

# Appendix D

## Derivation of Cost Estimates

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This appendix provides a detailed description of the cost estimates developed for the Aquatic Species Restoration Plan (ASRP) Phase 1 document, including restoration, protection, planning, institutional, and community involvement costs. The restoration costs are the largest cost component of the ASRP and have been developed with input and review by the Science and Technical Review Team (SRT). The other costs are preliminary and will be developed in greater detail during Phases 2 and 3 of the ASRP development.

It is important to note that these cost estimates have been prepared using current (2019) dollars and do not account for price inflation. Thus, the cost estimates have also been prepared to be conservative by using a wide cost range, from typically lower unit costs to a higher end of unit costs, in order to avoid underestimation of the total potential capital costs that could occur over 20 years or more. For example, cost savings could be achieved by using volunteer labor for riparian plantings, but these cost estimates currently assume commercial planting contractors would purchase and install all plantings for a more conservative estimate.

## CAPITAL COSTS

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The ASRP will require a large capital investment in the near term to conduct the scale of restoration proposed. The restoration costs that comprise this capital investment are described in the following sections. In addition, there will need to be ongoing monitoring, stewardship, maintenance, and other actions that will continue for the lifetime of the ASRP. Those are described as ongoing biennial costs in the second section of this appendix.

### Restoration Costs

Cost estimates were developed for the restoration components of the ASRP Phase 1 document by obtaining recent bid tabulations and actual costs to construct similar restoration features in Western Washington, and particularly in rural areas and the Chehalis Basin, where available. This information was obtained from the Washington Department of Transportation (WSDOT 2017), summaries of Salmon Recovery Funding Board projects (RCO 2019), current preliminary costs for the Early Action Reaches (Anchor QEA et al. 2019), and bid tabulations from a variety of recent projects where bidding and construction was supported by project team consultants (Anchor QEA 2019; Natural Systems Design 2017). This information was used to build a unit cost table, with ranges from low to high, based on the range of actual bids received and/or reported construction costs for these recent projects. Real estate values were obtained from recent reach-scale valuations prepared for the Early Action Reaches (Forterra 2019). All costs are in 2019 dollars.

Restoration treatment rates (or densities) were developed for three size classes of rivers (large, medium, and small<sup>1</sup>) in coordination with the SRT based on the following:

- Scientific literature regarding the effectiveness of various riparian buffer widths and natural wood loading rates for streams in Western Washington
- GIS analysis of Chehalis Basin characteristics such as valley width, floodplain width, and historical channel migration

The unit costs were then applied based on proposed restoration treatment rates (or densities) per mile for each of the active restoration scenarios that were modeled using the Ecosystem Diagnosis and Treatment (EDT) and National Oceanic and Atmospheric Administration (NOAA) Life-Cycle Models. The active restoration scenarios are shown in Table D-1.

**Table D-1**  
**Miles of Channel Treated for Active Restoration Scenarios**

RESTORATION SCENARIO	LOCATION	LARGE RIVERS (MILES) <sup>1</sup>	MEDIUM RIVERS (MILES)	SMALL STREAMS (MILES)
Scenario 1	Outside Managed Forests	33	93	7
	Inside Managed Forests	10	70	9
Scenario 2	Outside Managed Forests	35	102	37
	Inside Managed Forests	14	103	25
Scenario 3	Outside Managed Forests	58	132	68
	Inside Managed Forests	17	122	52

Note:

1. Number of miles proposed for restoration on large rivers includes “nodes” on the mainstem Chehalis River and South Fork Chehalis River.

Tables D-2, D-3, and D-4 outline the costs for Scenarios 1, 2, and 3 based on the unit costs and treatment rates.

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<sup>1</sup> Large rivers = >30 meters (97 feet) bankfull width (example rivers in this class are the middle and lower Chehalis River and the lower Humptulips River)  
 Medium rivers = >10 to 30 meters (>33 to 97 feet) bankfull width (example rivers in this class include the Skookumchuck and Newaukum rivers)  
 Small streams = 0 to 10 meters (0 to 33 feet) bankfull width (example streams in this class include Porter, Lincoln, and Bunker creeks)

**Table D-2**  
**Cost Summary for ASRP Scenario 1**

RESTORATION ELEMENTS	MILES OF TREATMENT	RIPARIAN/ FLOODPLAIN ACRES	COST RANGE BY ELEMENT		
			LOW	AVERAGE	HIGH
<b>LARGE RIVERS (OUTSIDE MANAGED FORESTS)</b>					
Large Wood	19		\$4,848,800	\$6,300,400	\$7,752,000
Riparian Plantings		1,727	\$11,659,091	\$14,250,000	\$16,840,909
Riparian Easements		1,157	\$4,339,773	\$8,534,886	\$12,730,000
Riparian Acquisition		570	\$3,705,000	\$8,407,500	\$13,110,000
Off-Channel Restoration			\$1,757,500	\$2,802,500	\$3,800,000
Structure Removal/Relocation <sup>1</sup>			\$950,000	\$1,425,000	\$1,900,000
Associated Costs <sup>2</sup>			\$12,994,117	\$22,639,799	\$34,731,974
		<b>Subtotal</b>	<b>\$40,300,000</b>	<b>\$64,400,000</b>	<b>\$90,900,000</b>
<b>LARGE RIVERS (MANAGED FORESTS)</b>					
Large Wood	10		\$2,382,000	\$3,171,000	\$3,960,000
Habitat Protection Acquisition			\$110,000	\$135,000	\$160,000
Associated Costs <sup>2</sup>			\$1,688,802	\$2,744,761	\$4,064,233
		<b>Subtotal</b>	<b>\$4,200,000</b>	<b>\$6,100,000</b>	<b>\$8,200,000</b>
<b>LARGE RIVER NODES</b>					
Excavation	14		\$5,950,000	\$8,225,000	\$10,500,000
Large Wood	14		\$1,890,000	\$2,205,000	\$2,520,000
Riparian Plantings		2,100	\$15,424,500	\$18,931,500	\$22,438,500
Riparian Easements		1,050	\$1,968,750	\$5,578,125	\$9,187,500
Riparian Acquisition		1,050	\$4,856,250	\$13,321,875	\$21,787,500
Associated Costs <sup>2</sup>			\$17,931,843	\$30,709,781	\$46,731,635
		<b>Subtotal</b>	<b>\$48,100,000</b>	<b>\$79,000,000</b>	<b>\$113,200,000</b>
<b>MEDIUM RIVERS (OUTSIDE MANAGED FORESTS)</b>					
Large Wood	93		\$15,977,400	\$21,101,700	\$26,226,000
Riparian Plantings		5,073	\$34,240,909	\$41,850,000	\$49,459,091
Riparian Easements		3,399	\$6,372,614	\$18,055,739	\$29,738,864
Riparian Acquisition		1,674	\$7,742,250	\$21,238,875	\$34,735,500
Off-Channel Restoration			\$10,802,500	\$16,742,500	\$22,450,000
Structure Removal/Relocation <sup>1</sup>			\$4,650,000	\$6,975,000	\$9,300,000
Associated Costs <sup>2</sup>			\$42,128,144	\$75,012,952	\$116,383,380
		<b>Subtotal</b>	<b>\$122,000,000</b>	<b>\$201,000,000</b>	<b>\$288,300,000</b>
<b>MEDIUM RIVERS (MANAGED FORESTS)</b>					
Large Wood	70		\$12,145,000	\$16,047,500	\$19,950,000
Habitat Protection Acquisition			\$770,000	\$945,000	\$1,120,000
Associated Costs <sup>2</sup>			\$8,662,909	\$13,968,968	\$20,584,991
		<b>Subtotal</b>	<b>\$21,600,000</b>	<b>\$31,000,000</b>	<b>\$41,700,000</b>

RESTORATION ELEMENTS	MILES OF TREATMENT	RIPARIAN/ FLOODPLAIN ACRES	COST RANGE BY ELEMENT		
			LOW	AVERAGE	HIGH
<b>SMALL STREAMS (OUTSIDE MANAGED FORESTS)</b>					
Large Wood	7		\$1,243,900	\$1,563,450	\$1,883,000
Riparian Plantings		127	\$859,091	\$1,050,000	\$1,240,909
Riparian Easements		85	\$319,773	\$628,886	\$938,000
Riparian Acquisition		42	\$273,000	\$619,500	\$966,000
Structure Removal/Relocation <sup>1</sup>			\$350,000	\$525,000	\$700,000
Associated Costs <sup>2</sup>			\$1,665,917	\$2,758,750	\$4,122,405
<b>Subtotal</b>			<b>\$4,800,000</b>	<b>\$7,200,000</b>	<b>\$9,900,000</b>
<b>SMALL STREAMS (MANAGED FORESTS)</b>					
Large Wood	9		\$1,936,800	\$2,520,900	\$3,105,000
Habitat Protection Acquisition			\$99,000	\$121,500	\$144,000
Associated Costs <sup>2</sup>			\$1,383,274	\$2,195,776	\$3,204,451
<b>Subtotal</b>			<b>\$3,500,000</b>	<b>\$4,900,000</b>	<b>\$6,500,000</b>
<b>FISH PASSAGE BARRIER REMOVAL/REPLACEMENT<sup>3</sup></b>			<b>\$45,000,000</b>	<b>\$45,000,000</b>	<b>\$45,000,000</b>
<b>GRAND TOTAL (ROUNDED)</b>			<b>\$289,500,000</b>	<b>\$438,600,000</b>	<b>\$603,700,000</b>

Notes:

1. Structure removal/relocation will occur at the rate of one structure removed and one structure relocated per mile of other restoration.
2. Associated costs include standard construction elements such as erosion control, water diversions, mobilization/demobilization, sales tax, permitting, design, construction management, and contingency.
3. Cost for removal/replacement of 200 fish passage barriers is 50% farm/forest roads at \$150,000 each and 50% city/county roads at \$300,000 each.

**Table D-3**  
**Cost Summary for ASRP Scenario 2**

RESTORATION ELEMENTS	MILES OF TREATMENT	RIPARIAN/ FLOODPLAIN ACRES	COST RANGE BY ELEMENT		
			LOW	AVERAGE	HIGH
<b>LARGE RIVERS (OUTSIDE MANAGED FORESTS)</b>					
Large Wood	21		\$5,359,200	\$6,963,600	\$8,568,000
Riparian Plantings		1,909	\$12,886,364	\$15,750,000	\$18,613,636
Riparian Easements		1,279	\$4,796,591	\$9,433,295	\$14,070,000
Riparian Acquisition		630	\$4,095,000	\$9,292,500	\$14,490,000
Off-Channel Restoration			\$1,942,500	\$3,097,500	\$4,200,000
Structure Removal/Relocation <sup>1</sup>			\$1,050,000	\$1,575,000	\$2,100,000
Associated Costs <sup>2</sup>			\$14,361,919	\$25,022,936	\$38,387,971
		<b>Subtotal</b>	<b>\$44,500,000</b>	<b>\$71,200,000</b>	<b>\$100,500,000</b>
<b>LARGE RIVERS (MANAGED FORESTS)</b>					
Large Wood	14		\$3,754,800	\$4,859,400	\$5,964,000
Habitat Protection Acquisition			\$154,000	\$189,000	\$224,000
Associated Costs <sup>2</sup>			\$2,657,248	\$4,200,845	\$6,115,042
		<b>Subtotal</b>	<b>\$6,600,000</b>	<b>\$9,300,000</b>	<b>\$12,400,000</b>
<b>LARGE RIVER NODES</b>					
Excavation	14		\$5,950,000	\$8,225,000	\$10,500,000
Large Wood	14		\$1,890,000	\$2,205,000	\$2,520,000
Riparian Plantings		2,100	\$15,424,500	\$18,931,500	\$22,438,500
Riparian Easements		1,050	\$1,968,750	\$5,578,125	\$9,187,500
Riparian Acquisition		1,050	\$4,856,250	\$13,321,875	\$21,787,500
Associated Costs <sup>2</sup>			\$17,931,843	\$30,709,781	\$46,731,635
		<b>Subtotal</b>	<b>\$48,100,000</b>	<b>\$79,000,000</b>	<b>\$113,200,000</b>
<b>MEDIUM RIVERS (OUTSIDE MANAGED FORESTS)</b>					
Large Wood	102		\$17,523,600	\$23,143,800	\$28,764,000
Riparian Plantings		5,564	\$37,554,545	\$45,900,000	\$54,245,455
Riparian Easements		3,728	\$6,989,318	\$19,803,068	\$32,616,818
Riparian Acquisition		1,836	\$8,491,500	\$23,294,250	\$38,097,000
Off-Channel Restoration			\$12,835,000	\$19,720,000	\$26,350,000
Structure Removal/Relocation <sup>1</sup>			\$5,100,000	\$7,650,000	\$10,200,000
Associated Costs <sup>2</sup>			\$46,893,501	\$83,429,753	\$129,394,748
		<b>Subtotal</b>	<b>\$135,400,000</b>	<b>\$223,000,000</b>	<b>\$319,700,000</b>
<b>MEDIUM RIVERS (MANAGED FORESTS)</b>					
Large Wood	103		\$17,870,500	\$23,612,750	\$29,355,000
Habitat Protection Acquisition			\$1,133,000	\$1,390,500	\$1,648,000
Associated Costs <sup>2</sup>			\$12,746,852	\$20,554,339	\$30,289,344
		<b>Subtotal</b>	<b>\$31,800,000</b>	<b>\$45,600,000</b>	<b>\$61,300,000</b>

RESTORATION ELEMENTS	MILES OF TREATMENT	RIPARIAN/ FLOODPLAIN ACRES	COST RANGE BY ELEMENT		
			LOW	AVERAGE	HIGH
<b>SMALL STREAMS (OUTSIDE MANAGED FORESTS)</b>					
Large Wood	37		\$6,574,900	\$8,263,950	\$9,953,000
Riparian Plantings		673	\$4,540,909	\$5,550,000	\$6,559,091
Riparian Easements		451	\$1,690,227	\$3,324,114	\$4,958,000
Riparian Acquisition		222	\$1,443,000	\$3,274,500	\$5,106,000
Structure Removal/Relocation <sup>1</sup>			\$1,850,000	\$2,775,000	\$3,700,000
Associated Costs <sup>2</sup>			\$8,805,559	\$14,581,964	\$21,789,857
<b>Subtotal</b>			<b>\$25,000,000</b>	<b>\$37,800,000</b>	<b>\$52,100,000</b>
<b>SMALL STREAMS (MANAGED FORESTS)</b>					
Large Wood	25		\$5,380,000	\$7,002,500	\$8,625,000
Habitat Protection Acquisition			\$275,000	\$337,500	\$400,000
Associated Costs <sup>2</sup>			\$3,842,427	\$6,099,377	\$8,901,253
<b>Subtotal</b>			<b>\$9,500,000</b>	<b>\$13,500,000</b>	<b>\$18,000,000</b>
<b>FISH PASSAGE BARRIER REMOVAL/REPLACEMENT<sup>3</sup></b>			<b>\$67,500,000</b>	<b>\$67,500,000</b>	<b>\$67,500,000</b>
<b>GRAND TOTAL (ROUNDED)</b>			<b>\$368,400,000</b>	<b>\$546,900,000</b>	<b>\$744,700,000</b>

Notes:

1. Structure removal/relocation will occur at the rate of one structure removed and one structure relocated per mile of other restoration.
2. Associated costs include standard construction elements such as erosion control, water diversions, mobilization/demobilization, sales tax, permitting, design, construction management, and contingency.
3. Cost for removal/replacement of 300 fish passage barriers is 50% farm/forest roads at \$150,000 each and 50% city/county roads at \$300,000 each.

**Table D-4**  
**Cost Summary for ASRP Scenario 3**

RESTORATION ELEMENTS	MILES OF TREATMENT	RIPARIAN/ FLOODPLAIN ACRES	COST RANGE BY ELEMENT		
			LOW	AVERAGE	HIGH
<b>LARGE RIVERS (OUTSIDE MANAGED FORESTS)</b>					
Large Wood	29		\$7,400,800	\$9,616,400	\$11,832,000
Riparian Plantings		2,636	\$17,795,455	\$21,750,000	\$25,704,545
Riparian Easements		1,766	\$6,623,864	\$13,026,932	\$19,430,000
Riparian Acquisition		870	\$5,655,000	\$12,832,500	\$20,010,000
Off-Channel Restoration			\$2,682,500	\$4,277,500	\$5,800,000
Structure Removal/Relocation <sup>1</sup>			\$1,450,000	\$2,175,000	\$2,900,000
Associated Costs <sup>2</sup>			\$19,833,126	\$34,555,483	\$53,011,960
		<b>Subtotal</b>	<b>\$61,500,000</b>	<b>\$98,300,000</b>	<b>\$138,700,000</b>
<b>LARGE RIVERS (MANAGED FORESTS)</b>					
Large Wood	17		\$4,049,400	\$5,390,700	\$6,732,000
Habitat Protection Acquisition			\$187,000	\$229,500	\$272,000
Associated Costs <sup>2</sup>			\$2,870,964	\$4,666,093	\$6,909,196
		<b>Subtotal</b>	<b>\$7,200,000</b>	<b>\$10,300,000</b>	<b>\$14,000,000</b>
<b>LARGE RIVER NODES</b>					
Excavation	29		\$12,325,000	\$17,037,500	\$21,750,000
Large Wood	29		\$5,220,000	\$6,090,000	\$6,960,000
Riparian Plantings		4,350	\$31,950,750	\$39,215,250	\$46,479,750
Riparian Easements		2,175	\$4,078,125	\$11,554,688	\$19,031,250
Riparian Acquisition		2,175	\$10,059,375	\$27,595,313	\$45,131,250
Associated Costs <sup>2</sup>			\$38,054,691	\$64,911,521	\$98,562,436
		<b>Subtotal</b>	<b>\$101,700,000</b>	<b>\$166,500,000</b>	<b>\$238,000,000</b>
<b>MEDIUM RIVERS (OUTSIDE MANAGED FORESTS)</b>					
Large Wood	132		\$22,677,600	\$29,950,800	\$37,224,000
Riparian Plantings		7,100	\$47,925,000	\$58,575,000	\$69,225,000
Riparian Easements		4,757	\$8,919,375	\$25,271,563	\$41,623,750
Riparian Acquisition		2,343	\$10,836,375	\$29,726,813	\$48,617,250
Off-Channel Restoration			\$15,610,000	\$24,145,000	\$32,350,000
Structure Removal/Relocation <sup>1</sup>			\$6,600,000	\$9,900,000	\$13,200,000
Associated Costs <sup>2</sup>			\$59,585,039	\$106,060,564	\$164,527,524
		<b>Subtotal</b>	<b>\$172,200,000</b>	<b>\$283,700,000</b>	<b>\$406,800,000</b>
<b>MEDIUM RIVERS (MANAGED FORESTS)</b>					
Large Wood	122		\$21,167,000	\$27,968,500	\$34,770,000
Habitat Protection Acquisition			\$1,342,000	\$1,647,000	\$1,952,000
Associated Costs <sup>2</sup>			\$15,098,212	\$24,345,916	\$35,876,699
		<b>Subtotal</b>	<b>\$37,700,000</b>	<b>\$54,000,000</b>	<b>\$72,600,000</b>



RESTORATION ELEMENTS	MILES OF TREATMENT	RIPARIAN/ FLOODPLAIN ACRES	COST RANGE BY ELEMENT		
			LOW	AVERAGE	HIGH
<b>SMALL STREAMS (OUTSIDE MANAGED FORESTS)</b>					
Large Wood	68		\$12,083,600	\$15,187,800	\$18,292,000
Riparian Plantings		1,236	\$8,345,455	\$10,200,000	\$12,054,545
Riparian Easements		828	\$3,106,364	\$6,109,182	\$9,112,000
Riparian Acquisition		408	\$2,652,000	\$6,018,000	\$9,384,000
Structure Removal/Relocation <sup>1</sup>			\$3,400,000	\$5,100,000	\$6,800,000
Associated Costs <sup>2</sup>			\$16,183,190	\$26,799,285	\$40,046,224
<b>Subtotal</b>			<b>\$45,800,000</b>	<b>\$69,500,000</b>	<b>\$95,700,000</b>
<b>SMALL STREAMS (MANAGED FORESTS)</b>					
Large Wood	52		\$11,190,400	\$14,565,200	\$17,940,000
Habitat Protection Acquisition			\$572,000	\$702,000	\$832,000
Associated Costs <sup>2</sup>			\$7,992,249	\$12,686,704	\$18,514,605
<b>Subtotal</b>			<b>\$19,800,000</b>	<b>\$28,000,000</b>	<b>\$37,300,000</b>
<b>FISH PASSAGE BARRIER REMOVAL/REPLACEMENT<sup>3</sup></b>			<b>\$101,250,000</b>	<b>\$101,250,000</b>	<b>\$101,250,000</b>
<b>GRAND TOTAL (ROUNDED)</b>			<b>\$547,150,000</b>	<b>\$811,550,000</b>	<b>\$1,104,350,000</b>

Notes:

1. Structure removal/relocation will occur at the rate of one structure removed and one structure relocated per mile of other restoration.
2. Associated costs include standard construction elements such as erosion control, water diversions, mobilization/demobilization, sales tax, permitting, design, construction management, and contingency.
3. Cost for removal/replacement of 450 fish passage barriers is 50% farm/forest roads at \$150,000 each and 50% city/county roads at \$300,000 each.

## ONGOING BIENNIAL COSTS

### Restoration Costs

#### Monitoring and Adaptive Management

A detailed Monitoring and Adaptive Management (M&AM) Plan will be developed for the final ASRP, but for the ASRP Phase 1 document, the M&AM Team has recommended a range of costs for a comprehensive monitoring program. It is expected that monitoring would likely be more intensive for the first 10 or more years of ASRP implementation, with a reduced frequency of monitoring occurring in later years. However, species population monitoring would continue through the life of the ASRP to document if the anticipated scale of benefits expected are occurring. Depending on the frequency of monitoring, comprehensive programmatic costs could range from \$4 million to \$6 million for the 2021–2023 biennium after construction of the first restoration elements is complete. Costs will be refined for full implementation of the M&AM Plan in the final ASRP.

## Stewardship and Maintenance

It is anticipated that multiple entities would own and manage the easements and lands acquired for the ASRP, including local land trusts, counties, and the state. Ongoing management, stewardship, inspections, and maintenance (i.e., for culverts or bridges) would need to be conducted. This cost will vary depending on the acreage acquired. For this document, the stewardship and maintenance cost has been estimated to include the following elements:

- Invasive plant management (e.g., spot spraying, mowing, and pulling of sparse invasive species) for one-half of the acreage of constructed riparian and floodplain projects at \$300 per acre for the first 3 years following construction; this is estimated to total \$1 million in the first biennium and \$2 million in the second biennium
- Annual inspection of up to 100 replaced culverts or bridges at \$50,000 per year
- Periodic debris removal and minor repairs at an average of 30 culverts or bridges per year (i.e., each would require maintenance on about a 10-year basis); this is estimated to total \$10,000 per culvert or bridge, for \$300,000 per year

## Protection Costs

The protection strategy includes several potential elements that will help protect water quality and quantity, habitats, and watershed processes. Protection could occur via actions such as the transfer of development rights, purchase or transfer of water rights, taxes or other incentives to landowners to provide stewardship of forest and floodplain habitats, or acquisition of easements or lands to protect high-quality habitats and functions. In addition, staff time at basin jurisdictions (cities, counties) may need to be increased to ensure floodplain and critical area requirements are enforced consistent with the ASRP. For this document, \$3 million on a biennial basis is proposed. More details on the costs for this strategy will be developed for the final ASRP.

## Community Planning, Institutional Capacity, and Community Involvement Costs

The community planning, institutional capacity, and community involvement strategies will support the Chehalis Basin communities to ensure consistency with the ASRP through integrating comprehensive plans and ordinances, developing sustainable economic (particularly agricultural and forestry) programs, streamlining state and local permitting, and fostering local organizational capabilities to manage and monitor natural resources consistent with the ASRP. The types of actions and potential costs are shown in Table D-5.

**Table D-5**  
**Preliminary Community Planning, Institutional Capacity, and Community Involvement Costs**

POTENTIAL BASIN-WIDE ACTIONS	EFFORT <sup>1</sup>	BIENNIAL COST
<b>COMMUNITY PLANNING</b>		
Assess consistency of floodplain regulations with ASRP; determine if updates are needed	Half full-time equivalent of staff time per county (2021–2023 biennium only)	\$1,000,000
Assess consistency of critical areas ordinances with ASRP; determine if updates are needed		
Ensure best management practices and performance standards effectively protect species and habitats		
Create sustainable agriculture grant program to facilitate community and cooperative facilities, transportation, and training		\$1,000,000
<b>INSTITUTIONAL CAPACITY AND COMMUNITY INVOLVEMENT</b>		
Develop streamlined permitting process for restoration projects (federal, state, local)	Half full-time equivalent of staff time at U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, NOAA, Washington Department of Fish and Wildlife, Washington Department of Ecology, Washington Department of Natural Resources, and four counties (2021–2023 biennium only)	\$1,000,000
Provide technical training for process-based restoration practices and techniques	Professional training pool for periodic training sessions; two to three per biennium (2021–2023 and 2023–2025 biennia only)	\$150,000
Continuation of ASRP SRT	Outside expert team to review ASRP monitoring results and recommend adaptive management actions (40 hours per year)	\$200,000
Provide restoration staff within the Office of Chehalis Basin or Washington Department of Fish and Wildlife to manage project development and monitoring	Two full-time equivalent of staff time	\$500,000
Provide tax incentives or grants to local jurisdictions to adopt ASRP recommendations		\$250,000
Provide technical assistance for landowners	Restoration professional pool; one full-time equivalent at conservation districts	\$350,000

Note:

1. Level of effort and cost has not yet incorporated local jurisdiction and organization input. This information will be further developed for the final ASRP.

Table D-6 outlines the total biennial cost estimate for this document. More detailed costs will be developed in coordination with local jurisdictions and organizations for the ASRP. Not all these biennial costs would continue for the lifetime of the ASRP; they could be one-time, periodic, or continuing costs.

**Table D-6**  
**Summary of Ongoing Biennial Costs**

STRATEGY	BIENNIAL COST	TIME PERIOD
Restoration Capital Cost <sup>1</sup>	\$30M to \$75M <sup>2</sup>	Estimated at 15 biennia
Restoration (Monitoring)	\$4M to \$6M	Up to 10 years, then reduced over time
Protection	\$3M	For 10 biennia
Community Planning, Institutional Capacity, and Community Involvement	\$4.5M	Up to 4 years, then reduced over time
<b>TOTAL</b>	<b>\$41.5M to \$88.5M</b>	<b>\$34M to \$80M over time</b>

Notes:

1. Cost for implementing restoration scenarios
2. Cost range for average to high scenario costs across 15 biennia

## ASSUMPTIONS FOR RESTORATION COSTS

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Table D-7 provides the detailed unit costs and assumptions for the restoration costs. The unit costs have been informed by the Early Action Reach designs based on the width of riparian and floodplain restoration, types of large wood structures proposed, and the ongoing easement and acquisition process. As the Early Action Reach projects are implemented, additional information on actual costs will be incorporated. It is important to note that price escalation for materials and land is uncertain, so costs may change over time.

**Table D-7**  
**Unit Costs, Relative Costs, and Assumptions Used in Estimates for Restoration Cost Estimates**

ITEM	UNIT COST ITEM	UNIT	UNIT COST RANGE <sup>1</sup>	LOW COST	AVERAGE COST	HIGH COST	NOTES <sup>2,3</sup>
1.01	Earthwork – Excavation	Cubic Yard	\$17 to \$30	\$17	\$24	\$30	Assumes off-site haul and disposal of all material (less than 5 miles). Unit cost includes clearing and grubbing within excavation. To be used as minor component of large wood placement or major component of off-channel and wetland reconnection and restoration.
1.02	Earthwork – Placement	Cubic Yard	\$26 to \$50	\$26	\$38	\$50	Unit cost includes import of select material, such as clean gravel and cobbles, from off-site source. Included with off-channel and floodplain restoration.
2.01	ELJs (Large Rivers, Mainstem Chehalis River Nodes Only)	Each	\$60,000 to \$80,000	\$60,000	\$70,000	\$80,000	Assumes typical construction of a 50-foot-wide by 50-foot-long, eight-layer (15-foot-tall), gravity or pile-supported ELJ. Typical LWM specification; 30 18- to 24-inch DBH at 30 to 50 feet long (key pieces), plus pilings and slash of various lengths. Typical placement is 3 per mile, located with floodplain and off-channel restoration at nodes.
2.02	ELJs (Large Rivers, Wynoochee, Satsop)	Each	\$30,000 to \$50,000	\$30,000	\$40,000	\$50,000	Assumes typical construction of a 50-foot-wide by 50-foot-long, three-layer (10-foot-tall), pile-supported ELJ. Typical LWM specification; 15- to 24-inch DBH at 30 to 50 feet long (key pieces), 15 key pieces, plus pilings and slash of various lengths. Typical placement rate is 6 per mile or located individually with floodplain and off-channel restoration at nodes.
2.03	ELJs (Medium Rivers)	Each	\$25,000 to \$45,000	\$25,000	\$35,000	\$45,000	Assumes typical construction of a 40-foot-wide by 40-foot-long, 10-foot-tall gravity ELJ. Typical LWM specification; 18-inch DBH at 30 to 40 feet long (key pieces), 15 key pieces, plus pilings and slash of various lengths. Typical placement rate is 4 per mile or located individually with floodplain and off-channel restoration.
2.04	Large Wood Multikey Piece Structures (Medium Rivers)	Each	\$6,500 to \$9,000	\$6,500	\$7,750	\$9,000	Assembly of average 5 key large wood pieces, plus 3 logs of varying lengths with ballast or pile supports. Typical key piece; 18- to 24-inch DBH 25-foot-long rootwad logs. Typical placement rate is 10 per mile.
2.05	Large Wood Multikey Piece Structures (Small Streams)	Each	\$4,500 to \$6,000	\$4,500	\$5,250	\$6,000	Assembly of average 3 key LWM pieces plus 3 logs of varying lengths with boulder ballast for habitat and/or sediment and smaller wood retention. Typical key piece; 12- to 18-inch DBH 25-foot-long rootwad logs. Typical placement rate is 22 per mile.
2.06	Beaver Dam Analogs (Small Streams and Medium Rivers)	Each	\$10,000 to \$20,000	\$10,000	\$15,000	\$20,000	Hand or small equipment placement of poles across channel with weaving of willow or cottonwood branches amongst poles. Typical placement rate is 2 per mile outside managed forests and 6 per mile inside managed forests.
2.07	Large Wood Key Pieces – Single Logs (Small Streams)	Each	\$500 to \$800	\$500	\$650	\$800	Assumes placement and limited to no burial of 14- to 18-inch DBH 25-foot-long rootwad logs. No soil anchors or ballast blocks. Typical placement rate is 75 to 80 per mile.
3.01	Riparian Plantings	Acre	\$8,500 to \$12,500	\$8,500	\$10,500	\$12,500	For areas with limited to no existing riparian trees. Cost assumes 6-foot on-center plant spacing and includes invasive species management (mowing, spraying, and/or disking). Low estimate assumes common plant types and easy site access. High estimate assumes a wider variety of plant types (higher cost) and more difficult site access. Cost includes temporary soil stabilization measures such as mulch and seeding.
3.02	Supplemental Riparian Plantings	Acre	\$5,000 to \$7,000	\$5,000	\$6,000	\$7,000	Assumed to be required in areas of existing deciduous riparian vegetation. Cost assumes 16-foot on-center plant spacing and includes invasive species management. Low estimate assumes common plant types, easy site access, and limited clearing of existing vegetation. High estimate assumes a wider variety of plant types, more difficult site access, and clearing of existing vegetation.
3.03	Wetland Plantings	Acre	\$10,000 to \$18,000	\$10,000	\$14,000	\$18,000	Adding native herbaceous seed plus shrubs and trees to wetland areas. Cost assumes 8-foot on-center woody plant spacing and includes pre-year of invasive species management before planting (i.e., mowing/spraying) plus 1 year post-construction invasive species management. Low estimate assumes common plant types and easy site access; high estimate assumes more diverse plant species, more difficult site access, and supplemental plantings 1 year after construction.
4.00	Restore Floodplain/Channel Nodes (Mainstem Chehalis River and South Fork Chehalis River Only)	Each	\$2,400,000 to \$5,700,000	\$2,400,000	\$4,300,000	\$5,700,000	Large site nodes of restoration, such as at tributary confluences or areas of existing oxbows/channels. Includes installment of three ELJs (large rivers); excavation of channel connections totaling 1,000 linear feet, average 5-foot depth with 20-foot bottom width and 3:1 side slopes (average of 15,000 cubic yards); other bench excavation (10,000 cubic yards); riparian plantings on 100 acres; supplemental riparian plantings on 50 acres; acquisition of 150 acres with due diligence.

ITEM	UNIT COST ITEM	UNIT	UNIT COST RANGE <sup>1</sup>	LOW COST	AVERAGE COST	HIGH COST	NOTES <sup>2,3</sup>
4.01	Reconnect Side Channels or Oxbows	Each	\$140,000 to \$330,000	\$140,000	\$235,000	\$330,000	Where opportunity exists and when needed for connectivity. Includes excavation for connection; assumes 500 linear feet of excavation, average 4-foot depth, with 10-foot bottom width and 3:1 side slopes (average of 1,500 cubic yards per site); placement of 200 cubic yards of gravel/cobble; placement of 30 single logs per site. No additional easements or acquisition within treated reaches.
4.02	Reconnect Floodplain Wetlands	Each	\$45,000 to \$70,000	\$45,000	\$60,000	\$70,000	Where opportunity exists and when needed for connectivity. Includes excavation for connection; assumes 500 linear feet of excavation, average 4-foot-depth swale, 10 feet wide, and 4:1 slopes (2,000 cubic yards per site); placement of 10 single logs per site; wetland plantings on 5 acres. No additional easements or acquisition within treated reaches.
4.03	Create Depressional Wetlands	Each	\$120,000 to \$210,000	\$120,000	\$165,000	\$210,000	For non-salmon species. Assumes creation of seasonally ponded depressional wetlands (open water and emergent) within riparian buffer areas. Includes excavation; assume 2 acres of excavation, average 2-foot depth (6,400 cubic yards per site); wetland plantings on 1 acre. No additional easements or acquisition.
4.04	Invasive Species Removal in Glacial Outwash Lakes	Each	\$200,000 to \$350,000	\$200,000	\$275,000	\$350,000	Intensive removal of invasive fish and amphibians (netting, traps, etc.) for up to 3 years.
5.01	Land Acquisition – Easement	Acre	\$1,250 to \$8,000	\$1,250	\$4,625	\$8,000	Assumes only an easement is purchased but 50% of land value.
5.02	Due Diligence for Land Acquisition – Easement	Each	\$25,000 to \$30,000	\$25,000	\$27,500	\$30,000	Assumed to be required at a rate of 1 per 40 acres of easement area purchased (or per 5 miles treated in managed forest). Includes appraisals, surveys, and recording fees.
5.03	Land Acquisition – Purchase	Acre	\$4,000 to \$20,000	\$4,000	\$12,000	\$20,000	Higher cost for residential or urban floodplain areas or for projects that will relocate/remove structures. Assumes entire parcel(s) is purchased. Only includes land and improvements cost; see due diligence costs. High end assumes improvements are present; low end assumes no improvements but zoned for development.
5.04	Due Diligence for Land Acquisition – Purchase	Each	\$25,000 to \$30,000	\$25,000	\$27,500	\$30,000	Assumed to be required for each parcel individually identified for purchase in the project area, or where no individual parcel was identified, it was assumed to be required at a rate of 1 per 40 acres of land area purchased. Includes appraisals, surveys, and recording fees.
6.01	Road or Infrastructure Removal	Square Yard	\$30 to \$70	\$30	\$50	\$70	Assumes demolition and off-site haul of asphalt, concrete, and piping and regrading, mulch, seed, and replanting. Low end represents removal of a paved road (~24 feet in width and excavation thickness of 4 feet); high end represents removal of buried pipelines and replacement/regrading of material.
6.02	Structure Demolition and Removal	Each	\$10,000 to \$25,000	\$10,000	\$17,500	\$25,000	Assumes demolition and off-site haul of structures and foundations within the project area or on purchased lands. High range represents a large farm; low end represents a single-family home. Removals are as individually identified for specific projects.
6.03	Structure Relocation	Each	\$50,000 to \$80,000	\$50,000	\$65,000	\$80,000	Assumes relocation of an existing structure (typically a large house) to a location outside the project area. Also includes removal of foundation at existing location. Relocations are as individually identified for specific projects.
7.01	Culvert Replacements	Each	\$300,000		\$300,000		Average from recent search of Salmon Recovery Funding Board-funded projects
ITEM	RELATIVE COST ITEMS	UNIT	RELATIVE COSTS <sup>2</sup>	LOW COST	AVERAGE COST	HIGH COST	NOTES
8.01	Temporary Erosion and Sediment Control – Plan and Measures	Lump Sum	1.5% to 2.5%	1.5%	2%	3%	Assumes site surface erosion and sedimentation control measures are permit requirements for all projects, including riparian and floodplain only projects. Includes development and approval of a Temporary Erosion And Sediment Control Plan. Taken only as a percentage of the work items; excludes property acquisition costs.
8.02	Care of Water – Diversion, Isolation, and Dewatering	Lump Sum	4% to 6%	4.0%	5.0%	6.0%	Assumes diversion of water and site isolation from the main channel is required. Assumes dewatering of excavations below the groundwater level during construction. Includes development and approval of a care of water plan. High estimate assumes high groundwater levels relative to excavation grades. Taken only as a percentage of the work items requiring excavation below the groundwater level; excludes property acquisition and planting costs.
8.03	Mobilization and Demobilization	Lump Sum	5% to 10%	5%	8%	10%	Assumes a regionally based contractor. Low estimate assumes minimal site access improvements and close proximity to an improved road. High estimate assumes major site access improvements and a more remote location. Taken only as a percentage of the work items; excludes property acquisition costs.
9.01	Lewis County Sales Tax	Lump Sum	7.80%		7.8%		Sales tax is for unincorporated areas. Applies to pre-tax project subtotal.
9.02	Grays Harbor County Sales Tax	Lump Sum	8.50%		8.5%		Sales tax is for unincorporated areas; the tax rate in Aberdeen is 8.63%. Applies to pre-tax project subtotal.
9.03	Thurston County Sales Tax	Lump Sum	7.90%		7.9%		Sales tax is for unincorporated areas. Applies to pre-tax project subtotal.

ITEM	UNIT COST ITEM	UNIT	UNIT COST RANGE <sup>1</sup>	LOW COST	AVERAGE COST	HIGH COST	NOTES <sup>2,3</sup>
9.04	Mason County Sales Tax	Lump Sum	8.50%		8.5%		Sales tax is for unincorporated areas. Applies to pre-tax project subtotal.
9.05	Pacific County Sales Tax	Lump Sum	7.80%		7.8%		Sales tax is for all areas. Applies to pre-tax project subtotal.
9.06	Cowlitz County Sales Tax	Lump Sum	7.70%		7.7%		Sales tax is for unincorporated areas. Applies to pre-tax project subtotal.
10.01	Permitting and Administration	Lump Sum	8% to 12%	8%	10%	12%	Applies to all projects. Does not account for very complicated cultural resources issues, but standard restoration site permitting. Does not apply to property acquisition costs or construction site preparation/plan costs.
10.02	Design and Engineering	Lump Sum	15% to 20%	15%	18%	20%	Applies to side channel development, floodplain reconnection, and LWM/ELJ projects. Assume 10% to 15% for design, 5% engineering during construction. Does not apply to planting, property acquisition, and construction site preparation/plan costs.
10.03	Contingencies	Lump Sum	25% to 35%	25%	30%	35%	Contingencies account for uncertainty in project scope, site conditions, material costs, and labor and equipment rates as no specific projects currently identified. Applies to pre-tax project subtotal.

Notes:

1. Unit cost ranges where shown represent variability in material costs, labor, land, and other values.
2. Relative costs are a percent of the project subtotals as specified in the notes.
3. ELJ and LWM placement rates are based on 75th percentile in Fox and Bolton (2007).

DBH: diameter at breast height

ELJ: engineered logjam

LWM: large woody material

## Restoration Treatment Rate Assumptions

### Installation of Large Wood

The treatment rate was based on the SRT recommendation and typical current standard practice in Western Washington to use the 75th percentile key piece loading rate from the Fox and Bolton (2007) research on natural wood loading in Washington State (Table D-8).

**Table D-8**  
**Proposed Wood Loading Rate**

RIVER SIZE CLASS (BANKFULL WIDTH)	FOX AND BOLTON (2007)- RECOMMENDED 75TH PERCENTILE LOADING RATE FOR KEY PIECES	PROPOSED INSTALLATION FOR COST BASIS
<b>OUTSIDE MANAGED FORESTS</b>		
Large Rivers	Greater than 64 per mile	3 to 6 ELJ per mile with 15 to 30+ key pieces each
Large River Nodes	Greater than 64 per mile	3 ELJs per node of 1 mile with 20 to 30+ key pieces each
Medium Rivers	Greater than 64 per mile	4 ELJ per mile with 15+ key pieces each and 10 multikey piece structures with 5 key pieces each
Small Streams	Greater than 176 per mile	22 multikey piece structures with 3 key pieces each, 2 beaver dam analogs, and 80 single log key pieces
<b>INSIDE MANAGED FORESTS</b>		
Large Rivers	Greater than 64 per mile	6 ELJs per mile with 15 to 30+ key pieces each
Medium Rivers	Greater than 64 per mile	12 multikey piece structures with 5 to 6 key pieces each
Small Streams	Greater than 176 per mile	22 multikey piece structures with 3 key pieces each, 6 beaver dam analogs, and 75 single log key pieces

Notes:

Key pieces are defined as having the following minimum size:

1. Large rivers – Logs of 18- to 24-inch DBH with rootwad and length of 30 to 40 feet
2. Medium rivers – Logs of 18-inch DBH with rootwad and length of 30 to 40 feet
3. Small streams – Logs of 12- to 18-inch DBH and length of 25 to 30 feet, with or without rootwad

ELJ: engineered logjam

### Riparian Buffer Restoration

Literature on recommended riparian buffer widths is typically based on the width that is necessary to provide a variety of functions including erosion protection, water quality, large wood recruitment, and habitat for wildlife. Literature recommendations include the following:

- 250-foot riparian width on each side of a river/stream is equivalent to the maximum site potential tree height of Douglas-fir (FEMAT 1993; Knutson and Naef 1997; Fischer and Fischenich 2000) and is commonly used for riparian buffer width recommendations.
- Hawes and Smith (2005) indicated buffer widths of up to 330 feet (each bank) could be necessary to fully provide pollutant removal, litter/debris inputs, and wildlife habitat (i.e., for mammals and songbirds).



- Wenger (1999) indicated that many functions could be achieved with buffers up to 100 feet in width; however, buffer widths from 220 to 574 feet would provide effective wildlife habitat, and widths up to 328 feet could be required for effective sediment control.
- Fischer and Fischenich (2000) indicated that most functions could be provided with buffer widths of 100 to 200 feet, but effective wildlife habitat could require buffer widths up to 1,640 feet.
- The Forest Practices Act requires a 200-foot buffer on each bank as measured from the bankfull channel edge or edge of the channel migration zone (Washington Administrative Code 220-30-021).

For the estimates in the ASRP Phase 1 document, the proposed width of riparian restoration was scaled based on river size classes, with consideration of historical channel migration, valley width, and provision of riparian functions. The width of riparian/floodplain restoration is informed by the width of riparian restoration proposed for the Early Action Reach designs and SRT recommendations—a riparian buffer width of 500 feet on each bank for large rivers, 300 feet for medium rivers, and 100 feet for small streams. It is not anticipated that the entire buffer can be restored due to infrastructure and other structures; it is assumed that 75% of this area would be treated. In practice, project implementation will not rely on meeting the minimum buffer widths that were used for costing and would instead vary depending on ecological, infrastructure, and/or landowner needs. Assumptions included the following:

- Historical migration width information (since 1938) is currently available for the mainstem Chehalis River. Median migration width from GIS analysis (comparison of 1938 to 2013 channel locations) is 356 feet (total width, 178 feet on each bank) or the 75th percentile channel migration width of 446 feet (total width, 223 feet on each bank). Adding a 200-foot buffer from this width of likely channel migration yields potential buffer widths of 378 feet or 423 feet, respectively. For the purposes of being conservative in the cost estimating, a width of 500 feet on each bank was used for the large river category.
- It is assumed that channel migration width and valley widths are proportionally narrower for medium rivers and small streams. This width was also informed by the actual widths of riparian restoration proposed for the predominantly medium river size category in the Early Action Reaches.

## **Floodplain Off-Channel Restoration**

### **Reconnect Side Channels or Oxbows (Active Connection)**

To account for the potential need for excavation to reconnect side channels or oxbows in multiple areas of the basin, the reconnection of one existing (but disconnected) side channel or oxbow per 2 miles was included in the cost estimates. Assumptions included the following:

- It is assumed that these sites are located within areas otherwise proposed for riparian restoration, so no additional acquisition is required.
- Reconnection would only be provided for sites that would likely remain disconnected until a greater than 5-year event after implementing other wood and riparian actions.
- It is assumed that placement of large wood and riparian actions will promote the formation of additional side channel habitats over time.

### **Reconnect Floodplain Wetlands**

Similar to the potential need to excavate to reconnect side channels and oxbows, there may be opportunities to reconnect floodplain wetlands. Thus, one floodplain wetland reconnection per 2 miles of other restoration elements has been included in the cost estimates. Assumptions included the following:

- It is assumed that these sites are located within other areas proposed for riparian restoration, so no additional acquisition is required.
- Annual connections are not anticipated, but 2-year or 5-year connectivity would likely be provided.

### **Create Depressional Wetlands**

The SRT recommended creating 10 depressional wetlands initially and monitoring for effectiveness at sustaining amphibian populations. Assumptions included the following:

- No additional acquisition would take place; the creation of depressional wetlands would occur within the riparian buffer.

### **Remove Invasive Species from Glacial Outwash Lakes**

The SRT recommended selecting five lakes for the initial removal of invasive fish and amphibian species and monitoring for effectiveness at sustaining native fish and amphibian populations. Assumptions included the following:

- No additional acquisition would take place.

### **Fish Passage Barrier Removal/Culvert or Bridge Replacement**

All fish passage barriers that are less than 100% passable within the geospatial units (GSUs) included in each scenario would be removed or replaced. Additional fish passage barriers from GSUs that provide the most benefit to coho salmon and/or steelhead would also be removed. A total of 200, 300, and 450 fish passage barriers are proposed for removal in Scenarios 1, 2, and 3, respectively.

### **Land Acquisition/Easements**

Acquisitions and easements apply to the riparian restoration and floodplain restoration actions (other acquisition assumptions are included in the protection strategy costs). Assumptions relative to restoration acquisitions and easements included the following:

- It is assumed that 33% of the riparian buffer area will require acquisition and 67% of the riparian buffer area will require easements. This is a very conservative estimate, as not all areas of riparian restoration will require a real estate transaction.
- For the nodes on large rivers, 50% of the riparian/floodplain area will require acquisition and 50% of the riparian/floodplain area will require easements. A total of 150 acres per node site is assumed.

## Structure Removal/Relocation

Structure removal and/or relocation could be required within restoration areas or purchased lands.

Assumptions included the following:

- There will be one removal and one relocation per 1 mile of other treatments.
- It is assumed that 5,000 square yards of road or utility removal would be included per 10 miles of other treatments.

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