Habitat Restoration in an Urban Waterway: Lessons Learned from the Lower Duwamish River

November 19, 2015 Workshop Report

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Volunteers help restore the Duwamish River by planting native vegetation at an Earth Day event hosted at Codiga Park, April 2008.

NOAA FISHERIES

NOAA's Damage Assessment, Remediation, and Restoration Program (DARRP) is made up of three offices within NOAA. DARRP staff include scientists, economists, restoration experts, and attorneys. This multidisciplinary team works closely with other agencies, industry, and citizens to protect coastal and marine resources, respond to pollution incidents, assess risk and injuries, and restore natural resources.

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Forward

Restoration is essential to recover listed species and critical habitats, support commercial and recreationally important fisheries, and restore injured natural resources and lost ecological services. Additionally, restoring degraded habitats contributes to the effort to address climate change by sequestering carbon. To address these and other priorities, habitat restoration has increasingly become a primary environmental management strategy across the nation.

Urban watersheds are one of the most challenging places to conduct habitat restoration. Restoration in remote, relatively undeveloped areas tends to be simpler, larger, faster to implement, and much less expensive on a per-acre basis. We have learned much from the many years of restoration in relatively undeveloped areas, making these efforts increasingly more efficient and effective. Conversely, restoration in highly developed and commercially important urban estuaries is complicated and expensive, and often takes much longer to implement. However, recent habitat restoration efforts in the heavily urbanized Lower Duwamish River (LDR), which flows into Seattle's Elliott Bay, have identified lessons and solutions that may aid others working in these challenging areas.

Despite the difficulty and expense of implementing habitat restoration projects in the LDR and other urban estuaries, there are a number of reasons for increasing restoration efforts in these areas, including:

- fulfilling mitigation requirements for development projects that impact critical habitats;
- addressing limiting factors to the recovery of Chinook salmon and/or other species protected under the Endangered Species Act (ESA) that depend, directly or indirectly, on urban estuaries;
- conducting compensatory natural resource damage assessment (NRDA) restoration to address injury to natural resources and resource services due to oil spills and hazardous substance releases;
- restoring habitats and natural resources important for Native American cultural purposes and that support fishing under Treaty Rights; and
- providing public access to shoreline areas suitable for recreation.

Recognizing both the importance of habitat restoration in the LDR and the challenges faced by those intending to conduct habitat restoration there, the National Oceanic and Atmospheric Administration (NOAA) sponsored a workshop on lessons learned from recent habitat restoration efforts in the LDR on November 19, 2015. The morning began with presentations by habitat restoration practitioners with recent project experience. Presenters described challenges, both expected and unexpected, that they faced when planning and/or implementing habitat restoration projects, and the attempts made to overcome these challenges. The final presentation of the morning discussed monitoring of four habitat restoration projects built or financially supported by the Elliott Bay/Duwamish Restoration Panel (EBDRP) between 2000 and 2006. Following the morning presentations, there were two afternoon panel discussions. The first panel consisted of the presenters from the morning session, who engaged in a discussion about common and unique challenges they faced, and solutions for these challenges. The second panel included agency staff, at the local and federal government levels, who are involved in consultation or permitting for restoration projects. These panelists shared thoughts on how project planners could facilitate timely permitting and consultation decisions by regulators, and discussed avenues for making the permitting process more efficient.

The information shared in this report is for the benefit of the Duwamish restoration community, as well as those interested in habitat restoration in other urban watersheds. Our focus is on projects primarily intended for habitat restoration in highly developed, estuarine areas, and on how to maximize and sustain ecological function and services from these projects. The authors of this report also recognize the importance of providing access to green spaces and shorelines to the public for recreational and educational purposes, and believe that lessons learned from the workshop will help to overcome the constraints projects with multiple goals pose for creating well-functioning habitats.

This report contains seven sections. Following the introduction, the second section is a brief description of the projects presented at the workshop. The next three sections cover issues raised in the planning/designing/permitting, construction, and post-construction phases of these projects. The following section summarizes the key points made in the workshop discussion about how project planners can move through the permitting and consultation process more efficiently. The final section provides recommendations about best practices for entities interested in conducting restoration in urban estuaries. In addition to the information presented at the workshop itself, this report also contains information discussed in planning calls for the workshop and during site visits by workshop planners, as well as in discussions among participants following the workshop.

Acknowledgements

The authors would like to thank all of the presenters at the workshop for their willingness to devote time to assist in workshop planning, develop their presentations, and participate in the workshop: Jon Sloan, George Blomberg, and Joanna Hingle (Port of Seattle), Shawn Severn and Bill Granger (Bluefield Holdings, Inc.), Mike Gleason (Boeing), Cliff Whitmus (AMEC, contractor to Boeing), Jon Hansen (King County), Mike Perfetti (City of Tukwila), and Jeff Krausmann (U.S. Fish and Wildlife Service). We also thank the members of the regulatory panel for sharing their perspectives: Mike Grady (NOAA), Shawn Blocker (Environmental Protection Agency), Sean Robertson (City of Seattle Department of Transportation), Margaret Glowacki (City of Seattle Department of Planning and Development), and Jacalen Printz (U.S. Army Corps of Engineers). Other individuals who helped plan or assist at the workshop, and whose efforts were essential to making the workshop happen includes: Brian Anderson, Donna Podger, Randy Carman, Michael Carlson, Elissa Ostergard, Kathy Minsch, Jeff Stern, and Michael Silagi. Finally, we would like to thank the audience at the workshop for engaging in the discussions, asking important questions, and sharing their own experiences and thoughts. The views expressed in this report are those of the authors and do not reflect official NOAA guidance or policy.

This report can be downloaded from the following link: https://casedocuments.darrp.noaa.gov/northwest/lowerduwamishriver/pdf/LDRLessonsLearnedReport.pdf

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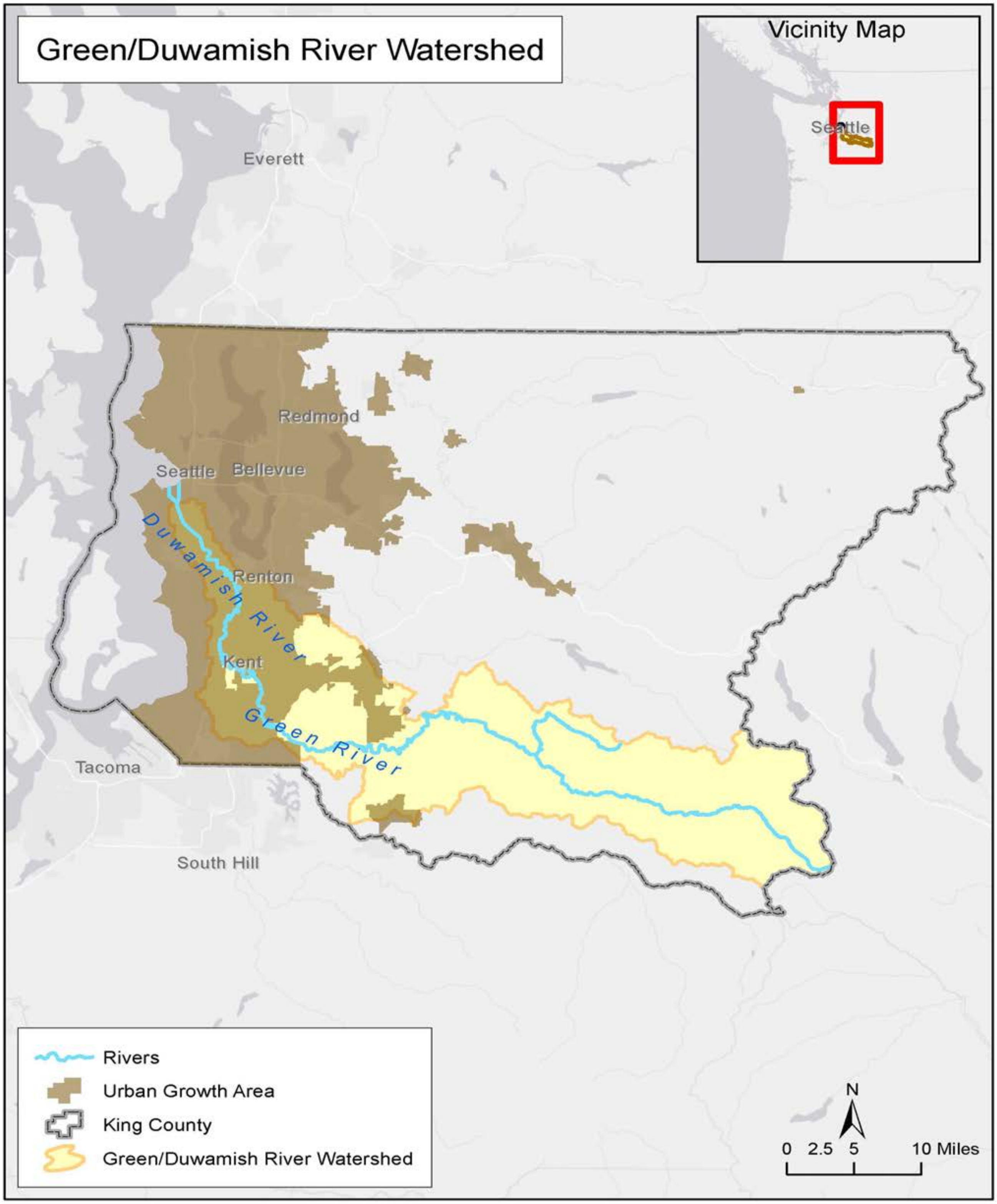

Figure 1: Map of the Green/Duwamish River watershed in Washington. The Lower Duwamish River ends about 2/3 of the distance between the mouth of the river and Renton. (Map courtesy of Jill Ory, NOAA Restoration Center)

Introduction

The Lower Duwamish River (LDR) in Seattle, Washington (Figure 1) was once a wide, meandering river with thousands of acres of mudflats and wetlands (Figure 2). It was channelized and narrowed by the 1940s (Kerwin and Nelson, 2000), and approximately 98 percent of its original estuarine wetlands and mudflats have been lost to dredging or filling for industrial and commercial purposes (U.S. Fish and Wildlife Service, 2012; U.S. Army Corps of Engineers, 2000). The result is a highly developed and extremely modified estuarine portion of the Duwamish River (Figure 3). Industrial and municipal activities have also resulted in heavy contamination of sediments, with three Superfund sites located within the LDR. One of these waste sites is Harbor Island, built from dredge material more than 100 years ago. It sits at the mouth of the LDR, creating the East and West Waterways that provide access to the river from Elliott Bay.[1]

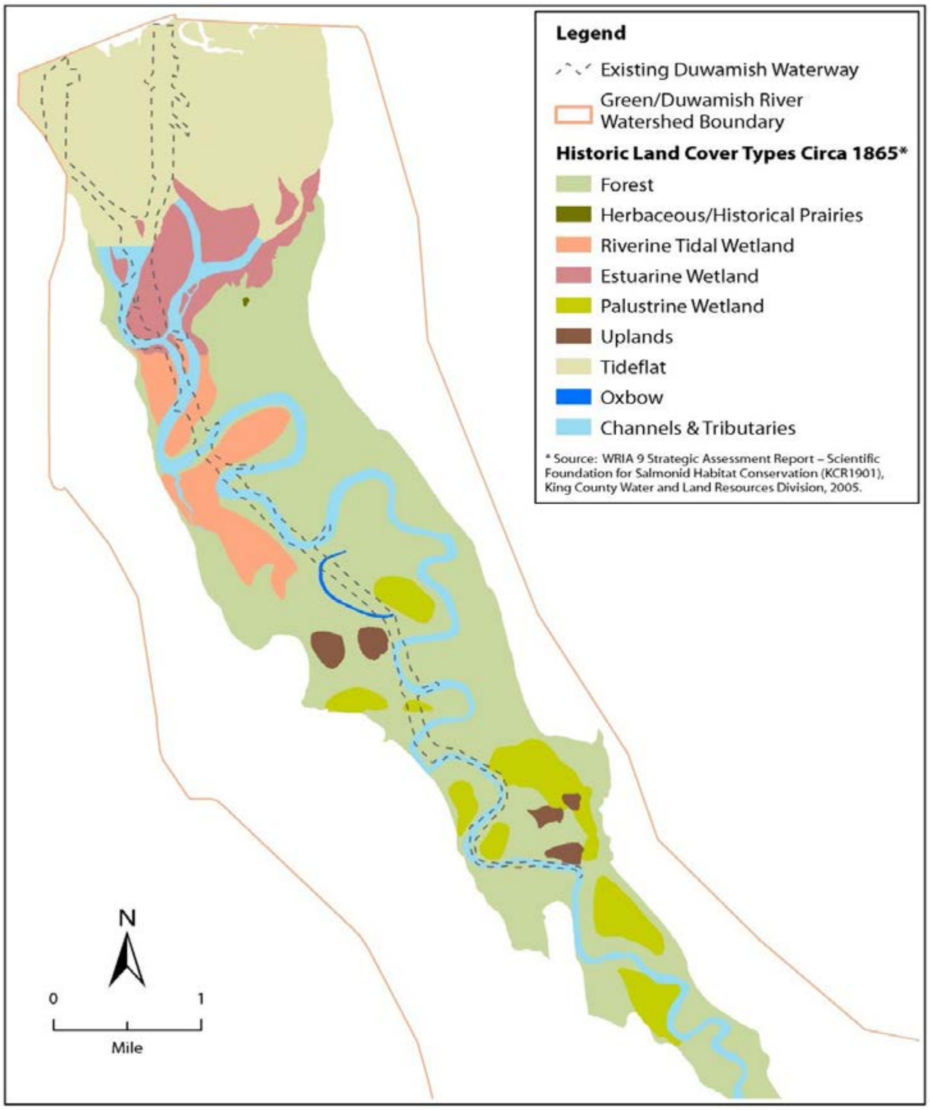

Figure 2: Duwamish River showing location of pre-development river and habitats; current configuration of river is shown by dotted lines. Approximately 2/3 of the river length shown is the Lower Duwamish River, as defined for the workshop.

For the purposes of the workshop, the LDR extends from the mouth of the river at Harbor Island, up to the natural rock formation named North Winds Weir (consistent with the definition used for the LDR NRDA). One project discussed at the workshop is located a short distance upstream from the rock weir, but was included because conditions at that site are largely similar to other projects in the vicinity.

Despite the highly developed and degraded state of the LDR, it serves as essential habitat for species listed under the Endangered Species Act, such as Puget Sound Chinook salmon. These anadromous fish spend many weeks in the estuarine portion of the Duwamish as juveniles, acclimating to higher salinities prior to entering Puget Sound. Additionally, the LDR supports tribal and recreational fishing, as well as kayaking and other water-dependent recreation for local residents. Habitat restoration in the LDR is important for many reasons, including recovering listed species, improving tribal and recreational fisheries, and enhancing the recreational experience. Many entities have developed restoration plans for the LDR; the Port of Seattle's (POS) Lower Duwamish River Habitat Restoration Plan (2009) describes these efforts.

Habitat restoration in the LDR, as in other urban estuaries, is constrained by industrial uses and other physical developments in the river and along the shoreline. Restoring to historical (pre-1900s) conditions is not possible in a system that has undergone such a high level of alteration and that supports

1. Simenstad et al. (2005) provide a thorough description of the extreme modifications to the Duwamish River and the stressors that affect habitat function.

Figure 3: Aerial photograph of the Lower Duwamish River. Harbor Island and Elliott Bay are shown in the top left and downtown Seattle in the top center of the photograph.

numerous land use types, including industrial, commercial, residential, and urban infrastructure. The inability to restore large areas of habitat to a structure identical to what existed prior to major development has led some researchers to use the term "rehabilitation" rather than "restoration" for habitat projects in these highly developed environments (Simenstad et al., 2005). However, in this report we use the term "restoration" in a broad sense, as defined in the Oil Pollution Act (OPA) NRDA regulations, which encompasses the concept of rehabilitation.[2]

It is a challenging enterprise to restore habitat function while facing the constraints of hydrologic alteration and urban development, high levels of contamination, use as a commercial waterway, and limited availability (and high property cost) of potential restoration sites. Despite these obstacles, federal, state, local, and tribal governments, and non-governmental organizations are successfully restoring habitat in the LDR. Some may believe that habitat restoration in urban estuaries is incompatible with an active working waterfront, but this is not necessarily true, provided the principal goal of restoration is recovery of habitat function, not recreating the specific habitat structures that previously existed. Despite the apparent internal contradiction of the "dual mandate" (Weinstein and Reed, 2005) of restoring habitat while maintaining commerce, the POS concluded that habitat restoration and commerce in the LDR can successfully co-exist (POS, 2009).

Beginning in the 1990s, significant efforts to restore habitat in the LDR began with the POS Terminal 108 project (1995) and the Turning Basin Number 3 demonstration project (1996). More extensive habitat restoration in the LDR followed, by the POS, the U.S. Army Corps of Engineers, King County, the City of Seattle, and federal, state, and tribal natural resource trustees (Simenstad et al., 2005; POS, 2009). See call out box above for more information on natural resource trustees.

Duwamish Natural Resource Trustees

Natural resource trustees conduct habitat restoration using funds from NRDA settlements for injuries to natural resources under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and OPA. Trustees for the LDR include NOAA, U.S. Department of the Interior/U.S. Fish and Wildlife Service, the state of Washington (Department of Ecology lead, assisted by Department of Fish and Wildlife), the Muckleshoot Indian Tribe, and the Suquamish Tribe. Restoration to date by the trustees in the LDR has been the result of an NRDA settlement with the City of Seattle and King County that established the Elliott Bay/Duwamish River Restoration Program, in which the trustees, together with Seattle and King County, built habitat projects, conducted sediment remediation, and undertook source control efforts.

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2. In the OPA regulations, restoration is defined as, "any action (or alternative), or combination of actions (or alternatives), to restore, rehabilitate, replace, or acquire the equivalent" 15 C.F.R. §990.30.

More recently, the private sector has become engaged in habitat restoration, including projects by Boeing and Bluefield Holdings, Inc. (a restoration banking firm), to address NRDA restoration requirements. With patience and much persistence, these projects have been successful to a large degree in restoring habitat function to degraded areas in the LDR despite all of the obstacles faced.

Additional restoration efforts will occur in the LDR, and sharing the many lessons learned from past and present restoration efforts could make future LDR restoration efforts more efficient, less expensive, and more successful in achieving desired ecosystem benefits. NOAA's Damage Assessment, Remediation, and Restoration Program contacted several parties who had recent experience in planning, designing, and implementing habitat restoration projects, and engaging in post-construction adaptive management at restoration sites. These restoration practitioners offered to share their experiences, both successes and failures, in a workshop for others interested in restoring habitat in the LDR. Although each project is unique in many ways, during the planning of the workshop it became evident that all of the projects faced some of the same issues (e.g., grazing by Canada geese (Branta canadensis) hindering establishment of marsh vegetation) and virtually all issues were shared by at least two projects. Figure 4 shows the locations of the projects discussed at the workshop.

Figure 4: Location of the nine habitat restoration projects discussed at the Lessons Learned from Habitat Restoration Efforts on the Duwamish River workshop on November 19, 2015. Note that the North and South Boeing projects are discussed as a single project in this report. (Map courtesy of Donna Podger, Washington Department of Ecology)

Project Descriptions

Tribal Elder Bernice White Place (Site 1)

Figure 5: Site 1 prior to construction. (Courtesy of Bluefield Holdings)

Bluefield Holdings, Inc. built the Tribal Elder Bernice White Place restoration project (Site 1) as the first of several NRDA restoration bank projects planned for the LDR. Parties with NRDA liability can purchase credits in these projects to address their liability, similar to the purchase of credits by parties in a mitigation bank. Bluefield Holdings obtained a master lease from the City of Seattle for several city-owned properties along the Duwamish River, including Site 1. After the Bluefield lease with the city expires, the city will manage and maintain the restoration sites. Because Site 1 is a NRDA restoration project, there are specific monitoring and other requirements that Bluefield Holdings must meet under NRDA regulations and policies. The project design maximized the number of credits for sale to potentially responsible parties wishing to resolve their NRDA liability, given site constraints. The project also has requirements under the terms of the lease from the city to provide for multiple uses, including public access, in addition to creating habitat for ecological purposes and use in resolving NRDA liability of potentially responsible parties in the LDR.

Project construction began in late 2012 and ended in November of 2013. The project site is adjacent to and beneath the Spokane Street Bridge on the western shore of the West Waterway (Figure 5). Prior to construction the site contained invasive plants, rubble and debris, existing utilities, and a shoreline largely armored with riprap and a treated wood bulkhead (Figure 6). The project converted this degraded area into approximately one acre of restored habitat, including off-channel mudflat and marsh with a channel for fish access, bordered by riparian and upland plantings (Figure 7). Adaptive management actions are under development to address issues that developed post-construction, as discussed later in this report. For more information about Bluefield Holdings and the Site 1 project, visit their website at http://bluefieldholdings.com/.

Figure 6: Pre-existing conditions at Site 1. (Photographs courtesy of Bluefield Holdings)

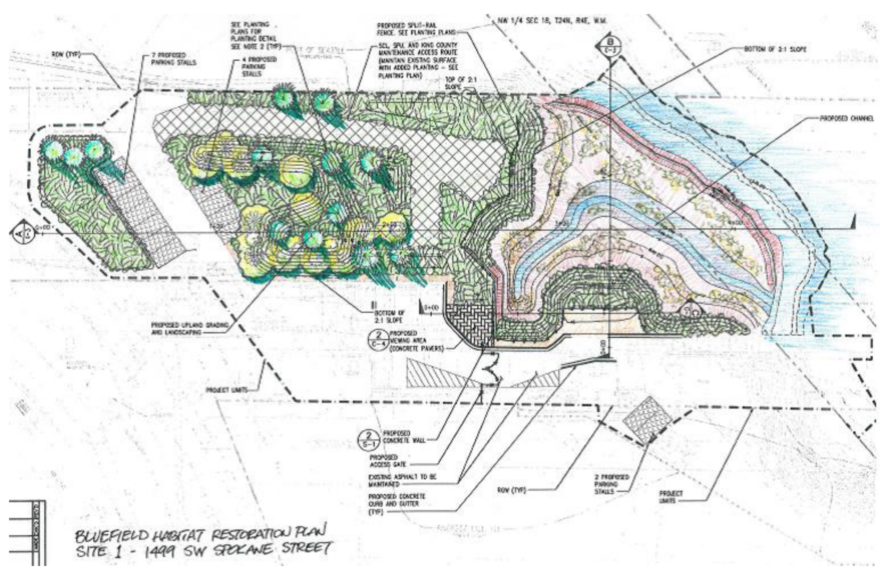

Figure 7: Final concept for Site 1. (Drawing courtesy of Bluefield Holdings)

Terminal 117

Figure 8: Aerial photograph of Terminal 117 project site prior to remediation. Dotted lines show limits of restoration project. (Photograph courtesy of the Port of Seattle)

The Terminal 117 POS restoration project is currently in the planning/permitting/design phase. It will be located on two adjacent Port-owned properties (Figure 8), one of which has undergone remediation. The other parcel currently has a steep, armored shoreline. Substantial mudflat habitat fronts both parcels, which suffers from reduced ecological value due to the lack of a bordering marsh or riparian habitat. This project will also become a NRDA restoration project under an anticipated future settlement agreement, subject to NRDA requirements similar to those for Site 1. The project will remove shoreline armoring and fill, and will create additional mudflat habitat as well as marsh and riparian habitat, resulting in the type of mudflat-marsh-riparian habitat complex preferred under the LDR's NRDA restoration plan (NOAA, 2013). Overall, the proposed project will create over four acres of additional mudflat, marsh, and riparian habitat converted from riprap and unvegetated uplands. The formation of the habitat complex will also improve the ecological function of over two acres of existing mudflat (Figure 9). The design incorporates public access features, including a viewing pier and kayak launch (Figure 10).

The planning for this project has benefitted from the experience of previous restoration implemented by the Port, incorporating approaches used to solve problems faced in these earlier projects. Additional information about plans for the Terminal 117 project is available at: https://www.portseattle.org/Environmental/Site-Clean-Up/Pages/Terminal-117-Habitat-Restoration.aspx.

Figure 9: Current concept of Terminal 117 project habitat types and locations. (Courtesy of the Port of Seattle)

Figure 10: Conceptual figure of the northern portion of Terminal 117, showing pier and kayak launch. (Courtesy of the Port of Seattle)

Boeing Restoration Project

Figure 11: Drawings of southern portion of Boeing habitat project before (top) and after (bottom) restoration.

To address NRDA liability, Boeing created habitat on two portions of their Plant 2 property on the east bank of the LDR. (For the purposes of this report, we treat the two areas of restoration as a single project.) For efficiency, Boeing implemented the restoration actions concurrently with EPA-led remedial actions and used one set of permits (as part of the ongoing cleanup of the LDR). Boeing removed overwater structures (including a building), shoreline armoring, and pilings, and created mudflat, marsh, and riparian habitat in the southern portion of the project (Figure 11). At the northern end of the project (adjacent to the mouth of Slip 4), Boeing removed a steep armored shoreline and fill, creating an open water channel bordered by marsh vegetation, with mudflat and riparian habitat (Figure 12). The southern portion of the project is similar, but without a channel. Project construction began in 2012 and was completed in September 2013 except for some additional work on the project required later because of subsequent remedial activities. The project created a total of approximately five acres of new habitat. Because the project addressed Boeing's NRDA liability, the terms of the settlement affected project timing, monitoring requirements, and required another level of review (by the Elliott Bay Trustee Council) beyond that of the permitting agencies. Additional information about Boeing's habitat project (and their role in the Duwamish cleanup) is available at: http://www.boeing.com/principles/environment/duwamish/index.page. NOAA also produced a video about the Boeing restoration project that can be viewed at: http://www.nmfs.noaa.gov/stories/2014/05/05_29_14duwamish_river_restoration.html.

Figure 12: Drawings of northern portion of Boeing habitat project before (top) and after (bottom) restoration.

North Winds Weir Restoration Project

The North Winds Weir Restoration Project was built by King County, in partnership with the U.S. Army Corps of Engineers (USACE) and the Washington Department of Natural Resources (which contributed aquatic lands for the project). Additional project funding was provided by the Salmon Recovery Funding Board, EBDRP, and the Cities of Seattle and Tukwila. The project is located on the east shore of the Duwamish, very close to the North Winds Weir, a natural rock weir feature upstream of Turning Basin Number 3 (Figure 13). King County completed removal of contaminated material at the site in 2009, and the USACE led construction of the restoration project. The installation of marsh and riparian plants in 2010 completed the project. Approximately two acres of new off-channel intertidal habitat were created (see Figure 14). More information about this project, including numerous photographs showing construction activities, is available at: http://www.govlink.org/watersheds/9/plan-implementation/srfb-northwinds.aspx.

Figure 13: North Winds Weir project location pre-restoration. (Courtesy of King County)

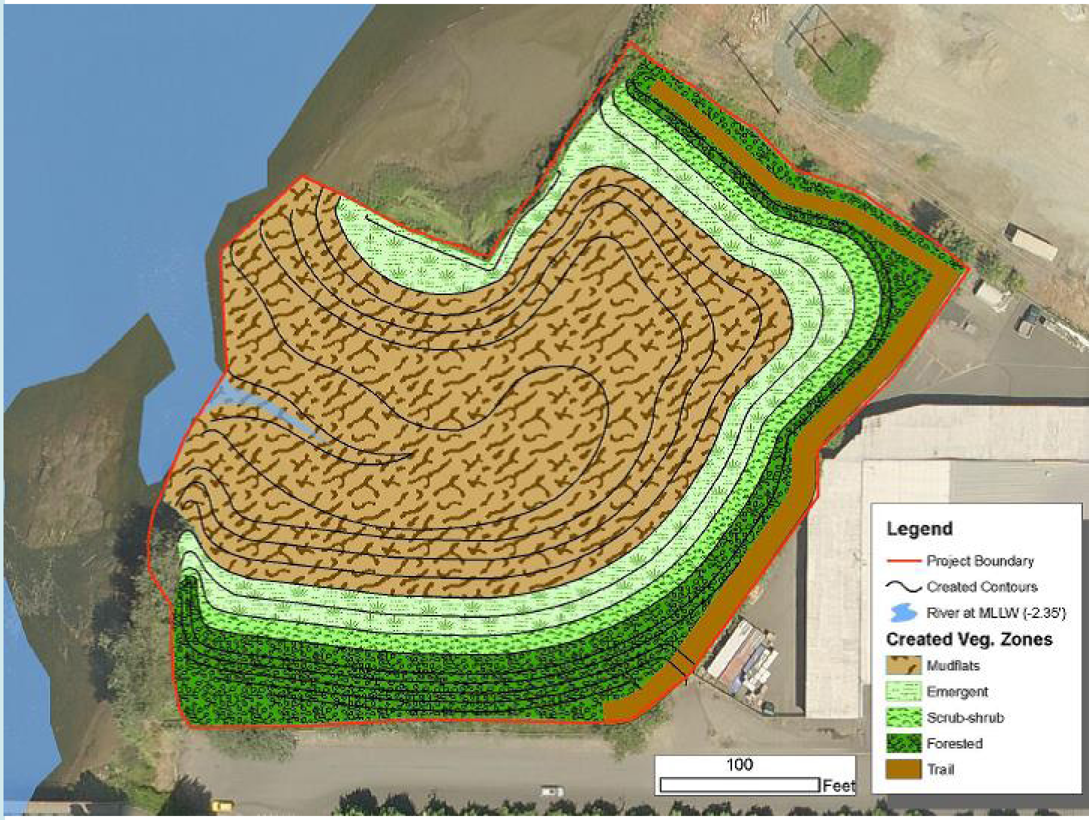

Figure 14: North Winds Weir restoration concept. (Courtesy of King County)

Duwamish Gardens Restoration Project

Figure 15: Duwamish Gardens project design concept. (Courtesy of Mike Perfetti, City of Tukwila)

The City of Tukwila began construction of the Duwamish Gardens restoration project in 2015. When complete, the project will create approximately two acres of intertidal habitat within a 2.7-acre site, and include public access and amenities (Figure 15). The project involves deep soil excavation and planting of native vegetation. It is located on the east bank of the Duwamish River, just downstream of where East Marginal Way crosses the river (Figure 16). In addition to funding from Tukwila, financial support came from a number of entities, including the Salmon Recovery Funding Board, the King Conservation District, and the King County Flood Control District. More information about this project is available at: http://www.govlink.org/watersheds/9/plan-implementation/SRFB-duwamish-gardens.aspx.

Figure 16: Duwamish Gardens project site pre-restoration. (Courtesy of Mike Perfetti, City of Tukwila)

Elliott Bay/Duwamish Restoration Program

The Elliott Bay/Duwamish Restoration Program (EBDRP) constructed three habitat restoration projects in the LDR from 2000 through 2006, and provided partial funding toward the 6.2-acre Hamm Creek restoration project, completed in 2000 (Figure 17). It provided access for salmonids to Hamm Creek by restoring 2 acres of freshwater marsh, 1 acre of intertidal estuarine marsh, and 1,900 feet of new stream and riparian habitat. Herring's House, completed in 2000, involved removal of mill structures, a dock, and contaminated sediments (Figure 18). The Herring House project resulted in restoration of 3.14 acres of estuarine wetland, 2.53 acres of nearshore upland habitat, and enhancement of 1.8 acres of intertidal bay with fringing emergent vegetation. In 2003 Cecil Moses Park was completed (Figure 19). This 1.03-acre project entailed removal of steep, hardened riverbank and installation of emergent and riparian vegetation to create off-channel habitat for out-migrating salmon. The final EBDRP restoration project, Kenco Marine, (also known as Turning Basin No. 3) was completed in 2006 (Figure 17). A building, dock, two grounded barges, and fill material were removed from the 0.41-acre project area. Marsh and riparian vegetation was planted to create intertidal and riparian habitat.

The workshop presentation about the EBDRP projects focused on the results of project monitoring at these four sites through 2010. More information on EBDRP and the projects is available at: https://casedocuments.darrp.noaa.gov/northwest/elliott/admin.html.

Figure 17: Hamm Creek (top area outlined in red) and Kenco Marine (bottom outlined area) restoration project locations.

Figure 18: Herring House restoration project location.

Figure 19: Cecil Moses Park project location.

Planning/Designing/Permitting: Challenges and Solutions

The pre-construction period for Duwamish habitat restoration projects can extend for many years following the acquisition or provision of property, and decisions made and actions taken during this period can significantly affect overall cost and ultimate project design. Projects intended to serve multiple purposes, such as ecological service provision and public access, will involve more parties in planning, design, and permitting than will single-purpose projects, and will face more constraints on the design of habitat features. The presence of contamination throughout large portions of the LDR means that project implementers must consider not only the implications of contamination within their proposed sites, but also remedial actions that will be occurring in the vicinity. Additionally, in the highly developed and commercially active LDR, project implementers must consider the effects of wakes from large commercial vessels and smaller boats (Figure 20), as well as large amounts of debris (both artificial and natural). Furthermore, most LDR property potentially available for restoration contains abandoned and/or active infrastructure requiring removal, relocation, or avoidance, in addition to potential contamination, shoreline armoring, and poorly characterized fill. Finally, the configuration of some available property (e.g., narrow strips along the river) may prevent inclusion of all desired habitat elements (riparian, marsh, mudflat). Considering all of these factors, it is not surprising that the pre-construction phase of LDR habitat projects requires a lot of time, patience, and flexibility.

Physical Constraints

With the exception of publicly owned properties, most parcels along the LDR are used for commercial or residential purposes, and there is relatively little land available for restoration. Even when private land is available for purchase, property values within an active waterway can be high, given competing demands from commercial interests. In addition, infrastructure (e.g., utility lines, sewer lines, underground storage tanks, etc.) and contamination are often present, which could limit the amount and location of restoration on a site, or result in additional costs for removal and remediation.

The presence of infrastructure often limits potential restoration projects to a relatively thin strip along the river, which may result in steep project slope designs that could be subject to failure without significant engineering. It is theoretically possible to increase the width of a restoration site by placing clean fill on shallow subtidal areas, to increase intertidal habitat and thereby creating a shallower slope. However, the placement of fill in this manner would reduce the amount of aquatic habitat available for net placement, interfering with tribal fishers utilizing their Treaty Rights, and therefore would be unlikely to survive the permitting process. Even when the presence of infrastructure on a potential restoration site does not limit the width of a restoration project, the footprint of the infrastructure along with access for routine maintenance may require use of designs that limit the ultimate dimensions of the restoration area. The problem of dealing with on-site infrastructure is illustrated in Figure 21, which shows the Site 1 project area ahead of restoration, and Figures 22 to 24, showing the changes in design and large reduction in habitat area required to address infrastructure and associated public safety issues. Boeing removed an entire building (part of which was overwater on pilings) in order to construct their project (Figures 25 and 26).

Figure 20: Boat activity in the LDR.

Figure 21: Site 1 from back of property looking east toward the LDR, showing bridge supports and utility tower limiting area available for restoration. Not visible is a buried fiber optic line. (Courtesy of Bluefield Holdings)

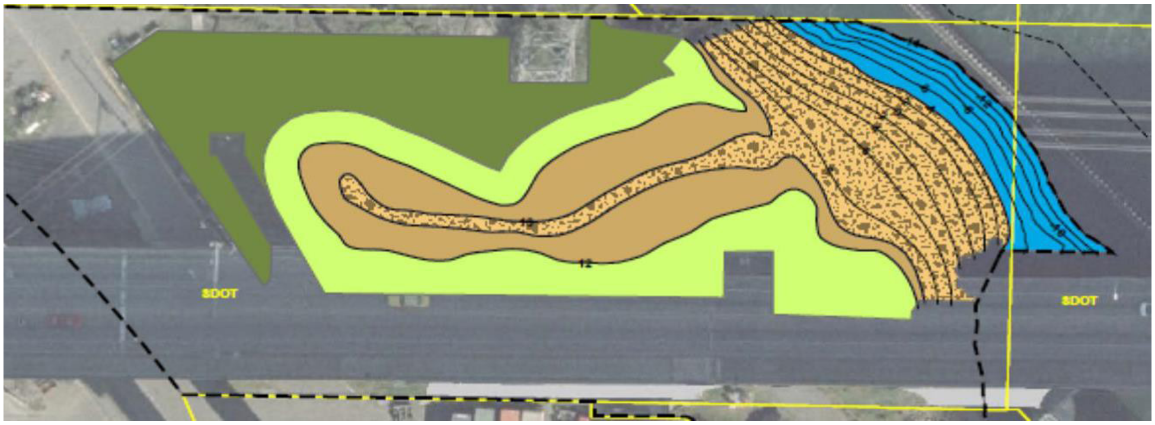

Figure 22: Initial restoration design concept for Site 1. (Courtesy of Bluefield Holdings)

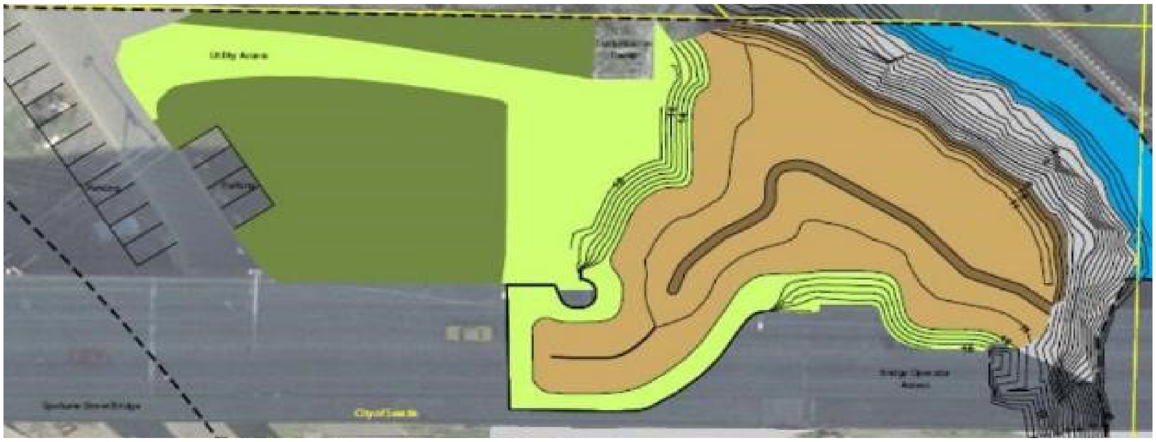

Figure 23: Site 1 30% design concept. (Courtesy of Bluefield Holdings)

Figure 24: Site 1 60% design concept as modified to address infrastructure issues. (Courtesy of Bluefield Holdings)

Figure 25: Boeing Plant 2 building prior to its removal for habitat restoration.

Figure 26: Removal of Boeing Plant 2 building in preparation for restoring habitat.

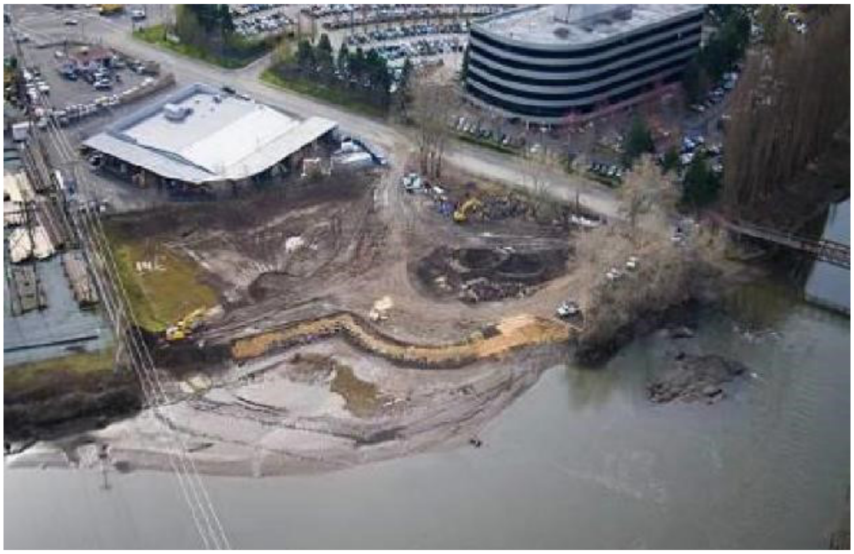

Figure 27: North Winds Weir project site remediation. (Courtesy of King County)

Contamination

Potential restoration sites in urban areas often include areas contaminated by hazardous substances at levels requiring disposal at approved locations. In many cases, the location and degree of contamination is uncertain. Extensive sampling may be required to identify the nature and extent of contamination, and the sample results may lead to changes in project design. Even if the location and levels of contamination across a potential restoration site has been determined, the cost of remediation may be prohibitively high.

The presence of large debris within the fill at Site 1 obstructed sampling in some areas, and due to contamination undiscovered during this initial sampling, Bluefield Holdings was required to spend more for proper disposal of the contaminated material than they had anticipated. They also changed the project design in some areas intended for excavation, and placed clean material on top of the contamination (with remedial agency approval), rather than excavating material there as originally planned. Boeing avoided a different and surprising potential contamination issue on their project by use of a specially designed compost mixture, developed when testing of some commercially available products contained higher levels of some contaminants than they were willing to accept.

An additional issue is that contaminant standards may change after property acquisition (as occurred at King County's North Winds Weir project), requiring unexpected additional remediation and/or additional costs due to the need to segregate soils with differing levels of contamination for appropriate disposal. King County was required to remediate the North Winds Weir site prior to the USACE's beginning restoration work (Figure 27). Remediation activities delayed construction for four years, and the project cost $1.9 million more than expected.

Some facilities located adjacent to the LDR do not have water-dependent uses, making it possible to create habitat on their shorelines without disrupting commercial activities. For example, the project constructed by Boeing around Plant 2 was feasible because Boeing did not require use of the shoreline in these areas. Boeing was also able to combine planning for their restoration work with required remedial actions, saving time and money in the pre-construction process. At the Terminal 117 project site, the POS did not undertake restoration actions while completing remedial actions as originally planned, but they did the remediation with the intention of creating habitat on the site later (Figure 28). Other parties in the Duwamish River that will be undertaking remediation at their sites may be able to address NRDA liability similarly, if it would not interfere with their commercial obligations, and this approach could be possible in other urban watersheds with similar contamination issues.

Figure 28: Terminal 117 remediation. (Courtesy of the Port of Seattle)

Erosion

One of the primary concerns for restoration planners in urban watersheds is designing a habitat project that will be sustainable over time, especially with respect to erosion. Two obvious potential reasons for erosion to consider in the LDR are vessel traffic and unstable slopes.[3]

As a busy commercial waterway, large commercial vessels and numerous smaller vessels including tribal and recreational fishing boats (Figure 29) create wakes that can erode shorelines. The conditions vary along the length of the LDR, so site-specific consideration of the effects of boat wakes is important in designing stable restoration projects. Steep slopes are less stable than shallower slopes, but restoration planners may want to incorporate different habitats (e.g., marsh habitat and riparian habitat) at different elevations within a thin restoration parcel bordering the river, and so cannot always avoid steep slopes. To address instability issues of steep slopes, the Terminal 117 project design concept includes vegetated log cribs, in which logs are interspersed with vegetation. Once the vegetation is established, the roots will maintain the slope after the logs have degraded. This structural engineered approach creates steep, but stable, slopes without relying on typical methods such as shoreline armoring (e.g., riprap). (See Figure 30.) This type of engineered approach is necessary to stabilize steep slopes at restoration sites, in lieu of riprap, bulkheads, or other hardened shoreline approaches.

Figure 29: Small boat moving quickly on the LDR.

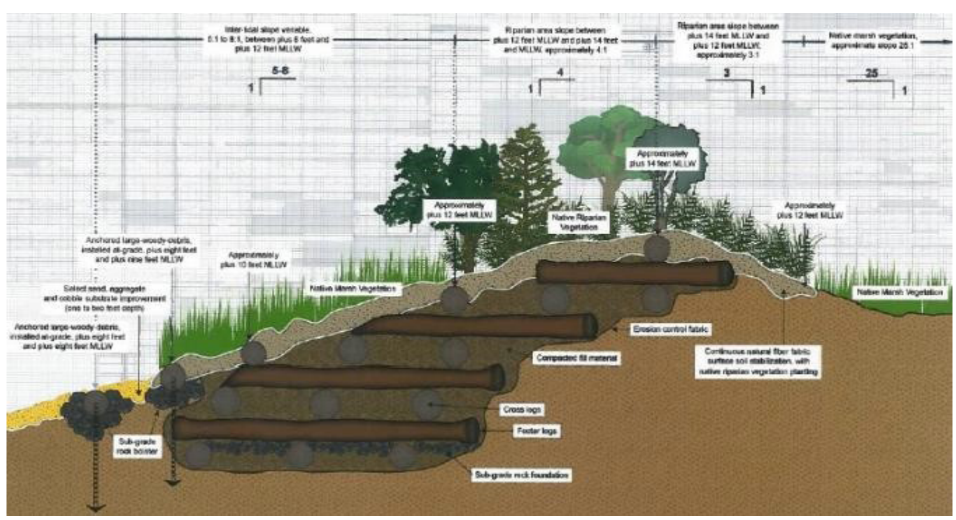

Figure 30: Design of vegetated log crib at north berm of Terminal 117 project. (Courtesy of the Port of Seattle)

3. Erosion due to flooding is not a major concern in the LDR due to the presence of the Howard Hanson dam on the Green River (which flows into the Duwamish), which allows management of flows to prevent flooding.

Figure 31: Terminal 108 shoreline prior to placement of logs and vegetation. (Courtesy of the Port of Seattle)

Figure 32: Log placement and thriving vegetation to address erosion from a steep slope at Terminal 108.

Figure 33: Close-up view of log placement showing anchoring chains. (Courtesy of the Port of Seattle)

This approach has also proved effective at Terminal 108, where the placement of logs with vegetation has stopped erosion on a steep slope (Figures 31-33). Although the logs will eventually degrade, the vegetation will have developed sufficiently by then for the roots to hold the bank together. Also at Terminal 117, an intertidal log sill will stabilize the transition between mudflat and low marsh habitats (see Figure 34). This type of engineered approach is necessary to stabilize steep slopes at restoration sites, in lieu of riprap, bulkheads, or other hardened shoreline approaches.

Groundwater seeps, another cause of erosion, have created problems at one part of the Boeing restoration project. These seeps were a surprise because it had not been a problem at any previous restoration project in the LDR. This issue is discussed later in the report.

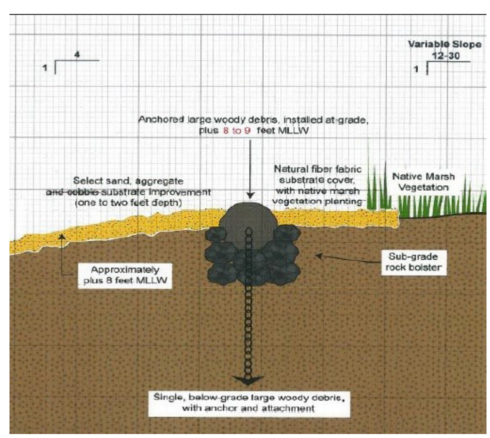

Figure 34: Terminal 117 intertidal log sill design. (Courtesy of the Port of Seattle)

Cultural and Historic Resources

In urban environments, many potential restoration sites will contain historical structures that are evident, but may also include buried cultural, historic, or archaeological resources protected under the National Historic Preservation Act (NHPA), discovered during excavation. For any existing building or structure there may be controversy over whether it meets NHPA criteria for preservation or requires some mitigating action (i.e., photography or other documentation). The Duwamish Gardens project site included an historic barn. The project proceeded with the mitigation approach of disassembling the barn and using the components to repair other historic barns (see Figure 35). Tukwila was also required to keep an archaeologist on site during excavation because of concerns about significant discoveries, a very expensive measure. Project proponents should include funding as part of the contingency component of budgets to address potential unexpected cultural and historic issues, unless it is very clear that no such discoveries are possible.

Figure 35: Carrisino barn on the Duwamish Gardens site, during salvage and prior to demolition. (Courtesy of Mike Perfetti, City of Tukwila)

Development of a Memorandum of Agreement (MOA) with plans on how to address unexpected finds may prevent long stoppages during construction to reach consensus on how to proceed, although development of the MOA can be time-consuming in itself. For the Duwamish Gardens project, the process to address cultural and historic issues was very involved, and this was the primary reason it took 18 months to obtain the USACE permit. However, although unexpected cultural resources were uncovered during construction of this project (Figure 36), the MOA allowed work to continue. Tukwila requested additional grant funding because of the unanticipated additional costs associated with cultural and historic resources because of these discoveries. Budgets and schedules for urban estuary restoration must take into consideration the significant amount of effort potentially required to address NHPA requirements.

Figure 36: Cultural artifacts discovered during construction of the Tukwila Gardens project. (Courtesy of Mike Perfetti, City of Tukwila)

Permitting

Restoration projects constructed within the LDR require a large number of different permits and consultations. This is especially true for projects built on public property, such as the Bluefield Holdings' Site 1, built on property leased from the City of Seattle. The terms of the lease require multiple uses for the site, including public access. Multiple entities within the city were involved in the permitting and approval process, including the Seattle Police Department, the Design Commission, Seattle City Light, Seattle Public Utilities, and the Seattle Department of Transportation. The concerns of these local entities did not always align, and this required multiple design changes (as noted earlier and shown in Figures 18-20). Other permits/consultations required for the Site 1 project included:

- USACE Section 404 permit
- Endangered Species Act Section 7 compliance
- Washington Department of Ecology: Section 401 water quality certifications
- Washington Department of Fish and Wildlife: Hydraulic project approval
- Washington Department of Natural Resources: Use authorizations for state-owned aquatic lands
- National Historic Preservation Act Section 106 compliance
- Shoreline Act compliance

Permitting and consultations for restoration projects was a new role for some of these entities, so there were no established procedures for coordination either within the city or with outside agencies such as the USACE. For example, Bluefield Holdings was required to obtain a street improvement permit from the Seattle Department of Transportation for their restoration project because it is located at a street end, and this was the first time that such a permit was issued for a habitat restoration project by the city. This resulted in a long, complicated permitting process, with modifications required by one agency necessitating further evaluations by other permitting agencies.

Further complicating matters, the ownership of some property in and along the Duwamish River is not clear, and therefore initially it may not be certain from whom a permit or authorization is required. The applicant in these instances will likely need to obtain permits or authorizations from both. This was an issue at Site 1, where there was a disagreement between Seattle and the Washington Department of Natural Resources (WDNR) about ownership of part of the site, and Bluefield Holdings was therefore required to secure an easement from WDNR in addition to satisfying city requirements.

One of the reasons that restoration project permitting can be challenging in urban environments is that local regulations are designed primarily to address normal commercial and residential construction requirements, not construction of habitat restoration projects. For example, King County's Jon Hansen was required to obtain waivers and exceptions in order to complete the permitting process for the North Winds Weir project. He noted that a modification to the state's Shoreline Protection Act specifically addressed one such problem for shoreline restoration projects. Until that modification, if a restoration project resulted in a pull back of the existing bank, thereby moving the location of the boundary of the shoreline zone inland from where it had been it could potentially impose additional restrictions on property adjacent to the restoration project site. Similar situations may exist in other areas, and revision of some laws could potentially speed the pre-construction process or even allow some restoration projects to occur that otherwise could not be built.

We anticipate that with the implementation of additional habitat restoration projects in the LDR, local permitting agencies will become more familiar with issues unique to restoration projects, and that as a result the process will take less time in the future. However, project planners will always need to be aware that permitting staff must handle an incredible load of applications, staff is limited, and that the best approach to expedite processing of permits is to be aware of the needs of the regulators. It is important to be thorough in providing details in permit applications and be consistent as much as possible in the descriptions and information provided when completing different permit applications, in order to avoid confusion and unnecessary effort.

Public Access

In urban environments with large populations, such as the area surrounding the LDR, there are demands for public access and multiple uses of restoration sites. Trying to incorporate public access into projects primarily intended to provide habitat function can be problematic for a number of reasons, including:

- Public amenities (trails, observation platforms, kayak launches) will directly reduce the area available for habitat restoration.
- Public safety issues on combined public access/habitat projects can affect design of habitat elements (e.g., Site 1) and species planted (due to concerns about maintaining views for police of public access areas).
- Presence of people and their pets can potentially reduce habitat use by some species (e.g., shorebirds).
- Vandalism or dumping trash on habitat areas will diminish habitat quality.
- Public access considerations may favor aesthetics and facilitation of access at the expense of ecological function.

Incorporating public uses while also providing functional habitat at the same site necessarily involves tradeoffs. For public entities, such as King County and Tukwila, the concern is to try to achieve an appropriate balance among different objectives. However, for projects intended to address NRDA liability, a requirement to include public access will increase cost, by reducing the amount of NRDA credits per unit area of the project (due to reduced habitat area/function), in addition to increasing the amount of effort required to obtain necessary permits and authorizations. For example, the Seattle Police Department required Bluefield Holdings to modify their project design to keep clear views for the police to monitor public access areas. In addition to the added cost of developing the new design, Bluefield also incurred additional unanticipated construction costs due to the need to dispose of more fill material than would have been required under the original design, and at the same time the project produced less habitat than anticipated.

The POS has combined public parks with habitat in a number of restoration sites, and has developed approaches to minimize potential reductions in habitat function while providing amenities for the public. The park areas include trails, viewing areas, benches, educational kiosks, and art installations (Figures 37 and 38). There are clear demarcations of habitat areas that are off-limits to the public, using fences and dense vegetation to make access difficult. Natural play features also encourage the public to stay out of designated habitat areas, while at the same time helping to instill a sense of appreciation for nature in children (see Figure 39).

POS uses volunteer site stewards, to help maintain habitat function by watering plants, removing invasive plant species, and conducting other activities. Based on their extensive experience with restoration projects POS believes that when the public makes use of access areas, this tends to discourage the establishment of homeless encampments, which can directly injure habitat by trampling vegetation and dumping garbage.

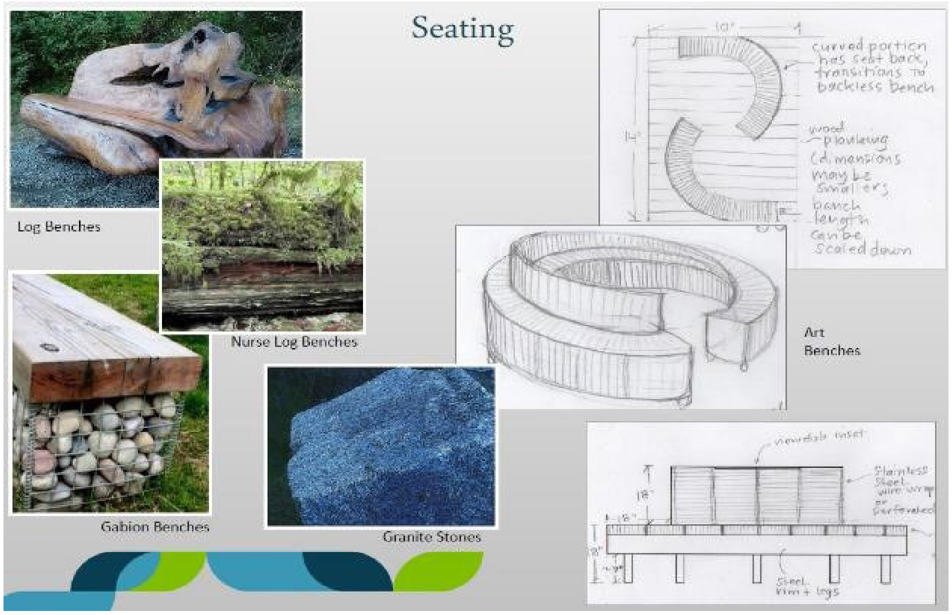

Figure 38: Variety of seating options used by POS at their sites. (Courtesy of the Port of Seattle)


Figure 37: Examples of public amenities at Port of Seattle sites. (Courtesy of the Port of Seattle)

Figure 39: Natural play features at POS sites. (Courtesy of the Port of Seattle)

Planting Plans

One of the key factors in designing successful habitat restoration projects in the LDR is determining the correct elevations for the establishment and survival of vegetation, especially marsh species. This is not difficult where existing marsh is present and can serve as a reliable guide when designing project elevations for planting at a nearby site. However, little natural marsh habitat remains to serve as a guide in the LDR because of the high degree of development and modifications to the system. Boeing therefore undertook a detailed marsh vegetation study, reviewing the literature on existing restoration projects in the LDR and nearby Commencement Bay, and conducting a field survey of restoration projects in the LDR upstream and downstream of their project location. The study investigated what species would be most likely to succeed in the project's specific salinity zone, and the elevations at which individual species would flourish. This effort identified marsh species that would likely establish themselves within the marsh zone, and as well as those requiring active planting in order to become established.

Figure 40: Installation of pre-vegetated coir mats in the marsh zone at the Boeing project.

George Blomberg shared another approach to determine the appropriate elevation for marsh establishment at specific sites, which he learned from the POS' long-term restoration efforts. It is sometimes possible that the pre-alteration marsh platform can be discovered based on the location of the original layers of fill, providing a very precise indicator of the elevations appropriate for marsh vegetation survival. Therefore, it may be beneficial when desiring to create marsh habitat in urban estuaries to conduct site investigations including a goal of identifying the elevation of the pre-development marsh platform.

The cost of planting will vary, depending on whether container plants, plugs, stakes, pre-vegetated coir mats, or a combination of these approaches is used. Container plants are more expensive than stakes or plugs, but there are advantages to using them. More plant varieties are available in containers than as plugs or stakes, and the rate of survival for container plants is generally higher.

Boeing was concerned about potential erosion occurring before marsh plants were established, and decided to grow marsh vegetation in coir mats to help establish marsh vegetation more quickly (Figure 40). Although the combination of Canada geese grazing and erosion have limited the effectiveness of the vegetated coir mats used in the Boeing project, Cliff Whitmus believes that the use of vegetated mats can be a worthwhile investment.

An additional consideration during the planning process is to plan for irrigation of riparian vegetation during the typically dry conditions of Pacific Northwest summers (Figure 41). Failure to include

Figure 41: Irrigation system at the Boeing project.

an irrigation system in the project design could result in additional costs for installation of a system following completion of project construction, as well as the need to replace dead plants. However, an irrigation system may not be required if another method of watering can be provided. For example, the North Winds Weir project did not have an irrigation system installed, instead relying on a water truck.

The presence of large numbers of resident Canada geese (Branta canadensis) in the Puget Sound area presents an additional problem for the establishment of marsh vegetation. Restoration projects in the LDR typically utilize some form of geese exclusion fencing to protect marsh vegetation from grazing (Figures 42 and 43). The fencing remains in place until the marsh plants are established. Protection of marsh vegetation from grazing should always be included in project planning.

Finally, it is important to design projects so that access for long-term maintenance can occur, including removal of invasive plant species, replacement of dead plants, mulch placement, and repair of protective fencing. The experience gained from the monitoring of four Duwamish habitat projects resulting from a 1991 settlement with King County (Metro King County) and Seattle demonstrates the need to provide for long-term stewardship at project sites. Similar requirements for long-term stewardship are likely common for restoration projects in other urban watersheds as well.

Figure 42: Example of the most common type of goose exclusion fencing used at LDR projects to date. This photo shows the fencing at Herring's House.

Figure 43: Goose exclusion fencing used initially at the Boeing project. This initial design did not work well; extensive grazing of marsh vegetation by geese occurred despite the fencing.

Project Construction: Challenges and Solutions

Uncertainty

During the construction phase of habitat restoration projects in urban areas such as the LDR, the most common problem[4] encountered is the discovery of previously unknown conditions, such as the presence of problematic material within fill (large debris and/or contamination), or incorrectly mapped locations of buried infrastructure that cannot be removed or relocated (for cost or other reasons). One of the most important factors in determining whether the construction phase of a habitat restoration project in an urban watershed goes smoothly, staying within budget and on-schedule, is the thoroughness of the pre-construction site investigations. Despite the site investigations that were performed for the restoration projects discussed at the workshop, all of the projects that have entered into or completed construction have run into significant unexpected discoveries. These included cultural resources (Duwamish Gardens), higher than anticipated levels of contamination (North Winds Weir, Site 1), infrastructure (Site 1), unanticipated materials within fill (Duwamish Gardens, North Winds Weir, Site 1), and the formation of groundwater seeps (Boeing). The high likelihood of some type of unexpected discovery during construction of a restoration project in the LDR (and presumably in other similar urban estuaries) strongly suggests that project implementers should incorporate time within the project schedule to address issues that might arise, and include sufficient contingency funds to address these issues. Modifications to project design may be required during construction to avoid an unexpected find that cannot be or is prohibitively expensive to remove, and this requires a lot of flexibility. For example, at Site 1, Bluefield Holdings found a fiber optics cable in a different location than had been shown on the maps provided to them, and had to modify the design to accommodate it (the alternative of relocating the cable was prohibitively costly). When developing the terms of the construction contract, planners should keep the likelihood of unexpected discoveries in mind, to minimize the risk of having to obtain additional funding in order to continue project construction. An important lesson is that contingency funding appropriate for a similar type of project in a remote, undeveloped area could easily be insufficient for projects in urban estuarine areas.

Time Constraints

Another challenge in the LDR is the limited in-water work window, due to the presence of ESA-listed salmonid species at sensitive life stages during much of the year. From the mouth of the LDR to the upper turning basin, the in-water work window extends from October 1 to February 15; upstream, including at the Duwamish Gardens project, the work window extends only from August 1 to August 31 (http://www.nws.usace.army.mil/Portals/27/docs/regulatory/ESA%20forms%20and%20templates/work_windows%20all_freshwaters_except.pdf). This limited construction period can affect the planning of a project if the in-water construction schedule exceeds the time available, forcing the construction to be extended over two or more years. Many of the habitat restoration projects in the LDR involve the creation of off-channel habitat, and for those projects it is often possible to start construction of restoration projects "in the dry"—working on the interior of a restoration site while leaving the current shoreline intact. Work on the actual shoreline, including breaching the berm that remains while interior excavations are occurring, then occurs during the in-water work window. By using this approach, project implementers may be able to complete a project within a single in-water work window. The Duwamish Gardens, North Winds Weir, and Site 1 projects all used this phased approach. However, even if construction is isolated from direct contact with the river, it is still possible to have issues dealing with water seeping into the interior of the project (the effect of a shallow water table and tidal influence), which can be challenging to address (Figure 44).

Figure 44: Site isolation and water intrusion at North Winds Weir site. (Photo courtesy of King County Department of Natural Resources and Parks)

4. Although difficulties with construction contractors is a somewhat common occurrence, issues related to poor contractor performance were not within the scope of the workshop, and so are not discussed in this report.

Excavation and Disposal

In areas with past placement of fill, another major issue is the sheer amount of fill material and soil requiring removal to achieve intertidal elevations and create off-channel habitat- the type of habitat that is very scarce in the LDR and is important for species such as the ESA-listed Puget Sound Chinook salmon. For example, the North Winds Weir project involved the removal of over 20 feet of fill at the lowest elevation point in the final project. Sometimes the excavated material can be reused on another portion of the project, such as at Duwamish Gardens, where 3,000 yd^3 of the 35,000 yd^3 of total material excavated was used elsewhere on the site.

Disposal of clean fill material can be expensive in itself, and disposal costs increase greatly when concrete and other debris are present (Figure 45). Many restoration projects are small, and there may be little space available to handle the excavated material on-site prior to disposal, making staging the project construction more difficult. The problem is much worse in cases where excavated soils have differing levels of contamination, with highly contaminated material that requires disposal in a specialized facility. This situation requires segregation of excavated materials according to their contamination levels, to avoid the much greater cost of having to dispose of all soils in a landfill approved for hazardous substances.

Figure 45: Unanticipated pipes removed from fill, and a water truck that fell into the septic tank. (Photo courtesy of Mike Perfetti, City of Tukwila)

Post-Construction: Challenges and Solutions

Stability

One of the keys to successfully restoring habitat is to design projects to deal with potential stability issues, either from settling of material post-placement (resulting in undesirable elevations and related effects), or erosion from boat wakes, high flows, and/or too-steep slopes. Both the Boeing and Bluefield Holdings projects suffered significant erosion, believed to be due at least in part to the effect of boat wakes (Figure 46). Although project planners had expected that the wakes from larger vessels would pose the greater threat, smaller boats appeared to produce more damaging wakes. The erosive effect of boat wakes on projects with steep slopes is greater than for shallower slopes, as might be expected. The steeper northern portion of the Boeing project lost more than one foot of elevation due to erosion, while the more gradually sloped southern portion did not have similar erosion issues. At Site 1, the sloped berm settled (compacted), resulting in water entering and leaving the off-channel intertidal area over the lowered berm, rather than through the intended outlet to the LDR (Figures 47 and 48).

Both Boeing and Bluefield Holdings are developing plans for addressing this erosion. Boeing is considering using gravel to stabilize the site, while Bluefield Holdings is evaluating a solution using logs, similar to what the Port has done at some of its projects.

It is noteworthy that the vegetated coir mats that Boeing used to help establish marsh were also intended to help keep the

Figure 46: Erosion at boundary between marsh and riparian habitats at Site 1 project, believed to be due mostly to the effect of boat wakes. (Courtesy of Bluefield Holdings)

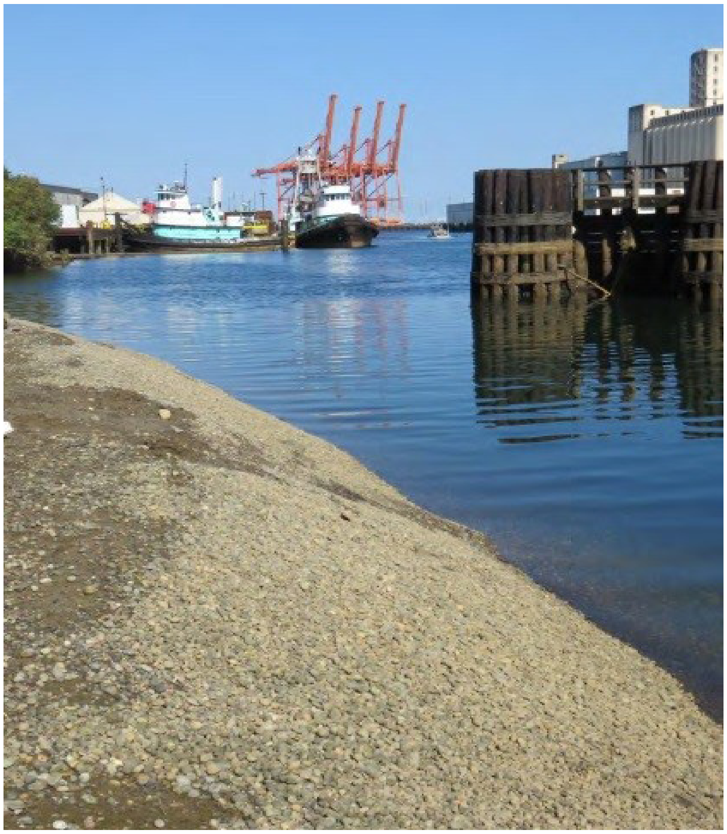

Figure 47: Berm at Site 1 shortly after construction and prior to settling. (Courtesy of Bluefield Holdings)

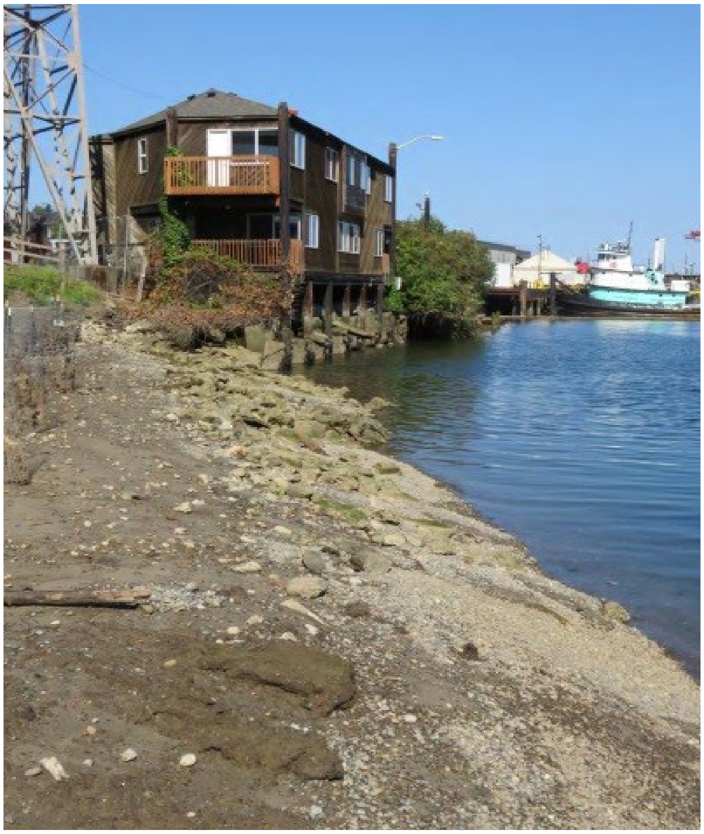

Figure 48: Berm at Site 1 after erosion and settling. (Courtesy of Bluefield Holdings)

sediment in place until the development of the marsh would stabilize the area. The coir mats were expected to last for several years, but they largely disintegrated by the end of the first year. However, the mats were somewhat successful in establishing marsh in limited areas that appear to be subject to less intense geese grazing. Also, some coir mat plants have become established at lower elevations (+5 ft. MLLW) than Boeing had expected based on their survey of habitat in the area. Project planners should consider using pre-planted coir mats in areas where erosive forces might be too strong for marsh to survive if planted normally, but the mats themselves may not last more than a year or two in a high-energy environment such as the LDR. Boeing purchased the coir mats from India, and shipped them to a greenhouse in Idaho where they added plants. Once the marsh vegetation had rooted in the coir mat and grown sufficiently, the vegetated mats were transported to the project site for installation. The cost for this was relatively high.

Figure 49: Alongshore view of patches of gravel placed at groundwater seeps at the Boeing habitat project.

A different erosive mechanism for LDR restoration projects was the appearance of groundwater seeps at the southern portion of the Boeing project. These seeps eroded the sediments around them, and the area affected by each seep increased over time. Boeing addressed the erosion issue by placing large gravel around each seep as it developed (Figures 49 and 50). This appears to have prevented further erosion from the seeps. However, the gravel does not provide the same habitat value as finer sediments for benthic organisms, which serve as prey items for juvenile salmonids. Although several seeps eventually formed, it appears that placement of gravel limited the impact to a relatively small total area.

Figure 50: View (from the riverside looking inland) of groundwater seep area covered by gravel.

Because the presence of freshwater sources can increase the ecological value of a restoration project (NOAA, 2013), some have suggested an alternate approach of incorporating seeps as a beneficial feature. However, Boeing has no clear understanding of why these seeps appeared, and it would require an ability to predict the development of seeps in order to be able to include them in project planning. To date erosion due to groundwater seeps has only been a problem at the southern portion of the Boeing project. Due to this uncertainty, trying to utilize groundwater seeps to improve a restoration project's value in the LDR would be very difficult at this time.

Figure 51: Geese inside goose exclusion fencing at Boeing Project. (Courtesy of Boeing)

Herbivory

Geese and nutria (Myocastor coypus) are problems for establishing vegetation at LDR restoration projects, although the nutria problem occurred only at the Boeing project. Of the projects presented at the workshop, the Boeing project also experienced the greatest amount of grazing by Canada geese (Figure 51). Their goose exclusion fencing, designed to survive impacts from floating debris, saw mixed success with withstanding debris. There was little success in reducing herbivory, however, since geese entered through the sides or swam in over the fence at high tide.

Effective goose exclusion fencing is necessary to establish marsh at new restoration sites in the LDR. A study of goose exclusion fencing conducted in the LDR recommended protecting restored marsh vegetation for a minimum of three years (Crandell, 2001). That study showed that marsh plants protected for that length of time were resilient to grazing by geese. The study also found that areas protected by fencing had many unplanted native marsh plant species colonize those areas naturally, but unprotected areas remained bare of vegetation.

Even a one-day delay in erecting the exclusion fencing can be problematic. For example, Boeing placed some vegetated coir mats but waited until the next day to erect fencing. This short delay resulted in massive grazing impacts on those marsh plants, despite using densely pre-vegetated mats.

It may be difficult to place goose exclusion fencing over a large area and successfully keep geese out because of the possibility that impacts from floating debris open a large area to grazing. Small cells of goose exclusion fencing at the North Winds Weir site appear to have been successful in keeping geese out and avoiding some of the problems that larger fenced areas seem to encounter. This is a more gradual approach to marsh development, protecting smaller areas from grazing, and moving cells to new locations once marsh is sufficiently established.

Boeing is currently testing different designs for smaller goose exclusion fencing, but also uses dog patrols to harass geese away. Another insight is that geese seem to prefer open areas to graze in, compared to areas tightly bordered by dense riparian vegetation. So including a tight riparian buffer in the project design could help reduce grazing by geese.

Nutria killed some of the riparian plantings at the Boeing project (Figure 52), but protective tubes around the trees successfully prevented additional grazing by nutria (Figure 53). Another issue faced at the Boeing site was an infestation of willow borers. Boeing removed infected

Figure 52: Plant after grazing by nutria.

branches, and that seems to have minimized the effect of the infestation. Some riparian vegetation also died at Site 1, due to a combination of two factors: A portion of the irrigation system malfunctioned, and some riparian plants were at too low an elevation. It is not clear whether nutria will become a widespread problem for establishing habitat in the LDR. It is clear that it is essential to place plants at the correct elevations with respect to the tide, and to irrigate riparian plants during hot, dry weather until they are well established.

Figure 53: Tree protectors around trees to prevent nutria grazing.

Invasive Plants

Invasive plants are a particular problem in urban estuaries, where native seed sources may be limited, and invasive seed sources are abundant. If left alone, invasive plants may largely replace native species, potentially reducing ecosystem services and impacting organisms adapted to the native plant community. Fortunately, the invasive plant problem tends to decrease over time as desired vegetation becomes established and shades out invasive species, but continued maintenance will still be necessary. At Site 1, invasive removal occurs on a regular basis (Figure 54), and restoration practitioners in urban areas should plan for invasive species removal on a frequent, regular basis in order to maintain habitat function.


Figure 54: Removal of invasive species at Site 1. (Courtesy of Bluefield Holdings)

Debris

Debris and garbage is another major issue for restoration sites in urban river/estuarine areas. In addition to the negative direct impact on the vegetation it covers, debris can be harmful to goose exclusion fencing (Figure 55). This problem is especially severe for the Boeing and Site 1 projects. At the northern portion of the Boeing project, the design of the channel (channel mouth facing downstream) appears to collect lots of floating material on incoming tides that strands when the tide recedes. Although most of this material is natural (branches and small logs), there is also a large amount of garbage (most notably to date: a couch). Boeing regularly removes trash and debris

Figure 55: Log stranded on goose exclusion fencing at Boeing Project.

from its restoration site, usually on a weekly basis.

Projects that are located farther upstream in the LDR appear to have fewer debris-related problems. The designs of Site 1 and the downstream portion of the Boeing project might have been factors contributing to the debris issue at these sites. The Site 1 project has a wing wall in front of it, which may act to collect debris floating upstream with the tide, while the Boeing project channel opening is relatively wide and oriented directly downstream. Projects such as the Cecil Moses Park EBDRP project have narrower mouths and are oriented perpendicular to the river; this may help to limit the amount of floating debris entering the sites. However, narrow entrances to restoration projects have the disadvantage of limiting use by juvenile salmonids, compared to similar projects with less restricted openings (Cordell, 2016).

Figure 56: Vehicles parked at Site 1, which temporarily became a homeless encampment, showing some of the garbage at the project site. (Courtesy of Bluefield Holdings)

Homeless Encampments

An increasingly common problem at restoration sites in the LDR are homeless encampments located near restoration sites. At Site 1, for example, a number of large occupied RVs moved to the parking area adjacent to the project (Figure 56). Vehicles backed into the fence (designed to keep the public out of habitat areas) causing damage, and garbage littered the site during this period. Regular visits were necessary to remove the garbage from the public access and habitat areas (Figure 57). Similarly, RVs have taken up residence beside the EBDRP Kenco Marine restoration project location, where vandals tore open a hole in the fence protecting the habitat, and littered it with garbage, such as tires (Figure 58). Although the city can require that these RVs move to a different location, there is a 72-hour grace period, and nothing prevents the RVs from returning to the site later. Similar issues may occur in other urban rivers and estuaries, especially at relatively isolated locations.

Figure 57: Litter found on Site 1 while homeless encampment was present. (Courtesy of Bluefield Holdings)

Success Criteria

It is a challenge to establish appropriate targets to measure the success of restoration projects in urban estuaries (Simenstad and Cordell, 2000). The workshop presentation on project monitoring for the EBDRP highlighted that issue. There are few potential "natural" reference sites available in the LDR to serve as guides for establishing targets for a restored marsh, and not all of the selected reference sites survived throughout the EBDRP monitoring program. Small relict patches of habitat within a highly developed estuary may not be appropriate reference sites for much larger restoration projects; differences in scale can affect various performance metrics.

An alternative approach is to use reference locations from other nearby estuaries that may be more natural, and less developed. For example, the Puyallup River estuary's Gog-Le-Hi-Te wetland restoration project used reference sites in the nearby Nisqually River estuary (Simenstad and Cordell, 2000). However, it is not clear that this provides a more appropriate reference. The landscape context of a project does matter. Habitat restoration projects in the LDR exist within a highly altered landscape, and therefore may not be able to achieve the performance of large areas of habitat within less disturbed landscapes. As Simenstad and Cordell note, the development and maintenance of habitat features and services at a site depend largely on external processes (e.g., "delivery" of detritus, invertebrate and plant propagules, etc.). The use of a site within a relatively unaltered estuary as a reference for a restoration project in a highly developed estuary is therefore of questionable validity, because these external forces would be expected to be very different between the two estuaries.[5] Environmental baselines in commercially active urban estuaries differ from those in undisturbed systems, and the performance criteria for habitat projects should reflect this (Weinstein and Reed, 2005).

Figure 58: Vandalized fence at Kenco restoration project with garbage (e.g., tire) within habitat area. (Courtesy of Donna Podger, Washington Department of Ecology)

Stewardship Requirements

All habitat restoration practitioners in the LDR have learned that completing project construction does not end the work necessary to ensure that the habitat project provides ecological services into the future. Habitat restoration projects built by the EBDRP on the LDR show that even 10 years after establishment, habitat restoration projects can still face invasive species issues (USFWS, 2012). The USFWS monitors of those projects have concluded that, "…continued site stewardship remains a vital part of maintaining valuable restored habitats at these sites." In addition to removal of invasive species, routine activities such as planting additional vegetation, replacing dead plants, and removing trash and debris is needed (USFWS, 2012). To address the need for continuing stewardship, natural resource trustees have begun to incorporate long-term stewardship into project planning. For example, the natural resource trustees responsible for NRDA restoration in Commencement Bay have instituted a stewardship program designed to continue indefinitely, maintained with a funding endowment.[6]

5. See Bell et al. (1997) for a detailed discussion of the link between landscape context and restoration.

6. Information on the Commencement Bay stewardship program is available at: http://www.habitat.noaa.gov/highlights/aninnovativenewstewardshipprogram.html.

Perspectives on Permitting: Challenges and Solutions

Although habitat restoration projects have beneficial goals, they are required to go through the permitting process because of possible impacts from project implementation. The common theme from the afternoon panel session on regulatory issues was that initiating early contacts with permitting agencies is a good way to avoid potential delays and unnecessary costs. Such early contact can help identify possible issues that may need to be resolved, and these can be addressed while developing early project designs, rather than in a redesign after submission of the permit application.

Where possible, having a pre-application meeting with many different regulators can facilitate the airing of concerns about the project in a setting where everyone can raise issues from each agency's perspective, helping everybody understand all the concerns about a project. Such meetings minimize the likelihood that a permit applicant will be directed to modify something about the project in a way that a different agency might not allow. For example, there was a pre-application meeting for the Boeing project. It included many regulators and was helpful in moving through the permitting process smoothly. The USACE Seattle District has standing monthly pre-application meetings in which a number of different agencies and tribes participate, and holds ad hoc pre-application meetings on other dates as needed. The standing monthly meetings help avoid difficulties in trying to get all appropriate agencies and tribes together to discuss a project.

One suggestion to increase the overall efficiency of permitting habitat projects was to "batch" restoration projects at pre-application meetings to discuss multiple restoration projects at a single meeting. This would serve to bring representatives of all agencies and tribes involved with restoration issues together, since some of them would not necessarily be involved with the non-restoration projects discussed at regular meetings. It might also be helpful if these USACE pre-application meetings included more regulatory agencies, and if project planners could encourage those agencies that have not participated in such meetings to do so for future projects.

In a contaminated system like the LDR, it is essential that project proponents coordinate their activities closely with any remedial actions in the project's vicinity, to minimize the potential for recontamination. Understanding what the Environmental Protection Agency (EPA) or state remedial agencies require for handling soils contaminated at different levels (e.g., segregating soils) is important from both a cost and project planning perspective. For example, after consulting with EPA, Bluefield Holdings changed its project design to avoid excavation in a contaminated area, and instead placed material on top of the existing surface. Close coordination with remedial agencies is also necessary for any party wishing to combine NRDA restoration with remediation on their site.

In planning for the permitting process, the project should be broken down into distinct components (activities), and each evaluated for conformity to existing regulations. This may be especially important when dealing with agencies that are not very familiar with permitting habitat restoration projects. Even if a project has multiple phases or someone is planning to undertake many similar projects in an area, it may be possible to get a permit for the entire project, rather than for each individual phase, by using a programmatic approach.

Permitting agencies may struggle to keep up with the pace of permit applications, so it is important for the application to be clear and complete. It is also important that different permits and consultation requests are consistent in details and terminology, to avoid potential issues later. Another suggestion from the panel was to work with technical staff on permit issues rather than engaging at a higher organizational level, which tends to slow down the permitting process.

If a restoration project includes public access in addition to habitat, expect a longer permitting process. This is largely due to the need to bring other entities, such as the police, into the process to address public safety issues. As discussed previously, the project plans may need revision to address related concerns, including restrictions on the types of vegetation allowed. Additionally, plans for public access may require a different level of remediation than projects with no public access, due to concerns about possible human exposure to harmful levels of contamination.

Recommendations for Urban Habitat Restoration Planners

Throughout the workshop planning, during the workshop itself, and in discussions afterward, there were several recommendations to increase the effectiveness and efficiency of the overall process of planning, constructing, and maintaining restoration projects in urban estuaries. Some recommendations, like conducting a very thorough site evaluation prior to designing a project, may seem obvious, but can be difficult to accomplish effectively in the LDR and other urban estuaries. Project planners in the LDR and similar environments must anticipate problems and make appropriate plans for a project's construction to be on time, on budget, and as designed, and we hope that these lessons learned and the recommendations resulting from them will be of help. Several of the key lessons from the workshop are:

Understand all permit requirements upfront. Initiate contact with regulatory agencies early (during the conceptual design phase and prior to development of detailed project designs), and gain an understanding of what permits and consultations are required. Breaking projects down into components and evaluating these with respect to things like the local shoreline master plan's regulations could be helpful. Be thorough and consistent in permit application materials.

Utilize Pre-application Meetings. Seattle's district of the USACE holds regular pre-application meetings (as well as occasional meetings on an ad hoc basis) where multiple regulatory agencies discuss upcoming projects with their proponents. Such forums offer an opportunity to hear concerns from different agencies early in the planning process, and helps identify potential inconsistencies among different agency requirements. If possible, try to include permitting agencies that would not normally participate in these pre-application meetings.

Minimize Uncertainty. Conduct extensive site investigations as part of planning, including thorough sampling for contamination where the potential exists for harmful levels of hazardous substances, as well as surveying for large debris and/or infrastructure, and potential cultural resources. This may be expensive in the short term, but could ultimately save much time, effort, and funds when the discovery of an issue occurs before, rather than during construction. Consult with EPA and/or state remedial agencies regarding their understanding of potential contamination on your site, and options to address such contamination if it exists. Site investigations should also evaluate the effect of wakes (both from large ships and smaller boats), high current flows, and wind-generated waves.

Expect Unknown Conditions. Even if a detailed site evaluation does not reveal the presence of problematic fill material, project planners should include contingency funding and add time to the project schedule to address things that may have been missed (contamination, debris, historical/cultural issues). It could be a serious mistake to assume that there will not be some unexpected discovery. It might be possible to set up a construction contract with flexibility that covers "routine" kinds of unknowns without needing to add money to the contract. It would also be prudent to include contingency funding in excess of what is typical for restoration projects built in less highly developed areas, since the risk of needing costly modifications is so much greater in urban estuaries.

Include a Memorandum of Agreement for Cultural, Historic, and Archaeological Issues. Although it may be time-consuming on the front end to develop an MOA along with a plan to address cultural, historic, or archaeological discoveries, having one will reduce the likelihood of having to stop work on a project during construction. Under most circumstances, a project manager would need to develop the MOA in cooperation with the State Historical Preservation Office and any tribes associated with the area.

Bunch Similar Projects for Permitting. The permitting process can be more efficient if similar restoration actions are approached programmatically, instead of through individual permits. For phased projects, try to secure a permit that covers all the project phases.

Encourage Better Coordination among Regulators. Establishment of a panel of regulatory agencies (and tribal representatives when appropriate) facilitates pre-application meetings for restoration projects. At a single meeting, guidance can be provided to the applicant, and issues identified and discussed by the panel, rather than holding individual meetings with each permitting agency. To maximize the utility of these meetings, planners may need to encourage the participation of agencies that typically do not review permit applications for restoration projects (e.g., Seattle Department of Transportation).

Phase Projects. For large projects, it may be beneficial to conduct construction in phases. This would allow discovery of issues and solutions early in the process, thus benefitting later phases, rather than building an entire project and then needing to make corrections for the whole project. It is also possible for a project to have an out-of-water phase occurring ahead of the in-water work window. The in-water work, including breaching of the bank to the interior of the project, would then occur in a second phase when the in-water work window opens. Phasing of projects could however be problematic for NRDA restoration, where specific targets are set and success evaluated over time.

Combine Restoration with Remediation. For restoration project sites that also require remediation, it may be possible to coordinate permitting so that one set of permits will cover both activities. Planning both remediation and restoration together can save time and money.

Design for Sustainability. Projects with shallow transitional slopes between habitat elevations tend to be more stable. If the dimensions of a project site will not allow shallow slopes when restoring a habitat complex, then some form of engineered approach (such as placement of large woody debris) may be required to achieve stability and prevent erosion. More structured approaches may also be necessary to address potential erosion issues due to boat wakes, strong currents, or other factors. Project planners may need to design projects that might not appear "natural," in order to ensure sustainability of project structure and function in an active commercial waterway.

Reduce Impacts from Combining Public Access with Habitat Creation/Function. Designs for sites intended for both public access and habitat function can include dense plantings or fencing to protect habitat areas. Areas intended for public access should include features that will tend to attract people and encourage them to stay within designated (non-habitat) areas. For example, the POS has used natural play features to attract children and keep them from disturbing habitat areas. Projects with heavily used and well-defined public areas also tend to have fewer problems with homeless encampments than do combined projects with lighter visitor usage.

Explore Beneficial Use of Groundwater Seeps. Inclusion of freshwater sources in restoration projects can increase the habitat value of projects in the LDR (NOAA, 2013), so there may be potential to derive benefit from groundwater seeps. However, the groundwater seep problem at the Boeing project was unexpected, and without more understanding of the cause of these seeps, it may be difficult to predict the presence and location of seeps ahead of construction, making it challenging to incorporate groundwater seeps in project design.

Overplant and Irrigate. Planting native species at high densities and installing an irrigation system may help establish native vegetation more quickly, and reduce problems with invasive plant species. Climate change trends may make long-term irrigation even more important for plant survival.

Reduce Herbivory. Placement of goose exclusion fencing should coincide closely with timing of marsh plantings, as demonstrated by the severe grazing at the Boeing project in the one day before fence installation. Geese appear to prefer to graze in relatively open areas, so projects with tight riparian fringes that are less open tend to have fewer problems. Using smaller cells of exclusion fencing may prove more successful than large enclosures; relocating cells to a new area can occur once marsh plants within them are well established (after three or more years). Although this is a more gradual and labor-intensive method for restoring marsh than using a single large fenced enclosure, it may ultimately be more cost-effective.

Plastic tree protectors can prevent plants from herbivory by nutria, although during the summer protectors may need to be removed to avoid heat stress. Currently nutria do not appear to be a common problem on the LDR, so it might not be worthwhile using tree protectors unless there are signs of nutria on the site.

Address Debris Issues. Frequent removal of debris may be needed, depending on the project design and location. Project design may reduce the amount of debris, for example by providing openings to off-channel features that are oriented perpendicular to the river instead of facing upstream or downstream. Smaller openings to an off-channel area appear to limit the amount of debris stranding within a project, but may need to be structurally engineered to deal with stronger currents, and excessively small channels could limit fish use. Debris will be a continuing problem that will require long-term removal actions.

Continue Stewardship. Continuing site stewardship is necessary to maintain site function (Simenstad et al., 2005). Although maintenance needs are much greater within the first few years following project construction, restoration projects in urban rivers will also need some degree of stewardship over the long term in order to maintain ecological function. Debris stranded on the project site (or garbage illegally dumped) will require removal indefinitely into the future, and invasive species will need to be removed until native vegetation is well established, if not indefinitely. Planners should anticipate this by including access for stewardship in the project design.

Utilize Volunteers. The use of volunteer site stewards (as by the POS) can be very effective in identifying potential problems early, and for conducting routine site maintenance activities. Volunteers represent extra eyes and may provide alerts if issues arise, such as stranding of large debris or vandalism. Volunteer site stewards on POS restoration projects also perform essential tasks, such as watering plants as necessary, and their presence on the sites could help reduce the threat of homeless encampments. Utilizing volunteers not only saves funds, but also helps instill a sense of connectedness with the environment; volunteers have been involved at LDR restoration projects as part of Earth Day and other events. It is especially valuable to involve children in these activities (Figures 59).

Figure 59: Installation of willow stakes by volunteers at Kenco Marine restoration project during Earth Day activities in 2006. (Photo courtesy of Sueann Kern)

References

Bell, S.S., M.S. Fonseca, and L.B. Motten. 1997. Linking restoration and landscape ecology. *Restoration Ecology* 5:318–323.

Cordell, J. 2016. If you build it they will come: Lessons learned from 20 years of monitoring habitat restoration in the Duwamish Estuary. Presentation at the Green-Duwamish Watershed Symposium, February 29, 2016.

Crandell, C. 2001. Effect of grazing by *Branta canadensis* (Canada Goose) on the fitness of *Carex lynbyei* (Lyngby's sedge) at a restored wetland in the Duwamish River Estuary. Master's thesis, Center for Urban Horticulture, University of Washington, Seattle, Washington.

Kerwin, J., and T. S. Nelson (Eds.). 2000. Habitat Limiting Factors and Reconnaissance Assessment Report: Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island). Washington Conservation Commission and King County Department of Natural Resources.

National Oceanic and Atmospheric Administration. 2013. Final Lower Duwamish River Natural Resource Damage Assessment Restoration Plan and Programmatic Environmental Impact Statement. June 2013.

Port of Seattle. 2009. Lower Duwamish River Habitat Restoration Plan: An Inventory of Port of Seattle Properties. Prepared by AHBL for the Seaport Planning Group July 7, 2009.

Simenstad, C. and J. Cordell. 2000. Ecological assessment criteria for restoring anadromous salmonid habitat in Pacific Northwest estuaries. *Ecological Engineering* 15:283-302.

Simenstad, C., C. Tanner, C. Crandell, J. White, and J. Cordell. 2005. Challenges of habitat restoration in a heavily urbanized estuary: Evaluating the investment. *Journal of Coastal Research* 40:6-23.

U.S. Army Corps of Engineers, Seattle District. 2000. Green/Duwamish River Basin Ecosystem Restoration Study: Final Feasibility Report.

U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office. 2012. Elliott Bay/Duwamish Restoration Program Intertidal Habitat Projects Monitoring Report: 2010 Final Report. Western Washington Fish and Wildlife Office, Lacey, Washington. 48 p. Released March 2012.

Weinstein, M.P. and D.J. Reed. 2005. Sustainable coastal development: The dual mandate and a recommendation for "Commerce Managed Areas." *Restoration Ecology* 13:174-182.

For more information on NOAA's work in the Lower Duwamish River, please visit:
https://darrp.noaa.gov/hazardous-waste/lower-duwamish-river