Appendix C
Draft Economics Study Update

Chehalis Basin Strategy

Draft Economics Study Update

Reducing Flood Damage and Restoring Aquatic Species Habitat

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Cover: *The Chronicle*, Centralia, Washington (left); Caitlin McIntyre, Lacey, Washington (center right and bottom right)

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ACRONYMS AND ABBREVIATIONS LIST

BCA	Benefit-Cost Analysis
CHTR	controlled handling, transport, and release
Ecology	Washington State Department of Ecology
EDT	Ecosystem Diagnosis & Treatment
EIA	Economic Impact Analysis
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FRFA	flood retention flow augmentation
FRO	flood retention only
HAZUS	Natural Disaster Model by Federal Emergency Management Agency
I-5	Interstate 5
IDC	interest during construction
NASS	National Agricultural Statistics Service
NPV	net present value
O&M	operation and maintenance
OM&R	operation, maintenance, and replacement
PV	present value
RM	river mile
TRA	Temporary Relocation Assistance
USACE	U.S. Army Corps of Engineers
WDFW	Washington Department of Fish and Wildlife
Work Group	Governor's Chehalis Basin Work Group
WSDOT	Washington State Department of Transportation

EXECUTIVE SUMMARY

This economic study is a technical analysis to be used in the process to develop the Chehalis Basin Strategy for reducing flood damage and restoring aquatic species habitat. The study was developed for the Washington State Department of Ecology (Ecology) in support of the State Environmental Policy Act Programmatic Environmental Impact Statement (EIS). This study updates the economic analysis completed in 2014 (EES and HDR 2014). The study analyzes the potential effect to the Chehalis Basin of alternative flood damage reduction and aquatic species habitat restoration actions. The economic study is a risk assessment of the expected impacts of different action alternatives on the costs of flooding and effects on aquatic species. The findings in this study will aid decision makers in determining next steps to reduce flood damage and restore aquatic species habitat in the Chehalis Basin.

Alternatives

There are five alternatives evaluated in the EIS and in this study. Each alternative, except for the No Action Alternative, has a combination of elements to reduce flood damage and restore aquatic species habitat.

No Action

The No Action Alternative is intended to represent the most likely future expected in the absence of implementing an action alternative. For the purposes of the EIS, Ecology considers the No Action Alternative to include:

- Projects and programs that have been planned and designed to address flood damage and/or aquatic species habitat
- Projects that are currently underway or being constructed
- Projects that have funding for implementation and are scheduled for implementation this biennium.

Under the No Action Alternative, existing activities, programs, and trends in the Chehalis Basin would continue, including compliance with State Forest Practice rules which will result in the maturation of riparian areas in commercial and state owned timberlands (Managed Forests).

Alternative 1: 2014 Governor's Workgroup Recommendation

The Governor's Chehalis Basin Work Group (Work Group) published its 2014 Recommendation Report, outlining a program of integrated, long-term, flood damage reduction and aquatic species habitat restoration actions for further study in the 2015 – 2017 state biennium budget. Since then, the Work Group membership has changed, and they are evaluating the alternatives in this EIS and public comments in crafting their recommendation to the Governor later in 2016. Alternative 1 would achieve flood damage reduction through implementation of a comprehensive package of actions to: provide Large-scale Flood Damage Reduction Actions (including the Flood Retention Facility) that target a broad geographic area, provide Local-scale Flood Damage Reduction Actions with more localized benefits, and restore aquatic species habitat. Action elements included in Alternative 1 are as follows:

- **Large-scale Flood Damage Reduction Actions –** Flood Retention Facility (flood retention only [FRO] or flood retention flow augmentation [FRFA]), Airport Levee Improvements, and Aberdeen/Hoquiam North Shore Levee
- **Local-scale Flood Damage Reduction Actions –** Floodproofing, Local Projects, Land Use Management, and Flood Warning System Improvements
- **Aquatic Species Habitat Actions –** Low- or high-scenario restoration actions that include restoring riparian habitat, removing fish passage barriers, restoring off-channel habitat, adding wood , restoring bank erosion to naturally occurring rates, reconnecting the floodplain, and creating/restoring/enhancing wetlands

For the purposes of the economic study, the benefits and costs of Alternative 1 do not include the Aberdeen/Hoquiam North Shore Levee, Local Projects, Land Use Management, and Flood Warning System Improvements. Information on the costs and impacts for these action elements were not available at the time of this study as these action elements are in the early stage of the planning process.

Alternative 2: Structural Flood Protection Without a Flood Retention Facility

Alternative 2 evaluates a scenario in which Large-scale Flood Damage Reduction Actions in the upper Chehalis Basin would be focused primarily on Interstate 5 (I-5) and the Chehalis-Centralia Airport. This alternative includes the Airport Levee Improvements, I-5 Projects, and Aberdeen/Hoquiam North Shore Levee. The rest of the action elements (the Local-scale Flood Damage Reduction Actions for more localized benefit and Aquatic Species Habitat Actions) are also included in Alternative 2. Action elements included in Alternative 2 are as follows:

- **Large-scale Flood Damage Reduction Actions –** I-5 Projects, Airport Levee Improvements, and Aberdeen/Hoquiam North Shore Levee
- **Local-scale Flood Damage Reduction Actions –** Floodproofing, Local Projects, Land Use Management, and Flood Warning System Improvements
- **Aquatic Species Habitat Actions –** Low- or high-scenario restoration actions that include restoring riparian habitat, removing fish passage barriers, restoring off-channel habitat, adding wood, restoring bank erosion to naturally occurring rates, reconnecting the floodplain, and creating, restoring, and enhancing wetlands

For the purposes of the economic study, the benefits and costs of Alternative 2 do not include the Aberdeen/Hoquiam North Shore Levee, Local Projects, Land Use Management, and Flood Warning System Improvements. Information on the costs and impacts for these action elements were not available at the time of this study as these action elements are in the early stage of the planning process.

Alternative 3: Nonstructural Flood Protection

Alternative 3 represents a "nonstructural" approach to reducing flood damage and restoring aquatic species habitat. In contrast to implementing Large-scale Flood Damage Reduction Actions, flood damage would be reduced through a programmatic effort to floodproof or remove existing structures. These structures and their contents would be protected from significant damage during floods through elevation and other measures. In limited situations where structures cannot be elevated or floodproofed, the most feasible action would be removal of structures. Though flooding would continue to occur, the damage from and cost of recovering from such floods would be reduced. This alternative includes the implementation of all of the Local-scale Flood Damage Reduction Actions and Aquatic Species Habitat Actions without any Large-scale Flood Damage Reduction Actions (Flood Retention Facility, Airport Levee Improvements, I-5 Projects, Aberdeen/Hoquiam North Shore Levee, or Restorative Flood Protection). Action elements included in Alternative 3 are as follows:

- **Local-scale Flood Damage Reduction Actions –** Floodproofing, Local Projects, Land Use Management, and Flood Warning System Improvements
- **Aquatic Species Habitat Actions –** Low- or high-scenario restoration actions that include restoring riparian habitat, removing fish passage barriers, restoring off-channel habitat, adding wood , restoring bank erosion to naturally occurring rates, reconnecting the floodplain, and creating/restoring/enhancing wetlands

For the purposes of this economic study, the benefits and costs of Alternative 3 do not include the Local Projects, Land Use Management, and Flood Warning System Improvements. Information on the costs and impacts for these action elements were not available at the time of this study as these action elements are in the early stage of the planning process.

Alternative 4: Restorative Flood Protection

The proposed actions under Alternative 4 include increasing the flood storage capacity of the Chehalis Basin watershed by adding roughness to the river and stream channels and floodplain, and by reconnecting floodplain storage to the river. It would reduce flood damage upstream of the confluence by relocating existing land uses out of the floodplain. This alternative focuses on reducing flood peaks downstream of the Newaukum River confluence on the mainstem Chehalis River, and would be accomplished through implementation of the Restorative Flood Protection action element. This alternative also includes implementation of all of the Local-scale Flood Damage Reduction Actions and

Aquatic Species Habitat Actions. The Restorative Flood Protection action element would be coordinated with and complement the Aquatic Species Habitat Actions within the treatment areas.

- **Large-scale Flood Damage Reduction Actions –** Restorative Flood Protection
- **Local-scale Flood Damage Reduction Actions –** Floodproofing, Local Projects, Land Use Management, and Flood Warning System Improvements
- **Aquatic Species Habitat Actions –** Low- or high-scenario restoration actions that include restoring riparian habitat, removing fish passage barriers, restoring off-channel habitat, adding wood , restoring bank erosion to naturally occurring rates, reconnecting the floodplain, and creating/restoring/enhancing wetlands

For the purposes of the economic study, the benefits and costs of Alternative 4 do not include the Local Projects, Land Use Management, and Flood Warning System Improvements. Information on the costs and impacts for these action elements were not available at the time of this study as these action elements are in the early stage of the planning process.

Methodology

Action alternatives are evaluated based on their costs and impacts relative to the No Action Alternative. Except with regard to fish populations, the No Action Alternative is modeled based on current conditions and does not consider population growth and development within the floodplain. Future growth within the floodplain is excluded to eliminate bias from forecasting future conditions, which could result in the inflation of benefits.

For the purposes of this study, the No Action Alternative includes Managed Forests. The inclusion of Managed Forests results in the action alternative impacts being compared with a fishery that is forecast to experience growth over the study period. In addition, the No Action Alternative does not include any flood damage reduction projects (other than those currently underway or being constructed, or scheduled for implementation this biennium). Costs for each action alternative are defined as the financial costs required to implement and operate each action alternative. Action alternative impacts are defined as the measurable change in flood damages and estimated fishery. Impacts may be either positive or negative.

Project implementation costs are compared with project impacts resulting in net benefits over the study period. Benefit-cost ratios are also reported for informational purposes. An uncertainty analysis is provided to demonstrate a range of project costs and impacts. The uncertainty analysis is based on available information and is not meant to show the full range of possible values.

> Business losses incurred within the basin during floods are felt locally but no loss is realized from a State or Federal Perspective.

Study Assumptions

Perspective

The economic study evaluates action alternatives from three perspectives:

- State – State of Washington
- Basin-wide – Lewis, Thurston, Grays Harbor, and Pacific counties
- Federal – National Economic Development account

The costs and impacts of action alternatives vary according to perspective.

General Assumptions

A 100-year study period was selected for the purposes of comparing action alternative implementation costs and estimated impacts. In using a 100-year study period, the full effect, positive or negative, from an action is assumed to be fully in place in year one of the 100-year period. All dollars are in real 2016 terms, thus inflation is excluded in the cost and impact estimates. Real interest rates are used for net present value (NPV) calculations and these discount rates may vary across perspectives. A discount rate of 1.5% was used to discount costs and impacts for the State and Basin-wide Perspectives. The Federal Perspective applied a 3.125% discount rate to the analysis based on federal requirements.

Action Alternative Costs

Action alternative costs include the capital costs needed to implement the project, annual operation and maintenance (O&M) costs needed to operate and maintain the project over the entire 100-year study period, and interest costs during the project construction phase. Interest during construction is calculated for structural action elements based on project construction schedules and a borrowing rate of 3.5%. Capital costs are provided in current 2016 dollars. Table ES-1 provides the initial capital costs and estimated present value (PV) of annual operating costs. Figures ES-1 and ES-2 summarize action alternative costs for the State Perspective.

Table ES-1
PV Capital and Operation and Maintenance ($2016), Millions

	CAPITAL	O&M
LOW RESTORATION SCENARIO		
Alternative 1		
FRO with CHTR Fish Passage	$548.0	$32.7
FRFA with Conventional Fishway and Forebay Collector	$793.7	$104.0
FRFA with CHTR and Forebay Collector	$747.5	$112.7
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$812.0	$71.1
Alternative 2	$405.7	$0.5
Alternative 3[1]	$297.9	$0.0
Alternative 4	$1,554.3	$12.2
HIGH RESTORATION SCENARIO		
Alternative 1		
FRO with CHTR Fish Passage	$875.4	$32.7
FRFA with Conventional Fishway and Forebay Collector	$1,121.1	$104.0
FRFA with CHTR and Forebay Collector	$1,074.9	$112.7
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$1,139.4	$71.1
Alternative 2	$733.1	$0.5
Alternative 3	$625.4	$0.0
Alternative 4	$1,797.8	$12.2

Notes:
1. Only floodproofing is included in the cost of Alternative 3. For this study it was assumed that floodproofing would not require annual O&M.
CHTR = controlled handling, transport, and release

Figure ES-1
Action Alternative Expected Cost Summary with Low Restoration Scenario, 100-year PV $2016

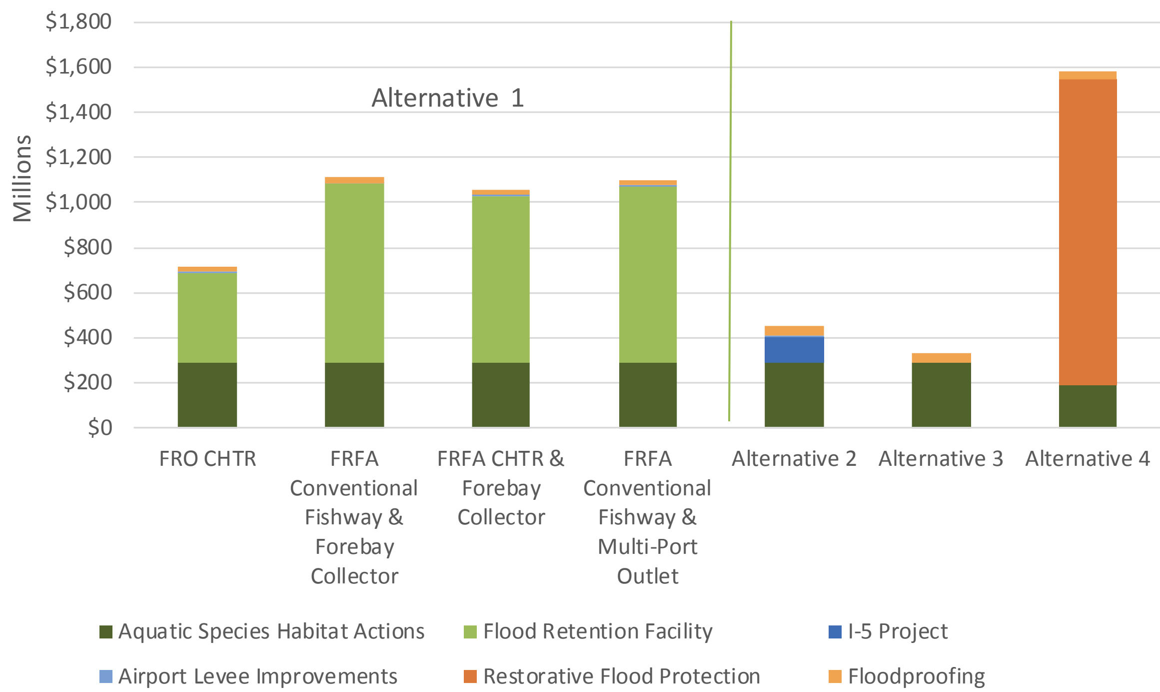
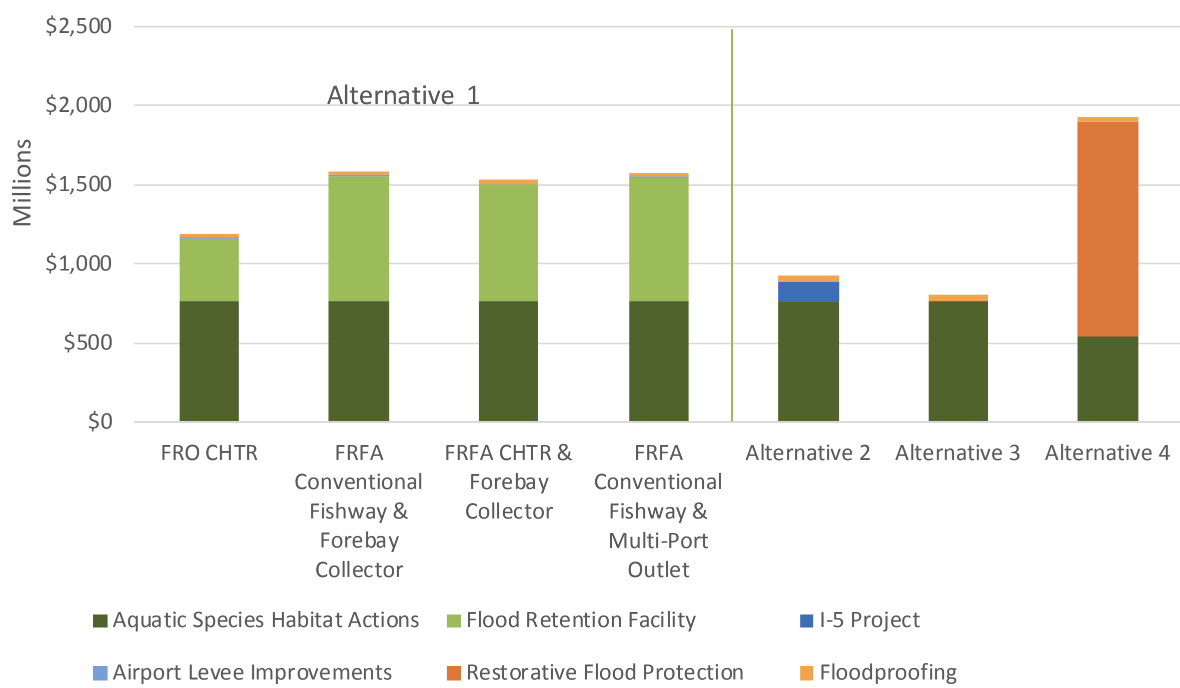


Figure ES-2
Action Alternative Expected Cost Summary with High Restoration Scenario, 100-year PV $2016



Action Alternative Impacts

If implemented, action alternatives may have both positive and negative impacts. The following impacts are quantified in this study:

- Flood damage to structures, content, and inventory
- Cleanup costs for buildings and agricultural acreage
- Vehicle damages
- Loss of agriculture crops due to flooding
- Transportation delays on I-5
- Temporary relocation costs for evacuated residents during flood events
- Public assistance during floods, including emergency protective measures for bridges, utilities, water control facilities, or debris removal
- Business interruption
- Commercial fishing
- Sport fishing
- Economic development

In addition, environmental non-use values are quantified and provided for informational purposes (but not included in the study net benefit results).

Results

This executive summary provides results for the State Perspective only. The main report includes results from the Basin-wide and Federal Perspectives.

Flood Damage Reduction

Flood damage reduction impacts were estimated for five flood events (2-, 10-, 20-, 100-, and 500-year). Based on the avoided damages, and probability of each flood event, expected annual impacts were calculated for each action alternative. Figure ES-3 demonstrates the breakdown of action alternative-expected annual flood reduction impacts in 100-year NPV from the State Perspective. Note that in Alternative 1, the flood damage reduction impacts are the same regardless of storage facility configuration (flood retention only versus flood control and flow augmentation). Aquatic Species Habitat Actions are excluded from the figure as they do not result in flood damage reduction impacts.

The most significant flood damage reduction impacts for action alternatives with storage options are due to avoided structure, content, and inventory damages. Second to structure, content, and inventory benefits, the Restorative Flood Protection greatly reduces damage to agricultural lands since under this alternative they are relocated out of the floodplain (avoided cleanup and crop damages). However, neither Alternative 3 nor Alternative 4 provide benefit by reducing I-5 transportation delays. The

I-5 Projects action element in Alternative 2 reduces some damages to property; however, the primary benefit is avoided I-5 closure costs. Floodproofing benefits are tied to floodproofing costs under each action alternative, as a larger number of buildings requiring floodproofing comes with both costs and benefits.

Figure ES-3
State Perspective: 100-year NPV Expected Annual Flood Damage Reduction Impacts

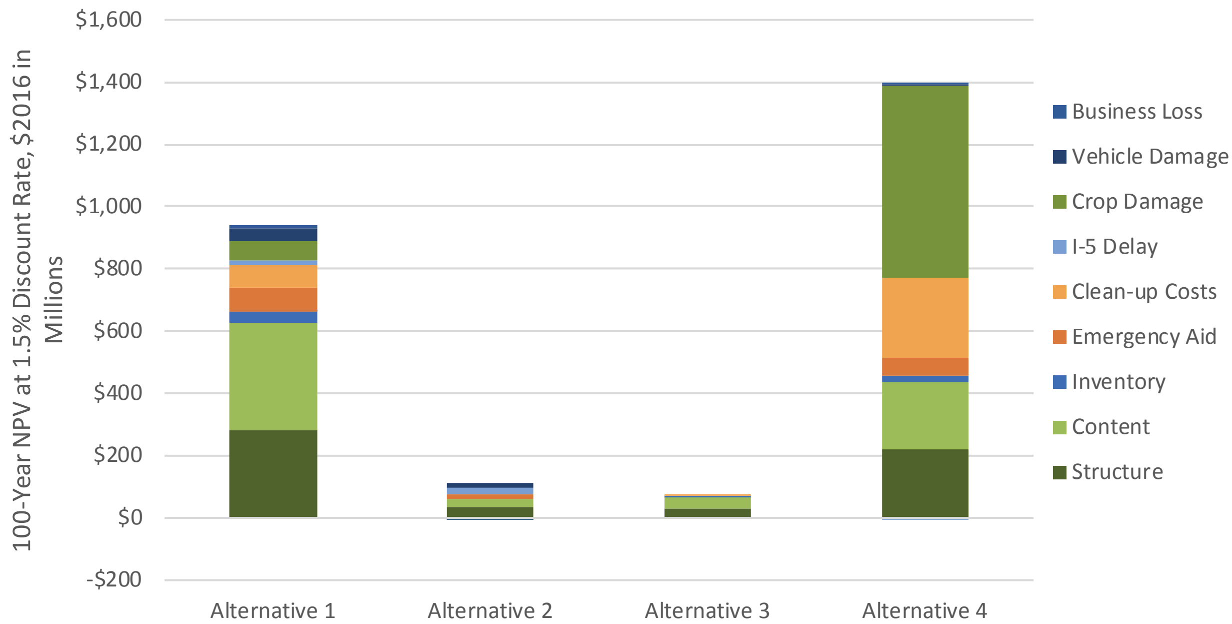


Table ES-2 summarizes the data provided in Figure ES-3.

Table ES-2
State Perspective: Flood Damage Reduction Impacts

100-YEAR NPV, MILLIONS ($2016)				
FLOOD DAMAGE REDUCTION	**ALTERNATIVE 1**	**ALTERNATIVE 2**	**ALTERNATIVE 3**	**ALTERNATIVE 4**
Structure	$283.4	$33.7	$29.4	$220.6
Content	$345.3	$26.2	$35.8	$215.0
Inventory	$33.0	-$0.4	$3.4	$21.4
Floodproofing	$69.3	$15.9	$0.0	$49.2
Public Assistance	$10.3	$2.4	$0.0	$7.3
Temporary Relocation Assistance	$8.9	$0.7	$0.0	$7.0
Clean-up Costs: Debris	$36.4	$0.1	$3.1	$26.9
Clean-up Costs: Structures	$18.2	-$1.1	$0.0	$162.4
Clean-up Costs: Agriculture Fields	$6.6	-$0.4	$0.0	$58.5
Clean-up Costs: Agriculture Re-seeding	$17.4	$16.3	$0.0	-$0.3
I-5 Transportation Delay	$58.7	-$1.0	$0.0	$617.6
Agriculture: Crop Damage	$41.4	$16.5	$0.0	$4.7
Vehicle Damage	$929.0	$108.9	$71.8	$1,390.3
Total	**$283.4**	**$33.7**	**$29.4**	**$220.6**

Fishery

Impacts to commercial, tribal, and sport fisheries (salmonid species) were estimated for each of the action alternatives based on:

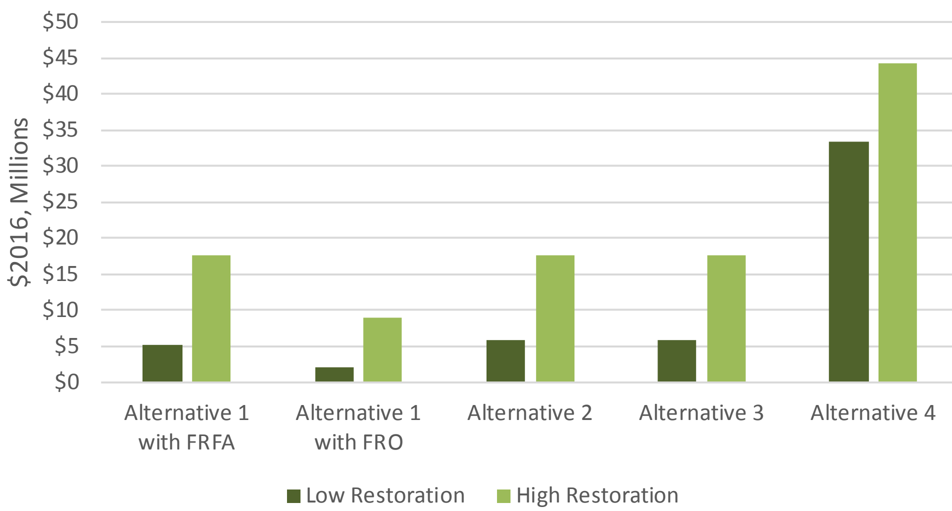
- Estimated changes in fish populations compared with the No Action Alternative [1]
- Commercial or sport value per fish.

> Benefits due to Managed Forest Practices are not included in action alternative benefits.

Although the flood retention facilities have fish passage structures included, these facilities have negative impacts on salmonid populations. When paired with Aquatic Species Habitat Actions, Alternative 1 impacts to fisheries are positive. Figure ES-4 illustrates the environmental impacts monetized in this study (use values only).

[1] The No Action with Managed Forest is estimated equal to the average of predicted populations resulting from 20% and 60% managed forest riparian buffer maturation. Since the No Action Alternative includes Managed Forest riparian maturation, the benefit of these practices is excluded from the action alternatives.

Figure ES-4
State Perspective: 100-year NPV Fishery Impacts



Net Benefits

Table ES-2 compares the action alternative implementation costs with the action alternative impacts for the State Perspective. Flood damage reduction impacts are reported separately from the environmental (fishery) impacts. All dollars are shown in 100-year NPV. The Net Benefit column shows the expected total net benefit for the full 100-year period of each element being fully implemented in year one. The costs and impacts shown in Table ES-2 are a result of the best available information and subsequent model output available at the time of this study's publication. The estimates in Table ES-3 represent the expected impacts and costs. Expected case results are calculated based on either an average or expected value from a range of input assumptions. For more discussion on action alternative non-quantifiable impacts please refer to the EIS.

Table ES-3
State Perspective: Net Benefits

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 1.5% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
	FLOOD DAMAGE REDUCTION	FISHERY USE VALUES (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1					
Low Restoration Scenario					
FRO with CHTR Fish Passage	$929	$15	$601	$342	1.6
FRFA with Conventional Fishway and Forebay Collector	$929	$7	$932	$4	1.0
FRFA with CHTR and Forebay Collector	$929	$7	$892	$45	1.0
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$929	$7	$916	$21	1.0
High Restoration Scenario					
FRO with CHTR Fish Passage	$929	$46	$929	$47	1.1
FRFA with Conventional Fishway and Forebay Collector	$929	$27	$1,260	-$304	0.8
FRFA with CHTR and Forebay Collector	$929	$27	$1,219	-$263	0.8
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$929	$27	$1,243	-$287	0.8
ALTERNATIVE 2					
Low Restoration Scenario	$109	$16	$408	-$283	0.3
High Restoration Scenario	$109	$47	$735	-$579	0.2
ALTERNATIVE 3					
Low Restoration Scenario	$72	$16	$298	-$210	0.3
High Restoration Scenario	$72	$47	$625	-$507	0.2
ALTERNATIVE 4					
Low Restoration Scenario	$1,390	$55	$1,450	-$5	1.0
High Restoration Scenario	$1,390	$82	$1,694	-$221	0.9

Uncertainty Analysis

The results in Table ES-2 are based on the best information available; however, there are many uncertainties related to this information. These uncertainties may include the following: uncertainty inherent in modeling, such as the hydraulic modeling and assumptions or flood damage modeling (HAZUS, a natural disaster model by the Federal Emergency Management Agency); uncertainty related to values or prices, i.e., the value of fish or the cost for cleanup of a residential building; uncertainty to land use for agricultural acreage, or uncertainty related to number estimates such as the number of people relocated during a flood or the change in fish populations. The uncertainty analysis evaluated low and high values for many of the study inputs and assumptions. These low and high values are not inclusive of the full possible range of outcomes; rather, they are based on available information via surveys, literature research, and conversations with local residents and business owners. Figures ES-5 and ES-6 demonstrate the results of the uncertainty analysis from the State Perspective. Alternative 4 has the greatest uncertainty due to the modeling of low impacts in agriculture. In the low impact scenario, crop damage is assumed to be zero for all action alternatives. This assumption is based on the timing of flood events during winter months during a time when crops may not be grown. Alternative 4 has the greatest impact to agriculture due to the relocation of acreage; therefore, the low impact scenario is significantly lower compared with the other action alternatives.

Figure ES-5

State Perspective: Uncertainty Summary with Low Restoration Scenario Actions

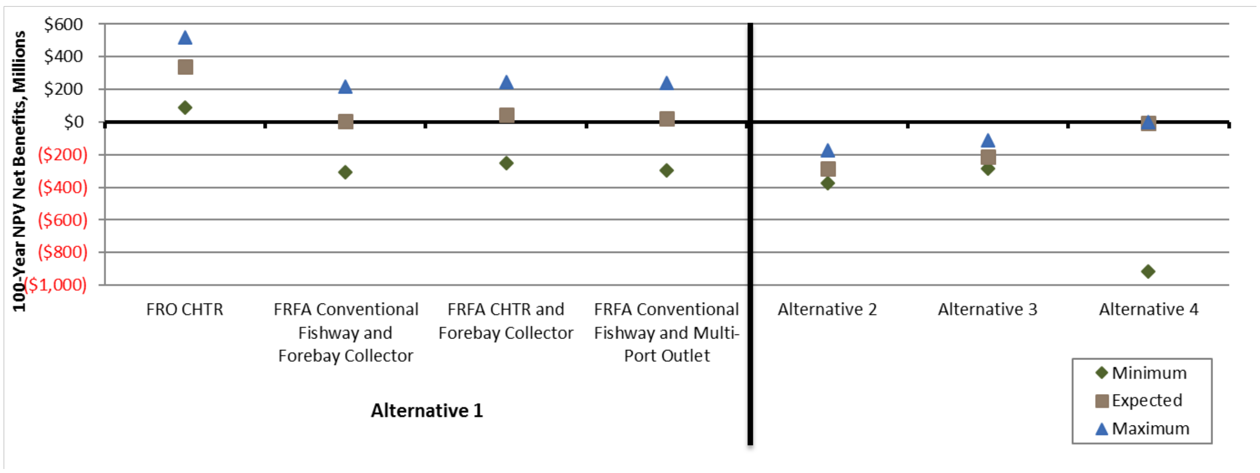
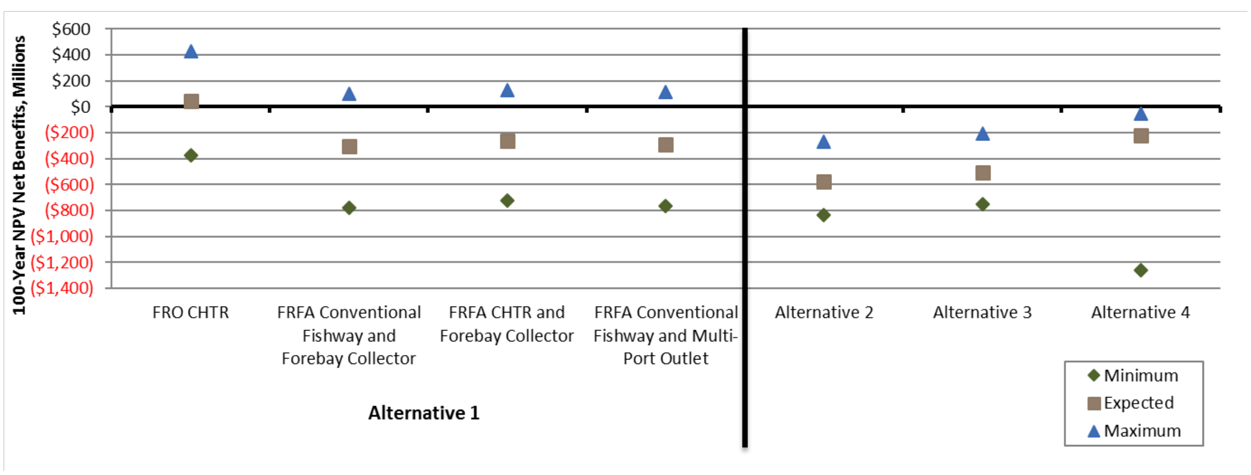


Figure ES-6

State Perspective: Uncertainty Summary with High Restoration Scenario Actions



Key Findings

This economic analysis indicates the following:

- The greatest flood damage reduction benefit from most action alternatives comes from eliminating damage to structures and their contents.
- More than 60% of the flood damage reduction benefit for Alternative 4 is due to the relocation of 10,300 acres of agriculture from the treatment area (average between 8,500 acres and 12,100 acres of relocated agricultural uses). However, acreage is based on land use zones and actual crop production may be less. Additionally, the value of the crops produced may vary depending on land location.
- Floodproofing is cost-effective when analyzed over 100 years for avoided damages.
- Alternative 4 provides the greatest benefit to fish populations.
- Any of the proposed flood retention facilities would reduce fish populations in the Chehalis Basin compared with the No Action Alternative; however, when paired with Aquatic Species Habitat Actions, the Chehalis Basin is estimated to realize greater fish population growth compared to the No Action Alternative.
- Avoided transportation delay benefits are greatest for Alternative 1 (flood retention).
-
- The uncertainty modeling shows that Alternative 4 net benefits have the widest range. Alternative 1 net benefits are sometimes positive, and Alternative 2 and 3 net benefits are always negative.

1 OVERVIEW AND OBJECTIVE

1.1 Introduction

This economic study is part of the Chehalis Basin Strategy: Reducing Flood Damage and Restoring Aquatic Species Habitat. The study was developed for the Washington State Department of Ecology (Ecology) in support of the State Environmental Policy Act Programmatic Environmental Impact Statement (EIS). The purpose of this study is to update the economic analysis completed in 2014 (EES and HDR 2014). The study analyzes the potential effect to the Chehalis Basin of alternative flood damage reduction and aquatic species habitat restoration actions. The economic study is a risk assessment of the expected value of flood damage reduction plus aquatic species effects under different action alternatives. The findings in this study will aid decision makers regarding next steps to reduce flood damage and restore aquatic species habitat in the Chehalis Basin.

1.2 Scope of Economic Study

The methodology used to evaluate the economics of potential alternatives is the result of decisions made by stakeholders and the interdisciplinary agencies participating in the technical meetings. In order for the EIS to evaluate the effects of various action alternatives, the EIS will need to be able to compare flood damage reduction and Aquatic Species Habitat Actions, which are then combined into action alternatives, in a consistent and comprehensive framework. The potential effect of each combined alternative is a complex issue that is difficult to summarize. The objective of this task is to provide sufficient information so that the decision makers can compare different alternatives and understand the potential effects of each alternative. The analysis provides consistent information about each action alternative. Though the study summarizes the results, the framework does not conclude which alternative is preferred. Rather, the decision makers will be deciding which alternative or alternatives are preferred based on the results and other factors.

1.3 Restricted Scope of Study

This study relies both on targeted, independent studies as well as “best available information” from the relevant literature. Not all conceivable topics were addressed nor all possible analyses performed. In addition, the phasing in of action alternative costs and impacts has not been addressed.

1.4 Report Organization

The model framework is described in the next section, followed by action alternative descriptions and cost estimates. The methodology used to determine the quantifiable impacts for each alternative is described next followed by a chapter describing the qualitative impacts for each alternative. The results of the economic analysis are provided in three sections, or one for each perspective. Appendices provide detailed information for each study component as well as more detailed results of the analysis.

2 MODEL FRAMEWORK

2.1 Project Purpose

The purpose of the Chehalis Basin Strategy: Reducing Flood Damage and Restoring Aquatic Species project is to evaluate action alternatives that reduce risk to life, property, and economy from flooding and restore habitat conditions in the Chehalis Basin. This study updates the work completed in 2014 to the same purpose.

2.2 Objective

The objective of this study is to evaluate the risks associated with flooding in the Chehalis Basin and to compare flood damage reduction and Aquatic Species Habitat Actions, which are then combined into action alternatives. The action alternatives evaluated were developed to represent a wide range of solutions addressing flood damage mitigation and aquatic habitat restoration. This study is the culmination of the work performed by numerous technical committees and is the result of collaboration among those most affected by the decisions. The methodology used to evaluate the economics of potential alternatives is the result of decisions made by stakeholders and the interdisciplinary agencies participating in the technical meetings.

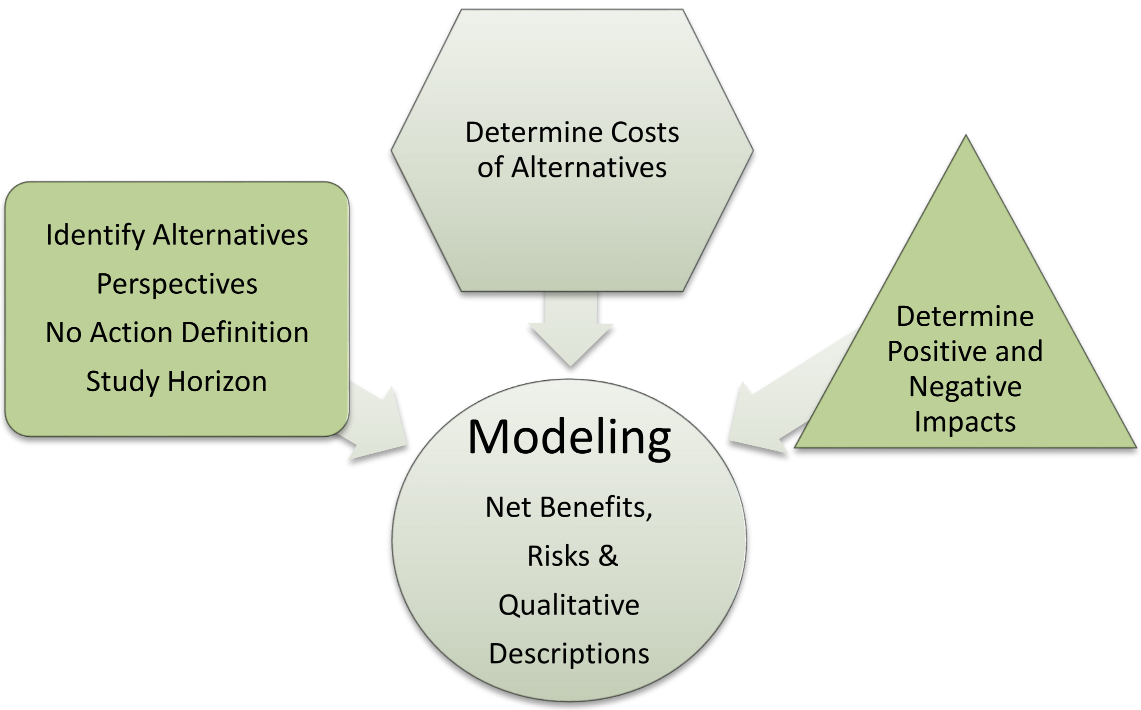
Because the analysis depends on input received from multiple technical committees, it was essential to define a consistent framework under which data and analyses were to be developed. In addition, the designed framework takes into account lessons learned from previous Chehalis Basin studies. In particular, the intent of this study is to incorporate the following principles:

- The study will measure the change in flood damage reduction and aquatic species habitat due to investments in each action alternative.
- The study evaluates multiple action elements, including Large-scale Flood Damage Reduction Actions, Local-scale Flood Damage Reduction Actions, and Aquatic Species Habitat Actions. The study evaluates all actions on a consistent basis and provides a comprehensive analysis and discussion of the effects of each action alternative.
- The study quantifies both environmental and non-environmental effects where possible and provides qualitative discussion of action alternative effects where quantitative analysis is challenging or impractical.
- The study incorporates uncertainty and risks associated with cost and impact estimates for each action alternative.

2.3 Overview of Methodology

Figure 1 provides an overview of the economic framework used in this study. The rectangle represents the foundation of the analysis; all of the remaining data gathering and analysis are based on this foundation. The hexagon describes the task of gathering cost data for each of the alternatives. These are the *financial* costs of implementing each alternative. The triangle represents the determination of impacts, both positive and negative, for each alternative and the determination of how to value each of these impacts. Finally, the circle represents the final calculation steps, which brings the analysis together and provides analysis and results that can be reviewed by decision makers and stakeholders.

Figure 1
Economic Analysis Process



Throughout the process, the economics research, analysis, and findings were shared and discussed with the agency experts and technical committees. The continual involvement of interested participants is an important part of the analysis in order for the economic results to be validated and approved once finalized.

There are generally nine steps in the development of an economics study methodology. These steps are listed below:

- Determine the No Action Alternative
- Identify action alternatives

- Determine the perspective from which the analysis will be conducted
- Develop cost of action alternative
- Analyze incremental impacts of the action alternative
  - Effects with action alternative
  - Effects without action alternative
- Gather data about the value of action alternative effects
- Develop a deterministic model to calculate the net present value (NPV) of expected net benefits
- Develop a risk profile around the expected net benefit
- Consider qualitative effects with the quantitative effects to inform decision makers

Each of these steps is described further below.

2.4 No Action Alternative

The No Action Alternative is intended to represent the most likely future expected in the absence of implementing an action alternative. For the purposes of the EIS, Ecology considers the No Action Alternative to include projects and programs that have been planned and designed to address flood damage and/or aquatic species habitat; are currently underway or being constructed; or have identified funding for implementation and are scheduled for implementation this biennium. Under the No Action Alternative, existing activities, programs, and trends in the Chehalis Basin would continue, including compliance with State Forest Practice Rules, which will result in the maturation of riparian areas in commercial and state owned timberlands (Managed Forests).

2.5 Action Elements and Proposed Alternatives

Table 1 provides a summary of the action elements evaluated in the EIS, and illustrates how the action elements are combined into the considered alternatives. Under the No Action Alternative, actions to reduce flood damage and improve aquatic habitat conditions would continue to a lesser extent than under the action alternatives (open circles demonstrate the reduced actions under this alternative).

Table 1
Action Elements and Combined Alternatives for Evaluation in the Draft EIS

ACTION ELEMENT	PROPOSED ALTERNATIVES				
	NO ACTION ALTERNATIVE	ALTERNATIVE 1: 2014 GOVERNOR'S WORK GROUP RECOMMENDATION	ALTERNATIVE 2: STRUCTURAL FLOOD PROTECTION WITHOUT FLOOD RETENTION FACILITY	ALTERNATIVE 3: NONSTRUCTURAL FLOOD PROTECTION	ALTERNATIVE 4: RESTORATIVE FLOOD PROTECTION
LARGE-SCALE FLOOD DAMAGE REDUCTION ACTIONS					
Flood Retention Facility (dam and associated reservoir)		●			
Airport Levee Improvements		●	●		
I-5 Projects		●	●		
Aberdeen/Hoquiam North Shore Levee		●	●		
Restorative Flood Protection					●
LOCAL-SCALE FLOOD DAMAGE REDUCTION ACTIONS					
Floodproofing		●	●	●	●
Local Projects	○	●	●	●	●
Land Use Management	○	●	●	●	●
Flood Warning System Improvements	○	●	●	●	●
AQUATIC SPECIES HABITAT ACTIONS					
Restore riparian habitat	○	●	●	●	●
Remove fish passage barriers	○	●	●	●	●
Restore off channel habitat	○	●	●	●	●
Add wood to streams for habitat	○	●	●	●	●
Reduce bank erosion to naturally occurring rates	○	●	●	●	●
Reconnect the floodplain	○	●	●	●	●
Create, restore, enhance wetlands	○	●	●	●	●

2.5.1 Action Elements[2]

2.5.1.1 Large-scale Flood Damage Reduction Actions

2.5.1.1.1 Flood Retention Facility

The Flood Retention Facility is a dam and associated temporary (flood retention only [FRO]) or permanent (flood retention and flow augmentation [FRFA]) reservoir located on the mainstem Chehalis River approximately 1 mile south of Pe Ell. The facility would temporarily store floodwater when major floods are predicted (where flows exceed 38,000 cubic feet per second [cfs] at the Grand Mound gage). Major floods have a 15% probability of occurrence in any given year, or once every 7 years on average.

2.5.1.1.2 Flood Retention Only Facility

The FRO facility stores water only during predicted major floods. The Chehalis River would flow normally during regular conditions or in smaller floods. The FRO dam would be designed to provide upstream and downstream juvenile and adult fish passage (salmonids, lamprey, and resident fish species) through approximately three or five 150-foot-long open tunnels installed at river grade at the base of the dam. During flood retention operations, a collection and transport system located below the dam would collect salmon, steelhead, and lamprey via a short fish ladder, hold the fish, and transport them in a truck to tributary or reservoir release points above the dam. The facility is composed of concrete and is estimated to be up to 226 feet high and 1,220 feet long. The reservoir, during maximum capacity, will hold 65,000 acre-feet from 68.9 square miles of the watershed.

2.5.1.1.3 Flood Retention Flow Augmentation Facility

The FRFA facility is a dam with a permanent reservoir and would continuously hold back water (instead of only during major floods). In addition to reducing flood damage during the winter, the water from the reservoir would be released in late spring through early fall to provide more water and cooler water temperatures in portions of the Chehalis River downstream of the dam. For upstream juvenile and adult salmon and steelhead passage, and adult lamprey passage, two alternatives are being evaluated: a fish ladder that would allow salmon and steelhead to volitionally pass over the dam and a collection and transport system (controlled handling, transport, and release [CHTR]) that would collect salmon, steelhead, and lamprey via a short fish ladder, hold the fish, and transport them in a truck to tributary or reservoir release points. One of these alternatives would be incorporated into the final dam design. For downstream passage of adult (steelhead) and juvenile salmon, two systems are being evaluated: a floating surface collection system (forebay) and a multi-port system.

The facility is composed of concrete and the structural height estimated to be up to 185 feet high and 2,470 feet long. The reservoir, during maximum capacity, will hold 130,000 acre-feet from 68.9 square miles of the watershed. This includes 65,000 acre-feet for the conservation pool and 65,000 acre-feet for the flood storage pool. The conservation pool would be filled during winter, and accessed under

[2] Summarized from the Draft Chehalis Basin Strategy Programmatic EIS.

low-flow conditions to augment downstream flows and reduce water temperatures. The flood storage pool would capture high flows to reduce downstream flooding during major floods. Actual flood-flow operations would depend on inflow and the need to hold water to relieve downstream flooding.

2.5.1.1.4 *Restorative Flood Protection*

Restorative Flood Protection is intended to rebuild the natural flood storage capacity of the Chehalis Basin by reversing landscape changes that contribute to downstream flooding and erosion. Restorative Flood Protection would increase the flood storage capacity of the Chehalis Basin by adding engineered large wood and plantings to create "roughness," or resistance to flow, to river and stream channels and the floodplain, and by reconnecting river channels to floodplain storage. This strategy would necessitate individual actions be taken on a large scale and linked, which requires voluntary participation from many landowners within the Chehalis Basin.

Actions to accomplish Restorative Flood Protection would include floodplain and streambank plantings, placement of engineered large wood structures in floodplains and on streambanks, and placement of engineered wood structures in channels, to mimic natural short-term and long-term ecological processes. These actions are proposed for flood protection, but would be coordinated with and complement Aquatic Species Habitat Actions. Restorative Flood Protection would reduce flood peaks on the Chehalis River downstream of the confluence with the Newaukum River, which is where the greatest flood damages have historically occurred.

Actions associated with Restorative Flood Protection, like reinstatement of native vegetation and the placement of engineered wood structures in floodplains and in channels, would occur in "treatment" areas. Most of the major river and stream floodplain areas within the mainstem Chehalis upstream from the Newaukum River confluence, South Fork Chehalis, and Newaukum River are potential Restorative Flood Protection treatment locations (or opportunity areas). There are about 140 river miles (RMs) within the Restorative Flood Protection treatment area, and the associated floodplain area that is engaged by these rivers during a 100-year flood is about 21,000 acres.

2.5.1.1.5 *Airport Levee Improvements*

The Airport Levee Improvements include elevating the height of the existing levee and raising a portion of Airport Road to provide 100-year flood protection for the Chehalis-Centralia Airport and local businesses as well as a portion of Interstate 5 (I-5). Improvements to the existing airport levee would be made by increasing the height of the 9,511-foot-long levee by between 4 and 7 feet. In addition to raising the existing levee, 1,700 feet of Airport Road would be raised to meet the raised airport levee height along the southern extent of the airport and all utility infrastructure would be replaced, terminating at the West Street overcrossing approach. Including the raised section of Airport Road, the Airport Levee Improvements would result in up to 11,211 linear feet of protective levee.

2.5.1.1.6 *I-5 Projects*

The I-5 Projects includes a series of earthen levees and structural floodwalls along I-5 and bridge replacements over Dillenbaugh and Salzer creeks. Stormwater treatment areas will be constructed to collect runoff from I-5 and to convey, store, or discharge stormwater as necessary to prevent closure of I-5 due to flooding. Placement of floodwalls at the locations identified will be designed to optimize potential collateral benefits (such as protection of urban areas) and to minimize adverse environmental impacts.

2.5.1.1.7 *Aberdeen/Hoquiam Northshore Levee*

The Aberdeen/Hoquiam North Shore Levee consists of previously considered smaller projects combined into a comprehensive approach to protect the cities of Aberdeen and Hoquiam, and would result in a total of approximately 5.8 miles (30,000 linear feet) of levees—3.5 miles (18,400 linear feet) in Aberdeen and 2.3 miles (11,600 linear feet) in Hoquiam. The Aberdeen/Hoquiam North Shore Levee includes an earlier, smaller project known as the Northside Levee. The Northside Levee alignment, which would encircle Aberdeen's city center along the north side of the Chehalis River in Aberdeen, would be designed to provide 100-year coastal flood protection to Aberdeen. The North Shore levee would run through low, flat, developed urban areas around the city center. The proposed levee system would be built to an elevation of 14.5 feet using a combination of earthen levees, floodwalls, raised streets, stop-log closures, and pump stations.

The Aberdeen/Hoquiam North Shore Levee would expand protection beyond Aberdeen's city center to encompass the majority of the lowlands in Aberdeen and Hoquiam laying east of the Hoquiam River, north of Grays Harbor, north of the Chehalis River, and west of the Wishkah River. Conceptual design features include earthen levees, concrete T-walls, raised streets, stop-log closures, and pump stations; sheetpile walls could also be needed. The elevation of the Aberdeen/Hoquiam North Shore Levee would also be designed accommodate potential future sea level rise.

According to Federal Emergency Management Agency HAZUS software, up to 2,715 structures could potentially be protected from coastal flooding after installation of this action element. The exact extent of flood protection and the number of structures protected would be determined during project-level design and environmental review. This action element is currently under design and very little information about it is available.

2.5.1.2 *Local-scale Flood Damage Reduction Actions*

2.5.1.2.1 *Floodproofing*

Floodproofing would protect existing structures in the Chehalis River floodplain by elevating structures above flood levels, building levees or floodwalls around them, demolishing or purchasing the structure, or other floodproofing measures. Within Lewis, Thurston, and Grays Harbor counties, approximately 75% of the residential homes within the Chehalis River floodplain could feasibly be elevated or floodproofed through other means. For other buildings (commercial, industrial, government, schools), it is assumed that approximately 25% of the buildings in the Chehalis River floodplain could feasibly be raised, retrofitted, or floodproofed by constructing flood barriers or walls. If structures cannot be floodproofed and are instead purchased in order to be demolished, community values would be taken into consideration with regard to creating open space, protecting natural resources, and avoiding creating areas of nuisance or visual blight.

This action element also includes protecting livestock and farm investments during floods by constructing farm pads and creating evacuation routes.

2.5.1.2.2 *Local Projects*

This action element includes a program of localized, area-specific projects aimed at immediately protecting critical infrastructure, frequently flood-damaged properties, and priority areas throughout the Chehalis Basin over the next 10 years. This action also includes projects that are intended to restore floodplain function. With or without Large-scale Flood Damage Reduction Actions, local projects would be needed to protect key infrastructure and improve the conveyance of water and drainage at key points in the Chehalis Basin (Ruckelshaus Center 2012). This action element is based on the Chehalis Basin Flood Authority's list of projects, with the exception of farm pads and evacuation routes, which are included in the Floodproofing action element. The Local Projects action element does not include those projects from the Chehalis Basin Flood Authority's list that have already been completed or are currently ongoing, but consists of additional projects proposed for implementation, including, but not limited to, the following:

- Protection of wastewater treatment plants, such as the Elma Wastewater Treatment Plant outfall stabilization project and the Montesano Wastewater Treatment Plant Wynoochee River bank protection project
- Protection of roads and infrastructure, such as the Grays Harbor County Wishkah Road flood hazard reduction project, the Oakville flood relief analysis project, and the Centralia China Creek (Phase II) project
- Certification of existing levees, such as the Aberdeen Southside Dike/Levee Certification, which could include some dike improvements
- Restoration of floodplains, such as the Satsop River Floodplain Restoration (future phases)

2.5.1.2.3 *Land Use Management*

This action element involves local governments improving and revising land use regulations and practices. Improved Land Use Management would protect remaining floodplain functions and avoid future damage by restricting land uses in the floodplain. The Land Use Management action element reflects model ordinance language for regulatory standards that are above the minimum state and

National Flood Insurance Program requirements. Specific Land Use Management recommendations are as follows:

- Regulatory Flood Data – These provisions would require additional flood data be utilized in floodplain regulations beyond that provided on the community's Flood Insurance Rate Map. Specific details are included in the EIS.
- Floodplain Protection – Minimizes development in flood-prone locations and protect natural flood plains.
- Construction Standards – Sets higher, more effective protection levels for buildings constructed or substantially improved in the floodplain.

2.5.1.2.4 *Flood Warning System Improvements*

The existing Chehalis Basin Flood Warning System, completed by the Chehalis Basin Flood Authority, features publicly accessible, real-time, web-based flood data and a monitoring and mapping site. Improvements include the following:

- Implementing a program to confirm the river gage rating curve/table for the Chehalis River at Centralia. This gage is located at the most populous area in the Chehalis Basin and is key to forecasting floods. The gage data used to convert river elevations to river flows has never been verified or confirmed with actual measurements of river flow.
- Expanding inundation mapping program to include the community of Bucoda.
- Adding a new NWS river forecast point on the Skookumchuck River near Bucoda.
- Working with the NWS River Forecast Center to implement a new hydraulic model in the lower Chehalis River.
- Revising inundation maps after significant floods to incorporate information obtained during the flood.
- Funding the addition of all Chehalis River inundation maps to the NWS inundation map website.

2.5.1.3 Aquatic Species Habitat Actions

Aquatic Species Habitat Actions would be designed to protect, improve, and create sustainable ecosystem processes and functions that support the long-term productivity of native aquatic and semi-aquatic species, and at much higher levels of abundance than current conditions support. Both a low and a high scenario are contemplated for this action. Action elements that would be implemented include the following:

- Restore riparian habitat along the lower mainstem Chehalis River and in tributaries throughout the Chehalis Basin (low and high restoration scenarios described below)
- Open up more than 295 miles of streams for migrating fish by removing partially or totally blocked fish passage barriers identified by the Washington Department of Fish and Wildlife; this

does not include the required Washington State Department of Transportation (WSDOT)-owned culvert corrections

- Restore off-channel habitat on the mainstem Chehalis River
- Add wood in the mainstem and tributaries to trap sediment and improve habitat for salmon and other species
- Restore bank erosion to naturally occurring rates
- Reconnect the floodplain, which could include:
  - Reconnecting oxbows in specific areas that would not exacerbate invasive predator issues
  - Removing levees and bank armoring
  - Allowing the river channel to migrate within the floodplain
- Create, restore, or enhance wetlands for use by semi-aquatic species

The low restoration scenario focuses on reaches in the middle and upper Chehalis Basin that improve habitat for spring-run Chinook salmon (104 RMs), whereas the high restoration scenario occurs across a greater geographic area with improvements to habitat focused on areas with the highest restoration potential for all salmonid species (356 RMs). Not all of these river reaches are likely to be restored under either restoration scenario, because restoration would be dependent on landowner willingness. For the purposes of this analysis, it is assumed that between 20% and 60% of these river reaches would be restored under either scenario. For the low restoration scenario, this equates to between approximately 21 RMs and 63 RMs (1,150 to 2,900 acres). For the high scenario, this equates to between approximately 71 RMs and 214 RMs (3,900 to 9,750 acres). Though these scenarios were developed based on habitat potential for salmonid species, the restoration actions will have benefits for other fish and amphibians as well.

2.5.2 Alternatives

2.5.2.1 No Action

The No Action Alternative is intended to represent the most likely future expected in the absence of implementing the proposed action alternative. For the purposes of the EIS, Ecology considers the No Action Alternative to include projects and programs that have been planned and designed to address flood damage and/or aquatic species habitat; are currently underway or being constructed; or have identified funding for implementation and are scheduled for implementation this biennium. Under the No Action Alternative, existing activities, programs, and trends in the Chehalis Basin would continue. For this economics study, the No Action Alternative includes Managed Forest effects.

2.5.2.2 Alternative 1: 2014 Governor's Workgroup Recommendation

The Governor's Chehalis Basin Work Group (Work Group) published its 2014 Recommendation Report, outlining a program of integrated, long-term, flood damage reduction and aquatic species habitat restoration actions for further study in the 2015-17 state biennium budget. Since then, the Work Group membership has changed, and they are evaluating the alternatives in this EIS and public comments in crafting their recommendation to the Governor later in 2016. This recommendation, the 2014 Governor's Work Group Recommendation (Alternative 1), would achieve flood damage reduction through implementation of a comprehensive package of actions to: provide Large-scale Flood Damage Reduction Actions (including the Flood Retention Facility) that target a broad geographic area, provide Local-scale Flood Damage Reduction Actions with more localized benefits, and restore aquatic species habitat. Action elements included in Alternative 1 are as follows:

- **Large-scale Flood Damage Reduction Actions –** Flood Retention Facility (FRO or FRFA), Airport Levee Improvements, and Aberdeen/Hoquiam North Shore Levee
- **Local-scale Flood Damage Reduction Action –** Floodproofing, Local Projects, Land Use Management, and Flood Warning System Improvements
- **Aquatic Species Habitat Actions –** Low- or high-scenario restoration actions that include restoring riparian habitat, removing fish passage barriers, restoring off-channel habitat, adding wood, restoring bank erosion to naturally occurring rates, reconnecting the floodplain, and creating/restoring/enhancing wetlands

For the economics study, Alternative 1 does not include costs or impacts for the Aberdeen/Hoquiam North Shore Levee, Local Projects, Land Use Management, and Flood Warning System Improvements. Information on the costs and impacts for these action elements were not available at the time of this study as these action elements are in the early stage of the planning process.

2.5.2.3 Alternative 2: Structural Flood Protection Without a Flood Retention Facility

Alternative 2 evaluates a scenario in which Large-scale Flood Damage Reduction Actions in the upper Chehalis Basin would be focused primarily on I-5 and the Chehalis-Centralia Airport. This alternative includes the Airport Levee Improvements, I-5 Projects, and Aberdeen/Hoquiam North Shore Levee as the Large-scale Flood Damage Reduction Actions. The rest of the action elements (the Local-scale Flood Damage Reduction Actions for more localized benefit, and Aquatic Species Habitat Actions) are also included in Alternative 2.

For the economics study, Alternative 2 does not include costs or impacts for the Aberdeen/Hoquiam North Shore Levee, Local Projects, Land Use Management, and Flood Warning System Improvements. Information on the costs and impacts for these action elements were not available at the time of this study as these action elements are in the early stage of the planning process.

2.5.2.4 Alternative 3: Nonstructural Flood Protection

Alternative 3 represents a "nonstructural" approach to reducing flood damage and restoring aquatic species habitat. In contrast to implementing Large-scale Flood Damage Reduction Actions, flood damage would be reduced through a programmatic effort to floodproof or remove existing structures. These structures and their contents would be protected from significant damage during floods through elevation and other measures. In limited situations where structures cannot be elevated or floodproofed, the most feasible action would be removal of structures. Though flooding would continue to occur, the damage from and cost of recovering from such floods would be reduced. This alternative includes the implementation of all of the Local-scale Flood Damage Reduction Actions and Aquatic Species Habitat Actions without any Large-scale Flood Damage Reduction Actions (Flood Retention Facility, Airport Levee Improvements, I-5 Projects, Aberdeen/Hoquiam North Shore Levee, or Restorative Flood Protection).

For the economics study, Alternative 3 does not include costs or impacts for Local Projects, Land Use Management, and Flood Warning System Improvements. Information on the costs and impacts for these action elements were not available at the time of this study as these action elements are in the early stage of the planning process.

2.5.2.5 Alternative 4: Restorative Flood Protection

The proposed actions under Alternative 4 include increasing the flood storage capacity of the Chehalis Basin watershed by adding roughness to the river and stream channels and floodplain, and by reconnecting floodplain storage to the river. This alternative focuses on reducing flood peaks downstream of the Newaukum River confluence on the mainstem Chehalis River, and would be accomplished through implementation of the Restorative Flood Protection action element. This alternative also includes implementation of all of the Local-scale Flood Damage Reduction Actions and Aquatic Species Habitat Actions. The Restorative Flood Protection action element would be coordinated with and complement Aquatic Species Habitat Actions within the treatment areas.

For the economics study, Alternative 4 does not include costs or impacts for Local Projects, Land Use Management, and Flood Warning System Improvements. Information on the costs and impacts for these action elements were not available at the time of this study as these action elements are in the early stage of the planning process.

2.6 Develop Perspectives (Geographic Boundary) for Analysis

When evaluating action alternatives, understanding the perspective of the stakeholders and decision makers is crucial to developing a useful study. For this study, stakeholders include not only the local community in the Chehalis Basin and the State of Washington, but also entities that may provide funding for future projects.

The three perspectives are described in more detail below:

- State: For the purposes of this study, a regional perspective is defined as the geographic area of the Washington (State Perspective). This perspective explores the impact of each action alternative on Washington and tribal lands located within Washington.
- Basin-wide: The Basin-wide Perspective examines each alternative based on the impacts within the basin. Because the focus is narrower, this perspective may not include all impacts included in the State Perspective; however, the Basin-wide Perspective may include additional social and economic impacts that would otherwise be excluded under the State or Federal Perspectives. The basin is defined as Lewis, Thurston, and Grays Harbor counties and parts from Cowlitz, Pacific, and Mason counties.
- Federal: Federal agencies, such as the U.S. Army Corps of Engineers (USACE) and the U.S. Bureau of Reclamation evaluate projects from a national perspective. These agencies examine impacts on a national level. For example, local business losses may not be included in the analysis as other businesses outside the basin may experience increases in economic activity during or following a flood. The Federal Perspective evaluates all impacts to the nation including impacts on the local Tribes.

Table 2 illustrates the types of impacts included for each of the perspectives. Blue or black circles indicate the impact is included. Blue circles indicate that the impact is included and may differ between perspectives. Black circles indicate that the impact is included and the estimated value is the same across perspectives.

Table 2
Perspective with Included Quantified Impacts

QUANTIFIED IMPACTS	STATE	BASIN-WIDE	FEDERAL
Structures, Content, and Inventory	●	●	●
Flood Cleanup Costs	●	●	●
Loss of Agriculture Crops	● (blue)	● (blue)	● (blue)
Transportation delays on I-5	● (blue)	● (blue)	● (blue)
Temporary Relocation Costs for Evacuated Residents	●	●	●
Emergency Protective Measures	●	●	●
Business Interruption		●	
Commercial Fishing	● (blue)	● (blue)	● (blue)
Sport Fishing	● (blue)	● (blue)	● (blue)
Environmental Non-use	●	●	
Economic Growth	● (blue)	● (blue)	

The action alternative costs and impacts are compared within each perspective. Though Table 2 shows which impacts differ across the three perspectives, the analysis compares action alternatives from different perspectives and it is not meant to compare projects or specific impacts across the perspectives.

2.7 Develop Costs for each Alternative

For each of the identified action alternatives the cost of implementing the included action elements is determined during the 100-year analysis period. The cost of each action element includes labor, equipment, and materials for the following cost categories:

- Initial and re-investment capital costs, including applicable taxes and financing costs
- Operations expenses
- Maintenance expenses
- Permitting expenses

2.8 Determine Incremental Impacts for Each Action Alternative

The fifth step of the analysis is to determine the impact of each of the alternatives. These impacts can be positive or negative (costs or benefits), and the impacts can be quantitative or qualitative results expected or resulting from the implementation of an action alternative. The impacts to be evaluated for the action alternatives were determined through several technical workgroup meetings involving various state agencies. The impacts evaluated in this study include the following:

- Commercial fisheries for salmon and steelhead
- Tribal fisheries for salmon and steelhead
- Recreational (sport) fisheries for salmon and steelhead
- Other environmental benefits such resiliency to climate change
- Structures, contents, and inventory damages
- Agricultural flood damages
- Cleanup costs
- Transportation
- Local employment and business income
- Environmental non-use value

The methodology and assumptions for how these impacts were evaluated in this study are described in detail later in this report. These impacts are compared with the No Action conditions described above.

2.9 Gather Data About the Value of each Action Alternative

Once the impacts have been identified, a value is determined. There are many methods for establishing value, including cost avoidance, cost savings, revenue generation, willingness to pay, and others. This step of the process involved a significant amount of research, analysis, and consultation with agencies and technical teams.

The quantitative analysis of action alternatives relies on hydraulic modeling to estimate flood damage reduction. The action elements analyzed for flood damage reduction include: Flood Retention Facility, Restorative Flood Protection, I-5 Projects, Airport Levee Improvements and Floodproofing. Costs and quantitative impacts for all other action elements within the action alternatives are not included in the economic study. Specifically, costs and impacts for the following are excluded:

- Aberdeen/Hoquiam Northshore Levee
- Flood Warning System Improvements
- Nonstructure Floodproofing (i.e., farm pads)
- Land Use Management

The costs and impacts for the above action elements are excluded from the economic analysis because cost and/or impact data were unavailable at the time of this study.

2.10 Develop Deterministic Model to Calculate Net Present Value of Expected Net-benefits

An essential impact analysis that needs to be completed for the economic study is a benefit-cost analysis (BCA). Traditionally, BCA is used to evaluate alternatives. BCA is a conceptual framework that quantifies in monetary terms as many of the costs and benefits of a project as possible. Benefits are broadly defined. They represent the extent to which people impacted by the project are made better-off, as measured by their own willingness to pay or willingness to accept. In other words, central to BCA is the idea that people are best able to judge what is “good” for them, what improves their well-being or welfare.

BCA also adopts the view that a net increase in welfare (as measured by the summation of individual welfare changes) is a good thing, even if some groups within society are made worse-off. A project or proposal would be rated positively if the benefits to some are large enough to compensate the losses of others.

Finally, BCA is typically a forward-looking exercise, seeking to anticipate the welfare impacts of a project or proposal over its entire life cycle. Future welfare changes are weighted against today’s changes through discounting, which is meant to reflect society’s general preference for the present, as well as broader inter-generational concerns.

The metric that is often used to compare alternatives is net benefit. Net benefits are equal to estimated benefits less estimated costs. For the impacts that can be quantified, i.e., represented by a dollar value, it is recommended that reported metrics for each alternative is the expected NPV of net benefits (benefits less costs) in constant dollars.

The BCA model is designed as a disaggregated model, so decision makers can understand the contribution to overall net benefits from each impact.

The specific methodology developed for this BCA is consistent with standard principles and includes the following general assumptions:

- All costs are in 2016 dollars
- The analysis period is 100 years
- The real discount rate used in the National Economic Development analysis (Federal Perspective) has been determined at 3.125% for studies conducted in 2016 (USACE 2015)
- A real discount rate of 1.5% is used for the State and Basin-wide Perspectives
- Results are also provided using a low (0%) real discount rate and a high (7%) real discount rate

2.11 Economic Benefits and Economic Impacts

An often misunderstood aspect in the evaluation of project impacts is the differences between BCA and Economic Impact Analysis (EIA). A BCA is the valuation of changes in societal welfare while an EIA is a measure of changes in expenditures resulting from a project. The combination of the two analyses results in a complete measure of economic benefits. Appendix N from the 2014 Study provides an example of the two analyses and how they are used together to determine the full impact of an action alternative.

This analysis will seek to evaluate both the improvements in societal welfare (net economic value) through BCA and the changes in expenditures as measured in the EIA framework.

2.12 Uncertainty and Risk

The risks and uncertainty associated with each action alternative is generally not reflected in the standard comparison of benefits and costs (BCA). In order to provide the Work Group with sufficient detail needed to make an informed decision, the economic study includes information about uncertainty and risks associated with the analyses.

In order to understand risks and uncertainties related to each alternative, the technical team used probability distributions where historical data is available and used deterministic analysis (high/medium/low) and ranges where data is not available.

3 ACTION ELEMENT COSTS

Action element costs were estimated for those components evaluated quantitatively in the economics study. Specifically, implementation costs were estimated for the following elements:

- Flood Retention Facility
- I-5 Projects
- Airport Levee Improvements
- Floodproofing
- Restorative Flood Protection
- Aquatic Species Habitat Actions

Project capital costs are provided in current, 2016 dollars. These capital costs are not discounted, levelized, or otherwise transformed. Interest during construction (IDC) is calculated based on a borrowing rate of 3.5% for all perspectives. The costs provided in this section account for the incremental cost for implementing and operating an action element. The amount of funding needed to finance an action element is a different value and is not discussed in this report. In addition, alternative funding sources and the cost of funding is not addressed as part of the study scope. Once a preferred action element is selected, funding sources will need to be evaluated and borrowing costs estimated.

3.1 Flood Retention Facility

FRO and FRFA cost estimates are summarized in Table 3. The expected, or medium case, costs are the average of the upper and lower bound. These costs include costs to construct the facilities including any roads and infrastructure needed for construction or maintenance. Annual operation, maintenance, and replacement (OM&R) costs are annualized costs required to maintain the facilities over the 100-year study period.

Table 3
Flood Retention Facility Estimated Project Costs

$2016, MILLIONS			
	CAPITAL	ANNUAL OM&R	INTEREST DURING CONSTRUCTION
EXPECTED			
FRO with CHTR Fish Passage	$274	$32	$21
FRFA with Conventional Fishway and Forebay Collector	$519	$104	$35
FRFA with CHTR and Forebay Collector	$473	$112	$32
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$538	$71	$33
LOWER BOUND			
FRO with CHTR Fish Passage	$212	$32	$16
FRFA with Conventional Fishway and Forebay Collector	$410	$104	$27
FRFA with CHTR and Forebay Collector	$373	$112	$25
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$424	$71	$26
UPPER BOUND			
FRO with CHTR Fish Passage	$337	$32	$25
FRFA with Conventional Fishway and Forebay Collector	$644	$104	$43
FRFA with CHTR and Forebay Collector	$584	$112	$39
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$667	$71	$41

Note: Detailed cost estimates are provided in Appendix A.

3.2 I-5 Projects

Ecology is evaluating several alternatives that would keep I-5 open during a 100-year flood as part of the EIS. Without any improvements it is estimated that I-5 would be closed for 5 days during a 100-year flood.

The cost of the I-5 Project is shown in Table 4 as provided by WSDOT and adjusted to 2016 dollars using the GDP deflator. WSDOT provided lower and upper bound cost estimates to encompass the project variations that could be implemented. For the purposes of this study, the expected cost is the average of upper and lower bounds provided by WSDOT. The operation and maintenance (O&M) costs are annualized costs required to maintain the project throughout the entire 100-year study period.

Table 4
I-5 Project Cost Estimates, $2016

	CAPITAL COSTS (MILLIONS)	ANNUAL O&M	INTEREST DURING CONSTRUCTION (MILLIONS)
Expected	$101.7	$5,000	$1.7
Lower Bound	$91.5	$5,000	$1.5
Upper Bound	$111.9	$5,000	$1.8

IDC is calculated based on a 4-year construction schedule where 25%, 30%, 30%, and 15% of the costs are needed for years 1 through 4. The same construction schedule is assumed for each cost estimate (lower bound, upper bound, and expected) regardless of whether or not a storage option is also implemented.

3.3 Airport Levee Improvements

WSDOT prepared a range of cost estimates for the airport levee as shown in Table 5 (adjusted to 2016 dollars). The expected cost is the average of the lower and upper bound. IDC is calculated based on a 4-year construction schedule where 25%, 30%, 30%, and 15% of the costs are needed for years 1 through 4. The same construction schedule is assumed for each cost estimate (lower bound, upper bound, and expected).

Table 5
Airport Levee Cost Estimates

$2016			
	CAPITAL COSTS	ANNUAL O&M	INTEREST DURING CONSTRUCTION
Expected	$4,600,000	$8,000	$71,000
Lower Bound	$4,100,000	$8,000	$71,000
Upper Bound	$5,100,000	$8,000	$81,000

3.4 Floodproofing

Floodproofing would protect existing structures in the Chehalis River floodplain by elevating structures above flood levels, building levees or floodwalls around them, demolishing or purchasing the structure, or through other floodproofing measures. Within Lewis, Thurston, and Grays Harbor counties, approximately 75% of the residential homes within the Chehalis River floodplain could feasibly be elevated or floodproofed through other means. For other buildings (commercial, industrial, government, schools), it is assumed that approximately 25% of the buildings in the Chehalis River floodplain could feasibly be raised, retrofitted, or floodproofed by constructing flood barriers or walls. Though some buildings, regardless of flood level, would be floodproofed, some building owners would not floodproof based on one or more of the following factors:

- Floodproofing is not cost-effective. The cost of floodproofing is too high compared with the perceived risk.
- Floodproofing is not feasible. The property or business is not conducive to floodproofing measures such as walls, berms, or levees due to lack of space or business function.
- Other location-specific factors.

The cost for commercial floodproofing is based on 25% of the total cost to floodproof all commercial buildings. Note that a cost-effectiveness evaluation for each building is not part of the study scope. The 25% achievability rate is the best approximation for achievability, cost, and impacts. In addition to the expected case, low and high achievability rates are analyzed. A low achievability rate of 10% is selected and a high rate of 50% is also analyzed. This range is based on conversations with local building owners regarding the applicability of floodproofing. The high value represents a high achievability rate given the issues raised by building owners. The selected range of achievability reflects the uncertainty related to how many commercial building owners would implement floodproofing if provided with the opportunity. The results with low and high achievability rates are presented as part of the uncertainty analysis. Similarly, a 75% achievability factor is used to calculate the number of residential buildings that will be floodproofed for each alternative. Table 6 shows the estimated number of structures that would be raised or floodproofed within the 100-year floodplain in the No Action Alternative and in each of the action alternatives.

Table 6
Floodproofing: Number of Buildings and Costs from Structure Survey

EXPECTED CASE 75% RESIDENTIAL AND 25% ACHIEVABILITY FOR NON-RESIDENTIAL $2016					
	BUILDINGS IN 100-YEAR FLOODPLAIN	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4
Residential Buildings	1,014	597	987	970	759
Non-Residential Buildings	349	207	288	299	302
Total Buildings[1]	1,363	804	1,275	1,269	1,061
Total Buildings Floodproofed[2]	848	500	812	802	645
Cost, Millions	$74.0	$40.5	$70.1	$68.6	$55.0

Notes:
1. Total buildings refers to buildings in the Chehalis River 100-year floodplain. Total buildings for Alternative 4 are buildings located downstream of the Neuwaukum confluence within the Chehalis River 100-year floodplain.
2. Achievability rates of 75% for residential and 25% for commercial buildings were applied to the structure survey analysis. Residential includes both residential and agriculture buildings.

It is important to note that even after floodproofing, properties will still be flooded and structures may be damaged depending of the severity and location of the flood.

3.5 Restorative Flood Protection

Restorative flood protection costs include the cost to buy out and relocate negatively affected homes and agricultural acreage located within the treatment area. Relocation and buy-out costs are estimated at between $265 and $505 million and include properties located within the 10- and 100-year floodplain, respectively. The low range cost estimate is associated with the relocation of 8,500 acres while the high range cost estimate is associated with the relocation of 12,100 acres of active farmland. The remainder of construction costs include instream restoration, floodplain wood installation, floodplain planting, taxes, planning, land acquisition, permitting, management, and engineering ($836.7 million). Annual O&M costs are estimated to total $24 million during the 100-year study period and include monitoring and adaptive management. O&M costs are higher in the first 20 years ($617,780/year) and reduce to $154,190/year after. Costs in Table 7 summarize the cost scenarios (low, expected, and high) for Restorative Flood Protection.

Table 7
Restorative Flood Protection Cost Estimates

$2016, MILLIONS			
ACTIVITY	LOW	EXPECTED	HIGH
Buy-out	$115	$160	$205
Relocation	$150	$225	$300
Construction Costs	$837	$837	$837
Total Implementation Costs	**$1,102**	**$1,222**	**$1,342**
100-year Monitoring and Adaptive Management (total)	$25	$25	$25

The costs above do not include costs to relocate or raise roads, utilities, or other infrastructure changes that may be needed. Construction spending is expected to occur over a period of 10 years; however, the timing of expenditures is not modeled in this study. It was also assumed that these projects would be funded through budgeting; therefore, IDC is not included. See Appendix B for supporting cost information.

3.6 Aquatic Species Habitat Actions

A range of costs was provided for each Aquatic Species Habitat Actions scenario (low restoration and high restoration). Costs for Aquatic Species Habitat Actions are provided separately for the combined action with Alternative 4 because there is some overlap in the treatment areas. The costs in the following table include implementation costs, acquisition costs, and culvert replacement. Maturation of riparian area in managed forestland (e.g., Managed Forest Practices) is not included in this Economics Study Update. For more information on Aquatic Species Habitat Actions, please refer to the EIS.

Table 8
Aquatic Species Habitat Actions Cost Estimates

$2016, MILLIONS			
ALTERNATIVE	LOW	EXPECTED	HIGH
ALTERNATIVES 1, 2, AND 3			
Low Restoration Scenario	$166.6	$229.3	$292.0
High Restoration Scenario	$345.7	$556.7	$767.7
ALTERNATIVE 4[1]			
Low Restoration Scenario	$127.6	$157.6	$187.6
High Restoration Scenario	$260.6	$401.1	$541.6

Note:
1. When combined with Restorative Flood Protection, Aquatic Species Habitat Actions cost estimates are reduced to account for areas of treatment that are common to both action elements.

4 ACTION ALTERNATIVE IMPACTS

4.1 Introduction

This section describes the methodology and assumptions behind the action alternative impact evaluations. Impact evaluation assumptions may differ across perspectives. These differences are described later within each perspective section. Impacts are separated into those related to flood damage and other impacts not related to flood damage (e.g., sport fishing impacts are not directly related to flood damages).

All action alternatives are compared to the No Action Alternative.

4.2 Quantified Impacts

The following project impacts are quantified in this study:

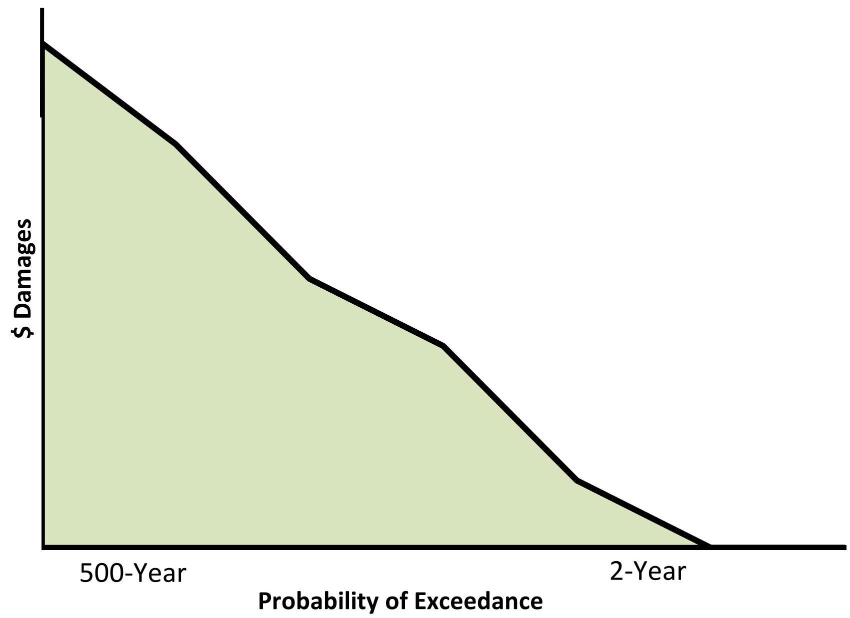
- Flood damage to structures, content, and inventory
- Cleanup costs for buildings and agricultural acreage
- Vehicle damages
- Loss of agriculture crops or crop damage
- Transportation delays on I-5
- Temporary relocation costs for evacuated residents
- Public assistance for emergency protective measures for bridges, utilities, water control facilities, or debris removal
- Business interruption
- Economic development
- Commercial fishing
- Sport fishing
- Tribal fishing
- Environmental non-use

Qualitative impacts are discussed in the next section.

4.3 Project Impacts on Flood Damages: Methodology

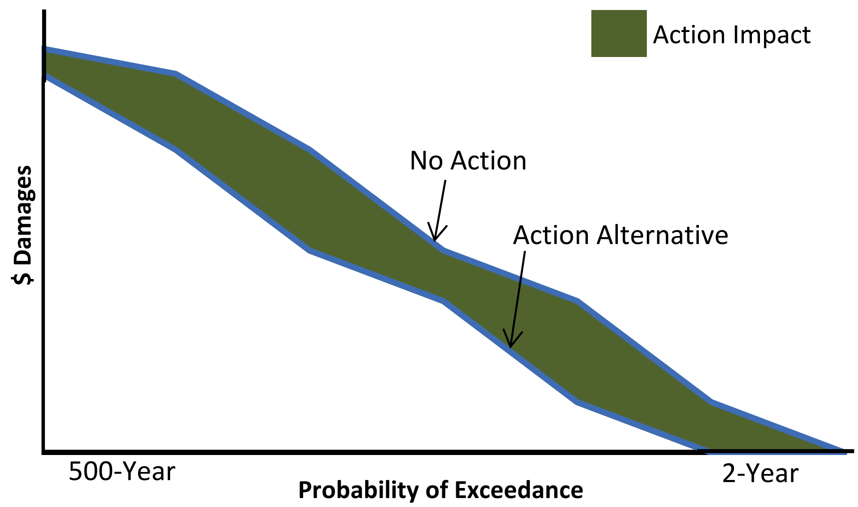
The value of flood damages for several flood return intervals (2, 10, 12, 100, and 500 years) is calculated for the No Action Alternative and each action alternative. A graph relating flood damage estimates with flood return intervals is referred to as a damage curve. Figure 2 is an example of a damage curve where the area under the curve is the expected damage for a given flood hazard. Figure 2 demonstrates that as the exceedance probability of a flood decreases, damages increase. In other words, a 100-year flood is much more severe and causes much more damage compared with a 10-year flood.

Figure 1
Example Damage Curve



Once a flood damage reduction project is introduced, the damage curve will shift such that damages are reduced or increased in some or all floods. Individual damage curves are estimated for No Action Alternative and each action alternative. The difference between an action alternative curve and the No Action Alternative curve is the impact of the action alternative. Impacts include values such as avoided damages to building structures and contents and agriculture products and equipment, avoided cleanup costs, and avoided costs due to transportation delays and detours. Figure 3 shows a sample shift in the damage curve resulting in an action alternative. The expected annual benefit (in dollars) of the flood reduction project is the area between the curves (green shading) in Figure 3.

Figure 2
Example of Reduction in Damage Curve



The above methodology is used to estimate action alternative impacts to flood damages. The resulting impacts are in expected annual values. Therefore, the economic study is a probabilistic analysis based on flood return intervals and related damages. Note that flood damage reduction impacts are the same for all four Flood Retention Facility configurations (dam and fish passage combinations) and are shown as such throughout the report.

4.4 Structure, Content, and Inventory

Flood damages to structures are estimated in HAZUS based on depreciated building values and average flood depth by census block. HAZUS used flood depth damage curves for each structure type to estimate the percent of the depreciated building value that is damaged. Flood depth damage curves relate feet of inundation with percent of building damage depending on the structure type. These damage curves are developed from national data; however, because the curves are applied to regional building types and basin-specific hydrology, the results are applicable to the Chehalis Basin. Content and inventory damages are based on structure value and structure type. For example, a residential structure may have 50% of its home value in contents while a hospital may have 150% of its structure value in contents. Both depreciated replacement value and full replacement value for structure and content damages are estimated. Business inventory (goods for resale) is not depreciated. Generally, flood damage reduction analyses present only depreciated replacement value; however, due to interest in the full replacement value, the State and Basin-wide Perspective results are presented for both depreciated and non-depreciated structure and content values. Non-depreciated replacement values are provided in Appendix C.

Floodproofing commercial and residential buildings to a 100-year flood is included in each of the action alternatives unless noted otherwise. The avoided damages due to floodproofing buildings or buying out properties over 100 years is significant. For the purposes of the economic study, the benefits of floodproofing are assumed to be equal to at least the costs of floodproofing. Floodproofing costs are estimated based on details from the structure survey completed for the EIS work. For the purposes of the economic analysis, it was assumed that 75% residential[3] and 25% of non-residential structures from the survey would be floodproofed.

4.5 Cleanup Costs

Cleanup costs include the labor and materials needed to remove debris and to clean a structure or property after a flood. The following three components are included in the cleanup cost estimates:

- Debris removal
- Building cleanup costs (commercial, residential)
- Agriculture field cleanup and enhancement

HAZUS provides the tons of debris generated from a flood, mainly damaged structures and contents. The cost to remove debris is estimated between $125 and $140 per ton ($2016).[4] Building cleanup costs are estimated at $5 per square foot ($2016). The number of buildings damaged and the average square foot for each building type damaged is also provided by HAZUS. Buildings that are substantially damaged (more than 50%) are excluded in cleanup costs because these buildings would be demolished. Demolished building cleanup costs are included in the debris removal costs.

Agriculture field cleanup cost and enhancement is based on the number of acres flooded (per HAZUS) and $508/acre to restore the fields to planting condition ($2016). In addition, re-seeding costs of $183 per acre are included.[5]

4.6 Vehicle Damages

Historically, during severe floods, vehicle damages have occurred. HAZUS estimates vehicle damages much the same way as structure damages are estimated. Damage estimates are calculated according to depth damage functions and vehicle depreciated replacement values. The economic analysis relies on default data within HAZUS to estimate vehicle damages for the 100- and 500-year floods. It is assumed that no damages occur for floods that are less severe.

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[3] Note that the achievability rate for residential structures is 85%; however, the structure survey does not include all residential buildings affected.

[4] Please refer to 2014 Study Appendix F. All costs are inflated to 2016 dollars.

[5] Id.

4.7 Agricultural Losses

4.7.1 Crop Damage

Damages to agricultural crops are based on either loss of currently planted crops or the lost use of acreage due to flood damage restoration. Depending on the time of year a flood occurs, farmers may need to reseed fields or they may experience total loss. Because most agricultural lands are located in or near the floodplain, flooding can cause significant loss to production. Crop damage is estimated based on the acreage flooded, cropping patterns by county, and value of crops by type. This methodology assumes that 100% of flooded acreage needs replanting, currently holds growing crops, or flood damage is great enough to delay production for at least one season. Cropping patterns are estimated using averages from the U.S. Department of Agriculture National Agricultural Statistics Service database.[6] Table 9 summarizes the cropping patterns assumed in the analysis.

Table 9
Cropping Patterns

AVERAGE ACREAGE 2002 TO 2012[a]				
LAND USE	**LEWIS**	**THURSTON**	**GRAYS HARBOR**	**TOTAL**
Field Crops	3,996	10,433	10,533	24,963
Barley (Grain)	747	0	98	845
Corn (Silage)	843	0	1,211	2,054
Wheat	1,864	0	2,281	4,145
Peas	205	3		208
Hay	338	10,430	6,908	17,677
Oats			35	35
Vegetables	1,407	192	2,240	3,839
Share of Field Crops				87%
Share of Vegetables				13%

Note:
a. U.S. Department of Agriculture, National Agricultural Statistics Service, Lewis, Thurston, and Grays Harbor counties.

The majority of acreage is in field crops. The share of crop type for each county is applied to the flooded acreage for each county. Crop yields (CWT/acre,[7] bushel/acre) are based on average historical yields for Washington State by crop type if available, or national data when unavailable. Prices for crops are based on average 5-year normalized national or state prices for all field crops depending on perspective. Vegetable prices are based on the 5-year average (2011 to 2015) of national or state prices depending

[6] Please refer to the 2014 Study, Appendix D.
[7] CWT (hundredweight or centum weight) is a unit of mass defined in terms of pounds. A short hundredweight is 100 lbs. This unit of mass is used in the United States.

on which was available and the relevant perspective. The table below shows the reduced flooding to agriculture for each action alternative. In the expected case, 10,300 acres of active agricultural land will be relocated in Alternative 4.

Table 10

Agricultural Acreage No Longer Flooded at Each Modeled Flood

ALTERNATIVE	2-YEAR	10-YEAR	20-YEAR	100-YEAR	500- YEAR
Alternative 1	3	2,249	2,652	2,400	1,941
Alternative 2	-37	-74	-22	31	105
Alternative 3					
Alternative 4	5,005	8,591	9,969	10,475	10,361

Note that the above methodology applies an average value for crop yield and pattern for acreage in each of three counties: Lewis, Thurston, and Grays Harbor. Additional refinement to the analysis would assign acreage values based on location to account for action alternatives that reduce flooding in high-value crop areas, pasture, or unused land.

4.8 Transportation Delays

4.8.1 Interstate 5

I-5 is closed for approximately 5 days during a 100-year flood. WSDOT estimated the cost a 100-year flood closure based on behavior surveys, traffic counters before and during the event, and the estimated cost of detour routes or delayed trips. WSDOT estimates that a 100-year flood costs a total of $11.5 million, or $2.2 million per day on average in additional travel costs ($2014). Based on survey information, this estimate assumes that only a share of “through” traffic takes a detour. When all “through” traffic takes a detour, the closure costs amount to $20.6 million ($2014). For the expected case scenario, the economic analysis uses the average between the two estimates provided by WSDOT. Even if some travelers delay or cancel their trip, there are indirect costs to the traveler that are not accounted for in this estimate ($11.5 million). For example, if the detour costs $100, but the trip is worth less than $100 to a traveler, the traveler would delay or cancel the trip. Delay and cancellation costs are not accounted for, if those costs are less than the detour cost. The WSDOT methodology, therefore, underestimates the cost of the closure in the lower estimate case. The expected case assumption for this study is a conservative estimate for transportation delay costs according to the USACE methodology.[8] More information on the WSDOT study can be found in the 2014 Study, Appendix E. All costs were inflated to 2016 dollars using the gross domestic product deflator.

8 WSDOT notes in their study that USACE allows for travel costs to be calculated assuming all through traffic takes a detour.

4.9 Emergency Aid

Emergency aid is a combination of Temporary Relocation Assistance (TRA) and Public Assistance. TRA is the cost to house relocated families during a flood. Public Assistance costs are emergency protective measures to secure infrastructure such as bridges, roadways, or utilities.

4.9.1 Temporary Relocation Assistance

Housing costs include reimbursements for hotel stays or public shelter costs. Those who relocate to stay with families or friends are included in the total damage estimate since the opportunity cost of staying with family is the cost of a public shelter or hotel. The total number of TRA claims is provided by HAZUS. HAZUS assumes that if a census block is at least partially flooded, the residents will need to be relocated due to loss of home, access, or utilities. The number of claims is multiplied by the estimated cost per claim. In the 2007 flood, the average claim was approximately $4,143 per relocated family. This figure is used for claims in the 100- and 500-year floods. For less severe floods, the average claim is approximately half of the 2007 amount, or $2,134 per claim.[9] These claims are per household.

4.9.2 Public Assistance

Public Assistance costs are calculated based on a ratio of costs compared with TRA costs. This methodology is consistent with previous studies conducted by USACE for the Chehalis Basin (USACE 2003). The expected case ratio of Public Assistance costs to TRA costs in this study is based on the 2007 flood (ratio of 5.4).

4.9.3 Business Interruption

Business interruption costs during a flood include the cost to businesses or landlords for building closure during floods, as well as the cost of delayed re-opening due to damages or relocation. Business interruption costs are composed of four parts (each of these components is described in more detail in the 2014 Study, Appendix I):

- Income (capital-related) losses
- Wage losses
- Relocation
- Rental Income losses

Business interruption costs are included only in the Basin-wide Perspective. From the State or Federal Perspective, these costs would be recouped by other businesses located outside the affected flood area but within the geographic boundaries of the perspective. Therefore, business interruption costs are local in nature and are not included when approaching the analysis from a wider geographic boundary.

9 Adjusted to $2016. Please refer to 2014 Study, Appendix G.

4.10 Other Impacts

4.10.1 Economic Development

To be provided in the final report.

4.10.2 Environmental

In the context of the economic study, environmental effects are defined as changes in fishery value for five species of fish. Changes to aquatic habitats would affect fish and non-fish species; however, this analysis monetizes benefits and costs of changes in salmonid populations, namely spring-run Chinook, fall-run Chinook, coho, and chum salmon and steelhead. As discussed in Appendix K of the 2014 Study, estimated benefits are determined by estimating a value per fish for different salmonid species and applying this value to the predicted changes in fish populations from each action alternative. Changes in fish population are estimated using the Ecosystem Diagnosis & Treatment (EDT) model, a habitat equilibrium model. Fish population changes for the action alternatives are compared to the No Action Alternative. The No Action Alternative includes managed forest practices; therefore, the action alternatives do not include the benefit of managed forest practices.

Fishery values are updated from the 2014 study based on inflation. The chum salmon value is estimated based on data from a Washington commercial fisheries study completed in 2008 (see Appendix E; TRG 2008).[10] Commercial, sport, and passive use values are calculated and applied to the change in fish population. Passive use values are reported separately in the quantitative summaries. Table 11 summarizes the values per fish used in the analysis. Additional information can be found in the 2014 Study, Appendix K.

Table 11

Economic Values per Fish, $2016

	OCEAN		GRAYS HARBOR		RIVER	TRIBAL	ANNUAL PASSIVE
SPECIES	COMM.	SPORT	COMM.	SPORT	SPORT	COMM.[1]	USE
Chinook[2]	$48.35	$85.56	$50.95	$103.70	$164.94	$25.57	$2,232
Coho	$10.28	$52.71	$10.31	$64.68	$146.80	$9.67	$2,232
Steelhead					$94.47		$2,232
Chum[3]	$5.35			$32.34	$73.40		$2,232

Notes:
1. This category combines the commercial value or catches via the Quinault Indian Nation “Treaty” and Confederated Tribes of the Chehalis Reservation “Non-treaty.”
2. Includes fall-run and spring-run Chinook salmon.
3. Chum salmon are valued only for commercial ocean and river sport. Tribal catches are not separated from commercial values. Grays Harbor and river sport values are based on relative value between commercial chum and coho salmon landings and the sport values for coho salmon (chum salmon is estimated to be valued at about half of the coho salmon value).

[10] Commercial Chum fishery is valued at $0.535 per pound applied to the average 10-pound fish.

Significant value that cannot be monetized is the cultural value that salmonids provide to the two principal tribes in the area: Quinault Indian Nation and the Confederated Tribes of the Chehalis Reservation. As discussed in the 2014 Study:

> An economic analysis of changes in salmonid fisheries to these Tribes can be estimated for commercial activities. However, the act of fishing and subsistence harvesting is recognized as a cultural way of life that is connected to their history and identity. These types of values are beyond economic valuation, which attempts to observe value behind the choices people make rather than to provide a definition of who people are. Instead of estimating an economic value of cultural impacts to salmonid population changes, it is recognized that the estimated benefits (and costs) are incomplete insofar as cultural values are not included in these estimates.

Economic benefits and costs are determined from the change in the impact of a project over time on salmonid populations relative to No Action Alternative conditions. For each project, it is assumed that it can be implemented within a 1-year construction period and impacts to species populations would be realized soon after. Impacts from either flood retention and restoration projects would be realized within 4 years for Chinook salmon and steelhead species and within 2 years for coho and chum salmon. Due to the magnitude of the restoration efforts, it would take several years to construct all of the projects. Though the benefits are assumed to be realized in the first few years, the actual benefits from the projects would likely take longer to be realized.

As with the 2014 Study, the No Action Alternative fish population is defined as Managed Forests where populations grow over the study period in the No Action Alternative. Because Managed Forest Practices are part of the No Action Alternative, the benefits of these practices are not included in the action alternatives benefits. Table 12 summarizes the population forecasts under the No Action Alternative.

Table 12
No Action Fisheries Population Forecasts: Managed Forest Practices

SPECIES	CURRENT	FUTURE[1]	PERCENT CHANGE
Spring-run Chinook Salmon	2,146	2,936	36.8%
Fall-run Chinook Salmon	25,844	27,816	7.6%
Steelhead	6,800	9,524	40.1%
Coho Salmon	40,642	58,482	43.9%
Fall/Winter Chum Salmon	190,550	209,776	10.1%

Note:
1. In the expected case, future No Action Alternative populations are equal to the average of the 20% and 60% managed forest practices results from EDT.

Finally, Table 13 presents the effects on each fish species from some combination of a flood retention structure and one or more restoration actions.

Table 13
Fish Population Changes with Combined Structure and Restoration (% Change from Projected Populations)

	SPRING CHINOOK	FALL CHINOOK	STEELHEAD	COHO	CHUM	TOTAL
Managed Forest[1]	2,936	27,816	9,524	58,482	209,776	**308,533**
CHANGE FROM MANAGED FOREST						
Low Restoration	103.1%	7.7%	7.5%	33.4%	2.6%	10.0%
High Restoration	312.9%	44.1%	28.5%	85.3%	11.1%	31.5%
Alternative 1						
FRO Low Restoration	101.2%	6.0%	6.8%	30.9%	2.6%	9.3%
FRO High Restoration	310.7%	44.0%	27.6%	83.9%	11.1%	31.2%
FRFA Low Restoration	34.8%	0.4%	2.9%	17.2%	1.5%	4.8%
FRFA High Restoration	85.0%	17.0%	19.8%	54.6%	9.8%	20.0%
Alternative 4 Low Restoration	499.6%	33.3%	19.8%	107.7%	5.1%	32.2%
Alternative 4 High Restoration	752.3%	70.4%	38.6%	148.4%	12.7%	51.5%

Note:
1. Expected value is average of 20% and 60% manufactured forest practices results.

It is assumed that no project would, by itself, trigger an Endangered Species Act (ESA) action. There may be a variety of contributing factors that could cause an ESA listing, but it has been assumed that the action alternatives alone would be unlikely to be a singular cause. It is recognized that an ESA listing, would lead to significant additional economic losses, litigation costs, and/or restoration actions and these costs could have far greater economic costs than those considered in this analysis.

4.11 Risk and Uncertainty Analysis

The action alternative impacts are modeled for some uncertainties. In most cases, probability distributions for the variables in the analysis were not available; therefore, a risk analysis (i.e., Monte Carlo simulation) could not be conducted. Where probability distributions are unavailable, the study team did not provide probabilities associated with the projected ranges. Therefore, uncertainty is modeled based on high and low values without probability distributions. The term uncertainty is used because the range of values selected for the analysis are based on available data to create low, medium, and high values. The ranges are subjective; however, the figures were reviewed by the Technical Committees as part of the process.

The medium values are referred to as the “expected values” or “expected case.” These values, as presented above and in the appendices, represent the best estimates for values over the study period; they do not represent the 50th percentile values as there is no probability distribution associated with them. The low values presented in this section are often the minimum or lowest value found in the literature for each value; however, the low values are not necessarily the lowest possible value. The low values are used to estimate a "low impact" evaluation of action alternative impacts. Alternatively, the high values are often the highest values found in the literature or through surveys. The high values are not intended to represent the highest possible value. The high values are modeled in a "High Impact" scenario where the impact of each action alternative is estimated as the highest expected impact.

The uncertainty analysis does not include additional hydraulic modeling or additional HAZUS modeling.

4.12 Structure, Content, and Inventory

Uncertainty related to structure, content, and inventory are modeled based on the work completed for the 2014 Study. The low impact scenario adjusts HAZUS output for structure, content, and inventory by 70% of the expected damages for these categories. The second scenario is the high impact scenario which assumes that HAZUS underestimates damages by 20%. These uncertainty assumptions are based on the uncertainty in the precision of first floor elevations plus uncertainty for other HAZUS modeling assumptions that are not modified. The range of uncertainty is not meant to reflect the full range of possibilities. Rather, the range of uncertainty for structure, content, and inventory impacts was selected such that a reasonable amount of uncertainty is represented without resulting in large variations that may not be useful to decision makers.

4.12.1 Floodproofing

As mentioned in the Action Element Costs section of this report, floodproofing non-residential buildings to the 100-year flood is not expected to be 75% achievable. In the expected case, it was assumed that 25% of the non-residential buildings would be floodproofed. In a low impact scenario, only 10% of non-residential buildings are floodproofed and 50% are floodproofed in a high impact scenario. In the high impact scenario, it is assumed that 100% of residential buildings are either floodproofed (or acquired), and the low scenario is 50% of residential buildings. Floodproofing impacts are modeled to equal floodproofing costs. Comparatively higher impacts mean that more buildings are floodproofed for a particular action alternative.

4.13 Cleanup Costs

Uncertainty related to cleanup costs is modeled by adjusting the cost for debris removal. Alternatively, or in addition to the cost variance, the amount of debris generated could be modeled. However, the relevant hydraulic modeling was not available as part of the study scope. Therefore, only the cost for cleanup and debris removal is varied. For debris removal, survey respondents estimated the cost between $92 to $207 per ton of debris for finishes (e.g., drywall, insulation) and between $125 and $207 per ton for structural components (e.g., wood, brick). These values are used in high and low impact scenarios where the low impact scenario is the low value and the high impact scenario assumes the high value.

Similarly, building cleanup cost estimates varied from $3.39 per square foot to $6.78 per square foot based on informal survey information. These values are utilized for low and high impact scenarios.

Agriculture field cleanup cost and restoration is based on the number of acres flooded (per HAZUS) and $508 per acre to restore the fields to planting condition. In addition, re-seeding costs of $183 per acre are included.[11] A range of agriculture cleanup costs are estimated based on the range of costs to cleanup fields and for re-seeding. For field cleanup costs, $305 per acre is assumed for the low impact scenario based on the USACE (2003) study in the Chehalis Basin (adjusted to $2016). The high value is based on the 2007 flood and is assumed to be the same as the expected value. For re-seeding costs, the range of cost is based on ranges provided in the Lewis County 2007 Disaster Recovery Strategy report (Cowlitz-Wahkiakum Council Governments 2009; $102 to $264 per acre in $2016).

4.14 Vehicle Damages

No uncertainty analysis has been performed for vehicle damage estimates. An uncertainty analysis would require additional hydraulic data, which is not within the scope of this study.

4.15 Agricultural Losses

4.15.1 Crop Damage

Damages to agricultural crops for the expected case are based on either loss of currently planted crops or the lost use of acreage due to flood damage restoration. Depending on the time of year a flood occurs, farmers may need to reseed fields or they may experience total loss. Crop damage is estimated based on the acreage flooded, cropping patterns by county, and value of crops by type.

In a low impact scenario, damaged fields could be restored and utilize the growing season immediately following a flood. This scenario assumes that crop production is not lost after floods.

A high impact scenario is consistent with the expected case where all crops are assumed lost for the year following a flood regardless of severity.

In addition, the relocation of agricultural land in Alternative 4 varies depending on the range provided. Specifically, in the high scenario, 12,100 acres are relocated compared with 10,300 acres in the expected case. The low impact case assumes 8,500 acres are relocated (included in Alternative 4 costs); however, production would not be lost due to the timing of the flood.

[11] Please refer to Appendix F in the 2014 Study.

4.16 Transportation Delays

4.16.1 Interstate 5

The WSDOT estimated that a 100-year flood would cost $11.5 to $20.6 million from an I-5 closure ($2014). The range of costs is based on the share of through traffic that takes a detour rather than delays a trip. The higher figure assumes that all through traffic would take a detour in the event of a closure. The expected case scenario is the average between the two estimates provided by WSDOT. The low impact scenario is modeled assuming the low value, while the high impact value assumes the high value. This uncertainty analysis is assumed for both the State and Federal Perspectives. Uncertainty is not modeled for the Basin-wide Perspective.

4.17 Emergency Aid

Emergency aid is a combination of TRA and public assistance. TRA is the cost to house relocated families during a flood. Public assistance costs are emergency protective measures to secure infrastructure such as bridges, roadways, or utilities.

4.17.1 Temporary Relocation Assistance

Housing costs include reimbursements for hotel stays or public shelter costs. In order to model uncertainty in TRA impacts, the cost per claim is varied based on different claim types for the 2007 flood. The low impact scenario assumes that all claims are based on lodging reimbursement costs. These claims are generally for shorter periods of relocation. Alternatively, the high impact scenario assumes that claims are equal to the average of rental assistance (longer-term housing) and lodging reimbursement. Table 15 summarizes the assumptions for the expected, high, and low impact scenarios.

Table 14

TRA Claim Cost Assumptions Under Uncertainty

	$2016/CLAIM		
FLOOD RETURN INTERVAL	EXPECTED	HIGH	LOW
2-year	$2,134	$4,143	$2,134
10-year	$2,134	$4,143	$2,134
20-year	$2,134	$4,143	$2,134
100-year	$4,143	$4,143	$2,134
500-year	$4,143	$4,143	$2,134

Uncertainty regarding the number of claims filed is not modeled because this would require hydraulic modeling that is not part of the study scope.

4.17.2 Public Assistance

Public Assistance costs are calculated based on a ratio of costs compared with TRA costs. The expected case ratio of Public Assistance costs to TRA costs in this study is based on the 2007 flood. The low impact scenario is based on the ratio assumed in the USACE (2003) study (ratio of 3.0). A high impact scenario is assumed to be the same as the expected case (ratio of 5.4).

4.17.3 Business Interruption

Business Interruption costs are included in only the Basin-wide Perspective. In order to estimate a range of Business Interruption costs, additional hydraulic modeling would be required; however, this modeling is not part of the study scope.

4.18 Environmental

Uncertainty for environmental use values are modeled in the same manner as in the 2014 study. Low and high fish values characterize the low and high impact scenarios. In addition, low and high population impacts are modeled based on EDT results. The EDT analysis produced low and high values for each restoration scenario, and these are used to model uncertainty. The expected case is the average between the low and high values for each restoration scenario.

5 STATE PERSPECTIVE

5.1 Introduction

The State Perspective includes only costs and impacts as they occur to the state as a whole. Transfers between regions within the state are not included. Impacts to areas outside of the state are not included. All dollars are in current (2016) dollars discounted using a 1.5%[12] discount rate.

Flood reduction impacts resulting from a Flood Retention Facility (FRO or FRFA) are the same regardless of configuration or fish passage design.

5.2 Expected Case Results

5.2.1 Structure, Content, and Inventory

Table 16 summarizes the avoided depreciated structure and content value for each action alternative. Inventory value is not depreciated; however, structure and content replacement values are depreciated based on structure age. Floodproofing benefits are included in Table 16. Alternative 4 structure, content, and inventory benefits are partly due to the buy-out of 462 properties in the treatment area. Of these properties, 182 currently experience flooding.

Table 15

State Perspective Depreciated Structure, Content, and Inventory

EXPECTED IMPACT, 100-YEAR NPV $2016, MILLIONS				
	STRUCTURE	CONTENT	INVENTORY	TOTAL
Alternative 1	$283.4	$345.3	$33.0	$661.7
Alternative 2	$33.7	$26.2	-$0.4	$59.5
Alternative 3	$29.4	$35.8	$3.4	$68.6
Alternative 4	$220.6	$215.0	$21.4	$457.0

5.2.2 Cleanup Costs

Alternative 4 avoids significant agricultural cleanup costs by reducing the flooded acreage by up 10,300 acres. Also, under Alternative 4, cleanup costs for residential buildings are significantly reduced due to both the buy-out of properties and reduced flooding downstream of the project area. Except for structure cleanup costs related to floodproofing, the impacts of Alternative 3 have not been modeled.

[12] Discount rate provided by Washington Department of Ecology.

Table 16
Cleanup Costs

IMPACT NET PRESENT VALUE $2016, MILLIONS					
ALTERNATIVE	DEBRIS REMOVAL	STRUCTURE (BUILDINGS)	AGRICULTURE FIELDS	AGRICULTURE RE-SEEDING	TOTAL
Alternative 1	$8.9	$36.4	$18.2	$6.6	$63.5
Alternative 2	$0.7	$0.1	-$1.1	-$0.4	-$0.3
Alternative 3	$0.0	$3.1	$0.0	$0.0	$3.1
Alternative 4	$7.0	$26.9	$162.4	$58.5	$196.3

5.2.3 Vehicle Damage

Avoided vehicle damage estimates are shown in the table below. Flood Retention Facilities provide the greatest protection for vehicles. The impacts of Alternative 3 have not been modeled.

Table 17
Vehicle Damage

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	TOTAL
Alternative 1	$41.4
Alternative 2	$16.5
Alternative 3	
Alternative 4	$4.7

5.2.4 Agricultural Losses

5.2.4.1 Crop Damage

Prices for crops are based on average 5-year normalized state prices for all field crops. Vegetable prices are based on the 4-year average of national or state prices depending on which was available. The analysis shows that Alternative 4 reduces crop damage significantly due to the significantly reduced number of flooded acres (see Table 10). The analysis assumes that all impacted acreage is currently productive farmland and that average crop values by county apply. The impacts of Alternative 3 were not estimated.

Table 18
Agriculture: Crop Damage

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	TOTAL
Alternative 1	$58.7
Alternative 2	-$1.0
Alternative 3	$0.0
Alternative 4	$617.6

5.2.5 Transportation Delays

Transportation delay benefits apply to reduced hours of flooding on I-5. The Flood Retention Facility provides the greatest benefit to I-5, while Alternative 4 increases transportation delays. The impacts of Alternative 3 have not been modeled.

Table 19
Transportation (I-5)

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	**TOTAL**
Alternative 1	$17.4
Alternative 2	$16.3
Alternative 3	
Alternative 4	-$0.3

5.2.6 Emergency Aid

5.2.6.1 Temporary Relocation Assistance

Alternative 4 has significant TRA benefits due to the purchase of 462 buildings and associated avoided relocation costs of those residents during floods. The impacts of Alternative 3 have not been modeled.

Table 20
Temporary Relocation Assistance

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	**TOTAL**
Alternative 1	$10.3
Alternative 2	$2.4
Alternative 3	$0.0
Alternative 4	$7.3

5.2.6.2 Public Assistance

Public Assistance impacts are calculated as a function of TRA benefits, Table 22 also shows that Alternatives 1 and 4 have significant Public Assistance benefits. The impacts of Alternative 3 have not been modeled.

Table 21
Public Assistance

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	**TOTAL**
Alternative 1	$69.3
Alternative 2	$15.9
Alternative 3	$0.0
Alternative 4	$49.2

5.2.7 Fishery

Use and passive use values are applied to fish population impacts as estimated by EDT. All action alternatives are estimated to have a positive impact on fish populations. Alternative 3 includes only the impacts from restoration actions and does not include impacts from any other action elements. Low and high restoration scenario results are provided in the following tables. Alternative 4 provides the greatest value to salmon fisheries.

Table 22
Fishery Impacts: Low Restoration

IMPACT NET PRESENT VALUE $2016, MILLIONS			
ALTERNATIVE	**USE VALUES**	**PASSIVE USE VALUES**	**TOTAL IMPACT**
Alternative 1: FRO	$14.8	$277.3	**$292.1**
Alternative 1: FRFA	$7.5	$138.4	**$145.8**
Alternative 2	$16.0	$299.5	**$315.5**
Alternative 3	$16.0	$299.5	**$315.5**
Alternative 4	$54.8	$991.8	**$1,046.6**

Table 23
Fishery Impacts: High Restoration

ACTION ALTERNATIVE IMPACT NET PRESENT VALUE $2016, MILLIONS			
ALTERNATIVE	**USE VALUES**	**PASSIVE USE VALUES**	**TOTAL IMPACT**
Alternative 1: FRO	$46.4	$937.9	**$984.3**
Alternative 1: FRFA	$26.9	$583.5	**$610.4**
Alternative 2	$47.0	$947.9	**$994.9**
Alternative 3	$47.0	$947.9	**$994.9**
Alternative 4	$82.4	$1,567.9	**$1,650.3**

5.3 State Expected Case Results Summary

Table 25 summarizes action alternative costs, impacts, net benefit, and benefit/cost ratios.

Table 24
State Perspective Results

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 1.5% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1 LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$929	$15	$601	$342	1.6
FRFA with Conventional Fishway and Forebay Collector	$929	$7	$932	$4	1.0
FRFA with CHTR and Forebay Collector	$929	$7	$892	$45	1.0
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$929	$7	$916	$21	1.0
ALTERNATIVE 1 HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$929	$46	$929	$47	1.1
FRFA with Conventional Fishway and Forebay Collector	$929	$27	$1,260	-$304	0.8
FRFA with CHTR and Forebay Collector	$929	$27	$1,219	-$263	0.8
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$929	$27	$1,243	-$287	0.8
ALTERNATIVE 2					
Low Restoration Scenario	$109	$16	$408	-$283	0.3
High Restoration Scenario	$109	$47	$735	-$579	0.2
ALTERNATIVE 3					
Low Restoration Scenario	$72	$16	$298	-$210	0.3
High Restoration Scenario	$72	$47	$625	-$507	0.2
ALTERNATIVE 4					
Low Restoration Scenario	$1,390	$55	$1,450	-$5	1.0
High Restoration Scenario	$1,390	$82	$1,694	-$221	0.9

5.4 Risk and Uncertainty Analysis

Several cost and impact scenario combinations were analyzed to determine a range of net benefits. The following scenarios were modeled for each action alternative:

- Expected costs and expected impacts
- Expected costs with low and high impacts

- Lower bound costs with low, expected, and high impacts
- Upper bound costs with low, expected, and high impacts

Figure 4 and 5 that follow summarize the range of net benefits for action alternatives, including low and high restoration actions, respectively (use-values only).

Alternative 3 has the lowest uncertainty as it reflects only Floodproofing and Aquatic Species Habitat Actions costs and benefits. Similarly, Alternative 2 has relatively low uncertainty. Alternative 1 uncertainty demonstrates primarily how the range of costs for the Flood Retention Facility and Aquatic Species Habitat Actions affect the net benefits.

Alternative 4 has the greatest uncertainty due to the modeling of low impacts in agriculture. In the low impact scenario, crop damage is assumed to be zero for all action alternatives. This assumption is based on the timing of floods during winter months at a time when crops may not be grown. Alternative 4 has the greatest impact to agriculture due to the relocation of acreage; therefore, the low impact scenario is significantly lower compared with the other action alternatives. Because the acreage relocated under Alternative 4 is tied to the cost scenario, the expected case for Alternative 4 is the maximum net benefit scenario. Based on current cost information, the cost of buying out and relocating properties in the 100-year floodplain (compared with just the properties located in the 10-year floodplain) increase by nearly the same amount of the avoided damage to those properties.

Figure 3
State Perspective Uncertainty Summary Low Restoration Scenario

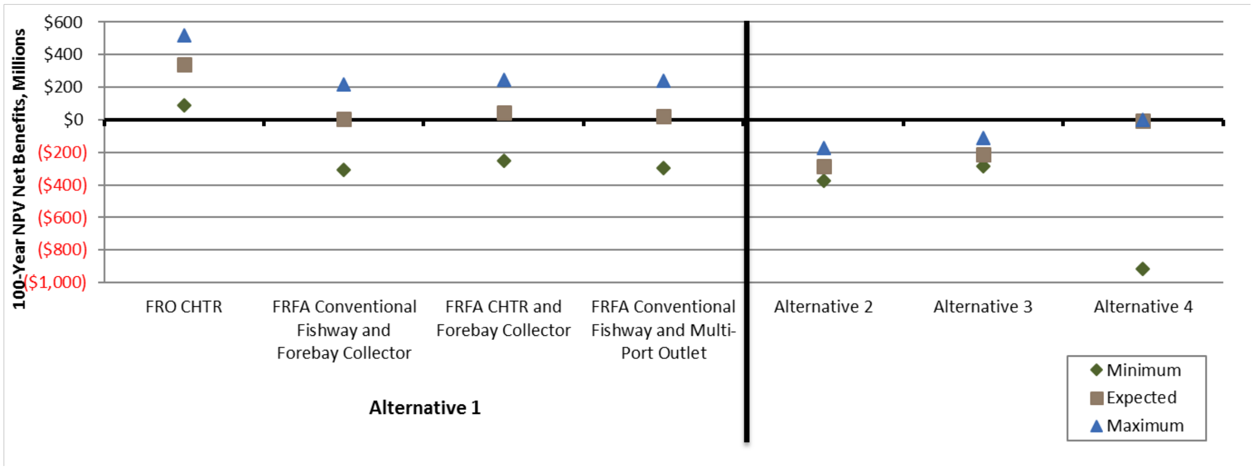
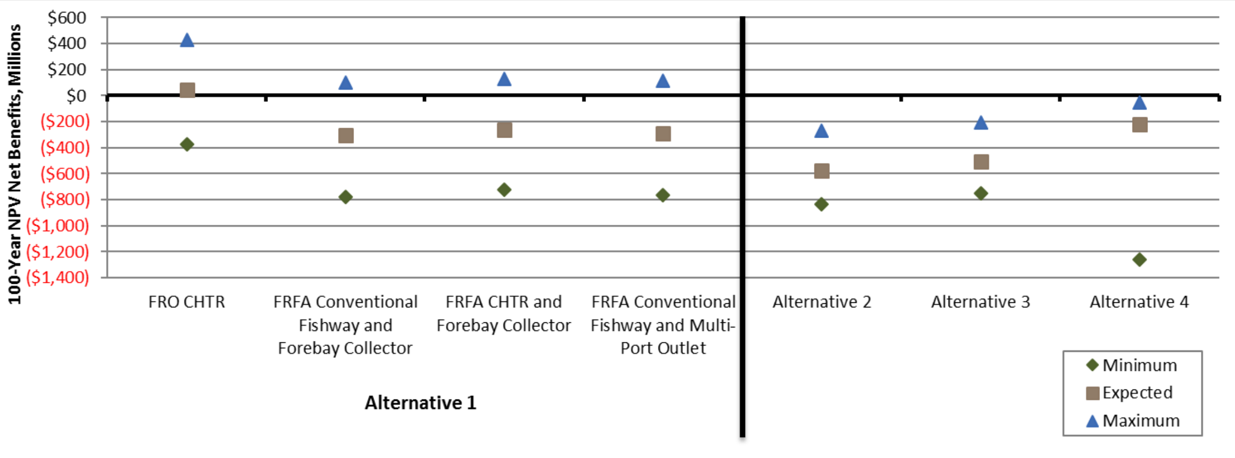


Figure 4
State Perspective Uncertainty Summary High Restoration Scenario



6 BASIN-WIDE PERSPECTIVE

6.1 Introduction

The Basin-wide Perspective includes only costs and impacts as they occur to the basin as a whole. Transfers between regions within the Chehalis Basin are not included. Impacts to areas outside of the basin are not included. All dollars are in current (2016) dollars discounted using a 1.5%[13] discount rate.

Flood reduction impacts resulting from a Flood Fetention Facility (FRO or FRFA) are the same regardless of configuration or fish passage design.

6.2 Expected Case Results

6.2.1 Structure, Content, and Inventory

Table 26 summarizes the avoided depreciated structure and content value for each action alternative. Inventory value is not depreciated; however, structure and content replacement values are depreciated based on structure age. Floodproofing benefits are not included in Table 26. Alternative 4 structure, content, and inventory benefits are partly due to the buy-out of 462 properties in the treatment area.

Table 25

Basin Perspective Depreciated Structure, Content, and Inventory

EXPECTED IMPACT, 100-YEAR NPV $2016, MILLIONS				
ALTERNATIVE	STRUCTURE	CONTENT	INVENTORY	TOTAL
Alternative 1	$283.4	$345.3	$33.0	$661.7
Alternative 2	$33.7	$26.2	-$0.4	$59.5
Alternative 3	$29.4	$35.8	$3.4	$68.6
Alternative 4	$220.6	$215.0	$21.4	$457.0

6.2.2 Cleanup Costs

Alternative 4 avoids significant agricultural cleanup costs by reducing the flooded acreage by up 10,300 acres. Also, under Alternative 4, cleanup costs for residential buildings are significantly reduced due to both the buy-out of properties and reduced flooding downstream of the project area. Except for structure cleanup costs related to floodproofing, the impacts of Alternative 3 have not been modeled.

[13] Discount rate provided by Washington Department of Ecology.

Table 26
Cleanup Costs

IMPACT NET PRESENT VALUE $2016, MILLIONS					
ALTERNATIVE	DEBRIS REMOVAL	STRUCTURE	AGRICULTURE FIELDS	AGRICULTURE RE-SEEDING	TOTAL
Alternative 1	$8.9	$36.4	$18.2	$6.6	$63.5
Alternative 2	$0.7	$0.1	-$1.1	-$0.4	-$0.3
Alternative 3	$0.0	$3.1	$0.0	$0.0	$3.1
Alternative 4	$7.0	$26.9	$162.4	$58.5	$196.3

6.2.3 Vehicle Damage

Avoided vehicle damage estimates are shown in the table below. Flood Retention Facilities provide the greatest protection for vehicles. The impacts of Alternative 3 have not been modeled.

Table 27
Vehicle Damage

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	TOTAL
Alternative 1	$41.4
Alternative 2	$16.5
Alternative 3	
Alternative 4	$4.7

6.2.4 Agricultural Losses

6.2.4.1 Crop Damage

Prices for crops are based on average 5-year normalized state prices for all field crops. Vegetable prices are based on the 4-year average of national or state prices depending on which was available. The analysis shows that Alternative 4 reduces crop damage significantly due to the significantly reduced number of flooded acres (see Table 10). The analysis assumes that all impacted acreage is currently productive farmland and that average crop values by county apply. The impacts of Alternative 3 have not been modeled.

Table 28
Agriculture: Crop Damage

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	TOTAL
Alternative 1	$58.7
Alternative 2	-$1.0
Alternative 3	$0.0
Alternative 4	$617.6

6.2.5 Transportation Delays

Transportation delay benefits apply to reduced hours of flooding on I-5. Alternative 1 provides the greatest benefit to I-5, while Alternative 4 increases transportation delays. The impacts of Alternative 3 have not been modeled.

Table 29

Transportation (I-5)

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	**TOTAL**
Alternative 1	$3.3
Alternative 2	$3.1
Alternative 3	
Alternative 4	-$0.1

6.2.6 Emergency Aid

6.2.6.1 *Temporary Relocation Assistance*

Part of the benefit of Alternative 4 is the relocation of 462 buildings and associated avoided relocation costs of those residents during floods. The impacts of Alternative 3 have not been modeled.

Table 30

Temporary Relocation Assistance

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	**TOTAL**
Alternative 1	$10.3
Alternative 2	$2.4
Alternative 3	
Alternative 4	$7.3

6.2.6.2 *Public Assistance*

Public Assistance impacts are calculated as a function of TRA benefits, Table 32 also shows that Alternatives 1 and 4 have the greatest Public Assistance benefits. The impacts of Alternative 3 have not been modeled.

Table 31

Public Assistance

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	**TOTAL**
Alternative 1	$69.3
Alternative 2	$15.9
Alternative 3	
Alternative 4	$49.2

6.2.6.3 *Business Interruption*

Impacts to local businesses are greatest for the Flood Retention Facility as flood water levels are reduced more under Alternative 1 than the other two modeled (Alternatives 2 and 4). The impacts of Alternative 3 have not been modeled.

Table 32
Business Interruption

EXPECTED VALUES 100-YEAR NPV 1.5% DISCOUNT RATE, MILLIONS ($2016)					
ALTERNATIVE	INCOME	RELOCATION	RENTAL INCOME	WAGE	TOTAL
Alternative 1	$1.3	$1.0	$0.3	$5.9	$2.6
Alternative 2	$0.0	-$0.3	$0.0	$0.0	-$0.3
Alternative 3					
Alternative 4	$0.0	$1.4	$0.0	$2.5	$1.4

6.2.7 Fishery

Similar to the 2014 study, State and Basin-wide Perspective impacts to fisheries were modeled in the same way (State and Basin-wide Perspective impacts were not modeled separately). Alternative 3 includes only the impacts from restoration actions and does not include impacts from any other action elements. Alternative 4 provides the greatest value to salmon fisheries.

Table 33
Fishery Impacts: Low Restoration

ACTION ALTERNATIVE IMPACT NET PRESENT VALUE $2016, MILLIONS			
ALTERNATIVE	USE VALUES	PASSIVE USE VALUES	TOTAL IMPACT
Alternative 1: FRO	$14.8	$277.3	**$292.1**
Alternative 1: FRFA	$7.5	$138.4	**$145.8**
Alternative 2	$16.0	$299.5	**$315.5**
Alternative 3	$16.0	$299.5	**$315.5**
Alternative 4	$54.8	$991.8	**$1,046.6**

Table 34
Fishery Impacts: High Restoration

ACTION ALTERNATIVE IMPACT NET PRESENT VALUE $2016, MILLIONS			
ALTERNATIVE	USE VALUES	PASSIVE USE VALUES	TOTAL IMPACT
Alternative 1: FRO	$46.4	$937.9	**$984.3**
Alternative 1: FRFA	$26.9	$583.5	**$610.4**
Alternative 2	$47.0	$947.9	**$994.9**
Alternative 3	$47.0	$947.9	**$994.9**
Alternative 4	$82.4	$1,567.9	**$1,650.3**

6.3 Basin-wide Expected Case Results Summary

Table 36 summarizes action alternative costs, impacts, net benefit, and benefit/cost ratios.

Table 35
Basin-wide Perspective Results

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 1.5% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1 LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$923	$15	$601	$337	1.6
FRFA with Conventional Fishway and Forebay Collector	$923	$7	$932	-$2	1.0
FRFA with CHTR and Forebay Collector	$923	$7	$892	$39	1.0
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$923	$7	$916	$15	1.0
ALTERNATIVE 1 HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$923	$46	$929	$41	1.0
FRFA with Conventional Fishway and Forebay Collector	$923	$27	$1,260	-$310	0.8
FRFA with CHTR and Forebay Collector	$923	$27	$1,219	-$269	0.8
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$923	$27	$1,243	-$293	0.8
ALTERNATIVE 2					
Low Restoration Scenario	$95	$16	$408	-$297	0.3
High Restoration Scenario	$95	$47	$735	-$593	0.2
ALTERNATIVE 3					
Low Restoration Scenario	$72	$16	$298	-$210	0.3
High Restoration Scenario	$72	$47	$625	-$507	0.2
ALTERNATIVE 4					
Low Restoration Scenario	$1,394	$55	$1,450	-$1	1.0
High Restoration Scenario	$1,394	$82	$1,694	-$217	0.9

6.4 Risk and Uncertainty Analysis

Several cost and impact scenario combinations were analyzed to determine a range of net benefits. The following scenarios were modeled for each action alternative:

- Expected costs and expected impacts
- Expected costs with low and high impacts

- Lower bound costs with low, expected, and high impacts
- Upper bound costs with low, expected, and high impacts

Figures 6 and 7 below summarize the range of net benefits for action alternatives, including low restoration scenario and high restoration scenario actions, respectively (use-values only).

Alternative 3 has the lowest uncertainty as it reflects only Floodproofing and Aquatic Species Habitat Actions costs and benefits. Similarly, Alternative 2 has relatively low uncertainty. Alternative 1 uncertainty demonstrates primarily how the range of costs for the Flood Retention Facility and Aquatic Species Habitat Actions affect the net benefits.

Alternative 4 has the greatest uncertainty due to the modeling of low impacts in agriculture. In the low impact scenario, crop damage is assumed to be zero for all action alternatives. This assumption is based on the timing of flood events during winter months at a time when crops may not be grown. Alternative 4 has the greatest impact to agriculture due to the relocation of acreage; therefore, the low impact scenario is significantly lower compared with the other action alternatives. Because the acreage relocated under Alternative 4 is tied to the cost scenario, the expected case for Alternative 4 is the maximum net benefit scenario. Based on current cost information, the cost of buying out and relocating properties in the 100-year floodplain (compared with just the properties located in the 10-year floodplain) increase by nearly the same amount of the avoided damage to those properties.

Figure 5
Basin-wide Perspective Uncertainty Summary Low Restoration Scenario

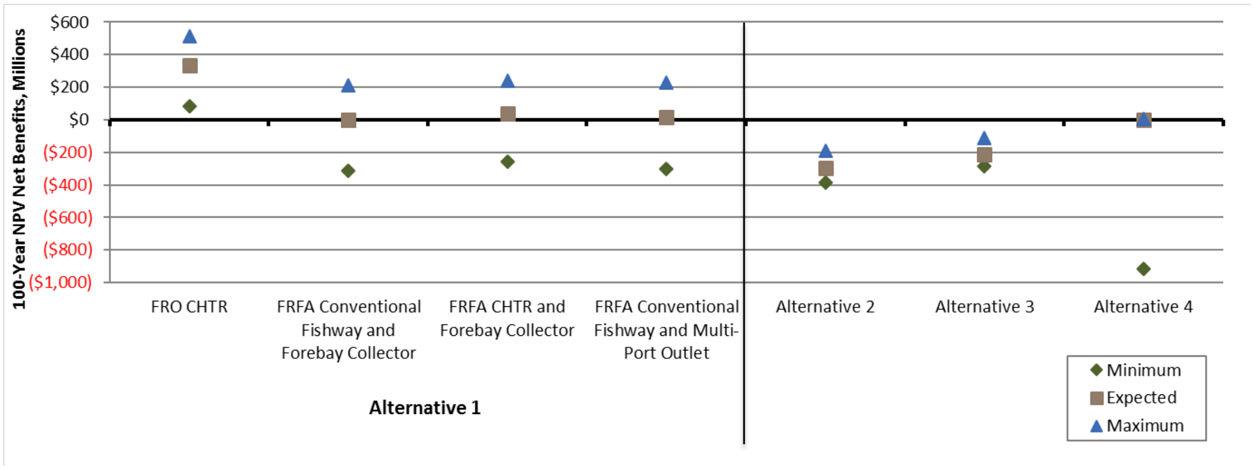
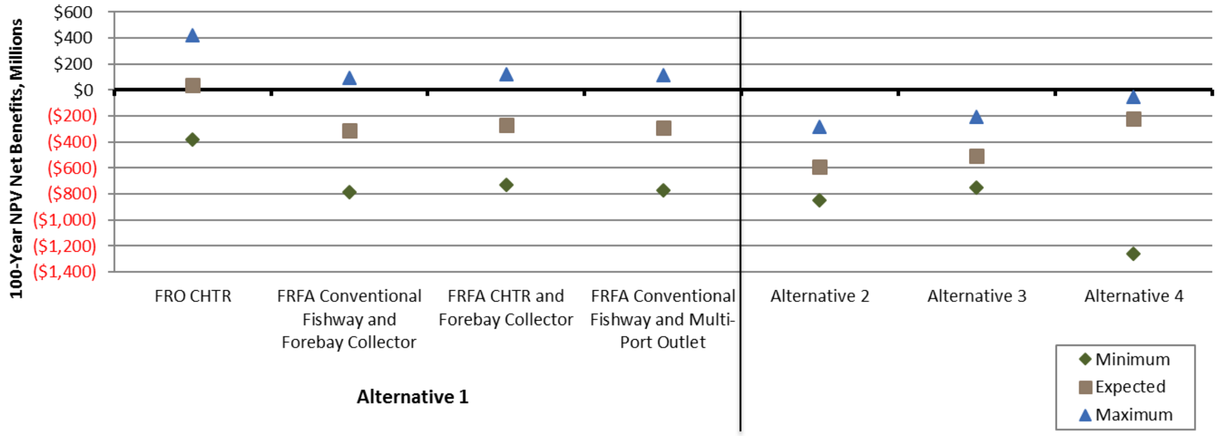


Figure 6

Basin-wide Perspective Uncertainty Summary High Restoration Scenario



7 FEDERAL PERSPECTIVE

7.1 Introduction

The Federal Perspective includes only costs and impacts as they occur to the nation as a whole. Transfers between regions within the United States are not included. Impacts to areas outside of the country are not included. All dollars are in current (2016) dollars discounted using a 3.125% (USACE 2015) discount rate.

Flood reduction impacts resulting from a Flood Retention Facility (FRO or FRFA) are the same regardless of configuration or fish passage design.

7.2 Expected Case Results

7.2.1 Structure, Content, and Inventory

Table 37 summarizes the avoided depreciated structure and content value for each action alternative. Inventory value is not depreciated; however, structure and content replacement values are depreciated based on structure age. Alternative 4 structure, content, and inventory benefits are partly due to the buy-out of 462 properties in the treatment area.

Table 36
Federal Perspective Depreciated Structure, Content, and Inventory

EXPECTED IMPACT, 100-YEAR NPV $2016, MILLIONS				
	STRUCTURE	CONTENT	INVENTORY	TOTAL
Alternative 1	$174.7	$212.8	$20.3	$407.8
Alternative 2	$36.2	$28.1	-$0.4	$63.9
Alternative 3	$29.4	$35.8	$3.4	$68.6
Alternative 4	$141.3	$137.7	$13.7	$292.7

7.2.2 Cleanup Costs

Alternative 4 avoids significant agricultural cleanup costs by reducing the flooded acreage by up 10,300 acres. Also, under Alternative 4, cleanup costs for residential buildings are significantly reduced due to both the buy-out of properties and reduced flooding downstream of the treatment area. Except for structure cleanup costs related to floodproofing, the impacts of Alternative 3 have not been modeled.

Table 37
Cleanup Costs

IMPACT NET PRESENT VALUE $2016, MILLIONS					
ALTERNATIVE	DEBRIS REMOVAL	STRUCTURE (BUILDINGS)	AGRICULTURE FIELDS	AGRICULTURE RE-SEEDING	TOTAL
Alternative 1	$5.2	$21.5	$10.8	$3.9	$37.6
Alternative 2	$0.4	$0.1	-$0.7	-$0.2	-$0.2
Alternative 3	$0.0	$1.9	$0.0	$0.0	$1.9
Alternative 4	$4.1	$15.9	$96.1	$34.6	$116.1

7.2.3 Vehicle Damage

Avoided vehicle damage estimates are shown in the table below. Flood Retention Facilities provide the greatest protection for vehicles. The impacts of Alternative 3 have not been modeled.

Table 38
Vehicle Damage

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	TOTAL
Alternative 1	$24.5
Alternative 2	$9.7
Alternative 3	
Alternative 4	$2.8

7.2.4 Agricultural Losses

7.2.4.1 Crop Damage

Prices for crops are based on average 5-year normalized state prices for all field crops. Vegetable prices are based on the 4-year average of national or state prices depending on which was available. The analysis shows that Alternative 4 reduces crop damage significantly due to the significantly reduced number of flooded acres (see Table 10). The analysis assumes that all impacted acreage is currently productive farmland and that average crop values by county apply. The impacts of Alternative 3 have not been modeled.

Table 39
Agriculture: Crop Damage

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	TOTAL
Alternative 1	$30.7
Alternative 2	-$0.6
Alternative 3	$0.0
Alternative 4	$348.5

7.2.5 Transportation Delays

Transportation delay benefits apply to reduced hours of flooding on I-5. Alternative 1 provides the greatest benefit to I-5, while Alternative 4 increases transportation delays. The impacts of Alternative 3 have not been modeled.

Table 40
Transportation (I-5)

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	TOTAL
Alternative 1	$10.3
Alternative 2	$9.7
Alternative 3	
Alternative 4	-$0.2

7.2.6 Emergency Aid

7.2.6.1 *Temporary Relocation Assistance*

Alternatives 1 and 4 have the greatest TRA benefits. For Alternative 1, the benefits are due to reduced flooding. In the case of Alternative 4 the benefits are due to both reduced flooding downstream of the Neuwaukum confluence and the purchase of 462 buildings and associated avoided relocation costs of those residents during floods. The impacts of Alternative 3 have not been modeled.

Table 41
Temporary Relocation Assistance

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	TOTAL
Alternative 1	$6.1
Alternative 2	$1.4
Alternative 3	
Alternative 4	$4.3

7.2.6.2 *Public Assistance*

Public Assistance impacts are calculated as a function of TRA benefits, Table 43 also shows that Alternatives 1 and 4 have the greatest Public Assistance benefits. The impacts of Alternative 3 have not been modeled.

Table 42
Public Assistance

IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	TOTAL
Alternative 1	$41.0
Alternative 2	$9.4
Alternative 3	
Alternative 4	$29.1

7.2.7 Fishery Value

From the Federal Perspective, only the use values for fishery impacts are included. Alternative 3 includes only the impacts from restoration actions and does not include impacts from any other action elements. Alternative 4 provides the greatest value to salmon fisheries.

Table 43
Fishery Impacts: Low Restoration

ACTION ALTERNATIVE IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	USE VALUES
Alternative 1: FRO	$6.3
Alternative 1: FRFA	$3.1
Alternative 2	$6.8
Alternative 3	$6.8
Alternative 4	$23.5

Table 44
Fishery Impacts: High Restoration

ACTION ALTERNATIVE IMPACT NET PRESENT VALUE $2016, MILLIONS	
ALTERNATIVE	USE VALUES
Alternative 1: FRO	$19.9
Alternative 1: FRFA	$11.5
Alternative 2	$20.2
Alternative 3	$20.2
Alternative 4	$35.4

7.3 Federal Expected Case Results Summary

Table 46 summarizes action alternative costs, impacts, net benefit, and benefit/cost ratios.

Table 45
Federal Perspective Results

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 3.125% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1 LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$562	$6	$588	-$20	1.0
FRFA with Conventional Fishway and Forebay Collector	$562	$3	$890	-$325	0.6
FRFA with CHTR and Forebay Collector	$562	$3	$846	-$281	0.7
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$562	$3	$887	-$322	0.6
ALTERNATIVE 1 HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$562	$20	$915	-$334	0.6
FRFA with Conventional Fishway and Forebay Collector	$562	$11	$1,217	-$644	0.5
FRFA with CHTR and Forebay Collector	$562	$11	$1,173	-$600	0.5
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$562	$11	$1,214	-$641	0.5
ALTERNATIVE 2					
Low Restoration Scenario	$93	$7	$408	-$308	0.2
High Restoration Scenario	$93	$20	$735	-$622	0.2
ALTERNATIVE 3					
Low Restoration Scenario	$71	$7	$298	-$221	0.3
High Restoration Scenario	$71	$20	$625	-$535	0.1
ALTERNATIVE 4					
Low Restoration Scenario	$828	$24	$1,446	-$594	0.6
High Restoration Scenario	$828	$35	$1,689	-$826	0.5

7.4 Risk and Uncertainty Analysis

Several cost and impact scenario combinations were analyzed to determine a range of net benefits. The following scenarios were modeled for each action alternative:

- Expected costs and expected impacts
- Expected costs with low and high impacts
- Lower bound costs with low, expected, and high impacts
- Upper bound costs with low, expected, and high impacts

Figures 8 and 9 summarize the range of net benefits for action alternatives, including low restoration scenario and high restoration scenario actions, respectively. Alternative 3 has the lowest uncertainty as it reflects only Floodproofing and Aquatic Species Habitat Actions costs and benefits. Similarly, Alternative 2 has relatively low uncertainty. Alternative 1 uncertainty demonstrates primarily how the range of costs for the Flood Retention Facility and Aquatic Species Habitat Actions affect the net benefits.

Alternative 4 has the greatest uncertainty due to the modeling of low impacts in agriculture. In the low impact scenario, crop damage is assumed to be zero for all action alternatives. This assumption is based on the timing of flood events during winter months at a time when crops may not be grown. Alternative 4 has the greatest impact to agriculture due to the relocation of acreage; therefore, the low impact scenario is significantly lower compared with the other action alternatives. Because the acreage relocated under Alternative 4 is tied to the cost scenario, the expected case for Alternative 4 is the maximum net benefit scenario. Based on current cost information, the cost of buying out and relocating properties in the 100-year floodplain (compared with just the properties located in the 10-year floodplain) increase by nearly the same amount of the avoided damage to those properties.

Figure 7

Federal Perspective Uncertainty Summary Low Restoration Scenario

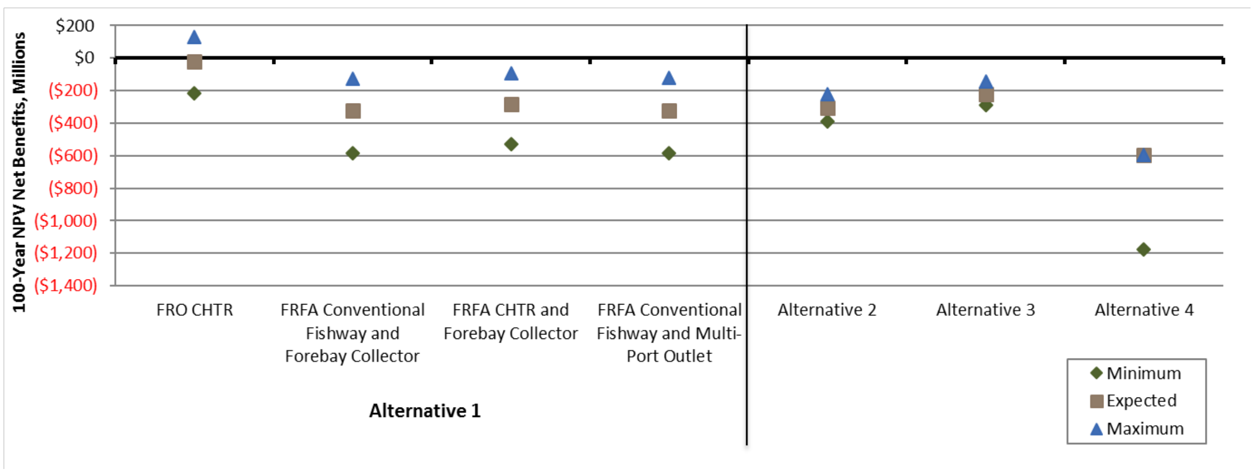
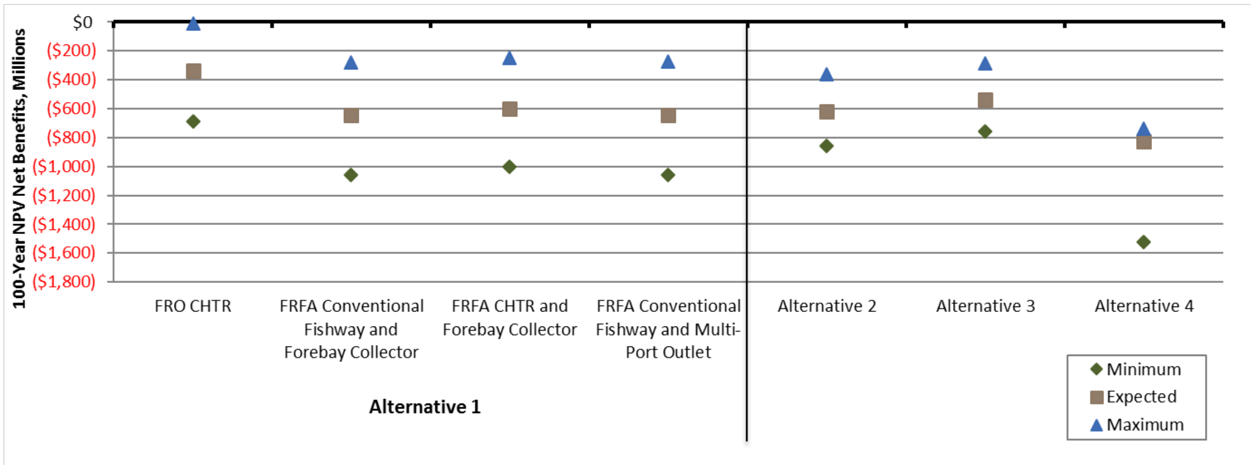


Figure 8
Federal Perspective Uncertainty Summary High Restoration Scenario



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Appendix A
Flood Retention Facility Cost Estimate Memorandum

Memo

Date:	Friday, July 15, 2016
Project:	Chehalis Basin Strategy
To:	Anne Falcon (EES Consulting) Cc: Bob Montgomery (Anchor QEA), Heather Page (Anchor QEA)
From:	Beth Peterson, Keith Moen, Keith Ferguson, Mike Garello, Dan Osmun and Ed Zapel
Subject:	**Cost Estimate for Use in EIS Dam Design and Fish Passage Cost Estimate**

EES has requested that the dam design team generate updates for the construction, operation and maintenance costs for the two dam alternatives, including fish passage. The costs were requested in current dollars ($2016). The EES request categorized the updated costs in the following basic areas:

1. Estimated life of project (years)

1.1. Dam

Large dams have a history of solid performance for well over 100 years. Understanding of the materials and construction techniques has improved, construction methods have become more efficient, and the quality of construction has increased significantly over that time. These important factors all contribute to the expected significant longevity of the dam and major hydraulic structures beyond decades, perhaps centuries. For this exercise, we have considered the reasonable lifespan of concrete features of the dam to be about 100 years, with the exception of the outlet sluice conduits for the Flood Regulation Only (FRO) alternative. Sediment transport processes are expected to wear the sluice conduit concrete and exposed steel features over time, with repairs expected at least every 5 years. Since sediment will not be typically passed through the outlet works of the Flood Regulation and Flow Augmentation (FRFA) multipurpose dam alternative, we do not expect significant wear of concrete surfaces. Therefore we have considered all concrete features to have a typical expected lifespan of 100 years.

Required maintenance and periodic rehabilitation and possibly replacement of mechanical and electrical features such as gates, valves, hoists, and other similar features are expected over the life of the project. Consideration of the various expected lifespan and operational regime has been made in the determination of the annualized Operation and Maintenance (O&M) costs of structural and mechanical equipment subject to wear or fatigue. As a result, we expect that major mechanical equipment such as radial gates and bulkheads will require rehabilitation every 20 years in the FRO alternative and every 50 years in the FRFA alternative.

1.2. Fish Facilities

Some fish passage facilities have records of solid performance for over 50 years while others are fairly new technologies that have been shown to be effective but are still being closely monitored by fisheries agencies. Continued maintenance and periodic rehabilitation are considered part of the estimated facility lifespan. For the purposes of this estimate, a fish passage facility is considered at the end of its useful life when the rehabilitation cost is estimated to be greater than the replacement cost. The estimated useful life of the fish passage facilities being considered is based on professional judgment and consideration of existing similar facilities.

For this project, we assume the following lifespans for various components of the Fish Passage Facilities:

Capture, Handling, Transport, and Release (CHTR) Facility:	25 years
Conventional Fishway:	50 years
Floating Surface Forebay Collector (FSC):	30 years
Fixed Multi-Port Forebay Collector (FMPC):	50 years

2. Estimated Years for Engineering and Construction

Based on experience with other similar projects involving large dam and fish passage facilities, the following overall project schedule should be considered for both the FRO and FRFA assuming a continuous process continuing through final design and construction: We expect, that since the Roller Compacted Concrete construction process is somewhat unique compared to the diversion tunnel construction, that the site preparation work and tunneling work would be more efficiently conducted as a separate contract ahead of the main dam construction contract. For this reason, we have divided the construction schedule into a first phase to include the diversion works and site preparation, and a second phase to include the main dam and appurtenant outlet works construction effort.

Final design (after completion of the preliminary design), including site characterization:	up to 2 years
Bidding and award of Phase 1 construction:	4 to 6 months
Construction Schedule Phase 1:	1 year
Bidding and Award of Phase 2:	4 to 6 months, concurrent with Phase 1 construction
Construction Schedule Phase 2:	2 to 3 years
Approximate total time for completion:	8 to 11 years

3. Total direct project cost (construction cost of the dam)

Total direct project construction costs for the FRO alternative are summarized in Table 1 at the end of this section, while total direct project construction costs for the FRFA alternative are summarized in Table 2 at the end of this section. It is important to note that this cost estimate update is being performed while our Conceptual Design phase work is ongoing, and as such does not represent a specific design milestone such as Conceptual Design or Preliminary Design costs. At this point in our Conceptual Design, we have included costs for several new project features that were not specifically listed in previous cost estimates, and we have reduced our design contingency to reflect advancement of the design. As we continue to advance the design, it is anticipated that more individual line item costs may be identified, and design contingency costs would be reduced. Therefore, increases or decreases in the cost estimate compared to previous cost estimates are not necessarily reflective of changes in project costs; HDR's opinion of probable cost is reflected in the ranges provided. Discussion of the cost development and particular considerations for each are discussed below.

3.1. Roads

Direct costs for roads construction ***not*** associated with dam construction and reservoir inundation in addition to the developed costs for the dam are not applicable for the following reasons:

Construction roads will be required to support construction activities within the dam footprint, quarry, diversion staging, and potential laydown and disposal areas, however they are included in the current overall dam construction costs

Access to lands affected by the reservoir will remain via alternate routes to forest harvest and management areas via existing forest roads. However, access to some parcels will be somewhat restricted without construction of new roads or extensions to existing road networks, which will increase the cost for timber maintenance and harvest. These costs have been included in the direct dam construction costs as an allowance for a nominal amount per mile of affected access roadways.

3.2. Land and Land Rights

Land and land rights were not included as line items in the ca. 2014 Phase 1, and were assumed to be covered under the contingency amount. In this Phase 2 effort, we have developed estimates based on the areas of inundation for the FRFA and FRO options. All lands inundated below the elevation of the 100-year flood anticipated reservoir pool level area assumed to require fee title purchase for the project, while lands between the maximum reservoir pool expected for the design flood event (roughly equivalent to the 2007 event) and the 100-year inundation limit are assumed to require a flooding easement. These costs are now included in the direct dam construction costs.

The valuation that was used as an estimate for the land cost-per-acre for this project is based on research done using the County Assessor's website and the Northwest Multiple Listing Service (NWMLS). After ascertaining the assessed value of the impacted parcels and looking at their use, the NWMLS was used to look up comparable land sales in the area of the project that were similar in use and size, and that have sold within six months of the current date. Three (3) sales were found for similar properties in the area and their value was used for the basis. This value was doubled to equal $4,356/acre to account for the fact that the cost of timber loss and the possible abandonment of access roads that will need to be negotiated with the landowners, and while these actual sales make for a solid valuation at this point in time, there are other similar properties currently listed that are in a higher range, and could possibly sell for a higher prices thus driving up the cost of the acquisition. By doubling the price range established by the comparable sales, we are hoping to lessen the impact of these variables, should the price increase when acquisition takes place for this project.

The anticipated number of landowners in the affected area is low (just 3 were identified), and the anticipated effort to work with to acquire the land needed for the project is not expected to be high. Although working with Weyerhaeuser Company will require a lot of negotiating, it will be a singular owner to work with for a lot of property for the project, so costs will be fairly low, but the process may be lengthy. Title and appraisal costs will be pretty standard for properties like this and will yield the best valuation to use for the acquisition of these properties

The FRO reservoir will be largely empty except during times of flooding. We have opted for a conservative approach, looking at the flood inundation levels for determination of the land acquisition requirements. We've considered that all lands inundated below the 100-year flood reservoir level would require outright purchase at full price, while inundated areas above that up to the maximum design reservoir elevations would require a flood easement equivalent to full price. However, depending on the landowner negotiations, the easement value may well decrease once more details are developed.

The FRFA option will have a permanent pool. In addition to the area of land directly inundated, access to some of the forest lands will be limited or unavailable unless and until the existing forest road network is extended to those orphaned parcels. Similar to the FRO alternative discussed above, all lands inundated below the 100-year expected flood reservoir level will require outright purchase, while those above the 100-year up to the maximum design reservoir level will require flooding easement at full purchase price. Again, these easement costs may decrease as the discussions with the landowner are continued.

Figure 1 below illustrates the affected real estate within the reservoir limits.

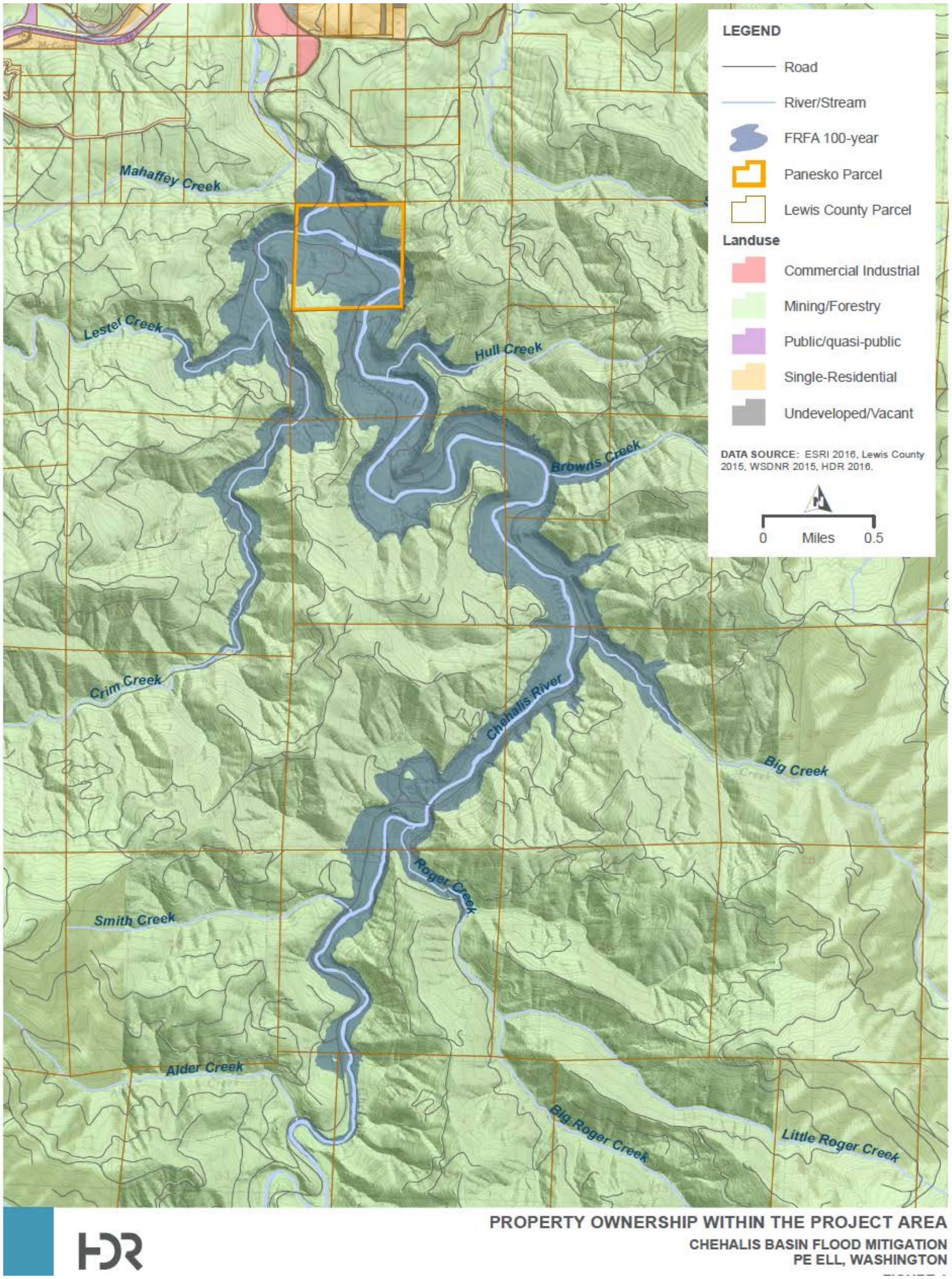

Figure 1 – Land and Land Rights Map of Project Area

3.3. Structure and Related Equipment

3.3.1. Dam Foundation Excavation

Surficial materials and weathered rock will need to be excavated to provide an adequate foundation for the RCC structure. Preliminary excavation quantities have been estimated by estimating two critical excavation depths: (1) depth to top of rock and (2) depth to limit of rippable rock. All of the subsurface information collected to date, including primarily borings and geophysical lines, was considered when estimating these depths. Excavation from the ground surface to the top of rock is considered general or common excavation. The unit price for this excavation was estimated to range from $5.50 to $8.00 per cubic yard. The top of rock surface is readily observable from the borings; however geophysics and other subjective judgment were applied to estimate the depth to top of rock at other locations. Excavation of weathered rock involves more effort, different equipment, and more time compared to common excavation. Some areas and types of weathered rock will be excavated more readily than other areas. The estimated depth to rippable rock was equated to the foundation excavation objective for the purpose of this quantity and cost estimate. Rippable rock is often an equipment performance based quality indicator, and is correlated to the geophysical p-wave velocity. Rock is considered rippable when a dozer (or track excavator) of a certain size (D10 for example), equipped with a single tooth ripper can remove rock in a production mode. For this site, the limit of rippable rock was assumed to equate to a p-wave velocity of approximately 9,000 ft/sec. The depth was selected based on consideration of all the subsurface data, particularly the rock description, rock weathering, RQD, fracture spacing, downhole testing, and other indications of rock quality. The unit price for this excavation was estimated to range from $25 to $36 per cubic yard. Subsequent cost estimate development will itemize dental excavation and related foundation preparation and treatment that are not differentiated in the current estimate detail.

Recent information from the Phase 2 field exploration generally indicates the RCC foundation excavation objective is slightly lower than what was assumed after the Phase 1 field exploration. In some cases, the depth to rock of adequate quality was in excess of 50 feet. The limits of the dam foundation will continue to be refined as the design evolves and specific consideration is given to stability and seepage control measures.

3.3.2. RCC Dam

Unlike the dam foundation quantities, which depend on the amount of rock excavation across the site, the quantity of RCC is less variable because the cross section geometry is fixed above the foundation contact. The slight increase in excavation depth mentioned above results in a slight increase in RCC quantities. The unit price of RCC is a more significant variable than the quantity, and it is primarily dependent on factors such as the facing and seepage control design choices, type and location of aggregate, the cost of cement, the cost of pozzolans, the size and production rate of the RCC plant, and the overall duration and speed of RCC placement. For purpose of this cost estimate, the unit price of the RCC is estimated to vary from $65 to $85 per cubic yard. This unit price is based on consideration of the actual unit price for several RCC dams constructed worldwide. Also, the estimate conservatively reflects separate line items now for foundation and facing non-reinforced concrete, recognizing design will evaluate and incorporate the most suitable facing and related design choices. While the unit price was not specifically built up for Chehalis, judgment level consideration was applied to upper and lower bounds for the major cost components revealing – although the unit price is still expected to be within the adjusted estimated range.

Table 3.1 and 3.2 below illustrate the anticipated project construction costs for the FRO RCC and FRFA RCC dam alternatives, respectively.

Table 3.1 – FRO Roller Compacted Concrete (RCC) Dam Project Construction Costs

Project:	Chehalis Dam Alternatives	**Computed By:**	ETZ	7/13/2016
Subject:	ACEC Class 5 Const. Cost Opinion	**Checked By:**	JCA	7/14/2016
Task:	(FRO) RCC - Flood Retention Only	**Page:**	1	
EBS Job #:	002-218397 **No:**	**of:**	2	

Bid Item	Sub-Category Line Item	Description	Quantity	Unit	Lower Bound Unit Cost	Upper Bound Unit Price	Lower Bound Cost	Upper Bound Cost
Phase 1 - Prep Work, Diversion & Dewatering, Temporary Construction								
1		**Clearing, Grubbing**						
	1.1	Clearing and grubbing, stripping topsoil, reclamation of construction areas	25	Acre	$29,560	$29,560	$ 739,000	$ 739,000
	1.2	Reservoir Clearing to 100-yr Flood Stage	756	Acre	$5,000	$7,500	$ 3,780,000	$ 5,670,000
2		**Temporary Construction Access, Facilities, Site Prep, Laydown, etc.**						
	2.1	Construction Surveying & Layout	25	Acre	$25,000	$30,000	$ 625,000	$ 750,000
	2.2	Pioneer/Access Roads (e.g. dam site, abutments, quarry site, etc.)	1.5	Mile	$750,000	$1,125,000	$ 1,125,000	$ 1,687,500
	2.3	Material Laydown Area Prep (minor excavation, grading, surfacing, drainage	5	Acre	$20,000	$30,000	$ 100,000	$ 150,000
	2.4	Temporary construction site access security control facilities (e.g. fencing, gates, etc.)	1867	LF	$10	$20	$ 18,668	$ 37,335
3		**Diversion & Dewatering**						
	3.1	Diversion Tunnel 20 ft diameter	1,420	LF	$7,670.00	$7,670.00	$ 10,891,400	$ 10,891,400
	3.2	Conventional Concrete Non-Reinforced Mass Concrete (100' plug following construction)	1,164	CY	$400	$476	$ 465,421	$ 553,851
	3.3	Coffer Dams (2) - Fill cells u/s and d/s + toe slopes	17,130	CY	$6.50	$13.00	$ 111,343	$ 222,685
	3.4	Foundation Excavation - seepage key (assume 20'wide x 150' long x 4' deep	444	CY	$5.50	$8.00	$ 2,444	$ 3,556
	3.5	Foundation Dewatering - assume several dewatering pump systems operating 24/7 over 6 month foundation construction period	180	Day	$1,400.00	$2,800.00	$ 252,000	$ 504,000
	3.6	Coffer Dams - Other assume 25' high x 150 top length, 35' base length, cell construction (e.g. sheet pile, steel, other fabricated metal items)	6,938	SF	$30.00	$35.00	$ 208,125	$ 242,813
	3.7	Coffer Dams - Risk contingency for overtopping	1	LS	$1,000,000.00	$2,000,000.00	$ 1,000,000	$ 2,000,000

Table 3.1, continued

4		**Lands and Easements**						
	4.1	Reservoir Extents Fee Title	756	Acre	$4,356.00	$4,356.00	$ 3,293,136	$ 3,293,136
	4.2	Reservoir Extents/Flood Easement	55	Acre	$4,356.00	$4,356.00	$ 239,580	$ 239,580
	4.3	Reservoir orphaned access roadway reconnection allowance (to WeyCo?)	5	Mile	$750,000.00	$1,125,000.00	$ 3,750,000	$ 5,625,000
		Subtotal					***$ 26,601,117***	***$ 32,609,856***
				Phase 2 - Main Dam				
5		**Main Dam Structure**						
	5.1	Excavation - Foundation General	458,519	CY	$5.50	$8.00	$ 2,521,855	$ 3,668,152
	5.2	Excavation - Foundation Rock	111,488	CY	$25.00	$36.00	$ 2,787,200	$ 4,013,568
	5.3	Fill - Roller Compacted Concrete	746,641	CY	$65.00	$85.00	$ 48,531,665	$ 63,464,485
	5.4	Fill - Foundation Backfill	312,720	CY	$4.50	$7.50	$ 1,407,240	$ 2,345,400
	5.5	Conventional Concrete Reinforced (miscellaneous)	500	CY	$600	$900	$ 300,000	$ 450,000
	5.6	Conventional Concrete Non-Reinforced Mass Concrete (bedding, abutment contact, cover over sluice conduits, assume nominal contact layer)	39,931	CY	$400	$476	$ 15,972,222	$ 19,006,944
	5.7	Concrete Non-Reinforced Facing Concrete System (facing of both slopes of dam 2.5' thickness)	38,828	CY	$100	$150	$ 3,882,778	$ 5,824,167
	5.8	Foundation Treatment - Grout Curtain Drilling	22,500	LF	$16.50	$37.50	$ 371,250	$ 843,750
	5.9	Foundation Treatment - Grout Curtain Cement	15,000	Sack	$15.00	$22.50	$ 225,000	$ 337,500
	5.10	Flood Regulating Conduit Control Structures - Reinforced Concrete (assume 2'thick around perimeter of sluices & air shafts)	4,967	CY	$600	$900	$ 2,980,000	$ 4,470,000
	5.11	Gates - Fab and Construct (assume 2 @ 30 tons + 1 @ 40 tons)	200,000	LB	$9.00	$20.00	$ 1,800,000	$ 4,000,000
	5.12	Bulkheads (assume 2 @ 25 tons, 1 @35 tons, and 4 @ 50 tons)	570,000	LB	$9.00	$20.00	$ 5,130,000	$ 11,400,000
	5.13	Hoists, cylinders, machinery	300,000	LB	$10.00	$15.00	$ 3,000,000	$ 4,500,000
	5.14	Reservoir drain valve in tunnel plug (assume 4x4' knife valve)	1	Each	$150,000.00	$250,000.00	$ 150,000	$ 250,000
	5.15	Trashrack (250 ft high, 10 members 3' dia x 4.5'deep, steel columns)	1,134,000	LB	$5.00	$8.00	$ 5,670,000	$ 9,072,000
	5.16	Trashrack (250 ft high concrete side walls, decking)	3,194	CY	$600	$900	$ 1,916,667	$ 2,875,000

Table 3.1, continued

6		**Spillway Flip Bucket**					
	6.1	Conventional Concrete Reinforced (assume 3' thick surface)	6,319	CY	$600	$900	$ 3,791,667	$ 5,687,500
	6.2	Non-Conventional Concrete Non-Reinforced (could be RCC grout enriched, assume 30ft wedge under reinforced concrete surface)	9,722	CY	$150	$250	$ 1,458,333	$ 2,430,556
7		**Sluice Stilling Basin**						
	7.1	Excavation - Foundation General	20,000	CY	$5.50	$8.00	$ 110,000	$ 160,000
	7.2	Excavation - Foundation Rock	10,000	CY	$25.00	$36.00	$ 250,000	$ 360,000
	7.3	Fill - Foundation Backfill	17,778	CY	$4.50	$7.50	$ 80,000	$ 133,333
	7.4	Conventional Concrete Reinforced	4,900	CY	$600	$900	$ 2,940,000	$ 4,410,000
	7.5	Conventional Concrete Non-Reinforced	2,000	CY	$400	$476	$ 800,000	$ 952,000
		Subtotal					***$ 106,075,876***	***$ 150,654,355***
		Total Base Construction Cost (BCC)					$ 132,676,993	$ 183,264,211
		Design Contingency (20% to 25%)					$ 26,535,398.59	$ 45,816,053
		Construction. CO/C Contingency					$ 10,614,159.44	$ 21,991,705
		Subtotal					$ 169,826,551	$ 251,071,969
		Permitting					$ 5,094,796.53	$ 15,064,318.11
		Design and Site Characterization					$ 11,038,725.81	$ 22,596,477.17
		Engineering Support During Construction					$ 15,284,389.59	$ 30,128,636.23
		Total Cost (Rounded)					**$ 201,200,000**	**$ 318,900,000**

Table 3.2 – FRFA Roller Compacted Concrete (RCC) Dam Project Construciton Costs

		Project:	Chehalis Dam Alternatives			**Computed By:**	ETZ	7/13/2016
		Subject:	ACEC Class 5 Const. Cost Opinion			**Checked By:**		
		Task:	(FRFA) RCC - Flood Retention Flow Au			**Page:**	1	
		EBS Job #:	002-218397	**No:**		**of:**	2	
Bid Item	Sub-Category Line Item	Description	Quantity	Unit	Lower Bound Unit Cost	Upper Bound Unit Price	Lower Bound Cost	Upper Bound Cost
Phase 1 - Prep Work, Diversion & Dewatering, Temporary Construction								
1		**Clearing, Grubbing**						
	1.1	Clearing and grubbing, stripping topsoil, reclamation of disturbed areas	28	Acre	$29,560	$29,560	$ 827,680	$ 827,680
	1.2	Reservoir Clearing to 100-yr Flood Stage	1206	Acre	$5,000	$7,500	$ 6,030,000	$ 9,045,000
2		**Mobilization and Layout of Temporary Construction Access, Facilities, Site Prep, Laydown, etc.**						
	2.1	Construction Surveying & Layout	28	Acre	$25,000	$30,000	$ 700,000	$ 840,000
	2.2	Pioneer/Access Roads (e.g. dam site, abutments, quarry site, etc.)	2	Mile	$750,000	$1,125,000	$ 1,500,000	$ 2,250,000
	2.3	Material Laydown Area Prep (minor excavation, grading, surfacing, drainage	7	Acre	$20,000	$30,000	$ 140,000	$ 210,000
	2.4	Temporary construction site access security control facilities (e.g. fencing, gates, etc.)	2209	LF	$10	$20	$ 22,088	$ 44,176
3		**Diversion & Dewatering**						
	3.1	Diversion Tunnel 20 ft diameter	1,420	LF	$7,670.00	$7,670.00	$ 10,891,400	$ 10,891,400
	3.2	Conventional Concrete Non-Reinforced Mass Concrete (100' plug following construction)	1,164	CY	$400	$476	$ 465,421	$ 553,851
	3.3	Coffer Dams (2) - Fill cells u/s and d/s + toe slopes	17,130	CY	$6.50	$13.00	$ 111,343	$ 222,685
	3.4	Foundation Excavation - seepage key (assume 20'wide x 150' long x 4' deep	444	CY	$5.50	$8.00	$ 2,444	$ 3,556
	3.5	Foundation Dewatering - assume several dewatering pump systems operating 24/7 over 6 month foundation construction period	180	Day	$1,400.00	$2,800.00	$ 252,000	$ 504,000
	3.5	Coffer Dams - Other assume 25' high x 150 top length, 35' base length, cell construction (e.g. sheet pile, steel, other fabricated metal items)	6,938	SF	$30.00	$35.00	$ 208,125	$ 242,813
	3.6	Coffer Dams - Risk contingency for overtopping	1	LS	$1,000,000.00	$2,000,000.00	$ 1,000,000	$ 2,000,000
4		**Lands and Easements**						
	4.1	Reservoir Extents Fee Title	1,206	Acre	$4,356.00	$4,356.00	$ 5,253,336	$ 5,253,336
	4.2	Reservoir Extents/Flood Easement	104	Acre	$4,356.00	$4,356.00	$ 453,024	$ 453,024
	4.3	Reservoir orphaned access roadway reconnection allowance (to WeyCo?)	5	Mile	$750,000.00	$1,125,000.00	$ 3,750,000	$ 5,625,000
		Subtotal					***$ 31,606,861***	***$ 38,966,520***
Phase 2 - Main Dam								
5		**Main Dam Structure**						
	5.1	Excavation - Foundation General	649,860	CY	$5.50	$8.00	$ 3,574,230	$ 5,198,880
	5.2	Excavation - Foundation Rock	202,632	CY	$25.00	$36.00	$ 5,065,800	$ 7,294,752
	5.3	Fill - Roller Compacted Concrete	1,319,700	CY	$65.00	$85.00	$ 85,780,500	$ 112,174,500
	5.4	Fill - Foundation Backfill	452,828	CY	$4.50	$7.50	$ 2,037,726	$ 3,396,210
	5.5	Conventional Concrete Reinforced (miscellaneous)	750	CY	$600	$900	$ 450,000	$ 675,000
	5.6	Conventional Concrete Non-Reinforced Mass Concrete (bedding, abutment contact, cover over sluice conduits, assume nominal contact layer)	51,389	CY	$400	$476	$ 20,555,556	$ 24,461,111

Table 3.2, continued

	5.7	Concrete Non-Reinforced Facing Concrete System (facing of both slopes of dam 2.5' thickness)	55,073	CY	$100	$150	$	5,507,333	$	8,261,000
	5.8	Foundation Treatment - Grout Curtain Drilling	50,000	LF	$16.50	$37.50	$	825,000	$	1,875,000
	5.9	Foundation Treatment - Grout Curtain Cement	33,000	Sack	$15.00	$22.50	$	495,000	$	742,500
	5.10	Flood Regulating Conduit Control Structures - Reinforced Concrete (assume 2'thick around perimeter of sluices & air shafts)	5,778	CY	$600	$900	$	3,466,667	$	5,200,000
	5.11	Flood Regulating Conduit Control Gates - Fab and Construct (assume 2 @ 30 tons)	120,000	LB	$9.00	$20.00	$	1,080,000	$	2,400,000
	5.12	Bulkheads (assume 2 @ 25 tons, and 2 @ 50 tons)	300,000	LB	$9.00	$20.00	$	2,700,000	$	6,000,000
	5.13	Hoists, cylinders, machinery	200,000	LB	$10.00	$15.00	$	2,000,000	$	3,000,000
	5.14	Reservoir drain valve in tunnel plug (assume 4x4' knife valve)	1	Each	$150,000.00	$250,000.00	$	150,000	$	250,000
	5.15	WQ Regulating Outlets w/ hollow cone valves (4 - 4'diameter)	4	Each	$300,000.00	$450,000.00	$	1,200,000	$	1,800,000
	5.16	WQ Regulating Outlet w/ hollow cone valves (1 - 7'diameter)	1	Each	$1,000,000.00	$1,250,000.00	$	1,000,000	$	1,250,000
	5.17	WQ Intake Tower - Conventional Concrete Reinforced (assume 20% of 300' high x 40'x40' 1/4 round section)	2,793	CY	$600	$900	$	1,675,516	$	2,513,274
	5.18	WQ Intake Tower - Conventional Concrete Non-Reinforced (assume 80% of 300' high x 40'x40' 1/4 round section)	11,170	CY	$400	$476	$	4,468,043	$	5,316,971
	5.17	Trashrack (300 ft high, 10 members 3' dia x 4.5'deep, steel columns)	1,360,800	LB	$5.00	$8.00	$	6,804,000	$	10,886,400
	5.18	Trashrack (300 ft high concrete side wall, decking)	1,944	CY	$600	$900	$	1,166,667	$	1,750,000
6		**Spillway Flip Bucket**								
	6.1	Conventional Concrete Reinforced (assume 3' thick surface)	7,778	CY	$600	$900	$	4,666,667	$	7,000,000
	6.2	Non-Conventional Concrete Non-Reinforced (could be RCC grout enriched, assume 30ft wedge under reinforced concrete surface)	9,722	CY	$150	$250	$	1,458,333	$	2,430,556
7		**Sluice Stilling Basin**								
	7.1	Excavation - Foundation General	20,000	CY	$5.50	$8.00	$	110,000	$	160,000
	7.2	Excavation - Foundation Rock	10,000	CY	$25.00	$36.00	$	250,000	$	360,000
	7.3	Fill - Foundation Backfill	17,778	CY	$4.50	$7.50	$	80,000	$	133,333
	7.4	Conventional Concrete Reinforced (assume 3' thick surface)	4,900	CY	$600	$900	$	2,940,000	$	4,410,000
	7.5	Conventional Concrete Non-Reinforced (assume 4.5'thick bedding under floor only)	2,000	CY	$400	$476	$	800,000	$	952,000
8		**Wing Dam Structure**								
	8.1	Excavation - Foundation General (assume footprint 270' @ widest x 10 ft deep)	33,333	CY	$5.50	$8.00	$	183,333	$	266,667
	8.2	Excavation Cutoff Trench - Foundation Rock (assume trench 30 ft wide x 20 ft deep)	13,333	CY	$25.00	$36.00	$	333,333	$	480,000
	8.3	Fill - Wingdam Embankment	117,768	CY	$4.50	$7.50	$	529,956	$	883,260
	8.4	Fill - Wingdam Riprap Facing (assume 5' blanket U/S and D/S)	8,009	CY	$28.00	$34.50	$	224,255	$	276,314
		Subtotal					***$***	***161,577,915***	***$***	***221,797,728***

Table 3.2, continued

		Total Base Construction Cost (BCC)		$ 193,184,776	$ 260,764,248
		Design Contingency (20% to 25%)		$ 38,636,955	$ 65,191,062
		Construction. CO/C Contingency		$ 15,454,782	$ 31,291,710
		Subtotal		$ 247,276,513	$ 357,247,020
		Permitting		$ 7,418,295	$ 21,434,821
		Design and site Characterization		$ 16,072,973	$ 32,152,232
		Engineering Support During Construction		$ 22,254,886.20	$ 42,869,642.43
		Total Cost (Rounded)		**$ 293,000,000**	**$ 453,700,000**

3.3.3. Fish Facilities

Multiple options for upstream and downstream fish passage facilities are currently being considered by the Fish Passage Subcommittee. The Fish Passage Subcommittee includes members from the National Marine Fisheries Service, Washington State Department of Fish and Wildlife, Washington State Department of Ecology, Quinault Indian Nation, and engineering and biological consultants. The current set of fish passage options has been refined by the subcommittee from a larger set. The cost estimates included herein reflect the decisions made to date and the state of development of the options as informed by the subcommittee. These options are still under development. As such, the cost estimates for these options will change as development progresses. The cost estimates herein are based on the cost estimates provided in the Combined Dam and Fish Passage Alternatives Technical Memorandum dated October 2014, and have been updated to reflect the current set of fish passage options and at the current level of design development. Table 3 at the end of this section summarizes the fish passage options considered.

Key changes from the previous cost estimate are as follows:

1) The Experimental Fishway and Combination Collection Facilities were eliminated from the set of fish passage options.
2) The Fixed Multi-Port Outlet was added as a downstream fish passage option. This option has not yet been developed. The cost estimate for this option is based on the fixed multi-port outlet currently under construction by the U.S. Bureau of Reclamation at Cle Elum Dam. If implemented at the Chehalis Dam, the Fixed Multi-Port Outlet would release roughly half the flow as Cle Elum. The estimated cost was assumed to be about 30% less than the Cle Elum outlet as half the flow does not relate directly to half the size and complexity of construction.
3) Upon refinement of the Conventional Fishway, the fish ladder exit will likely be more complicated than previously assumed. The cost of the ladder exit may be closer in cost to the fish ladder exit included in the previously considered Experimental Fishway. The cost estimate has been updated to reflect this complexity.
4) The Fish Passage Subcommittee has made several decisions relating to the Forebay Collector that changed the original assumptions regarding the operation of the facility. The changes in operation changed the size of the facility. These decisions have also provided additional direction, allowing the design to be developed further. These changes resulted in an increase in the estimated construction and operation and maintenance costs of the Forebay Collector. Some of the specific changes include:
    a. Nearly doubling the attraction flow of the floating surface collector facility

b. Fish guidance and barrier nets that are about 2.5 times longer then previously considered

c. Several supporting structure and facilities have been added to make the fish passage and handling facilities reflect the latest practice and experience.

5) The fish passage conduits in the FRO dam are integral to the FRO dam itself. Therefore the estimated construction cost of the fish passage conduits is included in the FRO dam cost estimate.

6) The estimated construction cost of the Capture, Handling, Transport, and Release (CHTR) facility is the same for the FRO and FRFA dam options

Table 3.3 – Fish Facilities Construction Costs

Fish Passage Option	Lower Bound Cost ($ Million)	Middle Cost ($ Million)	Upper Bound Cost ($ Million)
Upstream Fish Passage: Chtr Facility	$10.9	$13.6	$17.7
Upstream Fish Passage: Conventional Fishway	$47.8	$59.8	$77.7
Dowstream Fish Passage: Fixed Multi-Port Outlet	$83.6	$104.5	$135.9
Downstream Fish Passage: Forebay Collector	$69.0	$86.2	$112.1

3.3.4. Hydro Facilities

Not applicable

3.3.5. Transmission Lines Substation Equipment (if applicable)

Transmission lines are not required, however electrical distribution lines are required. Costs for electrical distribution service line extension to the dam site is assumed to be covered under the contingency applied to the direct dam costs.

3.3.6. Washington State Sales Tax

Sales tax breakdown assumed as follows:

Washington State Sales Tax	6.500%
Lewis County Sales Tax	1.300%
Pe Ell Sales Tax	0.000%
Total Sales Tax	7.800%

3.3.7. Contingencies

Contingency is applied to entire direct dam construction costs. An expected design contingency of 20% on the low side and 25% on the high side have been applied. A slight reduction in contingency relative to the ca. 2014 design contingency factor was considered, as additional detail has been developed and the design for the FRO and FRFA alternatives have been refined as part of this Phase 2 work. However, this contingency should be considered interim, as the Phase 2 design work is not yet complete, and as more detail is developed, we expect that this contingency will be refined additionally.

3.3.8. Engineering and Construction Management Assistance

For the FRO and FRFA alternatives, we applied an estimated Engineering and Construction Management factor to the total project construction costs after applying the design and construction contingency. We estimated a Design and Site Characterization contingency factor of 7% to 9%, and an Engineering and Construction management Assistance contingency factor of 9% to 12%.

3.3.9. Permitting Costs

We assumed a proportional factor of between 3% and 6% would be applied to cover the anticipated cost of permitting coordination prior to and during construction.

4. Schedule

Table 4.1 below provides an estimated construction schedule for the project.

Table 4.1 – Anticipated Project Schedule for Completion

CONSTRUCTION YEAR	YEAR 1				YEAR 2				YEAR 3			
CONSTRUCTION ITEM	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**
DAM CONSTRUCTION												
Mobilization/Site Prep	4											
Flood Contr. Outlet, Entry/Discharge Pools	4	6										
Cofferdams, Begin Outlet Diversion		3	4									
Water Quality Outlet Structure			6	4								
Concrete and RCC Dam				8	14	12	8	6				
Spillway and Stilling Basin							3	4	8			
Remove Cofferdams, Channel Modifications									2	4		
FISH PASSAGE CONSTRUCTION												
Upstream Fish Passage Fishway				20	25	30	25					
Downstream Fish Passage Floating Collector						30	40	30				
In Operation											X	

Notes: RCC = roller compacted concrete

4.1. Construction Start Date

We have not assumed a construction start date in our current work, as recent information suggests that the Washington Legislature has not yet authorized the 2017-2019 biennium budget, which was anticipated to include the Feasibility Design Phase and Final Design Phase of the project. However, if the budget and effort is authorized, we would expect the construction start date to begin approximately 2.5 years following commencement of the Feasibility Design Phase.

4.2. Project Implementation Date

As discussed above, we do not yet know whether the Preliminary and Final Design Phases of the project will be authorized under the 2017-2019 biennium budget, therefore no project implementation date can be given at this time. However, since the anticipated schedule for design and construction is between 8 and 11 years to construction completion, we would infer that, if the Preliminary and Final Design Phases and Construction Phase were commenced in 2017, the project would be complete and ready for commissioning in 2025 to 2028.

4.3. Construction Spending Schedule

This anticipated spending schedule will be developed as part of the continuing Phase 2 design development effort, however, a preliminary construction spending schedule is provided in Table 4.2.

Table 4.2 – Preliminary Construction Spending Schedule

Chehalis Dam and Fish Passage Construction Costs (no hydro)															
Quarterly Construction Cash Flow ($ million)			Construction Period (Quarters of Years)												
			Year 1				Year 2				Year 3				
Dam Alternative	Median Expected Project Cost ($ million)	Const Duration (quarters)	1	2	3	4	5	6	7	8	9	10	11	12	Totals
FRO RCC Dam		8	10%	12%	14%	16%	15%	14%	12%	7%					100%
Quarterly Cash Flow	**261**		**$26**	**$31**	**$37**	**$42**	**$39**	**$37**	**$31**	**$18**					**261**
FRFA RCC Dam		10	8%	9%	10%	12%	14%	12%	11%	10%	8%	6%			100%
Quarterly Cash Flow	**374**		**$30**	**$34**	**$37**	**$45**	**$52**	**$45**	**$41**	**$37**	**$30**	**$22**			**374**

5. Annual Operations & Maintenance Costs

Tables 5.1 and 5.2 at the end of this section summarizes the expected annual Operation & Maintenance Costs associated with the proposed project, separated by the particular dam option (i.e. FRO vs. FRFA), respectively.

5.1. Dam and Fish Passage Facilities Annual O&M Costs

An estimate of the operations and maintenance (O&M) cost associated with each fish passage facility option is provided below. The estimated O&M costs are based on the previous estimates and updated to reflect the decisions made by the Fish Passage Subcommittee and design development to-date, as described in Section 3.3.3 above. The significant changes to the estimated O&M costs are:

1) The Forebay Collector will now operate all year, rather than 8-months as previously assumed.
2) The Forebay Collector will now operate at nearly twice the flow for 2 months of the year. Flow during the remainder of the year will also require many more pumps to operate, in accordance with the changes to attraction flow decided by the subcommittee. These changes substantially increase the annual cost of power, which is assumed to be purchased from the power grid at the market rate.
3) The CHTR facility associated with the FRO dam option is only expected to operate for one month every seven years, on average. Therefore the operation and maintenance cost for the CHTR facility associated with the FRO dam option has annualized to reflect a once-in-every-seven-years operation and the minimal maintenance and power requirements between uses.
4) Monitoring and Evaluation (M&E) of the fish passage facilities has been added to the annual O&M costs. The Fish Passage Subcommittee recently agreed that M&E will likely become part of the project once it is constructed but no additional definition as to the size, scope, or cost was discussed. The M&E included in these O&M costs are a placeholder to represent an as-yet-undetermined level of effort.

5.2. Sedimentation Management

For the FRO dam alternative, sedimentation management costs are considered included in the annual Operations and Maintenance costs, since no additional staff would be required to conduct sediment management activities.

There are no sediment management costs expected for the FRFA dam alternative, as the reservoir lifespan assumes that reservoir dead storage volume is adequate to store the bedload generated during the expected lifespan of the project.

5.3. Reservoir Maintenance (Debris Management)

Reservoir debris management costs are assumed similar between the FRO and FRFA alternatives, and are expected to be conducted by the typically available staff. This is commensurate with other similar projects to the FRO and FRFA alternatives (Mud Mountain Dam and Howard Hanson Dam, respectively).

5.4. Property Tax, Insurance, etc. (if applicable)

Property taxes and insurance costs were not considered in this analysis, as it is expected that the real estate required for the project would be held by the State of Washington and as such would not be subject to taxation.

Table 5.1 – FRO Roller Compacted Concrete (RCC) Dam Annual O&M Costs

FRO RCC Flood Retention Dam		Annual Operations and Maintenance Costs				
Cost Area	**Cost Category**	**Cost Item**	**Cost Basis**	**Value**	**Unit $**	**Annual $**
Reservoir	Vegetation Management	Part Time Labor	FTE	1.5	$65,000	$97,500
Reservoir	Debris Handling	Part Time Labor	FTE	1	$65,000	$65,000
Reservoir	Debris Handling/Disposal	Loaders/Trucks/Operators	LS	1	$50,000	$50,000
Reservoir	Fish/Environmental	Monitoring/Reporting	LS	1	$30,000	$30,000
Dam	Operations	Dam Tender/Security	FTE	0.7	$85,000	$59,500
Dam	Administrative	Management	FTE	0.3	$120,000	$36,000
Dam	Administrative	Reporting	FTE	0.3	$90,000	$27,000
Dam	Administrative	Legal/Insurance	LS	1	$50,000	$50,000
Dam	Maintenance/Repairs	Part Time Labor	FTE	0.5	$80,000	$40,000
Dam	Inspections	Safety Inspections	LS	1	$9,000	$9,000
Dam	Mechanical	Repair/Replace Fund	% Cap	0.4%	$21,952,000	$88,000
Dam	Structural	Repair Fund	% Cap	0.1%	$50,850,000	$51,000
		Subtotal				**$603,000**
Fish Passage	Operations	Operator/Monitor	FTE	0.01	$122,550	$2,000
Fish Passage	Biological	Monitoring/Reporting	FTE	0.01	$129,000	$2,000
Fish Passage	Biological	Part Time Labor	FTE	0.02	$44,400	$1,000
Fish Passage	Maintenance	Part Time Labor	FTE	0.03	$129,000	$5,000
Fish Passage	Structural/Mechanical	Repair/Replace Fund	LS	1	$3,000	$3,000
Fish Passage	Trap and Haul	Loaders/Trucks/Maintenance	LS	1	$3,038	$4,000
Fish Passage	Electricity	General Service Loads/Pumping	kWh	38,577	$0.09	$4,000
Fish Passage	Biological	Monitoring & Evaluation	FTE	0.01	$129,000	$2,000
Fish Passage	Biological	Monitoring & Evaluation PT	FTE	0.01	$44,400	$1,000
Fish Passage	Science Costs	Lab Tests, etc.	LS	0	$37,000	$1,000
		Subtotal				**$25,000**
		Total Annual Cost				**$628,000**

Table 5.2 – FRFA Roller Compacted Concrete (RCC) Dam Annual O&M Costs

FRFA RCC Multi-Purpose Dam		Annual Operations and Maintenance Costs				
Cost Area	**Cost Category**	**Cost Item**	**Cost Basis**	**Value**	**Unit $**	**Annual $**
Reservoir	Vegetation Management	Part Time Labor	FTE	1	$65,000	$65,000
Reservoir	Debris Handling	Part Time Labor	FTE	1.5	$65,000	$97,500
Reservoir	Debris Handling	Loaders/Trucks/Operators	LS	1.5	$50,000	$75,000
Reservoir	Fish/Environmental	Monitoring/Reporting	LS	1	$40,000	$40,000
Dam	Operations	Dam Tender/Security	FTE	1.5	$85,000	$127,500
Dam	Administrative	Management	FTE	0.5	$120,000	$60,000
Dam	Administrative	Reporting	FTE	0.3	$100,000	$30,000
Dam	Administrative	Legal/Insurance	LS	1	$150,000	$150,000
Dam	Maintenance	Part Time Labor	FTE	1	$80,000	$80,000
Dam	Inspections	Safety Inspections	LS	1	$10,000	$10,000
Dam	Mechanical	Repair/Replace Fund	% Cap	0.8%	$12,767,588	$102,000
Dam	Structural	Repair Fund	% Cap	0.2%	$60,432,000	$121,000
		Subtotal				**$958,000**
Fish Passage Option 1 - Conventional Fishway & Forebay Collector (Middle Const Cost)						
Fish Passage	Operations	Operator/Monitor	FTE	0.75	$122,550	$92,000
Fish Passage	Biological	Monitoring/Reporting	FTE	1.5	$129,000	$194,000
Fish Passage	Biological	Part Time Labor	FTE	1.08	$44,400	$48,000
Fish Passage	Maintenance	Part Time Labor	FTE	0.15	$129,000	$20,000
Fish Passage	Structural/Mechanical	Repair/Replace Fund	LS	1	$20,000	$20,000
Fish Passage	Trap and Haul	Loaders/Trucks/Maintenance	LS	1	$5,321	$6,000
Fish Passage	Electricity	General Service Loads/Pumping	kWh	5,772,665	$0.09	$520,000
Fish Passage	Biological	Monitoring & Evaluation	FTE	0.53	$129,000	$68,000
Fish Passage	Biological	Monitoring & Evaluation PT	FTE	1.05	$44,400	$47,000
Fish Passage	Science Costs	Lab Tests, etc.	EA	2	$18,000	$36,000
		Subtotal				**$1,051,000**
		Total Annual Cost				**$2,009,000**
Fish Passage Option 2 - CHTR & Forebay Collector (Low Const Cost)						
Fish Passage	Operations	Operator/Monitor	FTE	1.25	$122,550	$154,000
Fish Passage	Biological	Monitoring/Reporting	FTE	2	$129,000	$258,000
Fish Passage	Biological	Part Time Labor	FTE	1.75	$44,400	$78,000
Fish Passage	Maintenance	Part Time Labor	FTE	0.23	$129,000	$30,000
Fish Passage	Structural/Mechanical	Repair/Replace Fund	LS	1	$15,000	$15,000
Fish Passage	Trap and Haul	Loaders/Trucks/Maintenance	LS	1	$13,533	$14,000
Fish Passage	Electricity	General Service Loads/Pumping	kWh	5,772,665	$0.09	$520,000
Fish Passage	Biological	Monitoring & Evaluation	FTE	0.53	$129,000	$68,000
Fish Passage	Biological	Monitoring & Evaluation PT	FTE	1.05	$44,400	$47,000
Fish Passage	Science Costs	Lab Tests, etc.	EA	2	$18,000	$36,000
		Subtotal				**$1,220,000**
		Total Annual Cost				**$2,178,000**
Fish Passage Option 3 - Conventional Fishway & Fixed Mulit-Port Outlet (High Const Cost)						
Fish Passage	Operations	Operator/Monitor	FTE	0.5	$122,550	$62,000
Fish Passage	Biological	Monitoring/Reporting	FTE	1	$129,000	$129,000
Fish Passage	Biological	Part Time Labor	FTE	0.75	$44,400	$34,000
Fish Passage	Maintenance	Part Time Labor	FTE	0.12	$129,000	$16,000
Fish Passage	Structural/Mechanical	Repair/Replace Fund	LS	1	$20,000	$20,000
Fish Passage	Trap and Haul	Loaders/Trucks/Maintenance	LS	1	$0	$0
Fish Passage	Electricity	General Service Loads/Pumping	kWh	21,900	$0.09	$2,000
Fish Passage	Biological	Monitoring & Evaluation	FTE	0.53	$129,000	$68,000
Fish Passage	Biological	Monitoring & Evaluation PT	FTE	1.05	$44,400	$47,000
Fish Passage	Science Costs	M&E Lab Tests, etc.	EA	2	$18,000	$36,000
		Subtotal				**$414,000**
		Total Annual Cost				**$1,372,000**

6. Schedule of Periodic Replacement Costs

6.1. Costs needed to keep the dam operating for the full 100-year life period not included in the annual O&M costs

6.1.1. Debris Handling

No additional costs associated with debris handling are expected beyond what has already been covered in the annual O&M cost table, as these regular costs can be absorbed within the typical manpower requirements expected for the project.

6.1.2. Dam Inspections

No additional costs associated with periodic dam inspections are expected beyond what has already been covered in the annual O&M cost table, as these periodic costs can be absorbed within the typical manpower requirements expected for the project.

6.2. Year(s) in which these Costs are Expected

Not applicable

7. Any Additional Fish Passage Costs not included above for the 100-year life Period

If the Forebay Collector is selected, new transmission lines will likely need to be run from the nearest substation to dam. The transmission lines will need to be capable of providing a minimum 600 kW. The cost for running the transmission lines has not been included above. This cost may be several million dollars or greater. Alternative sources of power for the Forebay Collector have not been examined and are not included in the estimate.

A placeholder for the Monitoring and Evaluation (M&E) of fish passing the dam and fish facilities has been provided above as part of the Operation and Maintenance cost. The Fish Passage Committee agreed that M&E will likely be required but, to-date, no detail has been provided addressing the scope and estimated cost. The estimated M&E cost provided in the O&M may change substantially in the future as additional detail is developed relating to the estimated size and scope of the M&E operation

8. Summary of Risk/Uncertainty Information Needed

At the present time, there is significant cost risk and uncertainty associated with the subsurface conditions at the site, and the unit price of the RCC. As additional phases of site explorations are performed, much of this uncertainty will be reduced as additional information is obtained. For example, more information about RCC aggregate quarry sites as well as additional RCC mix testing will reduce the uncertainty of the RCC unit price. Similarly, additional subsurface information will reduce uncertainty of the foundation excavation, foundation treatment, and grouting costs.

A list of specific items associated with rick and uncertainty are as follows:

1) Confirmation of annual and seasonal diversion overtopping risk and mitigating strategies
2) RCC mix design program results and incorporation plan
3) Final quarry characterization, potentially including a test quarry and crush investigation
4) Development of risk register, emphasizing construction risk, including delivery and procurement, and CM strategies
5) Initial and ongoing assessment of cementitious material price and availability
6) Thorough construction schedule development and sensitivity analysis

7) Built-up cost estimate, risk-based sensitivity development including risk-based contingency development, and re-visited market analysis and sensitivity
8) Development and determination of project design alternatives, i.e. facing selection, seepage control strategies
9) Confirm final foundation investigation and characterization includes confidence in the river bed bottom and/or includes mitigating strategies to address potential surprises during construction
10) Same confirmation for the diversion tunnel geotechnical design

Appendix B
Restorative Flood Protection Cost Estimate Memorandum

To: Amber Nyquist, Anne Falcon, and Lisa Fortney at EES Consulting

From: Natural Systems Design

Date: 8/16/2016

Re: Initial Data Request: Chehalis Restorative Flood Protection Alternative Cost Estimate Inputs for Economic Analysis

DATA REQUEST

The cost for Restorative Flood Protection (RFP) option with all costs should be provided in current dollars ($2016).

The following data was requested by EES, see Table 1. Some of this data has been provided in previous transmittals. A summary of the data requested and respective documentation and responses are listed below:

Table 1: List of EES data request with respective documentation

EES DATA REQUEST	DOCUMENTATION/RESPONSE
Detailed description of RFP and potential impacts if applicable	See PEIS restorative flood protection alternative description
Expected life of the RFP	Previously discussed. RFP restores natural processes that are predominantly self-sustaining.
Timing of Impacts	See Chehalis Phased Project Benefits.xls, C/O Ken Ghalambor
Construction start date (year)	TBD… 2020?
Project implementation date/ construction spending schedule	Implementation date is yet to be determined, construction spending may occur evenly over a period of 10 years.
Total Direct Project cost	See tables in this memo.
Annual Monitoring Costs	See tables in this memo. 100 years of monitoring.
Annual Adaptive Management Costs	See tables in this memo. High the first 20 years, then tapers off over time. Includes periodic unforeseen replacement costs.

RFPA Total Direct Project Costs, Annual Monitoring, and Adaptive Management Costs

Table 2. Restorative Flood Protection Alternative (RFPA) buy-out and relocation costs

ITEM #	ITEM DESC.	QUANTITY 10-YEAR FLOOD-PLAIN ONLY	QUANTITY 10 & 100-YEAR FLOOD-PLAIN COMBINED	UNIT	UNIT PRICE ($)	AMOUNT ($) 10-YEAR FLOODPLAIN ONLY	AMOUNT ($) 10 & 100-YEAR FLOODPLAIN COMBINED
1	Buy-outs in floodplain	980	1740	EA	$118,000	$115 million	$205 million
2	Relocation (see Note)	1	1	LS	$300 million	$150 million	$300 million
	Totals					**$265 million**	**$505 million**

Note: Relocation costs are a placeholder and require further enhancement by land use/development expert.
All floodplain extents come from modeled restorative flood protection alternative results (NSD, 2016).

Table 3. Restorative Flood Protection Alternative (RFPA) estimated planning-level construction costs

ITEM #	ITEM DESCRIPTION	QUANTITY (SEE NOTE)	UNIT	UNIT PRICE ($)	AMOUNT ($) (SEE NOTE)
1	In-stream restoration for streams with width less than 60'	40	MI	$450,000	$18 million
2	In-stream restoration for streams with width greater than 60'	110	MI	$725,000	$80 million
3	Floodplain wood installation	3,900	AC	$85,000	$332 million
4	Floodplain planting	15,610	AC	$8,000	$125 million
	Construction Sub-Total				$555 million
5	WA State Taxes	8.7%	*		$48 million
6	Planning, Land Acquisition and other Administrative Tasks, Permitting, Project Management, Engineering	10.0%	*		$55 million
7	Monitoring	1.0%	*		$5 million
8	Adaptive Management	2.5%	*		$14 million
	Total Estimated Construction Cost				**$677 million**

Note: All quantities rounded to the nearest unit of 10, and the unit price and amounts rounded to nearest $1000. Floodplain wood installation and planting items are for both 10 and 100-year RFPA floodplains. Items marked with an asterisk (*) in the unit column are calculated as a percent of the construction sub-total.

DRAFT COST BREAKDOWN

Project: Chehalis Restorative Flood Protection Alternative (RFPA)

Project Number: --

Analyst: D. Devier

Latest Revision: 9/14/16

Tax 8.7%

Escalation Included in "Subtotal Escalated"

0%	= Allowance for Indeterminates (%)
0%	= Inflation (%)
100%	=Total Escalation (%)

Item Description	Ref. ID	Ref. #	Page #	Quantity	Units	Unit cost ($)	Subtotal ($)	Subtotal Escalated ($)	Total Cost of bid item ($)	Assumptions
In-stream Restoration for streams with width less than 60'				**40**	**MI**		**$750,000**	**$750,000**	**$30,000,000**	
Miles of restored stream				1	MI	$750,000.00	$750,000	$750,000		Unit cost based on construction cost for Hurst Creek, [$70,000 for 1500 feet, or 0.28 miles, of channel].
In-stream Restoration for streams with width greater than 60'				**110**	**MI**		**$1,250,000**	**$1,250,000**	**$137,500,000**	
Miles of restored river				1	MI	$1,250,000.00	$1,250,000	$1,250,000		$250,000 per jam, 5 jams per mile (every 1000') = $1,250,000 per mile.
Floodplain wood installation				**550**	**EA**		**$750,000**	**$750,000**	**$412,500,000**	
Floodplain wood installation				1	EA	$750,000.00	$750,000	$750,000		Unit cost based on the following assumptions: 550 floodplain roughness strips (within the 100-year floodplain, 110 miles of channel >60 ft, five strips per mile, average area of five acres), $150,000 per acre, or $750,000 per strip.
Floodplain planting				**15,609**	**AC**		**$8,000**	**$8,000**	**$124,870,400**	
Floodplain planting cost for areas with less than 75% canopy cover				1	AC	$8,000.00	$8,000	$8,000		Unit cost based on the following assumptions: 80% of the 100-year floodplain area densely planted with a diversity of species. The constructed cost of five projects ranged from $2k to $20k per acre. A cost of $8k per acre was selected for this estimate.

Total Active Items	**$704,870,400**
Tax	61,324,000
Total cost	**$ 766,194,400**

Appendix C
Detailed Results

Table C-1

Full Results State Perspective

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 1.5% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1: 2014 GOVERNOR'S WORK GROUP RECOMMENDATION – LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$929	$15	$601	$342	1.6
FRFA with Conventional Fishway and Forebay Collector	$929	$7	$932	$4	1.0
FRFA with CHTR and Forebay Collector	$929	$7	$892	$45	1.0
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$929	$7	$916	$21	1.0
ALTERNATIVE 1: 2014 GOVERNOR'S WORK GROUP RECOMMENDATION – HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$929	$46	$929	$47	1.1
FRFA with Conventional Fishway and Forebay Collector	$929	$27	$1,260	-$304	0.8
FRFA with CHTR and Forebay Collector	$929	$27	$1,219	-$263	0.8
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$929	$27	$1,243	-$287	0.8
ALTERNATIVE 2: STRUCTURAL FLOOD PROTECTION WITHOUT A FLOOD RETENTION FACILITY					
Low Restoration Scenario	$109	$16	$408	-$283	0.3
High Restoration Scenario	$109	$47	$735	-$579	0.2
ALTERNATIVE 3: NONSTRUCTURAL FLOOD PROTECTION					
Low Restoration Scenario	$72	$16	$298	-$210	0.3
High Restoration Scenario	$72	$47	$625	-$507	0.2
ALTERNATIVE 4: RESTORATIVE FLOOD PROTECTION					
Low Restoration Scenario	$1,138	$55	$1,570	-$377	0.8
High Restoration Scenario	$1,138	$82	$1,814	-$593	0.7
INDIVIDUAL ACTION ELEMENTS					
Aquatic Species Habitat Actions – Low Restoration Only		$16	$229	-$213	0.1
Aquatic Species Habitat Actions – High Restoration Only		$47	$557	-$510	0.1
I-5 Projects and Airport Levee Improvements Only	$109	$0	$107	$2	1.0
Restorative Flood Protection Only	$1,083	$24	$1,366	-$259	0.8
Flood Retention Facility and Airport Levee Improvements Only					
FRO RCC with CHTR Fish Passage	$929	-$16	$327	$587	2.8
FRFA RCC with Conventional Fishway and Forebay Collector	$929	-$16	$658	$255	1.4
FRFA RCC with CHTR and Forebay Collector	$929	-$16	$617	$296	1.5
FRFA RCC with Conventional Fishway and Fixed Multi-port Outlet	$929	-$16	$641	$272	1.4

Table C-2

Full Results Basin Perspective

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 1.5% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1 LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$923	$15	$601	$337	1.6
FRFA with Conventional Fishway and Forebay Collector	$923	$7	$932	-$2	1.0
FRFA with CHTR and Forebay Collector	$923	$7	$892	$39	1.0
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$923	$7	$916	$15	1.0
ALTERNATIVE 1 HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$923	$46	$929	$41	1.0
FRFA with Conventional Fishway and Forebay Collector	$923	$27	$1,260	-$310	0.8
FRFA with CHTR and Forebay Collector	$923	$27	$1,219	-$269	0.8
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$923	$27	$1,243	-$293	0.8
ALTERNATIVE 2					
Low Restoration Scenario	$95	$16	$408	-$297	0.3
High Restoration Scenario	$95	$47	$735	-$593	0.2
ALTERNATIVE 3					
Low Restoration Scenario	$72	$16	$298	-$210	0.3
High Restoration Scenario	$72	$47	$625	-$507	0.2
ALTERNATIVE 4					
Low Restoration Scenario	$1,143	$55	$1,570	-$373	0.8
High Restoration Scenario	$1,143	$82	$1,814	-$589	0.7
INDIVIDUAL ACTION ELEMENTS					
Aquatic Species Habitat Actions – Low Restoration Only		$16	$229	-$213	0.1
Aquatic Species Habitat Actions – High Restoration Only		$47	$557	-$510	0.1
I-5 Projects and Airport Levee Improvements Only	$95	$0	$107	-$11	0.9
Restorative Flood Protection Only	$1,088	$24	$1,366	-$254	0.8
Flood Retention Facility and Airport Levee Improvements Only					
FRO RCC with CHTR Fish Passage	$923	-$16	$327	$581	2.8
FRFA RCC with Conventional Fishway and Forebay Collector	$923	-$16	$658	$250	1.4
FRFA RCC with CHTR and Forebay Collector	$923	-$16	$617	$290	1.5
FRFA RCC with Conventional Fishway and Fixed Multi-port Outlet	$923	-$16	$641	$266	1.4

Table C-3

Full Results Federal Perspective

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 3.125% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1: LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$562	$6	$588	-$20	1.0
FRFA with Conventional Fishway and Forebay Collector	$562	$3	$890	-$325	0.6
FRFA with CHTR and Forebay Collector	$562	$3	$846	-$281	0.7
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$562	$3	$887	-$322	0.6
ALTERNATIVE 1: HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$562	$20	$915	-$334	0.6
FRFA with Conventional Fishway and Forebay Collector	$562	$11	$1,217	-$644	0.5
FRFA with CHTR and Forebay Collector	$562	$11	$1,173	-$600	0.5
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$562	$11	$1,214	-$641	0.5
ALTERNATIVE 2:					
Low Restoration Scenario	$93	$7	$408	-$308	0.2
High Restoration Scenario	$93	$20	$735	-$622	0.2
ALTERNATIVE 3:					
Low Restoration Scenario	$71	$7	$298	-$221	0.3
High Restoration Scenario	$71	$20	$625	-$535	0.1
ALTERNATIVE 4					
Low Restoration Scenario	$682	$24	$1,566	-$860	0.5
High Restoration Scenario	$682	$35	$1,809	-$1,091	0.4
INDIVIDUAL ACTION ELEMENTS					
Aquatic Species Habitat Actions – Low Restoration Only		$7	$229	-$222	0.0
Aquatic Species Habitat Actions – High Restoration Only		$20	$557	-$537	0.0
I-5 Projects and Airport Levee Improvements Only	$93	$0	$107	-$14	0.9
Restorative Flood Protection Only	$627	$10	$1,366	-$728	0.5
Flood Retention Facility and Airport Levee Improvements Only					
FRO RCC with CHTR Fish Passage	$562	-$7	$313	$242	1.8
FRFA RCC with Conventional Fishway and Forebay Collector	$562	-$7	$615	-$60	0.9
FRFA RCC with CHTR and Forebay Collector	$562	-$7	$571	-$16	1.0
FRFA RCC with Conventional Fishway and Fixed Multi-port Outlet	$562	-$7	$612	-$57	0.9

Table C-4

Replacement Values State Perspective

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 1.5% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1: LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$1,187	$15	$601	$600	2.0
FRFA with Conventional Fishway and Forebay Collector	$1,187	$7	$932	$262	1.3
FRFA with CHTR and Forebay Collector	$1,187	$7	$892	$303	1.3
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$1,187	$7	$916	$279	1.3
ALTERNATIVE 1: HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$1,187	$46	$929	$305	1.3
FRFA with Conventional Fishway and Forebay Collector	$1,187	$27	$1,260	-$46	1.0
FRFA with CHTR and Forebay Collector	$1,187	$27	$1,219	-$5	1.0
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$1,187	$27	$1,243	-$29	1.0
ALTERNATIVE 2:					
Low Restoration Scenario	$2,205	$16	$408	$1,813	5.4
High Restoration Scenario	$2,205	$47	$735	$1,516	3.1
ALTERNATIVE 3:					
Low Restoration Scenario	$72	$16	$298	-$210	0.3
High Restoration Scenario	$72	$47	$625	-$507	0.2
ALTERNATIVE 4					
Low Restoration Scenario	$1,320	$55	$1,570	-$195	0.9
High Restoration Scenario	$1,320	$82	$1,814	-$411	0.8
INDIVIDUAL ACTION ELEMENTS					
Aquatic Species Habitat Actions – Low Restoration Only		$16	$229	-$213	0.1
Aquatic Species Habitat Actions – High Restoration Only		$47	$557	-$510	0.1
I-5 Projects and Airport Levee Improvements Only	$2,205	$0	$107	$2,098	20.6
Restorative Flood Protection Only	$1,265	$24	$1,366	-$77	0.9
Flood Retention Facility and Airport Levee Improvements Only					
FRO RCC with CHTR Fish Passage	$1,187	-$16	$327	$845	3.6
FRFA RCC with Conventional Fishway and Forebay Collector	$1,187	-$16	$658	$513	1.8
FRFA RCC with CHTR and Forebay Collector	$1,187	-$16	$617	$554	1.9
FRFA RCC with Conventional Fishway and Fixed Multi-port Outlet	$1,187	-$16	$641	$530	1.8

Table C-5

Replacement Values Basin Perspective

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 1.5% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1: LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$1,181	$15	$601	$595	2.0
FRFA with Conventional Fishway and Forebay Collector	$1,181	$7	$932	$256	1.3
FRFA with CHTR and Forebay Collector	$1,181	$7	$892	$297	1.3
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$1,181	$7	$916	$273	1.3
ALTERNATIVE 1: HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$1,181	$46	$929	$299	1.3
FRFA with Conventional Fishway and Forebay Collector	$1,181	$27	$1,260	-$52	1.0
FRFA with CHTR and Forebay Collector	$1,181	$27	$1,219	-$11	1.0
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$1,181	$27	$1,243	-$35	1.0
ALTERNATIVE 2:					
Low Restoration Scenario	$2,191	$16	$408	$1,799	5.4
High Restoration Scenario	$2,191	$47	$735	$1,503	3.0
ALTERNATIVE 3:					
Low Restoration Scenario	$72	$16	$298	-$210	0.3
High Restoration Scenario	$72	$47	$625	-$507	0.2
ALTERNATIVE 4					
Low Restoration Scenario	$1,324	$55	$1,570	-$191	0.9
High Restoration Scenario	$1,324	$82	$1,814	-$407	0.8
INDIVIDUAL ACTION ELEMENTS					
Aquatic Species Habitat Actions – Low Restoration Only		$16	$229	-$213	0.1
Aquatic Species Habitat Actions – High Restoration Only		$47	$557	-$510	0.1
I-5 Projects and Airport Levee Improvements Only	$2,191	$0	$107	$2,084	20.5
Restorative Flood Protection Only	$1,269	$24	$1,366	-$73	0.9
Flood Retention Facility and Airport Levee Improvements Only					
FRO RCC with CHTR Fish Passage	$1,181	-$16	$327	$839	3.6
FRFA RCC with Conventional Fishway and Forebay Collector	$1,181	-$16	$658	$508	1.8
FRFA RCC with CHTR and Forebay Collector	$1,181	-$16	$617	$548	1.9
FRFA RCC with Conventional Fishway and Fixed Multi-port Outlet	$1,181	-$16	$641	$524	1.8

Climate Change

A climate change analysis was performed for Alternatives 1, 2, and 3. Hydrology data was not provided for Alternative 4; however, Ecosystem Diagnosis & Treatment results were available for all alternatives. The following tables show the results of the climate change analysis for each action alternative; however, only environmental values are shown for Alternative 4. It should be noted that in the climate change analysis, the change in fish population is calculated based on a baseline climate change condition, while the main economic analysis uses a Managed Forest riparian maturation baseline. Further, the environmental impact of Alternatives 1 and 4 are estimated based on one figure, and not a range as was provided in the main economic analysis using current climate conditions.

Table C-6
Climate Change State Perspective

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 1.5% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1: LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$1,317	$17	$601	$733	2.2
FRFA with Conventional Fishway and Forebay Collector	$1,317	$17	$932	$401	1.4
FRFA with CHTR and Forebay Collector	$1,317	$17	$892	$442	1.5
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$1,317	$17	$916	$418	1.5
ALTERNATIVE 1: HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$1,317	$63	$929	$451	1.5
FRFA with Conventional Fishway and Forebay Collector	$1,317	$65	$1,260	$122	1.1
FRFA with CHTR and Forebay Collector	$1,317	$65	$1,219	$162	1.1
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$1,317	$65	$1,243	$138	1.1
ALTERNATIVE 2:					
Low Restoration Scenario	$209	$28	$408	-$171	0.6
High Restoration Scenario	$209	$49	$735	-$477	0.4
ALTERNATIVE 3:					
Low Restoration Scenario	$119	$28	$298	-$151	0.5
High Restoration Scenario	$119	$49	$625	-$457	0.3
ALTERNATIVE 4					
Low Restoration Scenario		$38			
High Restoration Scenario		$99			

Table C-7

Climate Change Basin Perspective

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 1.5% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1: LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$1,288	$17	$601	$704	2.2
FRFA with Conventional Fishway and Forebay Collector	$1,288	$17	$932	$372	1.4
FRFA with CHTR and Forebay Collector	$1,288	$17	$892	$413	1.5
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$1,288	$17	$916	$389	1.4
ALTERNATIVE 1: HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$1,288	$63	$929	$422	1.5
FRFA with Conventional Fishway and Forebay Collector	$1,288	$65	$1,260	$93	1.1
FRFA with CHTR and Forebay Collector	$1,288	$65	$1,219	$134	1.1
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$1,288	$65	$1,243	$110	1.1
ALTERNATIVE 2:					
Low Restoration Scenario	$176	$28	$408	-$204	0.5
High Restoration Scenario	$176	$49	$735	-$511	0.3
ALTERNATIVE 3:					
Low Restoration Scenario	$78	$28	$298	-$192	0.4
High Restoration Scenario	$78	$49	$625	-$498	0.2
ALTERNATIVE 4					
Low Restoration Scenario		$38			
High Restoration Scenario		$99			

Table C-8

Climate Change Federal Perspective

EXPECTED, DEPRECIATED VALUES 100-YEAR NPV 3.125% DISCOUNT RATE ($2016), MILLIONS					
	IMPACTS				
ALTERNATIVE	FLOOD DAMAGE REDUCTION	FISHERY USE VALUE (SALMON)	PROJECT COSTS	NET BENEFIT	BENEFIT/ COST
ALTERNATIVE 1: LOW RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$787	$7	$588	$206	1.4
FRFA with Conventional Fishway and Forebay Collector	$787	$7	$890	-$96	0.9
FRFA with CHTR and Forebay Collector	$787	$7	$846	-$52	0.9
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$787	$7	$887	-$93	0.9
ALTERNATIVE 1: HIGH RESTORATION SCENARIO					
FRO with CHTR Fish Passage	$787	$27	$915	-$102	0.9
FRFA with Conventional Fishway and Forebay Collector	$787	$27	$1,217	-$403	0.7
FRFA with CHTR and Forebay Collector	$787	$27	$1,173	-$359	0.7
FRFA with Conventional Fishway and Fixed Multi-port Outlet	$787	$27	$1,214	-$400	0.7
ALTERNATIVE 2:					
Low Restoration Scenario	$151	$12	$408	-$245	0.4
High Restoration Scenario	$151	$21	$735	-$563	0.2
ALTERNATIVE 3:					
Low Restoration Scenario	$99	$12	$298	-$188	0.4
High Restoration Scenario	$99	$21	$625	-$506	0.2
ALTERNATIVE 4					
Low Restoration Scenario		$16			
High Restoration Scenario		$42			

Appendix D
Economic Development

To be provided in final draft.

Appendix E
Chum Salmon Assumptions

CHUM SALMON ASSUMPTIONS

Introduction

New to the Chehalis Basin Strategy 2016 study is the addition of fall/winter chum salmon population estimates from Ecosystem Diagnosis & Treatment (EDT) modeling. The use-value of these fish are included in the economic analysis. The assumptions are provided in this appendix for review.

Sport and Commercial Fishery

The EDT population estimates (based on habitat capacity) are split into commercial and sport fisheries. Based on currently available data, the commercial value of the tribal fishery is assumed to be included in these estimates. Based on information provided by Washington Department of Fish and Wildlife (WDFW; Ecology 2016) and a 2013 sport catch report (Kraig 2016), the distribution of chum salmon catches is estimated at 70% treaty/non-treaty, 18.5% commercial, 1.5% river sport, and 0.3% Grays Harbor.

Reasonably, some of the chum salmon population would be caught outside of Washington, or even the United States; however, a difference between perspectives was not assumed based on data available. In other words, the Federal and State Perspectives discussed in the report assume the same value of chum salmon. Recall that a Basin-wide economic analysis for fisheries was not included in the 2014 Study (EES and HDR 2014), nor is one completed for the 2016 update. Therefore, it was assumed that the State and Basin-wide Perspectives are the same as well.

Economic Value

The commercial value of chum salmon is estimated based on the revenue per pound from a 2008 WDFW study (TRG 2008). Based on the average chum salmon weight of 10 pounds (WDFW 2016), and an 80% profit assumption (EES and HDR 2014), the commercial value of chum salmon is estimated at $5.35 per fish in 2016 dollars. This value is approximately half of the commercial value of a coho salmon assumed in the 2014 Study.

The sport fishery for chum salmon is valued based on the ratio of commercial value of chum and coho salmon. Chum salmon sport values are for river fishing and are estimated at $73.40 per fish in 2016 dollars (half the value of coho salmon for sport river fishing) and $32.34 per fish for Grays Harbor catches.

References

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