# INCORPORATING AQUATIC HABITAT RESTORATION/MITIGATION INTO DREDGING PROJECTS

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## ABSTRACT

A substantial portion of the world's dredging occurs in urbanized areas where aquatic habitats have been degraded by a range of necessary human uses. In recent years, urban waterfronts have been increasingly viewed as important habitat for a range of fish and wildlife species. For example, in Washington

state the listing of Puget Sound Chinook salmon as threatened under the Endangered Species Act (ESA) has led to increased focus on restoring habitat in the individual sub-estuaries of Puget Sound, including the Puyallup River estuary in Commencement Bay.

Navigation and remedial dredging provide unique opportunities for accomplishing cost-effective aquatic habitat restoration. These actions can be either mitigation for impacts to habitat caused by dredging or restoration in the absence of significant habitat impacts. In either case, the aquatic habitat that is constructed in conjunction with dredging is typically much higher quality than the existing altered habitat.

This paper describes a number of large and small scale habitat restoration/mitigation projects that have been implement in Commencement Bay over the last 20 years in conjunction with dredging projects. Projects range from construction of beaches with dredge material to shoreline cutbacks to create salt marshes. Topics will include: technical biological criteria for designing and locating appropriate habitat; incorporating multiple non-habitat benefits into the restoration action such as beneficial use of dredge material; sequencing of dredging and restoration work to minimize costs; and lessons learned negotiating habitat design and location with federal and state resource agencies.

This paper demonstrates the range of aquatic habitat restoration actions that can be incorporated into dredging projects, while providing practical advice on how to implement them in the challenging urban environment and regulatory process.

**Keywords:** Beneficial use of dredged material, Commencement Bay, Salmon, Confined Disposal Facility, CERCLA.

## INTRODUCTION

The Port of Tacoma is located on Commencement Bay in the south central portion of Puget Sound, which is located in Washington, USA. The Port of Tacoma is the sixth largest container shipping port in the United States and is within the top twenty-five container ports worldwide. In 2006, the Port handled 2.1 million container TEU's (twenty-foot equivalent units).

The Port is adjacent to the mouth of the Puyallup River, a glacial-fed stream that drains from the slopes of Mount Rainier (Figure 1). The Puyallup River supports populations of wild-spawning and hatchery-produced salmon and trout including Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*), that are listed as a threatened species under the Endangered Species Act (ESA), and Puget Sound steelhead trout (*Oncorhynchus mykiss*) that are under consideration for listing. Southern Resident Killer Whales (*Orcinus orca*), which are listed as endangered under the ESA, occur occasionally in Commencement Bay.

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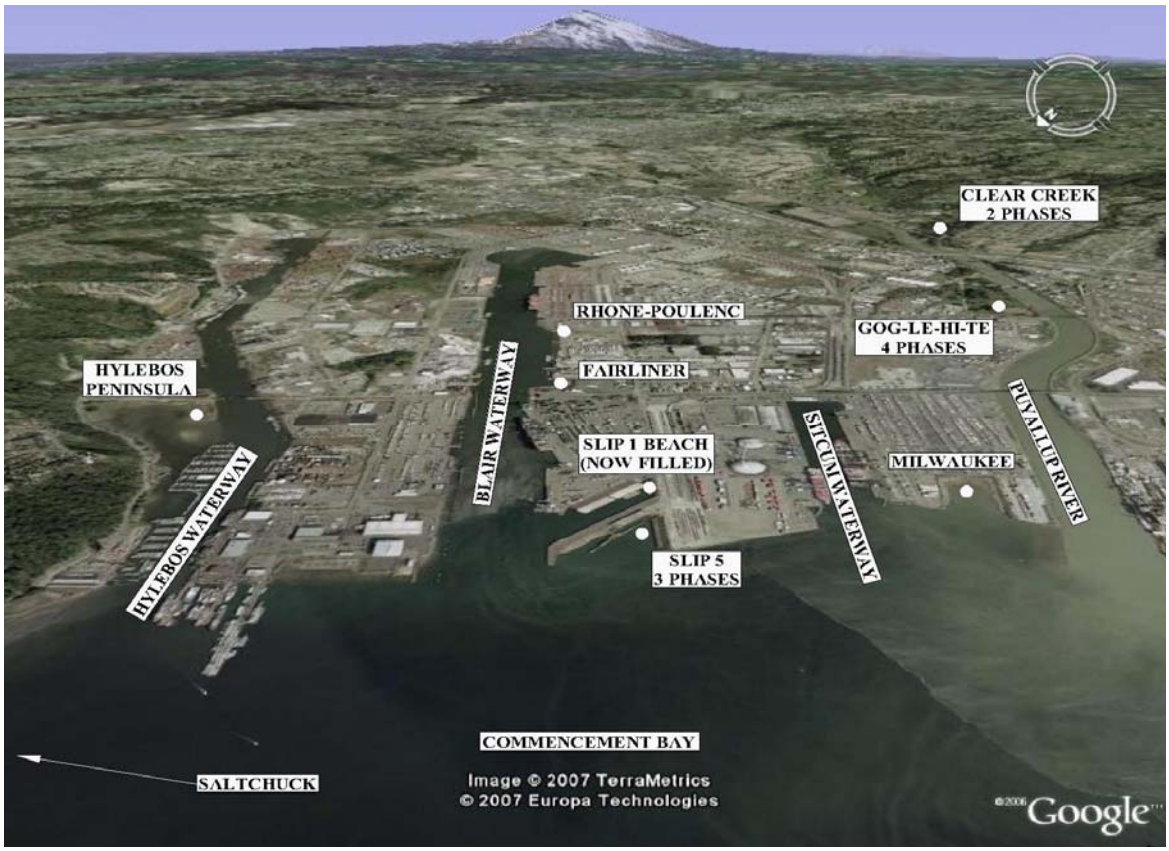


**Figure 1. Port of Tacoma habitat mitigation sites.**

To secure permits and/or approvals for the in-water components of its development and sediment remediation projects, the Port interacts with four agencies of the United States government, four Washington state agencies, the City of Tacoma, and two Native American Tribes. Environmental issues, particularly water quality and salmon habitat, are the primary drivers of the review process, although archaeological and cultural resource issues are also important. The myriad of agencies and personalities provide a challenging environment for resolving complex issues on complicated projects within time frames that can meet the demands of shipping lines for new or expanded facilities.

## BACKGROUND

The Port of Tacoma was formed in 1918 by the citizens of Pierce County, Washington, and has served the needs of the domestic and international shipping lines since that time. Through much of the 20th century the tide flats of Commencement Bay were home to chemical companies, sawmills, and an aluminum smelter, all of which have now closed. Redevelopment of the Port of Tacoma into a major international shipping port took a great leap forward in the mid 1980's when SEA-LAND, a major container shipping line, relocated from the Port of Seattle to the Port of Tacoma. Due to an abundance of developable land, the Port of Tacoma was poised for rapid development to serve the explosive growth in container-based shipping throughout the Pacific Rim.

However, the Port faced several major challenges:

- The Puyallup Tribe of Indians was asserting ownership claims to lands covering most of the industrial area of the filled tide flats in Commencement Bay, including the Port's holdings, pursuant to treaties ratified in the 1850's.
- The importance of the shallow water areas of Commencement Bay as habitat for juvenile salmon was gaining greater attention. Further, the U.S. Supreme Court had ruled that the federal government had an obligation to protect salmon habitats that sustain tribal fisheries. This meant that the potential environmental impacts of future development actions at the Port, and other areas of Puget Sound, would be under much greater scrutiny than previously.

- The nearshore/tidal flats area of Commencement Bay had been designated one of the ten most contaminated sites in the United States under CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) more commonly known as the U.S. Environmental Protection Agency's (EPA) Superfund Program.

- The Port's waterways were generally too shallow and in some cases too narrow to accommodate the new generations of vessels entering into service on the trans-pacific shipping routes.

The Port faced a substantial need for dredging to accommodate new vessels with greater beam and draft, and to remediate contaminated sediments. All of the dredging would need to be accomplished within an evolving regulatory paradigm where salmon habitat and the treaty fishing rights of Native Americans were assigned the utmost importance.

The first challenge that was resolved was the land claims of the Puyallup Tribe of Indians. The United States government, Port of Tacoma, City of Tacoma, and private industry entered into negotiations with the Tribe that yielded a comprehensive land claims settlement in late 1988. The settlement included job opportunities for Tribal members, transfers of land to tribal ownership, cash payments and habitat protection and restoration. Specific elements of the settlement required the Port to incorporate substantial habitat mitigation actions into development projects and to work closely with the Tribe to protect and restore salmon habitat. The settlement began a relationship between the Port and Tribe that has been beneficial for the redevelopment of the Port, and implementation of sediment remediation and salmon habitat restoration in Commencement Bay.

Over the last twenty years, the Port has successfully expanded its facilities and aggressively pursued sediment remediation. These actions have typically been conducted in degraded salmon habitats but have, in some cases, entailed unavoidable habitat losses. Pursuant to federal, state, and local law, the Port has implemented compensatory habitat mitigation actions ranging from excavation of upland to create aquatic habitat to placement of clean dredged material to convert low value aquatic habitat to high value shallow nearshore beaches.

Over the last twenty-two years, the Port has constructed 13 mitigation actions on 8 sites that provide an area of more than 27 hectares of aquatic habitat (67 acres) to offset impacts to salmon habitat. In addition, one site is currently under construction and another site is in the planning phase. Within the next five years the Port will have a total of approximately 48 hectares (119 acres) of salmon habitat built and functioning. All of these actions are located in the estuarine areas of the lower Puyallup River and the nearshore shallow water habitats of Commencement Bay and are focused on the needs of juvenile salmon.

## MITIGATION SITE LOCATION CRITERIA

The Port has taken the long-term perspective on aquatic habitat mitigation to ensure that opportunities exist to offset the anticipated impacts of development and to locate the sites for maximum ecological benefit and long-term protection. The following considerations have guided the Port's selection of locations:

- Locate habitat that will be used by large numbers of juvenile salmon

  In the mid to late 1980's the Port examined the configuration of its lands and identified several areas that could be committed to salmon habitat. The pattern of habitat use by juvenile salmon was very important in selecting the locations. Salinity is a very important factor in determining the numbers of juvenile salmon that will use these habitats. Low salinity means high use. Locations adjacent to the lower river, near the mouth of the Puyallup River, and areas that are often bathed by the freshwater plume of the river were good candidates for habitat. Gog-le-hi-te and the mouth of the Milwaukee Waterway are located in or adjacent to the mouth of the river (Figure 1). Slip 5 is often in the plume of the Puyallup River. Subsequent biological studies at these locations demonstrated that high numbers of juvenile salmon used each of these sites. The Port identified the mouth of Milwaukee Waterway, Slip 5, and Gog-le-hi-te as focus areas for salmon habitat.

- Compatibility with physical processes

  Sedimentation is an important physical process at the mouth of the Puyallup River. The delta that is growing at this location is naturally converting deep water habitat to shallow water habitat. The Port's Milwaukee Habitat Area was designed to take advantage of this physical process. Each year the aquatic habitat complex at the mouth of the Puyallup River increases in area.

Other mitigation sites (e.g., Slip 5) have been built in locations that are cut off from substantial supply of sediments. Those sites incorporate design features such as placement of gravel substrate and wave protection structures or reefs, to contain the sediments on site that will not be replaced by natural sediment deposition.

- Potential interference with navigation or redevelopment.

  In an area under intense development pressure, such as the Port of Tacoma, it is difficult to anticipate all of the future development scenarios. The new classes of vessels, with wider beams and deeper drafts, pose particular challenges because they have yielded the need for widening as well as deepening waterways. The most successful strategy has been to establish several large mitigations sites in safe locations rather than a larger number of small sites.

## PORT OF TACOMA MITIGATION PROJECTS

### Slip 1 Beach

The Port built this site in mid 1980's by placing gravel and rock to form a small shallow beach (Figure 1). Subsequent biological studies determined that very high numbers of invertebrates that are eaten by juvenile salmon were produced by this substrate. This site demonstrated how valuable gravel substrate was for producing prey for juvenile salmon. However, the site was small and improperly located. A few years after it was built it was recognized that this slip would be filled in the future to accommodate redevelopment of a container shipping terminal. Slip 1 was filled in 2005 as a confined disposal facility (CDF) for contaminated sediments as part of the CERCLA remediation of sediments from Hylebos Waterway (Figure 1). The surface of the fill was developed into a container shipping terminal.

### Gog-le-hi-te

The Port completed the first phase of habitat at this site in 1986 which yielded approximately 2.3 hectares (5.5 acres) of aquatic habitat (Figure 2). The site is located in an area of the estuary that is important for juvenile salmon as they undergo the physiological transition that allows them to move from freshwater to marine waters. The project entailed excavation of portions of an abandoned uncontrolled municipal garbage dump to form a mud flat and freshwater marsh.

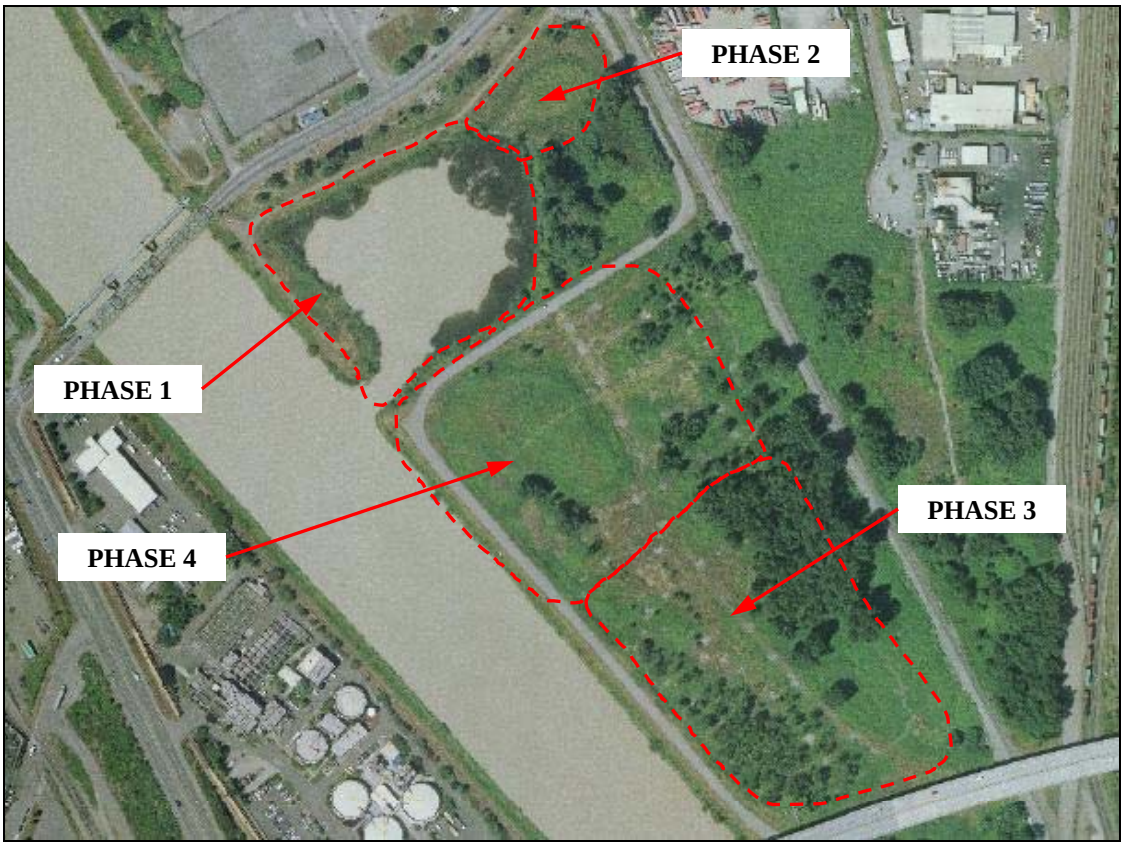


**Figure 2. Gog-le-hi-te mitigation site.**

Construction costs for this site were very high due to the presence of the municipal garbage. The Port expanded this site in 2003 (Phase 2) by excavating an additional area of habitat at an elevation that supports estuarine marsh vegetation (Figure 3).

**Figure 3. Gog-le-hi-te phase 2.**

The site will be expanded by approximately 2.5 hectares (6 acres) in 2007 (Phase 3 on Figure 2). The high construction costs associated with removal of the municipal garbage at this site has been the major reason for the

sequential construction. A fourth phase of construction will occur in the future to connect all of the phases into one habitat covering a total of approximately 10.5 hectares (26 acres) of aquatic habitat located in an ecologically vital portion of the estuarine system.

**Slip 5 Habitat Area**

Slip 5 was first used for a habitat mitigation action in 1988, by placement of dredged material to convert deep water habitat to form 1.1 hectares (2.7 acres) of shallow nearshore habitat (Figure 4). From the outset it was conceived as an expandable mitigation site; therefore, dredged material fill was placed throughout the site including the area between the obsolete piers to fill this area from -12.1 meters (m) Mean Lower Low Water (MLLW) (-40 ft) up to -7.6m MLLW (-25 ft) in preparation for future fill actions. Dredged material and gravel substrate were placed to build the beaches. Because of the distance from the mouth of the Puyallup River, essentially no sediment is transported by natural processes to the site. During the design of the initial habitat phase it was recognized that placed material would need to be protected from wave energy. As part of Phase 1, the obsolete piers were retained and fortified with soldier pile to provide wave protection. Subsequent biological studies demonstrated that high numbers of prey organisms are produced on the beaches and juvenile salmon are abundant. A small additional area of habitat was built in 1991 by placement of gravel.


**Figure 4. Slip 5 after phase 1 construction.**

The filling of Slip 1 as a CDF to contain contaminated sediments from the CERCLA remediation of portions of Hylebos Waterway, generated a need for substantial habitat mitigation. A portion of this mitigation need was satisfied by building habitat at Slip 5. The third phase of habitat construction was completed in 2005 and entailed placement of approximately 230,000 cubic meters ($m^3$) (300,000 cubic yards ($yd^3$)) of clean dredged material from elevation of -13.7m MLLW (-45 ft) to +1.8m MLLW (+6 ft). The final phase included a multi-year sequence of construction to provide adequate time for consolidation of dredged sediments adequate to yield appropriate static and seismic factors of safety during construction. The piers were removed as part of this phase because a protective reef was incorporated to provide wave protection (Figure 5).

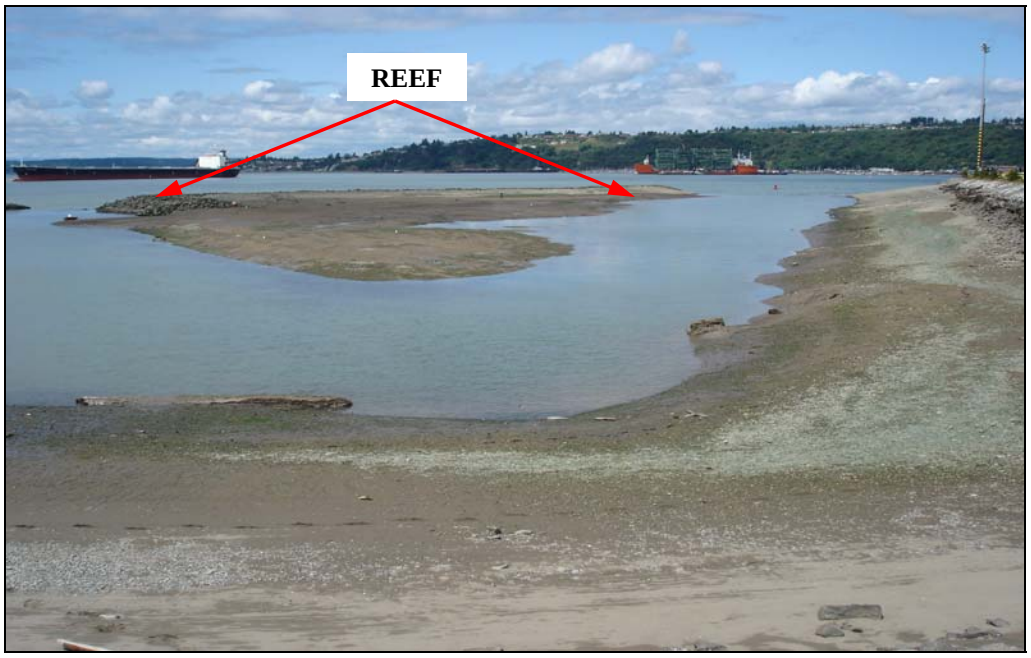


**Figure 5. Slip 5 after phase 3 construction.**

The reef is armored with rock on the side facing the bay and has a substrate that ranges from gravel to sand dredged material behind the reef. The reef allows the site to provide three shallow shoreline edges consisting of the original beaches, the landward face of the reef, and the bayward face of the reef (Figure 6). Each area has a different energy regime which allows the range of substrate types to persist. The site now provides approximately 3.8 hectares (9.5 acres) of shallow water habitat for juvenile salmon in a location with favorable salinity.

**Figure 6. Slip 5 phase 3 reef.**

**Milwaukee Habitat Area**

As part of the land settlement agreement with the Puyallup Tribe of Indians, the Port had agreed to only fill a portion of the obsolete Milwaukee Waterway to build a container shipping terminal and convert the mouth of the old waterway into shallow water habitat for salmon. In the early 1990's the Port implemented the Sitcum Waterway

Remediation Project and Blair Waterway Navigation Dredging Project under the auspices of U.S. EPA's CERCLA authority. The dredging project yielded approximately 1.9 million $m^3$ (2.5 million $yd^3$) of dredged material of which approximately 0.75 $m^3$ (1 million $yd^3$) required isolation in the CDF located in Milwaukee Waterway. The balance of the sediments were not contaminated and were used to construct the containment berm of the CDF, fill the CDF to grade, and build shallow water habitat at the mitigation site. The Port then incorporated the surface of the CDF into a container shipping terminal (Figure 7).


**Figure 7. Milwaukee habitat area.**

The mitigation action filled the deep entrance of the waterway between two areas of adjacent shallow water habitat to form a continuous habitat complex. The mitigation action raised the mouth of the waterway from an average elevation of approximately -10.7m MLLW (-35 ft) to +0.6m MLLW (+2 ft) through placement of approximately 0.75 $m^3$ (1 million $yd^3$) of dredged material. The Port's mitigation site consists of approximately 8.1 hectare (20 acres) of aquatic habitat that is part of one mud flat system covering approximately 20 hectare (50 acres) (Figures 8 and 9). The final configuration of the site was much larger than that envisioned in the settlement agreement. This occurred because the Port recognized the full habitat potential of the site and the engineering advantages of a larger mitigation action. This entailed designing the mitigation site as an integral component of the CDF. The massive fill, configured as gently sloped mud flat, greatly increased the seismic stability of the CDF by buttressing the containment berm.

**Figure 8. Milwaukee habitat area from southeast corner.**

**Figure 9. Milwaukee habitat area outer edge.**

The mitigation site was designed to compliment the adjacent shallow water habitat by providing beaches at higher elevations than the surrounding mud flat. The portion of the mitigation site inside the mouth of the old waterway consists of beaches that range from Mean Higher High Water (MHHW) +3.6 m (+11.8 ft) to 0 m MLLW (0 ft). The adjacent habitats do not provide habitat at these elevations. Such habitat diversity is important for juvenile salmon

during their early residence in the estuarine/marine habitats of Commencement Bay because they are typically located in shallow water (about 1m) throughout the tidal cycle. The intent was to provide a habitat complex which would support juvenile salmon throughout the tidal cycle and encourage them to reside at the site for several days. Subsequent biological studies have demonstrated that juvenile salmon do reside in the habitat site for several days to a week or more.

**Rhone Poulenc Habitat Area**

The Port built this site in 1996 by excavating upland to create mud flat and salt marsh (Figure 10). The site was located within Blair Waterway at the insistence of the resource agency staff who were concerned that no habitat would be available in the waterway as it was fully developed. The site does not fit well with the Port's perspective on the proper location of mitigation sites due to its position back in the waterway away from the bay where fewer fish encounter it (See Figure 1). Further, it may be in the path of future redevelopment.

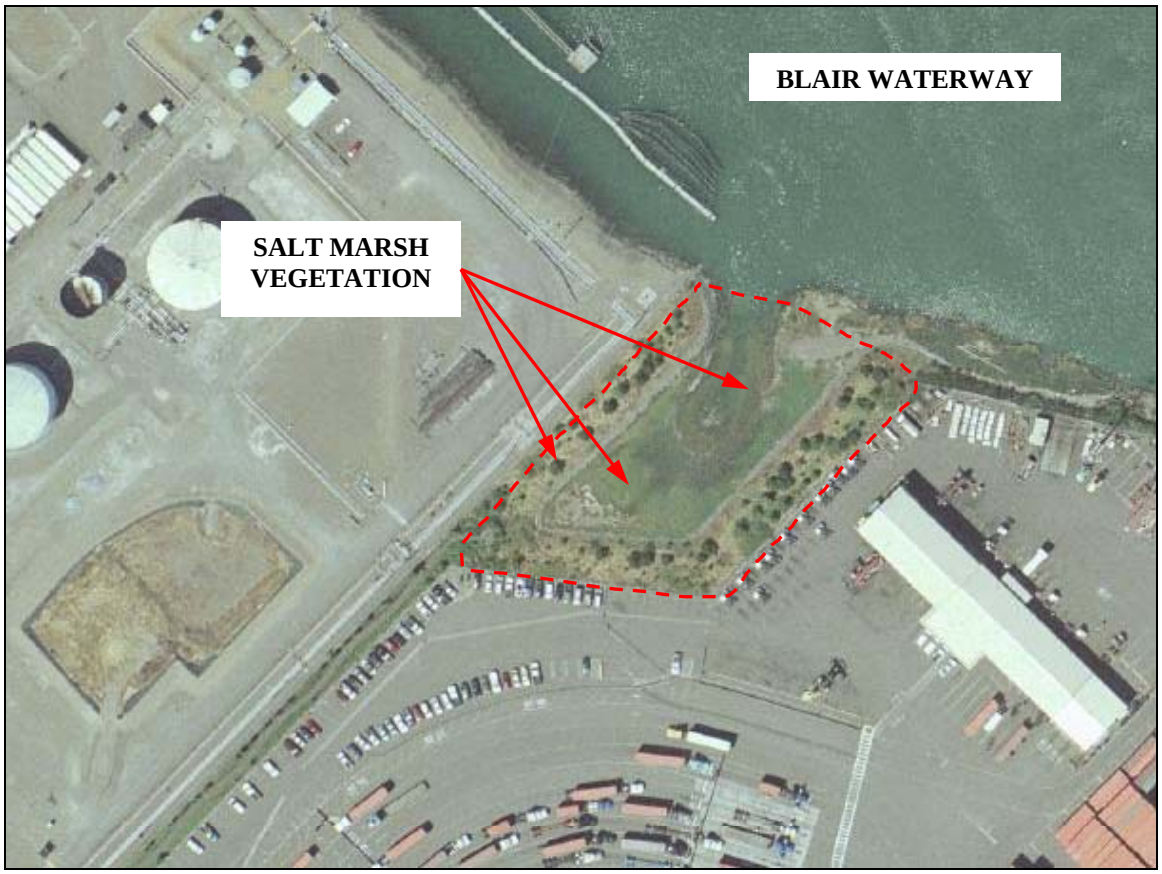


**Figure 10. Rhone-Poulenc habitat area.**

**Fairliner Habitat Area**

This site was completed in 1997 by placing dredged material to convert deep water habitat to shallow water beach (Figure 11). The site encompasses approximately 1.2 hectare (3.0 acres). Although the site provides functional habitat for juvenile salmon, it is poorly located relative to redevelopment needs. The Port was convinced that this area would never be incorporated into a proposal to widen Blair Waterway due to the existence of an active wharf near the facility that was believed to preclude widening at this location. In 2005 and 2006 a portion of the wharf was removed as part of a Blair Waterway Widening Project and a small portion of the mitigation site was eliminated. Substantial habitat mitigation will be built in 2007 at another location (a portion of Gog-le-hi-te Phase 3) to offset this impact to the mitigation site.


**Figure 11. Fairliner habitat area.**

**Clear Creek Habitat Area**

Excavation of upland yielded 3.2 hectare (8 acres) of aquatic habitat in the upper portion of the Puyallup River estuary adjacent to Clear Creek (Figure 12). The site has been built in two phases over five years. The rural nature of the site yielded reasonable construction cost due to low land values and lack of soil contamination. Further, existing trees and other site features were incorporated into the design to limit the impacts of construction and speed development of a wide range of biological functions (Figure 13).


**Figure 12. Clear Creek habitat area phase 1 and 2.**

**Figure 13. Clear Creek habitat area phase 2.**

**Hylebos Peninsula**

The Port excavated upland in 2005 to create 0.7 hectares (1.7 acres) of mud flat that is designed to complement an area of adjacent mud flat (Figure 14). The adjacent mud flats had limited high elevation habitat. The Port's site was designed to provide that habitat component to the adjacent mud flat complex (Figure 15).


**Figure 14. Hylebos peninsula mitigation site.**


**Figure 15. Hylebos peninsula mitigation site - ground level view.**

**Saltchuck Habitat Area**

This site is in the early design stage and applies the lessons that have been learned over the last 20 years at the Port of Tacoma. The site is large (up to 18 hectares, 45 acres) and is located in an area away from development pressures; therefore, it will be easy to protect over the long-term (Figure 16).

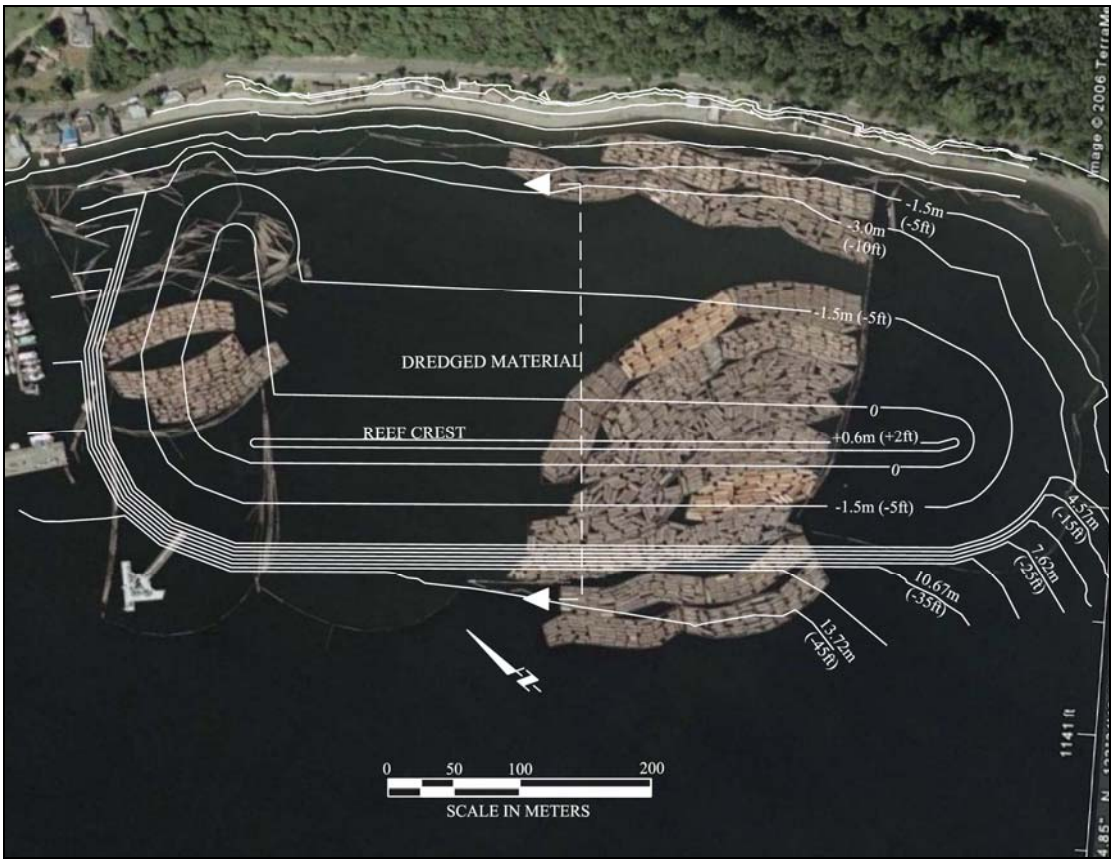


**Figure 16. Conceptual design of the Saltchuck mitigation site.**

The site is expandable and could be built in any one of a number of logical phases depending upon the availability of dredged material. A protective reef is incorporated in the design to reduce wave energy levels and allow range of habitat types including possibly eelgrass (*Zostera marina*) a highly desirable seagrass (Figure 17). The project would entail placement of approximately 1.76 million $m^3$ (2.3 million $yd^3$) of dredged material to convert deep water habitat to shallow nearshore beaches. The exiting substrate at the site consists of wood debris from log rafting activities, that either needs to be removed or capped. The Port's mitigation action would accomplish capping of the site while providing substantial habitat mitigation credit.

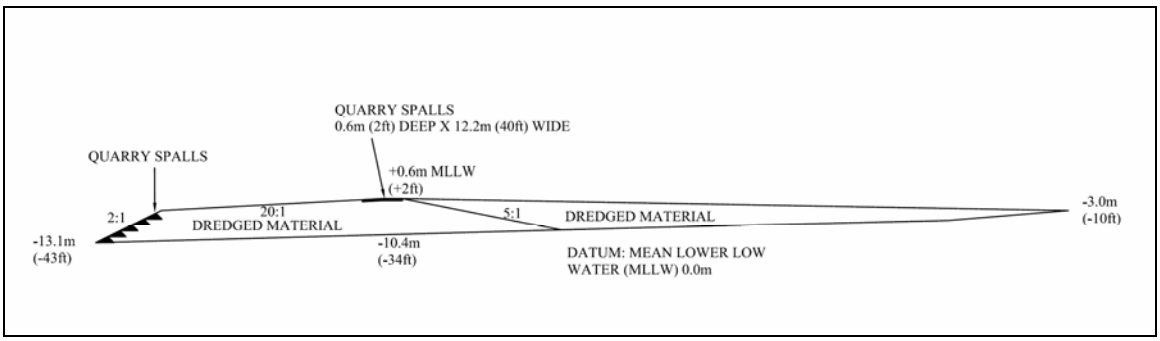


**Figure 17. Cross section of the Saltchuck mitigation site.**

## CONCLUSIONS

A number of important perspectives have emerged over the last twenty of implementing habitat mitigation actions at the Port of Tacoma including:

- Dedicate appropriate locations for habitat mitigation actions and be willing to keep them free from future development. Treat mitigation site selection with the same care as other major infrastructure decisions. Don't discount substantial future redevelopment risks.

- Own the problem. Habitat/development conflicts are not going away. Solve the problem by providing highly functioning habitat. Be proactive and understand the habitat needs of the target species in your area and how to provide them.
- Keep control of your dredged material and recognize it as an asset that is useful for building habitat that may provide multiple non-habitat benefits (e.g., sediment capping or structural integrity) as part of building habitat.
- If your organization has ongoing mitigation needs or can sell mitigation credits to others that do, keep an inventory and range of mitigation options available that vary in cost and habitat yield. This allows management of schedules and costs over time. Don't be forced by your development schedule to use the most expensive mitigation action in your inventory. Include expandable sites in the inventory and actions that that may not be economically viable now but may be in the future.
- Be bold in sediment cleanup and wrap in economic drivers for the project. The Port of Tacoma has used two major CDF's for disposal of contaminated sediments. Use of these sites generated substantial needs for mitigation; however, overall the projects yielded high benefits for salmon habitat and lower overall disposal costs, while providing land for expansion of needed container shipping terminals.
- All of the mitigation sites described above have been important components of the Port's overall approach to its mitigation needs. However, one class of actions stands out as particularly desirable. The construction of aquatic habitat through the placement of dredged material offers significant advantages over the other types of actions including: lower cost per hectare of habitat, location flexibility, phased construction, and preservation of disposal capacity at designated disposal sites.
- Recognize that it is often more difficult to complete a project with substantial habitat benefits than it is to complete one with minimal benefits. Typically the creativity that is required to implement the best solution will tax the flexibility of the regulatory program. Be persistent particularly if your organization routinely needs permits or approvals for in-water construction projects. Defining the permitting process by implementing a large number of successful habitat mitigation projects will increase your predictability and success for gaining approval for future projects.

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