CHAPTER FOUR
ALTERNATIVES

*4. ALTERNATIVES

4.1. Formulation and Screening of Alternatives

No updating of the existing information in this section was necessary for the Final SEIS (see the Final IFR/EIS, August 1999).

4.2. No Action Alternative

No updating of the existing information in this section was necessary for the Final SEIS (see the Final IFR/EIS, August 1999).

4.3. revised Non-Structural Alternative

For the Final SEIS, updated information has been added to this section concerning LoadMax. An analysis for the theoretical maximum potential benefits of LoadMax was included in the 1999 Final IFR/EIS. Since the 1999 analysis, the computer models providing LoadMax forecasts have been substantially updated, although there was not a significant change in the accuracy of the forecast. Accordingly, at this time, it is clear that the maximum potential benefits of LoadMax improvements would be essentially zero.

The National Weather Service's Northwest River Forecast Center provides the basic data for LoadMax. The center provides a forecast of river stages to the Port of Portland once a day. In addition to the six gauge points previously noted in the 1999 Final IFR/EIS, there are now gauge points at Portland Harbor, Kelso and Woodland. The center's models have been updated and now include four river systems (Willamette, Columbia, Lewis and Cowlitz). The center is now sharing modeling systems with the Corps, and has improved the hydraulic model with additional cross sections and more refined roughness factors. The center utilizes the Corps' quarterly information on channel bottom profiles to forecast water surface elevations. Therefore, improvements to LoadMax were evaluated and implemented; even with all of these improvements, there has been no significant change in the accuracy of the LoadMax forecast. Also, since these improvements were found to have no monetary benefit, they are not included in the benefit-to-cost analysis. The Technical Review Panel convened by the Corps to review benefit and cost projections concurred with the conclusion that no further benefits are likely to be obtained from further refinements to the LoadMax system (Casavant et al. 2002). This analysis, therefore, confirms the decision in the 1999 Final IFR/EIS to not carry forward the non-structural alternative for further detailed analysis.

4.4. revised Structural Alternatives

4.4.1. Regional Port Alternatives

No updating of the existing information in this subsection was necessary for the Final SEIS (see the Final IFR/EIS, August 1999).

4.4.2. Channel Deepening Alternatives

No updating of the existing information in this subsection was necessary for the Final SEIS (see the Final IFR/EIS, August 1999).

4.4.3. revised Disposal Alternatives

No updating of the existing information in Subsections 4.4.3.1 to 4.4.3.9 was necessary for the Final SEIS (see the Final IFR/EIS, August 1999). However, Subsection 4.4.3.10 has been added to provide updated information on the disposal plan modifications.

4.4.3.10. new Disposal Plan Modifications Following Consultation

This subsection addresses disposal plan modifications resulting from the ESA consultation process and using updated 2001-2002 hydrographic survey data. The construction dredging volume has been reduced from 18.4 million cubic yards (mcy) to 14.5 mcy for the 43-foot channel improvement project. The rock removal volume was reduced from 590,000 to 490,500 cubic yards. Of this amount, blasting is needed to remove about 50,500 cubic yards of rock at Warrior Rock near St. Helens; the remaining 440,000 cubic yards of loose rock at Longview, Vancouver Bar, and Vancouver turning basin will be removed by mechanical dredge. The maintenance dredging volumes in the 1999 Final IFR/EIS have not changed.

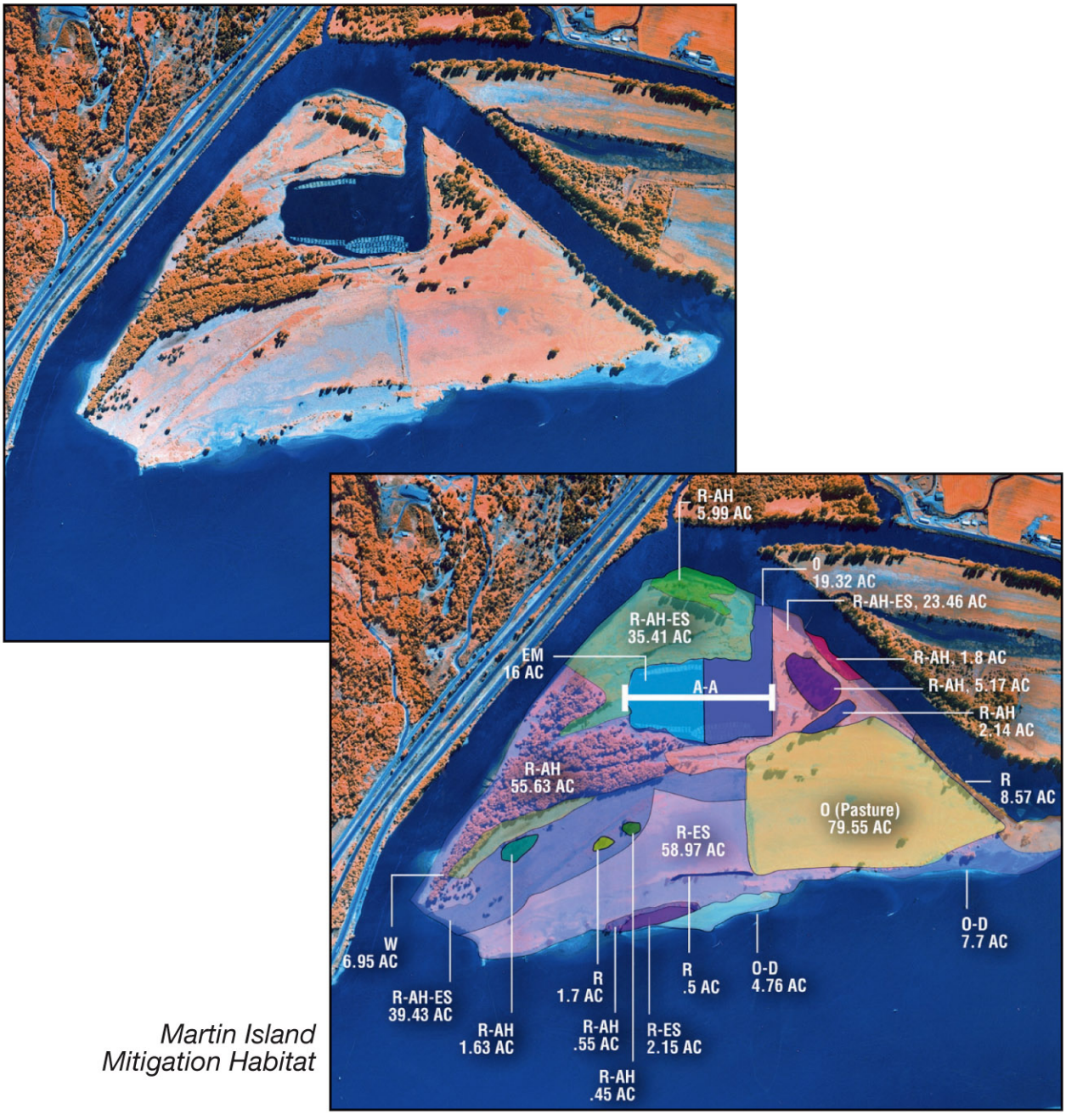
The disposal plan changes result from new information regarding volumes to be dredged, changed plans for the use of previously identified sites, and the addition of new ecosystem restoration features that involve beneficial use of dredged material. The following changes to project impacts have occurred:

- Reduction in impact to riparian forest from 67 acres to 50 acres (approximately 25%) due to reduced disposal site acreage at Lord Island (O-63.5).
- Reduction in impact to agricultural lands from 200 acres to 172 acres (approximately 14%) primarily due to reduced disposal site acreage required at Gateway (W-101) and Mt. Solo (W-62).
- Reduction in impact to wetlands from 20 acres to 16 acres (approximately 20%) due to a reduction at the Mt. Solo site resulting from correcting a mapping inconsistency.
- The Martin Island embayment wetland mitigation site was reduced from 32 acres to 16 acres in order to comply with the Cowlitz County Shoreline Master Plan provisions regarding recreational use and to respond to public comments received (Figure S4-1).

Table S4-1 provides revised information on all disposal sites as modified following consultation, including information on prior disposal history, anticipated timing of usage during construction and the first 20 years of maintenance, site acreage, site capacity, anticipated disposal volume, and final height. In addition, due primarily to the beneficial use of dredged materials at the Lois Island embayment and Miller-Pillar ecosystem restoration features under the preferred option discussed in this Final SEIS, it is projected that use of the Deep Water Site will not be necessary for construction and should not be necessary for the first 20 years of maintenance of the channel improvement project.

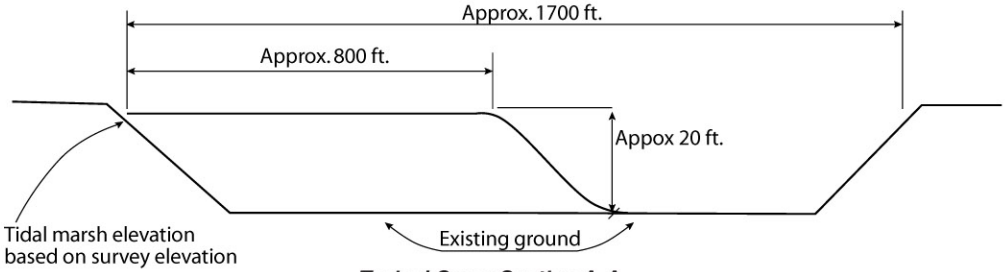
Figure S4-1. Martin Island Embayment Wetland Mitigation Plan (revised)

Martin Island



Martin Island Mitigation Habitat

Martin Island Embayment Marsh Development



Typical Cross Section A-A
Not to Scale

Figure S4-1 Martin Island Embayment Wetland Mitigation Plan (Revised)

Table S4-1. Proposed Disposal Plan Including Beneficial Use Sites, Ecosystem Restoration and Wildlife Mitigation (Martin Island Embayment)

Disposal Site *	Disposal History**	Location/Name	Site Acres (rounded)	Site Capacity (cu yds)	Construction Disposal Volume Rounded (cu yds)	O&M Use for 20-year Term	43-foot O&M Disposal Volume Rounded (cu yds)	Total Disposal Volume Rounded (Construction and O&M)[a]	Final Height for Total Volume Placed (feet CRD)
In-water	DMMS	CRM 3-106 - 50'-65' deep, in or adjacent to channel***	NA	NA	2,000,000	20	26,000,000	28,000,000	NA
O-105.0	DMMS	West Hayden Island	102	5,750,000	600,000	20	3,900,000	4,500,000	60
W-101.0	New	Gateway	40	2,300,000	587,000	20	1,600,000	2,300,000	65
W-97.1	DMMS	Fazio Sand & Gravel	27	650,000	112,000	20	1,000,000	1,200,000	Varies due to resale
W-96.9	New	Adjacent to Fazio	17	475,000	0	6-20	As needed	Varies	Varies due to resale
O-91.5	New	Lonestar	45	5,350,000	900,000	20	3,200,000	4,400,000	NA; gravel pit
O-87.8	New	RR Corridor	12	540,000	300,000	20	0	400,000	46
W-86.5	Used	Austin Point	26	1,645,000	136,000	20	1,500,000	1,700,000	Varies due to resale
O-86.2	Used	Sand Island	28	1,250,000	150,000	20	860,000	1,000,000	Shoreline; varies due to erosion
O-82.6	Used	Reichold	49	1,285,000	320,000	20	2,300,000	2,600,000	Varies due to resale
W-82.0	Used	Martin Bar	32	1,500,000	46,000	20	700,000	760,000	51
W-80.0	New Mitigation Site	Martin Is. Mitigation	16	550,000	370,000	Not used	0	460,000	-8
O-77.0	Used	Lower Deer Island	29	1,498,000	440,000	20	700,000	1,200,000	44
O-75.8	DMMS	Sandy Island	30	1,100,000	120,000	20	860,000	1,000,000	42
W-71.9	Used	Northport	27	900,000	189,000	20	1,800,000	1,900,000	Varies due to resale
W-70.1	Used	Cottonwood Is.	62	3,200,000	240,000	20	1,300,000	1,500,000	49
W-68.7	DMMS	Howard Island	200	6,400,000	0	20	600,000	600,000	29
O-67.0	Used	Rainier Beach	52	1,095,000	450,000	20	2,400,000	3,000,000	65
W-67.5	Used	International Paper	29	1,000,000	140,000	20	2,700,000	2,900,000	Varies due to resale
O-64.8	DMMS	Rainier Industrial	53	2,235,000	270,000	20	2,400,000	2,700,000	64
O-63.5	DMMS	Lord Island Upstream	25	1,255,000	0	20	600,000	600,000	63
W-63.5	Used	Reynolds Aluminum	13	500,000	180,000	20	0	200,000	Varies due to resale
W-62.0	New	Mt. Solo	47	2,500,000	300,000	20	2,100,000	2,400,000	49
W-59.7	DMMS	Hump Island	69	1,500,000	400,000	6	900,000	1,500,000	42
O-57.0	DMMS	Crims Island	46	1,600,000	30,000	20	1,100,000	1,200,000	40

Disposal Site *	Disposal History**	Location/Name	Site Acres (rounded)	Site Capacity (cu yds)	Construction Disposal Volume Rounded (cu yds)	O&M Use for 20-year Term	43-foot O&M Disposal Volume Rounded (cu yds)	Total Disposal Volume Rounded (Construction and O&M)[a]	Final Height for Total Volume Placed (feet CRD)
O-54.0	Used	Port Westward	50	1,875,000	150,000	20	1,500,000	1,700,000	46
W-46.3/ 46.0	DMMS	Brown Island	72	4,700,000	1,200,000	20	3,400,000	4,700,000	66
W-44.0	New	Puget Is. (Vik Prop.)	100	3,500,000	500,000	20	2,700,000	3,300,000	41
O-42.9	DMMS	James River	53	1,280,000	240,000	20	830,000	1,070,000	39
O-38.3	DMMS	Tenasillahe Island	42	2,300,000	0	10	2,300,000	2,300,000	60
O-34.0	DMMS	Welch Island	42	446,000	0	3 (18-20)	400,000	400,000	25
W-33.4	Used	Skamokawa	11	250,000	0	As needed	varies	varies	Shoreline; varies due to erosion and resale
O-27.2	DMMS	Pillar Rock Island	56	2,555,000	0	20	1,000,000	1,000,000	34
	New Restoration	Miller-Pillar Ecosystem Restoration Feature	235	5,500,000	0	15	5,500,000	5,500,000	Surveyed reference (tidal marsh & intertidal flat) elev.
O-23.5	DMMS	Miller Sands	151	NA	0	20	7,000,000	7,000,000	Shoreline; varies due to erosion
W-21.0	DMMS	Rice Island	228	5,500,000	0	20	5,500,000	5,500,000	53
	New Restoration	Lois Island Embayment Ecosystem Restoration Feature	191	6,200,000	4,000,000	20	2,000,000	6,000,000	Surveyed reference (tidal marsh) elev.
Shallow Water Site	Used	Ocean	580	NA	MCR O&M(1)	20	0	0	NA
Deep Water Site	New	Ocean	8,980	225,000,000	0	20	0	0	NA

(1) Between 2.0-2.5 mcy per year in Site E and North Jetty Site per year.
(2) Construction plus 20 years channel project only; additional material from MCR operations and maintenance (O&M) as needed. 50-year volume 37 mcy.
* "W" and "O" refer to the Washington or Oregon shoreline. The number refers to the approximate river mile on the navigation channel.
** DMMS = site is in the No Action Alternative (existing 40-foot channel maintenance)
New = site is new for this study
Used = site previously used by Corps for disposal
*** Disposal would occur in depths over 65 feet at CRMs 5, 29-35, 36.5-37.5, 39-40, 54-56.3, and 72.2 - 73.2
a - Total includes 40-foot O&M volume that is included in material dredged with 43-foot construction material.

Joint USEPA and Corps guidance for designation of ocean dredged material disposal sites was published in 1984. It provides procedures for the identification, evaluation, and selection for final designation of the ocean disposal sites. A management plan that includes monitoring is mandatory. The USEPA and Corps followed the procedures and conducted/reviewed studies with information on living resources, physical processes, geology, sediment quality, water quality, cultural resources, and recreation. In total, 143 separate studies are found in Appendix H of the 1999 Final IFR/EIS.

The USEPA is responsible for designation and administration of ocean disposal sites under the Marine Protection, Research, and Sanctuaries Act of 1972, as amended. The Corps is the primary user of those sites. The Corps and USEPA cooperated throughout the IFR/EIS study process leading to identification of the Shallow Water and Deep Water Sites as candidates for formal designation by USEPA in the 1999 Final IFR/EIS. The USEPA is a cooperating agency on the 1999 Final IFR/EIS and this Final SEIS, and intends to adopt the pertinent portions of these documents.

Additional environmental information (e.g., baseline characterizations) has been collected by the Corps and USEPA and included in Exhibit N of the Final SEIS. In addition, the Final SEIS discusses new channel improvement project alternatives, such as the identification and evaluation of ecosystem restoration elements as the preferred disposal alternative for river material that was identified in the 1999 Final IFR/EIS for ocean disposal. The USEPA concurs with the preferred use of channel improvement material. The Corps' preferred plan does not utilize ocean disposal for construction and the first 20 years of maintenance, due primarily to the beneficial use of dredged material at the Lois Island embayment and Miller-Pillar ecosystem restoration features. Under the preferred option in this Final SEIS, it is projected that use of the Deep Water Site will not be necessary for construction and should not be necessary for the first 20 years of maintenance of the channel improvement project. If the restoration features in the estuary are not fully implemented, then the alternative would be to dispose of material into USEPA-designated ocean sites as described in the 1999 Final IFR/EIS. The primary need for new ocean sites is driven by maintenance of a separate Corps project, the MCR navigation channel. With regard to diversion of the channel improvement material for the restoration projects, that volume amounts to approximately 7% of the site capacity. The USEPA regards this as reducing the overall height of material placed in the Deep Water Site, as well as increasing the potential life of this site by a few years. However, it does not significantly alter the need for the site or its size.

The need for designating new ocean disposal sites off of the MCR remains fundamentally unchanged and will proceed as discussed in the 1999 Final IFR/EIS to formal rulemaking by USEPA. The USEPA expects to initiate formal rulemaking on the Shallow Water and Deep Water Sites in February 2003, with the designations becoming effective by summer 2003.

The Deep Water Site is located about 4.5 miles west of the MCR, with depths ranging from 200-300 feet (Figure S4-2). The Deep Water Site is 17,000 by 23,000 feet (8,980 acres) and consists of an inner rectangle measuring 11,000 by 17,000 feet (inner dumping zone), surrounded on all sides by a 3,000-foot buffer zone. The overall site dimensions were developed based on volumes from the MCR project and up to CRM 29 of the inner channel.

Figure S4-2. Ocean Disposal Area

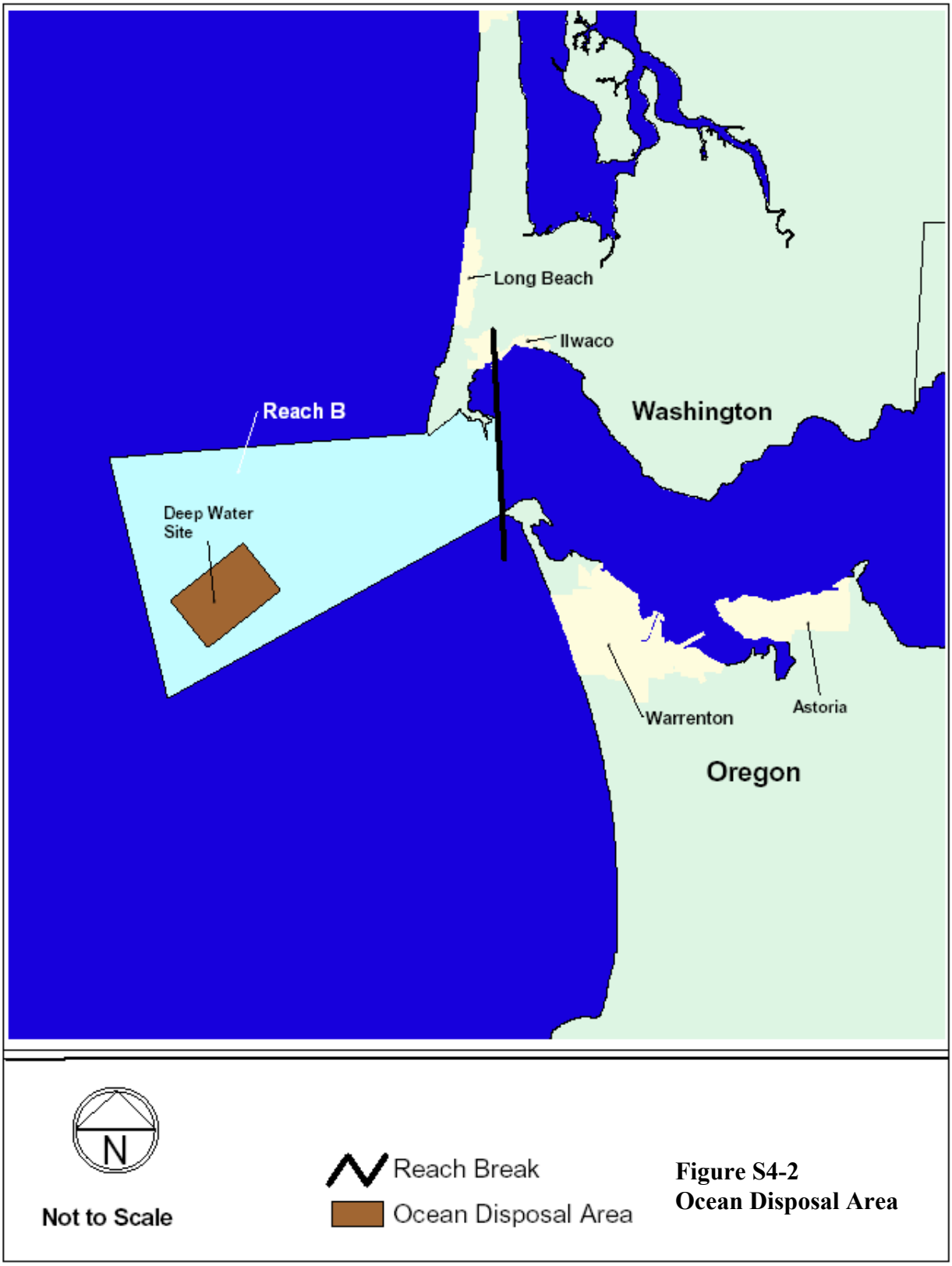


Figure S4-2
Ocean Disposal Area

Dredged material disposal will only be allowed in the inner dumping zone, which has a total area of 4,293 acres and a static disposal capacity of 225 mcy. Material placed is expected to create a mound about 40 feet high in the inner zone over the estimated 50-year life of the site. The buffer zone allows for the sloughing of material from the mound. No dredged material generated by the project is scheduled for disposal at the Shallow Water Site.

In this Final SEIS, two options have been identified for disposal of dredged material originating from CRM 3-29 for the channel improvement project. The first option was discussed in the 1999 Final IFR/EIS, which stated that during construction of the 43-foot alternative, about 7 mcy of material (5 mcy new work plus 2 mcy of O&M materials from the 40-foot channel maintenance) would be disposed of in the Deep Water Site. An additional 9 mcy derived from channel maintenance would be placed in the site during years 1-20, and an additional 21 mcy from years 21-50. The total volume estimated from the channel improvement project for ocean disposal was 37 mcy.

The project as defined in Chapter 1 includes the second option for treatment of CRM 3-29 material for disposal, which is the construction of two restoration features beneficially using sand that otherwise would have been disposed of in the ocean. The Lois Island embayment and Miller-Pillar restoration features are described in Subsection 4.8.6 and in the Biological Opinion (Exhibit H available on the Corps' website). As part of the ESA consultation, the three federal agencies identified these two restoration features as being beneficial to listed salmonid stocks. The Corps' preferred plan in this Final SEIS does not utilize ocean disposal (Deep Water Site) for construction and the first 20 years of maintenance for the channel improvement project, due to the beneficial use of dredged materials at the Lois Island embayment and Miller-Pillar ecosystem restoration features. Should either of these restoration features be substantially modified or discontinued through the public review process for this NEPA document, the Deep Water Site option described in the 1999 Final IFR/EIS would be used for disposal of the balance of the dredged material.

Table S4-2 displays the construction volumes and O&M for the proposed alternative from CRM 3-29 for the 1999 IFR/EIS and Final SEIS. Under the second option also described in Subsection 4.4.3.10, the Corps would dispose of the material using a combination of ecosystem restoration, flowlane disposal, and existing upland and shoreline sites.

Table S4-2. Disposal Volumes for the Proposed Alternative from CRM 3-29

Document	Construction	Years 1-20 of O&M	Years 21-50 of O&M
1999 Final IFR/EIS	7 mcy (5 mcy new work; 2 mcy 40-foot O&M) Deep Water Site	9 mcy Deep Water Site	21 mcy Deep Water Site
Final SEIS	6 mcy Lois Island Embayment (4 mcy new work; 2 mcy 40-foot O&M)	5.5 mcy Miller Pillar, 15 years (additional material would go to a combination of Rice Island, Pillar Rock, Miller Sands, and flowlane disposal)	Rice Island, Pillar Rock, and Miller Sands, and Flowlane disposal; potential for ocean disposal and/or beneficial use

Both the Lois Island embayment and Miller-Pillar restoration features have been modified since the Draft SEIS in response to comments and coordination with stakeholders and state and federal resource agencies. The modifications for these features focus on establishing tidal marsh and intertidal habitat, which is one of the most impacted habitat types in the Columbia River estuary.

The Lois Island embayment feature would restore about 191 acres of tidal marsh habitat by placement of dredged material to a target elevation of approximately 6.5 feet mean lower low water (MLLW). The target elevation is predicated on the approximate elevation break between low and high tidal marsh plant communities (Figure S4-3). Based on current hydrographic surveys, it is estimated that 6 mcy would be available for placement at the Lois Island embayment in the 2-year construction period. This material would originate from the navigation channel between CRM 3-29.

Construction of this feature would occur in two related operations (Figure S4-4). Material dredged would be transported via hopper dredge to a temporary location (sump), located within 600 feet of the federal navigation channel between CRM 18-20 on the Oregon side. Hopper dredges would use this location as a temporary construction sump. A pipeline dredge would then be used to pump dredged materials to the embayment. Hopper dredges would charge this sump prior to the in-water work period (November 1 to February 28). Hopper and pipeline dredges would then work concurrently throughout the in-water work period to sustain material delivery to the sump and embayment. Should additional material be required during the in-water work period of construction in year two, the sump would again be charged with material beforehand and the same scenario would be implemented to complete the ecosystem restoration.

Figure S4-3. Lois Island Embayment Ecosystem Restoration Feature (191 acres)

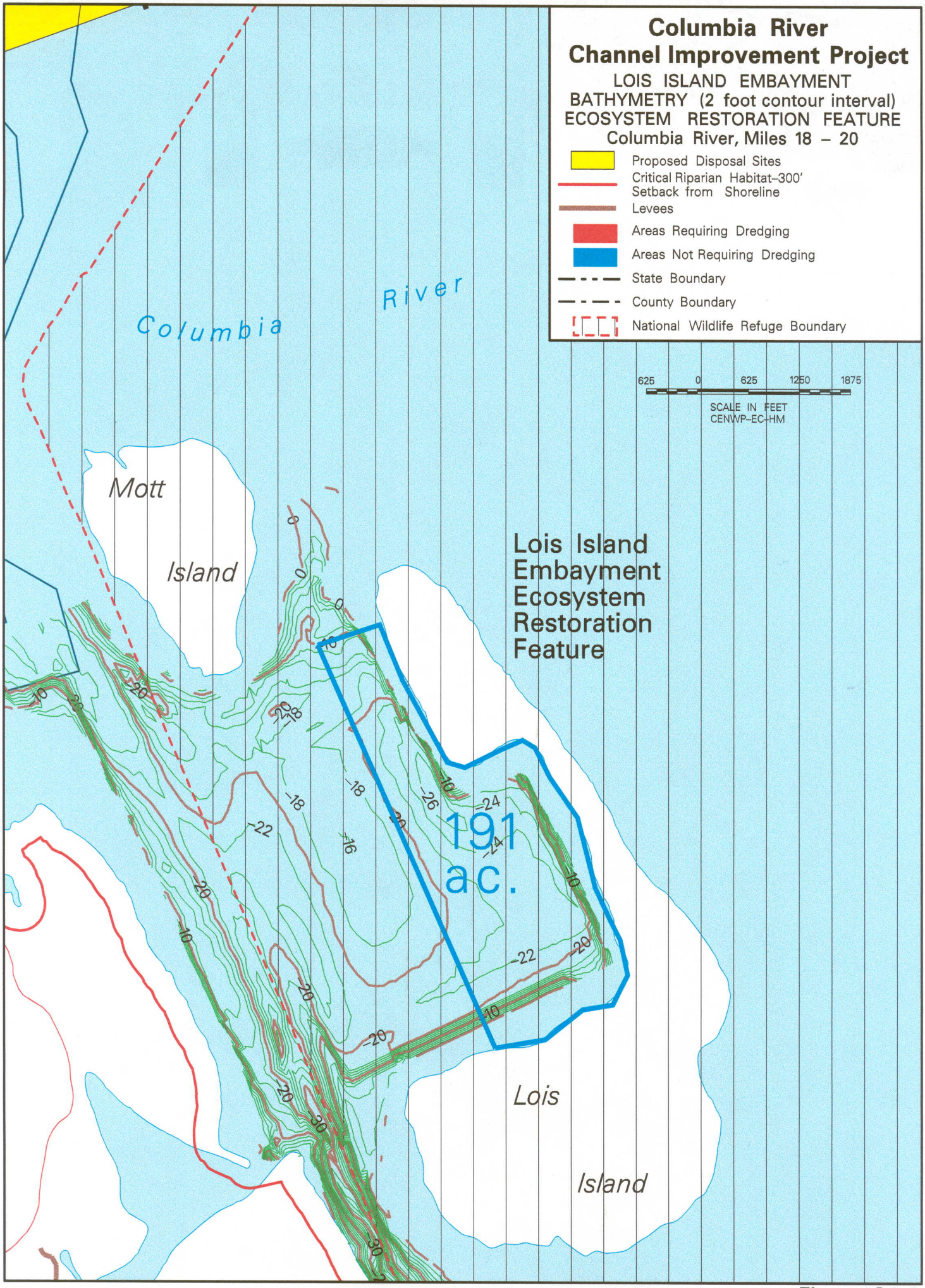

Columbia River Channel Improvement Project
LOIS ISLAND EMBAYMENT
BATHYMETRY (2 foot contour interval)
ECOSYSTEM RESTORATION FEATURE
Columbia River, Miles 18 – 20
Proposed Disposal Sites
Critical Riparian Habitat–300' Setback from Shoreline
Levees
Areas Requiring Dredging
Areas Not Requiring Dredging
State Boundary
County Boundary
National Wildlife Refuge Boundary
625 0 625 1250 1875
SCALE IN FEET
CENWP-EC-HM
Columbia River
Mott Island
Lois Island Embayment Ecosystem Restoration Feature
191 ac.
Lois Island

Figure S4–3

Figure S4-4. Lois Island Embayment Bathymetry, Temporary Sump with Pipeline

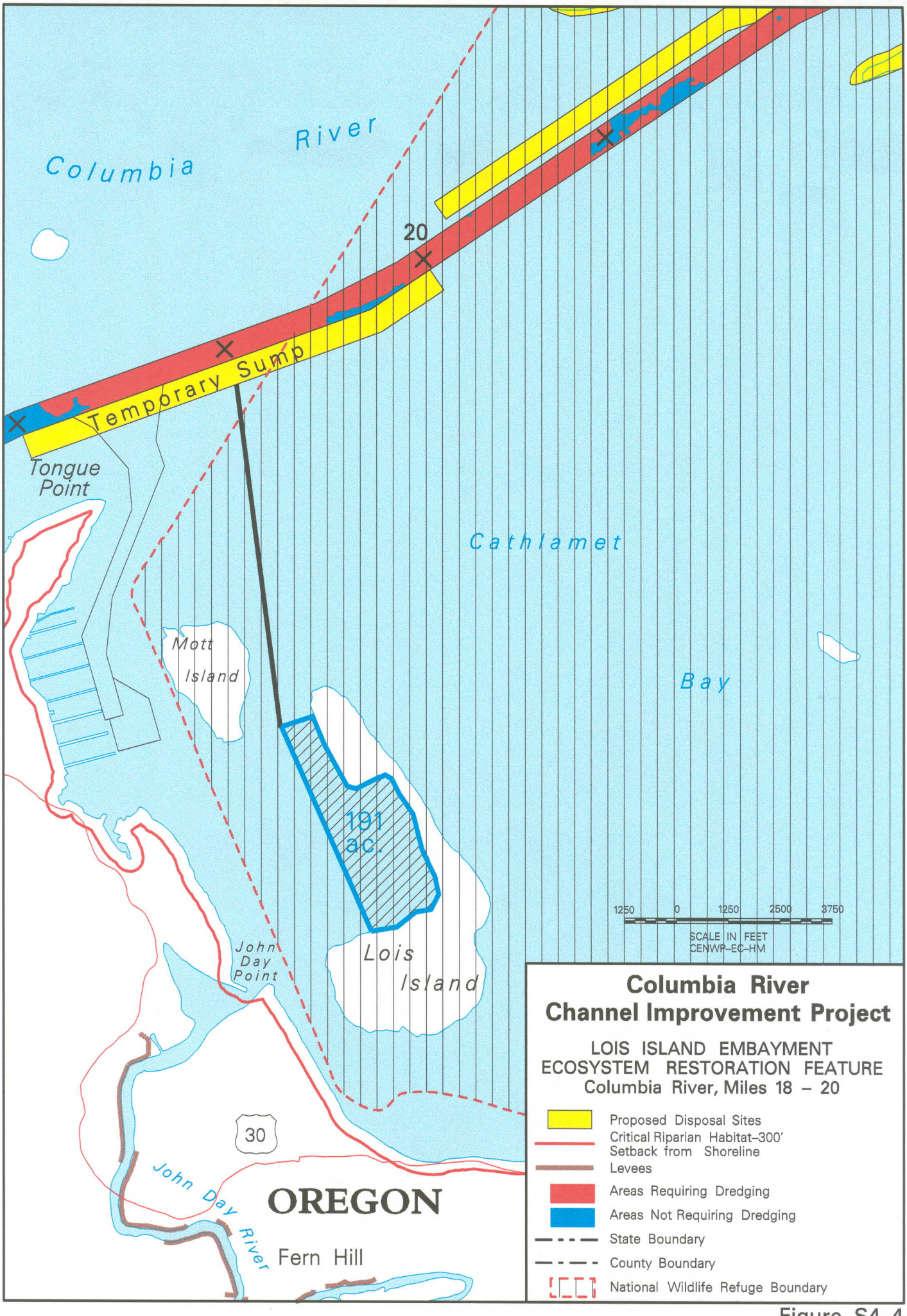

Columbia River
20
Temporary Sump
Tongue Point
Cathlamet Bay
Mott Island
191 ac.
Lois Island
John Day Point
30
John Day River
OREGON
Fern Hill
1250 0 1250 2500 3750
SCALE IN FEET
CENWP-EC-HM
Columbia River
Channel Improvement Project
LOIS ISLAND EMBAYMENT
ECOSYSTEM RESTORATION FEATURE
Columbia River, Miles 18 – 20
Proposed Disposal Sites
Critical Riparian Habitat–300' Setback from Shoreline
Levees
Areas Requiring Dredging
Areas Not Requiring Dredging
State Boundary
County Boundary
National Wildlife Refuge Boundary

Figure S4–4

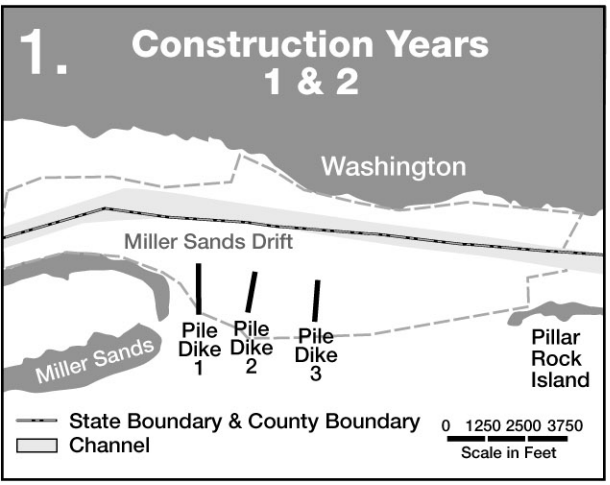
The Miller-Pillar restoration feature is located between Miller Sands and Pillar Rock Islands (CRM 25-26) and restores approximately 235 acres of tidal marsh and intertidal flat habitat at a presently erosive, subtidal location (Figure S4-5). Natural processes are currently eroding material south of the navigation channel and redepositing it in the navigation channel. This erosive action has been occurring since 1958 at an average annual rate of about 70,000 cubic yards. The erosion is affecting productive, shallow subtidal habitat (0 to 5.9 feet CRD) and converting the area to less productive, deep subtidal habitat (a minimum depth of 24.9 feet CRD; Hinton, et al. 1995). Based upon coordination with the Oregon Department of Fish and Wildlife (ODFW) and Oregon Department of Land Conservation and Development among others, the restoration emphasis at this location is directed toward tidal marsh and intertidal flat habitat. Tidal marsh represents one of the most impacted habitat types in the Columbia River estuary.

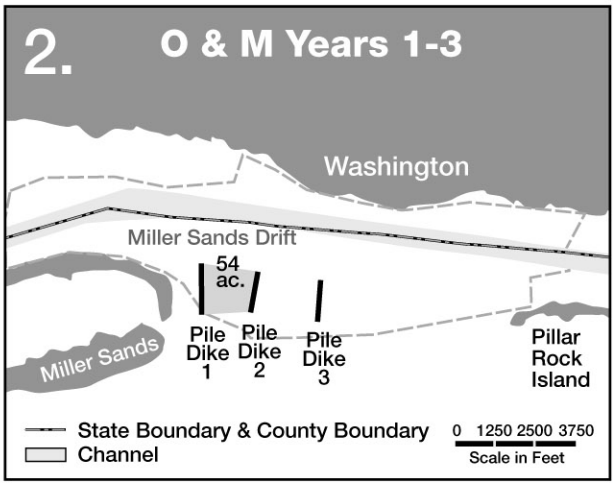
The Miller-Pillar restoration feature requires construction of a pile dike field. Three pile dikes would be constructed initially to implement the tidal marsh-intertidal flat habitat restoration; ultimately the restoration effort would consist of five pile dikes to hold material in place. The dredged material would be obtained from the maintenance of the deepened channel (approximately 15 years). This restoration feature would be accomplished with fill placed to the target elevation derived from the adjacent tidal marsh-intertidal flat habitat immediately upstream of Miller Sands Island and abutting a portion of the restoration area. The restoration action would be phased, beginning at the downstream border and moving upstream. Fill would be placed initially in the cell between the first and second pile dikes until the target depths for tidal marsh-intertidal flat habitat are reached. At that time, the downstream cell would no longer receive dredged material and monitoring for tidal marsh plant establishment and productivity would begin. Subsequently, dredged material would be placed between the second and third pile dikes until target depths are reached and this segment was complete. Monitoring would then be initiated to evaluate productivity of this section.

Results of the monitoring effort will be reviewed by an Adaptive Management Team (AMT), composed of interagency representatives, who will determine if modifications of the restoration effort are required to attain tidal marsh-intertidal flat habitat. The construction of this feature would continue incrementally, with modification if deemed necessary, until the entire 235 acres of tidal marsh-intertidal flat habitat was created. This approach creates tidal marsh-intertidal flat habitat that would be available to salmonids and other aquatic species and more importantly, generates detrital export to the estuary, which provides a forage base for benthic invertebrates, an important prey resource for juvenile salmonids and other aquatic species. The timeframe to accomplish this restoration depends on the volume of maintenance material that accumulates in the navigation channel, but is currently estimated to be approximately 15 years. Once this ecosystem restoration feature is completed, no further dredged material would be placed at this location. Bird excluders would be placed on top of the pilings and spreaders comprising the pile dikes to preclude fish-eating birds from perching there.

Figure S4-5. Miller-Pillar Implementation Plan

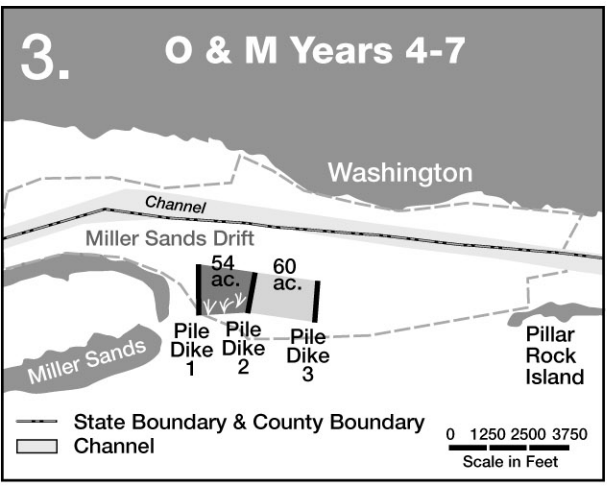
Miller-Pillar Ecosystem Restoration Feature Implementation Plan

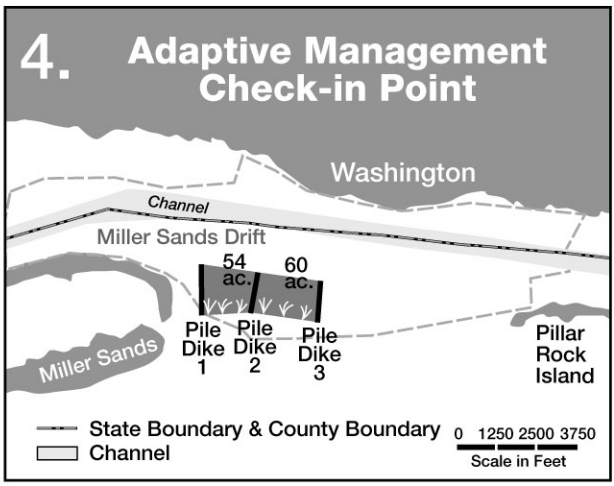




Pile dikes

Dredged material placed to tidal marsh elevation

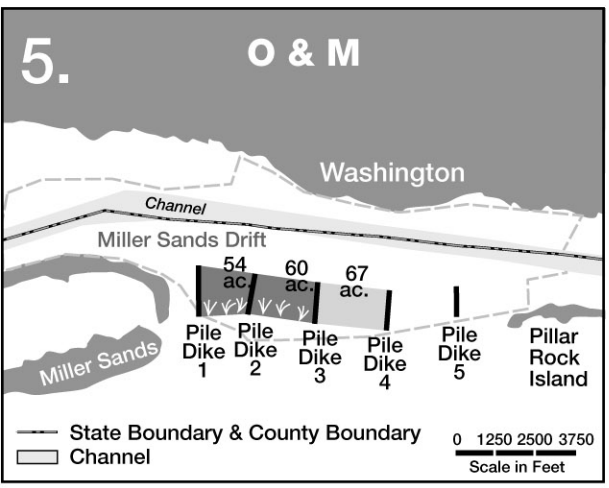


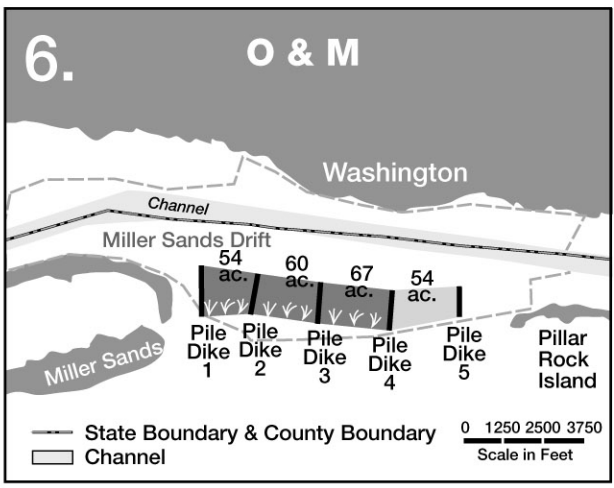


Tidal marsh vegetation

Dredged material placed to tidal marsh elevation

Tidal marsh vegetation





Tidal marsh vegetation

Dredged material placed to tidal marsh elevation

Tidal marsh vegetation

Dredged material placed to tidal marsh elevation

Figure S4-5 Miller-Pillar Ecosystem Restoration Feature Implementation Plan

The Corps' preferred option is to beneficially use the dredged material from construction of the channel improvement project from CRM 3-29 for tidal marsh development at Lois Island embayment. The first 15 years of project maintenance would be used for the Miller-Pillar ecosystem restoration feature, as well as placement at those disposal sites that have historically been used during O&M of the 40-foot channel including flowlane, Miller Sands Spit, Rice Island and Pillar Rock Island (instead of exclusively using the Deep Water Site). Once the Miller-Pillar restoration feature is completed, no additional material will be placed there and maintenance material from years 15-20 would be placed at a combination of sites including flowlane, Miller Sands Spit, Rice Island and Pillar Rock Island.

With the use and implementation of the two estuarine restoration sites, and subsequent use of traditional estuarine disposal sites, placement of material in the ocean disposal site should not be necessary for construction of the channel improvement project and the first 20 years of maintenance. In the event dredge material from the channel did go to the ocean because the ecosystem features were not fully implemented, it would go to a site designated for ocean disposal under Section 102 of the Ocean Dumping Act. At this time, we fully anticipate that the site proposed for designation under the Ocean Dumping Act for potential use for this project will be the Deep Water Site. Compliance with applicable provisions of Goal 19 and the Oregon Territorial Sea Plan, Part II Resource Inventory and Effects Evaluation, will be met once the requirements and criteria contained in Parts 227 and 228 are completed. Remaining actions to be completed include a biological baseline study and further analysis of potential Dungeness crab impacts. Additional discussion of effects on ocean resources and activities is included in the following section.

4.5. [revised] Comparison of Alternatives

The NEPA and SEPA require a comparison of alternatives in an EIS. Corps regulations for navigation projects require additional analysis of benefits and costs for such projects. To address both of these requirements, this chapter is structured as follows. Sections 4.5 through 4.7 pertain only to those measures that Corps regulations require as part of the benefit-to-cost analysis for a navigation project. For the purposes of the project as defined in Chapter 1, this includes all navigation features (dredging, disposal, wildlife mitigation, terms and conditions of the Biological Opinions, berthing areas, utility relocations) and Lois Island embayment and the Miller-Pillar ecosystem restoration features. These two restoration features are included in the benefit-to-cost analysis because they have been identified as a beneficial use of dredged material, provide ecosystem benefits, and are less expensive than the selected disposal alternative in the 1999 Final IFR/EIS. All other ecosystem restoration features are discussed in Section 4.8 and are not included in the benefit-to-cost analysis per Corps regulations.

In addition to the alternatives identified in the 1999 Final IFR/EIS, this Final SEIS carries forward for detailed evaluation the modified disposal plan discussed in Section 4.4.3.10, including the revisions to the Lois Island embayment and Miller-Pillar ecosystem restoration features developed in response to comments on the Draft SEIS.

4.5.1. revised Environmental Comparison

Table S4-3 has been updated to provide information on the anticipated environmental impacts discussed in this Final SEIS resulting from the Columbia River Channel Improvement Project. Additional discussion of these impacts is included in Chapter 6, *Environmental Consequences*. While this section generally pertains only to those measures that Corps regulations require as part of the benefit-to-cost analysis for a navigation project, the comparison of alternatives in Table S4-3 covers all aspects of the project, including the other ecosystem restoration features discussed in Section 4.8.

4.5.1.1. revised Physical Impacts

See Subsection 4.4.3.10, *Disposal Plan Modifications Following Consultation*, for updated information on dredging volumes and disposal of dredged material for the 43-foot alternative. Additional studies, discussed in detail in Chapter 6, confirm the analysis and conclusions presented in the 1999 Final IFR/EIS regarding the impacts of the 43-foot alternative on estuarine salinity and circulation, sedimentation, water quality, erosion and sediment quality, as compared to the No Action Alternative.

4.5.1.2. revised Biological Impacts

For the Final SEIS, the following updated information has been added to this subsection. Disposal plan changes result from new information regarding volumes to be dredged, changed plans for the use of previously identified sites, and the addition of new ecosystem restoration features that involve beneficial use of dredged material. The following changes to project impacts have occurred:

- Reduction in impact to riparian forest from 67 acres to 50 acres (approximately 25%) due to reduced disposal site acreage at Lord Island (O-63.5).
- Reduction in impact to agricultural lands from 200 acres to 172 acres (approximately 14%) primarily due to the reduced disposal acreage required at Gateway (W-101) and Mt. Solo (W-62).
- Reduction in impact to wetlands from 20 acres to 16 acres (approximately 20%) due to a reduction at the Mt. Solo site resulting from correcting a mapping inconsistency.

As discussed in Chapter 1, subsequent to issuance of the 1999 Final IFR/EIS, the Corps, NOAA Fisheries and USFWS conducted an extensive reconsultation process, focused primarily on ESA-listed fish species. The results of that consultation are discussed in detail in Chapter 6. After conducting detailed analysis of potential impacts on listed species, the Services concluded that any expected impacts to key physical processes potentially affecting listed fish species would be limited and short-term in nature. They further concluded that there is some low level of risk and uncertainty surrounding the long-term biological response to physical change, but that monitoring and adaptive management will address the limited risk and uncertainties. The consultation process also resulted in substantial information on the No Action Alternative, which is presented in more detail in Chapter 6 and included in Table S4-3.

Table S4-3. Updated Summary of Environmental Impacts

Affected Resources	No Action	43-foot Channel (Least Cost Disposal)	Proposed Disposal (Sponsor Preferred)	Ecosystem Restoration
Physical				
Salinity Intrusion	No effect	Increase salinity (< CRM 30) by up to 0.5 ppt in shallow embayments & up to 5 ppt in navigation channel under low flow conditions.	Same as Least Cost	No effect
Shoreline Erosion	Erosion at former shoreline disposal sites.	Same as No Action	Same as No Action	No effect
Sediment Quality	All dredged material suitable for unconfined in-water disposal	Same as No Action	Same as No Action	Sediment testing and analysis to be performed at Bachelor Slough ecosystem restoration feature.
Water Quality	Minor turbidity & sediment suspension created by dredging/disposal	Short-term increase in turbidity & sediment suspension from initial deepening.	Same as Least Cost	Short-term increase in turbidity & sediment suspension from initial restoration implementation.
Ocean	Use of this site by the MCR project results in bathymetric & sediment changes over a 4,293-acre area.	Use of this site not anticipated.	Same as Least Cost	The Corps' preferred plan does not utilize ocean disposal for construction and first 20 years of maintenance, primarily to the beneficial use of dredged materials at Lois Island embayment and Miller-Pillar restoration features. Under the preferred option, it is projected that use of the Deep Water Site will not be necessary for construction and should not be necessary for the first 20 years of maintenance of the project.
Biological				
Riverine Aquatic	Temporary, short-term habitat alteration & disturbance from dredging/disposal.	Comparable to No Action but additional bottom habitat disturbed by dredging.	Same as Least Cost	Improve water circulation at Bachelor Slough (85 ac.) & Lord-Walker & Fisher-Hump embayments (335 ac.); preserve 60 acres tidelands (Cottonwood-Howard); improve fish access to 38 tributary mi. & 92 ac. of backwater channel (Tenasillahe Is. interim); restore tidal connection to ~1,800 ac. (Tenasillahe Is. long-term), restore 426 ac. of tidal marsh-intertidal flat habitat (Miller-Pillar & Lois Island).

Affected Resources	No Action	43-foot Channel (Least Cost Disposal)	Proposed Disposal (Sponsor Preferred)	Ecosystem Restoration
Ocean	Ocean disposal from MCR project would affect 4,293 acres of benthic habitat and impacts commercial fishing.	Reduced impacts to commercial fishing by beneficial use sites in the estuary.	Same as Least Cost	The Corps' preferred plan does not utilize ocean disposal for construction and first 20 years of maintenance, primarily to the beneficial use of dredged materials at Lois Island embayment and Miller-Pillar restoration features. Under the preferred option, it is projected that use of the Deep Water Site will not be necessary for construction and should not be necessary for the first 20 years of maintenance of the project.
Riparian	Minor effects to riparian fringes at some upland disposal sites	50 acres affected at 7 disposal sites.	50 acres affected at 7 disposal sites.	Restore 52 acres of riparian habitat (Bachelor Island).
Wetland	No effect	24 acres affected at 3 disposal sites.	16 acres affected at 2 disposal sites.	Restore 470-839 acres of emergent wetlands (Shillapoo Lake), 191 acres of tidal marsh at Lois Island embayment, 235 acres of tidal marsh-intertidal flat at Miller-Pillar and 1,778 acres of intertidal marsh (Tenasillahe Is. long-term); implement 5-yr. control program for purple loosestrife from CRM 18-52
General Wildlife	About 1,165 acres of upland habitat affected by past disposal actions.	Impacts 287 additional acres at 5 new disposal sites.	Impacts 195 additional acres at 4 new disposal sites.	Secures 650 acres of habitat for Columbian white-tailed deer (Cottonwood-Howard Is.), provides 191 acres of tidal marsh at Lois Island embayment, 235 acres of tidal marsh-intertidal flat at Miller-Pillar and 1,778 acres of intertidal marsh (Tenasillahe Is. long-term); maintains natural tidal marsh communities through implementation of 5-yr. control program for purple loosestrife from CRM 18-52.
Mitigation	None required	Mitigation for 257 acres agricultural, 50 acres riparian, & 24 acres wetland losses.	Mitigation for 172 acres agricultural, 50 acres riparian, & 16 acres wetland losses.	None required

Affected Resources	No Action	43-foot Channel (Least Cost Disposal)	Proposed Disposal (Sponsor Preferred)	Ecosystem Restoration
Socio-Economic				
Cultural Resources	No effect	No effect	No effect	No effect
Land Use	Use existing disposal sites only.	Forested land/open space changed to disposal site use. Agricultural land changed to disposal site use at 5 locations. No change in port-industrial use.	Forested land/open space changed to disposal site use. Agricultural land changed to disposal site use at 4 locations. No change in port-industrial use	Converts agriculture land to fish & wildlife use at Shillapoo Lake.
Recreation	Minor impacts to recreational fishery.	Same as No Action	Same as No Action	Long-term fishery & waterfowl hunting improvement with implementation of features; some impact to recreational fishing at Lois Island.
Aesthetics	Minor impact from upland disposal actions.	Minor additional impact in rural agricultural setting.	Same as No Action	Change of open space perspective from agriculture to wetland habitat (Shillapoo).
Air Quality	Minor impact from wind borne sand and dredge operation.	Minor additional impact at new upland disposal sites.	Same as Least Cost	No change
Noise	Minor impact from dredge operation.	Minor additional impact from dredge operation.	Same as Least Cost	No change
Commercial Fishery	Minor impact from dredging and disposal.	Minor impacts to drift fishery and crab fishing.	Same as Least Cost	Impact to Select Area Fishery at Tongue Point and drift net fishery at Miller Sands Drift.

Subsequent to issuance of the 1999 Final IFR/EIS, the Corps and state resource agencies engaged in coordinated efforts to evaluate potential impacts to other aquatic resources, including sturgeon, smelt and crab. Results of these efforts are presented in detail in Chapter 6 and are summarized in Table S4-3. For purposes of comparing alternatives, this effort indicates that the impacts of the preferred alternative and the No Action Alternative are similar in kind, with some impacts being slightly larger quantitatively under the preferred alternative due to the higher quantity of dredging activity associated with construction and early maintenance of the channel improvement project. However, it appears that any increased effects of the project from higher dredge quantities (such as crab entrainment) can be avoided or minimized using information developed since issuance of the 1999 Final IFR/EIS (such as the crab-salinity information).

Implementation of the Lois Island embayment and Miller-Pillar ecosystem restoration features will result in temporary adverse impacts to fish and wildlife resources associated with habitat modification and disturbance during construction. Certain species would incur habitat losses with implementation of these features. However, over the long term, these ecosystem restoration features would produce beneficial, direct effects substantially greater than baseline conditions. The features are geared toward restoration of tidal marsh habitat, a habitat that has incurred significant losses in acreage. Tidal marsh and associated intertidal flat restoration (Miller-Pillar) will benefit salmonids, waterfowl, other aquatic birds, shorebirds, benthic invertebrates, and estuarine fish species. Additionally, implementing these features avoids any impacts that would result from ocean disposal.

Impacts to terrestrial species under USFWS jurisdiction for the three original ecosystem restoration features and Miller-Pillar were previously addressed in the BA to the USFWS for the project (Exhibit G, 1999 Final IFR/EIS). Those determinations are incorporated by reference. Also, impacts to marine mammals and sea turtles were addressed in the BA for the *Dredged Material Management Plan* (DMMP; Corps 1998). The conclusion of "no effect" for marine mammals and sea turtles from that document is incorporated by reference and applies to the ecosystem restoration features and evaluation actions described here.

Ten listed terrestrial species (Columbian white-tailed deer, bald eagle, marbled murrelet, western snowy plover, brown pelican, Oregon silverspot butterfly, Howellia, golden paintbrush, Bradshaw's lomatium, and Nelson's checkermallow) occur in the project area. For detailed information on these species, see the BAs and Biological Opinions published for the DMMP (Corps 1998) and the 1999 Final IFR/EIS. Two species, the peregrine falcon and the Aleutian Canada goose, have been delisted since the Final IFR/EIS was completed. A summary of the previous Corps' determinations is presented below.

Seven of the 10 species listed above (marbled murrelet, western snowy plover, Oregon silverspot butterfly, Howellia, golden paintbrush, Bradshaw's lomatium, and Nelson's checkermallow) do not occur in the areas identified for the ecosystem restoration features and evaluation actions or were addressed in the previous BA (Exhibit G of the 1999 Final IFR/EIS). Therefore, it is our determination that there will be "no effect" to these species from the five proposed ecosystem restoration features and the evaluation actions set forth in the 2001 BA. The ecosystem restoration features and evaluation actions would have no

effect on hump-backed, right, fin, sei, blue, or sperm whales, or on Pacific leatherback, loggerhead, green, or Pacific Ridley sea turtles. These species do not occur in the area for the restoration features or evaluation actions. Biological impacts for 12 federally listed salmonid ESUs, one listed DPS, one DPS proposed for listing, and one candidate ESU, Columbian white-tailed deer, bald eagles, brown pelicans and northern sea lions associated with the additional ecosystem restoration features and evaluation actions are addressed in the 2001 BA.

Dredged material disposal sites will occur within the formerly designated critical habitat zone for NOAA Fisheries-listed salmonids along the Columbia River. While the critical habitat designation for NOAA Fisheries-listed species has since been withdrawn, the reconsultation process evaluated potential effects on critical habitat, and concluded that the project would not destroy or adversely modify designated critical habitat. On November 14, 2002, the USFWS proposed to designate critical habitat for threatened bull trout in the Columbia River Basin. Critical habitat is proposed for the Mainstem Columbia River Critical Habitat Unit, from the MCR (CRM 0) to Chief Joseph Dam (CRM 545). This proposed critical habitat unit includes the Columbia River within the channel improvement project action area. Section 7(a)(4) of the ESA requires, when critical habitat is proposed, federal agencies to confer with the Service on any action which is likely to adversely modify or destroy proposed critical habitat.

The proposed Mainstem Columbia River Critical Habitat Unit serves as a migration corridor, provides foraging habitat, and is an overwintering area for bull trout. Three primary Constituent Elements are provided by the Columbia River to bull trout in the project area: water quality, migratory corridor, and an abundant food supply. The Corps believes that, based on the extensive analysis found in the Corps' 2001 BA and the USFWS's 2002 Biological Opinion, the project will not adversely modify or destroy proposed critical habitat in the action area. Therefore, no additional conferencing is necessary. Upon finalization of the bull trout critical habitat rule, and if the Columbia River within the project's action area is formally designated as critical habitat, the Corps will reinitiate ESA consultation with the USFWS. The AMT will remain updated on the USFWS's progress in finalizing the critical habitat rule, and ensure that coordination between the Corps and USFWS continues.

Habitat development, principally riparian and wetland habitats, is the principal management objective for mitigation actions. Mitigation actions at Webb and Woodland Bottoms locations would occur behind flood control levees under the current prescription. Insect, detrital and large woody debris export from these locations under their present conditions is negligible. An increase in insect faunal export under the wildlife mitigation prescription to the mainstem Columbia River or side channels is forecast with the mitigation feature in place and operational. This would be attributable to the development of riparian forest at these locations. Insect faunal export from these mitigation locations would not be as substantial as for locations directly connected to the Columbia River.

Creation of intertidal marsh habitat (16 acres) at the Martin Island navigation site would occur in an embayment excavated for I-5 construction fill. Dredged material would be placed in the embayment to attain the proper depths for development of an emergent marsh

plant community. Adjacent intertidal marsh habitat would be surveyed to determine a reference target elevation. Riparian forest habitat development at Martin Island would occur on lands directly connected to the Columbia River. The direct effect of these actions at Martin Island would be beneficial to listed ESA salmonids and their Critical Habitat. Insect and detrital export from riparian and emergent marsh habitat along with large woody debris export would be expected from Martin Island mitigation actions.

The determinations for Lois Island embayment and Miller-Pillar ecosystem restoration features were *may affect and is likely to adversely effect*. The ecosystem restoration features proposed at in-water sites (Miller-Pillar and Lois Island embayment) would result in initial, temporary adverse direct effects to ESA salmonids or their Critical Habitat, but over the long-term would produce beneficial direct effects substantially greater than baseline conditions.

The introduction of Columbian white-tailed deer to Cottonwood-Howard Island is intended to assist development of another secure and viable population of this listed species. The feature would assist attainment of the recovery plan goals and objectives and aid efforts to delist this species. Implementation of the Tenasillahe Island long-term restoration feature, which is dependent upon delisting of Columbian white-tailed deer, would provide a substantial acreage base (~1,800 acres) for habitat restoration for ESA salmonids.

4.5.1.3. revised Socio-Economic Impacts

For the Final SEIS, the following updated information has been added to this subsection. Implementation of the ecosystem restoration features at Lois Island embayment and Miller-Pillar will impact commercial fishermen. A net-pen program and associated select area fishery has been established at Tongue Point with other select area fisheries upstream at South Channel and Blind Slough. Restoration of the Lois Island embayment would reduce the available acreage for commercial fishing by 191 acres or about 19% of the select area fishery at Tongue Point. The restoration action would create tidal marsh habitat, which is not conducive to commercial fishing as compared to the uniform depth, open water area that currently exists. For the 2002 spring gillnet season, a total of 2,440 spring chinook salmon and 159 white sturgeon [preliminary ODFW results] were harvested in the Tongue Point select area fishery. Coho salmon landings from 1996 through 2000 ranged from 900 to 10,700 fish; chinook salmon landings were 50 to 431 fish and white sturgeon 59 to 106 fish (ODFW 2001, *Fall Select Area Fisheries Fact Sheet*).

Implementation of the Miller-Pillar restoration feature would eliminate a portion of the drift net (gill and/or tangle net) fishing site. The construction of the pile dike field plus restoration of site bathymetry to tidal marsh-intertidal flat habitat elevations would preclude commercial fishing activity at this location. This ecosystem restoration feature would impact approximately 14% (when fully implemented) of the area within the Miller Sands Drift for commercial fishermen. Long term, the proposed restoration features are intended to aid the recovery, and ultimately assist in the delisting of Columbia River ESA listed ESUs. The ecosystem restoration features represent increments in the regional efforts to recover these ESUs and will not achieve recovery by themselves.

4.5.2. revised Economic Comparison

This subsection is updated for the Final SEIS to show revised benefits and costs for the 43-foot channel improvement project and to exclude benefits and costs associated with the Willamette River portion of the authorized project, which has been deferred (see Chapter 1). The other alternatives (non-structural/LoadMax, regional port; 41- and 42-foot alternatives) were not updated because they were screened out in Chapter 4 of the 1999 Final IFR/EIS, which was adopted in the December 1999 Corps of Engineers Chief's Report.

The benefits of improving the navigation channel would result from reductions in transportation costs for each benefiting commodity. As shown in the fleet projections (Chapter 3), there are a number of vessels that load at less than their maximum capacity due to current channel depth constraints. For those vessels, a 3-foot deepening would essentially allow an increase in capacity of 6,000 to 7,400 tons. For example, a bulk carrier with a 43-foot maximum draft typically has a maximum cargo capacity of approximately 65,000 short tons. In a 40-foot channel, the capacity of this vessel is reduced to 58,000 tons. Round-trip vessel operating costs for that vessel carrying a load of corn out of the Columbia River would average $670,000 per trip. Therefore, a 3-foot deepening can reduce transportation costs from $11.23 to $10.13 per ton, or $1.09 per ton.

As shown in the fleet projections, each commodity and trade route combination is expected to make varying use of the deepening. For wheat, the additional 3-foot channel depth would result in an initial average transportation cost per-ton reduction of $0.27 on a per ton basis. Corn is projected to take greater advantage of the deepening, with an initial cost reduction of about $0.79 per ton. Soybeans, like corn, would take advantage of the deeper channel, saving about $0.85 per ton. Container transportation benefits are greater than for bulk commodities, with cost reductions of $2.68 per ton.

Table S4-4 displays the average annual transportation benefits for the 43-foot channel improvement project by commodity. The annual benefits total $18.8 million. Container traffic provides about two-thirds of the benefits, and corn and wheat benefits make up most of the remainder. More detailed information, including destination regions, can be found in the revised Economic Analysis located in Exhibit M of this Final SEIS.

Table S4-4. Average Annual Transportation Benefits, 43-foot Channel Improvement

Commodity	Average Annual Benefit
Corn	$3,842,000
Wheat	$2,054,000
Barley	$185,000
Soybeans	$976,000
Containers	$11,748,000
Total	$18,806,000

Benefits were not allocated by reach because this is an update to a Congressionally authorized project. The revised analysis shows 62% of the benefits accrue from container traffic, which requires a channel to the Portland/Vancouver area.

4.6. revised Plan Selection

This section has been updated for the Final SEIS. Table S4-5 shows the current estimated costs and benefits for the 43-foot channel improvement project. The updated costs for the project are shown in Table S4-6. This section describes the Federal Government's least cost option for navigation improvement to the Columbia River portion of the project. The costs of the channel improvement project include costs for turning basins, anchorages, and berthing areas that must be deepened in order to achieve the benefits of the project.

Table S4-5. Current Costs and Benefits, 43-foot Channel Improvement Project

Category	43-foot Channel Improvement Project*
First Cost	$118,625,000
Annualized First Costs	$7,395,000
Annual Operation and Maintenance Cost**	$3,619,000
Total Average Annual Cost**	$11,014,000
Benefits	$18,806,000
Benefit-to-cost Ratio	1.7
Net Benefits	$7,792,000

* Federal Government least cost option.
** Costs represent the incremental cost over No Action.

Table S4-6. Updated Costs, 43-foot Channel Improvement Project

First Costs Item	**Total Cost* ($)**
Construction	97,618,000
Land Acquisition	17,436,000
Berthing Areas	843,000
Interest During Construction	2,728,000
Total First Cost (rounded)	**118,625,000**
Annualized Costs	
First Costs (5 7/8%, 50 years)	7,395,000
O&M Dredging	3,334,000
Mitigation Site Management/Monitoring	250,000
Real Estate required throughout O&M	35,000
Total Average Annual Costs	**11,014,000**

* Federal Government least cost option.

The revised benefit and cost information, in combination with the new information on and revised analysis of environmental impacts of the project (see Chapter 6), confirms the analysis in the 1999 Final IFR/EIS and demonstrates that the benefits of the 43-foot channel alternative, as modified following ESA consultation, provides significant economic benefit that exceeds economic cost, and is consistent with protection of the environment. In contrast, the other alternatives analyzed in detail, including the No Action Alternative, would not result in significantly reduced environmental impacts. Further, as discussed in more detail in Chapter 6, compared to the No Action Alternative, the restoration features, including the new ecosystem restoration features discussed below in Section 4.8.6, provide substantial habitat benefits for fish and wildlife resources and have only limited, short-term environmental impacts.

4.6.1. Turning Basins

No updating of the existing information in this subsection was necessary for the Final SEIS (see the Final IFR/EIS, August 1999).

4.6.2. Anchorages

No updating of the existing information in this subsection was necessary for the Final SEIS (see the Final IFR/EIS, August 1999).

4.6.3. revised Berthing Areas

For the Final SEIS, the following updated information has been being added to this subsection. Current information indicates that the U.S. Gypsum sheetrock facility (formerly Port of St. Helens) near Rainier, Oregon will require berth deepening to benefit from channel deepening. Impacts from deepening at U.S. Gypsum are anticipated to be similar to those projected for deepening other berths analyzed in the 1999 Final IFR/EIS. Any such deepening will be subject to additional environmental review and permitting, including sediment sampling, under NEPA, the Clean Water Act, and the ESA.

4.7. revised Selected Plan

This section has been updated for the Final SEIS. Under Corps regulations, the non-federal sponsors (sponsor ports) can modify the Federal Government's least cost option for navigation improvement provided they pay all incremental costs. The costs displayed in Table S4-7 represent the sponsor ports selected plan.

Table S4-1 provides revised information on all disposal sites in the selected plan, including information on prior disposal history, anticipated timing of usage during construction and the first 20 years of maintenance, site acreage, site capacity, anticipated disposal volume, and final height.

Table S4-7. Current Estimated Costs, 43-foot Channel Improvement Project

First Costs Item	**Total Cost* ($)**
Construction	$99,840,000
Land Acquisition	$18,215,000
Berthing Areas	$843,000
Interest During Construction	$2,817,000
Total First Cost (rounded)	**$121,714,000**
Annualized Costs	
First Costs (5 7/8%, 50 years)	$7,588,000
O&M Dredging	$3,450,000
Mitigation Site Management/Monitoring	$150,000
Real Estate required throughout O&M	$35,000
Total Average Annual Costs	**$11,222,000**

* Sponsor Ports selected plan.

4.7.1. revised Channel Optimization Measures

Since the analysis in the 1999 Final IFR/EIS, the computer models providing the LoadMax forecasts have been substantially updated, although there was not a significant change in the accuracy of the forecast. The Technical Review Panel convened by the Corps to review benefit and cost projections concurred with the conclusion that no further benefits are likely to be obtained from further refinements to the LoadMax system (Casavant et al. 2002).

4.8. revised Ecosystem Restoration Plan

Additional information has been added to Subsections 4.8.1, 4.8.2, 4.8.4 and 4.8.5 for the Final SEIS. Subsection 4.8.6 has been added to address the ecosystem restoration features developed during the ESA consultation for the project. Also, Subsection 4.8.7 has been added to provide a cost effectiveness and incremental cost analysis for the ecosystem restoration features.

4.8.1. revised Shillapoo Lake

The Shillapoo Lake restoration feature will substantially improve waterfowl and wildlife habitat management capabilities on 470 to 839 acres (Figure S4-6). It will be done in collaboration with the Washington Department of Fish and Wildlife (WDFW). Once completed, the WDFW will perform all maintenance. The concept for the Shillapoo Lake ecosystem restoration feature in the 1999 Final IFR/EIS (eight cells hydraulically separated by levees, but interconnected by water control channels and structures) has been modified. These modifications are a result of a value engineering study, actions by other agencies, and the presence of private real estate. Cell 8 (195 acres) will not be constructed because the WDFW will pursue other management options in the cell to accomplish their objectives. The Natural Resource Conservation Service will construct Cell 1 (214 acres) in partnership with the WDFW. The proposed restoration feature will complement management actions in Cell 1 through an enhanced capability to provide or drawdown water.

Figure S4-6. Shillapoo Lake Embankment, Conveyance, and Control Structures

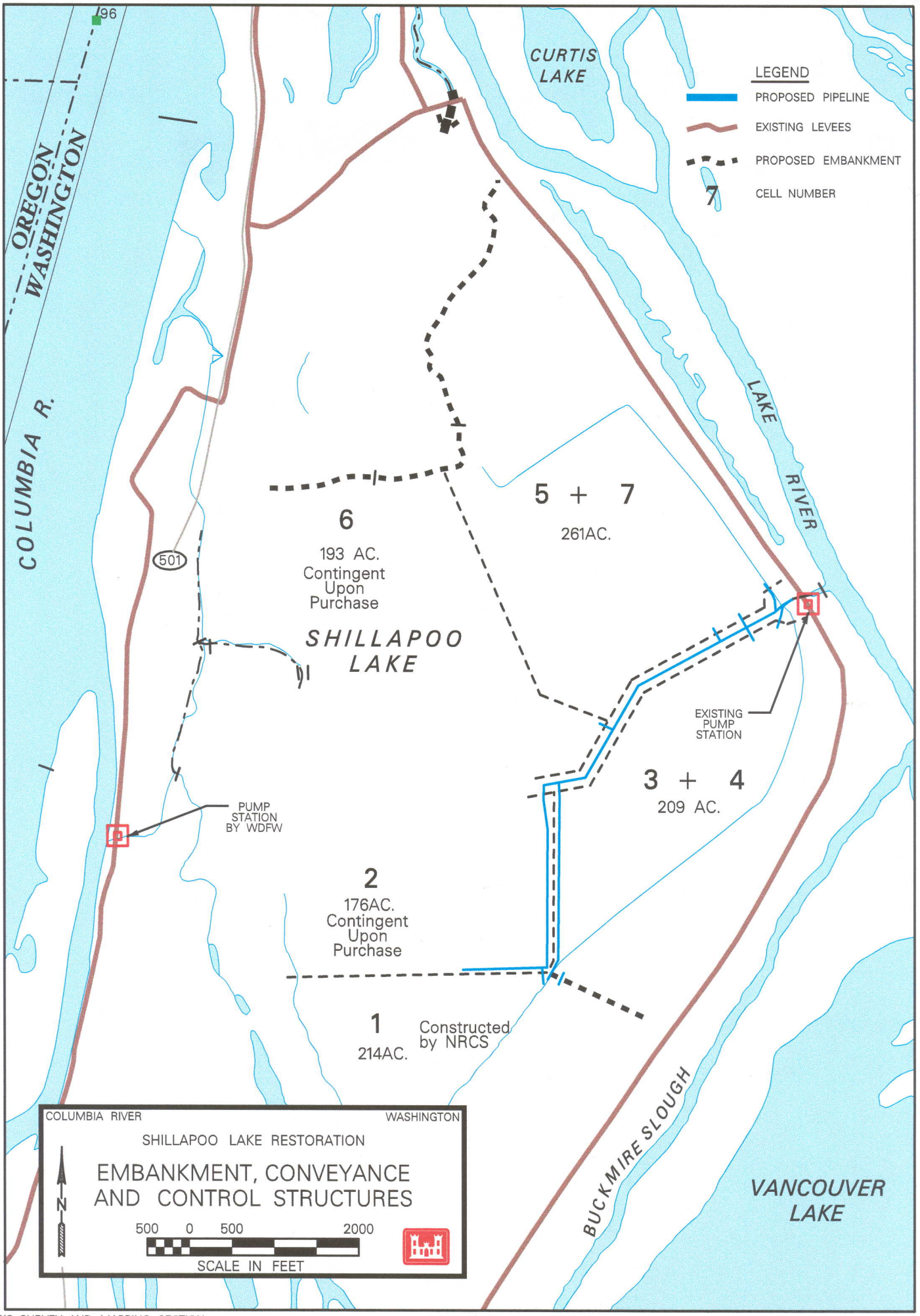


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Figure S4-6

Cells 3 and 4 (209 acres) will be combined as will be Cells 5 and 7 (261 acres) based upon results of the value engineering study. Their combination will reduce construction, operation, and maintenance costs. A large central pump and underground pipe system (rather than the system of channels and water control structures) will manage water supply and withdrawal. Lastly, Cell 2 (176 acres) and Cell 6 (193 acres) are privately held and would not be constructed until acquired in the future. Drainage capability for the private land will be provided via pumps and pipelines.

The modified action retains a controlled hydraulic connection to Lake River via a tidegate and pumping station. The modified feature will encompass 470 to 839 acres, depending upon purchase of the remaining private lands by WDFW commensurate with the construction timeframe for the channel improvement project. As currently designed, this restoration feature will not provide for juvenile salmonid access. A porous rock fill dike will be constructed as part of the feature at the tidegate/pump station outlet as a means to preclude carp, and thus other fish, from the management area. Carp compromise emergent and aquatic plant management objectives because of their foraging actions that reduce sunlight penetration of the water column and their consumption of the plants.

4.8.2. [revised] Tide Gate Retrofits for Salmonid Passage

Except for the Burris Creek tidegate retrofit, there has been no revision to the tidegate ecosystem restoration feature as detailed in the 1999 Final IFR/EIS (see Figure S4-7). The tidegate at the downstream end of the Cowlitz County Consolidated Diking Improvement District No. 2, through which Burris Creek waters were formerly exhausted to the Columbia River, has been plugged with concrete. The District currently uses their pump station to exhaust Burris Creek and internal drainage waters. Implementation of the Burris Creek tidegate component of this ecosystem restoration feature would entail construction of a new culvert with tidegate through the flood control levee. Burris Creek waters would be directed to flow through this new tidegate. Flood flows from Burris Creek that exceed the flood storage capacity of the immediately adjacent 97 acre wetland development (a wildlife mitigation feature) would be directed through an overflow structure in the wetland perimeter levee to the current pumping station. The proposed action would allow for restoration of coho and coastal cutthroat trout runs to the stream.

4.8.3. Improved Embayment Circulation

No updating of the existing information in this subsection was necessary for the Final SEIS (see the Final IFR/EIS, August 1999 and the Reach 4 map at the end of this chapter).

4.8.4. [revised] Restore Shallow Water Habitat

No updating of the existing information in this subsection was necessary for the Final SEIS. While restoration of shallow water habitat at Miller-Pillar was evaluated in the Draft SEIS, the Corps has revised the proposal for the Miller-Pillar ecosystem restoration feature in response to comments and in coordination with state and federal resource agencies (see Section 4.8.6.3).

4.8.5. revised Summary

The following updated information has been added for the Final SEIS. As discussed in more detail in Chapter 6, compared to the No Action Alternative, the restoration features (including the new ecosystem restoration features discussed below in section 4.8.6) provide substantial habitat benefits for fish and wildlife resources and have only limited short-term environmental impacts. Short-term impacts are associated with implementation of these features that will result in disturbance to fish and or wildlife resources in the immediate area of the construction action. Disposal operations for Lois Island embayment and Miller-Pillar will initially result in the loss of benthic invertebrate populations in the feature construction area. Recolonization by benthic invertebrates is anticipated upon completion of the features although the species complex may change with the alteration in depth and conversion to a tidal marsh habitat. Detrital export from these tidal marshes is expected to improve benthic invertebrate productivity in the estuary and thereby improve foraging and rearing conditions for juvenile salmonids, sturgeon and other fisheries resources for the long term. Fisheries resources will incur short-term impacts from construction of these features that would be more than offset by the long-term productivity of the features.

Implementation of these ecosystem restoration features, particularly tidal marsh and riparian forest restoration, will provide long-term environmental benefits, as most have no limitation to their effectiveness. Tidal marsh primary productivity will continue indefinitely, as it has for the natural tidal marshes in the estuary, which can be recognized on the basis of their shape and location from the maps of the early explorers to the Columbia River estuary. Some restoration features, such as tidegates and Shillapoo Lake, will require periodic O&M but those actions are not dissimilar to those ongoing in the many diking districts that have existed in the estuary since the early 20th century. Thus, they are perceived as relatively stable, long lasting, productive features.

These restoration features also represent important contributions to the recovery of ESA-listed and proposed salmonid stocks in the Columbia River. Wetland and riparian habitats have significantly declined along the lower Columbia River since the 1880s because of agricultural and urban/industrial development. While much has been done to improve salmon passage at Columbia River dams, relatively little has been done to improve juvenile salmonid rearing habitat and therefore, survival on the Columbia River below the dams. The restoration of 2,200 acres of tidal marsh habitat with its associated long-term productivity represents a substantial effort to recapture the juvenile salmonid rearing capability formerly associated with the estuary.

Table S4-8 provides information on type, function, value and area impacted by all of the proposed ecosystem restoration features currently included in the project.

Figure S4-7. Fish Passage Improvements at Tidegates

COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT

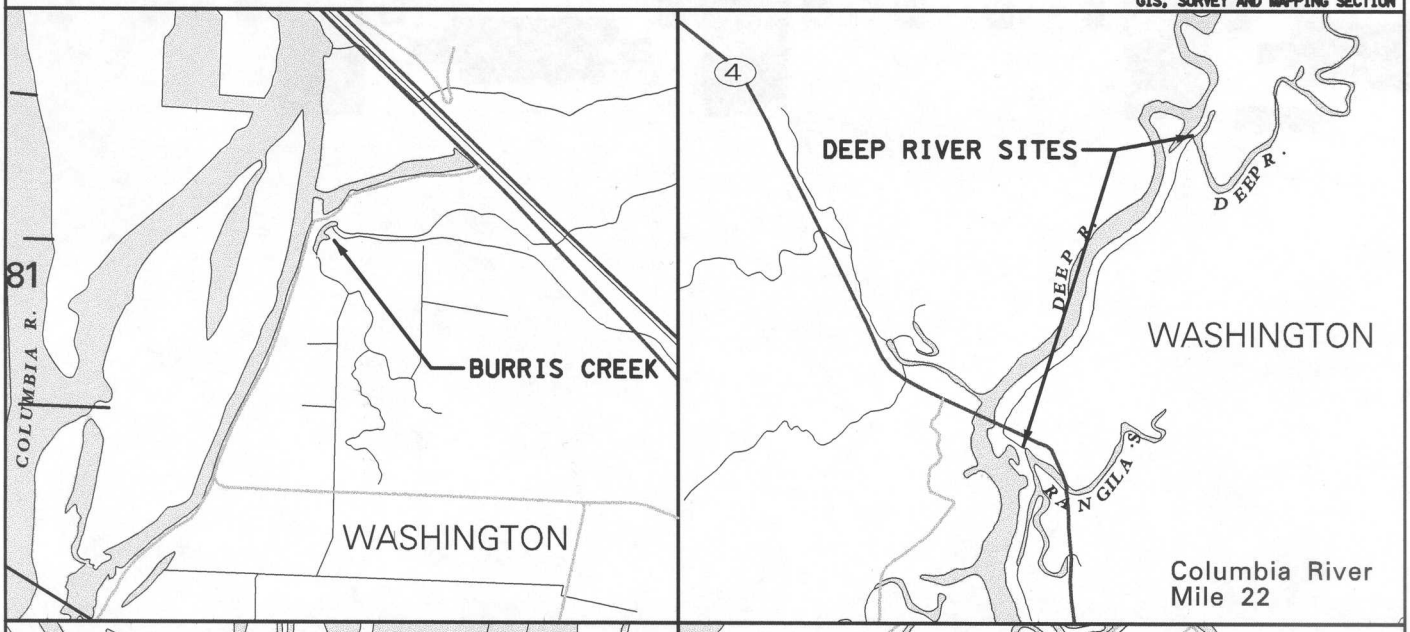
FISH PASSAGE IMPROVEMENTS AT TIDEGATES

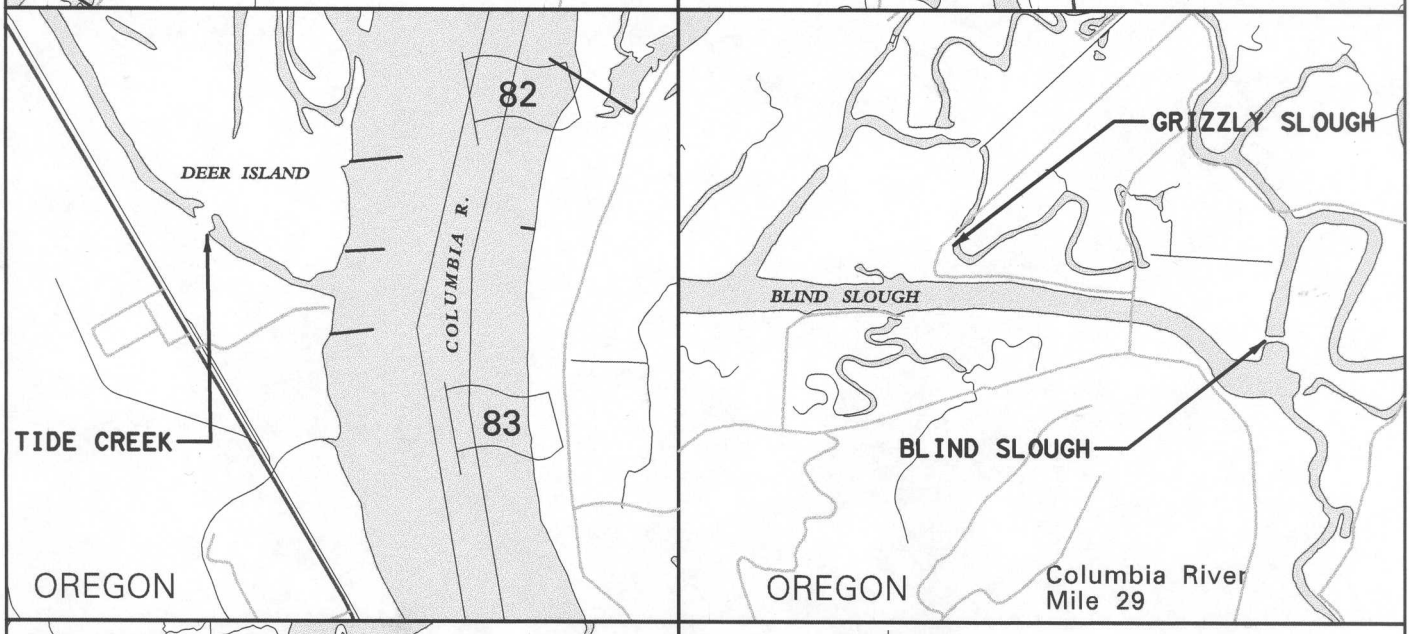
N

1000 0 1000 3000

SCALE IN FEET

GIS, SURVEY AND MAPPING SECTION





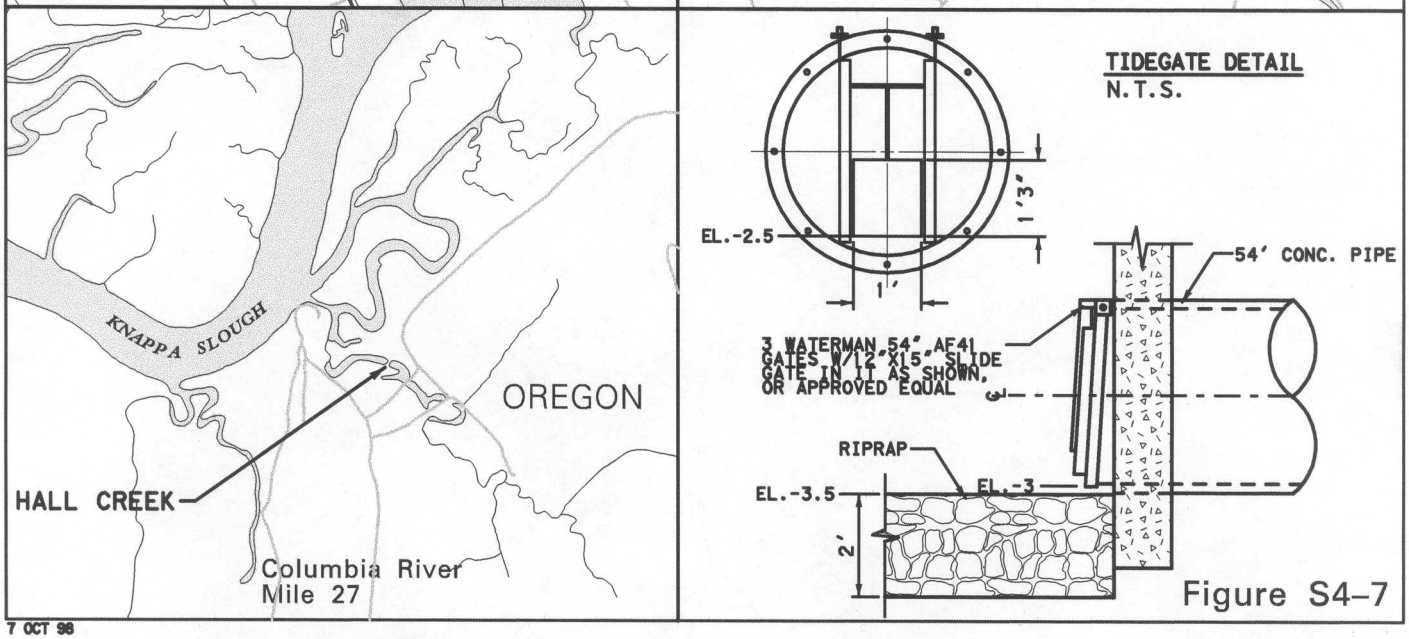


Figure S4-7

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Table S4-8. Ecosystem Restoration Features

Feature	Area Affected by Restoration	Type, Function, and Value
Lois Island Embayment Habitat Restoration	191 acres	Type: Tidal marsh habitat Function: Provide rearing habitat for ocean-type salmonids; increase detrital export Value: High
Purple Loosestrife Control Program	CRM 18-52	Type: Tidal marsh Function: Maintain native Tidal marsh plant community; increase detrital export Value: High
Miller-Pillar Habitat Restoration	235 acres	Type: Tidal marsh and flats habitat Function: Provide rearing habitat for ocean-type salmonids; increase benthic invertebrate productivity Value: High
Phase 1: Tenasillahe Island Interim Restoration[1] (Tidegate/Inlet Improvements)	92 acres	Type: Backwater/side channel reconnection to Columbia River Function: Increase access/egress for ocean-type salmonids Value: Moderate
Phase 2: Cottonwood-Howard Island Proposal[2] Columbian white-tailed Deer Introduction	650 acres (Columbian white-tailed deer; 60 acres tidelands)	Type: Translocation of Columbia white-tailed deer Function: Establish secure, viable subpopulation of Columbian white-tailed deer Value: High
Phase 3: Tenasillahe Island Long-term Restoration[3] (Dike Breach)	1,778 acres	Type: Tidal marsh/swamp; shallow water/flats habitat Function: Provide rearing habitat for ocean-type salmonids; increase detrital export Value: High
Tidegate Retrofits for Salmonid Passage (1999 Final IFR/EIS)	38 miles	Type: Tributary reconnection to Columbia River Function: Increase access/egress for ocean-type salmonids; improve access for adults to headwaters for spawning Value: High
Walker-Lord and Hump-Fisher Islands Improved Embayment Circulation (1999 Final IFR/EIS)	335 acres	Type: Marsh/swamp; shallow water/flats habitat Function: Provide rearing habitat for ocean-type salmonids; increase benthic invertebrate productivity Value: Moderate
Bachelor Slough Restoration[4]	85 ac. (instream restoration); 6 ac. (Bachelor Slough riparian restoration); 46 ac. (riparian restoration using Bachelor Sl. sediments - old disposal location and 2 add'l upland locations)	Type: Shallow water/flats habitat; riparian forest Function: Provide rearing habitat for ocean-type salmonids; increase detrital export Value: Moderate (side channel); high (riparian forest)
Shillapoo Lake Restoration[5] (1999 Final IFR/EIS)	470-839 (acreage restored depends on private land acquisition and prior restoration by others	Type: Managed wetlands Function: Increase waterfowl, shorebird, wading bird, and raptor habitat Value: High

Notes: The Tidegate Retrofits for Salmonid Passage, Walker-Lord and Hump-Fisher Islands Improved Embayment Circulation, and Shillapoo Lake Restoration features were proposed in the Final IFR/EIS. The remaining restoration features were added during the ESA consultation process.
[1] This restoration is contingent on hydraulic analysis results.
[2] This restoration primarily benefits Columbian white-tailed deer.
[3] This restoration feature is contingent on the delisting of Columbian white-tailed deer.
[4] This restoration feature is contingent on sediment testing and approval by WDNR.
[5] This restoration primarily benefits waterfowl, but would create detrital input to the Columbia River.

4.8.6. [new] Additional Ecosystem Restoration Features

This new subsection for the Final SEIS addresses the ecosystem restoration features developed during the ESA consultation process. It also reflects modifications to the Lois Island embayment and Miller-Pillar ecosystem restoration features developed in response to comments on the Draft SEIS and in conjunction with state and federal resource agencies.

Pursuant to Section 7(a)(1) of the ESA, the federal agency (Corps), "shall utilize their authorities in furtherance of the purposes of this chapter by carrying out programs for the conservation of endangered species and threatened species" [16 U.S. Code §1536(a)(1)]. These actions are measures that the Corps, with the assistance of the NOAA Fisheries and USFWS, has determined to be important to aid in the recovery of listed salmonids and, in some cases, address habitats that were the subject of much discussion and analysis during the consultation process. Columbian white-tailed deer and bald eagles also would benefit from some of the proposed ecosystem restoration features.

The Corps, USFWS, and NOAA Fisheries developed lists of potential ecosystem restoration alternatives during the ESA consultation. The USFWS list was based on information received from managers of the Julia Butler Hansen and Lewis and Clark National Wildlife Refuge, and the Ridgefield National Wildlife Refuge. The information pertained to acreage, habitats, and species that would benefit from the potential restoration alternatives. The NOAA Fisheries suggested that consideration be given to the list that was developed at the 2001 Lower Columbia River and Estuary Habitat Conservation and Restoration Workshop. All of these potential alternatives were evaluated based on a set of criteria that included habitat type, function and value to the species; location; implementability; and land acquisition requirements. The agencies agreed that the ecosystem restoration features proposed for addition to the project best fit the set of criteria.

The Corps proposes to implement these ecosystem restoration features under Section 7(a)(1) of the ESA. They will be cost-shared by the sponsor ports and are considered part of the project. The restoration features will create or improve salmonid habitats, specifically tidal marsh and shallow water/flats habitats plus certain features provide benefits to bald eagles and Columbian white-tailed deer.

In addition to the original ecosystem restoration features in the 1999 Final IFR/EIS (Shillapoo Lake, tidegate retrofits and improved embayment circulation), the Corps proposes to implement additional restoration features: Lois Island Embayment Habitat Restoration, Purple Loosestrife Control Program, Miller-Pillar Habitat Restoration, Tenasillahe Island Tidegate/Inlet Improvements (interim action) and Dike Breach (long-term action), Cottonwood-Howard Island Columbian White-tailed Deer Reintroduction, and Bachelor Slough Restoration. Tenasillahe Island interim and long-term actions, plus Cottonwood-Howard Island Columbian White-tailed Deer Reintroduction are discussed as phased actions of one overall feature below due to their interrelationship. The interim action at Tenasillahe Island is contingent on hydraulic engineering analyses demonstrating its feasibility and that no adverse impacts would occur to Columbian white-tailed deer.

Implementation of the long-term action at Tenasillahe Island is contingent on delisting of Columbian white-tailed deer and the determination that such actions are compatible with the purposes and goals of the refuge. The Cottonwood-Howard Restoration also is contingent on site acquisition by the sponsor ports. The Bachelor Slough Restoration is contingent on securing easements from the WDNR and sediment testing results that are below established threshold limits for contaminants. The additional restoration and evaluation actions are described in the following subsections.

4.8.6.1. [new] Lois Island Embayment Habitat Restoration

This ecosystem restoration feature is located between Lois and Mott Islands in the Columbia River estuary (CRM 19-20; Figures S4-3 and S4-4). Approximately 191 acres of tidal marsh habitat will be restored as described in section 4.4.3.10 (*Disposal Plan Modifications Following Consultation*; Figures S4-2 and S4-3). The embayment between Lois and Mott Islands was dredged during the World War II era to provide moorage for decommissioned naval ships. Prior to construction of the embayment, the area contained intertidal mudflats and shallow subtidal flats plus a centralized subtidal channel 12-18 feet in depth running from northwest to southeast across much of the area. The average depth of the area was minus 5-6 feet with substantial area above zero feet in elevation [Columbia River Estuary Data Development Program (CREDDP) 1983: 1935 bathymetric map]. Intertidal habitat would have ranged from -2 to 10 feet in this area of the Columbia River. Lois and Mott Islands and South Tongue Point were formed from material dredged from this location.

Post-construction of the moorage area, an embayment with rough dimensions of 3,750 feet by 4,375 feet was formed, with depths ranging from 12-30 feet and averaging 25-26 feet (CREDDP 1983). The eastern portion of the embayment is wider and juts slightly into Lois Island. By 1982 (CREDDP 1983: 1982 bathymetric map), depths in the embayment were approximately 21 feet on average, ranging from 18-24 feet. Lois and Mott Islands have developed narrow, fringing intertidal marsh habitat post-dredging on their interior shorelines bordering the embayment. Bathymetry for Lois Island embayment obtained in 2002 demonstrates that the majority of the 191-acre area proposed for this ecosystem restoration feature is 20-22 feet deep. There is also a substantial area along the Lois Island shoreline that is 10 feet or less in depth. A small portion of the restoration area near the center of the feature is 24-26 feet deep (see Figure S4-3).

The restoration feature includes restoration of the area to tidal marsh habitat elevations using dredged material from the Columbia River navigation channel. The target elevation for this habitat would be based upon surveyed reference elevations in adjacent tidal marsh habitat to maximize the potential success of the development. The original feature proposed for Lois Island embayment entailed restoration of shallow subtidal habitat to mimic pre-moorage conditions at this location. Comments on the Draft SEIS and subsequent discussion with the resource agencies led to the determination that tidal marsh-intertidal flat habitat was preferred over shallow subtidal habitat because of the significant historical losses of the former habitat and abundance of the latter. Thus, the Corps modified the ecosystem restoration feature accordingly. Disposal operations will be comparable although the target elevation for the new habitats is at an increased elevation.

The tidal marsh habitat proposed for restoration is more productive than the current, moderately deep, subtidal habitat. Gross benthic productivity for the fringing intertidal mudflat habitat at the embayment was 31-46 grams of carbon per square meter per year (CREDDP 1983), which is comparable to other highly productive intertidal mudflat habitat in Cathlamet Bay. Tidal marsh plant density at South Tongue Point was slightly above average for Cathlamet Bay (CREDDP 1983).

Cates (1983) conducted fish sampling operations in the Tongue Point area in 1979 and again in 1981. Five of his seven sampling locations were within the Lois Island embayment. These sampling locations were just beyond the intertidal marsh/mudflat interface on the periphery of the embayment. Cates (1983) captured 14 species, including four anadromous salmonids (chinook salmon, coho salmon, chum salmon, and cutthroat trout) in 1981, the year for which he provided the most detailed results. Chinook salmon were the most abundant salmonid captured in 1981, 3,411 individuals of the 3,619 salmonids captured (94%). Chinook salmon juveniles were present in the area from March to late August, with peak abundance in May. Based on their size and period of occurrence, most of the fish captured were subyearling fall chinook salmon.

Chum salmon (147 fish), coho salmon (61 fish), and cutthroat trout (2 fish) were of lesser abundance based on beach seine results. Cates (1983) indicated that chum salmon were thought to be of wild origin as their occurrence preceded hatchery releases. He also captured juvenile chinook and coho salmon with coded wire tags at Tongue Point sampling locations. These included chinook salmon from the Klaskanie River, which empties into Youngs Bay immediately downstream of Astoria, and one coho salmon from the Grays River, Washington. These captures were an indication of upstream movement of chinook salmon to the Tongue Point area for estuarine rearing and cross-river movement for coho salmon.

Tongue Point waters and the embayment are used to harvest salmon through the Select Area Fishery program. Juvenile salmonids are reared currently in net pens located at the old Corps dock at South Tongue Point, then released as smolts into the estuarine waters at Tongue Point/Lois Island embayment to which they will return as adults. Commercial gill netting also occurs for sturgeon in the embayment. Sport fishing in the embayment is limited. Most sport fishing boats that launch from the nearby John Day boat ramp fish for sturgeon on the channel side of Mott Island and off Tongue Point proper.

Emmett et al. (1986) investigated benthic invertebrates in Cathlamet Bay, including the embayment between Lois and Mott Islands. They identified 28 benthic invertebrate species or groups (order, family, genus) as occurring within the embayment. Eight species [*Cumacea*, *Corophium salmonis*, *Harpacticoida, Helidae* (larvae), *Insecta, Diptera* (adult), *Scottolana canadensis,* and *Chironomid*] are preferred prey resources of juvenile salmonids. The sampling occurred at depths of 16-20 feet. These species also are expected to be present in the intertidal mudflat habitat that would be present after restoration.

The area for the restoration is approximately 191 acres. It runs from approximately the mid-point of the southern portion of Lois Island on a northwest-bearing line to Mott Island. The inner channel from John Day Point along South Tongue Point to Tongue Point and

approximately 166 acres of the embayment would not be affected by the restoration. The edge of the restoration area is about 3,000 feet off the South Tongue Point shoreline. See Subsection 4.4.3.10 for a description of the activities that would occur to create this ecosystem restoration feature. The Corps will:

- Fund and implement construction effort, and
- monitor post-construction benthic productivity and fish species composition and density on the restoration site and an adjacent control site.

4.8.6.2. [new] Purple Loosestrife Control Program

This ecosystem restoration feature will implement an integrated pest management approach, including bio-control of purple loosestrife in the Columbia River estuary (CRM 18-52). Purple loosestrife is an introduced exotic plant that is spreading throughout emergent tidal marshes in the Columbia River estuary. Native vegetation such as Lyngby's sedge, tufted hair grass, and softstem bulrush are being displaced. Currently more than 10,000 acres of estuarine tidal marsh are infested, although the degree of infestation varies widely among locations. Large, dense stands, totaling perhaps 300 acres, are found at Karlson Island (CRM 26), Miller Sands (CRM 22.5), and North Wallace Island (CRM 50).

Loosestrife densities range from light (a few scattered plants) to moderate in other areas of the estuary. Given its history in other regions of North America, it is likely that loosestrife, if left unchecked, will dominate the emergent marsh habitat of the estuary to the exclusion of native vegetation. This would greatly reduce biological diversity and negatively affect most estuarine wildlife, including salmonids and other native fish, waterfowl, water birds, shorebirds, neotropical migrant birds, bald eagles, native mammals, and amphibians.

Purple loosestrife occurs in the vegetated, upper intertidal marsh zone. Typically, marsh vegetation in this zone is very dense and tall during the summer growing season and vegetative covers remains well into the fall. Incised tidal channels bisect the intertidal marsh habitat. Juvenile salmonid utilization is primarily associated with these incised tidal channels and the vegetative zone on their perimeter during high tides. Juvenile salmonid use of the densely vegetated intertidal marsh habitat is considered relatively minimal due to the dense vegetation. Presence of juvenile salmonids in intertidal marsh habitat probably coincides with the primary out-migration period, principally spring and early summer.

Purple loosestrife control efforts using the herbicide Rodeo©, a USEPA-registered herbicide approved for over-water application, would be targeted for application from June to October. Application would follow label instructions and would occur during low tide periods when the plant is exposed. Rodeo© would be wicked onto the plants (dispersal of herbicide through direct contact between plant and fabric containing with Rodeo herbicide) and spot sprayed when the plants are actively growing. Translocation of the herbicide throughout the plant would occur and result in a lethal effect. Although application of herbicide during the in-water work period (November 1-February 28) has been suggested, it would be ineffective because plants would be dormant and difficult to recognize given the loss of above ground vegetative structure.

Wicking the herbicide onto the plants results in a target specific application with minimal transfer to non-target species and would be used when plants are sparsely distributed and occur as individuals or small clusters of individuals. Spot spraying would be used for denser populations of plants, as it is more efficient relative to time and coverage. Given the considerable acreage involved and the intertidal nature of the marsh habitats, there is only a limited timeframe both seasonally and daily for implementation of herbicide and/or mechanical treatments. Complete spraying of blocks of intertidal marsh is not proposed. Spot spraying and wicking will limit the total amount of herbicide applied as compared to a complete (full coverage) spraying operation.

The ongoing effort to establish bio-control in the Columbia River estuary for purple loosestrife will be supported and expanded, as warranted, by implementation of this feature. Concurrent with the control operation, evaluation actions will be conducted to determine geographic spread and plant density of purple loosestrife, and to evaluate efficacy of integrated pest management actions. The Corps with assistance from USFWS and sponsor ports will provide:

- Project funding for field implementation of survey and control actions, including equipment and personnel expenses, for a 5-year period.
- All necessary coordination with local, state, and federal government agencies to accomplish the effort.
- Annual and final reports describing the nature and extent of the effort and results.

4.8.6.3. ^{new} Miller-Pillar Habitat Restoration

This ecosystem restoration action is located between Miller Sands and Pillar Rock Islands in the Columbia River estuary (CRM 25-26; Figure S4-5). Approximately 235 acres of tidal marsh-intertidal flat habitat will be restored as described in section 4.4.3.10 (*Disposal Plan Modifications Following Consultation*). Natural processes are currently eroding material south of the navigation channel and redepositing the material in the navigation channel. This erosive action has been occurring since 1958 at an average annual rate of approximately 70,000 cubic yards. The erosion is affecting productive, shallow water and flats habitat (0 to 5.9 feet CRD) and converting the area to less productive, deep subtidal habitat (a minimum depth of 24.9 feet CRD; Hinton et al. 1995).

The original feature proposed for Miller-Pillar entailed restoration of shallow subtidal habitat to mimic historic conditions at this location. Subsequent discussion with resource agency representatives led to the determination that tidal marsh-intertidal flat habitat was preferred over shallow subtidal habitat because of the significant historical losses of the former and abundance of the latter habitat. Thus, the Corps has modified the ecosystem restoration feature accordingly. Disposal operations will be comparable although the target elevation for the new target habitats is at an increased elevation. Pile dikes to retain the dredged material will still be required.

Restoration of the erosive area to a productive, tidal marsh and intertidal flats habitat can be accomplished by placement of dredged material at the location to mimic substrate elevations in the adjacent Miller Sands tidal marsh-intertidal flat habitat. Approximately 5.5 mcy of material will be placed at this location to attain the habitat objectives. Dredged material used would be comparable to *in situ* materials. Dredged material retention will require the construction of pile dikes to reduce water velocities, preclude erosion and thus maintain the desired substrate elevations. Snag Island, immediately south of the proposed Miller-Pillar location, features pile dikes and associated tidal marsh-intertidal flat habitat. Three pile dikes would be constructed during the initial construction phase of the project.

Monitoring of the habitat restoration feature would begin upon completion of the first cell between the downstream most pile dikes. The interagency AMT would review monitoring results and recommend any necessary modifications to the habitat restoration feature to attain the desired results. The attainment of successful results and the completion of the first two cells would trigger construction of the last two pile dikes and completion of the necessary fill actions for the upstream two cells.

Concerns were previously raised that construction of pile dikes would create perches that aid bird predation of juvenile salmonids, particularly by double-crested cormorants. To address this concern, the Corps has placed bird excluders on top of numerous Columbia River estuary pile dikes. These excluders are placed on top of pilings and spreaders on pile dike structures to preclude perching. In 2000 and 2001, Oregon State University researchers monitored these devices and their efficacy in precluding cormorants. The monitoring indicates that the bird excluders effectively preclude cormorants from perching on pile dikes, and also significantly reduces the number of cormorants foraging in the water column in the vicinity of the pile dikes. See Subsection 4.4.3.10 for a description of the activities that would occur to create this ecosystem restoration site. The Corps with the assistance of the sponsor ports will:

- Fund and implement the construction effort.
- Monitor post-construction benthic productivity and fish species composition and density on the restoration site and an adjacent control site.
- Operate and maintain pile dikes and associated bird excluders for project life.

4.8.6.4. [new] Tenasillahe Island Phased Restoration

Three specific, phased actions are associated with this ecosystem restoration feature; Tenasillahe Island interim, reintroduction of Columbian white-tailed deer at Cottonwood-Howard Island and the long-term restoration action at Tenasillahe Island. The two interim and long-term actions, which would occur on Tenasillahe Island, are shown on Figures S4-8 and S4-9. The interim action would be directed at improving connectivity and water exchange between sloughs and backwater channels interior to the flood control levees that encompass Tenasillahe Island and the Columbia River. For the long-term action, the levees would be breached to restore full tidal circulation to former intertidal marsh/mudflat and forested swamp habitats.

Figure S4-8. Tenasillahe Island Interim Ecosystem Restoration Feature

Tenasillahe Islands

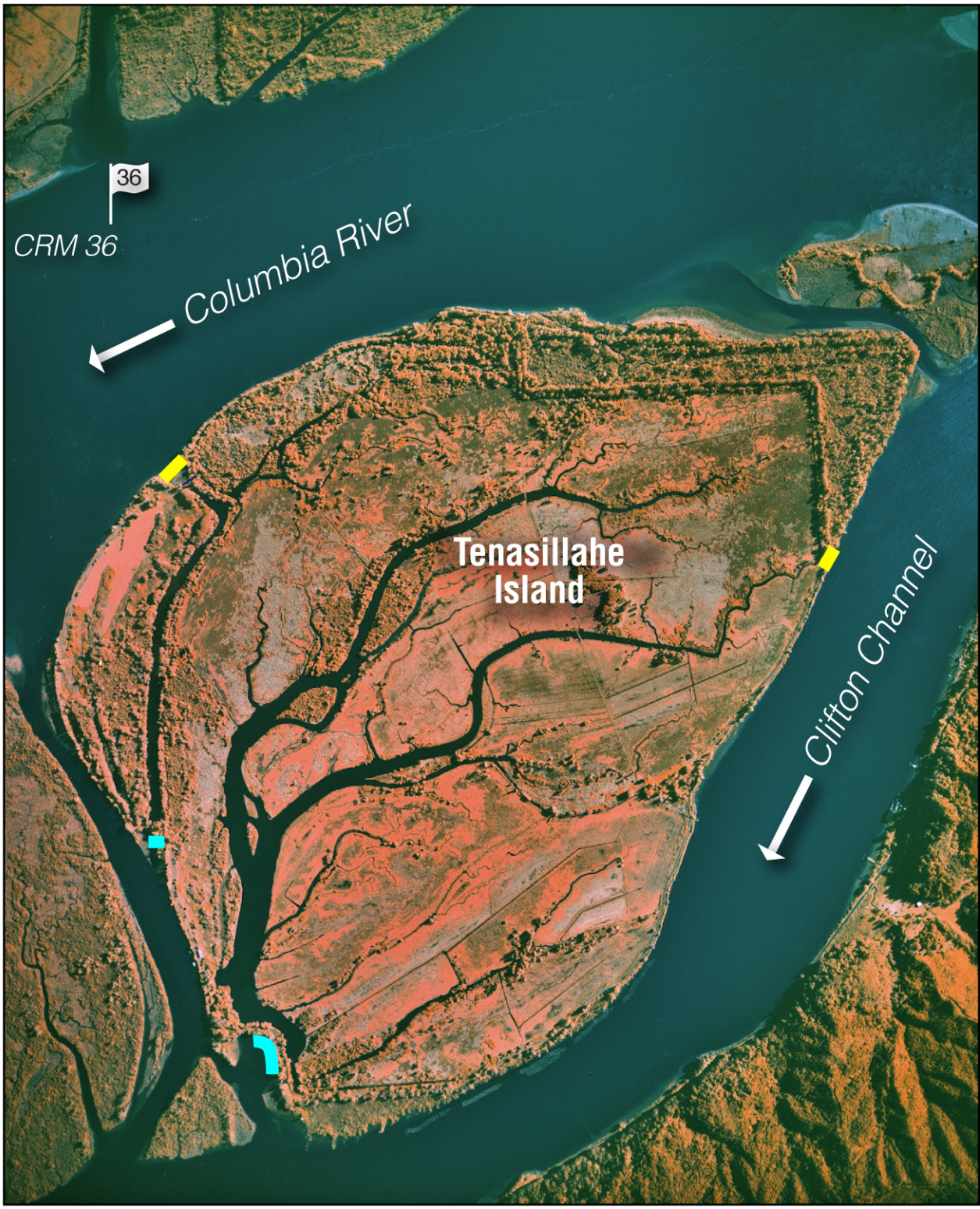


Figure S4-8 Tenasillahe Island Phase 1 - Interim Ecosystem Restoration Feature

Figure S4-9. Tenasillahe Island Long-term Ecosystem Restoration Feature

Tenasillahe Islands

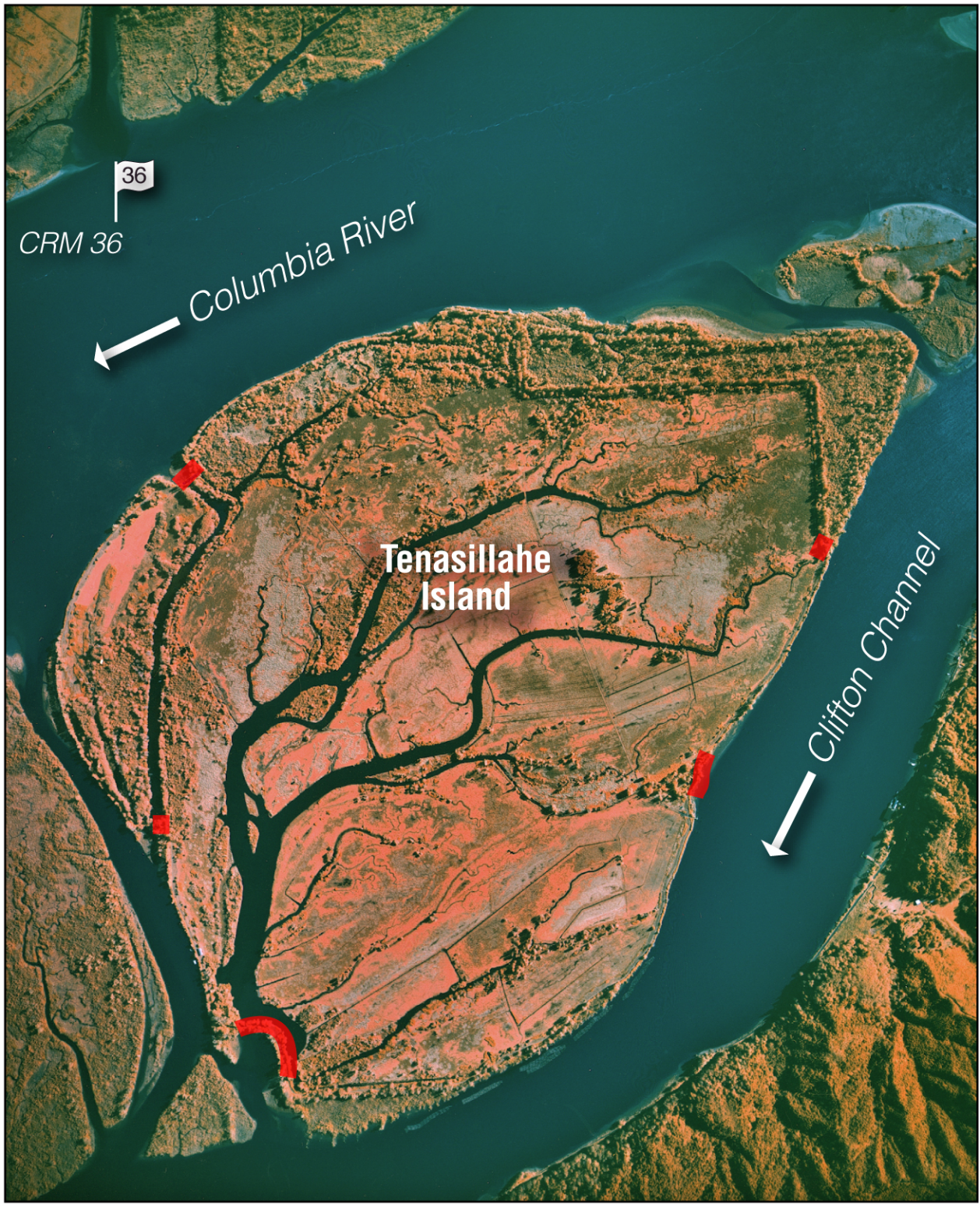


Figure S4-9 Tenasillahe Island Phase 3 - Long-Term Ecosystem Restoration Feature

Interim improvements to tidegates and provision of controlled inlets to improve water movement and accessibility for juvenile salmonids would be implemented only if hydraulic engineering analyses determine that any improvement will not compromise habitat integrity for Columbian white-tailed deer that inhabit Tenasillahe Island.

For the long-term action, the levees on Tenasillahe Island would be breached to restore full tidal circulation to approximately 1,778 acres of former intertidal marsh/mudflat and forested swamp habitats. Implementation of this action is contingent on delisting of the Columbian white-tailed deer and determination that such actions are compatible with the purposes and goals of the refuge, to include restoration of intertidal marsh/mudflat and forested swamp habitat for ESA Critical Habitat for salmonids.

Tenasillahe Island is a large natural island in the Columbia River estuary between CRM 35 and 38 and immediately downstream of Puget Island. Actions to place levees around the bulk of the island began around 1910. Currently, about 1,778 acres of Tenasillahe Island are protected from inundation by the Columbia River. A flood protection levee encompasses the majority of the island except for a parcel at the upstream tip. Tidegates, located at the downstream tip of the island, drain interior waters to Clifton Channel. Prior to construction of the levees, the island was primarily intertidal in nature, with three major and numerous minor natural drainage channels bisecting the island. Intertidal marsh and mudflats, subtidal channels, and forested swamp historically would have been the principal fish and wildlife habitat on the island. Juvenile salmonids use of this historical habitat was likely extensive given the large extent of subtidal channels. The intertidal marsh and mudflat habitat would have supported substantial populations of various waterfowl and shorebirds, plus many other species, and would have exported considerable detritus to the Columbia River estuary.

Tenasillahe Island is currently a component of the Julia Butler Hansen Columbian White-tailed Deer National Wildlife Refuge. The island is managed to provide habitat for the deer, a federal endangered species. The levees, tidegates, and other associated infrastructure are maintained to aid in deer management. Interior lands are primarily maintained as wet pastures through mowing and grazing activities to provide adequate quantity and quality of forage for the deer.

The USFWS recovery goal for Columbian white-tailed deer is a minimum of 400 deer occurring in three secure and viable subpopulations (e.g., 50 deer with 32 breeding adults). There are currently four recognized subpopulations of white-tailed deer located at Tenasillahe Island, Oregon, private lands around Westport, Oregon, the mainland portion of the Julia Butler Hansen Refuge (Washington), and Puget Island, Washington. However, only the subpopulations on the Julia Butler Hansen Refuge and Tenasillahe Island are considered secure and viable since both are refuge lands owned by the USFWS. Consequently, one additional secure and viable population is required to meet the recovery plan goal. Prior to implementation of the long-term restoration feature at Tenasillahe Island, two additional secure and viable populations of Columbian white-tailed deer would have to be established. The reintroduction of Columbian white-tailed deer to Cottonwood-Howard Island, plus ongoing USFWS reintroduction efforts at Crims Island and Fisher Island, represent attempts to establish additional secure and viable populations of this deer.

Phase 1–Tenasillahe Island Interim Restoration Action. This action includes retrofitting tidegates and introduction of Columbia River flows to the heads of two sloughs in order to reintroduce juvenile salmonids to the interior sloughs and assure their viability. Tidegates would be retrofitted with aluminum doors or other suitable structures to allow fish access and egress over longer periods of time and tidal flows. Controlled inlet structures could be placed at the heads of sloughs to allow for ingress of Columbia River waters, thus drawing juvenile salmonids into the slough system. About 92 acres of backwater channel habitat would be affected by this interim action to improve tidegates for fish access/egress and to install water control structures to improve flow and circulation.

Implementation of this action would occur in the August-September timeframe. Although outside the in-water work period for the Columbia River, the proposed timeframe would allow construction when levees are dry and firm, thus minimizing sediment runoff. Further, interior waters of the Tenasillahe Island sloughs would be too warm for salmonid use at that time, thus lessening the potential for impacts to juvenile salmonids that had managed to enter the system through the current tidegates.

The north interior slough that separates the main portion of Tenasillahe Island from the small island abutting the Multnomah Slough and the Columbia River could be improved by placement of a controlled inlet structure at the Columbia River and improvements to the tidegates at Multnomah Slough. The headwaters of the main western slough channel, in the interior of Tenasillahe Island, are adjacent to Clifton Channel. Historically, there was a pump house and tidebox at this location. The tidebox is no longer functional. A controlled inlet could be constructed at this location for importation of Columbia River flows and thus, juvenile salmonids. Similar to the north slough, improvements to the tidegates would be required to ensure flows are exhausted and juvenile salmonids can readily exit the system. The Corps with the assistance of the sponsor ports will:

- Conduct hydraulic engineering analyses of inlet and tidegate structures to ensure water control structures are of sufficient design and capacity to safeguard Columbian white-tailed deer habitat interior to the main flood control levees.
- Fund and implement construction efforts for the interim action.
- Monitor post-construction benthic productivity and fish species composition and density on the restoration site and an adjacent control site.
- Prepare annual reports of post-construction results to the AMT (includes the Corps, NOAA Fisheries, USFWS, and sponsor ports).

Phase 2–Reintroduction of Columbian White-tailed Deer to Cottonwood-Howard Islands. This restoration action is intended to provide secure habitat for Columbian white-tailed deer (Figure S4-10). Securing habitat at Cottonwood-Howard Islands allows Columbian white-tailed deer to be moved from elsewhere in their range so that Tenasillahe Island can ultimately be restored to tidal marsh habitat with inherent benefits for salmon, waterfowl, shorebirds, and many other species. This restoration action, located at CRM 68-71.5, will occur on the remainder of the Port-owned lands (outside the disposal site boundaries).

Figure S4-10. Phase 2–Reintroduction of Columbian White-tailed Deer to Cottonwood-Howard Islands

Howard and Cottonwood Islands

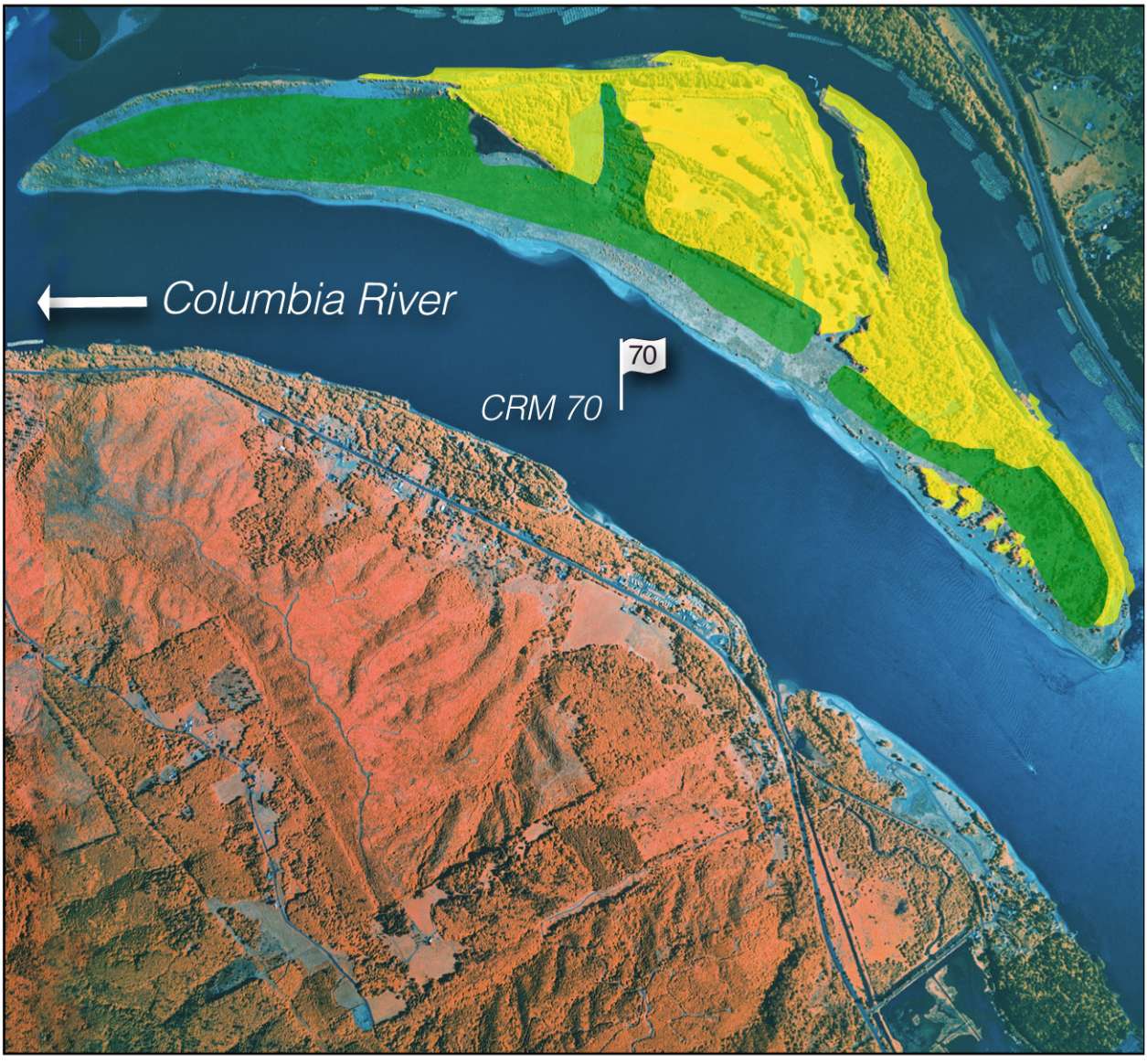


Figure S4-10 Tenasillahe Island Phase 2 - Reintroduction of Columbian White-tail Deer to Cottonwood-Howard Islands

There are approximately 650 acres at Cottonwood-Howard Islands outside the disposal site boundaries for preservation as Columbian white-tailed deer habitat. Approximately 60 acres of tidal lands would also be acquired. Riparian forest currently exists in a relatively large block on the Carroll's Channel side of the island. Buffer zones (300 feet wide per agreement with NOAA Fisheries) have been established around the selected disposal sites to allow for natural development of riparian forest. Given the large size of these islands, which are presently joined as one island, and the presence of large blocks of riparian forest, the re-introduction of Columbian white-tailed deer is considered viable at this location. Post-introduction monitoring will be required to determine the success of the re-introduction and whether a secure, viable population of Columbian white-tailed deer has been established. Those areas designated for dredged material disposal and access of dredging-related equipment in the 1999 Final IFR/EIS will be retained for that category of use for the life of the project. Only lands exterior to the designated disposal site will be considered for restoration purposes. The Corps with the assistance of the sponsor ports will provide:

- Land acquisition.
- Funding of 50 percent of translocation costs for deer.

The USFWS will provide:

- Funding of 50% of translocation costs for deer.
- All actions necessary to accomplish translocation of Columbian white-tailed deer to Cottonwood-Howard Island, including NEPA/ESA coordination.
- Habitat operations and maintenance.
- Monitoring efforts to assess Columbian white-tailed deer translocation, including preparing an annual report for the AMT.

Phase 3–Tenasillahe Island Long-term Restoration Action. This action includes restoring Tenasillahe Island to its historical habitat mix. It is contingent on obtaining two (for a total of three) secure and viable Columbian white-tailed deer habitat sites. Options include obtaining lands in the subpopulation areas previously identified and possible acquisition of lands and habitat development at Lord-Walker, Fisher-Hump, and/or Cottonwood-Howard Islands (Cottonwood-Howard is discussed above). These deer habitat acquisition actions are proceeding at various paces and entail a number of governmental resource agencies and non-governmental organizations acting independently of this project. However, the time frame for obtaining two additional secure and viable white-tailed deer habitat sites is unknown.

Obtaining three secure and viable subpopulations of Columbian white-tailed deer, not to include Tenasillahe Island, would provide an excellent opportunity to restore 1,778 acres of ESA critical habitat for salmonids in the Columbia River estuary. The restoration action requires removal of the downstream plugs on the interior drainage channels and reconnection via open channels of historical upstream connections. Construction actions could be easily implemented in a short timeframe at a minimal cost. The Corps with the assistance of the sponsor ports will:

- Develop a plan to remove downstream plugs on the interior drainage channels and reconnect upstream connections via open channels through the flood control dike when Columbian white-tailed deer are delisted.
- Monitor post-construction benthic productivity and fish species composition and density on the restoration site and an adjacent control site.
- Submit annual reports of post-construction results to the AMT.

4.8.6.5. [new] Bachelor Slough Restoration

Implementation of the Bachelor Slough ecosystem restoration feature is contingent on the Corps' evaluation of sediment chemistry to determine suitability for upland disposal and approval by WDNR and/or the USFWS to dispose of dredged material on their property. Sediment sampling to determine contaminant levels is planned in federal Fiscal Year 2003. Backwater channels are more likely to contain fine-grained sediments (silts) with a high organic content and a greater likelihood of contaminants (e.g., PCBs, DDT, DDE) than the coarser-grained sands with low organic content found in the main navigation channel. If sediment samples fail to meet established thresholds, or an upland dredged material disposal site on Bachelor Island is unavailable, this restoration feature would not be implemented.

Two principal actions compose this restoration proposal feature: improving in-stream salmonid habitat and restoration of riparian habitat (Figure S4-11). The first action was proposed by the USFWS Ridgefield National Wildlife Refuge and includes dredging of Bachelor Slough to increase depth and through flow of Columbia River waters in order to restore and improve in-stream salmonid habitat. Increased depth and flow should also address water temperatures in Bachelor Slough, which currently exceed the temperature tolerance of salmonids from mid-summer until fall. The second action includes the restoration of riparian forest habitat on about 6 acres of Bachelor Slough shoreline, primarily downstream of the bridge crossing; and establishment of up to 46 acres of riparian forest on the upland disposal site(s).

The Bachelor Slough restoration feature is located within the boundaries of the Ridgefield National Wildlife Refuge near Ridgefield, Washington. Bachelor Slough is a 2.75-mile-long side channel of the Columbia River, branching off the mainstem at CRM 91.5. The slough empties into Lake River, which opens into the Columbia River at CRM 87.5. Bachelor Slough delineates the east boundary of Bachelor Island. The instream action would affect 85 acres along the length of the slough. An estimated 132,000 cubic yards of material would be dredged from the slough. Bathymetric surveys will be implemented to verify dredging quantities prior to implementation of this feature. Bachelor Slough submerged lands and the upland disposal site adjacent to the Columbia River are the property of WDNR. Discussions are under way to secure appropriate use agreements from WDNR for use of their property for disposal. Two upland disposal sites on USFWS refuge lands are proposed, one adjacent to Bachelor Slough downstream of the confluence with Lake River and one adjacent to the dike near Wigeon Lake.

Figure S4-11. Bachelor Slough Ecosystem Restoration Feature

Bachelor Slough

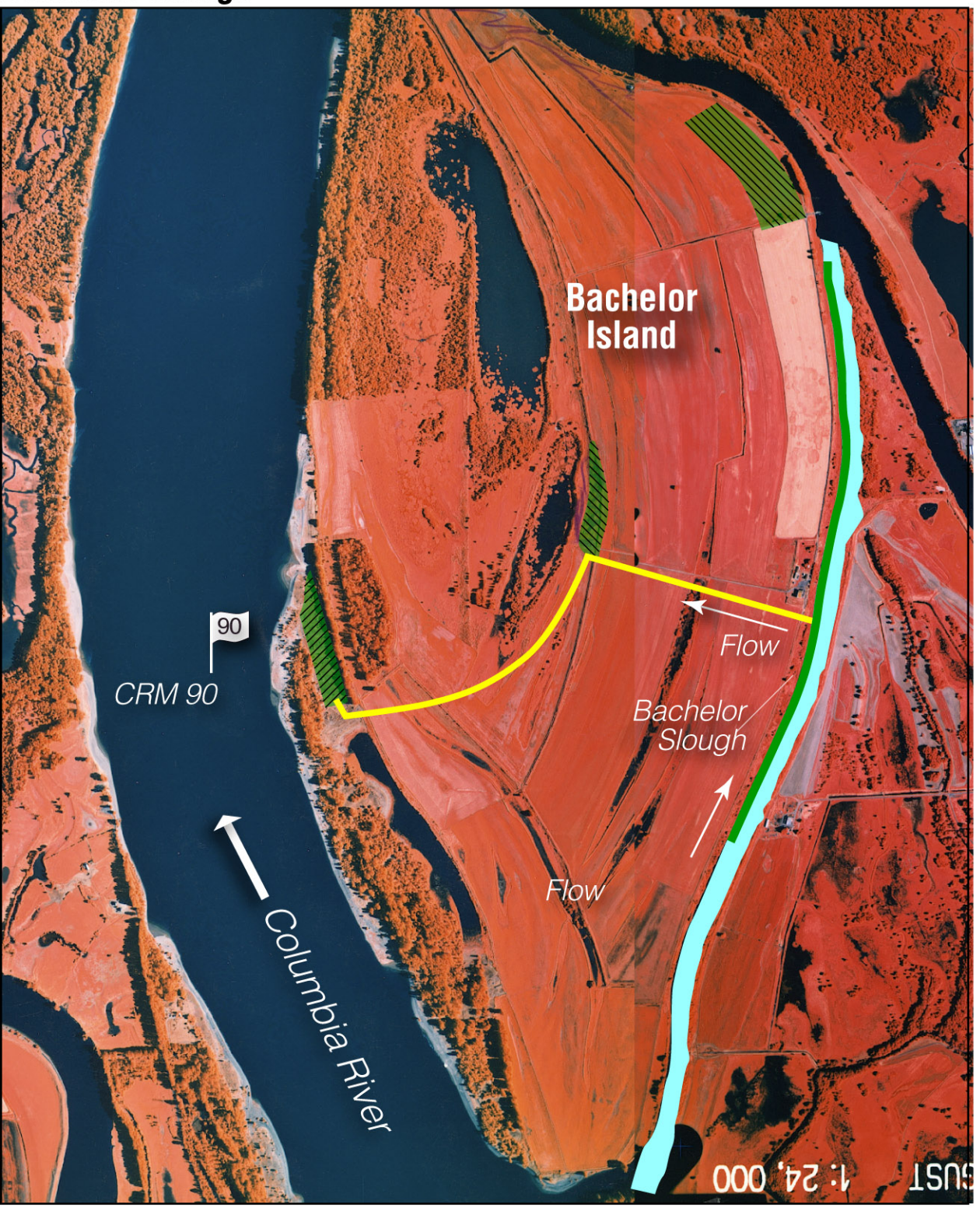


Figure S4-11 Bachelor Slough Ecosystem Restoration

The slough provides salmonid rearing habitat and possibly minor habitat for adult migration. The slough currently is heavily silted, which impedes seasonal water flow, elevates water temperatures, reduces vegetation growth, and inhibits fish passage. The restoration action will remove silt approximately 300 feet north of the slough mouth (south tip of Bachelor Island) to the north end of the slough (where it merges with Lake River). The first 300 feet of the slough mouth will not be dredged completely so as to discourage recreational boating. Recreational boating, including jet skis, is a recognized source of wildlife disturbance and erosion in the slough.

Current conditions (i.e., shallow water and minimal access at the mouth) limit boating activities to relatively small watercraft and seasonal use. Removing some silt while retaining some of the natural barriers to boat traffic will enhance fish habitat. This restoration feature also includes removing invasive tree species and reed canarygrass on about 6 acres along the Bachelor Island shoreline of the slough and establishing native willows, ash, and cottonwoods on these lands.

Dredging of Bachelor Slough would be implemented from July 1 to September 15 to comply with in-water work timeframes. Work is anticipated to be completed by a small pipeline dredge with dredged material placed in diked, upland cells with return water discharge via weirs to the Columbia River, Lake River, Bachelor Slough and/or interior lands. Potential areas for dredged material disposal include an upland portion (about 23 acres) of Bachelor Island immediately downstream of the junction of Bachelor Slough and Lake River and inland of the flood protection dike. A second location, approximately 6 acres, is an upland site adjacent to the dike near Wigeon Lake. The third location is an old dredged material disposal location on WDNR land that abuts the Columbia River at about the center of the island. This site is approximately 17 acres. The WDNR site would be prepared prior to disposal to scarify the Scots broom from the site. Low levees would be constructed from sandy dredged material that comprises the substrate of the area.

Natural establishment of riparian forest trees would be relied on for stand development on the disposal locations. The presence of bare mineral soil in May through early June during seed dispersal by cottonwoods and willows will result in natural establishment of riparian forest stands. Dredged material will provide that type of substrate. Minor tillage in spring prior to seed dispersal would be sufficient to control weeds or other competitive vegetation that may develop between disposal and spring.

The slough will be dredged to a bottom depth of approximately zero feet NGVD, with approximate slopes of 7:1 to the adjacent embankments. About 85 acres of Bachelor Slough would be dredged. The Ridgefield National Wildlife Refuge has three pump stations along Bachelor Slough. Deeper excavations will occur around these intake pumps to improve pump efficiency. Each pump intake is screened to prevent entrainment of juvenile salmonids.

Restoration of approximately 6 acres of riparian forest along the shoreline of Bachelor Slough would be implemented via scarification and sloping of the bank line. The preferred timeframe for this work would be early May and would provide for a bare soil environment

that coincides with seed dispersal by cottonwoods and willows from mid-May into June. Scarification would be used to remove the reed canary grass and false indigo bush vegetation, roots and/or rhizomes. Native shrubs (willows and red-osier dogwood) and trees that are present would be left in place. The bank line would be sloped, with side slopes as gentle as 1 vertical to 6 horizontal. Presently, there is a sharp cut bank 4 to 6 feet in height at the water's edge. Where adequate width is available outward of the levee toe, scarified vegetation will be placed in an excavated trench and buried. If inadequate width for burial and/or burial would compromise the levee's integrity, the scarified vegetative material will be hauled to an upland location and buried. Excavated soil free of vegetation would be graded into the levee or bank slope as appropriate.

This overall effort is a collaborative effort with the USFWS to create this habitat restoration feature. Involvement by the Corps and sponsor ports is limited to 5 years. At that point, maintenance of the restoration site will be performed by the USFWS. The Corps with the assistance of the USFWS and the sponsor ports will:

- Conduct sediment chemistry evaluation.
- Obtain real estate instruments in order to place materials at an upland location.
- Conduct dredging of Bachelor Slough.
- Provide initial tillage of upland dredged material disposal site, if necessary, to provide suitable substrate for riparian tree seedling establishment.
- Restore 52 acres of riparian forest habitat.
- Perform riparian forest operations and maintenance.
- Monitor fisheries use of Bachelor Slough for a 3-year period, including providing annual and final reports on findings to the Corps, NOAA Fisheries, and WDFW.

The USFWS will perform maintenance dredging, as required, to maintain restoration depths in the slough.

4.8.7. [new] Cost Effectiveness–Incremental Cost Analysis for the Ecosystem Restoration Features

This new subsection for the Final SEIS addresses a cost effectiveness and incremental cost analysis conducted for the ecosystem restoration features. This incremental analysis does not include Lois Island or the Miller-Pillar ecosystem restoration feature because they both use dredged material beneficially. The non-monetary benefits of the ecosystem restoration alternatives are measured in average annual environmental outputs. In this case, the average annual environmental outputs are measured as weighted acres. It should be noted that the average annual outputs listed represent the net increase in output above and beyond the without-project condition.

The value of each ecosystem restoration feature was evaluated during the ESA consultation phase. During the consultations, the Biological Review Team decided on the high, medium, and low weighting process. The assignment of high, medium or low values for each feature was predicated upon the habitat type being restored and the functional value of that habitat

type to fish and wildlife species, particularly listed salmonid stocks. The valuation was used to weight the habitat acreage encompassed by each feature; thus a high value provides a weight of three times the habitat acreage; medium weight is a factor of two times and low has a factor of one.

Ecosystem restoration at Tenasillahe Island has three phases. The Tenasillahe Island interim ecosystem restoration feature (Phase 1) was assigned a moderate value. While the feature does provide for juvenile salmonid access to rearing and refugia habitat, that access is not unimpeded nor is the associated habitat returned to its natural state (tidal marsh), thus allowing juvenile salmonids an increased area for rearing and foraging activities.

Establishment of a secure and viable population of Columbian white-tailed deer on Cottonwood-Howard Island (Tenasillahe Island Phase 2) was assigned a high weighting factor. Reintroduction of deer to their native habitat, present on these islands, will aid their de-listing as a federal endangered species. Further, their de-listing leads to implementation of the long-term feature at Tenasillahe Island (Phase 3) that has substantial benefit for listed salmonids, bald eagles, waterfowl, shorebirds and other species.

The Tenasillahe Island long-term ecosystem restoration feature (Phase 3) was given a high weighting factor due to the importance of the habitat to be restored. This feature would produce tidal marsh habitat that is an important contributor to the primary production, via detrital export, of the estuarine ecosystem. Benthic invertebrates, which forage on this detrital export, are an important prey resource for juvenile salmonids, including those of the 13 ESA listed ESUs that migrate through and/or rear in the estuary. Tidal marsh habitat also provides refugia during high tide to juvenile salmonids.

The purple loosestrife control effort was also ranked high in value in the BA. This exotic plant species has attained dominance in some tidal marsh locations in the lower Columbia River (e.g., Wallace Island and Pillar Rock Island). The species is now dispersed throughout the tidal marshes of the lower river and may become the dominant tidal marsh plant species in the next few decades. Purple loosestrife dominance of the tidal marsh plant community substantially decreases plant species diversity and utilization by wildlife resources, thus compromising their presence and abundance in the area. If not compatible with detritivores (benthic invertebrates), then forage resources for juvenile salmonids would be compromised resulting in decreased survival and/or fitness.

Tidegate retrofits for salmonid passage were assigned a high value because they would allow easier access/egress by juvenile and adult salmonids. Adult salmonid passage allows fish to access spawning habitat, in some cases restoring runs and in others improving runs.

The Walker-Lord and Hump-Fisher Islands embayment circulation improvements were assigned a moderate value. The action is intended to improve flow, circulation and water temperature conditions in these embayments formed via dredged material deposition. These water quality improvements would improve conditions for benthic invertebrates and juvenile salmonids, thus improving juvenile salmonid production, fitness and survival.

The Bachelor Slough ecosystem restoration feature was assigned a moderate value for the channel portion of the feature. While improving habitat conditions through modest water quality improvements, it did not result in the addition of habitat. The riparian forest component of this feature was assigned a high weighting factor because there would be an increase in this habitat component; it benefited multiple species, in addition to listed species; and it provide detrital and ultimately large woody debris input to the ecosystem.

Shillapoo Lake also was assigned a high value because the managed wetland habitat provides habitat improvements in quality and quantity of wetlands. The action also would benefit a diverse array of species.

The costs of implementation include all costs associated with the potential projects, such as development costs, real estate costs, monitoring costs, and operation and maintenance costs. In order to compare costs with average annual environmental outputs, it is necessary to convert implementation costs to average annual costs. All costs were amortized at the Fiscal Year 2003 federal discount rate of 5.875% over the 50-year project life, to develop equivalent average annual costs.

For determining the economic cost of the potential projects and various components, a calculation is made to determine the cost of interest during construction. This interest is added to the other costs of the project, and included as part of the average annual cost. Interest during construction is included as an economic cost, but it is not included as a financial cost. It is calculated using the Fiscal Year 2003 discount rate of 5.875% for costs incurred during construction of the project. The project costs are expressed in terms of average annual dollars per average annual environmental output.

In conjunction with the environmental analysis of potential projects, cost effectiveness and incremental cost analyses are required. The following explanations clarify the difference between cost effectiveness and incremental cost analyses, and the purpose for each analysis.

- *Cost effectiveness analysis* is conducted to ensure that the least cost solution is identified for various levels of environmental output. Its purpose is to eliminate inefficient alternatives, based on comparing environmental outputs with the *average cost* of an alternative.

- *Incremental cost analysis* is conducted to show changes in costs for increasing levels of environmental outputs. It provides data for decision-makers to address the question, Is the next level worth it? It measures the incremental or *additional cost* of the next additional level of environmental output.

Table S4-9 summarizes the net gains in average annual environmental outputs, the average annual costs, and the average annual cost per environmental output for each of the sites. As the table shows, the average annual cost per environmental output is directly associated with the number of environmental outputs gained by development of each alternative. Note that the average annual environmental outputs represent the gain over the no action condition.

Table S4-9. Average Annual Environmental Outputs, Average Annual Costs, and Average Annual Cost per Environmental Output

Sites	Average Annual Output	Average Annual Cost	Average Annual Cost per Output
No Action*	0	$0	$0
Walker-Lord & Hump-Fisher	670	$10,466	$16
Tidegate Retrofits	276	$33,616	$122
Bachelor Slough	262	$188,517	$720
Purple Loosestrife	22,440	$154,707	$7
Shillapoo Lake	1,410	$326,850	$232
Tenasillahe Island	6,254	$342,339	$55

*The no action condition represents the base conditions at each of the sites considered for ecosystem restoration. The without project condition serves as the basis for comparison for alternative with-project conditions.

Table S4-10 displays the cost-effective, least-cost alternatives listed in ascending order of average annual environmental outputs. Alternatives that had a higher cost for a given level of environmental outputs were not cost-effective, and were dropped from further consideration. Table S4-10 also displays the supply schedule of the average annual cost for each level of output, which serves as the basis from which to derive the incremental cost analysis.

Table S4-10. Cost-effective, Least-cost Combinations - Average Annual Environmental Outputs and Average Annual Cost

Alternative	Average Annual Output	Average Annual Cost
No Action	0	0
Walker-Lord/Hump-Fisher	670	$10,466
Walker/Hump, Tidegates	946	$ 44,082
Purple Loosestrife	22,440	$154,707
Walker/Hump, Purple Loosestrife	23,110	$165,173
Walker/Hump, Purple Loosestrife, Tidegates	23,386	$198,789
Walker/Hump, Purple Loosestrife, Bachelor Slough, Tidegates	23,648	$387,306
Purple Loosestrife, Shillapoo Lake	23,850	$481,557
Walker/Hump, Purple Loosestrife, Shillapoo Lake	24,520	$492,023
Tenasillahe, Purple Loosestrife	28,694	$497,046
Tenasillahe, Purple Loosestrife, Walker/Hump	29,364	$507,512
Tenasillahe, Purple Loosestrife, Walker/Hump, Tidegates	29,640	$541,128
Tenasillahe, Purple Loosestrife, Walker/Hump, Bachelor Slough, Tidegates	29,902	$729,645
Tenasillahe, Purple Loosestrife, Shillapoo Lake	30,104	$823,896
Tenasillahe, Walker/Hump, Purple Loosestrife, Shillapoo Lake	30,774	$834,362
Tenasillahe, Purple Loosestrife, Walker/Hump, Tidegates, Shillapoo Lake	31,050	$867,978
Tenasillahe, Purple Loosestrife, Walker/Hump, Bachelor Slough Shillapoo Lake, Tidegates	31,312	$1,056,495

Table S4-11 shows the final incremental cost analysis. Incremental cost analysis is required to address whether the incremental or additional cost of the next level of output is cost effective. In environmental studies, the comparison is between dollar incremental costs and non-dollar incremental units of output.

In order to facilitate the required calculations, the Institute of Water Resources "Cost Effectiveness and Incremental Cost Analysis" (Eco-Easy) software program was used to do the calculations necessary to eliminate the irregular, non-continuously increasing cost changes that occur in the incremental average annual cost per output calculations. To get to the final incremental cost table, it was necessary to do a series of calculations to determine the lowest average cost for additional output from amongst the remaining levels of output. Each of the recalculations begins with the previous step's lowest average cost level of output set as the new "zero level." The calculation in this step uses the additional cost and additional outputs above those of the previously identified level of output with the lowest average cost (for further details on this process, refer to *Cost Effectiveness Analysis for Environmental Planning: Nine Easy Steps*, Institute of Water Resources Report 94-PS-2, October 1994).

Table S4-11 summarizes the results of the final incremental cost analysis. The column on the right summarizes the incremental average annual cost per output.

Table S4-11. Summary of Final Incremental Cost Analysis

Alternative	Total Average Annual Cost	Total Average Annual Output	Added Average Annual Output	Added Average Annual Cost	Incremental Average Annual Cost/Output
Without Project	$0	0	0	$0	$0
Purple Loosestrife	$154,707	22,440	22,440	$154,707	$7
Purple Loosestrife, Walker-Lord/ Hump-Fisher	$165,173	23,110	670	$10,466	$16
Purple Loosestrife, Walker-Lord/ Hump-Fisher, Tenasillahe	$507,512	29,364	6,254	$342,339	$55
Purple Loosestrife, Walker-Lord/Hump-Fisher, Tenasillahe, Tidegates	$541,128	29,640	276	$33,616	$122
Purple Loosestrife, Walker-Lord/ Hump-Fisher, Tenasillahe, Tidegates, Shillapoo	$867,978	31,050	1,410	$326,850	$232
Purple Loosestrife, Walker-Lord/Hump-Fisher, Tenasillahe, Tidegates, Shillapoo, Bachelor Slough	$1,056,495	31,312	262	$188,517	$720

Based on the results of the cost effectiveness and incremental cost analyses, of the combinations evaluated above, the alternative including Tenasillahe, Walker-Lord/Hump-Fisher, Tidegates, Shillapoo Lake, and Purple Loosestrife (all sites except Bachelor Slough) are the best economic investment for the National Ecosystem Restoration plan.

The original project authorization included three ecosystem restoration features (Shillapoo, Lord-Walker/Hump-Fisher embayment, and tidegate retrofits). As a result of the consultation with NOAA Fisheries and USFWS under Section 7 of the ESA, and in consideration of the mandate by Congress under Section 7(a)(1) of the ESA to exercise agency authorities to carry out programs for the conservation of listed species, three additional ecosystem restoration features (Bachelor Slough, Tenasillahe Island Phased and Purple Loosestrife) were added to the project to provide increased benefit to listed species in the project area. Therefore, all of the ecosystem restoration features are considered part of the proposed alternative, including the two that use dredged material beneficially (Lois Island embayment and Miller-Pillar ecosystem restoration features).

4.9. [new] Ecosystem Evaluation Actions

This new section for the Final SEIS addresses the ecosystem evaluation actions developed during the ESA consultation process. Ecosystem evaluation actions are measures taken by the Corps as part of the project to assist the efforts of the Corps, NOAA Fisheries, USFWS, and others in the broader issues of understanding the lower Columbia River ecosystem. The evaluation actions address indicators of the salmonid conceptual model (see Chapter 6) and will advance the knowledge base for the conservation and recovery of salmonid species. The NOAA Fisheries strongly supports implementation of these ecosystem evaluation activities.

Effects to ESA-listed salmonids are expected to occur from implementation of some of the ecosystem evaluation activities. Therefore, these activities may require the issuance of permits authorizing direct take of ESA-listed salmonids by NOAA Fisheries under Section 4(d) or 10(a)(1)(A) of the ESA. Otherwise, the ecosystem evaluation activities are not anticipated to have any adverse effect on listed species or any significant adverse effect on the physical environment.

Why Evaluation Actions are Needed

Six ecosystem evaluation actions were identified as a result of the ESA consultation and the risk and uncertainty associated with the proposed project. Evaluation actions will provide background information on habitat parameters, including bathymetric information, for listed ESUs; specifically tidal marsh, shallow water and flats, and water column habitat. The SEI expert panel recommended that the Corps, NOAA Fisheries and the USFWS include specific actions to address contaminant issues potentially related to the channel improvement project even though no direct link between contaminants in listed ESUs and the material to be dredged were ascertained. As a result, the three federal agencies developed two specific evaluation actions to assess sublethal effects of contaminants on fish growth, disease and resistance, and juvenile salmonids and their prey. These contaminant data would be used to modify future project-related dredging or disposal actions. Even

though there did not seem to be a link between contaminants and fish at this time, the risk of advancing with project implementation in the absence of better data was considered too high. Data collected on an annual basis will be reviewed annually by the three federal agencies to determine whether any project actions should be altered to preclude detrimental effects to listed ESUs. The duration of these evaluation actions is variable and specific evaluation actions can be discontinued when warranted by analyses of data collected as decided by the AMT.

Evaluation Action 1 pertains to obtaining additional information on salmonid habitat and distribution in the estuary. This action would entail 1 or 2 additional transects in different habitats similar to those for NOAA Fisheries studies underway for the Anadromous Fish Evaluation Program. One of these transects would be in Cathlamet Bay. The numerical modeling completed for this project has identified Cathlamet Bay as an important area to evaluate pre- and post-project construction regarding juvenile salmonid use and habitat.

It is anticipated that this data would be obtained prior to construction and for three years after project completion. The estimated cost for this action is $2.8 million. The data would aid decisions regarding project modification should adverse impacts to the listed ESUs be determined. Additionally, the data could be used to modify/improve the proposed ecosystem restoration features and an enhancement of the environmental benefits associated with these features.

Evaluation Action 2 pertains to ascertaining coastal cutthroat trout use of tidal marsh habitat in the Columbia River estuary. Juveniles of this species rear in the estuary for an extended period of time as compared to other anadromous fish species. One year of data for this evaluation action has already been collected. One more year of pre-construction and two years of construction period data are to be collected. The estimated cost for this action is $1.1 million. These data would aid decisions regarding project modification should adverse impacts to the listed ESUs be determined. Additionally, these data could be used to modify/improve the proposed ecosystem restoration features and an enhancement of the environmental benefits associated with these features.

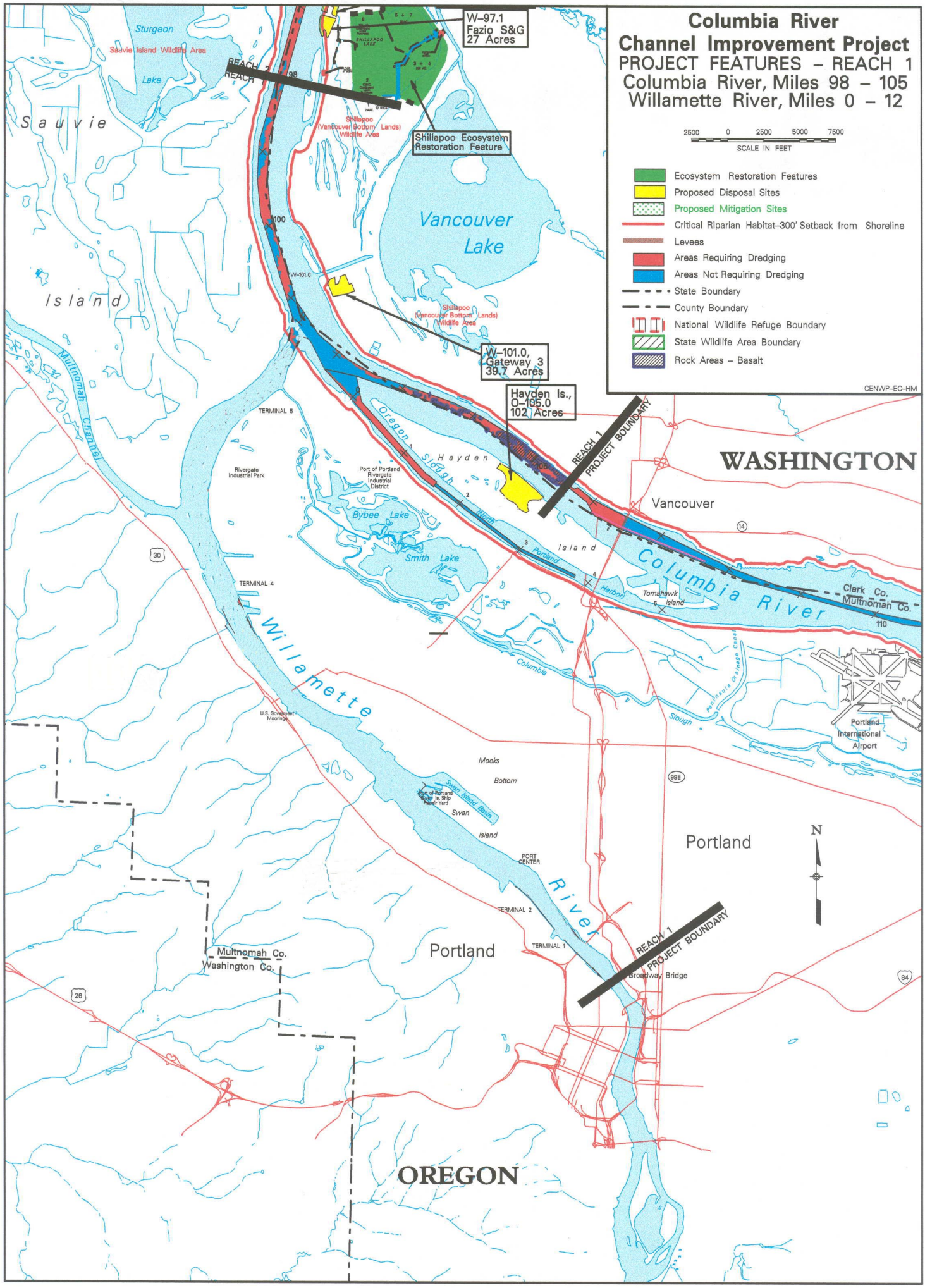
Evaluation Action 3 pertains to a bank-to-bank hydrographic survey of the estuary. This survey would provide valuable information on bathymetry and shallow water-flat habitat in the estuary. These data have not been collected since the mid-1980s and will aid development, construction and/or modification of the proposed ecosystem restoration features. The estimated cost for this action is $0.25 million.

Evaluation Actions 4 and 5 address contaminant issues in juvenile salmonids and their prey species plus sub-lethal impacts of contaminants on juvenile salmonids. These actions address the risks identified above regarding contaminants and the project. One year of pre-construction data has been collected (2002). Further data will be collected during construction and for three years post-construction. The estimate cost for these actions are $0.18 million and $0.16 million, respectively.

Evaluation Action 6, a term and condition of the NOAA Fisheries and USFSW Biological Opinions, requires convening of an "Estuary Turbidity Maximum Workshop." The purpose of the workshop is to better understand and propose meaningful management actions to conserve the ETM. The action is anticipated to cost $0.04 million.

Although some of these evaluation actions are costly and exceed the Corps policy threshold on monitoring costs for the project, they are consistent with a number of the Corps' Environmental Operating Principles. These evaluation actions proactively consider the environmental consequences of the channel improvement project and represent an appropriate response to the circumstances at hand. They represent an attempt to seek a balance and synergy between the proposed improvement project and the Columbia River estuary through designing economic and environmental solutions that support and reinforce one another. It represents an integrated effort by the Corps Portland District, the sponsor ports, NOAA Fisheries and the USFWS to build and share an integrated scientific, economic and social knowledge base that supports a greater understanding of the environment, particularly as it relates to juvenile salmonids of listed ESUs, and the channel improvement project. This effort reflects a unity of purpose amongst the principal parties. These evaluation actions represent a continuing effort by these parties to develop the scientific, economic and sociological measures to judge the effects of this project on the environment and to seek better ways of achieving environmentally sustainable solutions.

The region and the Corps have demonstrated their commitment to the recovery of these ESUs by investing over $1.5 billion on improvements to fish passage at the hydroelectric facilities on the Columbia/Snake System. The national importance in these ESUs warrants and justifies the evaluation actions being applied in this project to further safeguard the federal investment made to date. Emphasis on recovery of these ESUs is now shifting to the lower Columbia River (below Bonneville Dam to the mouth).


Columbia River
Channel Improvement Project
PROJECT FEATURES – REACH 1
Columbia River, Miles 98 – 105
Willamette River, Miles 0 – 12
2500 0 2500 5000 7500
SCALE IN FEET
Ecosystem Restoration Features
Proposed Disposal Sites
Proposed Mitigation Sites
Critical Riparian Habitat–300' Setback from Shoreline
Levees
Areas Requiring Dredging
Areas Not Requiring Dredging
State Boundary
County Boundary
National Wildlife Refuge Boundary
State Wildlife Area Boundary
Rock Areas – Basalt
CENWP-EC-HM
W–97.1
Fazio S&G
27 Acres
Shillapoo Ecosystem Restoration Feature
W–101.0,
Gateway 3
39.7 Acres
Hayden Is.,
O–105.0
102 Acres
REACH 1
PROJECT BOUNDARY
REACH 1
PROJECT BOUNDARY
Broadway Bridge
WASHINGTON
OREGON
Vancouver
Portland
Sauvie
Island
Vancouver
Lake
Sturgeon
Lake
Sauvie Island Wildlife Area
Shillapoo
(Vancouver Bottom Lands)
Wildlife Area
Multnomah Channel
Willamette
River
Columbia
River
Oregon
Slough
Hayden
Island
North
Portland
Harbor
Tomahawk
Island
Bybee
Lake
Smith
Lake
TERMINAL 5
TERMINAL 4
TERMINAL 2
TERMINAL 1
Rivergate
Industrial Park
Port of Portland
Rivergate
Industrial
District
U.S. Government
Moorings
Mocks
Bottom
Swan
Island
Swan Island Basin
PORT
CENTER
Peninsula Drainage Canal
Slough
Portland
International
Airport
Clark Co.
Multnomah Co.
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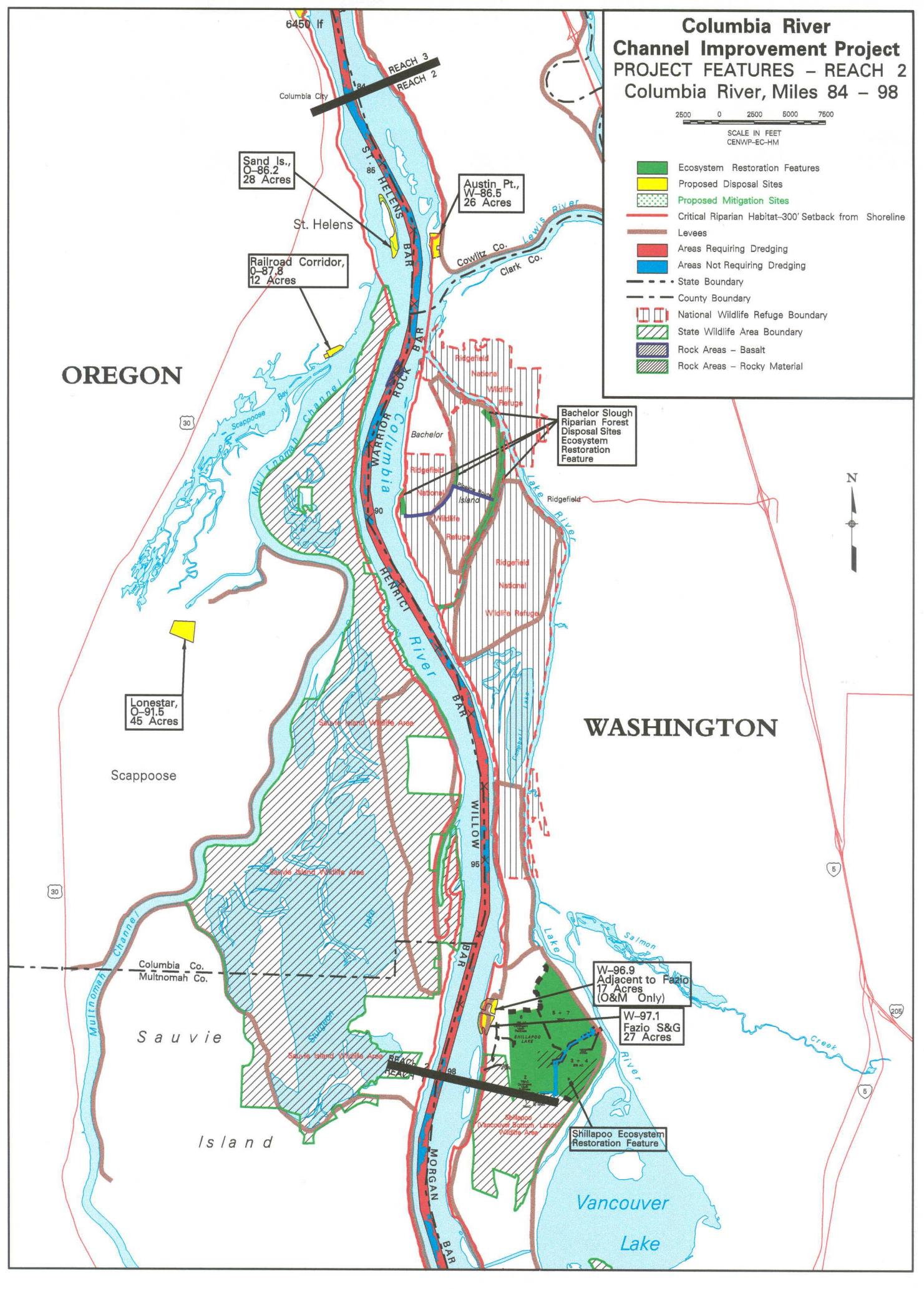
Columbia River
Channel Improvement Project
PROJECT FEATURES – REACH 2
Columbia River, Miles 84 – 98
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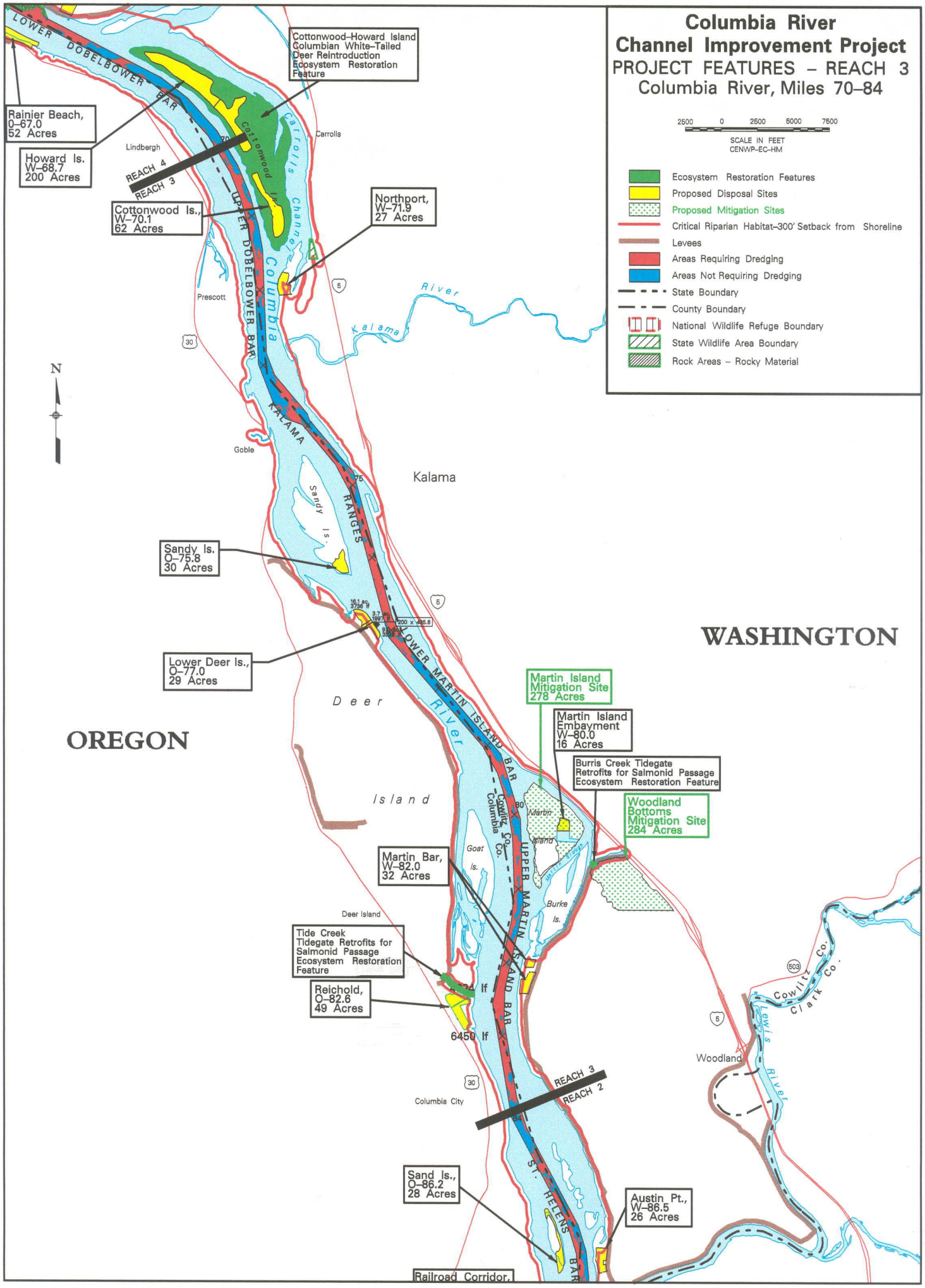
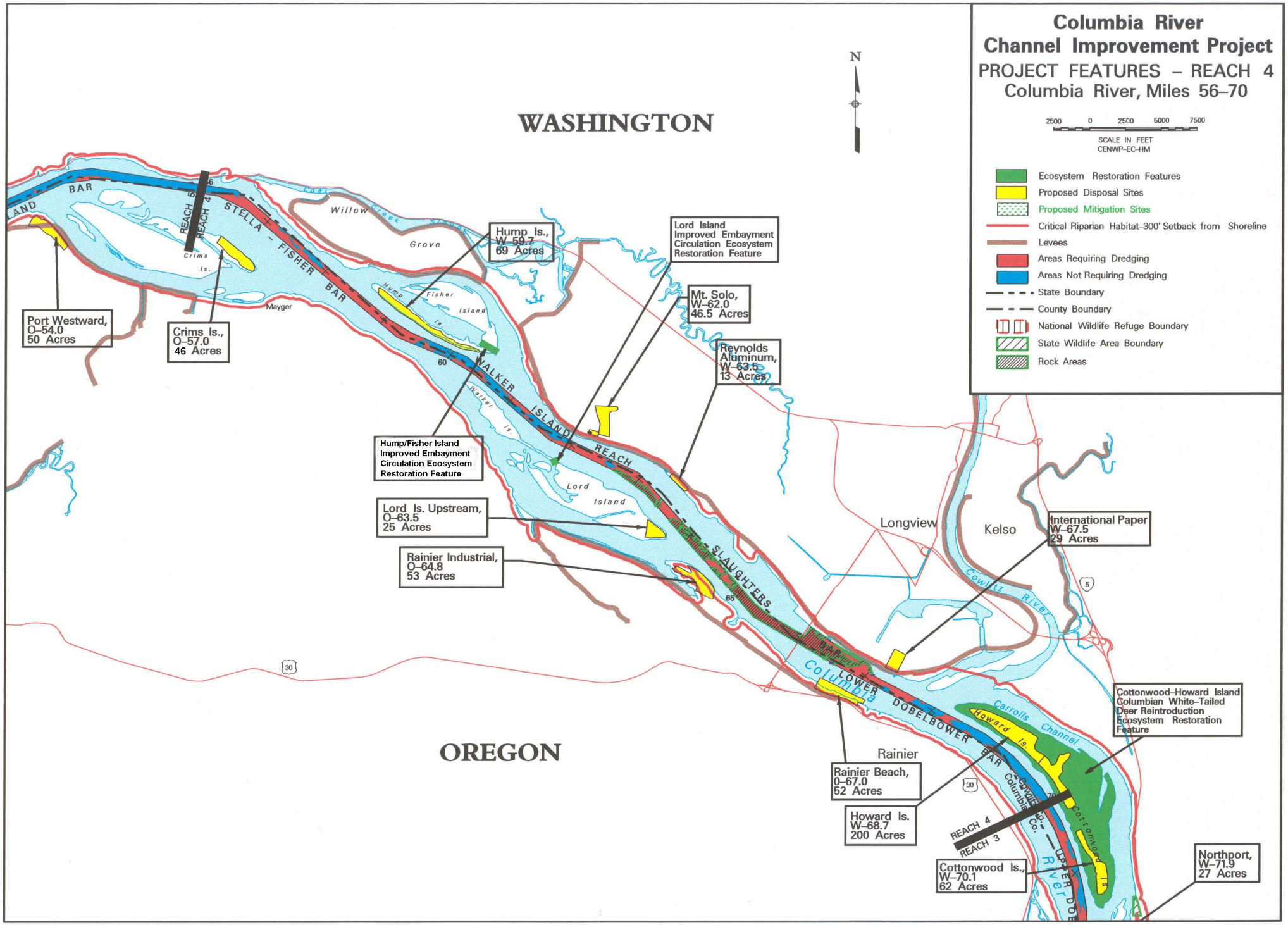
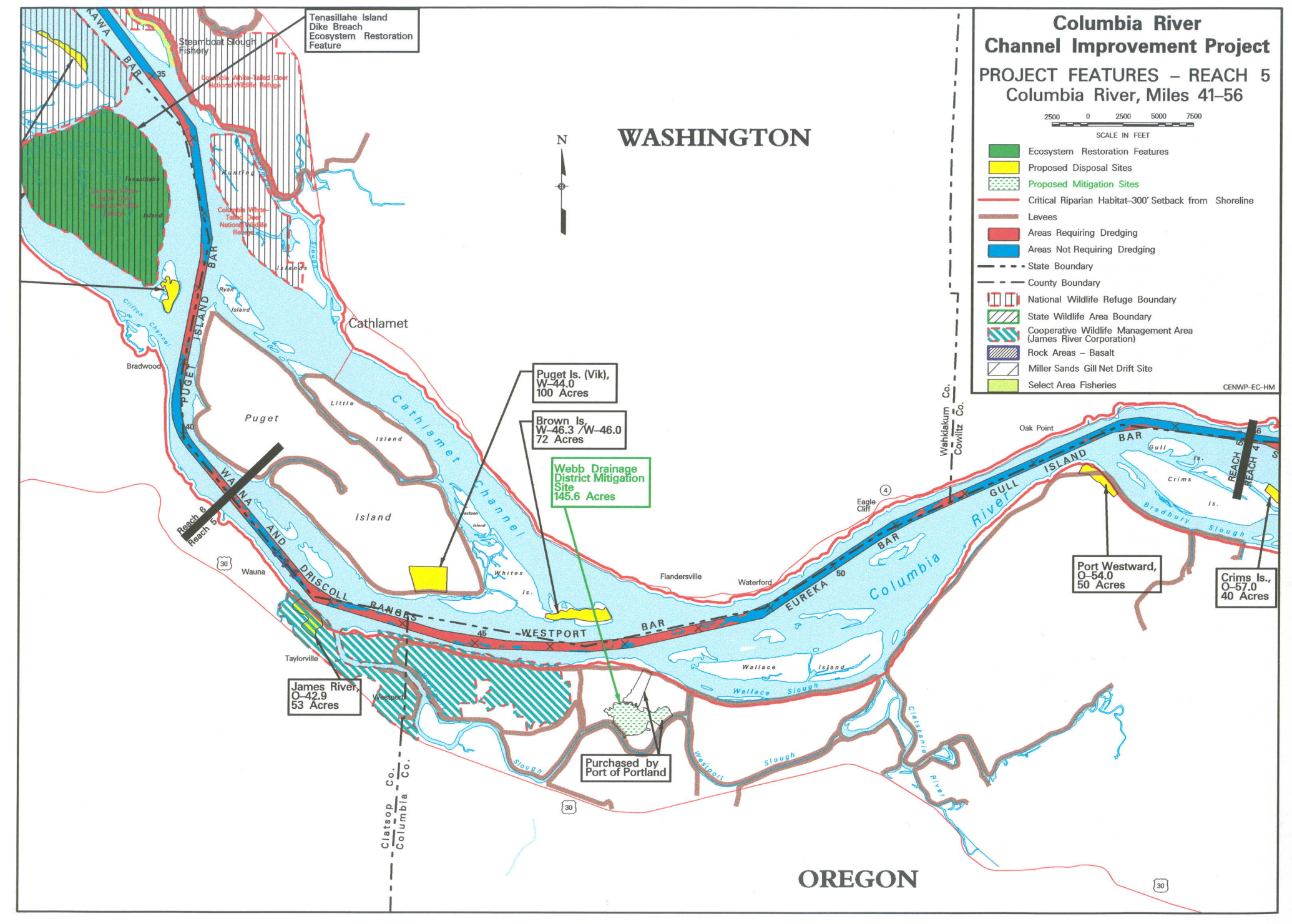
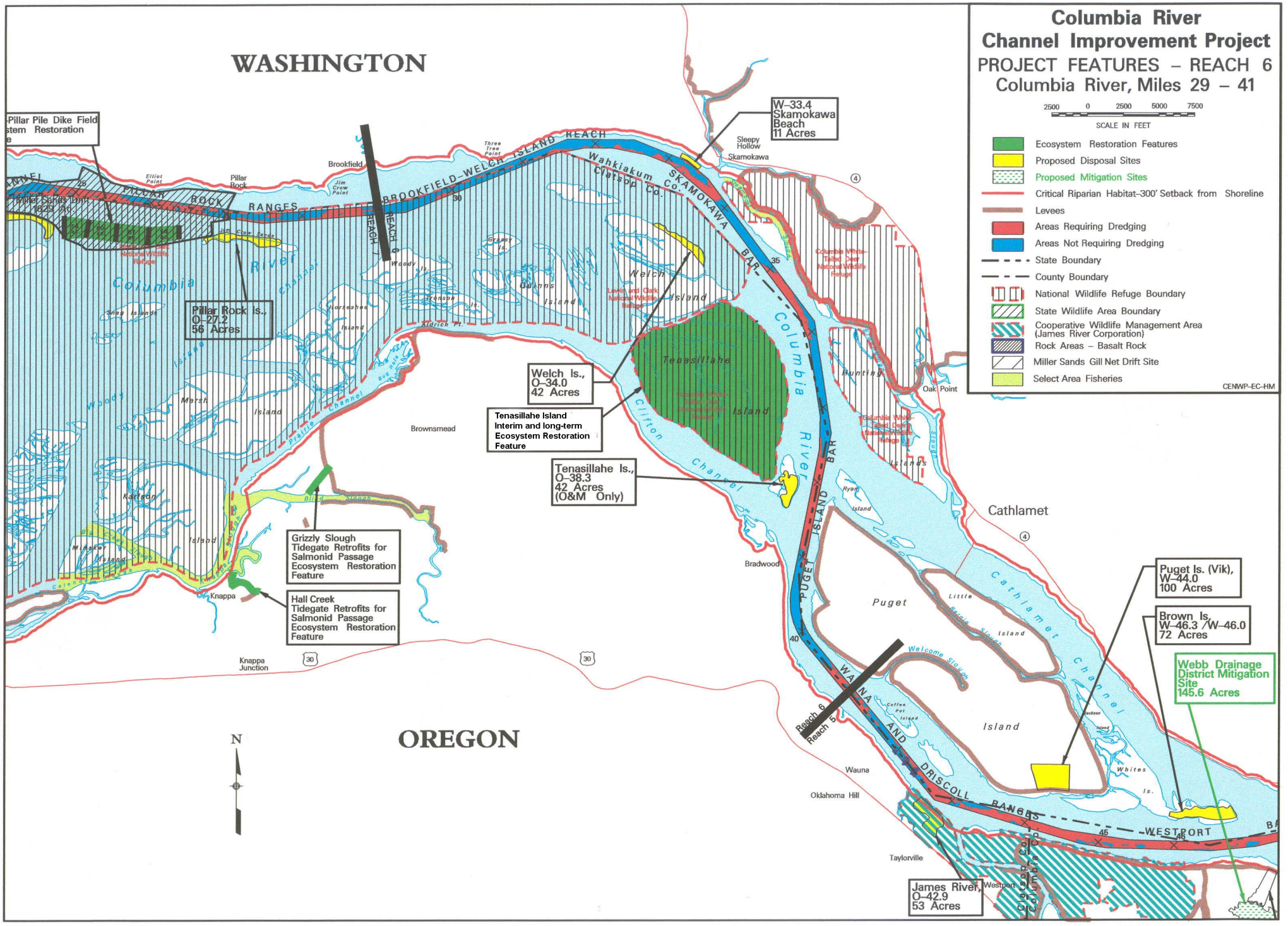
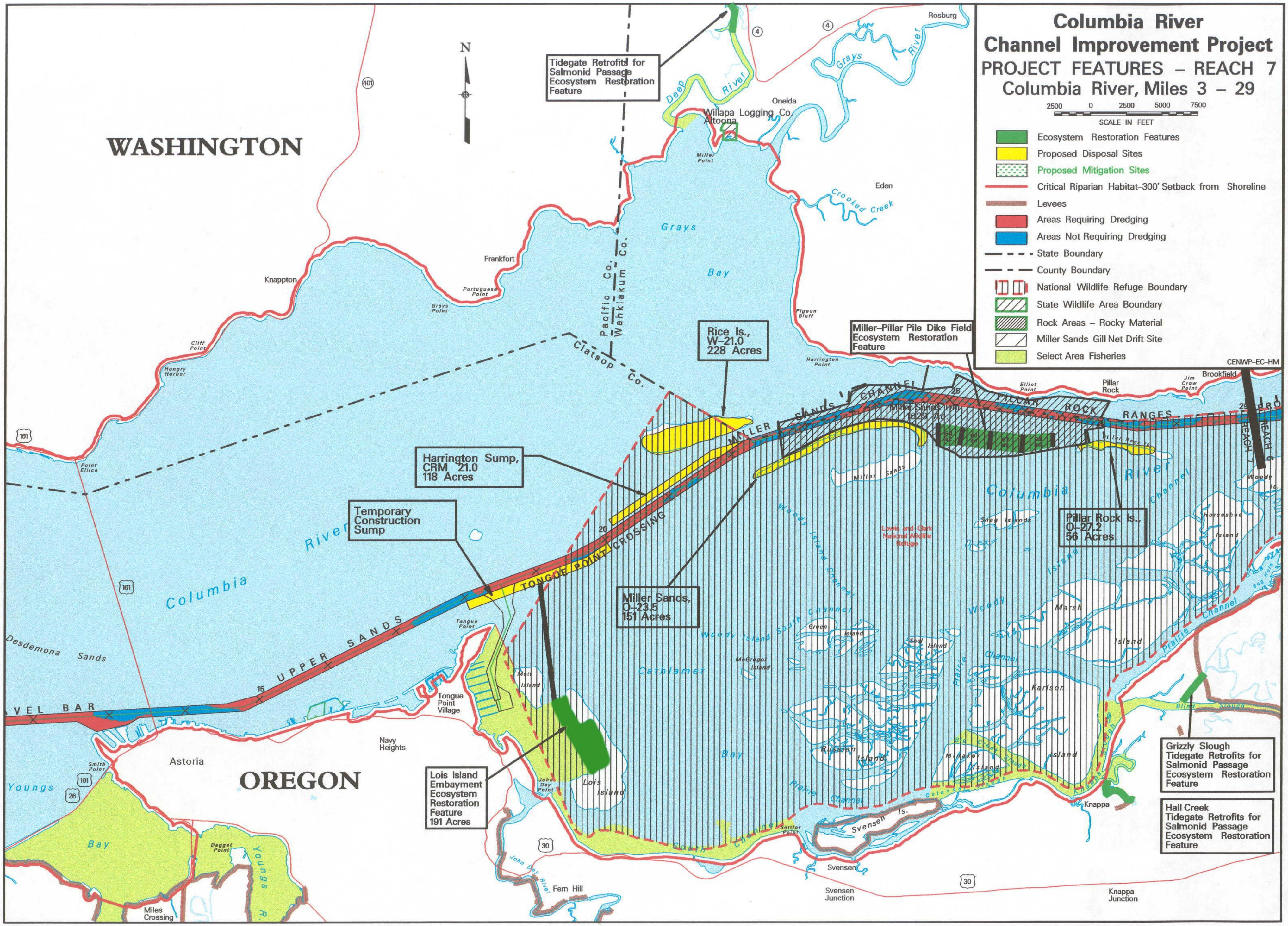
SCALE IN FEET
CENWP-EC-HM
Ecosystem Restoration Features
Proposed Disposal Sites
Proposed Mitigation Sites
Critical Riparian Habitat–300' Setback from Shoreline
Levees
Areas Requiring Dredging
Areas Not Requiring Dredging
State Boundary
County Boundary
National Wildlife Refuge Boundary
State Wildlife Area Boundary
Rock Areas – Basalt
Rock Areas – Rocky Material
6450 lf
REACH 3
REACH 2
Columbia City
Sand Is., O–86.2 28 Acres
Austin Pt., W–86.5 26 Acres
St. Helens
Railroad Corridor, O–87.8 12 Acres
OREGON
WASHINGTON
Bachelor Slough Riparian Forest Disposal Sites Ecosystem Restoration Feature
Lonestar, O–91.5 45 Acres
Scappoose
Sauvie Island
W–96.9 Adjacent to Fazio 17 Acres (O&M Only)
W–97.1 Fazio S&G 27 Acres
Shillapoo Ecosystem Restoration Feature
Vancouver Lake
Columbia Co.
Multnomah Co.
Multnomah Channel
Scappoose Bay
Lewis River
Cowlitz Co.
Clark Co.
Salmon Creek
Ridgefield National Wildlife Refuge
Sauvie Island Wildlife Area
ST. HELENS BAR
WARRIOR ROCK BAR
HENRICI BAR
WILLOW BAR
MORGAN BAR
REACH 98
N


Columbia River
Channel Improvement Project
PROJECT FEATURES – REACH 3
Columbia River, Miles 70–84
2500 0 2500 5000 7500
SCALE IN FEET
CENWP-EC-HM
Ecosystem Restoration Features
Proposed Disposal Sites
Proposed Mitigation Sites
Critical Riparian Habitat–300' Setback from Shoreline
Levees
Areas Requiring Dredging
Areas Not Requiring Dredging
State Boundary
County Boundary
National Wildlife Refuge Boundary
State Wildlife Area Boundary
Rock Areas – Rocky Material
Rainier Beach, O–67.0 52 Acres
Howard Is. W–68.7 200 Acres
Cottonwood–Howard Island Columbian White–Tailed Deer Reintroduction Ecosystem Restoration Feature
Cottonwood Is., W–70.1 62 Acres
Northport, W–71.9 27 Acres
Sandy Is. O–75.8 30 Acres
Lower Deer Is., O–77.0 29 Acres
Martin Island Mitigation Site 278 Acres
Martin Island Embayment W–80.0 16 Acres
Burris Creek Tidegate Retrofits for Salmonid Passage Ecosystem Restoration Feature
Woodland Bottoms Mitigation Site 284 Acres
Martin Bar, W–82.0 32 Acres
Tide Creek Tidegate Retrofits for Salmonid Passage Ecosystem Restoration Feature
Reichold, O–82.6 49 Acres
6450 lf
Sand Is., O–86.2 28 Acres
Austin Pt., W–86.5 26 Acres
Railroad Corridor
REACH 4
REACH 3
REACH 3
REACH 2
LOWER DOBELBOWER BAR
UPPER DOBELBOWER BAR
KALAMA RANGES
LOWER MARTIN ISLAND BAR
UPPER MARTIN ISLAND BAR
ST. HELENS BAR
Columbia River
Kalama River
Deer Island
Sandy Is.
Goat Is.
Burke Is.
Martin Island
Lindbergh
Carrolls
Prescott
Goble
Kalama
Columbia City
Woodland
Cowlitz Co.
Clark Co.
Lewis River
Columbia Co.
OREGON
WASHINGTON
N


Columbia River
Channel Improvement Project
PROJECT FEATURES – REACH 4
Columbia River, Miles 56–70
2500 0 2500 5000 7500
SCALE IN FEET
CENWP-EC-HM
Ecosystem Restoration Features
Proposed Disposal Sites
Proposed Mitigation Sites
Critical Riparian Habitat–300' Setback from Shoreline
Levees
Areas Requiring Dredging
Areas Not Requiring Dredging
State Boundary
County Boundary
National Wildlife Refuge Boundary
State Wildlife Area Boundary
Rock Areas
N
WASHINGTON
OREGON
Port Westward, O–54.0 50 Acres
Crims Is., O–57.0 46 Acres
Hump Is., W–59.7 69 Acres
Lord Island Improved Embayment Circulation Ecosystem Restoration Feature
Mt. Solo, W–62.0 46.5 Acres
Reynolds Aluminum, W–63.5 13 Acres
Hump/Fisher Island Improved Embayment Circulation Ecosystem Restoration Feature
Lord Is. Upstream, O–63.5 25 Acres
Rainier Industrial, O–64.8 53 Acres
International Paper W–67.5 29 Acres
Cottonwood–Howard Island Columbian White–Tailed Deer Reintroduction Ecosystem Restoration Feature
Rainier Beach, O–67.0 52 Acres
Howard Is. W–68.7 200 Acres
Cottonwood Is., W–70.1 62 Acres
Northport, W–71.9 27 Acres
REACH 5
REACH 4
REACH 3
STELLA – FISHER BAR
WALKER ISLAND REACH
SLAUGHTERS
DOBELBOWER BAR
LOWER Columbia
Willow Grove
Hump Fisher Island Is.
Walker Is.
Lord Island
Crims Is.
Mayer
Longview
Kelso
Cowlitz River
Carrols Channel
Howard Is.
Cottonwood Is.
Rainier
Columbia Co.
Upper Columbia River
30
5


Columbia River
Channel Improvement Project
PROJECT FEATURES – REACH 5
Columbia River, Miles 41–56
2500 0 2500 5000 7500
SCALE IN FEET
Ecosystem Restoration Features
Proposed Disposal Sites
Proposed Mitigation Sites
Critical Riparian Habitat–300' Setback from Shoreline
Levees
Areas Requiring Dredging
Areas Not Requiring Dredging
State Boundary
County Boundary
National Wildlife Refuge Boundary
State Wildlife Area Boundary
Cooperative Wildlife Management Area (James River Corporation)
Rock Areas – Basalt
Miller Sands Gill Net Drift Site
Select Area Fisheries
CENWP-EC-HM
WASHINGTON
OREGON
N
Tenasillahe Island Dike Breach Ecosystem Restoration Feature
Steamboat Slough Fishery
Columbia White-Tailed Deer National Wildlife Refuge
Tenasillahe Island
Hunting Island
Steamboat Islands
Ryan Island
Clifton Channel
Bradwood
Cathlamet
Puget Island
Little Island
Cathlamet Channel
Jackson Island
Whites Is.
Puget Is. (Vik), W–44.0 100 Acres
Brown Is, W–46.3 /W–46.0 72 Acres
Webb Drainage District Mitigation Site 145.6 Acres
Purchased by Port of Portland
James River, O–42.9 53 Acres
Port Westward, O–54.0 50 Acres
Crims Is., O–57.0 40 Acres
Reach 6
Reach 5
Reach 4
KAWA BAR
PUGET ISLAND BAR
WANA AND DRISCOLL RANGES
WESTPORT BAR
EUREKA BAR
GULL ISLAND BAR
Columbia River
Gull Is.
Crims Is.
Bradbury Slough
Oak Point
Eagle Cliff
Flandersville
Waterford
Wauna
Taylorville
Westport
Wallace Island
Wallace Slough
Westport Slough
Clatskanie River
Slough
Wahkiakum Co.
Cowlitz Co.
Clatsop Co.
Columbia Co.
35
40
45
50
30
4


WASHINGTON
OREGON
Columbia River
Channel Improvement Project
PROJECT FEATURES – REACH 6
Columbia River, Miles 29 – 41
2500 0 2500 5000 7500
SCALE IN FEET
Ecosystem Restoration Features
Proposed Disposal Sites
Proposed Mitigation Sites
Critical Riparian Habitat–300' Setback from Shoreline
Levees
Areas Requiring Dredging
Areas Not Requiring Dredging
State Boundary
County Boundary
National Wildlife Refuge Boundary
State Wildlife Area Boundary
Cooperative Wildlife Management Area (James River Corporation)
Rock Areas – Basalt Rock
Miller Sands Gill Net Drift Site
Select Area Fisheries
CENWP-EC-HM
Pillar Pile Dike Field Restoration
Pillar Rock Is., O–27.2 56 Acres
W–33.4 Skamokawa Beach 11 Acres
Welch Is., O–34.0 42 Acres
Tenasillahe Island Interim and long-term Ecosystem Restoration Feature
Tenasillahe Is., O–38.3 42 Acres (O&M Only)
Grizzly Slough Tidegate Retrofits for Salmonid Passage Ecosystem Restoration Feature
Hall Creek Tidegate Retrofits for Salmonid Passage Ecosystem Restoration Feature
Puget Is. (Vik), W–44.0 100 Acres
Brown Is, W–46.3 /W–46.0 72 Acres
Webb Drainage District Mitigation Site 145.6 Acres
James River, O–42.9 53 Acres
Brookfield
Sleepy Hollow
Skamokawa
Wahkiakum Co.
Clatsop Co.
Brownsmead
Oak Point
Cathlamet
Bradwood
Knappa
Knappa Junction
Wauna
Oklahoma Hill
Taylorville
Westport
Columbia River
Clifton Channel
Cathlamet Channel
Welch Island
Tenasillahe Island
Puget Island
Minor Island
Karlson Island
Woody Island
Marsh Island
Price Island
Ryan Island
Whites Is.
Brookfield-Welch Island Reach
Skamokawa Bar
Puget Island Bar
Wauna and Driscoll Ranges
Pillar Rock Ranges
Reach 6
Reach 5
Columbia White-Tailed Deer National Wildlife Refuge
Lewis and Clark National Wildlife Refuge
Miller Sands Unit 1629 Ac.



Columbia River
Channel Improvement Project
PROJECT FEATURES – REACH 7
Columbia River, Miles 3 – 29
2500 0 2500 5000 7500
SCALE IN FEET
Ecosystem Restoration Features
Proposed Disposal Sites
Proposed Mitigation Sites
Critical Riparian Habitat-300' Setback from Shoreline
Levees
Areas Requiring Dredging
Areas Not Requiring Dredging
State Boundary
County Boundary
National Wildlife Refuge Boundary
State Wildlife Area Boundary
Rock Areas – Rocky Material
Miller Sands Gill Net Drift Site
Select Area Fisheries
CENWP-EC-HM
WASHINGTON
OREGON
Tidegate Retrofits for Salmonid Passage Ecosystem Restoration Feature
Rice Is., W-21.0 228 Acres
Miller-Pillar Pile Dike Field Ecosystem Restoration Feature
Harrington Sump, CRM 21.0 118 Acres
Temporary Construction Sump
Miller Sands, O-23.5 151 Acres
Pillar Rock Is., O-27.2 56 Acres
Lois Island Embayment Ecosystem Restoration Feature 191 Acres
Grizzly Slough Tidegate Retrofits for Salmonid Passage Ecosystem Restoration Feature
Hall Creek Tidegate Retrofits for Salmonid Passage Ecosystem Restoration Feature
Willapa Logging Co.
Altoona
Grays Bay
Deep River
Grays River
Crooked Creek
Rosburg
Oneida
Eden
Frankfort
Knappton
Pacific Co.
Wahkiakum Co.
Clatsop Co.
Columbia River
Upper Sands
Tongue Point Crossing
Miller Sands Channel
Pillar Rock Ranges
Tongue Point Village
Navy Heights
Astoria
Desdemona Sands
Cathlamet Bay
Lewis and Clark National Wildlife Refuge
Brookfield
Pillar Rock
Svensen
Svensen Junction
Knappa
Knappa Junction
Fern Hill
Miles Crossing
Youngs Bay

Columbia River Channel Improvement Project

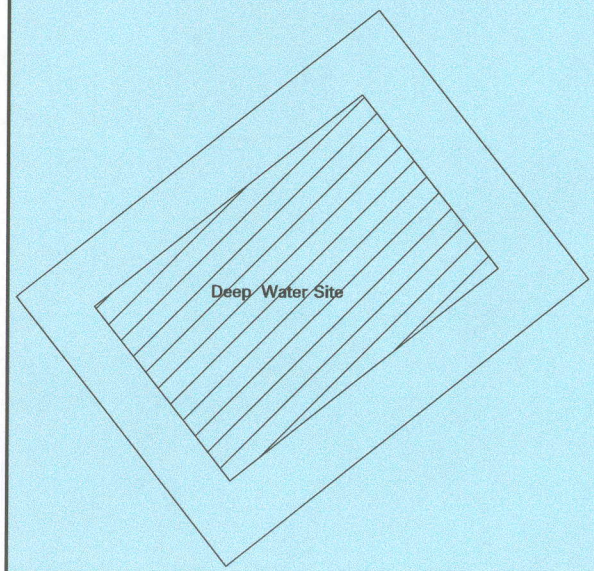
PROJECT FEATURES – REACH 7
Columbia River, Miles 3 – 29

2500 0 2500 5000 7500

SCALE IN FEET

- Ecosystem Restoration Features
- Proposed Disposal Sites
- Proposed Mitigation Sites
- Critical Riparian Habitat–300' Setback from Shoreline
- Levees
- Areas Requiring Dredging
- Areas Not Requiring Dredging
- State Boundary
- County Boundary
- National Wildlife Refuge Boundary
- State Wildlife Area Boundary
- Rock Areas – Rocky Material
- Miller Sands Gill Net Drift Site
- Select Area Fisheries

CENWP-EC-HM



WASHINGTON

OREGON

N

Ilwaco

Wallacut River

Baker Bay

Stringtown

Chinook River

Cape Disappointment

Peacock Spit

North Jetty

West Sand Island

East Sand Island

Jetty "A"

PROJECT BOUNDARY

REACH 7

Chinook

Chinook Point

McGowan

Pacific Co.

Clatsop Co.

South Jetty

DESDEMONA SHOAL

Columbia River

Clatsop Spit

Trestle Bay

Point Adams

Desdemona Sands

Hammond

Tansy Point

Youngs Bay

Warrenton

Skipanon Waterway

FLAVEL

2

3

5

8

10