumed DPE will remain constant regardless of reservoir elevation, temperature, or timing based on professional opinion since the structure will fluctuate with the pool and remain as a surface outlet. For FBW/SLAM/VSP sensitivity analysis, DPE was ranged from 60% to 90% in original Alden sensitivity tests. The FSC is assumed to have a passage survival greater than 98% if NOAA design principles are applied, based on similar structures in the Northwest (see section 2.5.5).

3.3.3.2. SS-DSP-H2-GPR: Downstream Passage with Temperature Benefits – Selective Withdrawal Structure with Floating Screen Structure

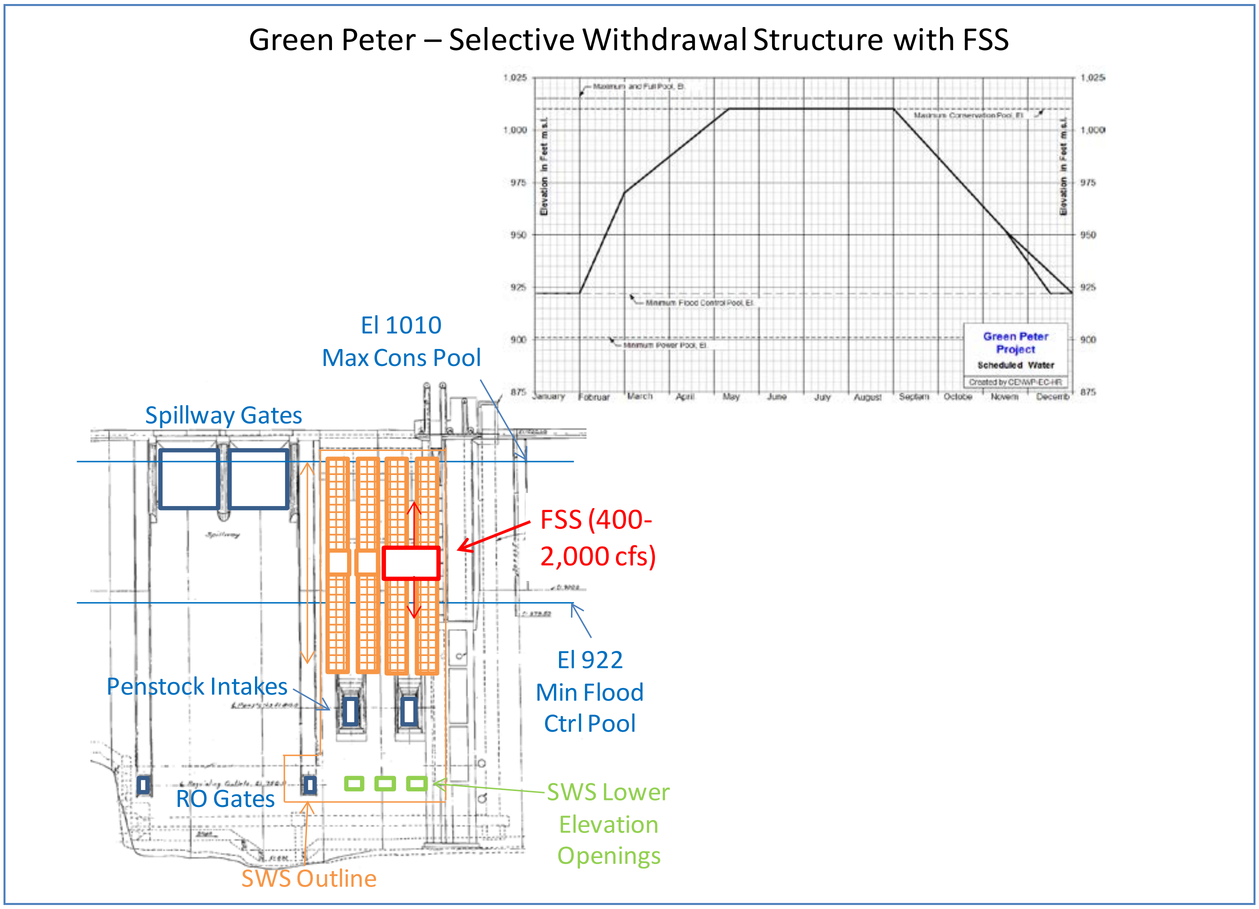
This alternative was carried forward for final analysis as it provided temperature and downstream passage benefits in the South Santiam that met replacement. This alternative for Green Peter Dam involves construction of a SWS for temperature control and installing a guide or track to allow a FSS to travel up and down along the upstream face of the SWS as the reservoir elevation changes (Figure 3-20).

Flow entering the FSS would be passed through a v-screen, with fish and a small percentage of the flow bypassing the screens through a bypass conduit at the downstream end of the screens. Based on preliminary temperature modeling, it is estimated that the FSS would handle surface flow ranging from 400 cfs up to 2,000 cfs. Captured fish would be kept in an attached live box before being transported. The most likely forms of transportation would be by truck or by a pipeline downstream of the dam(s). The FSS would screen fish from the surface and once collected, juvenile fish could be transported around the dam(s) to a downstream release site, or transported to a dam bypass system. This alternative includes a SWS with a common wet well that covers the penstock intakes, telescoping weirs for warm surface water and lower fixed elevation openings for cooler water. A conduit is provided to route temperature flow through the upper ROs.

Constructability and implementation timing impacts would be high because downstream passage structures are complex and require rigorous engineering and design. The structure would not impact reservoir elevations or outflows. A structural means to improve temperatures would not impact TDG as water would be discharged through the powerhouse, which results in lower TDG levels than use of the spillway and ROs. A structural means to improve temperatures would result in a high benefit since water can be withdrawn from multiple levels, allowing the seasonally correct temperature mix to match historical temperature regimes. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, downstream fish passage survival is expected to improve from 19% to 72% for Chinook, 20% to 63% for steelhead, and population viability is expected to improve from a VSP of 0.9 to 3.0 for Chinook, and 2.6 to 3.7 for steelhead.

Figure 3-20. Overview of SS-DSP-H2-GPR



Biological Modeling Assumptions: This alternative would enhance the existing populations of spring Chinook and winter steelhead and establish self-sustaining sub-populations above Green Peter Dam, based on the improvements assumed for downstream fish passage. However, it is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival). These uncertainties would be similar for those discussed for Detroit Dam FSS (Section 3.2.3.2).

Performance of the previously operated Green Peter juvenile fish collection system (fish horn) should also be considered. Collection efficiency of the Green Peter fish horn in the early years of operation for

Chinook was >80% and <57% for steelhead, however declined possibly in part due to increased predation as the fish community in the reservoir changed over time (Corps 1995). One major difference in the proposed FSS in comparison to the decommissioned fish horn is that the FSS and its entrance would be out in the forebay instead of flush with the face of the dam, which could make it more difficult for fish to find the entrance thereby decreasing the collection efficiency. The FSS at Green Peter is assumed to increase overall Chinook DPE from 39% to 81% based on professional opinion. Authors assume the FSS will result in improved DPE values equivalent to levels seen at the fish horns in Wagner and Ingram data (Alden BioAnalysts Inc 2014), and it is assumed DPE will remain constant regardless of reservoir elevation, temperature, or timing based on professional opinion since the structure will fluctuate with the pool and remain as a surface outlet. For FBW/SLAM/VSP sensitivity analysis, DPE was ranged from 60% to 90% in original Alden sensitivity tests to account for the possibility that fish may have problems finding the outlet. The FSS is assumed to have a passage survival of 98% if NOAA design principles are applied, based on similar structures in the Northwest (see section 2.5.5).

3.3.3.3. SS-DSP-H2-FOS: Upgrade Fish Weir for Year-round Use

This alternative was carried forward for final analysis as it provided downstream passage benefits in the South Santiam that met replacement. Although the VSP score for Chinook was less than 1.6, this measure could be combined with other measures in other subbasins and meet system average VSP score greater than 1.6. This alternative involves a redesign of the fish weir to improve downstream passage. The new design would provide safer passage of juvenile and adult salmon and steelhead over the weir to the downstream side of the dam (Figure 3-21). The new design may allow for operating the weir at various forebay pool elevations. Two flows were tested in ResSim (an average flow of 300 cfs and 860 cfs) were assumed to go over the fish weir each day. Two different pool configurations were modeled (water control manual rule curve and a modified rule curve). The results discussed below describe the higher spill operation.

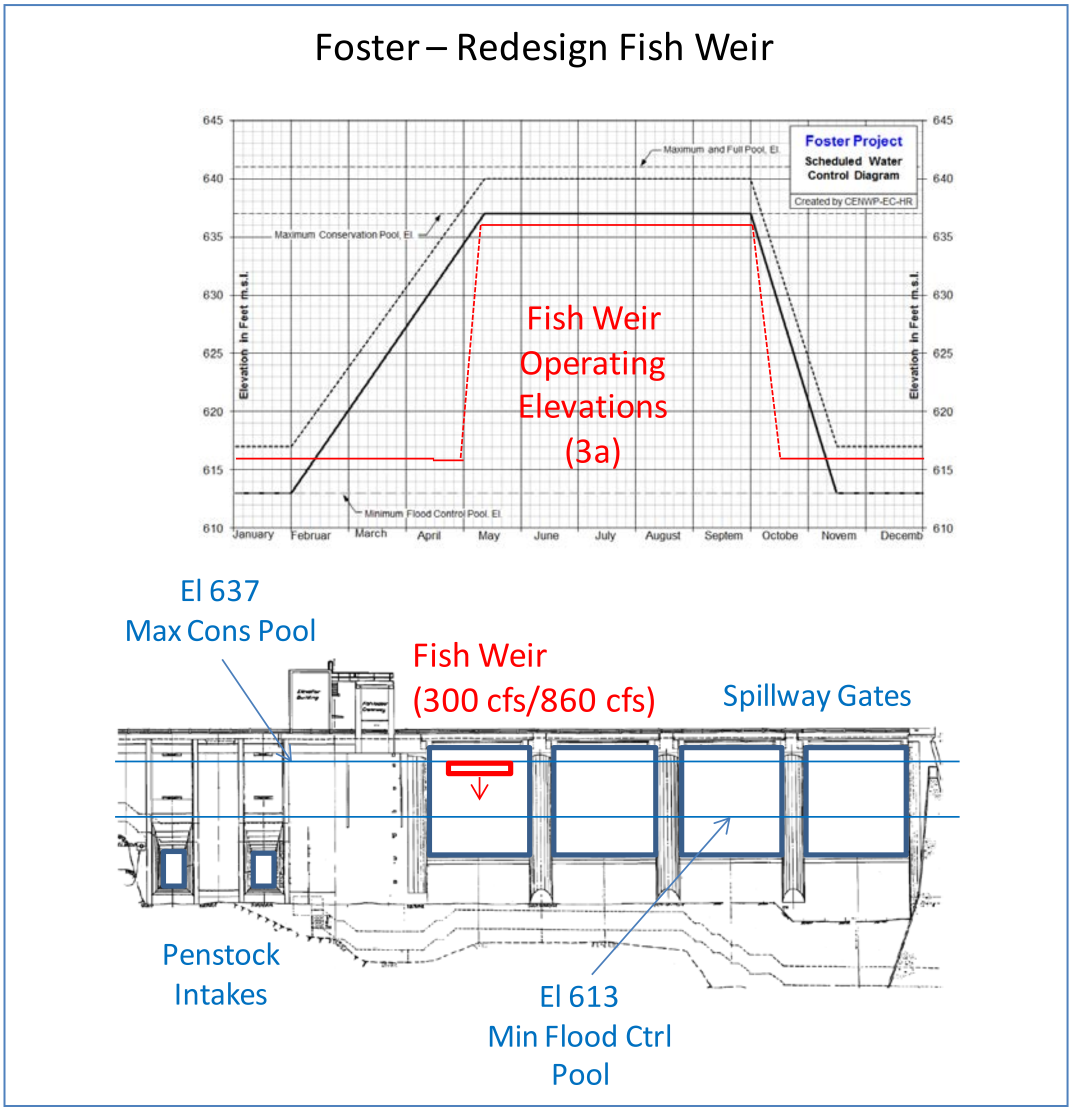
Little to no construction impact is anticipated and this project could be implemented in less than 4 years. There is a moderate negative impact to meeting tributary flows. Trying to maintain the pool range for the weir operation would make downstream flows more variable, which may not be in compliance with BiOp ramp rates. If there is storage available in Green Peter, the minimum fish flows should be met. Refill in early May is could cause higher downstream flows. The weir operation may need to be stopped to accommodate winter FRM operations since the Foster pool is used to attenuate peak flows downstream. It is anticipated that TDG exceedances would not likely change from baseline since additional spill amounts would remain small (less than 800 cfs). Operation of fish weir year-round should have little to no change to temperatures of the outflow from the dam. A small benefit may occur as more warm surface water would be spilled during summer, leaving a larger pool of cool water for fall releases. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, downstream fish passage survival is expected to improve from 65% to 73% for Chinook, 49% to 75% for steelhead, and population viability is expected to improve from a VSP of 0.9 to 1.0 for Chinook, and 2.6 to 3.3 for steelhead.

Biological Modeling Assumptions: This alternative would enhance the existing populations of spring Chinook and winter steelhead above and below Foster Dam, based on the improvements assumed for downstream fish passage. The benefits assumed in this analysis reflect a moderate reservoir survival assumption, based on recent juvenile Chinook and steelhead survival and distribution studies. Achieving fish attraction and passage survival assumptions with this alternative is likely when considering the weir is currently passing fish and the configuration is similar to dams on the Columbia River where new facilities have improved fish passage attraction and survival successfully.

The improved fish weir is assumed to increase overall steelhead DPE from 60% to 81% based on professional opinion. Authors assume the fish weir will result in improved DPE values as fish will be more readily attracted and passed over the redesigned fish weir. It is assumed DPE will remain constant regardless of reservoir elevation, temperature, or timing based on professional opinion since the fish weir will adjust with the pool and remain as a surface outlet (Alden BioAnalysts Inc 2014). The weir is assumed to have a passage survival greater than 87% for Chinook and steelhead assuming rates similar to the existing weir.

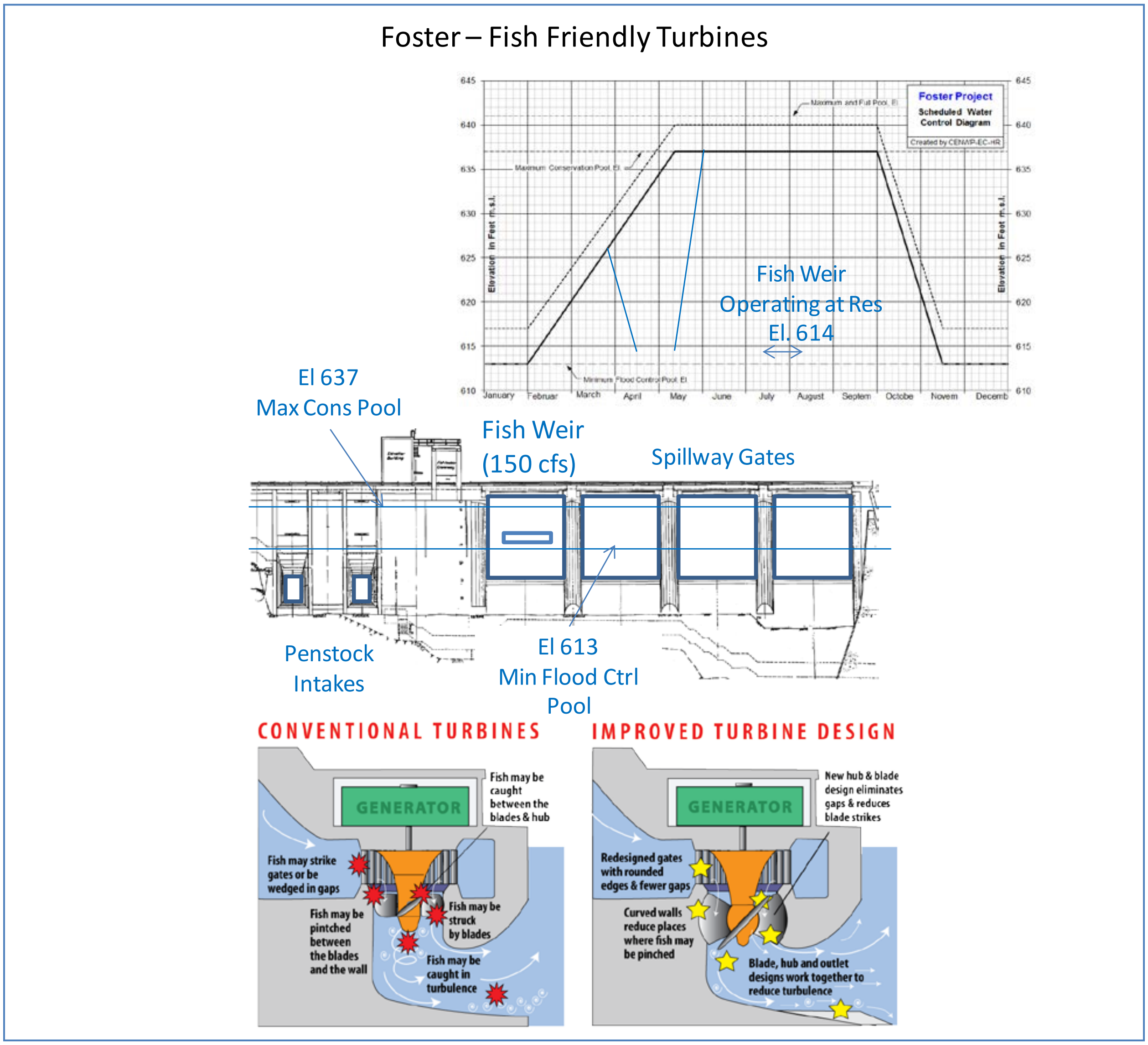
Figure 3-21. Overview of SS-DSP-H2-FOS



3.3.3.4. SS-DSP-H3-FOS: Upgrade to Fish Friendly Turbines

This alternative was carried forward for final analysis as it provided downstream passage benefits in the South Santiam that met replacement. Although the VSP score for Chinook was less than 1.6, this measure could be combined with other measures in other subbasins and meet system average VSP score greater than 1.6. This alternative (Figure 3-22) would upgrade the existing two Kaplan turbines at Foster with new fish friendly designs to increase efficiency and improve fish survival through the turbine route.

Figure 3-22. Overview of SS-DSP-H3-FOS



Moderate constructability and implementation timing impacts, turbine replacement is common in the hydropower industry but is considered one of the more complicated sectors. Hydropower turbines include highly complicated mechanical and electrical components relative to typical construction projects. Complex coordination is required to take units offline for an extended period of time. This alternative would take about 5 years to implement. Should not affect flows or reservoir elevations so should not affect TDG levels or temperatures, except during construction. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, downstream fish passage survival is expected to improve from 65% to 74% for Chinook, and 49% to 55% for steelhead, and population viability is expected to improve from a VSP of 0.9 to 1.1 for Chinook, and 2.6 to 2.8 for steelhead.

Biological Modeling Assumptions: Current turbine survival is estimated at 75% for yearlings, 80% for subyearlings and up to 85% for fry based on Normandeau 2013 data. Fish friendly turbines could bring turbine survival up to 92% for yearlings and subyearlings and up to 93% for fry based on observations from Columbia River dam performance testing for recent turbine upgrades. DPE values are assumed to be similar to the baseline DPE of 60% for Chinook and steelhead.

3.3.3.5. SS-HOR-02-GPR: Head of Reservoir Collection in Tributary

This alternative was carried forward for final analysis as it provided downstream passage benefits in the South Santiam that met replacement. This alternative involves two HOR collectors located in the Middle Santiam River and Quartzville Creek tributaries above the maximum reservoir pool elevation and designed to collect a portion of downstream migrating juveniles. Depending on the capture efficiency requirements for the collector, the concept designs could range from a well-placed trap, to a diversion capturing a significant portion of river flow, to a barrier dam. All capture systems would likely incorporate a screen system to remove the fish from a majority of the flow. Captured fish would need to be kept in a holding pond or attached live box before being transported. The most likely form of transportation would either be by truck, or by a pipeline downstream of the dam(s). Once collected, juvenile fish could be transported around the dam(s) to a downstream release site, or transported to a dam bypass system. It is assumed that a tributary HOR collector would not impact reservoir elevations or project outflows.

With this alternative, downstream fish passage survival is expected to improve for Chinook and steelhead but this alternative was not modeled with the FBW. Population viability is expected to improve from a VSP of 0.9 to 2.8 for Chinook, and 2.6 to 3.5 for steelhead.

Head-of-reservoir fish collection was more recently evaluated for Chinook in the Middle Fork Willamette as an alternative for improving downstream fish passage around Corps dams in that drainage (CH2M Hill, 2011). A total of 28 HOR and in-tributary conceptual alternatives were evaluated as part of this study, and performance information for similar facilities was summarized. The report recommended two alternatives for further study and evaluation: (1) a FSC located in the upper reservoir, and (2) an in-tributary off-channel collection facility located on the lower North Fork River at Westfir. Given the significant risks and uncertainties associated with both alternatives, the report recommended that a RM&E program be undertaken prior to preliminary design of a selected alternative to minimize the identified risks and uncertainties. Unknowns documented include the ability to successfully collect and transport fry, the effect of reservoir conditions on juveniles (a benefit or detriment), and the ability to achieve biological performance criteria (which have yet to be defined). Head-of-reservoir fish collectors, placed in the reservoir, were also recommended in Green Peter reservoir in the South Santiam Fishery Restoration Draft Reconnaissance Study (Corps 1995). However, since these were concepts as evaluated in the subject report, specific data on actual performance was not provided.

Constructability and implementation timing impacts would be high because HOR structures are complex and require multiple engineering disciplines for design. A HOR structure has added complexity due to high reservoir fluctuations (for in-reservoir structures), highly variable stream flows, and high debris loading. The structure would not impact reservoir elevations or outflows, so there would be no effect to TDG and temperatures. There should be no changes from baseline for the other non-monetized impact categories.

Biological Modeling Assumptions: The FBW tool was not configured to simulate a head of reservoir collector, so it was modeled within SLAM. In SLAM the head of reservoir structure was assumed to have an 80% DPE and a 90% survival (with sensitivity testing of 30% DPE and 70% survival). The alternative assumed juvenile collection and transportation around the dams, which avoided putting fish in the reservoir (and subjecting them to reservoir mortality).

3.3.3.6. SS-COMBO-2: Foster Fish Friendly Turbines and GPR Selective Withdrawal Structure/Floating Screen Structure (SS-DSP-H3-FOS + SS-DSP-H2-GPR)

This alternative was carried forward for final analysis as it provided temperature and downstream passage benefits in the South Santiam that met replacement. This combination alternative includes the installation of fish friendly turbines at Foster and a SWS-FSS at Green Peter. This combination would improve temperature and downstream fish passage at Green Peter and Foster. See the descriptions and technical assessment results provided above for the individual alternatives, SS-DSP-H2-GPR and SS-DSP-H3-FOS. Population viability is expected to improve from a VSP of 0.9 to 3.2 for Chinook and 2.6 to 3.7 for steelhead.

3.3.4. Monetized Costs and Impacts

Several facets of the alternative costs were estimated (Table 3-15). They included CRFM costs such as design, construction, EDC and S&A, project first costs, O&M as well as a total life-cycle cost (low, most likely and high). Additionally, forgone hydropower was estimated to assess impacts to other project purposes. A contingency factor (up to 50%) was included for all CRFM and O&M costs and costs with contingency are represented in the table.

Table 3-15. Summary of Monetized Costs and Impacts for South Santiam Alternatives

Alternative ID and Description	US $1,000,000 (present value, 50-year life, 2014 dollars) with 50% Cost Contingency									
	Design	Con-struc-tion	EDC + S&A Cost	Project First Cost (CRFM)	Annual O&M Cost	PV:O&M Cost @ 4%	Life-cycle Low	Life-cycle[1,2] Most Likely	Life-cycle High	Lost Hydro-power
SS-Baseline	--	--	--	--	--	--	--	--	--	0
SS-DSP-H1-GPR: Downstream Passage-FSC (includes Foster Fish Weir Upgrade)	34	93	18	146	1	32	128	177	297	0
SS-DSP-H2-GPR: Downstream Passage w/ Temperature-SWS w/FSS	54	168	33	255	1	12	201	267	468	2
SS-DSP-H2-FOS: Upgrade Fish Weir for Year Round Use	2	5	1	7	0	1	6	8	14	10
SS-DSP-H3-FOS: Upgrade to Fish Friendly Turbines	3	30	6	39	0	0	30	39	69	0
SS-HOR-02-GPR: Head of Reservoir Collector Trib.	48	246	49	343	1	17	270	360	630	0
SS-COMBO-2: Foster Fish Friendly Turbines/Green Peter SWS with FSS (SS-DSP-H3-FOS + SS-DSP-H2-GPR)	57	198	39	294	1	12	231	306	537	2

[1] Life-cycle costs include project first costs plus the present value of O&M.
[2] The costs above were developed during early alternative evaluations within sub-basins. The alternatives carried forward into the recommended option have updated cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

3.3.5. South Santiam Results Summary

The COP team summarized all the biological, technical and economic information for a range of alternatives into a single table as shown in Table 3-16. Cost-effectiveness factor is estimated for all alternatives using the CRFM cost and the average VSP improvement (average of steelhead and Chinook minus the baseline). The SS-DSP-H2-FOS is the most cost-effective, primarily due to the low cost; however, the alternative produces very small improvements for Chinook. The head of reservoir alternative (SS-HOR-02-GPR) is the least cost-effective. Alternatives that improve downstream water temperatures provide chub benefits.

In terms of biological confidence, the lowest confidence was assigned to SS-HOR-02-GPR due to the uncertainty in fish collection efficiency and ultimate survival during and after trap and transport from the HOR juvenile fish collection device. An evaluation of conceptual HOR and in-tributary collection and transportation facilities for the provision of downstream passage for juvenile salmonids at Lookout Point Dam was completed in 2011 (CH2M Hill 2011). Significant risks and uncertainties associated with the alternatives reviewed were identified, including the ability to successfully collect and transport fry, the effect of reservoir conditions on juveniles (a benefit or detriment), and the ability to achieve biological performance criteria (which have yet to be defined). The uncertainties discussed for Lookout Point Dam are assumed to apply when considering HOR fish collection at other Willamette system reservoirs.

Moderate biological confidence was assigned for SS-DSP-H1-GPR (Downstream Passage FSC) and SS-DSP-H3-FOS (Upgrade to Fish Friendly Turbines). The SS-DSP-H1-GPR alternative involves a FSC consisting of a floating barge structure with an attraction flow, dewatering v-screens, pump system to return flow to the reservoir, and fish transfer to a downstream passage system, and fish attraction and collection is expected to be lower than the original fish horn system since the structure will be placed in the forebay off-set from the face of the dam. This compares to the fish horn system which was flush with the dam face, allowing juvenile fish to traverse along the face of the dam and into the collection system, and did not involve a pump system like the FSC (which could create hydraulic conditions which impact collection efficiency). The SS-DSP-H3-FOS alternative would improve passage survival for juvenile Chinook and steelhead, however, is estimated to only provide minimal benefits at the population level since the fish weir is assumed to provide fish passage at Foster Dam.

The highest biological confidence was assigned to SS-DSP-H2-GPR (Downstream Passage w/Temperature-SWS-FSS), SS-DSP-H2-FOS (Upgrade Fish Weir for Year-round Use), and SS-COMBO 2 (Foster Fish Friendly Turbines/Green Peter SWS-FSS). Green Peter SWS-FSS is estimated to provide effective fish passage at Green Peter Dam, allow access to significant spawning habitat above this dam and providing structural improvements to manage water temperatures within targets under a range of hydrologic and operational conditions. The FSS is expected to perform better than an FSC since it involves diversion of all water through a single outlet from the dam, thereby increasing fish passage efficiency, in comparison to the FSC option. The SS-DSP-H2-FOS alternative provides for an upgrade surface fish passage route at Foster Dam with improved collection efficiency, and is operated through the spring and fall fish passage seasons to increase safe passage opportunity for juvenile Chinook and steelhead emigrating from upstream. The SS-COMBO 2 adds additional benefits to SS-DSP-H2-GPR by improving fish passage survival at Foster Dam using more fish friendly designed turbines.

Table 3-16. Results Summary for South Santiam Alternatives

Standard Project Information		Opportunity (Biological Benefits)						Investment (Costs)[1,2]				Impacts					Results	
		anadromous fish				resident fish												
		VSP Score																
COP Measure Number	Measure Name Description	Avg. VSP (Ch St)	Steelhead Population	Chinook Population	confidence level	Chub	confidence level	Project First Costs (Total CRFM) ($ MIL)	Additional O&M (PV) ($ MIL)	Lost Hydropower ($ MIL)	Total Life Cycle (Project First Costs + O&M) in $ MIL	Chub or Bull Trout Impacts? (Y/N)	Flood Risk Management Impact (Y/N)	Total Recreation Impact (Y/N)	Water Supply Impact (Y/N)	Hydropower Impacts (Y/N)	Cost Effectiveness (Project Lifecycle Cost over Change in Average VSP)	Projected Stakeholder Impact
SS-Baseline	South Santiam Baseline	1.8	2.6	0.9	M													
SS-DSP-H1-GPR	Downstream Passage-Floating Surface Collector + Foster Fish Weir	3.4	3.7	3.0	M	0	H	146	32	0	177	N	N	N	N	N	110	N
SS-DSP-H2-GPR	Downstream Passage w/Temperature-SWS-FSS	3.4	3.7	3.0	H	P	H	255	12	2	267	N	N	N	N	N	165	N
SS-DSP-H2-FOS	Upgrade Fish Weir for Year Round Use	2.2	3.3	1.0	H	0	H	7	1	10	8	N	N	N	N	N	19	N
SS-DSP-H3-FOS	Upgrade to Fish Friendly Turbines	2.0	2.8	1.1	M	0	H	39	0	0	39	N	N	N	N	N	182	N
SS-HOR-02-GPR	Head of Reservoir	3.1	3.5	2.8	L	0	H	343	17	0	360	N	N	N	N	N	258	N
SS-COMBO 2	Foster Fish Friendly Turbines/Green Peter SWS-FSS (SS-DSP-H3-FOS + SS-DSP-H2-GPR)	3.5	3.7	3.2	H	P	H	294	12	2	306	N	N	N	N	N	178	N

[1] US $1,000,000 (present value, 50-year life, 2014 dollars) with 50% Cost Contingency (except hydropower)

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact)

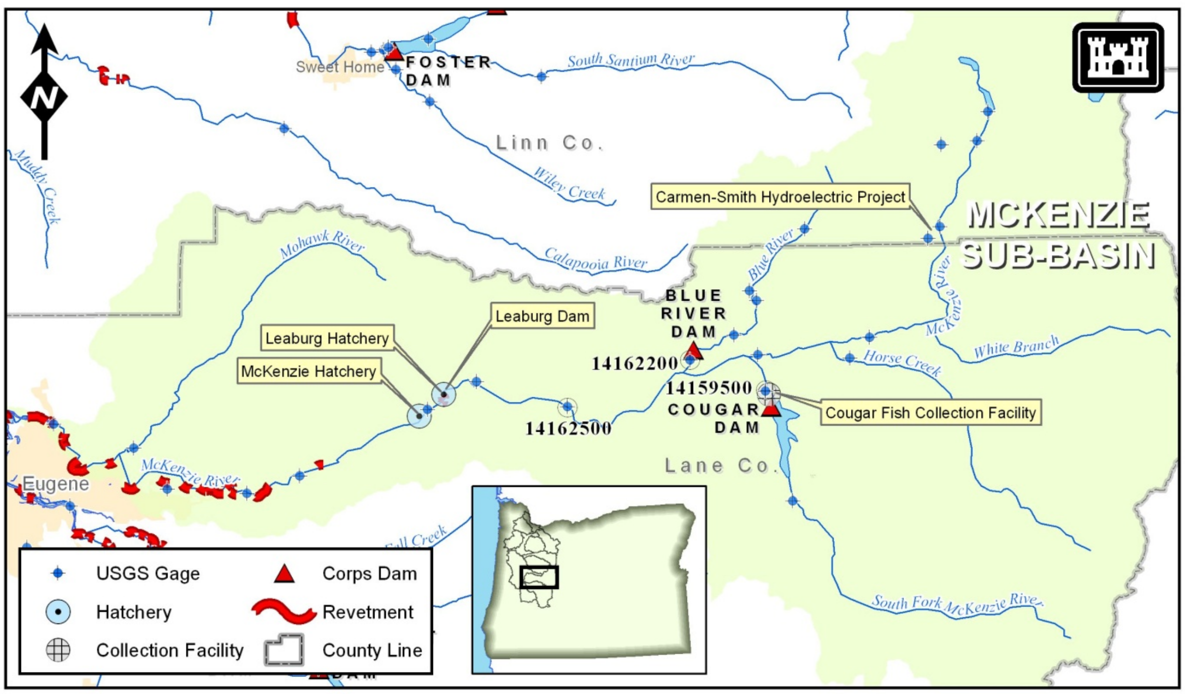
[2] The costs above were developed during early alternative evaluations within sub-basins. The alternatives carried forward into the recommended option have updated cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

3.4. McKenzie River Subbasin

3.4.1. Subbasin Overview

The McKenzie River is about 90 miles long and drains an area of about 1,340 square miles (Figure 3-23). Two Corps dams were constructed in the subbasin: Cougar dam at river mile 4.4 on the South Fork McKenzie River was completed in 1963, and Blue River dam at river mile 1.8 on the Blue River was completed in 1968. Multiple smaller diversions/canals and some higher dams are located on the McKenzie River including Leaburg Dam (river mile 29) and the Carmen-Smith Hydroelectric Project (river mile 82), both owned by the Eugene Water and Electric Board. Leaburg Dam was outfitted with new ladders and a screened diversion intake in 2005-2006. A temperature control tower at Cougar Dam was completed in 2005, improving attraction of adults to Cougar Dam. A new adult fish facility was completed in 2010 permitting efficient and safe collection and transport of adult fish (Chinook and bull trout) above the dam. Downstream fish passage is through the regulating outlet and turbines via the temperature tower when the reservoir elevation is above 1,571 feet, and directly through the regulating outlet and turbines when reservoir elevations are below. Downstream fish passage conditions (survival rates and passage efficiency) are summarized in Appendix K.

Figure 3-23. McKenzie Subbasin



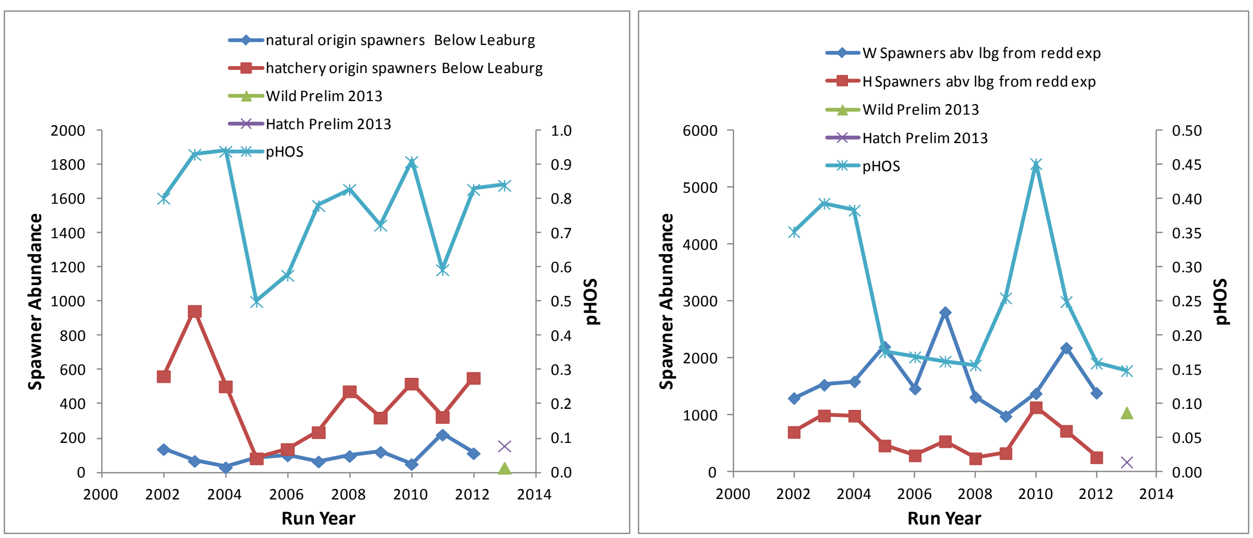
3.4.1.1. Spring Chinook

Cougar Dam is estimated to have blocked 16% of the historic spawning habitat in the entire McKenzie subbasin; this habitat is currently considered to be some of the best in the basin (ODFW 2005, NOAA Fisheries 2008). Based on habitat loss with the construction of the Cougar and Blue River dams (including the reservoir pools) and habitat loss and degradation below the dams, current spawner (egg) capacity was estimated at approximately 11,668 adult spawners (assuming 2,250 eggs per adult), with 65% of the capacity above Cougar reservoir (Appendix C).

The McKenzie River sustains the most abundant population of natural origin Chinook salmon in the Upper Willamette Basin. Average abundance based on otolith and coded wire tag analysis for 2002-2006 for natural origin fish that passed Leaburg Dam is 3,509 adults (McLaughlin et al. 2008). Adult abundance estimates in recent years have declined (Figure 3-24).

Although Cougar Dam's construction included both upstream and downstream passage facilities, low adult returns due to inadequate migration temperatures caused by the dam and inefficient collection and high mortality of juveniles lead to the eventual closure of both facilities. Hatchery-origin adults have been transported above the dam beginning in 1993 in an effort to enhance upstream habitat through the delivery of marine derived nutrients for bull trout recovery, and natural origin Chinook since 2010 when the new adult fish facility was completed. The pHOS below Leaburg Dam has ranged from about 60% to 85% and from about 15% to 25% above Leaburg Dam in recent years (Figure 3-24). Genetic pedigree analysis was used to estimate two demographic parameters, cohort replacement rate (CRR) and effective population size (N_e) (Banks et al. 2014). The study found that neither the 2007 or 2008 adult cohort replaced itself through adult recruitment to the Cougar Trap (CRR: 0.41 and 0.31, respectively). The existing poor downstream fish passage conditions at Cougar Dam (see Appendix K) was likely a primary factor explaining the low CRR rates. The study also found that N_e varied little between 2007 (185, CI_J: 169-203) and 2008 (184, CI_J: 169-204), suggesting that the risk of extinction from inbreeding depression was low for Chinook released above Cougar Dam.

Figure 3-24. McKenzie Subbasin Adult Spring Chinook Abundance and Proportion of Hatchery Origin Spawners Above and Below Leaburg Dam



Unpublished data provided by C. Sharpe, ODFW, 10/6/2014. Note very heavy rain event at peak spawning in 2013, and carcass recoveries and redd counts might have been affected.

3.4.1.2. Winter Steelhead

An independent population if winter steelhead was not designated for the McKenzie River subbasin, and the subbasin is not included in the Upper Willamette River winter steelhead DPS.

3.4.1.3. Bull Trout

The 2008 USFWS BiOp lists three populations of bull trout in the McKenzie subbasin: (1) South Fork McKenzie local population above Cougar Dam; (2) Trail Bridge reservoir local population in the upper McKenzie above Trail Bridge Dam; and (3) fluvial mainstem McKenzie local population (USFWS 2008). Based on survey data from 2005-2007, current population estimates of spawning adult bull trout throughout the McKenzie is 250-300 adults (ODFW 2007).

3.4.1.4. Oregon Chub

Scheerer and others (2007) documents there are currently Oregon chub populations at three sites in the McKenzie subbasin.

3.4.2. Alternatives

Table 3-17 lists the COP II alternatives considered for the McKenzie subbasin and indicates whether the alternative was carried forward for final analysis (shaded in blue). The results of the detailed biological analyses are summarized in Section 3.4.2.1. A summary table (Table 3-19) was prepared to compile the results from the biological and technical assessments for the McKenzie subbasin alternatives. A description of the three alternatives being carried forward for final analysis follows the tables. Note that winter steelhead are not considered in the McKenzie subbasin assessment.

Table 3-17. McKenzie Subbasin Alternatives

Alternative ID	Description	Carry Forward for Final Analysis?
MK-Baseline	McKenzie Baseline	Yes
MK-DSP-10-CGR	Floating Screen Structure (FSS) on Upstream Side of Water Temperature Control (WTC) Tower with Tower Mod. for Lower Pool Operation	Yes
MK-DSP-19-CGR	FSS for use above El. 1571 ft. and Preferential use of RO below El. 1561 ft.	Yes
MK-DSP-06-CGR	Operational – Delay Refill Cougar Res./Regulating Outlet (RO) Priority	No
MK-DSP-17-CGR	Operational –Drawdown of Cougar Reservoir to El. 1500 ft in December and RO Priority	No
MK-DSP-18-CGR	Operational –Drawdown of Cougar Reservoir to El. 1325 ft and Diversion Tunnel Priority in December	No
MK-TDG-H1-CGR	TDG Improvement – Structural Improvement	No
MK-DSP-01-CGR	Operational – RO Priority, Discharge Capped during Peak Migration	No
MK-DSP-02-CGR	Operational – RO Priority, Discharge Not Capped during Peak Migration	No
MK-DSP-03-CGR	Operational – Pulsing Flows Using Cougar ROs During Peak Outmigration	No
MK-DSP-04-CGR	Operational – Below Minimum Conservation Pool	No
MK-DSP-05-CGR	Operational – Below Minimum Conservation Pool with TDG Cap	No
MK-DSP-07-CGR	Weir Box/Collection Channel with WTC Tower Modification for Lower Pool Operation with Holding Barge and Truck Transport	No
MK-DSP-08-CGR	Weir Box/Collection Channel with WTC Tower Modification for Lower Pool Operation with Tower Bypass	No
MK-DSP-11-CGR	Floating Surface Collector (FSC) in WTC tower cul-de-sac with Tower Bypass	No
MK-DSP-12-CGR	FSC in WTC Tower cul-de-sac with Holding Barge/Truck Transport	No
MK-DSP-14-CGR	Operational – Cougar Reservoir at Higher Winter El./RO Priority	No
MK-DSP-15-CGR	Operational – Draft Cougar Reservoir Early/RO Priority	No
MK-DSP-16-CGR	Operational – Modify Weir Gate Settings in WTC Tower/RO Priority	No

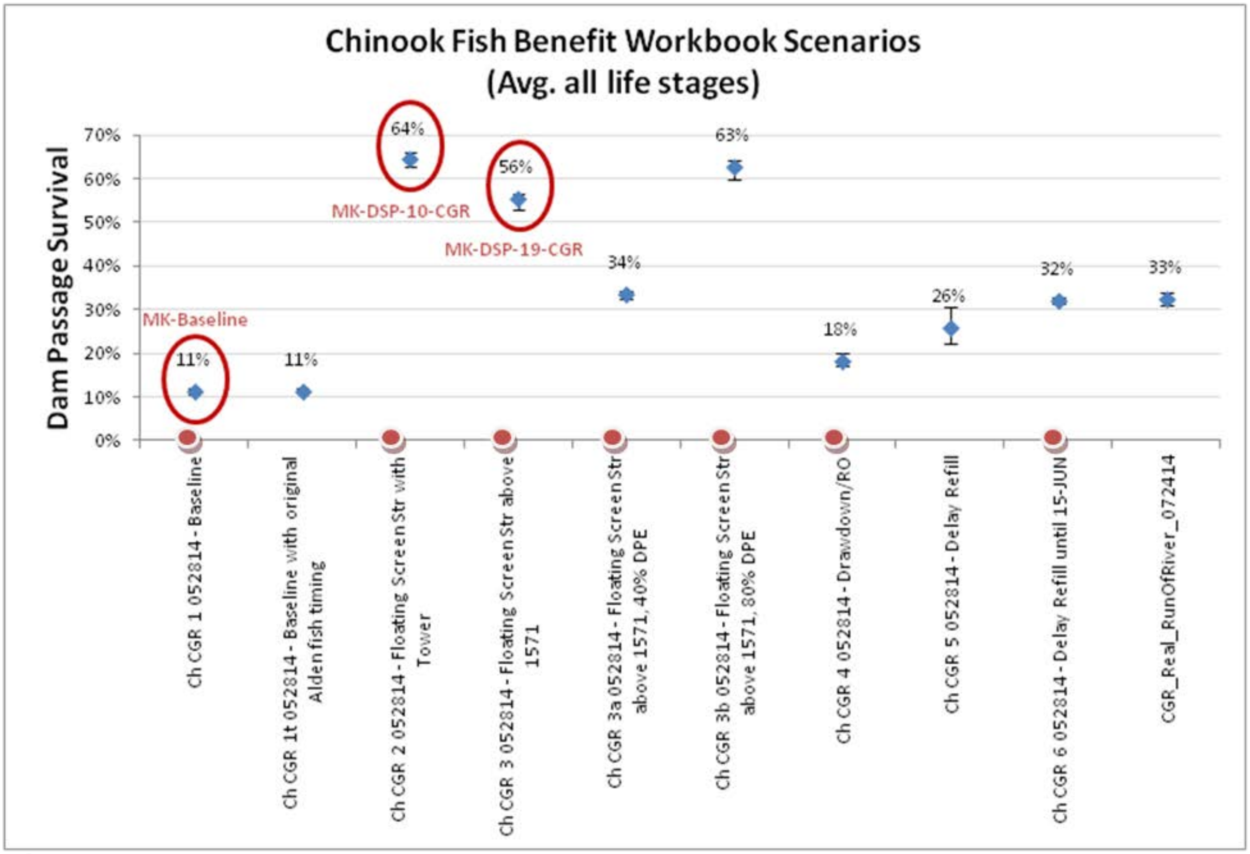
3.4.2.1. Biological Assessment of Alternatives

Several alternatives were assessed using the biological tools (FBW and/or SLAM). Details on the FBW results are discussed in Appendix K. Details on the SLAM modeling are included in Appendix C. Summaries of the FBW scores are shown in Figure 3-25 for Chinook. Measures carried forward for final evaluation are highlighted. Dam passage survival (concrete survival multiplied by dam passage efficiency) for all three life stages were averaged and are shown on the graph.

A range of alternatives were compared with the Chinook FBW tool. Some sensitivity runs were conducted to test different assumptions for DPE and fish timing. Several operational measures were tested including delay refill options, operating as a run-of-river project and drawdown scenarios (see alternative runs Ch CGR 4, Ch CGR 5, Ch CGR 6 and CGR_Real_Run-of-River). Results for each of the runs are included in Appendix K. Measures carried forward for final evaluation are highlighted, as are measures sent to SLAM for evaluation.

SLAM results for the McKenzie spring Chinook are shown in Figure 3-26. Measures carried forward for final evaluation are highlighted. A replacement analysis was done using the time series information generated by SLAM. The statistics were checked to see if, on average, the number of returning adult offspring replaced their parents. Additionally checks were made to verify that most of the individual years met replacement. The result of the replacement analysis is shown in Table 3-18.

Figure 3-25. Fish Benefits Workbook Results for Chinook in McKenzie Subbasin

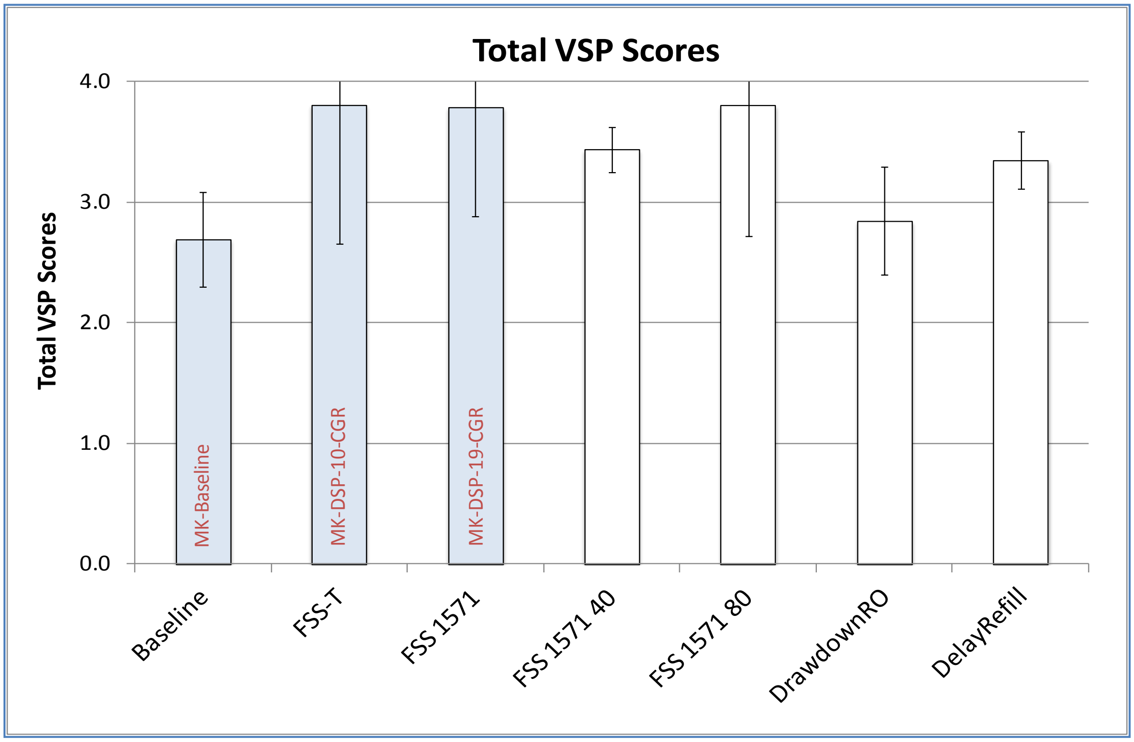


Identifies alternatives that were sent to SLAM

Key: (Red highlighted cases are carried forward for final analyses.)

MK-Baseline	=	Ch CGR 1 052814 – Baseline	(Final Parameters)
MK-Baseline	=	Ch CGR 1t 052814 – Baseline with original Alden fish timing	(Test Parameters)
MK-DSP-10-CGR	=	Ch CGR 2 052814 – Floating Screen Str with Tower	(Structural Run)
MK -DSP-19-CGR	=	Ch CGR 3 052814 – Floating Screen Str above 1571	(Structural Run)
MK -DSP-17-CGR	=	Ch CGR 3b 052814 – Floating Screen Str above 1571, 80% DPE	(Structural Run)
MK -DSP-06-CGR	=	Ch CGR 4 052814 – Drawdown/RO	(Operational Run)
(N/A)	=	Ch CGR 5 052814 – Delay Refill	(Operational Run)
(N/A)	=	Ch CGR 6 052814 – Delay Refill until 15-JUN	(Operational Run)
(N/A)	=	CGR_Real_RunOfRIver_072414	(Operational Run)

Figure 3-26. SLAM Results for Chinook in McKenzie Subbasin



Highlighted alternatives were included in the final system analysis.

Key: (Red highlighted cases are carried forward for final analyses.)

MK-Baseline	=	FBW: Ch CGR 1	SLAM: Baseline
MK-DSP-10-CGR	=	FBW: Ch CGR 2	SLAM: FSS-T
MK -DSP-19-CGR	=	FBW: Ch CGR 3	SLAM: FSS 1571
MK -DSP-17-CGR	=	FBW: Ch CGR 3b	SLAM: FSS 1571 40
MK -DSP-06-CGR	=	FBW: Ch CGR 4	SLAM: DrawdownRO
(N/A)	=	FBW: Ch CGR 6	SLAM: DelayRefill

Table 3-18. Summary of Replacement Analysis for Chinook

	AVER	Count > 1	Median	Percent Time >1	Percent Time >.95	Ave of Running Ave	Replacement Status
MK-Baseline	**79%**	**0**	**79%**	**0%**	**0%**	**78%**	**Does not meet**
FSS-T	**101%**	**67**	**99%**	**48%**	**75%**	**99%**	**Meets replacement criteria**
FSS 1571	**100%**	**67**	**99%**	**47%**	**73%**	**97%**	**Meets replacement criteria**
FSS 1571 40	92%	2	92%	1%	26%	90%	Does not meet
FSS 1571 80	101%	77	101%	55%	72%	99%	Meets replacement criteria
Drawdown RO	83%	0	84%	0%	0%	82%	Does not meet
Delay Refill	91%	0	91%	0%	15%	89%	Does not meet

See Section 2.5.2 for Replacement Criteria. Dark green meets criteria, light green nearly meets criteria, and white does not meet criteria. Bold text and boxed red cases were carried forward for final analyses.

Key: (Red highlighted cases are carried forward for final analyses.)

Alternative ID		**SLAM Run ID**
MK-Baseline	=	SLAM: MK-Baseline
MK-DSP-10-CGR	=	SLAM: FSS-T
MK-DSP-19-CGR	=	SLAM: FSS 1571

3.4.2.2. Non-Monetized Impacts

Table 3-19 summarizes the non-monetized impacts of all the assessed measures, regardless of whether or not they were carried forward for final analysis. Impacts were given a numerical value between 1 and 5 to indicate high negative impact (1) up to a high benefit (5). Biological benefits are also summarized including impacts to residential fish, Oregon chub and bull trout.

Table 3-19. Summary of Results for McKenzie Subbasin Alternatives

Alternative ID and Description (Bold denotes alternatives carried forward for final analysis)	Anadromous Fish			Resident Fish			Flood Risk Management	Meeting Downstream Tributary Flows	Meeting Mainstem Flows	Reservoir Recreation	River Recreation	Water Supply-M&I and Irrigation		Constructability	Implementation Timing	Clean Water Act (TDG)	Temperature
	FBW Avg. score [%]	VSP Score		Impact													
	Chinook	Chinook	Confidence Level	Bull Trout	Oregon Chub	Confidence Level	Yes/No Impact					Current Demand	Future (2050) Demand				
								1=High Negative Impact; 2=Moderate Negative Impact; 3= Low to No Negative/Positive Impact; 4=Moderate Positive Impact; 5=High Positive Impact									
MK-Baseline	11	2.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MK-DSP-10-CGR: FSS Upstream Side of WTC Tower with Tower Mod. for Lower Pool Op	64	3.8	H	P	0	M/H	N	3	3	3	3	3	3	1	1	3	3
MK-DSP-19-CGR: FSS for Use Above El. 1571 ft. and Preferential use of RO below El. 1561 ft.	56	3.8	M	P	0	M/H	N	3	3	3	3	3	3	1	1	3	3
MK-DSP-06-CGR: Operational-Delay Refill of Cougar Reservoir/RO Priority	26	3.3	L	0	0/N	M/H	N	1	1	2	4	3	3	3	3	3	2
MK-DSP-17-CGR: Drawdown Cougar Res. to El. 1500 ft in December/RO Priority	18	2.8	L	0	0/N	M/H	N	3	2	3	3	3	3	3	3	3	3
MK-DSP-18-CGR: Operational –Drawdown Cougar Res. to El. 1325 ft and Diversion Tunnel Priority in December	NM	NM	--	N	0/N	M/M	N	1	2	3	3	3	3	3	3	4	3
MK-TDG-H1-CGR: TDG Improvement-Structural Improvement	NM	NM	--	0	0	M/H	N	3	3	3	3	3	3	2	2	5	3
MK-DSP-01-CGR: Operational-Cougar RO Priority, Discharge Capped during Peak Migration	Not fully assessed – de-prioritized by PDT																
MK-DSP-02-CGR: Operational-Cougar RO Priority, Discharge Not Capped during Peak Migration	Not fully assessed – de-prioritized by PDT																
MK-DSP-03-CGR: Operational-Pulsing Flows Using ROs During Peak Outmigration	Not fully assessed – de-prioritized by PDT																
MK-DSP-04-CGR: Operational-Below Minimum Conservation Pool	Not fully assessed – de-prioritized by PDT																

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact); Color coding = Red (high negative impact), Green (high positive impact).

Table 3-19 (continued). Summary of Results for McKenzie Subbasin Alternatives

Alternative ID and Description	Anadromous Fish			Resident Fish			Flood Risk Management	Meeting Downstream Tributary Flows	Meeting Mainstem Flows	Reservoir Recreation	River Recreation	Water Supply-M&I and Irrigation		Constructability	Implementation Timing	Clean Water Act (TDG)	Temperature
	FBW Avg. score [%]	VSP Score	Confidence Level	Impact		Confidence Level											
	Chinook	Chinook		Bull Trout	Oregon Chub		Yes/No Impact	1=High Negative Impact; 2=Moderate Negative Impact; 3= Low to No Negative/Positive Impact; 4=Moderate Positive Impact; 5=High Positive Impact				Current Demand	Future (2050) Demand				
MK-DSP-05-CGR: Operational-Below Minimum Cons. Pool with TDG Cap	Not fully assessed – a drawdown deeper than el. 1516 feet was investigated																
MK-DSP-07-CGR: Weir Box/Collection Channel w/ WTC Tower Mod. for Lower Pool Op. w/ Holding Barge/Truck Transport	Not fully assessed – de-prioritized by PDT																
MK-DSP-08-CGR: Weir Box/Collection Channel with WTC Tower Mod. for Lower Pool Op. with Tower Bypass	Not fully assessed – de-prioritized by PDT																
MK-DSP-11-CGR: FSC in WTC tower cul-de-sac with Tower Bypass	Not fully assessed – de-prioritized by PDT																
MK-DSP-12-CGR: FSC in WTC Tower cul-de-sac w/ Holding Barge/Truck Transport	Not fully assessed – de-prioritized by PDT																
MK-DSP-14-CGR: Operational-Cougar Reservoir at Higher Winter El./RO Priority	--	--	--	--	--	--	Y	--	--	--	--	--	--	--	--	--	--
MK-DSP-15-CGR: Operational-Draft Cougar Reservoir Early/RO Priority	Not fully assessed – likely negative impacts to downstream water temperature management																
MK-DSP-16-CGR: Operational-Modify Weir Gate Settings in Cougar WTC Tower/RO Priority	Not fully assessed – operation may increase velocities over WTC tower intake weir and may create fish barrier																

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact); Color coding = Red (high negative impact), Green (high positive impact).

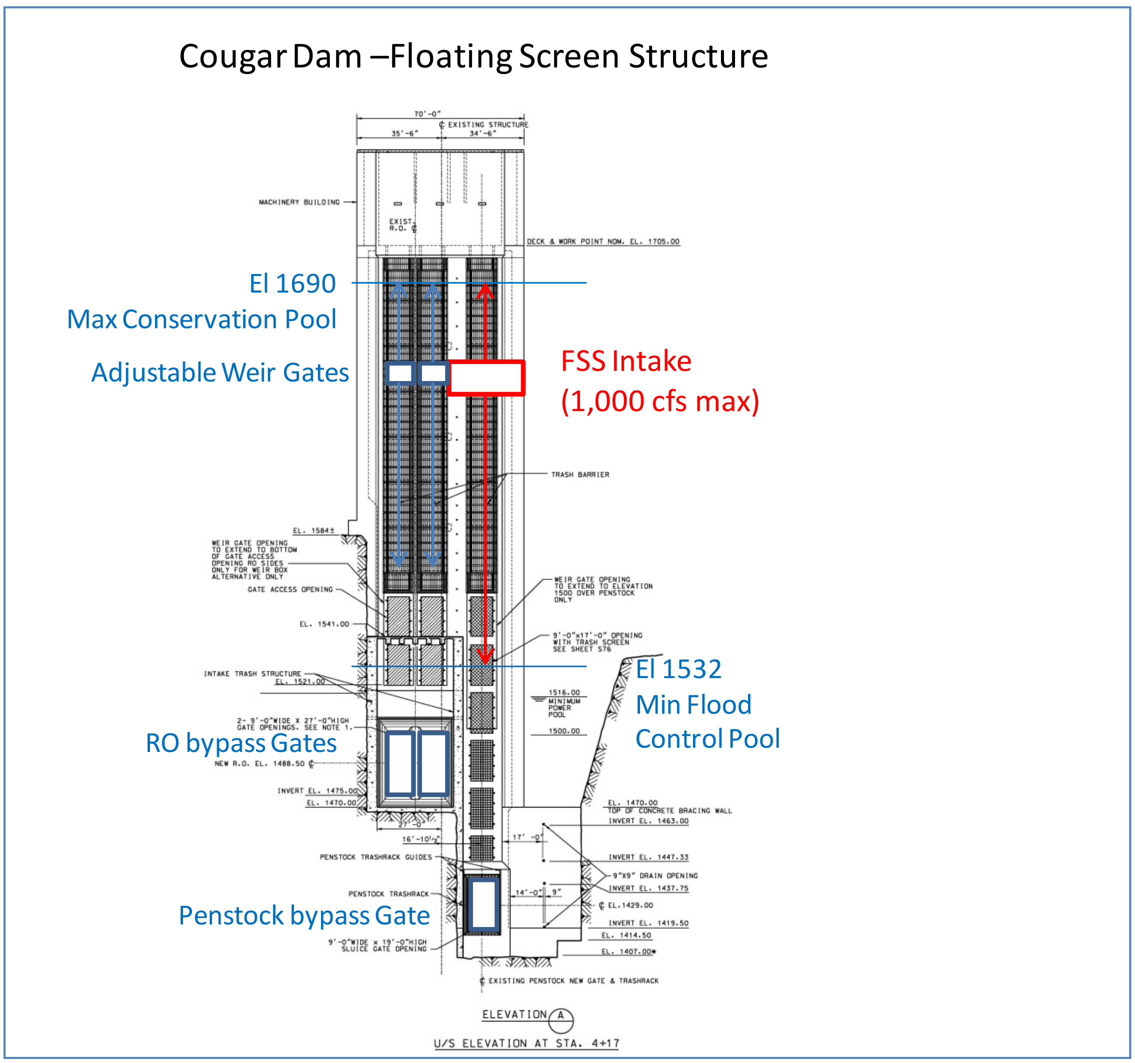
3.4.3. McKenzie Alternatives Carried Forward for Final System Analysis

In addition to the MK-Baseline, two alternatives (MK-DSP-10-CGR and MK-DSP-19-CGR) met replacement criteria and were carried forward for inclusion in the system analysis. These alternatives are described below with more detailed information included in Appendix D.

3.4.3.1. MK-DSP-10-CGR: FSS on Upstream Side of Water Temperature Control Tower with Tower Modification for Lower Pool Operation

This alternative was carried forward for final analysis as it provided downstream passage benefits in the McKenzie that met replacement. This alternative involves installing a guide or track to the existing water temperature control (WTC) tower at Cougar that would allow a FSS to float up and down along the upstream face of the WTC tower as the reservoir elevation changes (Figure 3-27).

Figure 3-27. Floating Screen Structure for MK-DSP-10-GCR



The FSS concept uses up to 1,000 cfs of project outflow as attraction flow. Up to 1,000 cfs of project outflow would be drawn as surface flow through the FSS entrance, dewatered through v-screens, and passed over the penstock-side WTC weir gate into the WTC tower and out the RO or penstock. Fish collected in the FSS and a small percentage of the flow would bypass the screens through a bypass channel at the downstream end of the screens. The bypass flow and fish would either be routed around the project or transported via truck.

Constructability and implementation timing impacts would be high because downstream passage structures are complex and require multiple engineering disciplines for design. Design complicated by the high debris loading on the intake screens and large reservoir fluctuations. The structure would not impact reservoir elevations or outflows, so there would be no effect on TDG and temperatures. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, Chinook downstream fish passage survival at Cougar Dam is expected to improve from 11 to 64%, and Chinook population viability is expected to improve from a VSP of 2.7 to 3.8.

Biological Modeling Assumptions: This alternative would result in self-sustaining populations of spring Chinook above Cougar Dam based on the improvements assumed for downstream fish passage. However it is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival). These uncertainties would be similar for those discussed for the Detroit Dam FSS (Section 3.2.3.2). However, the Cougar FSS would be expected to have a higher DPE for Chinook in comparison to an FSS at Detroit. Juvenile Chinook are currently attracted to the narrower portion of Cougar forebay referred to as the “cul de sac.” In this more confined area, the zone of influence of the FSS should be greater in comparison to an FSS placed at Detroit Dam. A more confined forebay may explain the relatively high DPE observed for juvenile sockeye salmon into the Baker FSC (Section 2.5.5).

The FSS at Cougar is assumed to increase overall Chinook DPE from 25% to 70% based on professional opinion and performance of Rocky Reach forebay collector, Lower Granite surface bypass collector, Lower Granite removable spillway weir and Cowlitz Falls. Authors assume the FSS will result in improved DPE values and will remain constant regardless of reservoir elevation, temperature, or timing based on professional opinion since the structure will fluctuate with the pool and remain as a surface outlet.

The FSS is assumed to have a route specific passage survival greater than 98% if NOAA design principles are applied based on similar structures in the northwest (see section 2.5.5). For FBW/SLAM/VSP sensitivity analysis, DPE was ranged from 60% to 80% in original Alden sensitivity tests for FSS.

3.4.3.2. MK-DSP-19-CGR: FSS for Use above El. 1571 ft. with Truck Transport or Tower Bypass and Preferential Use of RO below El. 1561 ft.

This alternative involves installing a guide or track to the existing WTC tower without modification of the tower that allows a FSS to float up and down along the upstream face of the WTC tower as the reservoir elevation changes providing floating anchorage above elevation 1561 feet (Figure 3-28 and Figure 3-29). The FSS would float upstream of the penstock-side weir gate. It would be active (screen flows into the WTC) above the forebay elevation of 1561 feet and inactive (float upstream while anchored to the WTC) while forebay elevations are below 1561 feet. The FSS concept uses up to 1,000 cfs of project outflow as attraction flow. Up to 1,000 cfs of project outflow would be drawn as surface flow through the FSS entrance, dewatered through v-screens, and passed over the penstock-side WTC weir gate into the WTC tower and out the RO or penstock.

Figure 3-29 shows the non-exceedance plots created for the Detroit project, as compared to the Early Implementation Benchmark. The top plot depicts simulated reservoir elevations while the bottom plot depicts simulated project outflows. The shaded areas represent the non-exceedance levels for the baseline data. Each operational measure that is modeled and evaluated is shown in each plot as colored line graphs. The white area, shown as the P05 (5%) non-exceedance, means that for 5% of the time, the elevation on each day of the year did not go above that level. These daily values are calculated for each day of the year independently. This means that the P05 (5%) curve does not represent any specific year.

Figure 3-28. Floating Screen Structure for MK-DSP-19-GCR

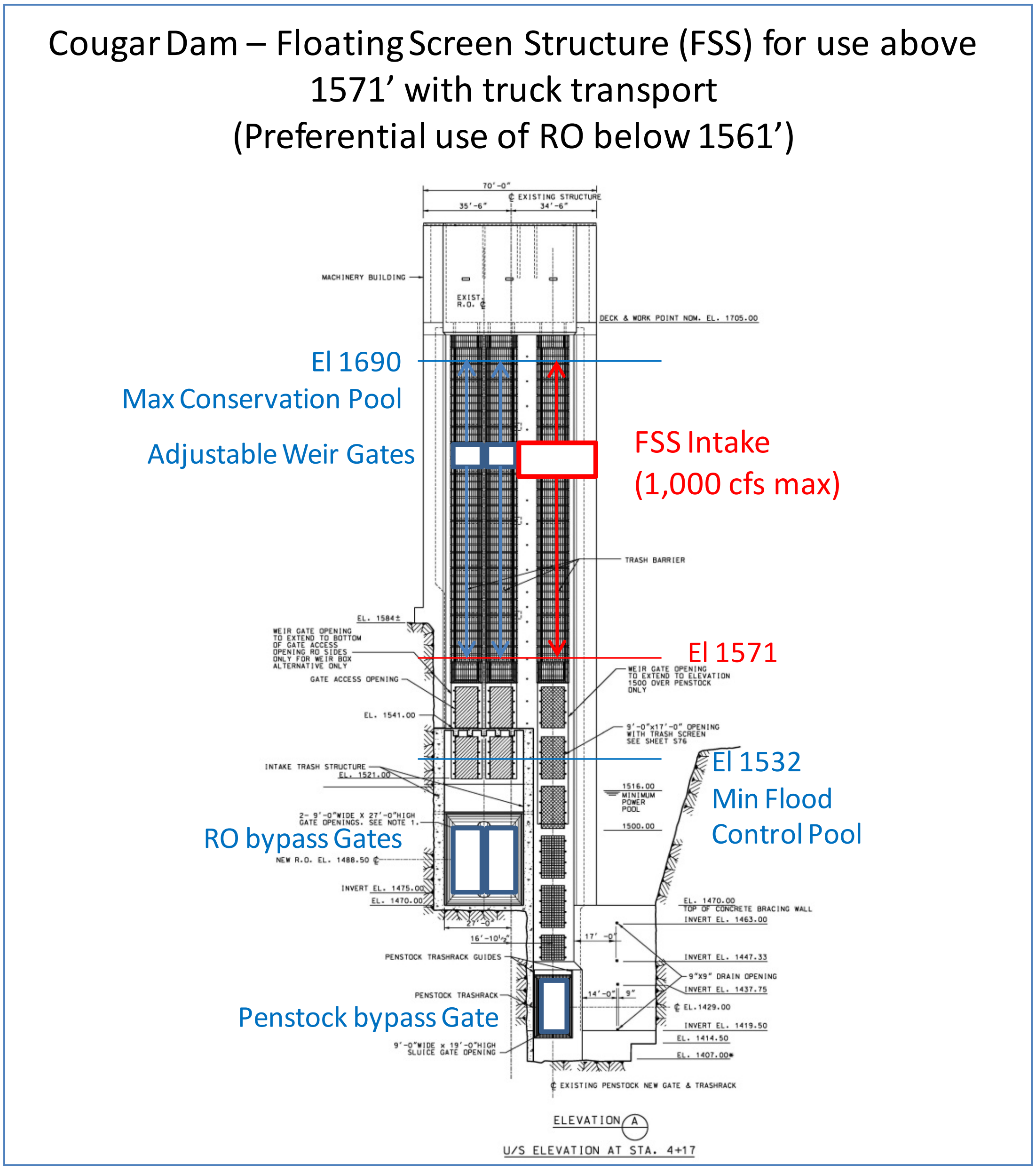
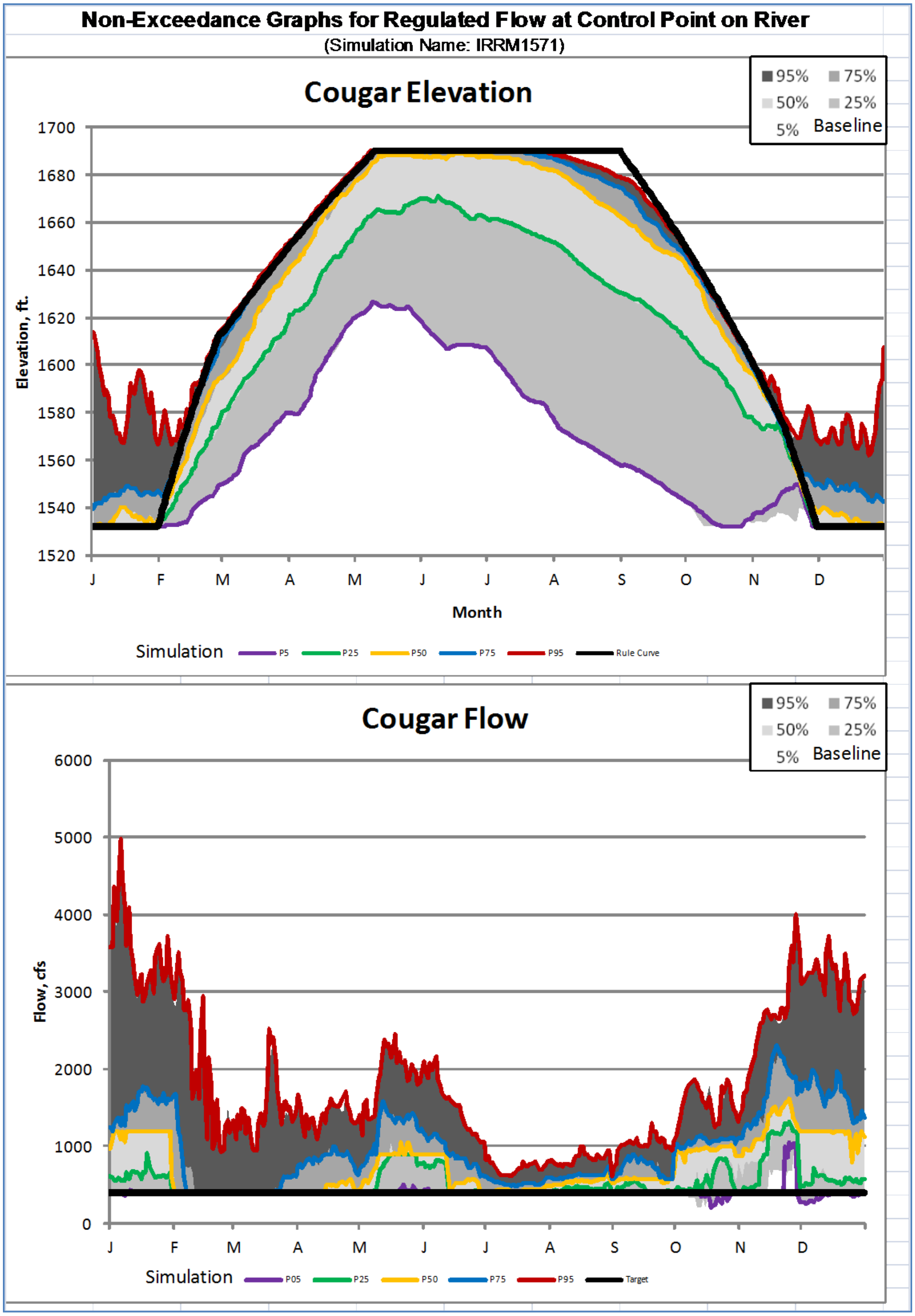


Figure 3-29. Simulated Baseline Elevations/Outflows for MK-DSP-19-GCR



Fish collected in the FSS and a small percentage of the flow would bypass the screens through a bypass channel at the downstream end of the screens. For truck transport, the bypass flow and fish would be sent to a separation and holding barge where they would be lifted to the top of the tower for truck transport. When the project was below elevation 1571 feet, preferential use of the ROs would occur. Direct survival tests during December 2010 showed higher survival through the RO than through the turbine, at least for lower project head conditions. This alternative prioritizes flow through the RO without consideration of additional TDG that may be produced by higher RO flows. The alternative was defined to prioritize flow through the RO as follows:

- First priority - outflow is 100 cfs to the turbine unit for station service.
- Second priority - remaining outflow through the RO, with the consideration that the RO gate opening must be at least the minimum gate opening (1.3 feet).

The minimum conservation outflow would be 400 cfs and 100 cfs of this would flow through the turbine. With the minimum RO gate opening, the RO flow would be more than 300 cfs at any elevation above 1,532 feet, so the outflow would increase slightly over the baseline.

Constructability and implementation timing impacts would be high because downstream passage structures are complex that require multiple engineering disciplines for design. Design complicated by the high debris loading on the intake screens and large reservoir fluctuations. Based on ResSim modeling, flow through the ROs would more than double relative to the baseline from November through January and sometimes February. This increased flow would result in an increase in TDG below the project. While TDG is expected to dissipate within a short distance downstream of the dam, there may be a slight impact to newly hatched salmon that may be present within the affected reach. Since the increase in flow through the ROs would occur mainly during the incubation period, affects on fish would be minimal. Should not affect total flows or reservoir elevations so should not affect temperature management. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, Chinook downstream fish passage survival is expected to improve from 11% to 56%, and Chinook population viability is expected to improve from a VSP of 2.7 to 3.8.

Biological Modeling Assumptions: This alternative would result in self-sustaining populations of spring Chinook above Cougar Dam based on the improvements assumed for downstream fish passage. However, it is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival). These uncertainties would be similar for those discussed for the Cougar Dam FSS with Tower Modification for Lower Pool Operation (Section 3.4.3.1).

The hybrid FSS at Cougar is assumed to increase overall Chinook DPE from 25% to 64% based on professional opinion and slightly lower performance than the full FSS. Authors assume the hybrid FSS will result in improved DPE values and will remain constant above 1571 ft regardless of reservoir elevation, temperature, or timing based on professional opinion since the structure will fluctuate with the pool and remain as a surface outlet. Lower DPE will occur below 1571 ft.

The FSS is assumed to have a route specific passage survival greater than 98% if NOAA design principles are applied based on similar structures in the northwest (see section 2.5.5). For FBW/SLAM/VSP sensitivity analysis, DPE was ranged from 60% to 80% in original Alden sensitivity tests for FSS.

3.4.4. Monetized Costs and Impacts

Several facets of the alternative costs were estimated. Those included CRFM costs such as design, construction, EDC and S&A, project first costs, O&M as well as a total life-cycle cost (low, most likely and high). Additionally, forgone hydropower was estimated to assess impacts to other project purposes. A contingency factor (up to 50%) was included for all CRFM and O&M costs and costs with contingency are represented in Table 3-20.

Table 3-20. Summary of Monetized Costs and Impacts for McKenzie Subbasin Alternatives

Alternative ID and Description	US $1,000,000 (present value, 50-year life, 2014 dollars) with 50% Cost Contingency									
	Design	Con-struc-tion	EDC + S&A Cost	Project First Cost (CRFM)	Annual O&M Cost	PV:O&M Cost @ 4%	Life-cycle Low	Life-cycle[1,2] Most Likely	Life-cycle High	Lost Hydro-power
MK-Baseline	--	--	--	--	--	--	--	--	--	--
MK-DSP-10-CGR: FSS Upstream Side of WTC Tower with Tower Bypass	23	90	18	131	0	10	105	140	245	2
MK-DSP-19-CGR: FSS for Use Above El. 1571 ft. and Preferential use of RO below El. 1561 ft. with Holding Barge/Truck Transport	23	75	15	113	1	11	93	124	218	27

[1] Life-cycle costs include project first costs plus the present value of O&M.
[2] The costs above were developed during early alternative evaluations within sub-basins. The alternatives carried forward into the recommended option have updated cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

3.4.5. McKenzie Results Summary

The COP team summarized all the biological, technical and economic information for a range of alternatives into a single table (Table 3-21). A cost-effectiveness factor is estimated for both alternatives, MK-DSP-10-CGR and MK-DSP-19-CGR. Although the Hybrid (MK-DSP-19-CGR) is more cost-effective when looking at the total CRFM costs, MK-DSP-10-CGR was more cost-effective when the hydropower losses are factored in. MK-DSP-10-CGR has more biological confidence since it provides a safe fish passage route during most operational conditions, in comparison to the MK-DSP-19-CGR alternative which includes fish passage below elevation 1571 feet through the RO (with lower fish passage survival). Both alternatives provide benefits to bull trout.

Table 3-21. Results Summary for McKenzie Subbasin Alternatives

Standard Project Information		Opportunity (Biological Benefits)					Investment (Costs)[1,2]				Impacts (Yes/No)					Results	
COP Measure Number	Measure Name Description	anadromous fish		resident fish			Project First Costs (Total CRFM) ($ MIL)	Additional O&M (PV) ($ MIL)	Lost Hydropower ($ MIL)	Total Life Cycle (Project First Costs + O&M) in $ MIL	Chub or Bull Trout Impacts? (Y/N)	Flood Risk Management Impact (Y/N)	Total Recreation Impact (Y/N)	Water Supply Impact (Y/N)	Hydropower Impacts (Y/N)	Cost Effectiveness (Project Lifecycle Cost over Change in VSP)	Projected Stakeholder Impact
		VSP Score Chinook Population	confidence level	chub	Bull Trout	confidence level											
MK-Baseline	McKenzie Baseline	2.7															
MK-DSP-10-CGR	Floating Screen Structure (FSS) on Upstream Side of WTC Tower	3.8	H	0	P	H/M	131	10	2	140	N	N	N	N	N	123	N
MK-DSP-19-CGR	Hybrid - FSS for Use Above El. 1571 ft. and Preferential use of RO below El. 1571 ft.	3.8	M	0	P	H/M	113	11	27	124	N	N	N	N	N	109	N

[1] US $1,000,000 (present value, 50-year life, 2014 dollars) with 50% Cost Contingency (except hydropower)

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact)

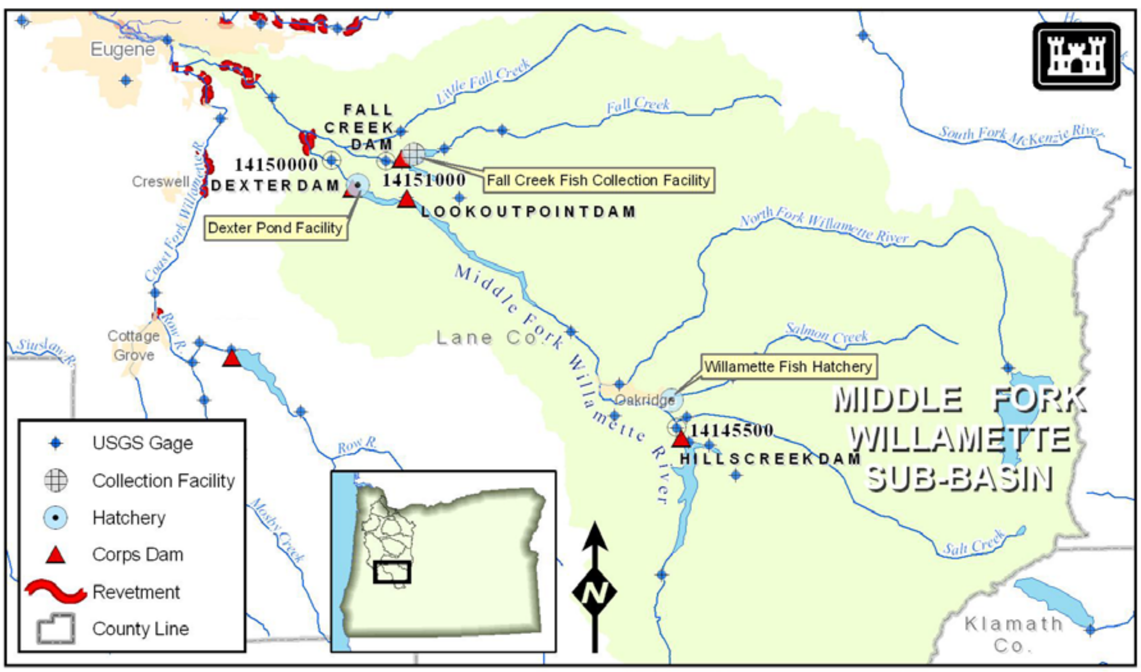
[2] The costs above were developed during early alternative evaluations within sub-basins. The alternatives carried forward into the recommended option have updated cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

3.5. MIDDLE FORK WILLAMETTE RIVER SUBBASIN

3.5.1. Subbasin Overview

The Middle Fork Willamette subbasin drains about 1,370 square miles (Figure 3-30). Four Corps projects were constructed in the subbasin. Hills Creek on the Middle Fork Willamette River (river mile 47.8) was completed in 1961. Lookout Point (river mile 19.9) and Dexter (river mile 16.8) on the Middle Fork Willamette were completed together in 1955. Fall Creek Dam on Fall Creek (river mile 7.9) was completed in 1965. The four projects form a complete barrier to upstream fish passage. Currently, ESA-listed spring Chinook, Oregon chub (delisted in 2015), and bull trout are present in the Middle Fork Willamette subbasin. Adult fish facilities are operated at Dexter and Fall Creek Dams for collection of hatchery brood and/or transport of Chinook upstream. These older facilities do not meet NOAA fish passage guidelines. Downstream fish passage at Fall Creek is provided by way of drawing the reservoir down to run-of-river conditions in late fall, and allowing fish to pass downstream through the diversion tunnel. Downstream fish passage at other Corps dams in the Middle Fork subbasin is through spillway, regulating outlets, or turbines. Downstream fish passage conditions (survival rates and passage efficiency) conditions are summarized in Appendix K.

Figure 3-30. Middle Fork Willamette Subbasin



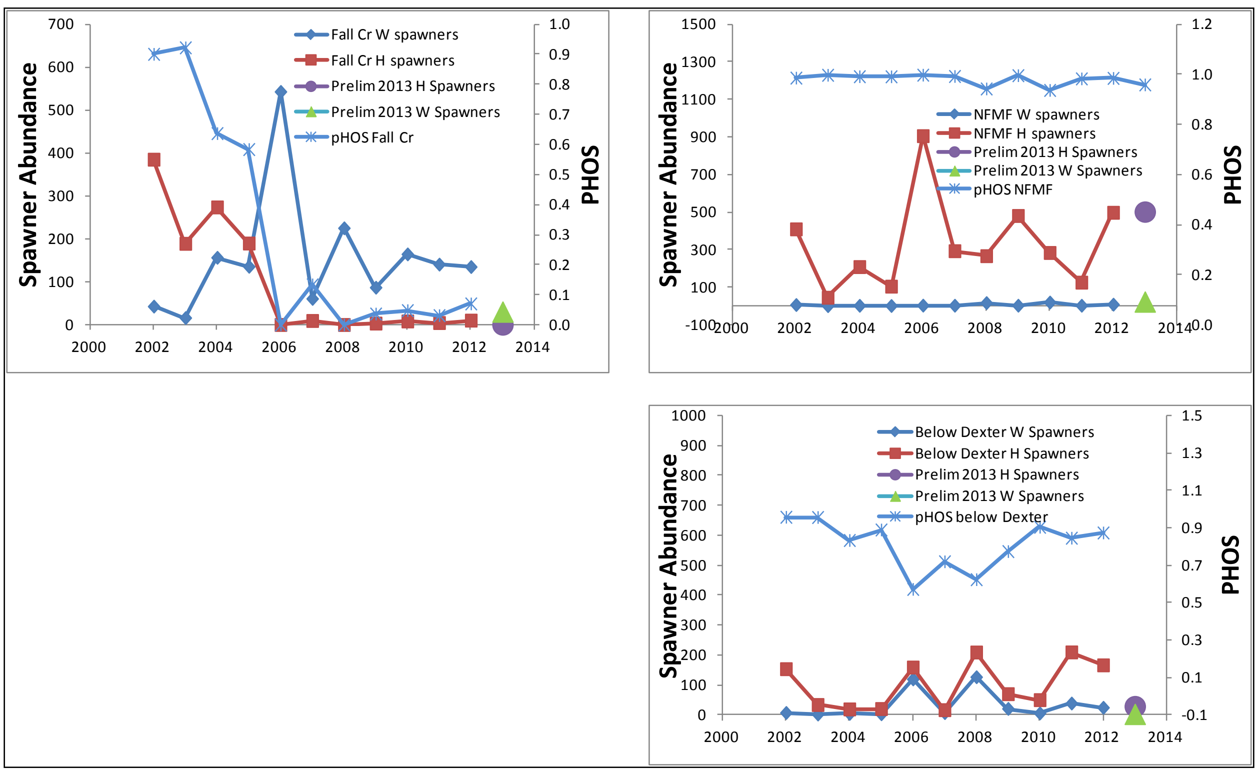
3.5.1.1. Spring Chinook

The majority of historic spawning habitat for spring Chinook in the Middle Fork Subbasin is located upstream of the Corps dams. Based on habitat loss with the construction of Dexter, Lookout, Hills Creek and Fall Creek dams (including the reservoir pools) and habitat loss and degradation below the dams, current spawner (egg) capacity is estimated at approximately 14,511 adult spawners (assuming 2,250 eggs per adult), with 98% of the capacity above Corps reservoirs (Appendix C).

Today, production of natural-origin Chinook is at extremely low levels in the Middle Fork Willamette subbasin (Figure 3-31) relative to pre-Corps dam estimates. In Fall Creek, Chinook abundance has increased coinciding with downstream passage being provided via reservoir drawdown. The Corps currently transports only unmarked Chinook upstream of the dam. Aside from Fall Creek, the Middle Fork Willamette subbasin does not appear to sustain a wild population due to blocked access to habitat and high pre-spawning mortality rates (NOAA Fisheries 2008). The total number of adult natural-origin Chinook for the Middle Fork Willamette River and Fall Creek is currently less than 500 fish, with most production occurring in the Fall Creek tributary of Middle Fork (Figure 3-31).

Spawning habitat is lacking in the lower reaches below Dexter Dam. In 1993, ODFW began transferring Chinook above Dexter and Fall Creek. Fall Creek's construction did include downstream juvenile passage through a series of fish horns, but low collection efficiency and high injury/mortality lead to its closure.

Figure 3-31. Middle Fork Willamette Subbasin Adult Spring Chinook Abundance and Proportion of Hatchery Origin Spawners Above and Below Fall Creek Dam and Dexter/Lookout Point Dam



Unpublished data provided by C. Sharpe, ODFW, 10/6/2014. Note very heavy rain event at peak spawning in 2013, and carcass recoveries and redd counts might have been affected.

Of all the subbasins affected by the Willamette system, the Middle Fork Willamette (with the exception of the Fall Creek tributary) poses the most challenges for reintroducing and establishing a stable population of spring Chinook salmon above the dams; therefore, feasibility is in question. This subbasin has the most dams and reservoirs in series (Hills Creek, Lookout Point and Dexter) which subdivide the spawning and rearing habitat for spring Chinook and present multiple large passage barriers. Lookout Point and Dexter reservoirs are inhabited by several species of fish known to prey on juvenile Chinook, and these two contiguous reservoirs (subdivided by Lookout Point Dam) have a combined length of over 20 linear miles at full pool, creating challenging conditions for downstream migrating juvenile Chinook. The 2008 BiOp RPA recognized these challenges and included a measure to investigate head-of-reservoir juvenile fish collection and transport, however to date no feasible options have been identified. Successful reintroduction of adult Chinook upstream of Lookout Point Dam and/or Hills Creek Dam is also complicated by having to trap adults below Dexter (where little adult holding habitat is available) and by high pre-spawn mortality rates of adult spring Chinook (as high as >90% in some years). High densities of adult hatchery-origin Chinook below Dexter Dam appear to contribute to high pre-spawn mortality rates, along with trapping protocols and the existing trapping facilities. The current trapping protocols employed are designed to meet hatchery management objectives and do not prioritize those for reintroduction and wild fish conservation. The existing fish facility was not designed to handle ESA-listed fish and needs to be upgraded to improve conditions for these fish and allow for safe sorting and transport, while managing the other species (often concurrently). The existing facility does not have suitable facilities for holding fish following sorting. In addition, the hopper and truck loading system does not provide a water-to-water transfer of adults from the hopper to the transport truck.

3.5.1.2. Winter Steelhead

An independent population if winter steelhead was not designated for the Middle Fork Willamette subbasin, and the subbasin is not included in the Upper Willamette River winter steelhead DPS.

3.5.1.3. Bull Trout

The 2008 USFWS BiOp documents that historically bull trout were prevalent throughout the Willamette, but were likely extirpated from the Middle Fork Willamette River in the 1980s. Reintroduction of bull trout in the Middle Fork began in the late 1990's. A fry transfer program that began in 1997 and has reintroduced bull trout fry from the McKenzie River to tributaries of the Middle Fork Willamette above Hills Creek reservoir (e.g. ODFW 2007). In more recent years, a captive rearing program has helped increase juvenile production in areas targeted for reintroduction (Zymonas, 2013). Spawning and reproductive success in the Middle Fork Willamette was documented in 2005-2007; population size was estimated at 20-30 adults, although in 2005 and 2006, the number of fish spawning was estimated at 12 (ODFW 2007). Overall, these ongoing reintroduction efforts have shown partial success (Zymonas, 2013).

3.5.1.4. Oregon Chub

The Middle Fork Willamette subbasin contains the greatest concentration of Oregon chub populations (>500 fish) in the Willamette Valley (USFWS 2008). Scheerer and others (2007) documented 12 populations in this subbasin (two at Dexter reservoir alcoves, East Fork Minnow Creek pond, Shady Dell pond, Buckhead Creek, two at Elijah Bristow State Park sloughs and an island pond, Barnhard slough, Hospital pond, Wicopee pond, and Fall Creek spillway ponds.

3.5.2. Alternatives

Table 3-22 lists the COP II alternatives considered for the Middle Fork Willamette subbasin and indicates whether the alternative was carried forward for final analysis (shaded in blue). Table 3-25 was prepared to compile the results from the biological and technical assessments for Middle Fork Willamette alternatives. A description of the alternatives being carried forward for final analysis follows the tables. Note that winter steelhead are currently not present in the Middle Fork Willamette subbasin.

Table 3-22. Middle Fork Willamette Subbasin Alternatives

Alternative ID	Description	Carry Forward for Final Analysis?
MF-Baseline	Middle Fork Willamette Baseline	Yes
MF-DSP-01-FAL*	Operational – Deeper Drawdown of Fall Creek/RO Priority with New Adult Fish Facility (AFF)	Yes
MF-HOR-01-HCR	Head of Reservoir (HOR) Collection in Tributary	Yes
MF-COMBO-1	HCR Floating Surface Collector (FSC) and LOP Selective Withdrawal Structure (SWS) with Floating Screen Structure (FSS)	Yes
MF-COMBO-2	Hills Creek HOR Collector and Lookout Point FSC	Yes
MF-COMBO-3	Hills Creek SWS and FSS with Lookout Point FSC	Yes
MF-DSP-H2-HCR	Hills Creek SWS with FSS	Yes
MF-DSP-H2-LOP	Lookout Point SWS with FSS	Yes
MF-DSP-01-HCR	Operational Measure – Hill Creek RO Priority in Winter	No
MF-DSP-02-HCR	Operational – Deeper Drawdown of Hills Creek/RO Priority	No
MF-DSP-03-HCR	Operational – Drawdown to El. 1428 ft with RO Priority	No
MF-DSP-H1-HCR	Downstream Passage – FSC	No
MF-DSP-01-LOP	Operational – Operate to Reduce Predation to Benefit Juvenile Salmon	No
MF-DSP-02-LOP	Operational - Lookout Point RO Priority in Winter	No
MF-DSP-03-LOP	Operational – Deeper Drawdown of Lookout Point/RO Priority	No
MF-DSP-04-LOP	Operational - Delayed Refill of Lookout Point/RO Priority	No
MF-DSP-05-LOP	Operational – Lookout Point as Run-of-River/RO Priority	No
MF-DSP-06-LOP	Operational – Operate at Minimum Conservation Pool Year-round except for Floods	No
MF-DSP-H1-LOP	Downstream Passage – FSC at Lookout Point	Not as standalone measure, included in MF-COMBO-2 and MF-COMBO-3
MF-DSP-01-DEX	Operational – Operate Dexter Powerhouse within 1% Peak Efficiency	No
MF-HOR-02-HCR	HOR in Hills Creek Reservoir	Not as standalone measure, included in MF-COMBO-2
MF-HOR-01-LOP	HOR in Lookout Point Reservoir	No
MF-HOR-02-LOP	HOR in Tributary	No
MF-HOR-01-FAL	HOR in Tributary	No
MF-HOR-02-FAL	HOR in Fall Creek Reservoir	No
MF-TMP-H1-HCR	Temperature Control Improvement - SWS	Not as standalone measure, included in MF-COMBO-3 and MF-DSP-H2-HCR
MF-TMP-01-LOP	Baseline with Operational Temperature Control	No
MF-TMP-M1-LOP	Temperature Control Moderate Improvement	No
MF-TMP-H1-LOP	Temperature Control Improvement - SWS	Not as standalone measure, included in MF-COMBO-1 and MF-DSP-H2-LOP
MF-TMP-M1-FAL	Temperature Control Moderate Improvement	No
MF-TDG-M1-LOP	TDG Improvement – Operational Improvement	No
MF-TDG-H1-DEX	TDG Structural Improvement	No
MF-ACH-H1-DEX	New Adult Fish Facility at Dexter (AFF)	Not as standalone measure, included in MF-HOR-01-HCR, MF-COMBO-1, MF-COMBO-2, MF-COMBO-3, MF-DSP-H2-HCR and MF-DSP-H2-LOP

*Note: MF-DSP-01-FAL alternative described in Section 3.5.3.1.

3.5.2.1. Biological Assessment of Alternatives

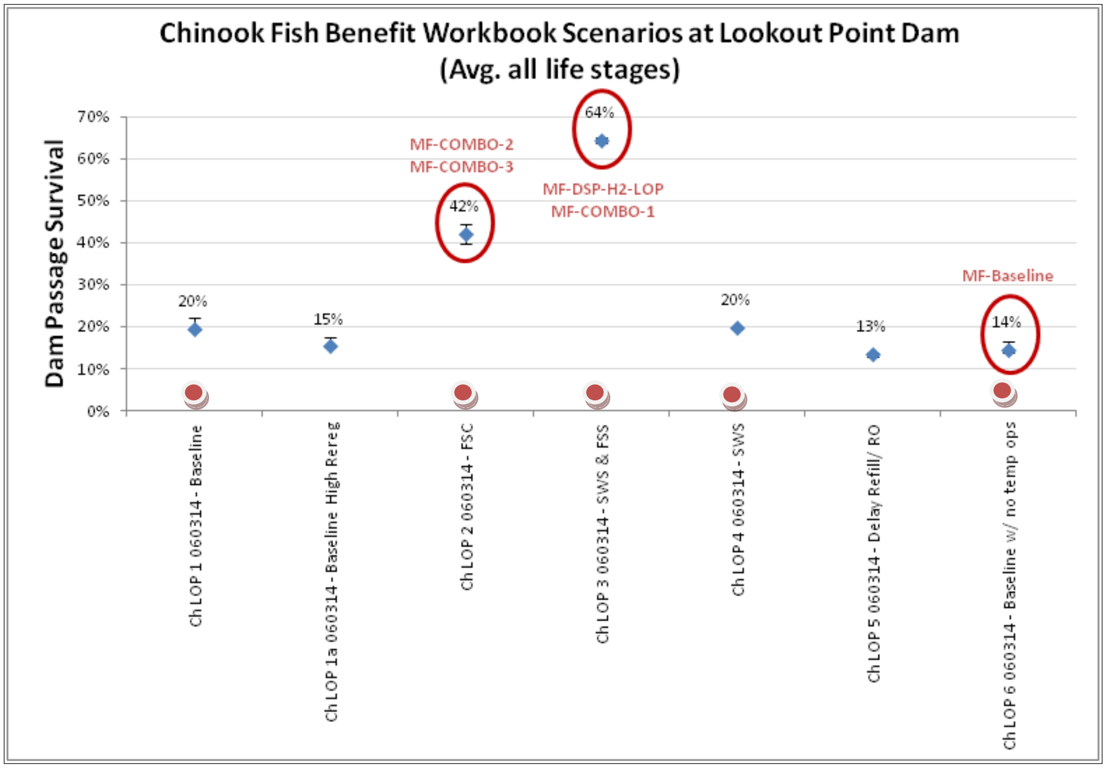
Several alternatives were assessed using the biological tools (FBW and/or SLAM). Details on the FBW results are discussed in Appendix K. Details on the SLAM modeling are included in Appendix C. Summaries of the FBW scores are shown in Figure 3-32 and Figure 3-33 for Chinook. Measures carried forward for final evaluation are highlighted. Dam passage survival (concrete survival multiplied by dam passage efficiency) for all three life stages were averaged and are shown on the graph.

A range of alternatives were compared with the Chinook FBW tool, primarily including temperature and passage options (SWS, SWS-FSS and FSC). A delay refill operations was also tested for Lookout Point. Results for each of the runs are included in Appendix K. Fish benefits workbook runs were prepared for Lookout Point and Hills Creek dams.

The measures that appeared to have the most biological benefit from FBW were sent to SLAM to be assessed at the subbasin level. In general, if the FBW results were similar or lower than the baseline score, they were not sent to the SLAM model. Runs that were sent to SLAM are identified in the above FBW figures. Final Middle Fork alternatives are highlighted with red circles.

SLAM results for Middle Fork Chinook are shown in Figure 3-34. Measures carried forward for final evaluation are highlighted. The NWFSC used slightly different assumptions for their 'Baseline run' that included operational temperature control. This corresponded to COP alternative MF-TMP-M1-LOP, not MF-Baseline. The SLAM run titled 'LOP_Baseline nSpill-HC_Baseline' better corresponded to the COP assumed baseline, MF-Baseline, and is labeled as such in the figure. A replacement analysis was done using the time series information generated by SLAM. The statistics were checked to see if, on average, the number of returning adult offspring replaced their parents. Additionally checks were made to verify that most of the individual years met replacement. For dams in series, the replacement for each reach was checked. The results of the replacement analysis by reach are shown in Table 3-23. A composite summary for all reaches is shown in Table 3-24 and serves as the final replacement analysis for the Middle Fork alternatives.

Figure 3-32. Fish Benefits Workbook Results for Chinook at Lookout Point Dam

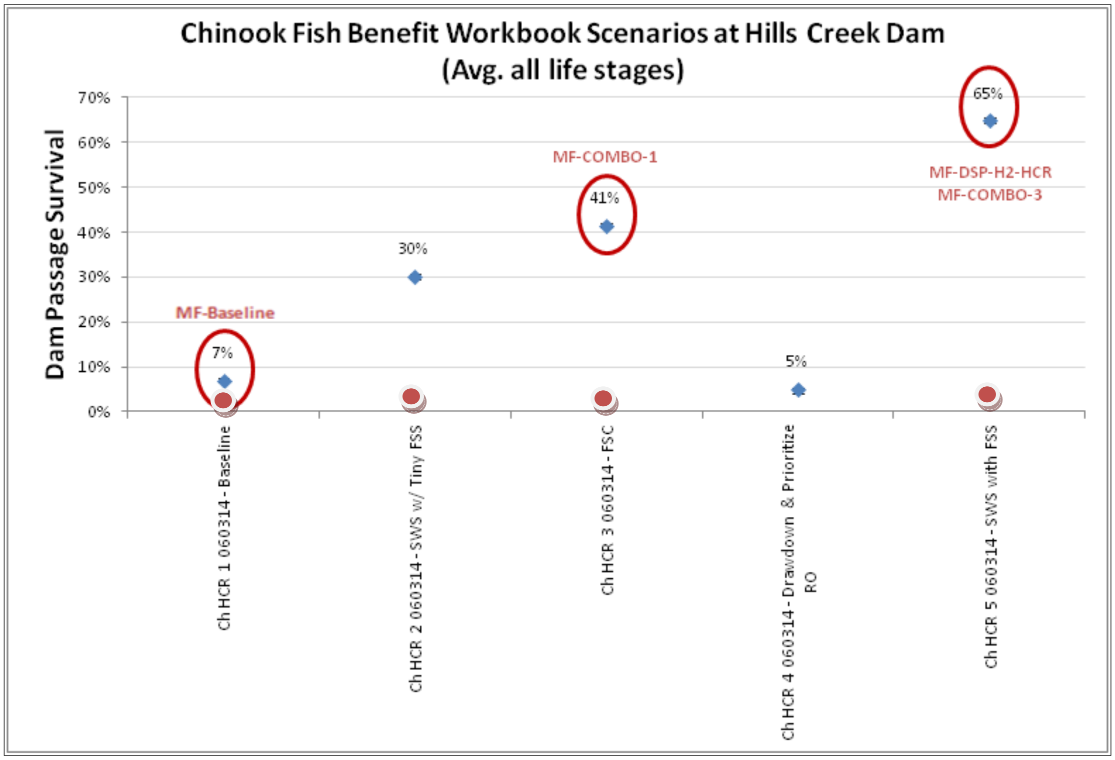


Identifies alternatives that were sent to SLAM.

Key: (Red highlighted cases are carried forward for final analyses.)

MF-TMP-01-LOP	=	Ch LOP 1 060314 – Operational Variation of MF-Baseline	(Operational)
MF-TMP-01-LOP	=	Ch LOP 1a 060314 – High Rereg (Ops. Variation of MF-Baseline)	(Operational)
MF -DSP-H1-LOP	=	Ch LOP 2 060314 – FSC (Part of MF-COMBO-2 and -3)	(Structural)
MF -DSP-H2-LOP	=	Ch LOP 3 060314 – SWS & FSS (Part of MF-COMBO-1)	(Structural)
MF -TMP-H1-LOP	=	Ch LOP 4 060314 – SWS	(Structural)
MF -DSP-04-LOP	=	Ch LOP 5 060314 – Delay Refill / RO	(Operational)
MF-Baseline	=	Ch LOP 6 060314 – Baseline w/ no temp ops	(IRRM Baseline)

Figure 3-33. Fish Benefits Workbook Results for Chinook at Hills Creek Dam



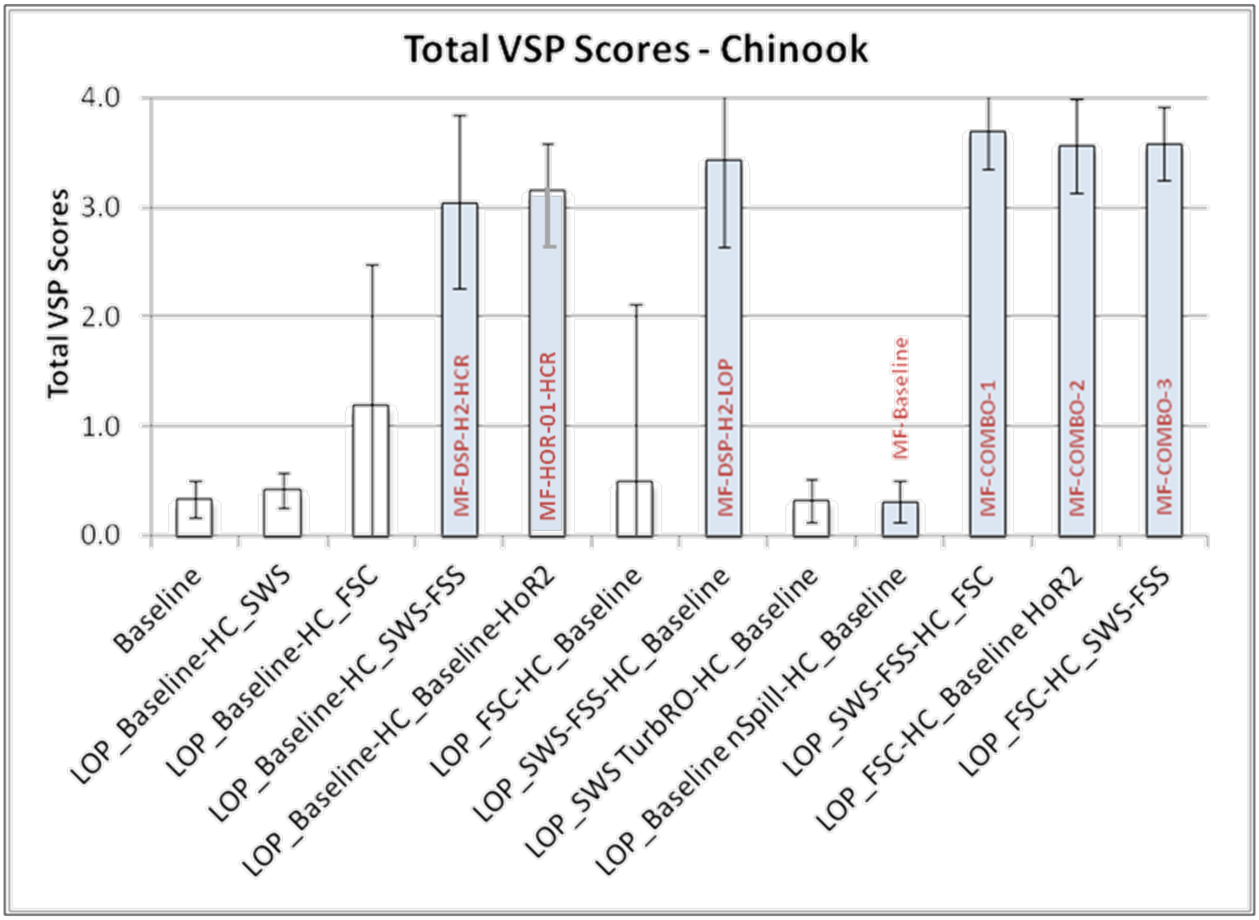
Identifies alternatives that were sent to SLAM

Key: (Red highlighted cases are carried forward for final analyses.)

MF-Baseline	=	Ch HCR 1 060314 – Baseline	(IRRM Baseline)
MF-TMP-H1-HCR	=	Ch HCR 2 060314 – SWS w/ Tiny FSS	(Structural)
MF -DSP-H1-HCR	=	Ch HCR 3 060314 – FSC	(Structural)
MF -DSP-03-HCR	=	Ch HCR 4 060314 – Drawdown & Prioritize RO	(Operational)
MF -DSP-H2-HCR	=	Ch HCR 5 060314 – SWS with FSS	(Structural)

Note that the Head or Reservoir alternative for Hills Creek, MF-HOR-01-HCR, is not plotted in the above Dam Passage Survival graph, although it is still evaluated in the FBW and passed to SLAM for analysis.

Figure 3-34. SLAM Results for Chinook in the Middle Fork Willamette Subbasin



Highlighted alternatives were included in the final system analysis.
Key: (Red highlighted cases are carried forward for final analyses.)

MF-Baseline	= FBW: Ch LOP 6 and Ch HCR 1	SLAM: Baseline
MF-TMP-H1-HCR	= FBW: Ch LOP 6 and Ch HCR 2	SLAM: LOP_Baseline-HC_SWS
MF -DSP-H1-HCR	= FBW: Ch LOP 6 and Ch HCR 3	SLAM: LOP_Baseline-HC_FSC
MF -DSP-H2-HCR	= FBW: Ch LOP 6 and Ch HCR 5	SLAM: LOP_Baseline-HC_SWS-FSS
MF-HOR-01-HCR	= FBW: Ch LOP 6 and HoR2 for HCR	SLAM: LOP_Baseline-HC_Baseline-HoR2
MF -DSP-H1-LOP	= FBW: Ch LOP 2 and Ch HCR 1	SLAM: LOP_FSC-HC_Baseline
MF -DSP-H2-LOP	= FBW: Ch LOP 3 and Ch HCR 1	SLAM: LOP_SWS-FSS-HC_Baseline
MF-TMP-H1-HCR	= FBW: Ch LOP 4 and Ch HCR 1	SLAM: LOP_SWS TurbRO-HC_Baseline
MF-Baseline	= FBW: Ch LOP 6 with spill and Ch HCR 1	SLAM: LOP_BaselinenSpill-HC_Baseline
MF-COMBO-1	= FBW: Ch LOP 3 and Ch HCR 3	SLAM: LOP_SWS-FSS-HC_FSC
MF-COMBO-2	= FBW: Ch LOP 2 and HoR2 for HCR	SLAM: LOP_FSC-HC_BaselineHoR2
MF-COMBO-3	= FBW: Ch LOP 2 and Ch HCR 5	SLAM: LOP_FSC-HC_SWS-FSS

Table 3-23. Summary of Replacement Analysis for Chinook

		AVE	Count > 1	Median	Percent Time >1	Percent Time >.95	Ave of Running Ave	Replacement Status
Above LOP - Below HCR	Baseline	14%	0	13%	0%	0%	13%	Does not meet
	MFR_LOP-Baseline-HC_SWS	14%	0	13%	0%	0%	13%	Does not meet
	MFR_LOP-Baseline-HC_FSC	22%	0	19%	0%	0%	21%	Does not meet
	MFR_LOP-Baseline-HC_SWS-FSS	101%	37	86%	38%	42%	96%	Does not meet
	MFR_LOP_Baseline-HC_Baseline-HoR2	Went to 0	0	N/A	0%	0%	N/A	Does not meet
	MFR_LOP_FSC-HC_Baseline	18%	0	17%	0%	0%	17%	Does not meet
	MFR_LOP_SWS-FSS-HC_Baseline-	106%	65	104%	65%	82%	101%	Meets replacement criteria
	MFR_LOP_SWS TurbRO-HC_Baseline	11%	0	10%	0%	0%	10%	Does not meet
	MFR_LOP_Baseline nSpill-HC_Baseline	8%	0	8%	0%	0%	8%	Does not meet
	MFR_LOP_SWS-FSS-HC_FSC	107%	73	104%	73%	86%	102%	Meets replacement criteria
	MFR_LOP_FSC-HC_Baseline HoR2	101%	58	102%	58%	73%	96%	Meets replacement criteria
	MFR_LOP_FSC-HC_SWS-FSS	102%	55	102%	54%	72%	98%	Meets replacement criteria
Above HCR	Baseline	1%	0	1%	0%	0%	1%	Does not meet
	MFR_LOP-Baseline-HC_SWS	3%	0	3%	0%	0%	3%	Does not meet
	MFR_LOP-Baseline-HC_FSC	77%	0	78%	0%	0%	74%	Does not meet
	MFR_LOP-Baseline-HC_SWS-FSS	107%	68	103%	68%	89%	102%	Meets replacement criteria
	MFR_LOP_Baseline-HC_Baseline-HoR2	108%	69	103%	68%	92%	103%	Meets replacement criteria
	MFR_LOP_FSC-HC_Baseline	24%	0	24%	0%	0%	23%	Does not meet
	MFR_LOP_SWS-FSS-HC_Baseline	Went to 0	0	N/A	0%	0%	N/A	Does not meet
	MFR_LOP_SWS TurbRO-HC_Baseline	1%	0	1%	0%	0%	1%	Does not meet
	MFR_LOP_Baseline nSpill-HC_Baseline	1%	0	1%	0%	0%	1%	Does not meet
	MFR_LOP_SWS-FSS-HC_FSC	106%	68	102%	68%	83%	101%	Meets replacement criteria
	MFR_LOP_FSC-HC_Baseline HoR2	111%	71	103%	70%	93%	105%	Meets replacement criteria
	MFR_LOP_FSC-HC_SWS-FSS	110%	66	104%	66%	90%	105%	Meets replacement criteria
Above FAL	Baseline	122%	68	112%	68%	71%	116%	Meets replacement criteria
	MFR_LOP-Baseline-HC_SWS	122%	64	113%	64%	68%	116%	Nearly meets replacement criteria
	MFR_LOP-Baseline-HC_FSC	123%	66	116%	66%	68%	118%	Nearly meets replacement criteria
	MFR_LOP-Baseline-HC_SWS-FSS	145%	67	118%	67%	71%	138%	Meets replacement criteria
	MFR_LOP_Baseline-HC_Baseline-HoR2	Went to 0	63	N/A	0%	0%	N/A	Does not meet
	MFR_LOP_FSC-HC_Baseline	42%	0	39%	0%	0%	40%	Does not meet
	MFR_LOP_SWS-FSS-HC_Baseline	138%	72	124%	72%	73%	132%	Meets replacement criteria
	MFR_LOP_SWS TurbRO-HC_Baseline	120%	69	114%	68%	70%	114%	Meets replacement criteria
	MFR_LOP_Baseline nSpill-HC_Baseline	119%	66	112%	66%	71%	113%	Meets replacement criteria
	MFR_LOP_SWS-FSS-HC_FSC	137%	72	123%	71%	72%	130%	Meets replacement criteria
	MFR_LOP_FSC-HC_Baseline HoR2	Went to 0	63	N/A	0%	0%	N/A	Does not meet
	MFR_LOP_FSC-HC_SWS-FSS	124%	70	115%	70%	77%	118%	Meets replacement criteria

See Section 2.5.2 for Replacement Criteria. Dark green meets criteria, light green nearly meets criteria, and white does not meet criteria

Table 3-24. Composite Summary of Replacement Analysis for Chinook

SLAM Run Name	Above LOP - Below HCR	Above HCR	Above FAL
Baseline (assumed temperature spill)	No	No	Meets
MFR_LOP-Baseline-HC_SWS	No	No	Nearly
MFR_LOP-Baseline-HC_FSC	No	No	Nearly
MFR_LOP-Baseline-HC_SWS-FSS	**NA**	**Meets**	**Meets**
MFR_LOP_Baseline-HC_Baseline-HoR2	NA	Meets	NA
MFR_LOP_FSC-HC_Baseline	No	No	No
MFR_LOP_SWS-FSS-HC_Baseline	**Meets**	**NA**	**Meets**
MFR_LOP_SWS TurbRO-HC_Baseline	No	No	Meets
MFR_LOP_Baseline nSpill-HC_Baseline (actual MF-Baseline)	**No**	**No**	**Meets**
MFR_LOP_SWS-FSS-HC_FSC	**Meets**	**Meets**	**Meets**
MFR_LOP_FSC-HC_Baseline HoR2	**Meets**	**Meets**	
MFR_LOP_FSC-HC_SWS-FSS	**Meets**	**Meets**	**Meets**

See Section 2.5.2 for Replacement Criteria. Dark green meets criteria, light green nearly meets criteria, and white does not meet criteria. Bold text and boxed red cases were carried forward for final analyses.

Key: (Red highlighted cases are carried forward for final analyses.)

Alternative ID		**SLAM Run ID**
MK-DSP-H2-HCR	=	SLAM: MFR_LOP-Baseline-HC_SWS-FSS
MK-DSP-H2-LOP	=	SLAM: MFR_LOP_SWS-FSS-HC_Baseline
MK-Baseline	=	SLAM: MFR_LOP_Baseline nSpill-HC_Baseline
MK-COMBO-1	=	SLAM: MFR_LOP- SWS-FSS-HC__FSC
MK-COMBO-2	=	SLAM: MFR_LOP_FSC-HC_Baseline HoR2
MK-COMBO-3	=	SLAM: MFR_LOP_FSC-HC_SWS-FSS

3.5.2.2. Non-Monetized Impacts

Table 3-25 summarizes the non-monetized impacts of all the assessed measures, regardless of whether or not they were carried forward for final analysis. Impacts were given a numerical value between 1 and 5 to indicate high negative impact (1) up to a high benefit (5). Biological benefits are also summarized including impacts to residential fish, Oregon chub and bull trout.

Table 3-25. Summary of Results for Middle Fork Willamette Subbasin Alternatives

Alternative ID and Description (Bold denotes alternatives carried forward for final analysis)	Anadromous Fish				Resident Fish			Flood Risk Management	Meeting Downstream Tributary Flows	Meeting Mainstem Flows	Reservoir Recreation	River Recreation	Water Supply-M&I and Irrigation		Constructability	Implementation Timing	Clean Water Act (TDG)	Temperature
	FBW Avg. score [%]		VSP Score	Confidence Level	Impact		Confidence Level											
	Hills Creek	Lookout Point	Chinook		Bull Trout	Oregon Chub		Yes/No Impact					Current Demand	Future (2050) Demand				
									1=High Negative Impact; 2=Moderate Negative Impact; 3= Low to No Negative/Positive Impact; 4=Moderate Positive Impact; 5=High Positive Impact									
MF-Baseline	7	14	0.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MF-DSP-01-FAL: Operational – Deeper Drawdown of Fall Creek/RO Priority with New Adult Collection Facility	--	--	--	--	NA	N	M	N	2	2	2	3	3	2	3	3	3	3
MF-HOR-01-HCR: Head of Reservoir (HOR) Collection in Tributary	NM	NM	3.1	L	N	NA	M	N	3	3	3	3	3	3	1	1	3	3
MF-COMBO-1 HCR: Floating Surface Collector (FSC) & LOP Selective Withdrawal Structure (SWS) w/ Floating Screen Structure (FSS)	41	64	3.7	L	0/P	P	M/M	N	3	3	3	3	3	3	1	1	3	5
MF-COMBO-2: HCR HOR Collector and LOP FSC)	--	42	3.6	L	N	0	M/H	N	3	3	3	3	3	3	1	1	3	3
MF-COMBO-3: HCR SWS and FSS with LOP FSC	65	42	3.6	L	P	P	M/M	N	3	3	3	3	3	3	1	1	3	5
MF-DSP-H2-HCR: Hills Creek SWS with FSS	65	--	3.1	L	P	P	M/M	N	3	3	3	3	3	3	1	1	3	5
MF-DSP-H2-LOP: Lookout Point SWS with FSS	--	64	3.4	L	0/P	P	M/M	N	3	3	3	3	3	3	1	1	3	5

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact); Color coding = Red (high/moderate negative impact), Green (high/moderate positive impact).

Table 3-25 (continued). Summary of Results for Middle Fork Willamette Subbasin Alternatives

Alternative ID and Description	Anadromous Fish				Resident Fish			Flood Risk Management	Meeting Downstream Tributary Flows	Meeting Mainstem Flows	Reservoir Recreation	River Recreation	Water Supply-M&I and Irrigation		Constructability	Implementation Timing	Clean Water Act (TDG)	Temperature
	FBW Avg. score [%]		VSP Score	Confidence Level	Impact		Confidence Level											
	Hills Creek	Lookout Point	Chinook		Bull Trout	Oregon Chub		Yes/No Impact	1=High Negative Impact; 2=Moderate Negative Impact; 3= Low to No Negative/Positive Impact; 4=Moderate Positive Impact; 5=High Positive Impact				Current Demand	Future (2050) Demand				
MF-DSP-01-HCR: Operational – Hills Creek RO Priority in Winter	NM	NM	NM	--	0	0	L/H	N	3	3	3	3	3	3	3	3	3	3
MF-DSP-02-HCR: Deeper Drawdown of Hills Creek/RO Priority	Not fully assessed – alternative replaced with one that provides less deep passage route.																	
MF-DSP-03-HCR: Operational- Drawdown to El. 1428 ft with RO Priority	5	--	NM	--	N	0	M/H	N	2	3	-	3	3	3	3	3	3	3
MF-DSP-H1-HCR: Downstream Passage with FSC	41	--	1.2	L	0/P	0	M/H	N	3	3	3	3	3	3	1	1	3	3
MF-DSP-01-LOP: Operational-Operate to Reduce Predation	NM	NM	NM	--	0	0	M/H	N	3	3	-	3	3	2	3	3	3	3
MF-DSP-02-LOP: Operational-Lookout Point RO Priority in Winter	NM	NM	NM	--	0	0	M/H	N	3	3	3	3	3	3	3	3	3	3
MF-DSP-03-LOP: Operational-Deeper Drawdown of Lookout Point/RO Priority	NM	NM	NM	--	0	N	L/H	N	1	1	3	3	2	2	3	3	3	3
MF-DSP-04-LOP: Operational-Delayed Refill of Lookout Point/RO Priority	--	13	NM	--	0	N	M/H	N	1	1	-	3	2	1	3	3	3	1
MF-DSP-05-LOP: Operational-Lookout Point as Run-of-River/RO Priority	NM	NM	NM	--	0	N	L/H	N	1	1	2	3	2	1	3	3	3	4
MF-DSP-06-LOP: Operational-Operate at Minimum Conservation Pool Year-round except for Floods	NM	NM	NM	--	0	N	M/H	N	1	1	-	3	2	1	3	3	3	1
MF-DSP-H1-LOP: Downstream Passage-FSC at Lookout Point	--	42	0.5	L	0	0	M/H	N	3	3	3	3	3	3	1	1	3	3
MF-DSP-01-DEX: Operational-Operate Dexter Powerhouse within 1% Peak Efficiency	Not fully assessed - limited flexibility of Dexter's single turbine and impacts spawning Chinook																	

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact); Color coding = Red (high/moderate negative impact), Green (high/moderate positive impact).

Table 3-25 (continued). Summary of Results for Middle Fork Willamette Subbasin Alternatives

Alternative ID and Description	Anadromous Fish				Resident Fish			Flood Risk Management					Water Supply- M&I and Irrigation					
	FBW Avg. score [%]		VSP Score		Impact													
	Hills Creek	Lookout Point	Chinook	Confidence Level	Bull Trout	Oregon Chub	Confidence Level	Yes/No Impact	Meeting Downstream Tributary Flows	Meeting Mainstem Flows	Reservoir Recreation	River Recreation	Current Demand	Future (2050) Demand	Constructability	Implementation Timing	Clean Water Act (TDG)	Temperature
MF-HOR-02-HCR: HOR in Hills Creek Reservoir	NM	NM	NM	--	N	NA	M	N	3	3	3	3	3	3	1	1	3	3
MF-HOR-01-LOP: HOR in Lookout Point Reservoir	NM	NM	NM	--	0/N	0	M/H	N	3	3	3	3	3	3	1	1	3	3
MF-HOR-02-LOP: HOR in Tributary	NM	NM	NM	--	0/N	0	M/H	N	3	3	3	3	3	3	1	1	3	3
MF-HOR-01-FAL: HOR in Tributary	NM	NM	NM	--	NA	0	H	N	3	3	3	3	3	3	1	1	3	3
MF-HOR-02-FAL: HOR in Fall Creek Reservoir	NM	NM	NM	--	NA	0	H	N	3	3	3	3	3	3	1	1	3	3
MF-TMP-H1-HCR: Temperature Control Improvement - SWS	30	--	0.4	L	P	P	M/M	N	3	3	3	3	3	3	1	1	3	5
MF-TMP-M1-LOP: Temperature Control Moderate Improvement	--	20	0.3	L	0/P	P	H/M	N	3	3	3	3	3	3	3	3	3	4
MF-TMP-H1-LOP: Temperature Control Improvement - SWS	--	20	0.3	L	0/P	P	H/M	N	3	3	3	3	3	3	1	1	3	5
MF-TMP-M1-FAL: Temperature Control Moderate Improvement	NM	NM	NM	--	0/P	P	M	N	1	1	1	3	2	1	3	3	3	4
MF-TDG-M1-LOP: TDG Operational Improvement	Not fully assessed – limited benefits of slight TDG improvement.																	
MF-TDG-H1-DEX: TDG Structural Improvement	NM	NM	NM	--	0	P	H/M	N	3	3	3	3	3	3	2	2	5	3
MF-ACH-H1-DEX: New Adult Collection Facility at Dexter	NM	NM	NM	--	0/P	0	M/H	N	3	3	3	3	3	3	2	2	3	3

Scale (columns Meeting Downstream Tributary Flows through Temperature): 1=High Negative Impact; 2=Moderate Negative Impact; 3= Low to No Negative/Positive Impact; 4=Moderate Positive Impact; 5=High Positive Impact

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact); Color coding = Red (high/moderate negative impact), Green (high/moderate positive impact).

3.5.3. Middle Fork Willamette Alternatives Carried Forward for Final System Analysis

In addition to the MF-Baseline, seven alternatives (MF-DSP-01-FAL, MF-HOR-01-HCR, MF-COMBO-1, MF-COMBO-2, MF-COMBO-3, MF-DSP-H2-HCR and MF-DSP-H2-LOP) met replacement criteria and were carried forward for inclusion in the system analysis. These alternatives are described below with more detailed information included in Appendix D.

3.5.3.1. MF-DSP-01-FAL: Operational – Deeper Drawdown of Fall Creek/RO Priority with New Adult Collection Facility at Fall Creek

The deep drawdown operation was carried forward for final analysis as it would continue to provide downstream passage benefits in the Fall Creek subbasin. This operation has been successfully implemented for several years and is estimated to meet replacement. This alternative would continue to draft Fall Creek reservoir to a deeper elevation than what is specified in the water control manual. The reservoir would be held at the deeper elevation of 685 feet from November through February, except during flood events, to improve fish passage and survival during migration.

The adult collection facility will provide improvements for upstream passage in the Fall Creek subbasin. When Fall Creek Dam was constructed, an adult fish collection system was included. The existing fish facility was not designed to handle ESA-listed fish and needs to be upgraded to improve conditions for these fish and allow for safe sorting and transport, while managing the other species (often concurrently). The existing facility does not have suitable facilities for holding fish following sorting. In addition, the hopper and truck loading system does not provide a water-to-water transfer of adults from the hopper to the transport truck. The new facility should minimize stress on the fish, provide safe sorting, transport and holding of fish, provide a safe and reliable water supply, and provide safe working conditions for employees. It is assumed that a new adult collection facility would not impact reservoir elevation or project outflows and result in less pre-spawning mortality for fish.

With this alternative, downstream fish passage survival is expected to improve but it was not modeled with the FBW. Adult Chinook returns increased after the drawdown operation was resumed in 2008, and appear to be close to meeting cohort replacement. An analysis is planned to summarize Fall Creek Chinook demographics for recent years, which will confirm if the population is meeting replacement in recent years.

A lack of winter storage can result in missing the incubation flow targets in some years below Fall Creek Dam. Water stored in Fall Creek is used to meet mainstem flow targets. This operation should not affect current flows, but there may be future impacts if refill is negatively affected; degree of impact would depend upon future M&I demands. Based on limited historical data, this would likely create downstream TDG that exceeds the state water quality standard. However, these exceedances would not be expected to be greater than what dam operations typically produce. Water temperatures should not be negatively impacted by this operation since release temperatures would be uniform regardless of where or how water is released from the dam. There should be no changes from baseline for the other non-monetized impact categories.

3.5.3.2. MF-HOR-01-HCR: Head of Reservoir Collector in Tributary

This alternative was carried forward for final analysis as it provided downstream passage benefits in the Middle Fork subbasin that met replacement. This alternative involves HOR collectors located in Middle Fork Willamette tributaries above the maximum reservoir pool elevation at Hills Creek and designed to collect a portion of downstream migrating juveniles. Depending on the capture efficiency requirements for the collector, the concept designs could range from a well-placed screw trap, to a diversion capturing a significant portion of river flow, to a barrier dam. All capture systems would likely incorporate a screen system to remove the fish from a majority of the flow. Captured fish would need to be kept in a holding pond or attached live box before being transported. The most likely form of transportation would either be by truck or by a pipeline downstream of the dam(s). Once collected, juvenile fish could be transported around the dam(s) to a downstream release site, or transported to a dam bypass system. It is assumed that a tributary head of reservoir collector would not impact reservoir elevations or project outflows.

Constructability and implementation timing impacts would be high because HOR collectors are complex and require multiple engineering disciplines for design. A HOR structure has added complexity due to high reservoir fluctuations (for an in-reservoir structure), highly variable stream flows, and high debris loading. This alternative would not impact reservoir elevations or outflows, so would not affect TDG or water temperatures. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, Chinook downstream fish passage survival is expected to improve but it was not modeled with the FBW. Chinook population viability is expected to improve from a VSP of 0.3 to 3.1 if the downstream fish passage assumptions are achieved. However it is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival). These uncertainties would be similar to those discussed for the Green Peter Dam HOR collector (Section 3.3.3.5).

Biological Modeling Assumptions: The FBW tool was not configured to simulate a head of reservoir collector, so it was modeled within SLAM. In SLAM the head of reservoir structure was assumed to have an 80% DPE and a 90% survival. The alternative assumed juvenile collection and transportation around the dams, which avoided putting fish in the reservoir (and subjecting them to reservoir mortality). It is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile collection efficiency, passage survival, and post-release survival).

In a separate effort from the COP, head-of-reservoir fish collection was evaluated for Chinook in the Middle Fork Willamette as an alternative for improving downstream fish passage around Corps dams in that drainage (CH2M Hill, 2011). A total of 28 HOR and in-tributary conceptual alternatives were evaluated as part of this study, and performance information for similar facilities was summarized. The report recommended two alternatives for further study and evaluation: (1) a FSC located in the upper reservoir, and (2) an in-tributary off-channel collection facility located on the lower North Fork River at Westfir. Given the significant risks and uncertainties associated with both alternatives, the report recommended that a RM&E program be undertaken prior to preliminary design of a selected alternative to minimize the identified risks and uncertainties. Unknowns documented include the ability to successfully collect and transport fry, the effect of reservoir conditions on juveniles (a benefit or detriment), and the ability to achieve biological performance criteria (which have yet to be defined). The Corps concluded that more research was needed before further investing in this concept, in particular reservoir survival of juvenile Chinook.

Head-of-reservoir fish collectors, placed in the reservoir, were also recommended in Green Peter reservoir in the South Santiam Fishery Restoration Draft Reconnaissance Study (Corps 1995). However, since these were concepts as evaluated in the subject report, specific data on actual performance was not available.

3.5.3.3. MF-COMBO-1: HCR Floating Surface Collector and LOP Selective Withdrawal Structure with Floating Screen Structure

This alternative was carried forward for final analysis as it provided temperature and downstream passage benefits in the Middle Fork subbasin that met replacement. This combination would utilize a FSC at Hills Creek and a SWS and FSS at Lookout Point to improve temperatures below Dexter and downstream fish passage at Hills Creek and Lookout Point dams (Figure 3-35 and Figure 3-36).

Constructability and implementation timing impacts would be high because HOR collectors are complex and require multiple engineering disciplines for design. This alternative would not impact reservoir elevations or outflows, so would not affect TDG. A benefit for temperature management is expected because a structural alternative would be capable of selecting water from multiple depths to more closely match the historical, natural temperature regime, however temperature targets may not be met at all times due to the temperatures available in LOP reservoir during summer and early fall. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, Chinook downstream fish passage survival is expected to improve from 7% to 41% at Hills Creek and from 14% to 64% at Lookout Point. Chinook population viability is expected to improve from a VSP of 0.3 to 3.7.

Biological Modeling Assumptions: This alternative would result in self-sustaining populations of spring Chinook above Lookout Point Dam based on the improvements assumed for downstream fish passage. However, it is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival). These uncertainties would be similar to those discussed for Detroit FSO-FSC and the Detroit FSS (Section 3.2.3).

The FSS at Lookout Point is assumed to increase overall Chinook DPE from 52% to 69% based on professional opinion and Detroit data collected by Beeman in 2013. The FSC at Hills Creek is assumed to increase overall Chinook DPE from 18% to 71%. Authors assume the FSS will result in improved DPE values equivalent estimates at Detroit, and it is assumed DPE will remain constant regardless of reservoir elevation, temperature, or timing based on professional opinion since the structure will fluctuate with the pool and remain as a surface outlet.

The Lookout Point FSS is assumed to have a passage survival greater than 98% if NOAA design principles are applied, based on similar structures in the Northwest (see section 2.5.5).

Figure 3-35. Hills Creek FSC for MF-COMBO-1

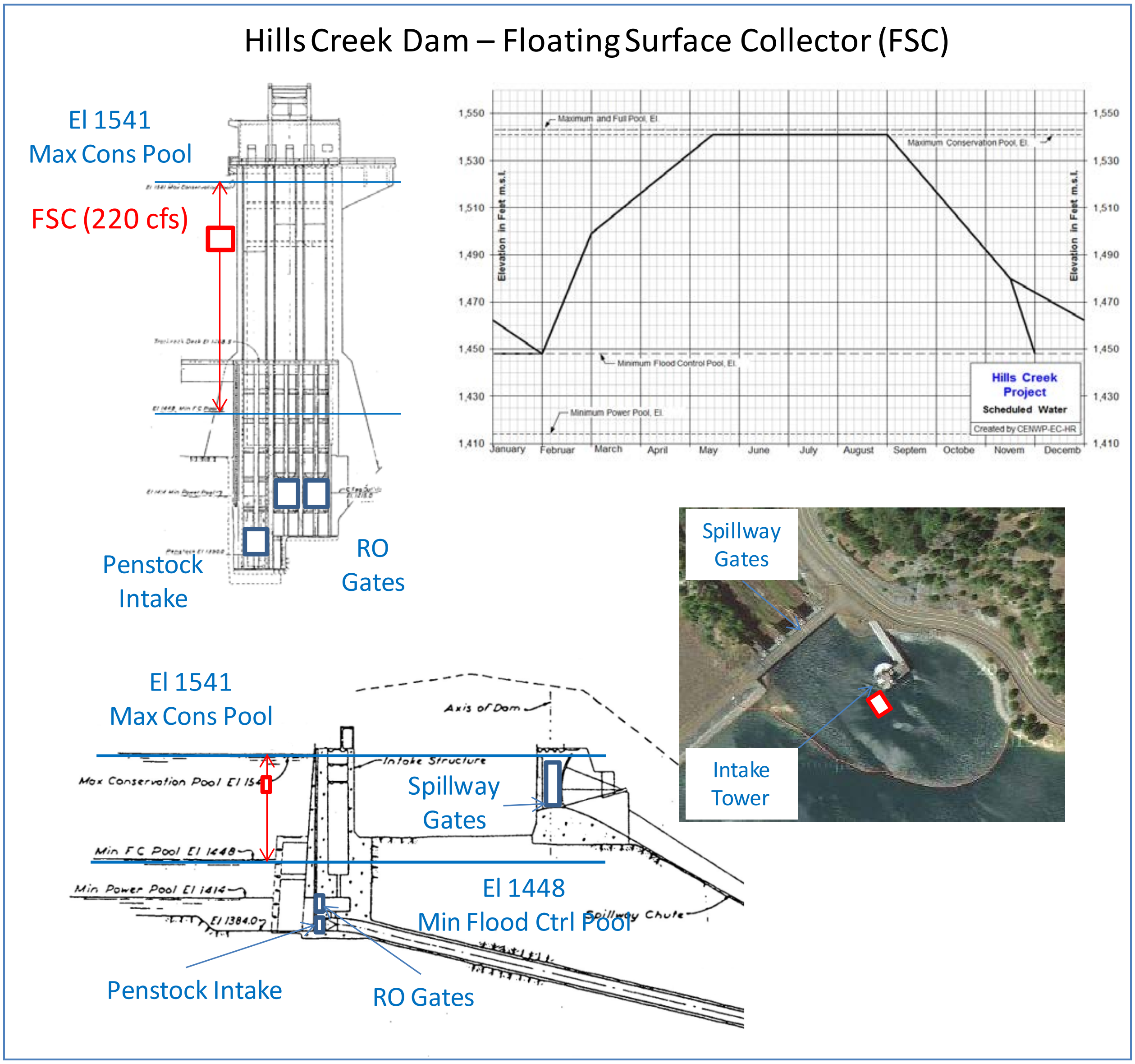
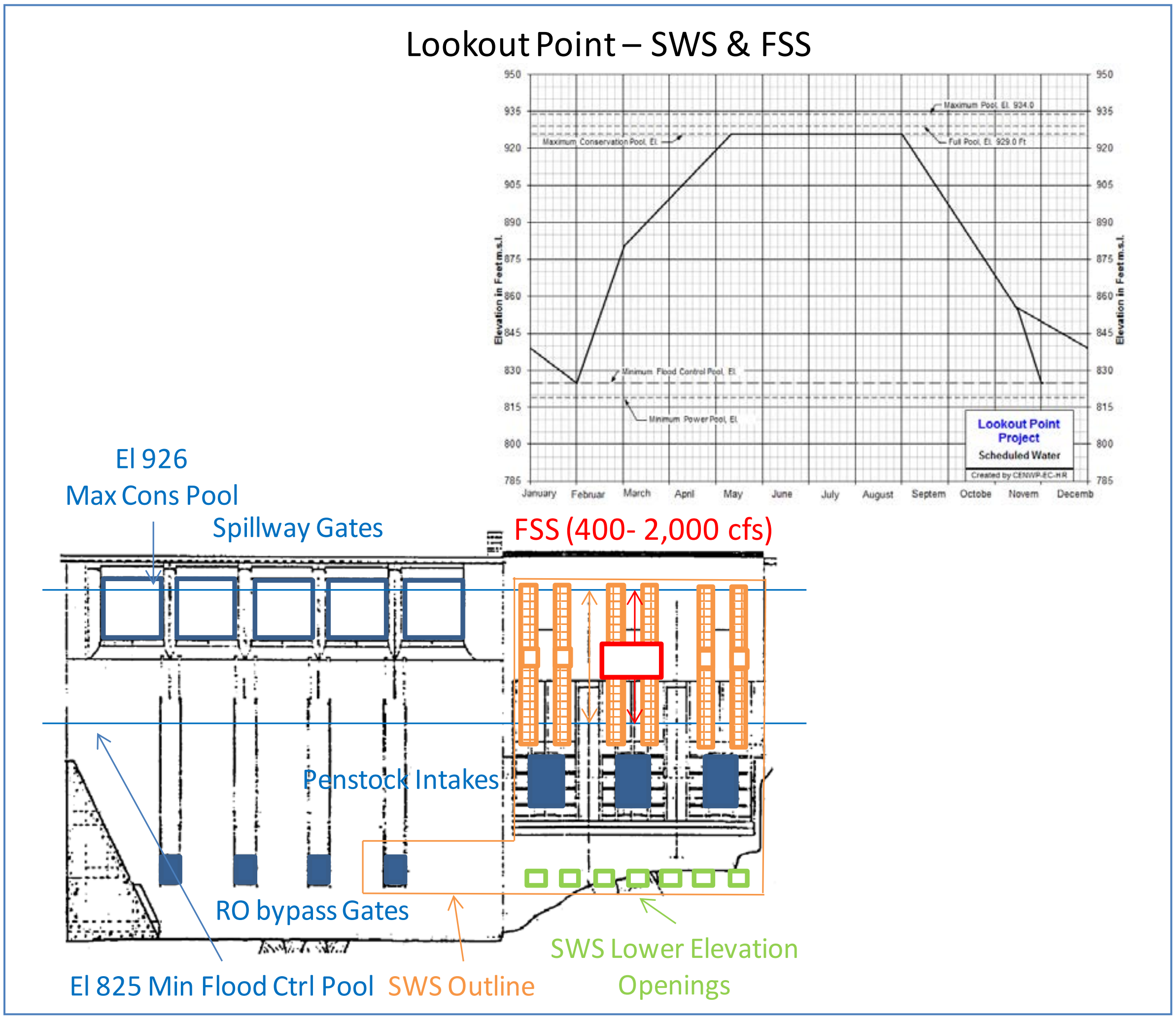


Figure 3-36. Lookout Point SWS and FSS for MF-COMBO-1



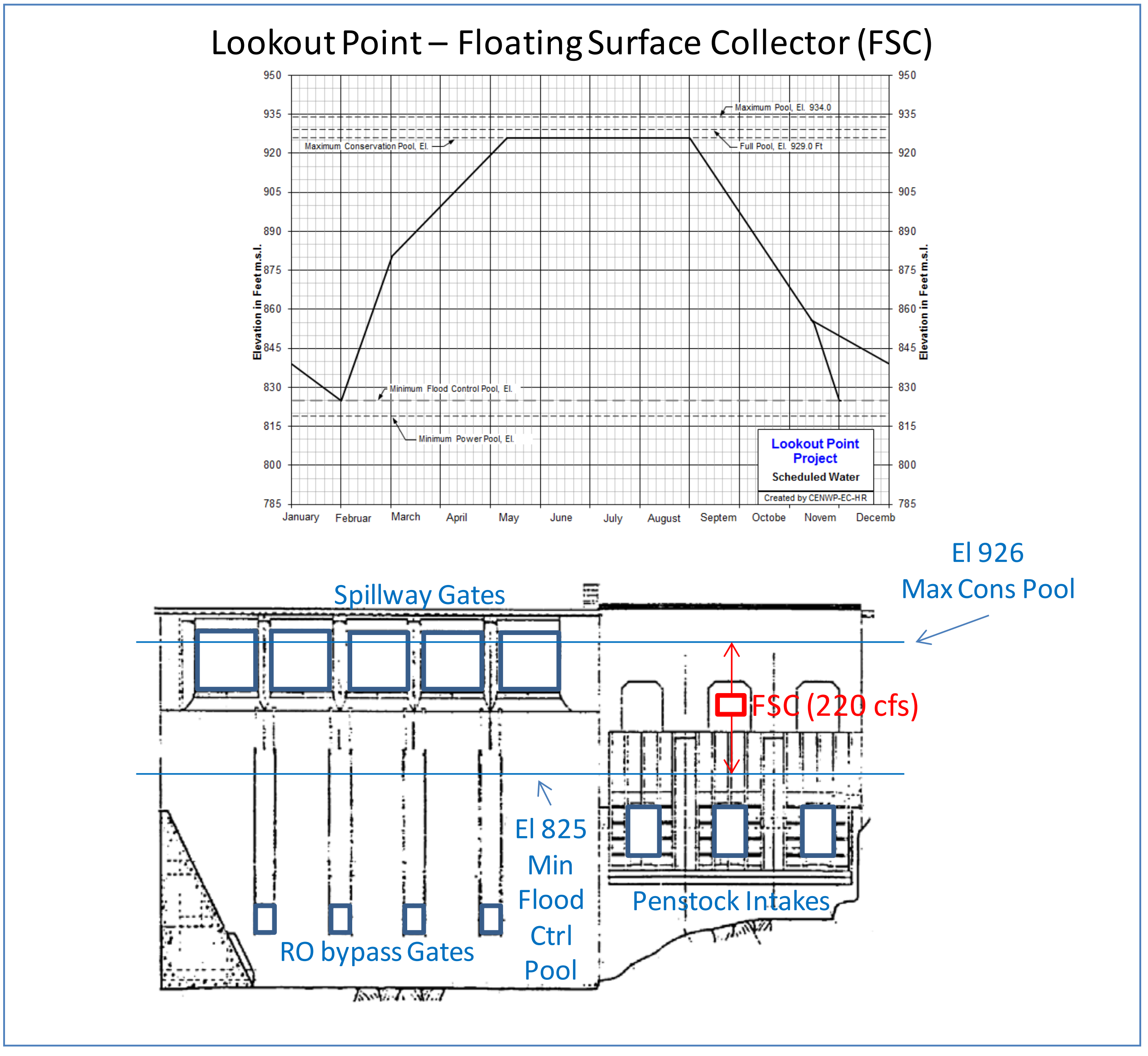
3.5.3.4. MF-COMBO-2: Hills Creek HOR Collector and Lookout Point FSC

This alternative was carried forward for final analysis as it provided downstream passage benefits in the Middle Fork subbasin that met replacement. This combination would utilize a HOR collector in Hills Creek reservoir and a FSC at Lookout Point (Figure 3-37) to improve downstream fish passage at Hills Creek and Lookout Point dams.

With this alternative, Chinook downstream fish passage survival is expected to improve from 14% to 42% at Lookout Point, and Chinook population viability is expected to improve from a VSP of 0.3 to 3.6. However, it is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival). These uncertainties would be similar to those discussed for Detroit FSO-FSC (Section 3.2.3) the Green Peter Dam HOR collector (Section 3.3.3.5), and the Hills Creek HOR collector (Section 3.5.3.2).

Biological Modeling Assumptions: The FBW tool was not configured to simulate a head of reservoir collector, so it was modeled within SLAM. In SLAM the head of reservoir structure was assumed to have an 80% DPE and a 90% survival. The confidence in achieving 80% DPE is low, since this assumption has not been directly tested, and no examples of the scope and scale envisioned for the Middle Fork Willamette are available for comparison. The alternative assumed juvenile collection and transportation around the dams, which avoided putting fish in the reservoir (and subjecting them to reservoir mortality).

Figure 3-37. Lookout Point FSC for MF-COMBO-2

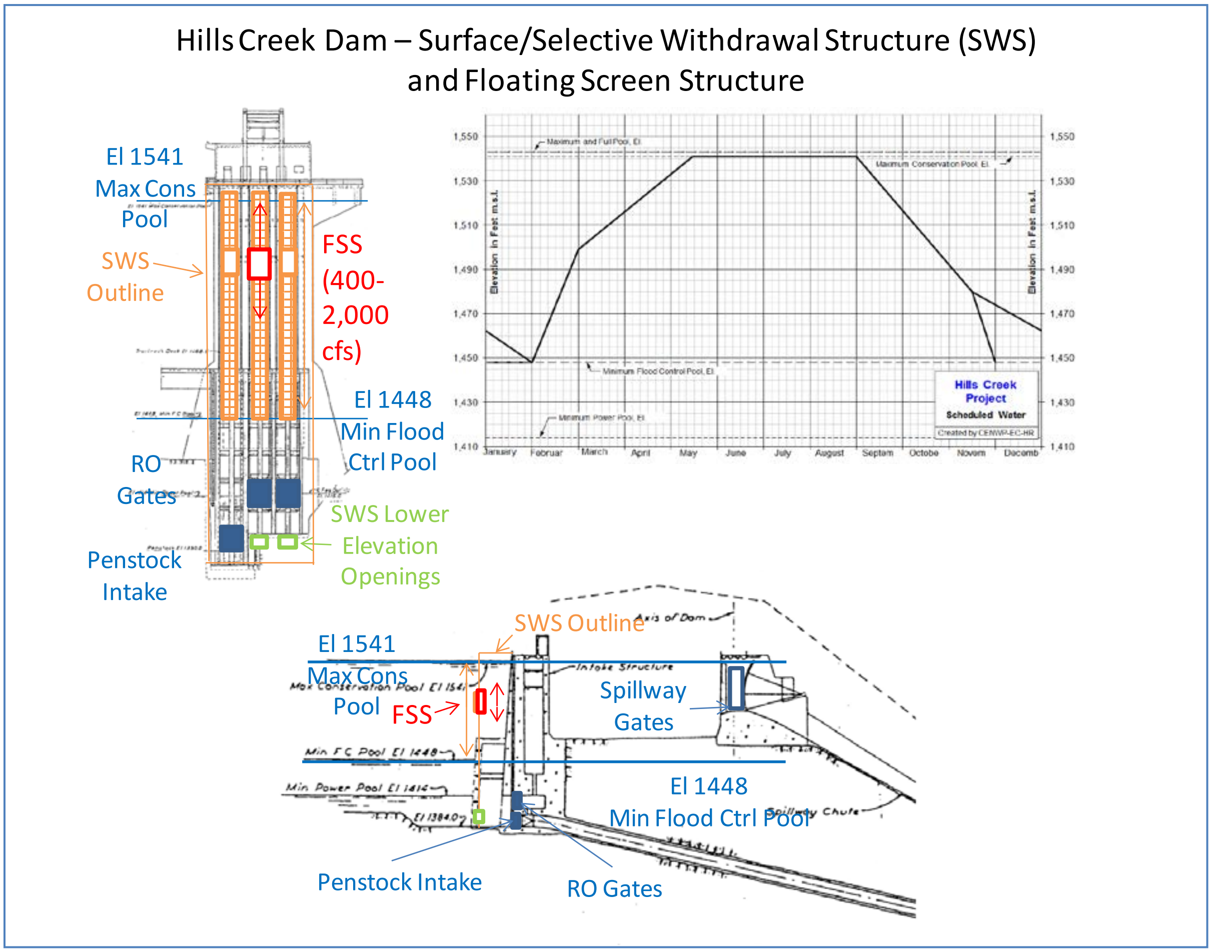


Constructability and implementation timing impacts would be high because HOR collectors are complex and require multiple engineering disciplines for design. Downstream passage structures in the reservoir have added difficulty due to the large reservoir fluctuations. This alternative would not impact reservoir elevations or outflows, so would not affect TDG and temperatures. There should be no changes from baseline for the other non-monetized impact categories.

3.5.3.5. MF-COMBO-3: Hills Creek SWS and FSS with Lookout Point FSC

This alternative was carried forward for final analysis as it provided temperature and downstream passage benefits in the Middle Fork subbasin that met replacement. This combination would utilize an SWS and a FSS at Hills Creek and a FSC at Lookout Point to improve temperatures in the Middle Fork and provide downstream passage at Hills Creek and Lookout Point dams (Figure 3-38).

Figure 3-38. Hills Creek SWS and FSS



Constructability and implementation timing impacts would be high because downstream fish passage and temperature control structures are complex and require multiple engineering disciplines for design. Structures at Hills Creek have added complexity due to large reservoir fluctuations. This alternative would not impact reservoir elevations or outflows, so would not affect TDG. A benefit for temperatures is expected because a structural alternative would be capable of selecting water from multiple depths to more closely match the historical, natural temperature regime. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, Chinook downstream fish passage survival is expected to improve from 7% to 65% at Hills Creek and from 14% to 42% at Lookout Point. Chinook population viability is expected to improve from a VSP of 0.3 to 3.6.

Biological Modeling Assumptions: It is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival). These uncertainties would be similar to those discussed for Detroit FSO-FSC and the Detroit FSS (Section 3.2.3).

The FSC at Lookout Point is assumed to increase overall Chinook DPE from 52% to 69% based on professional opinion and Detroit data collected by Beeman in 2013. The FSS at Hills Creek is assumed to increase overall Chinook DPE from 18% to 71%. Authors assume the FSS will result in improved DPE values equivalent to estimates at Detroit, and it is assumed DPE will remain constant regardless of reservoir elevation, temperature, or timing based on professional opinion since the structure will fluctuate with the pool and remain as a surface outlet.

The Lookout Point FSC and Hills Creek FSS is assumed to have a passage survival greater than 98% if NOAA design principles are applied, based on similar structures in the Northwest (see section 2.5.5).

3.5.3.6. MF-DSP-H2-HCR: Hills Creek SWS with FSS

This alternative was carried forward for final analysis as it provided temperature and downstream passage benefits in the Middle Fork subbasin that met replacement. This alternative involves construction of an SWS for temperature control and installing a guide or track to allow a FSS to travel up and down along the upstream face of the SWS as reservoir elevation changes. Flow entering the FSS would be passed through a v-screen, with fish and a small percentage of flow bypassing the screens through a bypass conduit at downstream end of the screens. Based on preliminary temperature modeling, it is estimated that the FSS would handle surface flow ranging from 400 cfs to 2,000 cfs. Captured fish would be kept in an attached live box before being transported. The most likely forms of transportation would be by truck or by a pipeline downstream of the dam(s). Once collected, juvenile fish could be transported around the dam(s) to a downstream release site or transported to a dam bypass system. The FSS would screen fish from the surface and once collected, the fish would be transported downstream. The FSS would have a common wet well that covers the penstock intakes, telescoping weirs for warm surface water and lower fixed elevation openings for cooler water. A conduit would be provided to route temperature flow through the upper ROs.

Constructability and implementation timing impacts would be high because downstream fish passage and temperature control structures are complex and require multiple engineering disciplines for design. Structures at Hills Creek have added complexity due to large reservoir fluctuations. This alternative would not impact reservoir elevations or outflows, so would not affect TDG. A high benefit for temperatures is expected because a structural alternative would be capable of selecting water from multiple depths to more closely match the historical, natural temperature regime. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, Chinook downstream fish passage survival is expected to improve from 7% to 65%, and Chinook population viability is expected to improve from a VSP of 0.3 to 3.1.

Biological Modeling Update: It is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival). These uncertainties would be similar to those discussed for Detroit FSO-FSC and the Detroit FSS (Section 3.2.3).

The FSS at Hills Creek is assumed to increase overall Chinook DPE from 18% to 71%. Authors assume the FSS will result in improved DPE values equivalent to estimates at Detroit, and it is assumed DPE will remain constant regardless of reservoir elevation, temperature, or timing based on professional opinion since the structure will fluctuate with the pool and remain as a surface outlet.

The Hills Creek FSS is assumed to have a passage survival greater than 98% if NOAA design principles are applied, based on similar structures in the Northwest (see section 2.5.5).

3.5.3.7. MF-DSP-H2-LOP: Lookout Point Selective Withdrawal Structure with Floating Screen Structure

This alternative was carried forward for final analysis as it provided temperature and downstream passage benefits in the Middle Fork subbasin that met replacement. This alternative assumes the construction of a SWS for temperature control, and involves installing a guide or track to allow a FSS to travel up and down along the upstream face of the SWS as the reservoir elevation changes. Flow entering the FSS would be passed through a v-screen, with fish and a small percentage of the flow bypassing the screens through a bypass conduit at the downstream end of the screens. Based on preliminary temperature modeling, it is estimated that the FSS would handle surface flow ranging from 400 cfs up to 2,000 cfs. Captured fish would be kept in an attached live box before being transported. The most likely form of transportation would either be by truck, or by a pipeline downstream of the dam(s). Once collected, juvenile fish could be transported around the dam(s) to a downstream release site, or transported to a dam bypass system. For this alternative, two parallel 1,000 cfs collectors were assumed and a 3.7 ft/s entrance velocity to match FSC values. Assumptions include a 15-foot draft; thus, a total width of 36 feet.

Constructability and implementation timing impacts would be high because downstream fish passage and temperature control structures are complex and require multiple engineering disciplines for design. Structures at Lookout Point have added complexity due to large reservoir fluctuations. This alternative would not impact reservoir elevations or outflows, so would not affect TDG. A high benefit for temperatures is expected because a structural alternative would be capable of selecting water from multiple depths to more closely match the historical, natural temperature regime. There should be no changes from baseline for the other non-monetized impact categories.

With this alternative, Chinook downstream fish passage survival is expected to improve from 14% to 64%, and Chinook population viability is expected to improve from a VSP of 0.3 to 3.4.

Biological Modeling Update: It is important to recognize the uncertainty in assumptions for downstream passage (specifically concerning juvenile reservoir survival, collection efficiency, and passage survival). These uncertainties would be similar to those discussed for the Detroit FSS (Section 3.2.3).

The FSS at Lookout Point is assumed to increase overall Chinook DPE from 52% to 69% based on professional opinion and Detroit data collected by Beeman in 2013. Authors assume the FSS will result in improved DPE values equivalent estimates at Detroit, and it is assumed DPE will remain constant regardless of reservoir elevation, temperature, or timing based on professional opinion since the structure will fluctuate with the pool and remain as a surface outlet.

The Lookout Point FSS is assumed to have a passage survival greater than 98% if NOAA design principles are applied, based on similar structures in the Northwest (see section 2.5.5).

3.5.4. Monetized Costs and Impacts

Several facets of the alternative costs were estimated. Those included CRFM costs such as design, construction, EDC and S&A, project first costs, O&M as well as a total life-cycle cost (low, most likely and high). Additionally, forgone hydropower was estimated to assess impacts to other project purposes. A contingency factor (up to 50%) was included for all CRFM and O&M costs and costs with contingency are represented in Table 3-26.

Table 3-26. Summary of Monetized Costs and Impacts for Middle Fork Willamette Alternatives

Alternative ID and Description	US $1,000,000 (present value, 50-year life, 2014 dollars) with 50% Cost Contingency (except MF-DSP-01-FAL)									
	Design	Con-struc-tion	EDC + S&A Cost	Project First Cost	Annual O&M Cost	PV:O&M Cost @ 4%	Life-cycle Low	Life-cycle[1,2] Most Likely	Life-cycle High	Lost Hydro-power
MF-Baseline	--	--	--	--	--	--	--	--	--	--
MF-DSP-01-FAL: Operational – Deeper Drawdown of Fall Creek/RO Priority with New Adult Collection Facility	7	12	2	21	0	2	17	23	40	0
MF-HOR-01-HCR: Head of Reservoir (HOR) Collection in Tributary	39	255	49	343	1	17	270	360	630	0
MF-COMBO-1 HCR: Floating Surface Collector (FSC) & LOP Selective Withdrawal Structure (SWS) w/ Floating Screen Structure (FSS)	69	263	49	382	2	44	320	425	744	2
MF-COMBO-2: HCR HOR Collector and LOP FSC)	61	323	62	446	2	48	371	494	864	0
MF-COMBO-3: HCR SWS and FSS with LOP FSC	68	245	47	359	2	43	302	401	702	2
MF-DSP-H2-HCR: Hills Creek SWS with FSS	45	177	33	255	1	12	201	267	468	2
MF-DSP-H2-LOP: Lookout Point SWS with FSS	45	165	33	243	1	12	192	255	447	2

[1] Life-cycle costs include project first costs plus the present value of O&M.
[2] The costs above were developed during early alternative evaluations within sub-basins. The alternatives carried forward into the recommended option have updated cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

3.5.5. Middle Fork Results Summary

The COP team summarized all the biological, technical and economic information for a range of alternatives into a single table (Table 3-27). A cost-effectiveness factor is estimated for all alternatives. The SWS-FSS alternatives, MF-DSP-H2-HCR and MF-DSP-H2-LOP, were the most cost-effective alternatives in the Middle Fork. All Middle Fork alternatives at Lookout Point and Hills Creek have low confidence. Effects on chub and Bull Trout are summarized in the table.

A high biological confidence value was given to MF-DSP-01-FAL, Operational Drawdown of Fall Creek/RO Priority since adult returns have increased and appear stable since this operation was resumed in 2009. All other alternatives were given a low biological confidence since the Middle Fork Willamette (with the exception of Fall Creek) poses the most challenges for reintroducing and establishing a stable population of spring Chinook salmon above the other Middle Fork Willamette system dams. This subbasin has the most dams and reservoirs in series (Hills Creek, Lookout Point and Dexter) which sub-divide the spawning and rearing habitat for spring Chinook and present multiple large passage barriers. Lookout Point and Dexter reservoirs are inhabited by several species of fish known to prey on juvenile Chinook, including large populations of northern pikeminnow (Monzyk et al. 2014). These two contiguous reservoirs (sub-divided by Lookout Point Dam) have a combined length of over 20 linear miles at full pool, creating challenging conditions for downstream migrating juvenile Chinook. Successful reintroduction of adult Chinook upstream of Lookout Point Dam and/or Hills Creek Dam is also complicated by having to trap adults below Dexter Dam, located downstream of the historic spring Chinook holding and spawning habitat, where water temperatures are warmer and little adult holding habitat is available. Warmer waters and poor holding conditions contribute to PSM, and spring Chinook in the Middle Fork subbasin have exhibited extremely high pre-spawn mortality (> 90%) in some years. If PSM is not reduced and controlled, re-establishing Chinook in the Middle Fork will likely not be possible (Keefer et al. 2010).

Table 3-27. Results Summary for Middle Fork Willamette Alternatives

Standard Project Information		Opportunity (Biological Benefits)					Investment (Costs)[1,2]				Impacts (Yes/No)					Results	
		anadromous fish		resident fish													
		VSP Score															
COP Measure Number	Measure Name Description	Chinook Population	confidence level	chub	Bull Trout	confidence level	Project First Costs (Total CRFM) ($ MIL)	Additional O&M (PV) ($ MIL)	Lost Hydropower ($ MIL)	Total Life Cycle (Project First Costs + O&M) in $ MIL	Chub or Bull Trout Impacts? (Y/N)	Flood Risk Management Impact (Y/N)	Total Recreation Impact (Y/N)	Water Supply Impact (Y/N)	Hydropower Impacts (Y/N)	Cost Effectiveness (Project Lifecycle Cost over Change in VSP)	Projected Stakeholder Impact
MF-Baseline	Middle Fork Baseline	0.3															
MF-DSP-01-FAL	Operational – Deeper Drawdown of Fall Creek/RO Priority with New Adult Collection Facility	NM	H	N	NA	M	21	2	0	23	Y	N	N	N	N	NA	N
MF-HOR-01-HCR	Head of Reservoir (HOR) Collection in Tributary	3.1	L	NA	N	M	343	17	0	360	Y	N	N	N	N	129	N
MF-COMBO-1	HCR Floating Surface Collector (FSC) and LOP Selective Withdrawal Structure (SWS) with Floating Screen Structure (FSS)	3.7	L	P	0/P	H/M	382	44	2	425	N	N	N	N	N	126	N
MF-COMBO-2	Hills Creek HOR Collector and Lookout Point FSC	3.6	L	0	N	H/M	446	48	0	494	N	N	N	N	N	151	N
MF-COMBO-3	Hills Creek SWS with Lookout Point FSS	3.6	L	P	P	H/M	359	43	2	401	N	N	N	N	N	122	N
MF-DSP-H2-HCR	Hills Creek SWS with FSS	3.1	L	P	P	0	255	12	2	267	N	N	N	N	N	96	N
MF-DSP-H2-LOP	Lookout Point SWS with FSS	3.4	L	P	0/P	H/M	243	12	2	255	N	N	N	N	N	83	N

[1] US $1,000,000 (present value, 50-year life, 2014 dollars) with 50% Cost Contingency (except hydropower)

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact)

[2] The costs above were developed during early alternative evaluations within sub-basins. The alternatives carried forward into the recommended option have updated cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

3.6. SYSTEM-WIDE SCENARIOS

3.6.1. Development of Scenarios

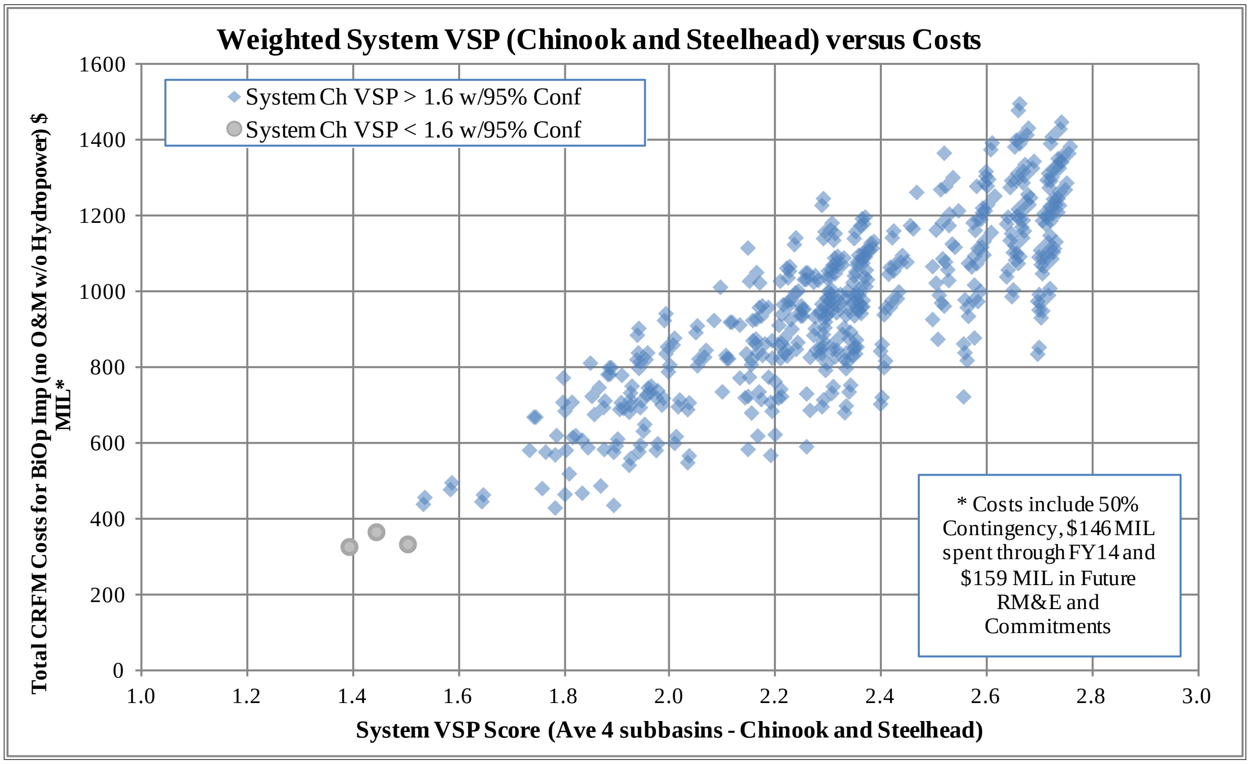
The subbasin alternatives that were carried forward for final analysis were combined into a set of system alternatives and assessed in a cost-effectiveness analysis. A summary of alternatives for each subbasin is shown in Table 3-28. The system alternatives were derived as combinations of the subbasin alternatives and totaled 441 (i.e., three North Santiam alternatives multiplied by seven South Santiam alternatives multiplied by three McKenzie alternatives multiplied by seven Middle Fork alternatives multiplied by one Fall Creek alternative).

Table 3-28. Subbasin Alternatives Used in System Analysis

Subbasin Alternatives				
North Santiam	**South Santiam**	**McKenzie**	**Middle Fork**	**Fall Creek**
NS-Baseline	SS-Baseline	MK-Baseline	MF-Baseline	MF-DSP-01-FAL
NS-DSP-H4-DET	SS-DSP-H2-GPR	MK-DSP-10-CGR	MF-DSP-H2-LOP	
NS-COMBO 1	SS-DSP-H1-GPR	MK-DSP-19-CGR	MF-DSP-H2-HCR	
	SS-HOR-02-GPR		MF-HOR-01-HCR	
	SS-DSP-H2-FOS		MF-COMBO 1	
	SS-DSP-H3-FOS		MF-COMBO 2	
	SS-COMBO 2		MF-COMBO 3	

Because only the North Santiam and South Santiam subbasins contained steelhead, a weighted system VSP was used to incorporate steelhead biological results with the Chinook biological results. The weighted VSP was calculated using an average of two species within four subbasins (so essentially eight populations assuming a zero VSP for steelhead in the McKenzie and Middle Fork subbasins). This allowed benefits for both Chinook and steelhead to be considered comprehensively in the cost-effective analysis. A graph of the weighted VSP scores versus the total CRFM costs for BiOp Implementation is shown in Figure 3-39. The system uncertainty was also assessed at this level by using the uncertainty of each of the individual alternatives. The grey circles in the figure represent those system alternatives that were not within the 95% confidence interval for a system Chinook VSP score of 1.6.

Figure 3-39. Biological Benefit versus Cost – COP Alternatives with Uncertainty



3.6.2. Application of Final Criteria

Some of the COP criteria and assumptions were applied to produce the subbasin alternatives used in the system analysis, such as having no impacts to dam safety or FRM, meeting replacement, and alternatives also used a phased approach where practical. The other criteria and assumptions were assessed at this system level. Key criteria applied at this point included:

- System VSP score ≥ 1.6 above 95% confidence interval.
- Actions should be cost-effective (including consideration of large hydropower hits).
- Improvements for more than one population per species needed.
- Middle Fork investments are most risky (technically and biologically).

At this point, hydropower impacts were considered with input from BPA and high impact alternatives (such as NS-COMBO-1) were identified. Of all the alternatives carried forward, NS-COMBO-1 had the highest hydropower impact at $48 MIL (see Table 3-8), which was considerably higher than all the other alternatives. In addition to high hydropower impacts, NS-COMBO-1 also had a lower confidence level for achieving biological benefits as well as for meeting downstream temperature targets (see Section 3.2.2.3). At this point NS-COMBO-1 was deprioritized for further consideration.

System alternatives meeting the above criteria were developed and are shown in Figure 3-40. These system alternatives were then looked at from a cost-effectiveness perspective.

Figure 3-40. Biological Benefit versus Cost for Final COP Alternatives

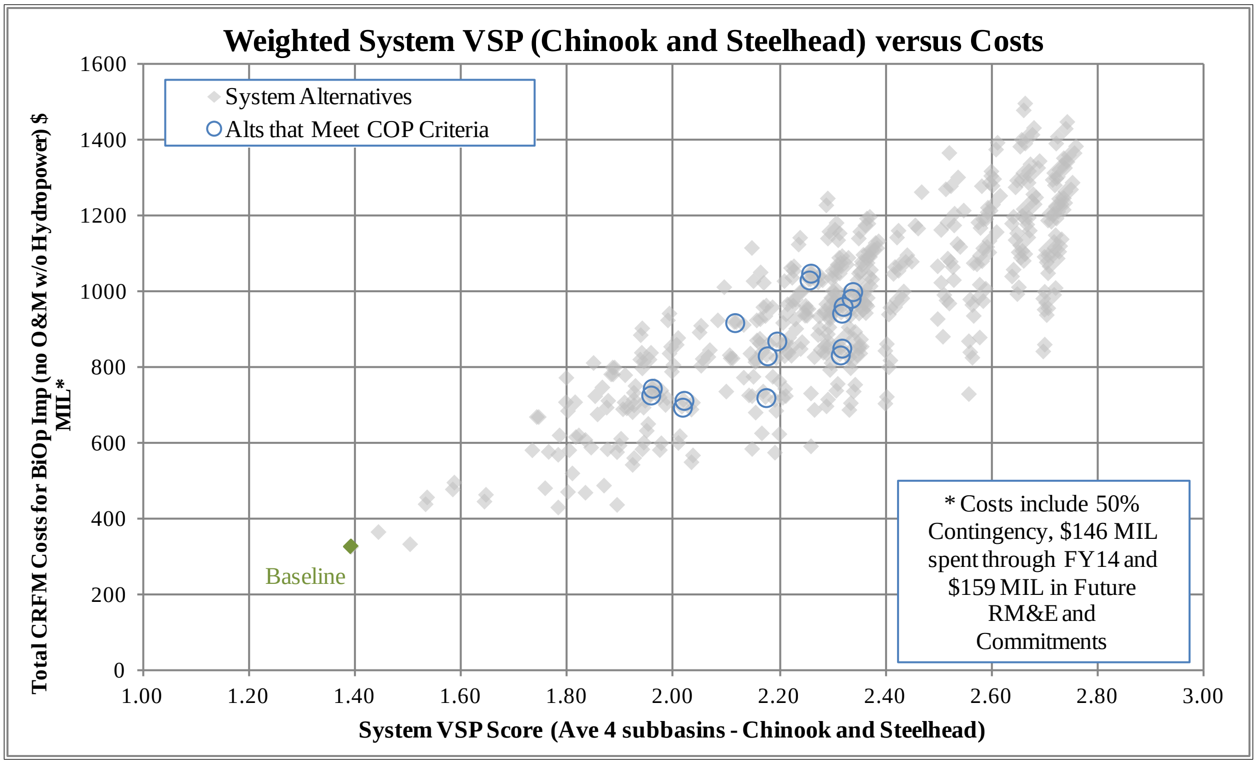


Table 3-29 summarizes the system alternatives that met COP criteria. The biological benefit information (VSP scores) is shown in the table. Included in the table are the VSP scores (Chinook by subbasin and average of system, steelhead by subbasin and a weighted average score for each system alternative). Also included are the 95% confidence scores for Chinook. Detailed cost information is summarized for the same system alternatives in Table 3-30.

Because the Middle Fork investments were considered the most risky, only system combinations that included the Middle Fork baseline (MF-Baseline) were carried forward. Additionally, some of the subbasin alternatives were not carried forward because of large hydropower impacts (such as NS-COMBO-1).

Table 3-29. VSP Scores for System Alternatives Meeting COP Criteria

North Santiam	South Santiam	McKenzie	Middle Fork	Weighted	Steelhead VSP		Mean Chinook VSP Scores (95% Conf VSP)				
				VSP	NS	SS	System	NS	SS	MK	MF
NS-Baseline	SS-Baseline	MK-Baseline	MF-Baseline	1.4	2.1	2.6	1.6 (1.3)	2.6 (1.1)	0.9 (0.7)	2.7 (1.4)	0.3 (0.2)
NS-DSP-H4-DET	SS-DSP-H3-FOS	MK-DSP-19-CGR	MF-DSP-01-FAL	2.0	3.7	2.8	2.3 (2.1)	3.9 (3.7)	1.1 (0.7)	3.8 (3.2)	0.3 (0.2)
NS-DSP-H4-DET	SS-DSP-H3-FOS	MK-DSP-10-CGR	MF-DSP-01-FAL	2.0	3.7	2.8	2.3 (2.2)	3.9 (3.7)	1.1 (0.7)	3.8 (3.5)	0.3 (0.2)
NS-DSP-H4-DET	SS-DSP-H2-FOS	MK-DSP-19-CGR	MF-DSP-01-FAL	2.0	3.7	3.3	2.3 (2.1)	3.9 (3.7)	1.0 (0.7)	3.8 (3.2)	0.3 (0.2)
NS-DSP-H4-DET	SS-DSP-H2-FOS	MK-DSP-10-CGR	MF-DSP-01-FAL	2.0	3.7	3.3	2.3 (2.2)	3.9 (3.7)	1.0 (0.7)	3.8 (3.5)	0.3 (0.2)
NS-DSP-H4-DET	SS-HOR-02-GPR	MK-Baseline	MF-DSP-01-FAL	2.1	3.7	3.5	2.4 (2.0)	3.9 (3.7)	2.8 (1.0)	2.7 (1.4)	0.3 (0.2)
NS-DSP-H4-DET	SS-DSP-H1-GPR	MK-Baseline	MF-DSP-01-FAL	2.2	3.7	3.7	2.5 (2.0)	3.9 (3.7)	3.0 (0.9)	2.7 (1.4)	0.3 (0.2)
NS-DSP-H4-DET	SS-DSP-H2-GPR	MK-Baseline	MF-DSP-01-FAL	2.2	3.7	3.7	2.5 (2.0)	3.9 (3.7)	3.0 (1.0)	2.7 (1.4)	0.3 (0.2)
NS-DSP-H4-DET	SS-COMBO 2	MK-Baseline	MF-DSP-01-FAL	2.2	3.7	3.7	2.5 (2.1)	3.9 (3.7)	3.2 (1.0)	2.7 (1.4)	0.3 (0.2)
NS-DSP-H4-DET	SS-HOR-02-GPR	MK-DSP-19-CGR	MF-DSP-01-FAL	2.3	3.7	3.5	2.7 (2.4)	3.9 (3.7)	2.8 (1.0)	3.8 (3.2)	0.3 (0.2)
NS-DSP-H4-DET	SS-HOR-02-GPR	MK-DSP-10-CGR	MF-DSP-01-FAL	2.3	3.7	3.5	2.7 (2.4)	3.9 (3.7)	2.8 (1.0)	3.8 (3.5)	0.3 (0.2)
NS-DSP-H4-DET	SS-DSP-H1-GPR	MK-DSP-19-CGR	MF-DSP-01-FAL	2.3	3.7	3.7	2.8 (2.4)	3.9 (3.7)	3.0 (0.9)	3.8 (3.2)	0.3 (0.2)
NS-DSP-H4-DET	SS-DSP-H2-GPR	MK-DSP-19-CGR	MF-DSP-01-FAL	2.3	3.7	3.7	2.8 (2.4)	3.9 (3.7)	3.0 (1.0)	3.8 (3.2)	0.3 (0.2)
NS-DSP-H4-DET	SS-DSP-H1-GPR	MK-DSP-10-CGR	MF-DSP-01-FAL	2.3	3.7	3.7	2.8 (2.3)	3.9 (3.7)	3.0 (0.9)	3.8 (3.5)	0.3 (0.2)
NS-DSP-H4-DET	SS-DSP-H2-GPR	MK-DSP-10-CGR	MF-DSP-01-FAL	2.3	3.7	3.7	2.8 (2.4)	3.9 (3.7)	3.0 (1.0)	3.8 (3.5)	0.3 (0.2)
NS-DSP-H4-DET	SS-COMBO 2	MK-DSP-19-CGR	MF-DSP-01-FAL	2.3	3.7	3.7	2.8 (2.4)	3.9 (3.7)	3.2 (1.0)	3.8 (3.2)	0.3 (0.2)
NS-DSP-H4-DET	SS-COMBO 2	MK-DSP-10-CGR	MF-DSP-01-FAL	2.3	3.7	3.7	2.8 (2.5)	3.9 (3.7)	3.2 (1.0)	3.8 (3.5)	0.3 (0.2)

Table 3-30. Cost Summary or System Alternatives Meeting COP Criteria (2014 Dollars)

North Santiam	South Santiam	McKenzie	Middle Fork	CRFM Costs ($ MIL)[1]						Other Costs ($MIL)	
				North Santiam	South Santiam	McKenzie	Middle Fork	Spent to Date + Future RM&E	Total CRFM Costs	Hydropower Losses[2]	O&M Increase
NS-Baseline	SS-Baseline	MK-Baseline	MF-Baseline	0	0	0	0	146[3]	146	0	0
NS-DSP-H4-DET	SS-DSP-H3-FOS	MK-DSP-19-CGR	MF-DSP-01-FAL	251	39	113	21	305	728	-47	26
NS-DSP-H4-DET	SS-DSP-H3-FOS	MK-DSP-10-CGR	MF-DSP-01-FAL	251	39	131	21	305	746	-72	24
NS-DSP-H4-DET	SS-DSP-H2-FOS	MK-DSP-19-CGR	MF-DSP-01-FAL	251	7	113	21	305	696	-37	26
NS-DSP-H4-DET	SS-DSP-H2-FOS	MK-DSP-10-CGR	MF-DSP-01-FAL	251	7	131	21	305	714	-62	25
NS-DSP-H4-DET	SS-HOR-02-GPR	MK-Baseline	MF-DSP-01-FAL	251	343	0	21	305	919	-74	31
NS-DSP-H4-DET	SS-DSP-H1-GPR	MK-Baseline	MF-DSP-01-FAL	251	145	0	21	305	721	-74	47
NS-DSP-H4-DET	SS-DSP-H2-GPR	MK-Baseline	MF-DSP-01-FAL	251	255	0	21	305	831	-72	26
NS-DSP-H4-DET	SS-COMBO 2	MK-Baseline	MF-DSP-01-FAL	251	294	0	21	305	870	-72	26
NS-DSP-H4-DET	SS-HOR-02-GPR	MK-DSP-19-CGR	MF-DSP-01-FAL	251	343	113	21	305	1,032	-47	43
NS-DSP-H4-DET	SS-HOR-02-GPR	MK-DSP-10-CGR	MF-DSP-01-FAL	251	343	131	21	305	1,050	-72	41
NS-DSP-H4-DET	SS-DSP-H1-GPR	MK-DSP-19-CGR	MF-DSP-01-FAL	251	145	113	21	305	834	-47	58
NS-DSP-H4-DET	SS-DSP-H2-GPR	MK-DSP-19-CGR	MF-DSP-01-FAL	251	255	113	21	305	944	-45	38
NS-DSP-H4-DET	SS-DSP-H1-GPR	MK-DSP-10-CGR	MF-DSP-01-FAL	251	145	131	21	305	852	-72	56
NS-DSP-H4-DET	SS-DSP-H2-GPR	MK-DSP-10-CGR	MF-DSP-01-FAL	251	255	131	21	305	962	-70	36
NS-DSP-H4-DET	SS-COMBO 2	MK-DSP-19-CGR	MF-DSP-01-FAL	251	294	113	21	305	983	-45	38
NS-DSP-H4-DET	SS-COMBO 2	MK-DSP-10-CGR	MF-DSP-01-FAL	251	294	131	21	305	1,001	-70	36

[1] US $1,000,000 (present value, 50-year life, 2014 dollars) with 50% Cost Contingency (except hydropower)

[2] A negative value indicates a reduction in lost hydropower, this can also be stated as the alternative produces more hydropower than Baseline

[3] Baseline costs do not include future RM&E, only BiOp Implementation funds spent to date ($144.5 MIL) (2008-2014)

3.6.3. Cost Effectiveness Analysis

This section provides the methodologies and tables used to perform a cost effectiveness analysis on different subbasin alternative combinations for the Willamette COP, including interest during construction (IDC) and average annual cost (AAC) calculations for options that were carried forward for analysis (Table 3-31). This report does not calculate a benefit-to-cost ratio as the benefits are a habitat unit in the form of a VSP score, rather than dollars, nor does it perform an incremental analysis. Although the COP analysis considered cost-effectiveness when developing a plan, many other factors were also considered including potential hydropower impacts (with stakeholder input), biological benefits for both Chinook and steelhead (by subbasin and system total), uncertainties in benefits and total costs of the preferred plan.

3.6.3.1. Cost Estimates

Cost estimates for the Willamette COP subbasin alternatives were provided by Portland District cost engineering. Costs are in 2014 dollars and have been split into different categories (i.e., construction, O&M, etc). A preliminary estimate of the year in which each cost is expected to be incurred was also supplied for construction. These data can be found in Table 3-31.

Table 3-31. Cost Estimates ($Millions[2]), Benefits and Average Annual Costs/Benefits (2014 Dollars, 3.375% Federal Interest Rate)

Subbasin COP Alternative	IWR Plan ID[1]	Imp. Date	Pro-rated VSP	Adj VSP (÷ 4)	Cost ($MIL)	O&M ($MIL)	IDC ($MIL)	AAC ($MIL)	AAVSP
NS-Baseline	N0	2014	2.3	0.6	0	0	0	0	0
NS-DSP-H4-DET	N1	2025	3.5	0.9	251	12.2	8.2	6.7	0.29
SS-Baseline	S0	2014	1.7	0.4	0	0	0	0	0
SS-DSP-H2-GPR	S1	2025	3.0	0.8	255	12.2	8.3	8.3	0.32
SS-DSP-H1-GPR	S2	2023	3.1	0.8	145	32.4	4.7	5.7	0.34
SS-HOR-02-GPR	S3	2023	2.9	0.7	343	17.1	11.2	11.9	0.29
SS-DSP-H2-FOS	S4	2018	2.1	0.5	7	7.5	0.2	0.6	0.10
SS-DSP-H3-FOS	S5	2020	1.9	0.5	39	0	1.3	1.5	0.05
SS-Combo 2	S6	2023	3.1	0.8	294	12.2	9.6	10.2	0.35
MK-Baseline	MK0	2014	1.3	0.3	0	0	0	0	0
MK-DSP-10-CGR	MK1	2020	1.8	0.5	131	9.6	4.3	5.1	0.13
MK-DSP-19-CGR	MK2	2020	1.8	0.5	113	11.3	3.7	4.9	0.12
MF-Baseline	MF0	2014	1.6	0.4	0	0	0	0	0
MF-DSP-01-FAL	MF1	2016	1.6	0.4	21	2.1	0.7	0.9	0

[1]Institute for Water Resources (IWR) Plan IDs.
[2] The above information was developed during early alternative evaluations within sub-basins. The alternatives carried forward into the recommended option have updated cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

3.6.3.2. Interest During Construction

Interest during construction was estimated using a spreadsheet assuming uniform, middle of the month payments and a federal discount rate of 3.375%. An example IDC calculation for subbasin option SS-DSP-H2-FOS is shown in Table 3-32. Since SS-DSP-H2-FOS would be implemented in 2018 (when construction is complete and benefits begin to accrue), construction would be in 2016 and 2017.The uniform middle of the month payments in the “monthly expenditure” column were calculated by dividing the construction cost by 24 months.

3.6.3.3. Average Annual Cost

With the IDC calculated for each subbasin option, the AAC was then calculated using the same spreadsheet. The yearly costs, total years in the period of analysis, base year, and the federal discount rate of 3.375% were entered into the spreadsheet for each option to perform the AAC estimate. Costs were entered in the years in which they accrue. For example, for SS-DSP-H2-FOS, with an implementation date of 2018, the constructions costs were split into 2016 and 2017, with O&M costs beginning to accrue in 2018 until 2064 (50-year period of analysis), as demonstrated in Table 3-33. For the AAC, the total costs spent to date ($144.5 MIL) were not included in any of the cost estimates as they are already expended, sunk costs. Additionally, future RM&E estimates ($144.9 MIL) were not included for any of the alternatives, since those costs would apply to each of the alternatives and would not change which alternatives were cost-effective.

Table 3-32. Interest During Construction Calculation for SS-DSP-H2-FOS ($1,000, 2014 Dollars, 3.375% Federal Interest Rate)

Month	Monthly Expenditure	Interest Rate Factor	Interest	Cumulative Interest
1	$292	0.065687205	19.15876816	$19
2	$292	0.062743502	18.30018795	$37
3	$292	0.059807929	17.44397936	$55
4	$292	0.056880466	16.59013584	$71
5	$292	0.053961089	15.73865086	$87
6	$292	0.051049776	14.88951789	$102
7	$292	0.048146504	14.04273046	$116
8	$292	0.045251253	13.19828206	$129
9	$292	0.042363999	12.35616626	$142
10	$292	0.03948472	11.51637659	$153
11	$292	0.036613394	10.67890664	$164
12	$292	0.03375	9.84375	$174
13	$292	0.030894515	9.010900278	$183
14	$292	0.028046918	8.180351101	$191
15	$292	0.025207187	7.352096117	$198
16	$292	0.022375299	6.526128987	$205
17	$292	0.019551234	5.702443391	$211
18	$292	0.01673497	4.881033028	$215
19	$292	0.013926486	4.061891613	$219
20	$292	0.011125758	3.245012879	$223
21	$292	0.008332768	2.430390574	$225
22	$292	0.005547492	1.618018467	$227
23	$292	0.00276991	0.807890342	$228
24	$292	0	0	$228

Table 3-33. Average Annual Cost for SS-DSP-H2-FOS ($1,000, 2014 Dollars, 3.375% Federal Interest Rate)

Year of Project	Year	Present Worth	Capital Recovery Factor	Total $$$ (Costs)	Present Worth $$$
0	2014	1	1	0	0
1	2015	0.9674	1.0338	0	0
2	2016	0.9358	0.5255	3708	3469.83
3	2017	0.9052	0.3561	3708	3356.55
4	2018	0.8757	0.2714	371	324.87
5	2019	0.8471	0.2207	371	314.27
6	2020	0.8194	0.1869	371	304.01
~~	~~~~~~~~~~~	~~~~~~~~~~~~~	~~~~~~~~~~~~~	~~~~~~~~~~~	~~~~~~~~
48	2062	0.2033	0.0424	371	75.41
49	2063	0.1966	0.0420	371	72.95
50	2064	0.1902	0.0417	371	70.57

3.6.3.4. Average Annual Benefit

Average annual benefit (AAB), or average annual VSP (AA VSP), was calculated using the assigned VSP scores for each subbasin option and baseline conditions. The weighted average VSP scores were used to account for steelhead and Chinook benefits. The baseline conditions were subtracted out of their related options to provide a VSP score that was “above” the baseline condition. The AA VSP was calculated for each subbasin by assuming the baseline VSP score up until the time the action was implemented, then used the projected VSP for the remainder of the 50-yr period. The VSP was then averaged over the 50-yr period producing a prorated VSP score. Once the prorated VSP score was computed, the baseline VSP score was subtracted from it.

Using NS-DSP-H4-DET as an example, with an implementation date of 2025, the weighted average VSP is 2.3 (baseline) from 2014 through 2025 (11 years) and 3.8 (improved condition) for the remaining years from 2026 to 2064 (39 years). Averaging over the 50 yrs, the prorated VSP was 3.5, from which the baseline score of 2.3 was subtracted, yielding an increase in VSP of 1.2.

Example for NS-DSP-H4-DET:

$$\text{Prorated VSP} = [\ 11 * (2.3) + 39 * (3.8)\ ] \ / \ 50 = 3.5$$

$$\text{Increase in VSP} = 3.5 - 2.3 = 1.2$$

The VSP score for each subbasin was calculated in this manner, and then a system VSP score computed for the alternative combinations. The system VSP score is the average VSP score from the four subbasins (North Santiam VSP plus South Santiam VSP plus McKenzie VSP plus Middle Fork VSP, divided by four).

The VSP scores are also used in the IWR cost effectiveness planning tool (see next section), but within that tool benefits are additive, not averaged. Benefits are input for each subbasin with one-fourth their increase in VSP (for the above example, it would be 1.2 / 4 = 0.3) so that the system benefit from the IWR tool still adds to the computed system VSP score.

It should be noted that no attempt was made to try to estimate whether or not the VSP would change throughout the 50 years, due to lack of information, so all alternatives were treated similarly.

3.6.3.5. IWR Planning Suite

After the AAC and AAB were calculated, they were entered into the Institute for Water Resources (IWR) Planning Suite decision support software (http://www.pmcl.com/iwrplan/) to formulate the subbasin options into alternatives to determine which were cost effective.

3.6.3.6. Results

The graphical representation of the output versus the cost of each alternative that met COP criteria is shown in Figure 3-41. The three COP preferred alternatives are represented in the figure as small black circles and are also identified in Table 3-34. Additional considerations of risk of attaining biological benefits was made when selecting COP recommended alternatives and are discussed below and in Table 3-34. The cost-effectiveness analysis focused on the USACE costs of design, construction, IDC and O&M. Results are shown, as well as whether or not the alternatives were ranked as cost effective.

The first two cost-effective alternatives were similar and included (downstream passage in the McKenzie, temperature and passage in the North Santiam and a minor downstream passage improvement at Foster). The COP team chose N1S4MK1MF1 as Preferred Alternative Option 1 to minimize biological uncertainty in the McKenzie, as MK1 has more confidence in benefits than MK2. The next cost-effective option was N1S2MK0MF1 and it included a major downstream passage improvement at Green Peter and temperature and passage improvements at Detroit. This option did not have any actions in the McKenzie. The COP team chose N1S2MK0MF1 as Preferred Alternative Option 2. The third grouping of cost-effective alternatives had benefits ≥ 0.75 and had higher benefit and cost characteristics. These options combined major fixes at Cougar, Green Peter and Detroit. The COP team chose N1S2MK2MF1 as Preferred Alternative Option 3 as it was the least expensive of the 4 options. The corresponding COP preferred alternatives are identified in the table for reference.

Figure 3-41. Cost Effectiveness Graph for Final COP Alternatives (2014 Dollars)

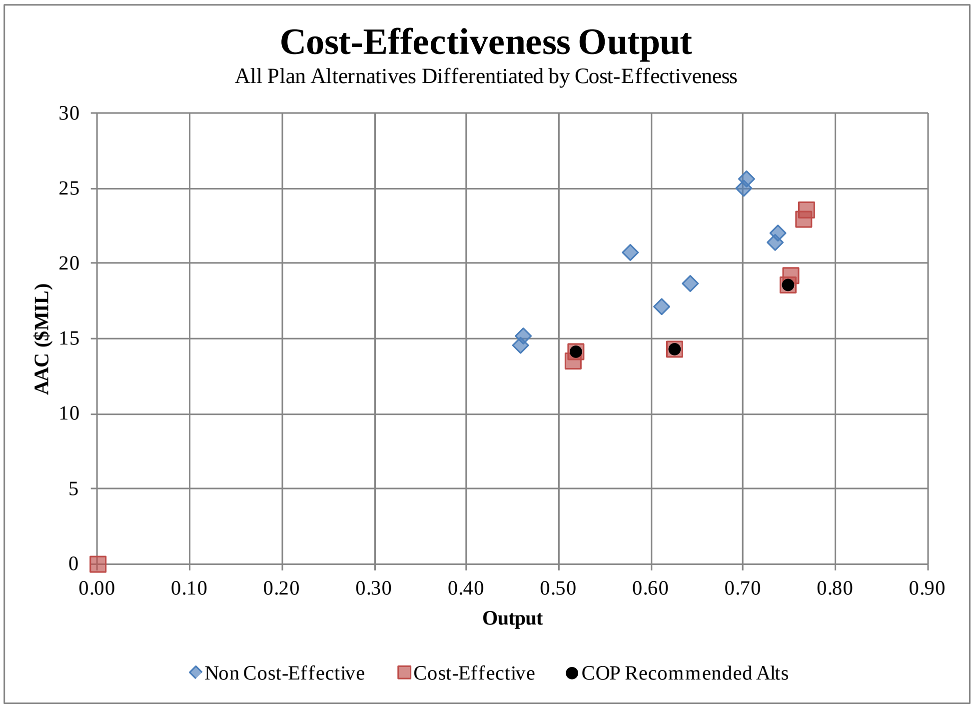


Table 3-34. Cost Effectiveness Summary for Final COP Alternatives ($1,000, 2014 Dollars)

COP Preferred Alternative	Alternative[1]	AAVSP	No Hydropower		CE with no Hydro	Comments for Consideration of CE Alternatives
			AAC	AAC/AAVSP		
	No Action Plan	0.00	0		Yes	
	N1S5MK2MF1	0.46	14,574	31,821	No	
	N1S5MK1MF1	0.46	15,194	32,959	No	
	N1S4MK2MF1	0.52	13,528	26,268	Yes	MK2 has more biological uncertainty than MK1
Option 1	N1S4MK1MF1	0.52	14,148	27,313	Yes	Selected as COP Option 1
	N1S3MK0MF1	0.58	20,753	35,967	No	
	N1S1MK0MF1	0.61	17,148	28,065	No	
Option 2	N1S2MK0MF1	0.63	14,316	22,906	Yes	Selected as COP Option 2, additional risk to McKenzie population with no action assumed. Biological uncertainties with S2.
	N1S6MK0MF1	0.64	18,687	29,107	No	
	N1S3MK2MF1	0.70	25,029	35,756	No	
	N1S3MK1MF1	0.70	25,649	36,485	No	
	N1S1MK2MF1	0.73	21,424	29,188	No	
	N1S1MK1MF1	0.74	22,044	29,910	No	
Option 3	N1S2MK2MF1	0.75	18,592	24,856	Yes	Selected as COP Option 3
	N1S2MK1MF1	0.75	19,212	25,582	Yes	
	N1S6MK2MF1	0.77	22,963	30,017	Yes	
	N1S6MK1MF1	0.77	23,583	30,707	Yes	

[1] Alternative nomenclature (IWR Plan IDs) are translated to equivalent subbasin COP alternatives.(see Table 3-31)

3.6.4. System Results Summary – Preferred Alternatives

The results are summarized for the biological benefits (opportunities) for steelhead, Chinook, Oregon chub and bull trout, as well as the costs (investments) and impacts. The baseline and three preferred alternatives are summarized in Table 3-36. Each option is discussed below. Based on the biological benefits, costs and impacts, Option 1 is the COP preferred plan. Analyses indicate that our goals will be achieved without fish passage structures at Lookout Point or Hills Creek dams, thus Options 1-3 do not include these structures. NMFS 2008 BiOp RPA indicates fish passage improvements in the Middle Fork are needed (preferable at Lookout Point Dam). However, there is uncertainty in the level of benefit that will be achieved, as documented in the NMFS 2008 BiOp, and in our analysis. We recognize improvements in the Middle Fork subbasin may be necessary in the future if the assumed benefits are not achieved in the other subbasins, and after future consultation with NMFS. RM&E is needed to investigate the feasibility of alternatives in the Middle Fork, in particular downstream fish passage, while actions in the other subbasins are implemented and evaluated.

3.6.4.1. Option 1

Option 1 has a weighted average system VSP score of 2.0. This option includes major actions in the North Santiam with construction of a Selective Withdrawal Structure (SWS) and Floating Screen Structure (FSS) to facilitate fish passage improvements and in the McKenzie with a downstream passage solution (FSS). Improvements to Chinook populations are expected in both subbasins. A smaller improvement in the South Santiam with the Foster fish weir will improve steelhead. The system Chinook VSP score improves from 1.6 at Baseline to 2.3 (with a 95% confidence of 2.2). The steelhead VSP for the two subbasins increases from 2.4 up to 3.5. The total CRFM costs are $778.7 million and include the funds spent to date ($144.5 MIL), estimated project first costs, O&M and future RM&E ($144.9 MIL). The Baseline assumes the continuation of operational spill for temperature at Detroit which results in $74 MIL less hydropower as compared to a no-spill, or turbine priority operation. Since the baseline is the point of reference for comparing alternatives, the Baseline lost hydropower was shown as $0. Option 1 estimates a hydropower loss of $12 MIL, which is actually lower than the Baseline (-$62 MIL hydropower loss, or $62 MIL more hydropower production than baseline), indicating more hydropower is produced under Option 1 than the Baseline.

Costs for Option 1 were calculated using the same methods as described in the cost effective analysis, (Section 3.6.3). The costs are shown in Table 3-35.

Table 3-35. Implementation Costs ($Millions, 2014 Price Level)

Year	RM&E	Design	Construction	O&M
2014				
2015	8.4	7.2	0.0	0.0
2016	8.4	0.5	14.4	0.0
2017	8.4	15.5	0.0	0.1
2018	8.4	13.1	5.4	0.1
2019	8.4	13.1	0.0	0.1
2020	8.4	5.6	36.0	0.1
2021	8.4	7.5	36.0	0.1
2022	8.4	1.9	66.0	0.6
2023	8.4	1.9	30.0	0.6
2024	8.4	5.6	39.0	0.6
2025	8.4	5.6	9.0	1.0
2026	8.4	5.6	0.0	1.0
2027	8.4	0.0	0.0	1.0
2028	8.4	0.0	30.0	1.0
2029	8.4	0.0	30.0	1.2
2030	8.4	0.0	30.0	1.2
2031	8.4	0.0	0.0	1.2
2032	8.4	0.0	0.0	1.2
2033	8.4	0.0	0.0	1.2

Note: The cost information above was developed during early phases of analysis to compare alternatives within sub-basins and not to develop overall costs. The alternatives carried forward into the recommended option have revised cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

Table 3-36. Results Summary for System Alternatives

Standard Project Information		Biological Benefits							Costs[1]			Impacts					Results	
		anadromous fish				resident fish												
		VSP Score																
COP System Alternative	Subbasin Measures	Weighted VSP	Steelhead Population	Chinook Population	confidence level	Oregon chub	Bull Trout	Confidence level	Total Life-cycle (Project First Costs + O&M + RM&E) in $ MIL[2,4]	Lost Hydropower[3]	O&M Increases	Chub or Bull trout Impacts? (Y/N)	Flood Risk Management Impact (Y/N)	Total Recreation Impact (Y/N)	Water Supply Impact (Y/N)	Hydropower Impacts (Y/N)	Cost Effectiveness (Change in Lifecycle Cost over Change in Average VSP)	Projected Stakeholder Impact
Baseline	Baseline	1.4	2.4	1.6					144.5									
Option 1	NS-DSP-H4-DET	2.0	3.5	2.3	H	P	Na	H	714	-62	25	N	N	N	N	N	646	N
	SS-DSP-H2-FOS					0	Na	H										
	MK-DSP-10-CGR					0	P	H/M										
	MF-DSP-01-FAL					0	0	Na										
Option 2	NS-DSP-H4-DET	2.2	3.7	2.5	M	P	Na	H	722	-72	47	N	N	N	N	N	495	N
	SS-DSP-H1-GPR					0	Na	H										
	MK-Baseline					0	0	Na										
	MF-DSP-01-FAL					0	0	Na										
Option 3	NS-DSP-H4-DET	2.3	3.7	2.8	H	P	Na	H	835	-45	58	N	N	N	N	N	565	N
	SS-DSP-H1-GPR					0	Na	H										
	MK-DSP-19-CGR					0	P	H/M										
	MF-DSP-01-FAL					0	0	Na										

[1] US $1,000,000 (present value, 50-year life, 2014 dollars) with 50% Cost Contingency (except hydropower)

Key: NM = not modeled; NA = not applicable; Confidence Level = H (high), M (medium), L (low); Resident Fish = P (positive impact), N (Negative impact), 0 (No impact), U (Unknown impact)

[2]Total Lifecycle costs include $144.5 MIL spent to date (2008-2014) and expected RM&E ($144.9 MIL) for Options 1-3, Baseline includes funds spent to date ($144.5MIL)

[3]A negative value indicates a reduction in lost hydropower, this can also be stated as the alternative produces more hydropower than Baseline.

[4]The cost information above was developed during early phases of analysis to compare alternatives within sub-basins and not to develop overall costs. The alternatives carried forward into the recommended option have revised cost estimates provided in Appendix H, Table 4-1, and the Executive Summary.

The base year is 2015 with 2064 being the end of the period of analysis. The PDT assumed that RM&E costs cease after 2033 while O&M costs are assumed to continue at a cost of $1.2 million per year until the end of the period of analysis. Table 3-37 captures the total costs for RM&E, Design, Construction and O&M, as well as the updated IDC and average annual cost estimates.

Table 3-37. Updated IDC and AAC ($Millions, 2014 Price Level)

COP Recommendation						
	RM&E	**Design**	**Construction**	**O&M**	**IDC**	**AAC***
Total Costs	144.9	38	432	19	118	24

* does not include hydropower
**does not include Lookout Point and Dexter construction
***cost information above was developed during early phases of analysis to compare alternatives within sub-basins and not to develop overall costs. The alternatives carried forward into the recommended option have revised cost estimates provided in Appendix H, Table 4-1, and the Executive Summary

3.6.4.2. Option 2

Option 2 focuses actions in the North and South Santiam with temperature and passage improvements at Detroit and passage improvements at Green Peter. Chinook VSP score for the system increases to 2.5 (with 95% confidence of 2.0), steelhead increases to 3.7 and the weighted average VSP increases to 2.2. Populations of steelhead and Chinook in the North and South Santiam subbasins see significant improvement. This alternative relies on the assumption that the McKenzie population is relatively stable. There is more uncertainty with this alternative than for Options 1 or 3. The 95% confidence in Chinook scores is actually lower in this alternative due to uncertainty with a Green Peter passage improvement. The total CRFM costs are $722 million and include the funds spent to date ($144.5 MIL), estimated project first costs, O&M and future RM&E ($144.9 MIL). The Baseline assumes the continuation of operational spill for temperature which results in $74 MIL less hydropower as compared to a no-spill, or turbine priority operation. Since the baseline is the point of reference for comparing alternatives, the Baseline lost hydropower was shown as $0. Option 2 estimates a hydropower loss of $4 MIL, which is actually lower than the Baseline (a -$72 MIL hydropower loss, or $72 MIL more hydropower production than baseline), indicating more hydropower is produced under Option 2 than the Baseline.

3.6.4.3. Option 3

Option 3 has major actions in three subbasins, McKenzie, North Santiam and South Santiam, including temperature control and passage improvements at Detroit and passage improvements at Green Peter and Cougar. The Chinook VSP score increases to 2.8, steelhead increases to 3.7 and the weighted system average VSP increases to 2.3. Populations of Chinook see significant improvement in all three subbasins, and steelhead are significantly improved in both the North and South Santiam. Total CRFM costs are $835 million and include the funds spent to date ($144.5 MIL), estimated project first costs, O&M and future RM&E ($144.9 MIL). The Baseline assumes the continuation of operational spill for temperature which results in $74 MIL less hydropower as compared to a no-spill, or turbine priority operation. Since the baseline is the point of reference for comparing alternatives, the Baseline lost hydropower was shown as $0. Option 3 estimates a hydropower loss of $31 MIL, which is actually lower than the Baseline (a -$45 MIL hydropower loss, or $45 MIL more hydropower production than baseline), indicating more hydropower is produced under Option 3 than the Baseline (but not as much as Option 1 or 2). Improvements are expected for bull trout in the McKenzie and for Oregon chub on the North Santiam.

3.6.4.4. Managing Risk

As described in Steps 10 and 11, the COP decision support process includes a discussion of managing risk (Section 2.11.2). There is some variability in confidence of biological benefits (Options 1 and 3 are high confidence and Option 2 is moderate). Additionally, there is some difference in the cost-effectiveness of the actions (Option 2 is more cost-effective than Options 3 or 1). Although Option 2 is more cost-effective, the total cost is higher than Option 1 (and it has less biological confidence). None of the options have any significant impacts to Oregon chub or bull trout, flood risk management, recreation, water supply or hydropower. As the three preferred alternatives do not have significant impacts for stakeholders, the discussion of managing risk becomes less critical.

This analysis recognizes the uncertainty in the level of benefit that will be achieved from the actions listed for Options 1-3 in each subbasin, and therefore improvements in the Middle Fork subbasin may be necessary in the future in order to achieve the overall targeted system-level benefits. RM&E is therefore needed to investigate the feasibility of alternatives in the Middle Fork, in particular downstream fish passage, while actions in the other subbasins are implemented and evaluated.

The recommendations and implementation strategy for the COP II effort is presented in Chapter 4, which also provides additional information and the fully funded costs are presented.

CHAPTER 4. RECOMMENDED PLAN AND IMPLEMENTATION STRATEGY

4.1. RECOMMENDED PLAN

In Chapter 3, the COP team developed three preferred alternatives that met COP criteria. Option 1 has been selected as the recommended plan. This plan includes the following actions:

- Downstream fish passage at Detroit through the Selective Withdrawal Structure (SWS) and the Floating Screen Structure (FSS)
- Downstream fish passage improvement at Foster with an upgraded fish weir
- Downstream fish passage at Cougar through the Floating Screen Structure (FSS)
- Upgraded adult fish facility (AFF) at Fall Creek
- Continued deep winter drawdown for downstream fish passage at Fall Creek
- Although the RPA indicates downstream fish passage in the Middle Fork is required, the COP determined that the prudent path forward is continued evaluation of feasibility and review of the need for providing fish passage in the Middle Fork, in consultation with NOAA Fisheries.
- Hatchery fish management changes

The overall success of improving conditions for ESA-listed fish will be determined based on the actual benefits achieved as the proposed actions are implemented. NMFS 2008 BiOp RPA indicates fish passage improvements in the Middle Fork are needed to avoid jeopardy for spring Chinook (preferably at Lookout Point Dam). There are concerns with the feasibility of providing effective fish passage in the Middle Fork subbasin, as documented in both the NMFS 2008 BiOp and in our analysis. A key decision point is therefore included for Middle Fork fish passage regarding determination of feasibility, and reviewing the necessary level of benefit needed to meet ESA obligations, before proceeding with design and construction (see Section 4.2). RM&E is recommended to investigate the feasibility of alternatives in the Middle Fork, in particular for downstream fish passage, while actions in the other subbasins are implemented.

This plan will provide improvements for spring Chinook salmon in the North Santiam, South Santiam, McKenzie and Fall Creek subbasins. Winter steelhead improvements will be made in the North and South Santiam subbasins. Benefits for Oregon chub are expected from temperature improvements in the North Santiam and bull trout would realize benefits from fish passage improvements in the McKenzie subbasin. A summary of biological benefits (VSP scores) and cost by feature is shown in Table 4-1.

Table 4-1 summarizes 2015 through 2033 fully funded capital costs by project and RM&E, for a total of $615.2 MIL. Fully funded costs were derived during the cost-risk analysis and are described in detail in Appendix H. Costs associated with BiOp implementation include capital infrastructure, RM&E, O&M and changes in hydropower. O&M costs over the same time period equates to $19 MIL. In addition to these costs, changes in dam operations will result in changes to hydropower production. Table 4-1 totals do not include implementation costs spent between 2008 and 2014 ($144.5 MIL).

A risk analysis was performed as part of the cost estimating process and coordination with the Walla Walla Center for Cost Expertise. The results of the analysis produced a contingency value related to each measure. The results of this risk analysis, as well as a detailed breakdown for the basis of contingency, are included in Section H.2 of Appendix H.

The fully funded cost estimate includes inflation to the estimated mid-point of construction for each feature. The fully funded table distributes the base level cost estimate across the appropriate years according to the schedule. Each feature account is inflated to the mid-point of expenditure activity using the Civil Works Construction Cost Index System factors. These inflated feature account totals are then summed to yield a total fully funded project cost.

The fully funded capital costs shown in the table are project estimates as of February 2015. These estimates were based on an assumed timing of project phases between 2015 and 2033. Actual project implementation timing may result in minor cost changes when compared to the COP estimates. The annual 5-year planning process will be the venue to document the specific adjustments in costs based on updated design level information.

Improving conditions for ESA-listed fish will also require actions by other responsible parties. This recommended plan is a key component of the overall effort to ensure the long-term success of the ESA-listed fish in the Willamette system. Additional discussion of actions to be implemented by other responsible parties in tandem with the recommended plan is included in Section 4.2.3.

Table 4-1. Summary of Biological and Future Cost Information for the Recommended Plan

(Costs do not include the $144.5 MIL From 2008-2014)	VSP Scores (95% confidence)		Total Costs ($MIL)[1] 2015-2033		Forgone Hydropower[4] 2015-2033
	Chinook	Steelhead	Fully Funded Capital Costs[2]	O&M[3]	
NS-DSP-H4-DET Selective Withdrawal Structure with Weir Box and Floating Screen Structure at Detroit	3.9 (3.7)	3.7	$ 314.9	$ 6.8	$ -74
SS-DSP-H2-FOS Upgraded Fish Weir at Foster	1.0 (0.7)	3.3	$ 6.8	$ 0.8	$ 10
MK-DSP-10-CGR Floating Screen Structure at Cougar	3.8 (3.5)	NA	$ 127.5	$ 8.8	$ 2
MF-DSP-01-FAL Deep Winter Drawdown and FAL Adult Collection Facility	0.3 (0.2)[5]	NA	$ 21.1	$ 2.6	$ 0
RM&E Research Monitoring and Evaluation to Support BiOp Implementation	NA	NA	$ 144.9	NA	NA
Willamette System Level	2.3 (2.2)	3.5	$ 615.2	$ 19.0	$ -62

NA = Not applicable
[1] Costs are in 2014 dollars and do not include expended dollars from 2008-2014 ($144.5 MIL). Costs do not include fish passage actions in the Middle Fork subbasin which could be included in the future if determined feasible and necessary. Costs for Middle Fork actions are summarized in Section 3.5.4 (Monetized costs and impacts). Costs shown in this table may differ from the 5-year plan due to further refinements after the cost analyses for the above figures were performed.
[2] Capital costs and RM&E are Columbia River Fish Mitigation (CRFM) appropriated funds from 2015-2033.
[3] O&M costs are Operations and Maintenance appropriated funds estimated over 2015-2033 accounting for inflation assumed at 3.5% with a 50% contingency. Costs shown are for those alternatives comprising Option 1 in Chapter 3.
[4] Forgone Hydropower (2015-2033) is the sum of net energy benefit and net capacity benefit, present valued over 50 years using a 3.75% interest rate. For full derivation of hydropower costs please refer to Appendix G. A negative value represents a gain in hydropower value.
[5] VSP scores are for the entire Middle Fork spring Chinook salmon population, including the Fall Creek sub-population component.

4.1.1. Performance Criteria

Performance criteria were developed for the proposed Cougar FSS to guide design, and assess performance after construction. An associated adaptive management framework was also developed to guide follow-on actions, as needed, to achieve performance criteria for the Cougar FSS. The Cougar FSS performance criteria and adaptive management plan are presented below. Performance criteria and adaptive management plans will also need to be developed for the other recommended downstream fish passage actions. It is expected that the Cougar performance criteria will be used as a framework for development of performance criteria for other fish passage actions at other dams before engineering document reports (EDR's) are completed.

4.1.1.1. McKenzie Subbasin

To achieve the pre-defined biological VSP criteria, each proposed action includes specific assumptions about project performance. Sensitivity of the specific assumptions for the Cougar FSS was evaluated to understand how variation from the original assumptions affected the VSP scores for each population. Table 4-2 shows a comparison of McKenzie Chinook VSP scores for different dam passage survival and passage efficiency assumptions modeled using FBW and SLAM. The COP alternatives that were developed are indicated, along with those that achieve replacement (spawners/recruits >1). VSP scores were prepared by the NWFSC using SLAM, and FBW results prepared by the Corps for the passage survival assumptions included in the table. Replacement was evaluated using the results provided from SLAM as described in Section 3.4.2.1 of this report.

Table 4-2. Comparison of McKenzie Chinook VSP Scores for Different Dam Passage Survival and Passage Efficiency Assumptions

McKenzie Subbasin VSP Score	Cougar Dam Subyearling Passage Survival	Cougar Dam Subyearling Passage Efficiency (DPE)	Cougar Dam Subyearling DPE*Survival	COP Alternative Equivalent	Meets Replacement?
2.7	0.43	0.34	0.15	Baseline	
3.3	0.80	0.40	0.32	Ops_delay refill	
3.1	0.80	0.58	0.46		
3.0	0.99	0.46	0.46		
3.4	0.85	0.61	0.52		Yes
3.8	0.87	0.66	0.58	Hybrid	Yes
3.8	0.93	0.70	0.64	FSS	Yes
3.6	0.99	0.65	0.64		Yes

Sensitivity analysis results indicated a project downstream passage survival rate, dam passage efficiency times survival or (DPE*Survival), of 0.52, having a combination of 0.85 passage survival and 0.61 DPE, resulted in population viability category at low risk of extinction (VSP score of ≥ 3.0) and resulted in replacement for the Chinook population component above Cougar Dam (Table 4-2.). State-of-the-art juvenile collection facilities implemented in the Pacific Northwest have observed DPE (i.e., collection efficiency) for Chinook and steelhead in the range of 5% to 60% and survival greater than 98%.

Based on Table 4-2 and the performance of other existing facilities, a project downstream passage survival of ≥ 0.52 (targeting 0.85 passage survival and 0.61 DPE) is estimated to result in a population that will be at or above replacement (self-sustaining). Sensitivity analysis results also indicated that various combinations of downstream passage efficiency and concrete survival can be used to achieve the

0.52 project downstream passage survival rate (i.e., if a survival rate higher than 0.85 is achieved, DPE would not need to be as high), allowing engineers flexibility in determining the final project design.

NMFS recommended assessing performance by evaluating the number of target fish collected by the designated passage route. Instead of using passage survival and DPE, specific criteria to evaluate collection of fish by the proposed Cougar FSS, definitions, study guidelines, and adaptive management plan for the Cougar FSS were then developed in cooperation with NMFS. The criteria and adaptive management plan were not finalized as of the completion date of this report. Any updates to the criteria and adaptive management plan for the Cougar FSS developed after the completion of this report will supersede the criteria provided below.

Attracting and Collecting Fish into the FSS bypass (Facility Collection Efficiency; FCE)

a. FCE Definition: The proportion of juvenile Chinook salmon that are collected by the FSS divided by the total number of fish in the *FCE measurement zone*.

b. FCE measurement zone: Area defined as the cul de sac per Corps (2011) and Beeman and others (2013).

c. Juvenile fish collection design criteria: 95% FCE (SE = 2.5%) achieved through adaptive management steps provided below in "Adaptive Management" section, with different measures required depending on monitoring/evaluation results.

d. Operating range: The FSS will be designed to function during all water years, operating from Maximum Conservation Pool (1690 ft) down to Minimum Conservation Pool (1532 ft). For rare hydrologic events, the FSS will also be designed to withstand maximum pool elevation (1699 ft) and minimum power pool elevation (1516 ft), but may operate at reduced capacity during those limited duration events.

e. Juvenile fish facility design criteria: Comply with NMFS Passage Design Guidelines (NMFS 2011).

f. Juvenile fish collection study design parameters:
The Action Agencies (Army Corps of Engineers and Bonneville Power Administration) will fund post-construction evaluations of FCE and fish survival through the FSS. The WATER RME Team will review study concepts, objectives, and plans, and the Action Agencies will address comments and attempt to reach consensus on these concepts, objectives, and plans. If NMFS and the Action Agencies' technical staff do not concur on final study plans, the dispute will be elevated for resolution following Federal Family and WATER procedures and protocols. Federal Family protocols for the Willamette Project that describe collaborative work and dispute resolution will be developed, where needed, and incorporated by reference. The Action Agencies will ensure evaluations are carried out and reports produced for NMFS and WATER team review within timelines necessary to inform adaptive management decisions outlined in this document.

    1. Test fish: Juvenile Chinook outfitted with active tags (e.g. radio, acoustic, or newer technology) and having physical characteristics (e.g. length and body form) representative of active downstream migrants seeking to exit the reservoir.
    2. FCE will be measured as the proportion of fish that are collected by the fish passage facility divided by the total number of fish in the *FCE measurement zone* over the test period. Study

design will include sufficient test fish such that point estimates of FCE can be made within a precision level, criteria error of ±2.5%.

3. Test periods: Annual FCE studies will require testing at times of the year representative of when most juvenile Chinook migrants are actively moving downstream. These test periods likely will cover portions of spring and fall/winter, and could be one longer test period or two separate seasonal periods within a year.
4. FCE studies will be conducted beginning the first year after completion of the FSS. If hydrologic conditions are unusual, the Action Agencies and NMFS will discuss results to determine if any aspect of the testing should be redone. If NMFS and the Action Agencies' technical staff do not concur on the need for additional tests, the dispute will be elevated for resolution as described in Section III, Decision Making. Unusual conditions are defined as test year conditions that fall outside the 20th to 80th percentile exceedance ranges of hydrologic conditions based on the period of record for the SF McKenzie River.
5. To determine FCE performance in a given year and across years, results of the test will be analyzed using appropriate methodology agreed to by the Action Agencies and NMFS. If we do not agree, the Action Agencies and NMFS will jointly agree on a statistician who the Action Agencies will contract with to advise on the most appropriate way to analyze and interpret results.
6. Two years of study are expected, but adjustments or modifications could be implemented after one year of study.
7. After modifications or adjustments are made, the Action Agencies will fund and conduct one or more years of tests to assess changes. Study concepts, objectives, and plans will be developed in collaboration with NMFS and the WATER RME Team in the same manner described above in Paragraph f.

g. Adaptive management, application of FCE study results, and step-wise measures to achieve performance criteria

1. If FCE of 95% or greater is achieved with two study years which meet the "study design parameters" section above, no further evaluation is required (this does not replace a separate requirement for ongoing monitoring required throughout the life of the facility).

2. If FCE $\geq$ 85%, but < 95%, NMFS and the Action Agencies will identify, and the Action Agencies will carry out minor changes, operational and/or structural, to improve FCE. However, if NMFS and the Action Agencies agree that further actions are not necessary or that efforts should be focused on other RPA measures, then no further actions will be taken.

3. If FCE $\geq$70% but < 85%, after two study years which meet the "study parameters" section above, the Action Agencies will carry out Operational or Facility Adjustment(s), as defined in Table 4-3 below, based on analysis of the completed facility.

    i. Timeframes for completing Adjustments (no design needed): Funding will be proposed for the first two years following scheduled facility completion to address any follow-on adjustments to ensure that the facility will physically operate as intended. The action is expected to be completed in 1-2 years (however, timeframes will be updated and defined during the design phase).
    ii. If, after two years of testing, FCE remains <85%,and all feasible Adjustments have been tried, then the Action Agencies will carry out Modifications, defined in Table 4-3 below, unless NMFS concurs that further modifications are not warranted.

4. If FCE < 70%, the Action Agencies will complete Adjustments first (if not already completed) and then Modification(s), defined in Table 4-3 below, with NMFS concurrence on the measures, based on analysis of the completed facility.

.

   i. Timeframes for completing Modifications (new design required) depend on design needs. If additional funding is needed, the timeline to complete a Modification will be determined by the design schedule (1-2 years) and receiving funds through the federal appropriations process (1 or more years); total up to 4 years.

h. Adaptive Management notes and examples

1. "Minor changes" – examples include but are not limited to the following:
   - Structural: rotating entrance, adjusting baffles, and other tuning of the existing facility; changing in debris management practices, changes in fish handling/holding/transport using existing facilities
   - Operational FSS: longer or shorter operational periods of FSS, pulsing operations; increasing or decreasing entrance flows, bypass flows, etc
   - Operational dam and reservoir: changes to operating intake gates of temperature tower, increasing or decreasing total or proportional through RO or turbine, operating dam with pulses
   - Note that operating the dam with outflow pulses is likely to result in BiOp ramping rates not being met due to project limitations

2. "Adjustments" – examples include but are not limited to the following:
   - Structural: pumps; nets, behavioral guidance structures; changing the entrance configuration
   - Operational FSS: changing debris management practices, fish handling/holding/transport practices
   - Operational: operating dam with pulses (with likely outcome of not meeting BiOp ramping rates due to project limitations)
   - Reservoir Operations related to Rule Curve: slight changes to pool elevation at any time of year that are lower than the project Rule Curve are considered a deviation. Timing and magnitude of deviation would need to be evaluated for impact to authorized purposes before approval by Division office. Deviations are considered temporary – a Water Control Manual change and approval is necessary for the change to be permanent.

3. "Modifications" – examples include but are not limited to the following:
   - Structural: pumps, nets, behavioral guidance structures; changing the entrance configuration,
   - Operational FSS: changing operating practices with new add-ons from Adjustments or Modifications
   - Operational Discussions related to Outflows: modifying downstream minimum flows or exceeding ramping rates is a deviation. Timing and magnitude would need to be evaluated for impact to authorized purposes.
   - Operational Discussions related to Rule Curve: starting refill earlier in the year than under current rule curve, not drawing reservoir down as low in winter, or delaying fall draft of project can be discussed. These are changes going above current rule curve and therefore would affect flood damage reduction, the primary authorization for the project. This change would also be a deviation for which the timing and magnitude would need to be evaluated for impact to authorized purposes. It is unknown how long it would take or

the level of study required for Congressional approval if this deviation was to become permanent.

4. Design Process: USACE will complete the EDR and begin the DDR design optimizing a specific alternative intended to achieve the performance criteria. Working collaboratively with our regional partners during the DDR phase, USACE will recommend a facility design, and include options for future adjustments (see sections 2 and 3 above), if needed, to reach the FCE performance criteria.

5. Facility start up: The Action Agencies and NMFS anticipate facility tuning will be needed at project start-up, including to operations, changing debris management practices, and changes in fish handling/holding/transport protocols. Facility changes may be warranted to address a wide range of fish responses, before study is completed.

6. Application of new information: An ongoing research program funded by the Action Agencies since 2008 informs selection, design, and adaptive management of actions addressing NMFS RPA. As new relevant information becomes available, NMFS and the Action Agencies agree to apply this information within the adaptive management context described above.

Table 4-3. Adaptive management based on measured FCE following construction of the Cougar Floating Screen Structure.

[Definitions of "Minor changes", "Adjustments," and "Modifications", and the complete Adaptive Management process are described in Section "h" above.]

Fish Guidance Efficiency	Actions defined; include both improvements and monitoring
Design performance criteria FCE ≥ 95%	Objective met. No further actions required.
Actual guidance FCE ≥ 85%, but < 95%	**Minor changes:** ● structural changes that can be made within existing design ● operational changes to the FSS that can be made within design specifications ● changes in dam and reservoir operations that can be completed within *existing* rule curve and downstream flow requirements ● changes in dam and reservoir operations that impact downstream flows if NMFS and WATER agencies concur to allow impacts to downstream flows.
FCE ≥70% but < 85%	**Adjustment(s):** ● structural additions that were part of the original design (DDR). ● operational changes to the FSS that can be made within design specifications, including operations that function with Adjustments ● changes in dam and reservoir operations that can be completed with slight deviations to existing rule curve and downstream flow requirements ● changes in dam and reservoir operations that impact downstream flows if NMFS and WATER agencies concur to allow impacts to downstream flows **Modification(s):** as defined below
FCE < 70%	**Adjustments** as defined above, and then **Modification(s) as authorized and funded:** ● physical alterations or additions to a physical passage facility that were not included in original design and require new design; ● operational changes to the FSS requiring new designs (which could include modifying reservoir operations or outflows); ● operational changes that require changes in the rule curve possibly affecting flood damage reduction or downstream flow management requirements may be discussed

Safely passing and handling fish once they are attracted into the juvenile fish collection facility

Once fish are guided into the collection facility, juvenile and adult fish must be passed safely through the facility with minimal injury and mortality. The juvenile fish facility will be designed in accordance with NMFS Passage Design Guidelines (NMFS 2011). If alternative materials, designs and specifications are used, the Action Agencies will conduct hydraulic and biological evaluations and make changes, if needed, to ensure the completed facility achieves the following design objectives. For the Willamette Project, NMFS will apply a 2% mortality (98% survival) design objective for all life stages (fry and smolts). NMFS acknowledges that with big screens (>1000 cfs) fry are challenging to handle. Any collection system needs an adequate cleaning system.

Mortality and injury will be tested following construction completion. Based on study results, NMFS and the Action Agencies will identify, and the Action Agencies will carry out actions according to Table 4-4, operational and/or structural, to reduce fish mortality and injury. Decision making will follow a similar approach as described for FCE studies and actions above.

Monitoring fish facility mortality and injury:

- testing in good conditions - system is clean of debris and flows are within typical operating flow ranges (not out of the average; 5-95% flow range);
- Fry (those smaller than taggable for FCE testing): release directly in front of collection system; only those collected in holding facility will be used to assess mortality.
- Larger sub yearling/smolts (taggable sized): tagged fish used in FCE testing that enter the FSS will be used to evaluate injury and mortality; (this could include fish lost once they enter the facility but are not recovered in holding tank).
- Injury and mortality rates are calculated based on fry recovered at the downstream end of the facility (in holding box, end of bypass pipe, etc).

Injury definition and metrics: visible trauma (including hemorrhaging, open wounds without fungus growth, gill damage, bruising greater than 0.5 cm in diameter, etc.), loss of equilibrium, or greater than 20% descaling. Descaling is defined as the sum of the area on one side of the fish that shows recent scale loss. This does not include the area where scales have regenerated or fungus has grown.

Table 4-4. Preliminary[1] mortality and injury criteria for juvenile Chinook in FSS, and types of actions that will be taken if mortality and injury are greater than design objectives.

Smolts	**Fry**	**Actions; include both improvement actions and monitoring**
Mortality or Injury	**Mortality**	
Design performance criteria ≤ 2%.	Design performance criteria ≤ 2%.	Objective met. No further actions required.
If either mortality or injury is > 2% but ≤ 4%, then minor changes are required.	If mortality is > 2% but ≤ 4% then minor changes are required.	Minor changes to facility structure or operations such as adjusting baffles, improving hydraulics, more frequent cleaning and trap checking.
If either mortality or injury is > 4%, then operational or structural changes are required.	If mortality > 4%, then operational or structural changes are required.	Operational or structural changes.

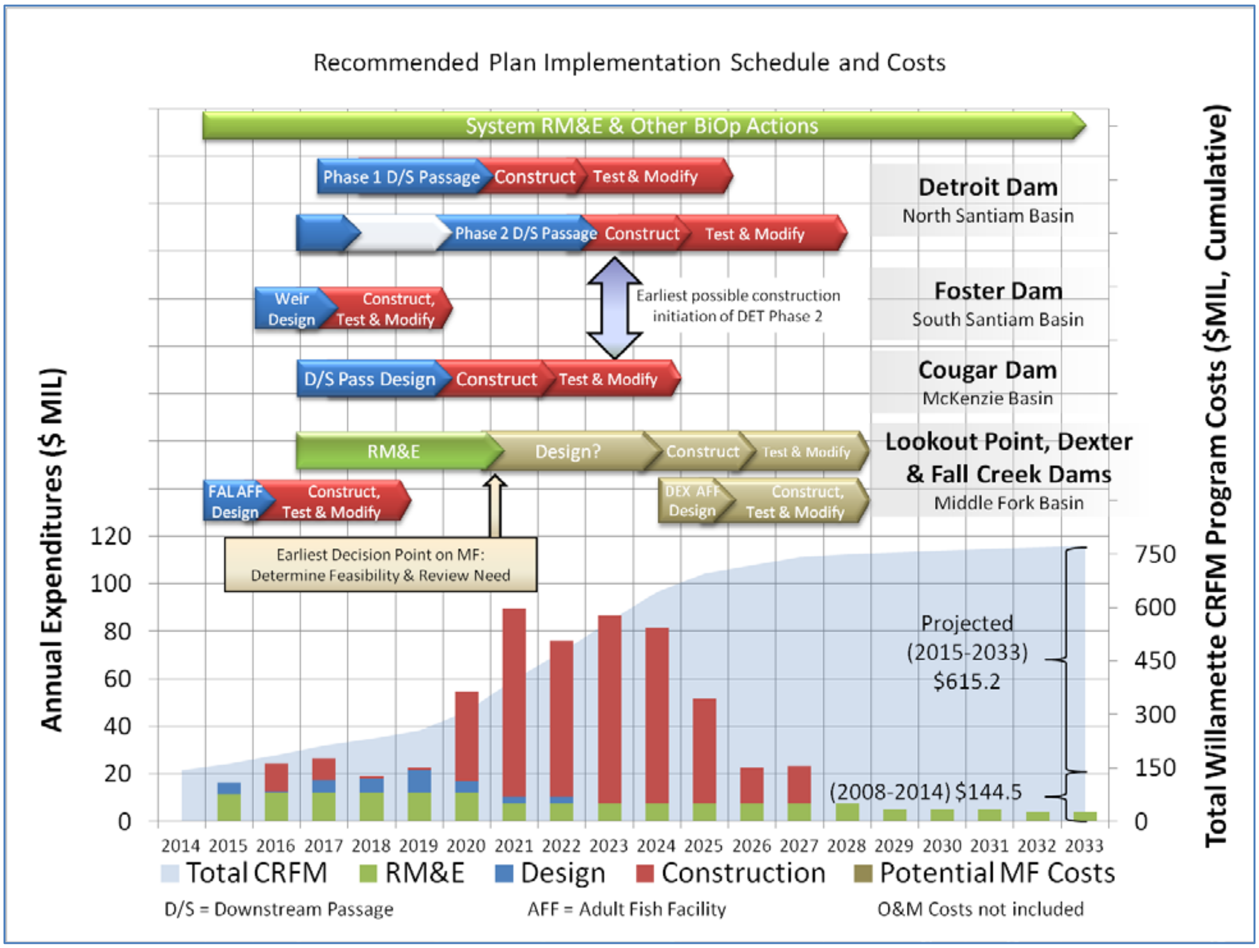
[1]Further work and collaboration with NMFS is needed to clarify how injury/mortality metrics would be applied. For example, if injury/mortality is applied as an annual average, by life-stage, or some other measure, has not been determined yet.

4.2. OVERALL IMPLEMENTATION PLAN

An implementation plan was developed to look at the scheduling for design, construction and testing of each component of the recommended plan. Looking at implementation from a system perspective ensures that yearly budgeting is reasonable and the construction windows fit within the system operation constraints. Figure 4-1 graphically displays the implementation plan for the recommended plan. NMFS was consulted on the schedule and the order of the actions to provide the necessary benefits in the most expeditious timeframe while allowing necessary time for design and construction of each action, and managing overall total annual program expenditures.

A timeline is shown for each subbasin with design, construction and testing by structure represented on the graph. Additionally, the yearly budget assumptions for each phase are plotted as well as a cumulative total of the CRFM funds through 2033. This estimate accounts for inflation over time. Finalization of the design at Detroit will be informed by earlier progress at Cougar.

Figure 4-1. Proposed Implementation Schedule for COP II Recommended Plan



As implementation proceeds, RM&E will be used to refine the design and details of the planned actions, confirm their performance, and inform decisions on the need and feasibility of additional actions in the Middle Fork subbasin to meet ESA requirements. An FY19 COP review and a FY21 recommendation will serve as important check-ins with NMFS for further discussions on downstream passage requirements in the Middle Fork. More details on required RM&E to support the recommended plan are described in Section 4.2.1.

In addition to the implementation costs, this recommendation will require future funds for O&M in order to keep new features operating properly. These costs are estimated in Table 4-1 through FY2033, based on the following assumptions for yearly O&M costs by project within the recommended plan:

Detroit Dam Phase 1 projects:	$0.35MIL per year
Detroit Dam Phase 2 projects:	$0.85MIL per year
Foster Dam projects:	$0.05MIL per year
Cougar Dam projects:	$0.68MIL per year
Fall Creek projects:	$0.15MIL per year

4.2.1. Research, Monitoring and Evaluation

Since 2008, RM&E activities on the WS have been completed to inform the COP analysis, implementation of interim actions called for in NMFS 2008 RPA, and to support alternative assessments to address specific elements of NMFS RPA. About $12 M per year has been spent on RM&E activities supporting design and implementation of actions to address NMFS 2008 BiOp, with a total expenditure of $144.5 M between FY08 and FY14. Additional RM&E will be required to support the COP preferred plan as summarized in this section. More specific RM&E needs for each subbasin are further described in the individual subbasin sections below.

Two downstream fish passage facilities at high-head dams (> 400 ft high) with large reservoir fluctuations (> 150 ft. in elevation change annually) are included in the plan, with construction to be completed at Cougar Dam and Detroit Dam. Improving fish passage under these conditions will be challenging. RM&E will be used to inform final design of fish passage facilities, and evaluate their effectiveness. At Cougar Dam, a portable research-based juvenile fish collector has operated since the spring of 2014 to provide additional insight on both fish behavior and operations under significant forebay elevation changes that occur annually at both Cougar and Detroit dams. A phased approach will allow for learning through RM&E from operation of the new fish facility at Cougar Dam before completing designs at Detroit Dam. Downstream fish passage is scheduled to be completed at Cougar Dam first where RM&E is most advanced at this time, and where high-head fish passage success is most likely, due to the configuration of Cougar's forebay.

In the South Santiam, an upgraded fish weir is planned at Foster Dam which will provide juvenile fish passage over the spillway. Foster Dam is a lower-head dam, and spillway fish passage improvements have proven very effective at similar facilities. RM&E in FY16 and FY17 will provide information to allow a final design to be chosen and completed. Fish passage will also be improved at Fall Creek Dam (a tributary to the lower Middle Fork) with an upgraded adult facility to provide safe and effective collection and transport of adult fish upstream, and continued operational juvenile downstream fish passage via seasonal reservoir drawdown.

RM&E is also needed to inform the feasibility of additional fish passage actions in the Middle Fork subbasin, and whether these additional improvements are needed to address ESA requirements. The NMFS BiOp 2008 included RPA actions for both upstream and downstream passage in the Middle Fork Willamette at Dexter and Lookout Point dams, respectively. However, the RPA acknowledged uncertainty in the level of benefits that would be achieved from the specified actions, and in the feasibility of those actions. The Corps' COP analysis contained in this report now indicates that an overall level of benefit may be attainable to address the BiOp goals without fish passage and temperature control structures at mainstem Middle Fork dams, and concluded that the feasibility of completing effective fish passage at WS dams in the Middle Fork remains uncertain citing issues created by the number of dams and reservoirs, predation risks, and pre-spawn mortality rates. Additional RM&E to assess the uncertainties regarding fish passage in the Middle Fork is expected to include the following: reservoir migration studies; evaluation of juvenile predation; operational passage feasibility assessments; and studies of juvenile reservoir forebay distribution and entry timing.

The COP preferred plan includes a FY19 review of COP assumptions based on the RM&E completed to that point. The purpose of this review will be to determine if enough information is available to recommend a path forward for ASA (CW) approval in FY21. RM&E will occur between FY15 and FY19 to support the FY19 and FY21 reviews and recommendations.

Following FY21, the RM&E program will focus on evaluating the effectiveness of actions as they are completed, provide information to support modifications where needed, and provide information to assess ESA listed fish population performance. Assessing population performance is needed to support consultations with NMFS on jeopardy avoidance for spring Chinook and winter steelhead. As the program progresses, the amount of RM&E funding to address design support and post-effectiveness evaluations is expected to decrease.

Between FY15 and FY33, the total RM&E budget is estimated to be $144.9 M.

4.2.2. Application of New Information and Performance Criteria

As actions are implemented, they will be evaluated against performance criteria and adjustments or modifications will be planned and made as needed (see Section 4.1.1). RM&E will be carried out as a part of this plan in order to support these evaluations and to monitor performance of the system.

A re-evaluation of actions will be considered as new information becomes available indicating differences from information relied on in this report. The level of difference that could initiate re-evaluation is a statistically significant difference between original information in this report in comparison to any updated information. Depending on the type of new information available and magnitude of difference from the original information relied upon, the analysis may re-apply the COP analysis framework to evaluate actions to achieve an overall level of performance for the collection of fish populations affected by the WS.

It is the intent of the Action Agencies to work closely with other stakeholders in the Willamette Basin to insure other factors impacting the fish are addressed. Any actions taken as a result of the recommended plan described in this report will be carried forward for analysis under the National Environmental Policy Act (NEPA) and other applicable environmental statutes.

This plan will be assessed on an annual basis and validated or adjusted in the out-years through the 5-year plan process. It is anticipated that the refinements, re-evaluations, and/or updates will continue to inform decision makers. It is not intended that this COP report will be updated, but the future assessments will be conducted and documented outside of this report.

4.2.3. Implementation Actions by Other Responsible Parties

A primary approach to meeting ESA obligations associated with the Corps Willamette Project operations is to re-establish ESA-listed spring Chinook and winter steelhead above select dams by providing effective fish passage. To achieve this goal and ensure benefits are realized from the fish passage improvements recommended in this plan, and to reduce costs from the Willamette hatchery mitigation program as fish passage is provided, the following additional actions are recommended for implementation in collaboration with state and federal fishery management agencies (Oregon Department of Fish and Wildlife and NOAA Fisheries):

1) Develop fish management plans for each wild spring Chinook and winter steelhead population affected by the WS which considers: a) near term actions to reduce hatchery effects as fish passage improvements are planned, b) reintroduction strategies to reestablish ESA listed Chinook and steelhead above dams, and c) long-term hatchery program plans following completion of fish passage improvements.
2) Eliminate hatchery summer steelhead production in the South Santiam in the North Santiam sub-basins to reduce impacts to wild winter steelhead.
3) Reduce hatchery Chinook production in the North Santiam and South Santiam and support reintroduction and brood needs for conservation production levels to reduce impacts to wild spring Chinook.
4) Reprogram Chinook hatchery production to support fisheries which do not impact wild spring Chinook natural production.
5) Protect reintroduced wild spring Chinook and winter steelhead above and below WS dams, by implementing new fishery regulations and designating critical habitat in the North Santiam above Detroit Dam.
6) Implement alternative mitigation to non-native trout stocking to reduce impacts to wild juvenile spring Chinook salmon, winter steelhead, and native trout where they co-occur.

The COP recommended plan, in conjunction with the actions above, will contribute to achieving the goals outlined in the UWR recovery plan (ODFW and NOAA Fisheries 2011). The COP recommended plan is most consistent with the Scenario #3 described in the UWR recovery plan.

Hatchery Fish Releases and Trap operations

The need to reform hatchery programs has been identified by scientists and policymakers based on growing concerns about the effects of artificial propagation on the viability of natural origin salmon and steelhead (HSRG 2015). Reducing or eliminating summer steelhead production in North and South Santiam is recommended to reduce impacts on ESA listed winter steelhead. For the same reasons, hatchery Chinook production in the North Santiam, South Santiam, and McKenzie should be reduced to "conservation" levels (supporting adult returns for reintroduction and brood needs). To support ongoing mitigation until fish passage is improved, Chinook hatchery production should be reprogrammed to support terminal fisheries which do not impact natural origin Willamette spring Chinook natural production. Trout releases to reservoirs should be eliminated once fish passage is improved and natural origin Chinook and/or steelhead are reintroduced.

Where hatchery fish are collected, trap operations currently prioritize needs of the ongoing hatchery programs. Trap operation protocols will need to prioritize wild fish needs as passage improvements are completed.

Fishery Management

Fishery protections should be added above and below Willamette system dams with increased enforcement of fishery regulations, alternative mitigation focused on native trout stocks, and/or by eliminating freshwater harvest or bycatch of juvenile spring Chinook salmon and winter steelhead. Current regulations are not designed to protect reintroduced wild spring Chinook and winter steelhead.

Critical Habitat

Critical habitat should be designated in North Santiam above Detroit Dam for Chinook and steelhead to provide the necessary environmental policy protections to support the re-established natural origin Chinook and winter steelhead above Detroit Dam.

Willamette Falls

ODFW's Willamette Falls adult fish ladder requires maintenance and possible improvements for adult migrating Chinook and steelhead. If this fish ladder fails, all benefits sought in this plan will be negated. Commitment is needed from ODFW and other responsible parties to maintain the Willamette Falls fish ladder.

Habitat Improvements

BPA leads an interagency Habitat Technical Team that is a sub-team of WATER. This group identifies potential habitat actions that will benefit listed species, explores possible partners for funding and execution, and utilizes available BPA funding to implement these projects.

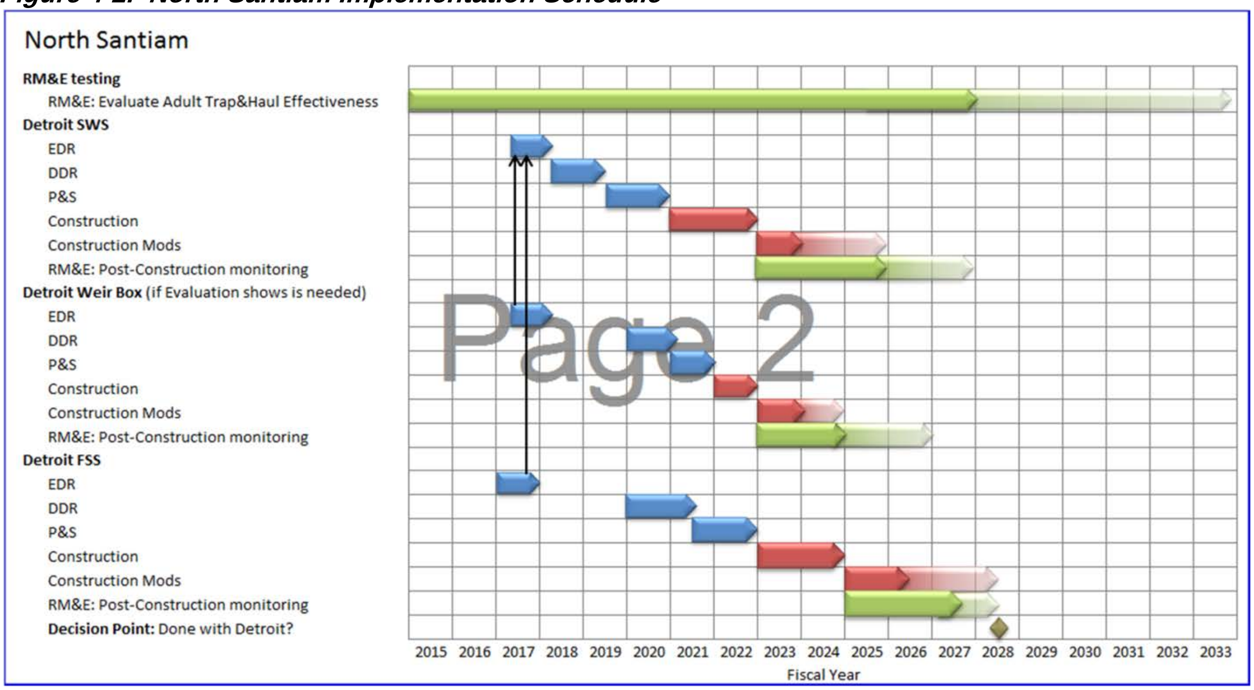
4.3. IMPLEMENTATION PLAN STRATEGY BY SUBBASIN

Additional implementation details by subbasin are provided in the following sections.

4.3.1. North Santiam Subbasin

A more detailed implementation schedule for the North Santiam is shown in Figure 4-2. The schedule includes design and construction timelines for the SWS, weir box and FSS, as well as general RM&E testing. Vertical lines in the figure show feedback between design teams.

Figure 4-2. North Santiam Implementation Schedule



Key implementation dates within the North Santiam subbasin are included in Table 4-5. Detailed assumptions for each of the dates are discussed in the subsections below.

Table 4-5. Key Implementation Dates for the North Santiam Subbasin

Fiscal Year	Action
2017	Detroit SWS design; initiate weir box and FSS design to support SWS design
2021-2023	Construction of SWS
2023-2028	Performance testing and adjustments of SWS
2021-2023	General time frame of using Cougar FSS design experience to inform Detroit FSS design
2022-2024	Construction of weir box
2024-2027	Performance testing and adjustments of weir box
2023	Earliest possible construction initiation of FSS
2025	Earliest completion date for Detroit FSS and testing
2028	Decision point on Detroit FSS effectiveness

4.3.1.1. Design Information Points

Design information points refer to opportunities to make adjustments to a design or evaluate the project through performance testing, perhaps at other projects. These points will allow agencies to consider the latest biological information and performance testing results to make necessary changes on subsequent actions. As the technology for high-head downstream passage is still being developed within the Willamette basin, careful consideration will need to be given to calling an action "done" and proceeding to the next action. Within the implementation schedule, three key design information points were assumed:

1) A decision to proceed with the weir box will occur before the design of the downstream passage.
2) Knowledge and data gained from the downstream passage design at Cougar, which is ahead of the Detroit schedule, will be used to inform the design of the Detroit FSS.
3) Upon completion of Detroit FSS and performance testing by 2028, determine the effectiveness of Detroit FSS in meeting performance criteria.

4.3.1.2. Detroit Selective Withdrawal Structure and Weir Box

Several key assumptions were made in the development of the implementation plan. In the North Santiam subbasin, it was assumed that the Corps could not initiate design of the SWS sooner than 2017. It was assumed that interim temperature operations would continue at Detroit until completion of the SWS. Because the SWS would need to accommodate a weir box and possibly a FSS, preliminary designs for all three components would need to occur prior to the commencement of the SWS DDR. The figure above shows vertical lines connecting the EDRs of these three components to emphasize their linkage. Current budget predictions indicate that there are no design funds for Detroit structures until after 2016. Therefore, the implementation schedule assumes that preliminary design for the weir box and FSS would begin in late 2017 with an EDR. The DDR and P&S phases for the SWS would be in 2018 to 2021 (18 months assumed for each). This puts construction of the SWS in 2021 and 2022 with one additional year scheduled for possible construction modifications in 2023. Final DDR and P&S for the weir box would occur in 2020 and 2021, with construction of the weir box assumed in 2022 and possible construction modifications occurring in 2023. The weir box would be tested in 2023-2025 to evaluate performance.

It is possible that the SWS and weir box could provide acceptable downstream fish passage benefits for juvenile Chinook and steelhead. The FSS construction period is assumed to begin two years later than the start of construction of the SWS and one year later than the start of the weir box construction to give the agencies an opportunity to assess the FSS and to learn from the Cougar FSS design and construction.

4.3.1.3. Detroit Floating Screen Structure

The Detroit FSS could complete design (DDR and P&S) no earlier than 2022. The construction of the FSS could occur in 2023-2024 with an additional year of construction modifications in 2025. Several years of performance testing and adjustment of the FSS would likely occur in 2025-2028.

4.3.1.4. Research, Monitoring and Evaluation

Key RM&E efforts would stem from the need to evaluate the effectiveness of the Detroit adult trap and haul program. This would include evaluation of adult spawning effectiveness and prespawning mortality. It would also include monitoring juvenile production and looking at genetics to determine the origin of returning adults and assess population replacement rates. The adult spawning effectiveness monitoring would likely occur until downstream passage was fully implemented (from 2015 through 2028, and possible as late as 2032). To support design of downstream passage, research needs include investigation into juvenile Chinook and steelhead forebay behaviors, timing and abundance of juvenile Chinook and steelhead in the Detroit forebay, and debris loads in the Detroit forebay.

Post-construction effectiveness monitoring would also occur for at least 2 years upon completion of each component - the SWS, weir box and FSS. The weir box and FSS studies would be looking specifically at fish passage efficiency and survival rates for the completed downstream passage structures and comparing them to the assumed performance criteria. Juvenile reservoir survival and steelhead kelt passage survival would be included.

4.3.2. South Santiam Subbasin

A more detailed implementation schedule for the South Santiam is shown in Figure 4-3. The schedule includes design and construction timelines for the Foster fish weir, as well as general RM&E testing.

Figure 4-3. South Santiam Implementation Schedule

Key dates within the South Santiam subbasin are included in Table 4-6 and are discussed in more detail in the subsections below.

Table 4-6. Key Implementation Dates for the South Santiam Subbasin

Fiscal Year	Action
2016	Foster fish weir DDR and P&S
2017	Construction of fish weir
2018-2019	Modification of design and performance testing and adjustments of fish weir

4.3.2.1. Foster Fish Weir

Improvements to the Foster fish weir can begin sooner than Detroit or Cougar since current budget plans have included this feature. The EDR will be completed in 2015, with DDR and P&S just after 2016. Construction is scheduled for 2017. Performance testing and adjustments will be made in 2018-2019.

4.3.2.2. Research, Monitoring and Evaluation

For the South Santiam subbasin, RM&E will focus on research regarding spill operations. Testing is planned for 2015 and 2016. Since the fish weir will require more spill, a TDG fish effects study will be scheduled for 2016-2017. Monitoring the effectiveness of the adult trap and haul program would continue with monitoring adult spawning effectiveness, prespawning mortality and juvenile production. Genetics work is planned to verify adult origins and population replacement rates. Other research needs include investigation into juvenile Chinook and steelhead forebay behaviors.

Post-construction effectiveness monitoring would also occur for at least 2 years upon completion of the fish weir. Studies would be looking specifically at fish passage efficiency and survival rates for the downstream passage structure and comparing it to the assumed performance criteria. Steelhead kelt passage survival would be included in the post-construction monitoring.

4.3.3. McKenzie Subbasin

A more detailed implementation schedule for the McKenzie is shown in Figure 4-4. The schedule includes design and construction timelines for the Cougar FSS and general RM&E testing. Key implementation dates within the McKenzie subbasin are included in Table 4-7. Detailed assumptions for each of the dates are discussed in the subsections below.

Figure 4-4. McKenzie Implementation Schedule

Table 4-7. Key Implementation Dates for the McKenzie Subbasin

Fiscal Year	Action
2017	Cougar FSS design restarts
2017-2019	Cougar FSS design (DDR and P&S)
2020-2022	Construction of Cougar FSS
2022	Earliest completion date for Cougar FSS
2022-2025	Modifications to design and performance testing and adjustments of Cougar FSS

4.3.3.1. Cougar Floating Screen Structure

The implementation plan assumes that Cougar FSS EDR would be completed prior to the end of 2017. Design of the FSS would recommence in 2017 with additional funding. Design work is scheduled for 2017-2019 for DDR and P&S (12 and 18 months, respectively) and construction could occur in 2020-2021 with an additional two years for construction modifications possible in 2022. Performance testing and adjustments would occur in 2022-2025.

4.3.3.2. Research, Monitoring and Evaluation

To support design of downstream passage, research needs include investigation into the timing and abundance of juvenile Chinook in Cougar forebay, and debris loads in the forebay. Near-term RM&E would involve evaluation and testing with the portable floating fish collector. This testing would also include evaluating juvenile Chinook distribution, juvenile forebay use as well as direct mortality studies. Information gathered would inform the design of the Cougar FSS.

The Cougar adult trap and haul program would continue to be monitored for adult spawning effectiveness, prespawning mortality and juvenile production. Genetics work is planned to verify adult origins and adult replacement rates.

Post-construction effectiveness monitoring would also occur for at least 2 years upon completion of the Cougar FSS. Studies would be looking specifically at fish passage efficiency and survival rates for the downstream passage structure and comparing it to the assumed performance criteria. Juvenile reservoir survival would also be evaluated at this time.

4.3.4. Middle Fork Willamette

A more detailed implementation schedule for the Middle Fork subbasin is shown in Figure 4-5. The schedule includes design and construction timelines for the Fall Creek adult fish facility and general RM&E testing. A key decision point is included for Middle Fork fish passage regarding determination of feasibility, and reviewing the necessary level of benefit needed to meet ESA obligations, before proceeding with design and construction. To support this decision point, RM&E is therefore recommended to investigate biological and technical feasibility of achieving a self-sustaining population of Chinook above Lookout or Hills Creek dams in the Middle Fork. The RM&E effort would be focused on fish passage and temperature issues in the Middle Fork. A summary table of key dates within the Middle Fork is included in Table 4-8. Detailed assumptions for each of the dates are discussed in the subsections below.

Figure 4-5. Middle Fork Willamette Implementation Schedule

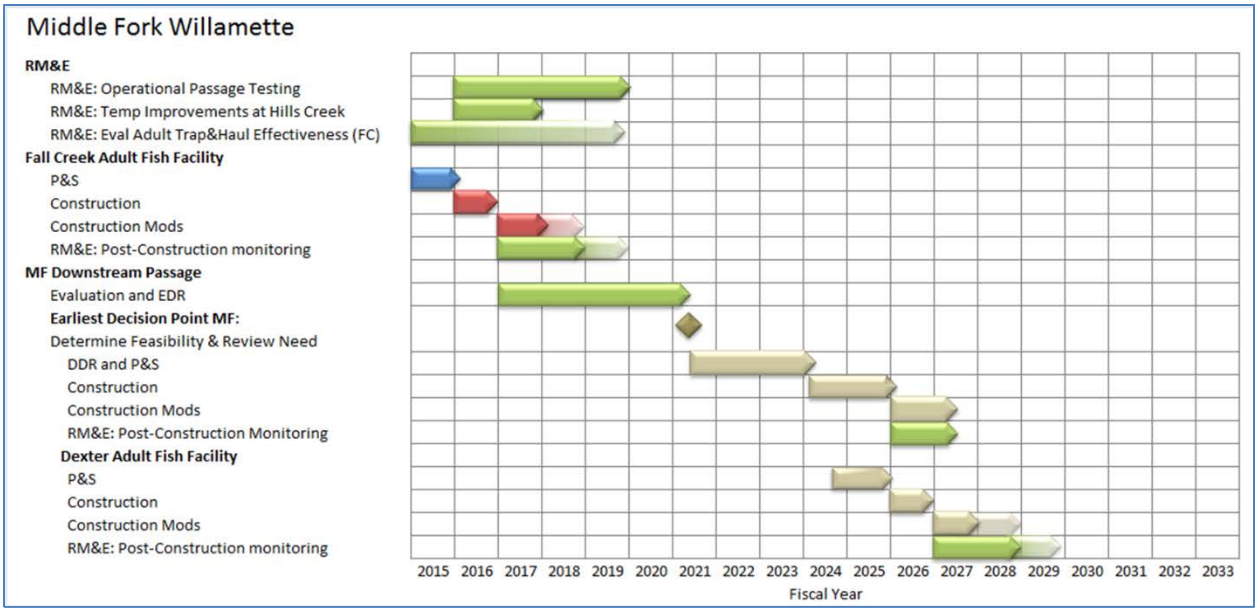


Table 4-8. Key Implementation Dates for the Middle Fork Subbasin

Fiscal Year	Action
ongoing	Fall Creek deep winter drawdown operation
2016	Adult fish facility construction
2017	Modifications to fish facility as necessary
2017-2019	Evaluation and testing at Fall Creek
2017-2021	Evaluation and EDR of Middle Fork fish passage options
2021	Earliest decision point on proceeding with design of fish passage options

4.3.4.1. Fall Creek Winter Drawdown

Fall Creek would continue with the deep winter drawdown that has occurred since 2011. The lake will continue to be lowered from the normal minimum winter level of 728 feet to elevation 680 to 690 feet for a short period in November or December. This draws the lake down to within about 10 feet of the regulating outlet entrance near historical streambed. Some additional post-implementation monitoring may continue with evaluation of dam safety requirements, sedimentation analysis or other engineering monitoring.

4.3.4.2. Fall Creek Adult Fish Facility

The Fall Creek adult fish facility will be the next construction project to be completed for BiOp implementation. Design work will be completed in 2015 with construction of the facility scheduled for 2016.

4.3.4.3. Middle Fork Temperature and Downstream Passage Team

The Middle Fork temperature and downstream passage PDT was initiated in 2014 with the intent of exploring temperature improvement options and downstream passage at Hills Creek, Lookout Point and Dexter Dams. This team is scheduled to complete an EDR to the 90% level in 2015, identifying possible preferred alternatives, but no recommendation. Furthermore, Figure 4-5 above indicates ongoing evaluations for downstream passage studies into 2021, with a decision to be made on whether to proceed with final designs for Lookout Point downstream passage and Dexter adult fish facility and their construction. The point indicated in the figure is the earliest that such a decision would be made, but could be made later than that date.

4.3.4.4. Research, Monitoring and Evaluation

Middle Fork Willamette (with the exception of Fall Creek) poses the most challenges for reintroducing and establishing a stable, self-sustaining population of spring Chinook salmon above Willamette system dams. This subbasin has the most dams and reservoirs in series (Hills Creek, Lookout Point and Dexter) which sub-divide the spawning and rearing habitat for spring Chinook and present multiple large passage barriers. Lookout Point and Dexter reservoirs are inhabited by several species of fish known to prey on juvenile Chinook, including large populations of northern pikeminnow (Monzyk et al. 2014). These two contiguous reservoirs (sub-divided by Lookout Point Dam) have a combined length of over 20 linear miles at full pool, creating challenging conditions for downstream migrating juvenile Chinook. Successful reintroduction of adult Chinook upstream of Lookout Point Dam and/or Hills Creek Dam is also complicated by having to trap adults below Dexter Dam, located downstream of the historic spring Chinook holding and spawning habitat, where water temperatures are warmer and little adult holding habitat is available. Warmer waters and poor holding conditions contribute to PSM, and spring Chinook in the Middle Fork subbasin have exhibited extremely high pre-spawn mortality (> 90%) in some years. If PSM is not reduced and controlled, re-establishing Chinook in the Middle Fork will likely not be possible (Keefer et al. 2010).

Within the Middle Fork subbasin, continued evaluation of downstream fish passage will be investigated focused on the issues described above. A range of structural and operational alternatives will be evaluated. Evaluations of the effectiveness of the adult trap and haul program would continue with monitoring adult spawning effectiveness, prespawning mortality and juvenile production. Key questions to resolve include:

- Can survival at key life stages be sufficiently improved and maintained to support a self-sustaining spring Chinook population above Lookout or Hills Creek dams?
    - Adult Chinook pre-spawn mortality (PSM)
    - Survival of juvenile Chinook in Lookout Point Reservoir
- Which is likely to better support population viability needs: rearing in reservoirs, or reservoir bypass?

4.4. CONCLUSION

The recommended plan outlined in this report will address our ESA obligations as it relates to the operations and maintenance of the Willamette System.

A cost-effective plan was developed based on the best biological, technical and cost information available. The costs presented in this document reflect the scientific and technical analyses supporting the COP team recommendations, including a cost contingency based on the uncertainties. As the plan components are designed and constructed and RM&E continues, new data will provide important information that will influence out-year actions to be implemented. Biological information compiled through the ongoing RM&E effort will be evaluated against the performance criteria and adjustments or modifications to design and construction will be re-evaluated to achieve goals for the affected fish populations.

The Action Agencies will pursue the necessary funding and initiate design and construction of Foster Fish Weir, Cougar downstream fish passage and the first component of the Detroit downstream fish passage structures. Detailed design work and ongoing RM&E will continue to inform the details of the plan. It is anticipated the plan can be implemented within the cost estimate developed.

This plan will be assessed on an annual basis and validated or adjusted in the out-years. It is anticipated that the refinements and updates will continue to inform decision makers. It is not intended that this COP report will be updated, but the annual assessment will be conducted and documented outside of this report.

It is the intent of the Action Agencies to work closely with other stakeholders in the Willamette Basin to insure other conditions negatively impacting the fish are addressed concurrently with the measures implemented by the Action Agencies.

4.5. ADDENDUM: COMPARISON OF COP COST ANALYSIS TO THE 5-YEAR STRATEGIC IMPLEMENTATION BUDGET

Purpose

Two separate documents have been developed to demonstrate the path forward for the Willamette System Biological Opinion. The first is this Configuration/Operation Plan (COP), and the second is the Willamette BiOp 5-year Implementation Plan. Although these two documents have similar goals, their development was for different purposes and over different time frames. As such there are differences in costs associated with the various alternatives, both within the COP and the 5-year Plan. Their overlap is in the total dollar figures for the Willamette CRFM budget for FY08 through FY33. This addendum outlines the reason for differences between the cost estimates of the COP Phase II Report and 5-Year budget report.

Initial Cost Estimates in COP Report

This COP Phase II Report contains descriptions of a number of alternatives for each sub-basin within the Willamette watershed. Costs were developed in 2014 for the COP primarily for analyzing alternatives and assisting in future budgeting. The analyses for each alternative are documented in the report for all evaluations conducted. Some alternatives were carried forward to be evaluated in combination with other alternatives to achieve system-wide criteria.

Three system-wide combinations were carried forward in the report as preferred alternatives.
All of the tables in Chapter 3 of this report that indicate costs are initial cost estimates used in evaluation of full range of alternatives. These were Project First Costs in 2014 dollars with 50% contingency but no escalation, as schedules were unknown. All alternatives were evaluated using the same cost estimate methodology in determining which ones to move forward with. These costs from Chapter 3 do not represent estimates to be used for budgeting in 2017-2023 since they were initial costs only.

Final COP Cost Estimate in Report

This COP Phase II Report documents a selected Preferred Plan (as recommended by the PDT), which is one of the final three Options in the document. The COP Preferred Plan is a specific set of individual sub-basin alternative combinations.

A Total Project Cost Spreadsheet (TPCS) cost estimate was developed for the COP Preferred Plan components in 2015. These costs and the TPCS were documented in the Cost Appendix H of the COP Phase II Report for the Agency Technical Review (ATR) by the Walla Walla Cost Center of Expertise and are documented in Chapter 4 and the Executive Summary of this COP report. These are Fully Funded Capital Costs with 50% contingency and escalation included, based on an effective level price date of 01 Oct 2014 for Program Year (Budget EC) of 2015.

The ATR of the Cost Appendix H resulted in some minor revisions to the TPCS. The final costs from the revised TPCS presented in this report are for the Preferred Plan only. Note that TPCS costs require the use of an assumed set of fiscal year quarters for all component design and construction midpoints. The 5-Year Plan for 2017-2023 was based on these fully funded capital costs.

COP Briefings

Following the completion of the Agency Technical Review of the COP report and preferred plan, a variety of implementation options were discussed at meetings with NWD and NMFS. In addition, a briefing was held at COE Headquarters, including attendance by high level Agency participants from BPA, NMFS and USFWS, where the agreed upon 5 year implementation plan varied slightly from the COP Preferred Plan presented in the report.

Summary of COP Costs and 5-Year Budget Numbers

While this COP Phase II Report was under final review, the Willamette System 5-Year Plan budget was developed and submitted. The 5-Year Plan submittal was drafted using the schedule implementation spreadsheet from the regional agreement, which differed slightly from the Preferred Plan spreadsheet. Some differences in costs were identified as a result of refined data, and two differences were identified as errors or omissions in the initial draft spreadsheet. This section outlines the differences between the COP report costs and 5-year plan budget numbers. Refer to the attached Table for specific cost differences for the implementation plan actions.

Errors and Omissions

Detroit Downstream Fish Passage: The information from the schedule implementation spreadsheet used for the 5-year plan development did not include the $15.5MIL Weir Box, which is included in this COP Phase II Report. During development of the 5-year plan, it was not recognized that this cost was omitted from the Detroit components. This component will be not be added to the current 5-year plan but will be considered in strategic implementation plans developed in later years.

Cougar: The information from the schedule implementation spreadsheet used for the 5-year plan development erroneously used the Cougar TPCS cost that was in the pre-ATR estimate. The COP ATR identified some slight changes to the Cougar estimate. Cougar costs in the 5-year plan are around $4.3MIL more than in the COP report.

Refined Cost Information

Foster Fish Weir: This COP report uses the TPCS cost estimate for this component. For the development of the 5-year plan additional, updated information was provided by the project design team. This estimate is approximately $3MIL greater than this COP report.

Fall Creek: Updated project costs were used in the 5-year plan rather than the COP TPCS estimates used in this COP report.

Characterization of Cost

RM&E: This COP report makes a general lump sum statement of $144.9MIL for RM&E, while the 5-year plan breaks out numerous projects that are associated with RM&E activities such as: Middle Fork downstream passage, high head bypass, and close out costs associated with the Foster and Minto adult fish facilities. Program coordination and collaboration costs are also broken out separately in the 5-year plan.

Table 4-9. Cost Breakdown for the 5-Year Plan and this COP Report, in Millions of Dollars

Action and Location	5-Year Strategic Implementation Plan Budget	COP Report	Implementation Plan Difference to COP	Reason for 5-Year Plan Difference
FY08 to FY14 already spent:	**$144.5**	**$144.5**	**$ 0.0**	
FY15 to FY33:				
Downstream Fish Passage				
Detroit (Phase 1 and 2)	$299.7	$299.4	$ 0.3	
Detroit Weir Box	-	$ 15.5	($15.5)	Omission[1]
Cougar Downstream Passage	$131.8	$127.5	$ 4.3	Pre-ATR cost[2]
Foster Fish Weir	$ 9.8	$ 6.8	$ 3.0	Refined Data[3]
Upstream Fish Passage				
Fall Creek – Adult Fish Facility	$ 18.3	$ 21.1	($ 2.8)	Refined Data[3]
RM&E Related				
Research, Monitoring, and Evaluation	$136.5	$144.9		
Minto Adult Fish Facility	$ 0.7			
Foster Adult Fish Facility	$ 1.4			
Middle Fork Willamette D/S Passage	$ 2.5			
High Head Bypass	$ 3.3			
Program Coordination/Collaboration	$ 0.6			
Sub-Total	$144.9	$144.9	$ 0.0	
Sub-Total for FY15 through FY33	**$604.5**	**$615.2**	**($ 10.7)**	
Total CRFM FY08 through FY33	**$749.0**	**$759.7**	**($ 10.7)**	

[1]DET Weir Box mistakenly not included in data provided for 5-year planning purposes
[2]Pre-ATR COP cost data mistakenly provided for 5-year planning purposes
[3]Data from project specific PDTs (post-COP ATR analyses) were obtained for 5-year planning purposes

4.6. RECOMMENDATION

The COP team gave careful consideration to the overall public interest, including the environmental, social, economic and engineering impacts, during the development of the alternatives and the recommended plan described in this report. The recommended plan is based on the best biological, technical and cost information available at this time and documents what is necessary to cost-effectively meet the requirements of the Willamette Biological Opinion. Any actions taken as a result of the recommended plan described in this report will be carried forward for analysis under NEPA and other applicable environmental statutes.

The recommendations contained herein reflect the information available at the time and current Department of the Army policies governing formulation of projects. They do not reflect program and budgeting priorities inherent in the formulation of national Civil Works construction program.

Date: 20151016

Jose L. Aguilar
Colonel, Corps of Engineers
District Commander

CHAPTER 5. REFERENCES

Al-Chokhachy, R. October 2013. Development of New Information to Inform Fish Passage Decisions at the Yale and Merwin Hydro Projects on the Lewis River. A review of existing data to anadromous fish reintroduction, collection and transport of anadromous fish above hydropower/dam facilities. U.S. Geological Survey, Bozeman, MT.

Alden BioAnalysts Inc. 2014. Willamette River Fish Benefit Workbook Parameterization: Chinook", Technical Memorandum, 01 Apr 2014.

Alden BioAnalysts Inc. 2014. Willamette River Fish Benefit Workbook Parameterization: Steelhead", Technical Memorandum, 01 Apr 2014.

Banks, M. A., and coauthors. 2014. A genetics-based evaluation of the spring Chinook salmon reintroduction program above Cougar Dam, South Fork McKenzie River, 2007-2013. Prepared by Oregon State University for the U.S. Army Corps of Engineers.

Bangs, B.L., P.D. Scheerer, and S.E. Jacobs. 2010. Effects of U.S. Army Corps of Engineers Willamette Project Operations on Oregon Chub and Other Floodplain Fishes. Oregon Department of Fish and Wildlife, prepared for the U.S. Army Corps of Engineers under Task Order W9127N-09-2-0007-0001 and U.S. Fish and Wildlife Service Cooperative Agreement Number 13420-8-J837.

Beeman et al. 2013. (Draft) Behavior and Passage of Juvenile Chinook salmon and Juvenile Steelhead at Detroit Reservoir and Dam, Oregon, March 2012-February 2013.

Beeman, J.W., Hansel, H.C., Hansen, A.C., Evans, S.D., Haner, P.V., Hatton, T.W., Kofoot, E.E., Sprando, J.M., and Smith, C.D. 2014. Behavior and Dam Passage of Juvenile Chinook Salmon at Cougar Reservoir and Dam, Oregon, March 2012–February 2013: U.S. Geological Survey Open-File Report 2014-1177.

Buchanan, D.V., M.G. Wade, and D.L. Higley. 1993. Restoration of the Native Winter Steelhead Runs on the South Santiam River above Foster Dam. Completion Report. Fish Research Project, Oregon. Oregon Department of Fish and Wildlife, Portland.

CH2M HILL. 2011. Lookout Point Dam, Head of Reservoir Collection Alternatives Study. Final Report. Prepared for the U.S. Army Corps of Engineers by CH2M HILL, AECOM, and BioAnalysts.

Corps. See U.S. Army Corps of Engineers.

Dalton, M.M., P.W. Mote, and A.K. Snover (eds.). 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Island Press, Washington, DC.

Doppelt, B., R. Hamilton, C. Deacon-Williams, M. Koopman, and S. Vynne. March 2009. Preparing for Climate Change in the Upper Willamette River Basin of Western Oregon. Co-Beneficial Planning for Communities and Ecosystems. CLI Institute for Sustainable Environment, University of Oregon, and National Center for Conservation Science and Policy.

ENSR, Inc. 2007. Surface Bypass Program Comprehensive Review Report. Prepared for the U.S. Army Corps of Engineers, Portland District, Portland, OR. by ENSR/AECOM.

Ford, M.J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-113.

Fulton, L.A. 1970. Spawning areas and abundances for steelhead trout and coho, sockeye, and chum salmon in the Columbia River Basin - past and present. National Marine Fisheries Service Special Scientific Report – Fisheries No. 618. 37 p.

Good, T.P., R.S. Waples, and P. Adams (eds.). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commerce, NOAA Tech. Memo., NMFS-NWFSC-66.

Groot, C. and L. Margolis. 1991. Pacific salmon life histories. UBC Press, Vancouver, British Columbia, Canada.

Hamlet, A.F., P. Carrasco, J. Deems, M.M. Elsner, T. Kamstra, C. Lee, S.Y. Lee, G.S. Mauger, E.P. Salathé, I. Tohver, and L.W. Binder. 2009. Final Report for the Columbia Basin Climate Change Scenarios Project. Climate Impacts Group, University of Washington, Seattle. Available at http://warm.atmos.washington.edu/2860/products/sites/.

House Resolution Document No. 81-531, 1950. Federal Columbia River Flood Control System. U. S. House of Representatives, Washington, D.C.

HSRG 2015. Annual Report to Congress on the Hatcheries. A report on the application of up-to-date science in the management of salmon and steelhead hatcheries in the Pacific Northwest. 39p.

Johnson, Gary E. and Dauble, Dennis D. 2006. Surface Flow Outlets to Protect Juvenile Salmonids Passing Through Hydropower Dams. Reviews in Fisheries Science. Vol. 14, Iss. 3, 2006

Keefer, M. L., G. A. Taylor, D .F. Garletts, G. A. Gauthier, T. M. Pierce, and C. C. Caudill (2010) Prespawn mortality in adult spring Chinook salmon outplanted above barrier dams. Ecology of Freshwater Fish 19:361-372.

Maher, M.T., M. Sheer, A. Steel, and P. McElhany. 2005. Atlas of salmon and steelhead habitat in the Oregon Lower Columbia and Willamette Basins. Northwest Fisheries Science Center, Seattle, WA.

Mattson, C.R. 1948. Spawning ground studies of Willamette River spring Chinook salmon. Research Briefs of the Oregon Fish Commission 1(2):21-32.

McElhany, P., M. Ruckelshaus, M. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, A. Steel, C. Steward, and T. Whitesel. 2003. Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids. Willamette/Lower Columbia Technical Recovery Team (W/LC TRT). Northwest Fisheries Science Center, Seattle, WA.

McElhany, P., M. Chilcote, J. Myers, and R. Beamesderfer. 2007. Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins. Prepared for Oregon Department of Fish and Wildlife and National Marine Fisheries Service. Northwest Fisheries Science Center, Seattle, WA.

McLaughlin, L. K. Schroeder, and K. Kenaston. 2008. Interim Activities for Monitoring Impacts Associated with Hatchery Programs in the Willamette Basin, USACE funding: 2007. Oregon Department of Fish and Wildlife, Salem.

Monzyk, F.R., R. Emig, J.D. Romer, and T.A. Friesen. June 2014. Life-History Characteristics of Juvenile Spring Chinook Salmon Rearing in Willamette Valley Reservoirs. Prepared for U.S. Army Corps of Engineers, Portland District. Oregon Department of Fish and Wildlife, Task Order Number W9127N-10-2-0008-0020.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D. M. Van Doornik, and M. T. Maher. 2006. Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins. Dept. of Commerce, NOAA Tech. Memo., NMFSNWFSC-73.

NMFS (National Marine Fisheries Service). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.

NOAA Fisheries (National Oceanic and Atmospheric Administration, National Marine Fisheries Service). 2006. NMFS Science Center Evaluation of the Peer Reviews of the Long-Term Central Valley Project and State Water Project Operations Section 7 Consultation. Prepared by S. Lindley, C. Legault, P. Mundy, J. Murphy, and R. Waples.

NOAA Fisheries. 2008. Endangered Species Act Section 7(a)(2) Consultation, Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation, Consultation on the Willamette River Basin Flood Control Project. Log Number F/NWR/2000/02117. Northwest Region, Seattle, WA.

NOAA Fisheries. 2014. Endangered Species Act Section 7(a)(2) Consultation, Supplemental Biological Opinion, Consultation on Remand for Operation of the Federal Columbia River Power System. Log Number NWR-2013-9562. Northwest Region, Seattle, WA.

Normandeau. 2013. Estimates of Direct Effects of Steelhead Salmon During Downstream Passage through a Turbine and Weir at Foster Dam, Oregon. Contract No. W912ef-08-D-0005, Task Order Dt04. Prepared for the U.S. Army Corps of Engineers Portland District – Willamette Valley Project. Prepared by Normandeau Associates, Inc. Normandeau Project Number 21464.009. January 2013.

NWP Office of Counsel. 2015. Verbal communications between COP PDT and NWP Office of Counsel.

O'Malley, K. G., M. L. Evans, M. A. Johnson, M. A., D. P. Jacobson, and M. Hogansen. 2015a. *An Evaluation of Spring Chinook Salmon Reintroductions Above Detroit Dam, North Santiam River, Using Genetic Pedigree Analysis.* Prepared for: U. S. ARMY CORPS OF ENGINEERS, PORTLAND DISTRICT. Prepared by: Oregon State University, Department of Fisheries and Wildlife, Coastal Oregon Marine Experiment Station, Hatfield Marine Science Center. 26p.

O'Malley, K. G., M. L. Evans, M. A. Johnson, M. A. Banks, D. P. Jacobson, and M. Hogansen. 2015b. Genetic parentage analysis of spring Chinook salmon on the South Santiam River. P. 27. Portland, OR.

Oregon Department of Agriculture. 1994. Amended request for reservation of the unappropriated waters of the Willamette River and its tributaries, including water stored within Corps of Engineers reservoirs, known as the Willamette Basin Project, for agricultural economic development (Reservation Request). Salem, OR.

Oregon Department of Fish and Wildlife (ODFW). 2005. 2005 Oregon Native Fish Status Report, Volume 1. Salem.

ODFW. 2007. Oregon ESA Recovery Plan for the Upper Willamette River Domain. Corvallis.

ODFW and NOAA Fisheries. 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. Prepared by ODFW, Salem, OR and NOAA Fisheries, Northwest Region, Seattle, WA.

Parkhurst, Z.E., F.C. Bryant, and R.S. Nielson. 1950. Survey of the Columbia River and its Tributaries. Part 3 (Area 2). U.S. Fish and Wildlife Service Special Scientific Report - Fisheries No. 36.

Portland General Electric. 2013. Bringing a Brighter Future. PGE Sustainability Report Fiscal Year 2013. Portland General Electric, Portland, OR.

Scheerer, P.D., P.S. Kavanagh, B. Bangs, and S.E. Jacobs. 2007. 2007 Oregon Chub Investigations. Oregon Department of Fish and Wildlife, Fish Research Project EF-07, Annual Progress Report, Salem.

Smith, E.M. and Korn, L. 1970. Evaluation of fish facilities and passage at Fall Creek Dam on Fall Creek in Oregon: Portland, Fish Commission of Oregon, Research Division, U.S. Army Corps of Engineers contract No. DA–35–026–CIVENG–66–400.

University of Washington, Climate Impacts Group, http://cses.washington.edu/cig/

U.S. Army Corps of Engineers. October 1994. Cost Effectiveness Analysis for Environmental Planning: Nine Easy Steps. Institute for Water Resources.

U.S. Army Corps of Engineers. 1995. South Santiam Fishery Restoration Draft Reconnaissance Study. South Santiam Subbasin Study. Portland District, Portland, OR.

U.S. Army Corps of Engineers. July 1996. Regional Recreation Demand Models for Large Reservoirs: Database Development, Model Estimation and Management Applications. Waterways Experiment Station, Vicksburg, MS.

U.S. Army Corps of Engineers. 2000. Willamette Basin Reservoir Study Interim Report. Portland District, Portland, OR.

U.S. Army Corps of Engineers. 2000. Planning Guidance Notebook (ER 1105-2-100).

U.S. Army Corps of Engineers. 2009. Willamette Valley Projects, Configuration/Operation Plan (COP). Phase I Report. Portland District, Portland, OR.

U.S. Army Corps of Engineers, Bonneville Power Administration, and U.S. Bureau of Reclamation. 2007. Supplemental Biological Assessment of the Effects of the Willamette River Basin Flood Control Project on Species Listed under the Endangered Species Act. Portland, OR.

U.S. Army Corps of Engineers, 2011. Portland District U.S. Army Corps of Engineers, Willamette Valley Project BiOp Implementation Program, Standardization of Passage and Survival Metrics. May 2011.

U.S. Army Corps of Engineers, 2011. Assuring Quality of Planning Models (EC 1105-2-412).

U.S. Army Corps of Engineers, 2014. Safety of Dams – Policy and Procedures (ER 1110-2-1156).

U.S. Army Corps of Engineers, 2014. Operational Measures Evaluation Team (OMET) Report, Portland District, Portland, OR.

U.S. Army Corps of Engineers, 2015. Corps of Engineers Civil Works Direct Program Development Policy Guidance Fiscal Year 2017 (EC 11-2-208).

U.S. Bureau of Reclamation. January 2007. Estimating Future Recreation Demand: A Decision Guide for the Practitioner. Denver, CO.

U.S. Fish and Wildlife Service (USFWS). 2008. Endangered Species Act Section 7 Consultation, Biological Opinion on the Continued Operation and Maintenance of the Willamette River Basin Project and Effects to Oregon Chub, Bull Trout, and Bull Trout Critical Habitat Designated Under the Endangered Species Act. File Number 8330.F0224(07). Tails Number 13420-2007-F-0024. Oregon Fish and Wildlife Office, Portland, OR.

Vynne, S., S. Adams, R. Hamilton, B. Doppelt. January 2011. Building Climate Resiliency in the Lower Willamette Region of Western Oregon. CLI Climate Leadership Initiative, a program of The Resource Innovation Group. Eugene, OR.

Wade, M.G., D.V. Buchanan, and S.P. Trask. 1987. Restoration of the native winter steelhead run of the South Santiam River above Foster Dam. Oregon Department of Fish and Wildlife Annual Progress Report, Portland, Oregon. 21 pp.

Wallis, J. 1963a. An evaluation of the North Santiam River Salmon Hatcheries. Oregon Fish Commission Research Laboratory. 66p.

Wevers, M.J., J. Wetherbee, and W. Hunt. 1992. Santiam and Calapooia Subbasin fish management plan. Oregon Department of fish and Wildlife. 174 p.

Zymonas, Nick. Bull Trout Reintroduction Efforts in the Upper Willamette Basin – Past, Present, and Future. Presentation at the Willamette Fisheries Science Review by Nick Zymonas, Oregon Department of Fish and Wildlife. February, 2013.