City of Olympia
West Bay Environmental Restoration Assessment
Final Report

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EXECUTIVE SUMMARY

The West Bay Environmental Restoration Assessment provides a science-based assessment of environmental restoration opportunities for the West Bay shoreline in Olympia, WA. The assessment supports the implementation of habitat restoration and water quality strategies. The strategies inform the prioritization of restoration projects by the City of Olympia (City), Port of Olympia (Port), Squaxin Island Tribe (Tribe), and other interested parties. Also included are evaluations of recreational opportunities within the project study area, particularly in West Bay Park and the lagoon located south of the developed park.

Need for Restoration

Historically, West Bay supported shallow water with extensive mudflats during low tides. The Deschutes River as well as the smaller Garfield and Schneider Creeks discharged to West Bay resulting the mixing of salt and fresh waters typical of high quality estuaries. The vast mudflats supported key shellfish species including Olympia oysters, clams and crabs, and provided productive habitat for many marine organisms. These organisms provided the diets of fish, birds and mammals and served to filter the sediment and water, thereby contributing to water quality in the estuary. The shoreline was forested with coniferous trees and shrubs that provided habitat, shading, erosion control, and foraging opportunities.

Shorelines, mudflats, and watersheds within the 1.8 mile long study area (5th Avenue Dam to the north by the City limit) have been heavily altered from natural conditions. Ample opportunity exists for environmental restoration. Historical ecological impacts to the shoreline include disconnecting uplands habitats from the marine waters, converting shallow mudflats into both deeper waters and uplands, reducing sediment supply and large wood inputs from bluffs and rivers/creeks, reducing water quality, and degrading the shoreline by filling, placing shoreline, armor, and contamination from past land uses.

The restoration strategy revolves around reversing ecological impacts to the extent possible under the existing developed conditions. The assessment focuses primarily on City, Port, and Tribe-owned properties along West Bay. However, private properties are also considered for potential restoration. Property owner agreement would be necessary.

Methodology

Habitat restoration focuses on improving impaired habitat functions. This assessment identified and studied nine reaches or sub-areas along West Bay based upon physical and habitat characteristics as well as property ownership. Initial restoration concepts for each reach were developed to address existing limiting factors and restoration objectives through a design workshop. These initial concepts were then refined based upon additional analysis and design as well as input from the City, Port, and Tribe.

Restoration concepts include improving the connection between upland and marine habitats, removing historical fill, rebuilding natural beaches, and creating salt marshes. Better connecting

uplands with more natural beaches also provides an opportunity for improved sea level rise adaptation and recreation.

Semi-quantitative and qualitative measures were developed and scores assigned to restoration alternatives. The mix of measures provide both science and professional judgement based evaluation and decision-making.

Outcome

Twelve restoration alternatives were developed and 18 potential stormwater improvements identified. Taken as a whole, the potential restoration projects provide the opportunity to enhance the ecological functions of West Bay. Connecting the restoration sites would promote natural coastal processes and resiliency compared to piecemeal efforts at isolated sites. The concepts also include overlays of recreation opportunities that would accommodate increased public use of the shoreline.

The Lagoon Alternative 4 restoration may provide the largest overall habitat restoration opportunity, but Alternative 2 has a higher habitat value per dollar spent. Both alternatives would remove portions of the railroad berm at the lagoon resulting in improved tidal circulation and sediment processes within the lagoon. Conversely, Lagoon Alternative 1 provides relatively little habitat value. Regardless of lagoon alternative, historical fill beneath the 4th Avenue Bridge pushes water flows from Capitol Lake to the north and east of the lagoon. The fill would continue to influence flows with or without future Deschutes estuary re-establishment.

Improving public access and recreation in the lagoon area could be accomplished through a range of trail alternatives including an option along West Bay Drive. Regardless of the restoration alternative selected for the lagoon, coordination of restoration and recreation elements during permitting, design and construction will be important. Coupling restoration and recreation improvements could provide an opportunity to leverage multiple funding sources. Construction access to the lagoon area would require a comprehensive constructability evaluation.

Opportunities to improve Budd Inlet water quality by treating stormwater include both small end-of-pipe retrofits and larger upstream retrofits. The larger drainage basins such as Garfield Schneider Creeks include sites appropriate for upstream treatment facilities.

As proposed, creating mudflat and marsh habitats connected with vegetated upland areas is compatible with sea level rise adaptation in West Bay. Such features provide a natural buffer that is adaptable through natural processes. Incorporating sea level rise adaptation within the restoration strategy for West Bay may provide additional funding opportunities.

Implementation

Conceptual level design and construction costs are estimated for the restoration alternatives. The estimated cost for the restoration of West Bay ranges from $24.7 million to $33 million, depending upon the alternatives selected for each shoreline area. Similarly, conceptual public access and recreation improvement costs range from about $3.8 million to $11 million. Finally, stormwater improvements in watersheds associated with the study area may range from $11 million to $16 million. Implementation and cost sharing could occur as part of restoration, mitigation, capital improvements, or private development activities along the shorelines of West Bay. Multiple grant funding sources may be available to help implement West Bay restoration. The identified restoration, recreation, and stormwater management opportunities broaden the number of potential funding sources.

Due to the relatively disjointed nature of existing habitat along the shoreline, implementation of the various projects can be accomplished independently or in phases. Cost savings are expected if both recreation and restoration elements are implemented concurrently.

Next Steps

While limited in its scope and level of detail, this restoration assessment can support future planning and design work along the West Bay shoreline. The environmental methodology, engineering approaches, and cost-estimating protocols are consistent with established restoration practices. Detailed site-specific restoration project designs can build upon the work provided in this assessment.

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Acronyms and Abbreviations

BNSF	Burlington Northern Santa Fe
CHE	Coast & Harbor Engineering
City	City of Olympia
DOH	Department of Health
EPA	Environmental Protection Agency
ESA	Environmental Science Associates
LWD	Large wood debris
MLLW	Mean Lower Low Water
NOAA	National Oceanic and Atmospheric Administration
Port	Port of Olympia
SAIC	Science Applications International Corporation
SPSSEG	South Puget Sound Salmon Enhancement Group
TSS	Total Suspended Solids
Tribe	Squaxin Island Tribe
USGS	United States Geological Survey
USCGS	United States Coast and Geodetic Survey
WA	Washington
WDFW	Washington Department of Fish and Wildlife

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1 INTRODUCTION

Coast & Harbor Engineering (CHE), a division of Hatch Mott MacDonald, prepared this report for the City of Olympia's (City) West Bay Environmental Restoration Assessment. The purpose of the project is to complete a science-based environmental restoration assessment for West Bay, Budd Inlet, located in Olympia, WA. The project will support the implementation of a water quality and habitat restoration strategy, including the prioritization of restoration projects for planning by the City of Olympia, Port of Olympia (Port), Squaxin Island Tribe (Tribe), and other public entities.

This report summarizes the methodology and results of the assessment including data review, identification of potential ecological restoration and stormwater improvement opportunities, development and evaluation of conceptual alternatives, prioritization, and implementation strategies. Also included are evaluations of recreational opportunities within the project study area, particularly in West Bay Park and the lagoon located south of the developed park.

The appendices provide conceptual graphics, more detailed analysis and evaluation of the lagoon, stormwater analysis, conceptual cost estimates, and previously developed memoranda that are referenced throughout the body of this report.

2 METHODOLOGY

The assessment was completed in steps, beginning with review of existing information, compilation of a project database, and identification of data gaps. Critical data gaps were filled through limited field data collection and desktop research. Subsequently, historic habitat functions and physical processes within West Bay were reviewed to evaluate the extent and manner that human actions have altered the existing habitat functions. Criteria were then developed to guide the approach for developing restoration concepts and to provide a basic framework for evaluation and prioritization of restoration alternatives.

2.1 Project Area

The project study area is located along the west shoreline of West Bay within Budd Inlet, including associated upland drainages and adjacent intertidal and subtidal areas. The assessment area is bounded to the south by the 5th Avenue Dam and to the north by the City limit, with a total length of approximately 1.8 miles. As identified in previous shoreline characterizations, the study area lies within BUDD-3 shoreline reach and has been heavily altered (ESA 2008). Land use varies greatly within the project area, as described in other studies (ESA 2008, TRPC 2009).

While the assessment effort is focused on the shorelines and nearshore zone within the stated area, analysis includes watersheds that flow into West Bay and evaluation of physical and biological processes throughout Budd Inlet. This restoration assessment focuses on City, Port, and Tribe-owned properties along West Bay. However, private properties were considered for potential restoration opportunities recognizing the property-owner agreement would be necessary prior to further analysis and design.

The project study area was partitioned into reaches based primarily on consideration of site physical characteristics and property ownership. Figure 1 illustrates the locations and names of the project reaches identified and cited in subsequent sections of this report.

2.2 Existing Data Review and Compilation

A wide variety of data were reviewed, including existing plans, previous analyses and characterizations, existing utilities and infrastructure, stormwater facilities, parcel and municipal boundaries, GIS data, cultural resource data, bathymetry, and topography. Port-provided data included sediment investigation data and cleanup plans. Tribe-provided data included a wide array of GIS products including landscape and nearshore analysis.

Valuable studies referenced throughout the assessment included City of Olympia Restoration Plan (City of Olympia 2012), shoreline inventory and characterizations (ESA 2008, TRPC 2009), and West Bay Park Master Plan documentation (Anchor 2011, among others). Other critical data and reference studies are listed in the reference sections of the Historic and Existing Functions Analysis Memo (Appendix B), the Criteria Development Memo (Appendix E), and herein.

The primary basemap source data utilized were City-provided LiDAR topography from 2011, City-provided high resolution aerial photography from 2015, and property ownership and stormwater infrastructure information in GIS format. Figure 2 shows the extent of the project study area, including one-foot topographic contours referenced to Mean Lower Low Water (MLLW) and aerial photography from 2015.

A database of digital files used to conduct this study will be made available to the City upon project completion.

2.3 Data Gaps and Targeted Data Collection

As identified in the Data Gaps Memorandum (CHE 2015), limited historical photographs and charts were made available to CHE for this study. Therefore, CHE obtained historical aerial imagery from readily available public sources such as the USGS, WA Dept. of Ecology, and Washington State Archives.

Limited archeological and cultural resource data were available from West Bay Park studies provided by the City. Further investigation of cultural resources was not performed and may be needed upon initiation of more detailed design and prior to implementation of restoration actions.

Available geotechnical data were limited to groundwater investigations at West Bay Park, and geotechnical studies for design of the 4th Avenue Bridge. Other miscellaneous soils and sediment investigation data are listed in the reference section of this report and Appendices.

Engineering properties of surface and sub-surface soils are generally not well-characterized throughout the project area.

The project team, in coordination with the City, Port, and Tribe conducted a one-day field visit to observe conditions in the project area. Subsequent field visits were conducted to observe conditions of existing beaches at the north extent of the project area, and to observe portions of the stormwater system that ultimately discharge into West Bay. Given the high quality and recent City-provided data in the basemap, only limited supplemental field data were needed to complete the assessment. The City collected and provided CHE with invert elevations of two culvert pipes and associated manholes within West Bay Park at Garfield Creek and South Garfield Creek.

Figure 1. Project reaches, parcel boundaries, and aerial photograph from 2015.

Figure 2. Project base map showing project reaches, 1-ft topographic contours, and aerial photograph from 2015.

2.4 Historical and Existing Functions

The following summarizes key findings of the historic and existing functions analysis within West Bay, as further documented in Appendix B.

2.4.1 Historical Modification Timeline for West Bay

- Earliest “modern” development occurred in the 1850’s.
- Railroad spur along West Bay was built in 1878.
- Dredging to deepen the channel was first attempted unsuccessfully in 1885.
- Dredging deepened channel between 1893 and 1894 and again between 1909 and 1911 resulting in creation of 29 city blocks using two million cubic yards of spoils on the Port Peninsula to the east of West Bay.
- The bluff and shoreline along West Bay was modified by regrading and fill placed at base of West Bay bluff to create land for sawmills in the late 1800’s through the mid-1900’s.
- The railroad trestle along West Bay (including the current lagoon berm) changed hands several times, was abandoned in 1894, rebuilt by BNSF and rock/gravel fill placed to form the existing berm in the early 1970’s[1]. The railroad trestle was not in use after 1996.
- The West Bay Marina was established on former sawmill/log storage area by the early 1960’s.
- At least four sawmills existed along West Bay historically. The mill at West Bay Park was removed in 1963 and land use was converted to log storage.
- West Bay fill placed from 1870s – 1970s created approximately 40 acres of new uplands.
- City purchased land form the Port of Olympia for West Bay Park in 2004. Phase 1 of park improvements were constructed in the summer of 2010.

2.4.2 Target Species and Habitats

West Bay provides habitat for many fish and wildlife species including great blue heron (Ardea herodias), grebes, cormorants, ducks, raptors, gulls, forage fish, flatfish, salmonids, harbor seals (Phoca vitulina), Dungeness crab (Cancer magister) and numerous other birds, fish, mammals and shellfish. Many of these species depend on the same habitat types and ecological processes for survival, growth and reproduction. The Tribe has identified a common approach in defining and understanding ecosystems through an indicator species of interest and there are numerous instances of using salmonids, which have been argued to be a keystone species (Squaxin, 2010). The following section identifies the target species for this restoration analysis.

Based upon the established project criteria, the historic and existing functions analysis targeted two keystone species, Chinook salmon (Oncorhynchus tshawytscha) and Olympia oyster (Ostrea lurida) and their habitats. This approach also allowed direct assessment of habitats used by other important species such as marine birds, shorebirds, forage fish, other shellfish, and marine and terrestrial mammals.

2.4.2.1 Chinook Salmon

Chinook salmon was selected as the primary target species for three reasons: 1) Chinook is federally listed as threatened under the Endangered Species Act ; 2) Chinook have multiple life

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[1] Oblique aerial photographs from Washington State archives show the unfilled trestle in existence as late as 1971, with complete fill placed by 1974.

history strategies, which include diverse habitat requirements; and 3) known Chinook use of Budd Inlet and West Bay. The diet of Chinook salmon varies widely ranging from invertebrates and crustaceans to small fish including Pacific herring (Clupea pallasii) and sandlance (Ammodytes hexapterus). To successfully restore habitat for Chinook, habitat must not only benefit this species directly, but must also be restored to benefit Chinook prey species. Therefore, using Chinook salmon as a target species will allow this assessment to focus on the overall ecological processes required by Chinook and their prey species.

Although wild Chinook salmon populations are not present in tributaries within the project area, the shallow, nutrient-rich waters of the South Sound are optimal rearing conditions for Chinook and are known to attract juvenile Chinook from waters as far north as the Green River (Thurston County Conservation District 2005). Estuaries are critical habitat features for both juvenile and adult Chinook, providing feeding opportunities as well as transition from freshwater to saltwater and back. In the marine environment Chinook require habitats ranging from shallow intertidal mudflat, beach and marsh used for foraging, migration and refuge by juveniles to deep-water marine areas used by resident and returning adults (Fresh et al., 2011).

Chinook prey species in estuarine and marine environments include terrestrial invertebrates, freshwater and marine invertebrates, and forage fish (Fresh et al., 2011). A diverse array of habitat types should be present within an ecosystem to support Chinook prey species. Terrestrial invertebrates depend on riparian vegetation; freshwater invertebrates need clean gravel and cobble substrate, while marine invertebrates require salt marsh, mudflats, sandy beaches and/or other suitable vegetation or substrate. Forage fish spawning requirements vary by species. Surf smelt (Hypomesus pretiosus) and sandlance require gravel and sand substrate, respectively, within the middle and upper intertidal ranges, while Pacific herring require macroalgae as substrate to attach their eggs (Pentilla, 2007).

2.4.2.2 Olympia Oyster

Olympia oysters were also selected as a target species because they are the only species of oyster native to Washington and were once prolific in the south Puget Sound. This species occupies lower intertidal and shallow subtidal habitat and requires suitable hard substrate such as shells, shell fragments and rock, generally found over sand and silt, for attachment and growth to maturity. Olympia oysters, and other shellfish, have multiple important ecosystem functions; they create hard shells that provide physical habitat structure for juvenile fish and crustaceans, they tend to stabilize substrate, and they also filter plankton and nutrients from the water (Peabody and Griffin, 2008). Olympia oysters are generally a lower intertidal species, but can also occur at higher elevations associated with habitat features including lagoons, drainage channels and seepage areas (Peabody and Davis, 2013). Olympia oysters tolerate freshwater in short durations, but prefer water with a salinity of 22 parts-per-thousand or higher (Peabody and Griffin, 2008). Efforts are underway by WDFW, the Tribe, and others to re-establish Olympia oyster abundance and density throughout Budd Inlet.

2.4.3 Historical Ecological Processes and Habitat Functions

Historically, West Bay was an estuarine mudflat with unrestricted flows from the Deschutes River and numerous small pocket estuaries from Garfield Creek, Schneider Creek and other small drainages. West Bay was an important ecological connection between Budd Inlet and the adjacent freshwater and upland habitats. The estuary provided a transitional area critical for out-migrating juvenile salmon and returning adults.

The vast mudflats of West Bay supported key shellfish species including Olympia oysters, clams and crabs, and provided habitat for primary production of benthic and epibenthic invertebrates. Shellfish and other invertebrates provided a primary component for the diets of fish, birds and mammals and served to filter the sediment and water, thereby contributing to suitable water quality in the estuary. Furthermore, the intertidal mudflats were exposed during low tides, which allowed West Bay to flush on a frequent basis.

The bluff-backed shorelines were densely forested with coniferous species and likely a dense understory of smaller trees and shrubs, which provided overhanging vegetation for refuge habitat, shading, erosion control, detritus/nutrient export, and foraging opportunities on terrestrial invertebrates. The bluffs also contributed sediment ranging from fines to cobbles and boulders and large wood debris (LWD) from shoreline erosion events. LWD served as refuge habitat for juvenile salmonids, other fish, birds and mammals in the nearshore environment and the eroded sediment provided suitable substrate for invertebrates and spawning habitat for forage fish.

2.4.4 Existing Ecological Processes and Habitat Functions

Development of West Bay and the surrounding vicinity over the last 150 years degraded the ecological functions and processes of the bay in numerous ways. Riparian habitat was disconnected from the shoreline along much of the shore of West Bay. Fill placed along the shoreline for the railroad grade and industrial facilities eliminated potential for the adjacent bluffs to provide sediment to nourish the beaches. Buried stream outfalls of Garfield Creek, Schneider Creek, and other small tributaries and the construction of the dam at Capitol Lake substantially reduced the amount of available estuarine habitat and the input of sediment from these freshwater sources into West Bay. These modifications also altered the natural salinity transition zone for out-migrating juvenile salmonids.

Removing the connection between these freshwater features and West Bay has severely degraded estuarine ecological functions. Juvenile salmon depend on properly functioning pocket estuaries as they leave their natal streams to adjust from freshwater to saltwater. Impeding the outfalls of the Deschutes River and other creeks also cut off sediment sources. Sediment inputs are a critical component to healthy beaches and provide suitable substrate for forage fish spawning and invertebrate production. Few patches of beach substrate suitable for forage fish spawning are available within the project area; therefore very limited spawning opportunity is present. The presence of surf smelt spawning in the study area implies that more forage fish spawning could occur in the project area if additional spawning substrate was available.

Riparian habitat along the west shore of West Bay has been impacted by the removal of coniferous forests, which were replaced by deciduous-dominated forests largely isolated from the shoreline by roads and fill material. Marine shoreline riparian forests provide important ecological functions including overhanging vegetation, recruitment of LWD along the shoreline, organic matter and terrestrial insect inputs, and habitat structure for a variety of wildlife. The shoreline is largely devoid of properly functioning LWD habitat structures and overhanging vegetation (Brennan 2007). The western shoreline of West Bay contains a narrow strip of salt marsh wetland habitat and the innermost portion of the lagoon contains a significant salt marsh component.

Dredge and fill activities in West Bay and the construction of Capitol Lake has significantly reduced mudflat habitat in West Bay over the last 150 years (USCG 1873). The reduction in the amount of mudflat habitat resulted in reduced habitat for critical juvenile salmonid food sources and Olympia oysters. Fill placed between the East and West Bays of Budd Inlet and associated bulkheads and overwater structures have displaced mudflat habitat and degraded intertidal habitat. Dredging has also transformed a vast intertidal mudflat into deeper subtidal marine habitat. This has increased the volume of water present and reduced the percentage of water that is flushed out during each tidal cycle.

2.4.4.1 Water and Sediment Quality

Water quality is a concern and has been influenced by many of the factors described above. Portions of the Deschutes River, Capitol Lake, and Budd Inlet do not meet current water quality standards and are listed on the Clean Water Act Section 303(d) list for one or more of the following parameters: fecal coliform, temperature, dissolved oxygen, pH, or fine sediment (TSS). Additional factors that have degraded water quality in West Bay include the development of uplands with impervious surfaces and the lack of treatment and flow control for stormwater generated on these surfaces. Poor water quality has caused shellfish harvest closures in West Bay and the depletion of local stocks of Olympia oysters that has occurred in parallel with other stressors such as habitat loss/degradation, overharvest and introduction of non-native invasive species.

Water and sediment quality were also affected by industrial development including log processing facilities, steel manufacturing, and ship building/repair facilities. These facilities were an important component of the development of Olympia, but were also point sources for harmful chemical pollutants to enter the water and potentially accumulate in the sediments of the Bay. In the 2008 Sediment Characterization Study of Budd Inlet, pollutants were identified including petroleum hydrocarbons, dioxin/furan, arsenic, copper and other heavy metals (SAIC, 2008). Log storage has also degraded the sediments through accumulation of wood debris, which degrades the ecological functions of the substrate for benthic and epibenthic production. Bacteria related to the breakdown of wood waste also increase the demand for dissolved oxygen, further impacting benthic and epibenthic organisms.

Marine sediments provide habitat for many invertebrates such as worms, clams and crustaceans. Contaminated sediments can be lethal to benthic organisms at high concentrations, and can accumulate in these organisms at lower concentrations (EPA 2015). Benthic organisms provide a food source for fish including salmon; which are, in turn, prey for marine wildlife including seals, whales and bald eagles. Mortality of benthic organisms reduces the prey base for larger animals and humans, while sublethal exposure of benthic organisms to contaminants results in accumulation of these harmful chemicals in animal tissue (EPA 2015) which can accumulate to dangerous levels in fish and wildlife, resulting in impaired health and mortality.

2.4.5 Existing and Historic Physical Processes

Shoreline and nearshore physical processes in West Bay are predominantly driven by wind-waves, salinity gradients (e.g., freshwater input), and tidal circulation. Sediments in West

Bay generally consist of fine, silty materials historically sourced from upstream terrestrial areas (Port of Olympia, 2014). Although historically consisting predominantly of inter-tidal mudflats (as determined from T-sheets), about 100 acres of mudflats in West Bay have been lost to deepening. Deepening is caused by the combined effects of dredging (on the east side of the bay in particular), scouring due to concentrated flows from 5th Avenue Dam, and sediment impoundment behind the dam. Nearshore bathymetry on the west side of West Bay, however, appears to have been minimally impacted by mudflat deepening, though historic tidal channels are no longer prevalent.

Sediment supply to West Bay shorelines is very limited, due to the armoring of shoreline, disconnection from adjacent bluffs, and reduction of sediment input from the historic Deschutes River Estuary. Most of West Bay, however, experiences no appreciable longshore sediment drift (Ecology, 2015).

Waves in West Bay are produced from wind blowing along Budd Inlet from the north and through West Bay, from the south. The strongest winds typically blow from the south. The fetch to the north, however, is considerably longer and produces larger waves. Shorelines along West Bay are relatively sheltered and low energy, with 1- to 2-foot wind-waves during a 50-year return period windstorm event. With no tidal exchange between the historic Deschutes River Estuary and Bay, circulation is severely constrained. Pre-dam conditions exhibited considerably more circulation and mixing than current conditions (USGS, 2006).

Prior to impoundment of Capitol Lake, the head-of-tide for the Deschutes River extended all the way up to the base of Tumwater Falls (USCGS 1873). Capitol Lake was then composed almost entirely of mudflats, where freshwater from the Deschutes River mixed with salt water from Budd Inlet. Following construction of the dam, salt water was incapable of entering the former Deschutes River Estuary, forming a freshwater lake. Freshwater discharge from Capitol Lake to West Bay now occurs abruptly and in addition to deepening West Bay as discussed above, this has likely produced sharper salinity gradients in the bay.

2.4.6 Summary

West Bay has undergone substantial modification over the last 150 years. Impacts to the ecological functions of the bay include:

- Conversion of coniferous riparian forests to deciduous forests.
- Disconnection of riparian forest and freshwater habitats from West Bay.
- Conversion of shallow intertidal mudflats into navigable waters and uplands.
- Loss of sediment and large wood inputs from bluffs and rivers/creeks.
- Degradation of intertidal beaches by armoring and fill placement.
- Loss of pocket estuary habitat.
- Water quality impacts from deepening the bay and from pollution sources including untreated stormwater runoff from impervious surfaces.
- Increased erosion and scour in small tributary creeks
- Contaminants and shoreline modification from historical uses.

These impacts have degraded habitat for marine-dependent species including Chinook salmon and Olympia oysters. Future restoration alternatives should focus on improving ecological functions for:

- Intertidal and nearshore salmonid habitat
- Forage fish spawning habitat
- Olympia oyster and other shellfish habitat
- Estuarine habitat and pocket estuaries
- Freshwater streams and wetlands
- Marine bird, shorebird, raptor, wading bird and mammal habitat
- Marine and freshwater riparian establishment/connectivity
- Salt marsh habitats

Primary physical processes impacted and in need of restoration include:

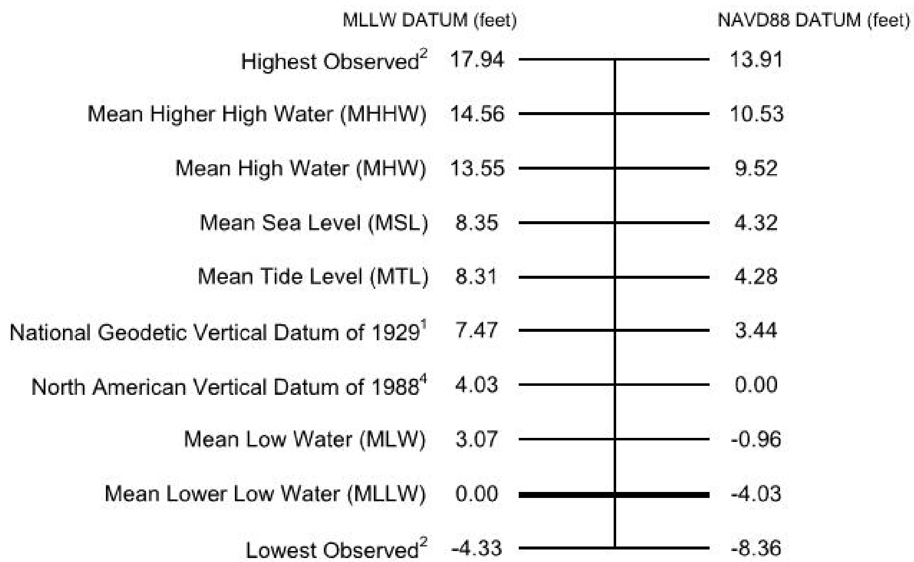
- Tidal circulation and flushing
- Salinity mixing and transition zones
- Sediment supply and transport along the shoreline
- Freshwater quality and quantity

2.5 Criteria Development

The following key criteria guided the approach for developing restoration concepts and provided a basic framework for evaluation and prioritization of restoration alternatives. More information and detail can be found in the Criteria Development Memo (Appendix E).

2.5.1 General Criteria

Given the ecological nature of the assessment, the project vertical datum is Mean Lower Low Water (MLLW). Tidal datum relationships are provided in Figure 3, with notes provided below for clarity.



Notes:

[1] Per Standard City of Olympia standard relationship, 0.00' NGVD29 = +3.44' NAVD88

[2] As observed at NOAA Station 9446969 between 4/1977 and 4/1978

[3] Tidal datum relationships per NOAA Station 9446969, Epoch 1983-2001

[4] To convert an elvation from MLLW to NAVD88 Datum, subtract 4.03'

Figure 3. Project vertical datums.

2.5.2 Assumptions

- Private Property: Private lands located within the project area will be considered for typical restoration treatments (such as beach nourishment seaward of revetments, or balanced cut fill) that may be implemented as these parcels are redeveloped and that minimize loss of existing upland areas.
- Deschutes Estuary Restoration: If restoration were to occur, the future conditions considered are as described in the Deschutes Estuary Feasibility Study Reports (2006). http://www.des.wa.gov/about/pi/CapitolLake/Pages/CapitolLakeReports.aspx
- Future sea level rise scenarios: These are based on the latest published scientific literature for medium-rise scenarios.
- Contaminant Remediation: Due to former industrial operations in West Bay, contaminated soils and sediments existing within the study area (SAIC 2008). At least four known cleanup sites are present within the project area. Cleanup action analysis and design was not part of this study and thus potential costs and design concepts specifically for cleanup actions are not included. In areas with known contamination (soil, sediment,

groundwater), more detailed studies are needed. The following remedial actions sites are noted, proceeding from south to north:

- Solid Wood, Inc. located in West Bay Park South Reach, in West Bay Park.
- Industrial Petroleum Distributers located in Port Tidelands Reach.
- Reliable Steel located in the Reliable Reach.
- Hardel Mutual Plywood located in the Hardel Reach.

2.5.3 Restoration Opportunities Matrix

A variety of restoration opportunities are recognized as possible at sites along West Bay. The restoration opportunities matrix, Table 1, summarizes overall restoration objectives and opportunities that guided the development of alternatives. The notes provide more detailed criteria associated with each opportunity used in developing concepts.

2.5.4 Recreation Opportunities Matrix

A variety of recreation opportunities are identified as possible at sites along West Bay, primarily within West Bay Park. The restoration opportunities matrix, Table 2, summarizes overall recreation objectives and opportunities that guided the development of alternatives, particularly at West Bay Park. The notes provide more detailed criteria associated with each opportunity used in developing concepts.

Table 1. Restoration Opportunties Matrix

Objective	Remove/reduce or setback bulkheads 1	Remove/reduce intertidal fill 2	Remove in-water/overwater structures	Beach nourishment 3	Regrading shorelines to natural slopes 4	Expand salt marsh prevalence 5	Enhance existing freshwater wetland 6	Riparian corridors 7	Backshore dune and riparian habitat 8	Large wood structures	Daylight creeks/streams to create pocket estuary	Beneficial use of clean dredge spoils 9	Remove creosote trestle structures	Olympia oyster habitat/substrate enhancement 10	Signage	Water Quality Treatment Facilities11
Intertidal and nearshore juvenile salmon habitat	x	x	x	x	x	x	x	x		x	x	x	x	x		x
Forage fish spawning habitat	x	x	x	x	x	x	x	x		x	x	x	x	x		x
Olympia oyster and shellfish habitat (non-harvest)	x	x	x	x	x		x	x			x	x	x	x		x
Estuary functions	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Marine bird/mammal habitat	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Nearshore vegetation abundance	x	x	x	x	x	x					x	x	x	x		x
Tidal circulation/flushing/water quality		x	x		x						x	x	x			x
Climate Change Resiliency	x	x				x	x	x	x	x	x	x				
Public Education	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Connectivity and migration corridor	x	x	x	x	x	x	x	x		x	x	x	x	x		x
Restore underrepresented/lost habitat types	x	x		x	x	x	x	x	x	x	x	x		x		x
Sediment sources and beach substrate	x			x	x				x		x	x		x		
Compatibility with future estuary restoration	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stormwater quality improvements	x	x	x		x	x	x	x			x					x

Restoration Opportunities

1. Target structures at or below EL. 16 ft MLLW.
2. Lower elevations to below EL. 16 ft MLLW.
3. Beach target range EL. 6.0 to EL. 16 ft MLLW. Substrate sandy gravel fish mix.
4. Both cut and fill may be required to achieve target intertidal elevations, maximize reuse of clean local materials for bulk fill. Import surface fish mix materials. Use local referenc site elevations.
5. Salt marsh target range EL. 12 to 15.5 ft MLLW, silt sandy gravel substrate, and should include tidal channels for fish access and tidal circulation.
6. Pre-treatment option prior to discharge into West Bay.
7. Target conifiers such as Douglas Fir, Western Hemlock, and Sitka Spruce.
8. Backshore Target above EL. 16.0 ft MLLW to 17.5 ft MLLW.
9. Depending on grain size, as beach fill (sand/gravel), bulk fill base layer (misc) or for intertidal marsh (silt/sand).
10. Oyster substrate silty sand with shell/gravel/cobble. Salinity above 24 PPM. Elevation range below -1.0 ft MLLW is ideal.
11. May include wetlands or other physical treatment alternatives.

Table 2. Recreation Opportunties Matrix

Objective	Elevated corridors and structures 1	Pedestrians and bicycles trails 2	ADA accessible touchpoints 3	New backshore and upper intertidal beach 4	Kayak/Water trail landings & launches 5	Restroom 6	Parking 6	Shelters/tables/gathering areas 6	Fishing 7	Nature viewing & interpretive areas 8
	Recreation Opportunities									
Non-motorized corridor connecting Capitol Lake to West Bay Park	x	x	x		x	x	x	x	x	x
Passive recreation	x	x	x	x	x	x	x	x	x	x
Visual acces through view preservation	x	x	x							x
Non-motorized corridor connectivity from West Bay Park north to Raft Ave. [A]	x	x	x	x	x		x	x	x	x
Preserve & enhance natural shoreline aesthetics (from water and land)	x			x	x					x
Preserve critical public infrastructure (roads, utilities)		x	x	x	x	x	x			
Provide physical public access to beach/West Bay	x	x	x	x	x		x		x	x
Compatible with Restoration	x	x	x	x	x				x	x

1. Elevated corridor at or above EL. 19.0 ft MLLW. Will not cause a net loss of shoreline ecological functions, processes, adverse impacts on other shoreline uses.

2. Corridor options: 3' wide soft – pedestrian, more rustic 5' wide crushed rock – pedestrian and off road bicycle 10' wide multi-use twith 2' shoulders – more formal, ABA friendly; subject to the mitigation sequencing process and shall be designed to minimize impacts to the ecological functions of the shoreline while providing access and waterfront enjoyment to the public.
3. Slope, rise, run and material surfaces must meet ADA and applicable design codes for use and experience.
4. Target elevations above EL. 15.0 ft MLLW at appropriate areas (sediment source, wave energy, geomorphology).
5. Firm substrate at moderate slopes. Motorized launches are not included.
6. Refer to City SMP requirements.
7. Intentional water access for fishing will require determine specific locations and access points, including closures and exclusion in restoration areas until establishment.
8. Refer to City SMP requirements.

A. May include or consider neighborhood connections to upland recreation areas.

3 RESTORATION ASSESSMENT

This section describes the development of conceptual restoration alternatives and evaluation of these alternatives using science based semi-quantitative and qualitative frameworks. Habitat restoration opportunities and concepts were developed first, followed by identification of stormwater improvements that could bolster ecological restoration in the identified habitat areas. This resulted in a unified analysis of restoration potential in West Bay. Finally, recreation opportunities compatible with restoration were developed and overlaid on the restoration alternatives for evaluation.

3.1 Habitat Restoration Concept Development

Habitat restoration concepts were guided by the Criteria Development Memo (Appendix E) and site visits to observe existing conditions. Initial schematic concepts were developed for each reach through a design workshop. These initial concepts were then refined to a conceptual level based upon input from the City, Port and Tribe, and by additional analysis and design.

In general the concepts were developed to respond to the ecological needs identified by review of historic and existing conditions. This strategy revolves around reconnection of riparian and intertidal habitats, restoration of intertidal areas through removal of historical fill, placement of natural beach substrates at appropriate slopes and elevations, creation of salt marsh in the upper intertidal zone, and limited freshwater marsh and upland meadow. The concept of connecting upland riparian areas with intertidal beaches provides an opportunity for sea level rise adaptation and resilient design through incorporation of a vegetated berm with both flood mitigation and habitat value.

Many of the sites considered for restoration already require soil, groundwater, or sediment remediation. Detailed analysis of remediation requirements was not performed nor was remediation design included. Potential efficiencies exist for remediation actions to be combined with restoration actions (for removal and capping with beach substrate, capping with beach substrate and cobble materials, etc.); therefore the interface between restoration and remediation would require further review during more detailed design of the restoration projects.

3.1.1 Description of Habitat Zones

Restoration of shoreline habitat zones along West Bay includes landscape restoration of riparian zones, natural meadows, salt marsh, freshwater marsh, intertidal beach (non-vegetated), and mudflats as described below. Table 3 provides a conceptual planting list by habitat type.

3.1.1.1 Riparian

Riparian plantings extend from elevation 16.5’ to elevation 19’ or above, with slopes from 3:1 to 50:1. The riparian planting zone ranges from approximately 25’ wide to 50’ or more, where space allows. A variety of native conifers, deciduous trees, and large and small shrubs will be planted in this zone. Overhanging vegetation along the shoreline drops leaf litter and insects into the nearshore, shades the upper beach, provides food for juvenile salmon, and food web support for a wide variety of other species. Small containerized plants (1 gallon and 2 gallon size) are used to plant shrubs and small trees to control costs and improve survival rates. A few 4’ to 6’ tall conifers and deciduous trees are mixed in with the smaller plants to accelerate the visual and habitat impact of the riparian planting

3.1.1.2 Natural Meadow

Meadow areas are seeded with a variety of native grasses and wildflowers that can provide habitat for insects and birds. Meadows occur in natural and informal areas of the shoreline environment between riparian plantings and upland of marsh habitats. Maintenance of meadows typically consists of annual mowing in the late summer to prevent invasion by woody plants such as Himalayan blackberries and Scots broom.

3.1.1.3 Lawn

Lawn areas are located in upland areas such as West Bay Park where frequent public use is anticipated and a flexible open space is desired. Lawns are seeded with ornamental perennial grasses that can tolerate public use.

3.1.1.4 Salt Marsh

The salt marsh zone extends from elevation 12’ to elevation 15.5’ and consists of plants such as pickleweed, tufted hairgrass and saltgrass. This zone ranges in slope from maximum 8:1 to very gentle gradient where space allows. Where the salt marsh is low (12’ MLLW) and on a gentle gradient with fine substrate with freshwater inputs (e.g., Garfield Creek); it may support plants such as Lyngby Sedge (Carex lyngbyei) and American Threesquare (Schoenoplectus pungens). Salt marsh areas can be planted with bare root plants and tubling plants or potentially colonized naturally with seeds brought in by the tides (depending on species and proximity to existing seed sources).

Table 3. Conceptual plant list by habitat type

Habitat Type	Plant Type	Common Name*	Scientific Name*
Riparian	Trees	Sitka spruce	Picea sitchensis
		Cascara	Rhamnus purshiana
		Western red cedar	Thuja plicata
		Douglas fir	Pseudotsuga menziesii
		Bigleaf maple	Acer macrophyllum
		Oregon ash	Fraxinus latifolia
		Bitter cherry	Prunus emarginata
	Shrubs	Indian plum	Oemleria cerasiformis
		Oceanspray	Holodiscus discolor
		Vine maple	Acer circinatum
		Red elderberry	Sambucus racemosa
		Nootka rose	Rosa nutkana
		Beaked hazelnut	Corylus cornuta
		Hooker's willow	Salix hookeriana
		Snowberry	Symphoricarpos albus
		Pacific crabapple	Pyrus fusca
		Tall Oregon grape	Mahonia aquifolium
	Groundcover/Forbs	Coastal Strawberry	F. chiloensis
		Douglas Aster	Aster subspicatus
		Common Yarrow	Achillea millefoilum
		Sword fern	Polystichum munitum
Salt Marsh	Grass/ emergents	Pickleweed	Sarcocornia pacifica
		Puget Sound gumweed	Grindelia integrifolia
		Seacoast bulrush	Scirpus maritimus
		Saltgrass	Distichilis spicata
		Spear saltbrush	Atriplex patula
		Fleshy jaumea	Jaumea carnosa
		Baltic rush	Juncus balticus
		Salt-marsh plantain	Plantago maritima
		Pacific silverweed	Potentilla pacifica
Freshwater Wetland		Slough sedge	Carex obnupta
		Water Parsley	Oenanthe sarmentosa
		Soft stem bulrush	S. tabernaemontani
		Spike Rush	Eleocharis palustris
		Jointed Rush	Juncus articulatus

*Specific plants lists and zones should be refined as projects move to detailed designs. Other species may be appropriate depending on specific habitat types and hydrology (e.g., scrub/shrub or forested wetland).

3.1.1.5 Freshwater Wetland

Freshwater wetland habitat currently exists in West Bay Park above the elevation of the existing salt marsh. The existing wetland consists of both native emergent plants and scrub/shrub wetland. There is potential to expand on the existing fresh wetland area to create native emergent and scrub/shrub areas that can transition to brackish and salt marsh over time as the sea level rises. Fresh wetland plantings may include emergent perennial species in herbaceous areas and willows, Pacific crabapple, native roses, and Oregon Ash in scrub-shrub and forested wetlands.

3.1.1.6 Intertidal Beach

The beach zone extends from approximately elevation 6' to elevation 15.5' and is essentially unvegetated due to tidal inundation and wave action. This zone ranges in slope from maximum 7:1 to 9:1 gradient where space allows.

3.1.1.7 Intertidal Mudflat

The mudflat zone extends from approximately elevation -5' to elevation 6' and a low gradient unvegetated tide flat that wets and dries during the typical tidal cycle and is composed of fine sediment, sand, and gravel.

3.1.2 Design Alternatives

3.1.2.1 Reach 1 - Lagoon

The Lagoon reach is located at the southern extent of the study area and is characterized by a former railroad trestle and presumed gravel berm that separates the shallow lagoon from West Bay. The west shore contains steep slopes and relatively intact riparian areas, fronted by sparse salt marsh. Tidal communication between West Bay and the lagoon currently occurs via two openings in the berm. Property ownership includes the Port, City, and private landowners. Primary opportunities for restoration include removal of historic fill to improve tidal circulation and flushing, beach creation, salt marsh creation, and stormwater quality improvements. The Shoreline Restoration Plan (City of Olympia 2012) identifies West Bay Project No. 9 in this reach as potential restoration of functional riparian area along the existing berm.

Four conceptual restoration alternatives were developed for the Lagoon, including consideration of potential recreational opportunities. These are based on and modified from previous analysis and design conducted by the City during development of the internal unpublished Draft West Bay Park Master Plan. Four conceptual stormwater improvement opportunities that would be supportive of restoration were identified and investigated in this reach, including treatment along West Bay Drive. A more extensive description of the Lagoon alternatives development and analysis is provided in Appendix D.

3.1.2.2 Reach 2 – West Bay Park South

The West Bay Park South reach is located immediately north of the Lagoon and is characterized by uplands, sparse salt marsh, and low quality wetlands heavily impacted by historic log storage and processing. This reach excludes the recently improved portion of the park to the north. Shorelines are relatively steep and coarse, with a high vertical bank composed of fill above the MHHW and little to no native riparian vegetation within 50 feet of the shoreline. Surface water flows south into the lagoon through a series of perched low quality wetlands. Property ownership is primarily City, with a small area owned by the Port.

Primary opportunities for restoration include removal of historic fill to create intertidal salt marsh and mudflat habitat, beach restoration, and daylighting of Garfield Creek and South Garfield Creek with West Bay. The Shoreline Restoration Plan (City of Olympia 2012) identifies West Bay Project No. 1 & 2 for restoration of the Garfield Creek and estuary, and daylighting of Garfield Creek.

Two restoration alternatives were developed for this reach, both of which allow for recreation connection between the Lagoon and developed West Bay Park. The alternatives generally align with previous analysis and design conducted by the City during development of the unpublished internal Draft West Bay Park Master Plan. Five conceptual stormwater improvement opportunities that would be supportive of restoration were identified and investigated in this reach, including two opportunities in the upper watershed and treatment along West Bay Drive.

Alternative 1 removes fill from the historic tidelands to create a beach and wide salt marsh complex, with improved connections to partially daylighted Garfield Creek and South Garfield Creek. New beaches would be created and tied into the developed portion of West Bay Park to the north. Riparian and meadow areas would be planted above the intertidal salt marsh zone.

Alternative 2 partially recreates the historic pocket estuary shore form by cutting further back into the uplands and Garfield Creek and creating a pocket estuary by pulling back the adjacent shoreline and creating beach areas. South Garfield Creek, which is a small local drainage, would be daylighted and routed south through regraded uplands to the Lagoon. It is expected that some limited freshwater marsh would develop, but vegetation would gradually transition to salt tolerant marsh species southward or as sea levels rise. Snags and large wood would be placed adjacent to the day lighted creek channel and marsh areas. Existing uplands would be regraded to create wide salt marsh benches at the southern end of the reach.

3.1.2.3 Reach 3 – Port Tidelands

The Port Tidelands reach includes the north end of West Bay Park owned by the City and Port-owned uplands and shallow mudflats areas. This reach is relatively constrained by the adjacent road, railroad grade, and characterized by armored shorelines and sparse riparian vegetation. Surface water flows west to east through West Bay Drive as was observed during site visits. The conveyance of flow is uncertain, but may result from a buried outfall pipe. Intertidal beach areas are largely absent and significant rubble and debris is present in offshore areas. Primary opportunities for restoration include remediation of contaminants, softening of the shoreline along West Bay Drive through beach creation, removal of debris and associated substrate enhancement, and riparian plantings. The Shoreline Restoration Plan (City of Olympia 2012) identifies West Bay Project No. 15 in this reach for cleanup of toxics at the Petroleum Distributers site.

One restoration alternative was developed for this reach, focused on the above items. Beach and marsh creation would create upland riparian areas and allow for potential recreation connections between West Bay Park and areas north. Four conceptual stormwater improvement opportunities that would be supportive of restoration were identified and investigated in this reach, including treatment along West Bay Drive.

3.1.2.4 Reach 4 – Reliable Steel

The Reliable Steel reach lies between the Port Tidelands and former Hardel Plywood site. This reach is characterized by upland fill and armored shorelines (rubble, riprap, debris) that abruptly transition to shallow mudflats. The property is privately owned and requires cleanup of contaminated soils, groundwater, and sediment. Surface water flows through a small culvert and discharges onto the armored shoreline. Functional intertidal beach areas are largely absent on the south end of the site and significant debris (steel slag, concrete, deteriorated buildings) is present along the entire shoreline. Primary opportunities for restoration include remediation of contaminants, removal of armor/debris to create intertidal beach areas, re-contouring of the shoreline, and riparian plantings. Two restoration alternatives were developed for this reach. Two conceptual stormwater improvement opportunities that would be supportive of restoration were identified and investigated in this reach, including treatment along West Bay Drive.

Alternative 1 essentially maintains the existing uplands and shoreline plan form, but creates fronting intertidal beach and marsh areas primarily through placing beach substrates offshore of the existing revetment and contouring the upland areas to promote riparian vegetation. These strategies could form part of a sea level rise adaptation strategy.

Alternative 2 applies a similar beach creation strategy but also takes advantage of existing heavily impacted intertidal areas located in the north part of the property. Additional fill would be removed to create a large intertidal marsh and pocket beach area near the Hardel site to the north. These strategies could also form part of a sea level rise strategy.

3.1.2.5 Reach 5 – Hardel Plywood

The Hardel Plywood reach is composed primarily of upland fill and steep riprap armored shorelines that abruptly transition to mudflats and deeper subtidal areas. Surface water appears to flow from west to east and large derelict concrete structures remain in the tidelands. The property is privately owned and recent upland contaminant remediation has been completed. Assuming that the existing uplands are to remain intact, restoration opportunities are limited to creation of intertidal beach and marsh areas through substrate placement, riparian plantings along the backshore, and removal and restoration of intertidal structures areas. The Shoreline Restoration Plan (City of Olympia 2012) identifies West Bay Project No. 27 in this reach for potential removal of nearshore fill.

One restoration alternative was developed for this reach that essentially maintains the existing uplands and shoreline plan form, but creates fronting intertidal beach and marsh areas primarily through placing beach substrates offshore of the existing revetment. Riparian plantings could be installed above the beach. Sea level rise adaptation could be included in this alternative. Given the relatively deep water depths in this reach, substrate would be placed in the low intertidal for establishment of an Olympia Oyster reef. Substrate placement may require permission from WA DNR. Four conceptual stormwater improvement opportunities that would be supportive of restoration were identified and investigated in this reach, including treatment along West Bay Drive.

3.1.2.6 Reach 6 – Schneider Creek

The Schneider Creek reach is characterized by armored shorelines (deteriorated timber bulkheads, monolithic concrete crane pads, a steel bulkhead, and riprap) fronting a diverse range of tidelands, mudflats, and former log pond. Schneider Creek discharges into the reach via a large culvert, delivering sediment and freshwater and redistributing sediments in the mudflats. The property is owned by two private property owners and the Tribe. Restoration opportunities are vast, including removal of bulkheads, Schneider Creek daylighting, creation of intertidal beach and marsh areas through substrate placement, restoring the log pond to natural grades, riparian plantings along the backshore, removal of intertidal and upland structures, and shellfish enhancement. The Shoreline Restoration Plan (City of Olympia 2012) identifies West Bay Project No. 12 in this reach for stabilizing Schneider Creek channel to prevent erosion. Creek daylighting was beyond the scope of the Plan.

One restoration alternative was developed for this reach based primarily upon conceptual design developed by Coast & Harbor Engineering (CHE 2015) for the SPSSEG. The alternative includes bulkhead and structure removal, shoreline set back to create intertidal beach and marsh areas, and material placed in the mudflats to restore natural grades and enhance shellfish habitat for Olympia Oyster and other bivalves. Three conceptual stormwater improvement opportunities that would be supportive of restoration were identified and investigated in this reach, including one opportunity in the upper watershed and treatment along West Bay Drive.

3.1.2.7 Reach 7 – Delta Illahee

The Delta Illahee reach is characterized by armored riprap shorelines that rapidly transition to tidal and subtidal zones with no transitional habitat. The property is privately owned and currently operated as laydown and staging area for construction equipment. Assuming that the existing uplands are to remain intact, restoration opportunities are limited to creation of intertidal beach and marsh areas through substrate placement and riparian plantings along the backshore.

One restoration alternative was developed for this reach that essentially maintains the existing uplands and shoreline plan form, but creates intertidal beach and marsh areas primarily through placing beach substrates offshore of the existing revetment. Riparian plantings could be installed above the beach. Relatively deep water would require a coarse gravel cobble mix beach at the north end of potential beach substrate placement. Two conceptual stormwater improvement opportunities that would be supportive of restoration were identified and investigated in this reach, including treatment along West Bay Drive.

3.1.2.8 Reach 8 – Marina

The Marina reach is characterized by armored riprap and rubble shorelines fronted by an active marina located over relatively deep subtidal areas. The property is privately owned. No specific habitat restoration opportunities were identified in this reach due to its current condition and use. The site is subject to tidal flooding which would increase with future sea level rise. Two conceptual stormwater improvement opportunities that would be supportive of restoration were identified and investigated in this reach, including treatment along West Bay Drive.

3.1.2.9 Reach 9 – Logyard

The Logyard reach is characterized by armored shorelines fronted partially by low intertidal beaches adjacent to log rafting and offshore log handling equipment. Wood waste covers much of the nearshore area. The property is privately owned. Dunlap Towing currently operates it as an active logyard. No specific habitat restoration opportunities were identified in this reach due to its current condition and use. One conceptual stormwater improvement opportunity was identified and investigated in this reach, including treatment along West Bay Drive. North of the logyard, beaches with overhanging riparian vegetation were observed. These areas were visited and considered as reference beaches for West Bay, with potential forage fish spawning habitat.

3.2 Stormwater Improvements

Untreated or inadequately treated stormwater from urban environments can negatively impact water quality in estuaries and other marine environments by lowering dissolved oxygen levels and increasing levels of harmful pollutants including nutrients, metals, hydrocarbons, bacteria and other constituents (EPA 2005). These pollutants have a significant impact on marine organisms ranging from reduced productivity to mortality. Poor water quality results in closures of recreational and commercial harvest of shellfish each year (DOH 2015). At higher trophic levels, bio-magnification occurs when top predators, such as killer whales or humans consume lesser predators, resulting in high concentrations of pollutants at the top of the food chain.

Therefore, conceptual stormwater treatment opportunities were developed as part of this assessment, in concert with habitat restoration alternatives. As further detailed in Appendix C, the conceptual stormwater analysis identified surface water pollutants and potential sources within the study area, identified a range of practical treatment options and technologies using a screen matrix, and developed conceptual level costs for these improvements.

A total of 18 specific stormwater treatment opportunities were identified and detailed. These opportunities are roughly indicated on the illustrative graphics in Appendix A, and detailed within the Conceptual Stormwater Analysis Memo in Appendix C. Key outcomes and findings from the analysis are briefly summarized below:

- Many of the identified outfalls have constraints such as terrain slope, high discharge rates, and limited available area for treatment.
- The study did identify a small number of stormwater outfalls with smaller drainage basins where end-of-pipe retrofits are feasible.
- Up-drainage stormwater retrofits offer more feasible scale projects to treat sub-basins within larger basins that discharge into West Bay, particularly for Garfield Creek and Schneider Creek.
- Up-drainage retrofits can be scaled or replicated to achieve additional water quality benefits within other areas of the basin as feasible.
- Collection and treatment of stormwater from portions of West Bay Drive also provides retrofit opportunities throughout the project area. The retrofits could be implemented incrementally as stormwater infrastructure and roadway improvements are realized.

3.3 Public Access and Recreation

Conceptual recreation opportunities were considered and developed for consistency and compatibility with restoration objectives for West Bay and previously provided by the City's Shoreline Master Program. The objective is to provide for ecologically sensitive public access to the shoreline and connectivity to recreation infrastructure along West Bay. Illustrative graphics in Appendix A depict potential recreation opportunities throughout the study area, primarily focused in the Lagoon and West Bay Park South reaches. Recreation elements shown in the graphics are briefly described below.

3.3.1 Multi-Use Trail

The multi-use trail is a 10-foot wide trail with 2-foot crushed rock shoulders. It is well-defined, handicap accessible, accommodates families, and encourages slow wandering, water-viewing and bicycle use. This trail type is consistent with the Thurston County Plan and designed for compatibility with Accessibility Guidelines for Outdoor Developed Areas (section T303) in accordance with the following:

- Uphill and downhill segments separated by level transition segments with slopes less than or equal to 5%.
- Running slope options include 1:20 for any length, 1:12 max for 200 feet, 1:10 max for 30 feet, 1:8 max for 10 feet.
- Cross slope of 2%.
- Trails and boardwalks will typically be located at elevation 19' MLLW or above. Shoreline restoration includes grading within the riparian zone to raise the backshore and riparian areas to elevation 19' MLLW or above.

The West Bay Drive trail alternative was developed with input from City transportation planners and depicts facilities adequate to accommodate multi-modal recreational use in addition to typical use for a major collector street. Additional transportation infrastructure planning is required to refine this alternative and the connection to downtown and/or Capital Lake.

3.3.2 Boardwalk

Two types of boardwalk structure are proposed, with widths and slopes consistent with a multi-use trail and ADA requirements.

- Boardwalk over Marsh or Uplands: This type of boardwalk is constructed with pin-pile footings, steel framing, light penetrative types of grating and a wooden railing. The pin-pile footings minimize disturbance of marsh habitat and allow installation in poor quality soils.
- Overwater Walkway: This structure is an elevated and walkway constructed with steel or concrete piles, robust metal framing, durable decking (including light penetrative types of grating) and railing. This type of structure could span over the water with relatively little in-water footprint but with relatively high cost compared to boardwalks.

3.3.3 Large View Deck

Associated with a boardwalk, a large view deck is a widened portion of the boardwalk that provides space for groups to gather to enjoy the view or for a teacher to incorporate as part of an outdoor classroom program about natural systems or site and regional history. The view deck is approximately 20 feet long and 6 to 8 feet wide with two benches for seating.

3.3.4 Small View Deck

Also associated with a boardwalk, a small view deck is a widened portion of the boardwalk that provides a place for a few people to stop and enjoy the view and sit on a bench. The view deck is approximately 10 feet long and 4 feet wide.

3.3.5 Viewpoint/Plaza

Viewpoint plazas extend off of the asphalt multi-use trail in locations with interesting or beautiful views where visitors might like to stop, rest, and enjoy the view and possibly see wildlife making use of the restored habitat areas. A view point plaza is approximately 400 to 500 square foot in size with a wooden railing and a bench. These locations may also be a place for beach access.

3.3.6 Interpretive Signage

Interpretive signs at a series of locations along the shoreline can be used to tell a story about the natural systems, wildlife, and history of West Bay. Interpretive signs are constructed of high pressure laminated panels (24” x 36” size or smaller) printed with colorful images and text and mounted on a powder-coated steel frame with concrete embedded steel post(s).

3.3.7 Wayfinding / Interpretive Kiosk

Wayfinding and interpretive kiosks provide a map showing the West Bay shoreline, and information such as the proposed shoreline restoration plan and existing and proposed recreation opportunities. Interpretive information about the natural systems, restoration efforts or area history could add interest to the wayfinding information provided. The kiosk is constructed with a small metal shed roof supported by large wooden posts. The wayfinding/interpretive sign is constructed of a high pressure laminate material mounted on a framed wooden panel. Kiosks can be one or two-sided.

3.3.8 Gathering Area/Picnic Area

Outdoor gathering areas can be used as outdoor classrooms and for a variety of family or community events. A gathering area would include a landform that defines the gathering space and seating stones such as in a small stone amphitheater. Some gathering areas could be picnic areas consisting of a group of three or four picnic tables set into a grassy open space defined by low, mounded landforms.

3.3.9 Kayak Launch

Kayak/hand-carry boat launch opportunities are found where there is an existing road and parking for a few cars in close proximity to a gently sloped beach. Currently, there are a couple locations in West Bay Park where kayak launching from existing beaches is possible. Additional locations may be possible at the Port tidelands or at the Reliable property, depending on shoreline restoration implementation.

3.3.10 Kayak Landing (Day Use)

Kayak/hand-carry boat landings for day-use consist of any gently-sloped beach that is accessible by kayak during a wide array of tidal elevations. Kayakers that launch beyond the Bay or within the Inlet can find a rest spot on beaches that provide protection from wind and waves. No infrastructure is needed for this type of landing, although beach logs are often welcomed as a place to sit.

3.4 Restoration Alternatives Evaluation

Evaluation of potential restoration alternatives and scenarios include semi-quantitative and qualitative measures. When taken together, these evaluation measures provide a science-based approach to facilitate discussion and decision-making, while also considering the inherent uncertainties, stakeholder experience, and professional judgement that is needed to produce a restoration strategy for West Bay.

3.4.1 Semi-Quantitative Evaluation Framework

The Semi-quantitative evaluation and ranking of the habitat benefits for each conceptual alternative was accomplished using a habitat value quantification model based on existing marine and estuarine habitat equivalency analysis methodologies. Habitat types were obtained from documents including Determining Habitat Value and Time to Sustained Functioned (Iadanza 2001) with additional habitat types developed specifically for the West Bay assessment. The habitat scores are intended only to provide relative, science-based, quantification of habitat improvements as “Relative Habitat Scores” for the purpose of this assessment.

Note that this evaluation methodology is considered semi-quantitative because the evaluation was developed at a highly conceptual level over a very large and diverse study area. Thus, the evaluation relies upon readily available data and application of professional judgement to map habitat values for existing site conditions and restored site conditions. Therefore, use for development of mitigation credits would require additional work and more detailed analysis at a reach scale.

3.4.1.1 Habitat Classifications and Metrics

The West Bay restoration alternatives were developed to improve the ecological functions and processes of the shoreline and nearshore environment within the study area. Target species for this assessment include Chinook salmon, Olympia oyster, and avian species such as shorebirds, waterfowl, and great blue heron. The Iadanza (2001) guidance was selected as the primary basis for this assessment because it assigns value to each habitat type based on its value to estuarine fish and birds.

Iadanza identifies two key fish species; Chinook salmon and juvenile English sole (Parophrys vetulus) as surrogate fish species in estuaries and other nearshore habitats. Although the Deschutes River does not have a wild population of Chinook, the assessment included juvenile Chinook values because: 1. Deschutes River hatchery Chinook population utilizes the West Bay of Budd inlet for osmoregulation, migration, refuge and foraging, 2. juvenile Chinook from systems as far north as the Snohomish have been documented utilizing estuaries in the south Puget Sound (Cutler 2009). Additionally, habitat values developed for juvenile Chinook still provide surrogate values for other nearshore fish species.

The Iadanza values also include the habitat requirements of resident and migratory bird assemblages to provide nearshore habitat quality ratings for associated or dependent avian species. Habitat values based on functions for Olympia oysters were not available in existing models reviewed for this assessment. Therefore, Olympia oyster habitat was considered as described in the Qualitative Evaluation section of this report.

The West Bay habitat valuation model uses four primary inputs; 1) existing habitat type value, 2) proposed habitat type value, 3) size, and 4) year to maturity. Habitat types obtained from existing models include estuarine marsh, intertidal, and shallow subtidal from Iadanza (2001) Riparian habitat type was obtained from unpublished draft guidelines. Figure 4 shows a typical profile of the habitat types used in the assessment.

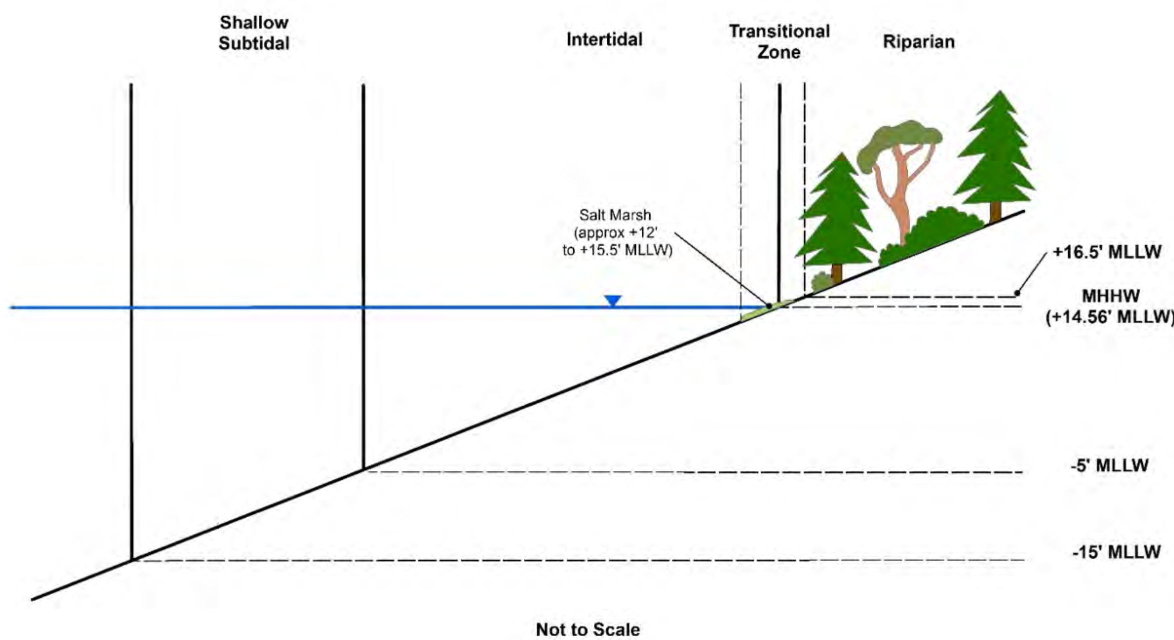


Figure 4. West Bay Habitat types cross section.

Upper and lower habitat values established for each habitat type reflect fully functioning and degraded conditions, respectively. Habitat value ranged from 0.0 for developed land to 1.0 for estuarine marsh and freshwater/brackish wetlands. Baseline adjusted habitat values are also included to discount the value of functioning habitat adjacent to degraded habitat. The number of years required for habitat types to mature to fully functioning conditions is also defined in existing models and used in habitat improvement calculations. This value is incorporated into the model to reflect the specific amount of time each restored habitat type takes to achieve the level of function that would occur naturally and the respective increase in value of each habitat type over time as it matures. Modifications made for the West Bay assessment include the addition of freshwater/brackish wetlands habitat type, partially functioning conditions, and reduced habitat function under elevated structures as shown in Table 4.

Table 4. West Bay Relative Habitat Values [1,2]

Habitat Type	Habitat Condition						Years to Full Function [3]
	Fully Functioning	Baseline Adjusted	Partially [3] Functioning	Degraded	Grated Structure	Upland Trail Developed [4]	
Estuarine Marsh	1.00	0.85	0.70	NA	0.43	NA	15
Intertidal	0.90	0.75	0.45	0.10	0.38	NA	8
Shallow Subtidal	0.70	0.55	0.35	0.10	0.28	NA	8
Freshwater Wetland [5]	1.00	0.85	0.50	0.10	0.43	NA	15
Riparian	0.55	0.40	0.28	0.10	0.20	0.00	10
Armoring	NA	NA	NA	0.10	NA	0.00	NA
Developed	NA	NA	NA	0.00	NA	0.00	NA

Table 4 Notes: 1. Grey cells indicate values developed for the West Bay assessment. 2. Green cells indicate values updated through informal discussions with US Fish and Wildlife Service (Kraussmann pers. com. 2016). 3. Partially functioning intertidal includes additional values of 0.55 and 0.65 to assess the incremental improvements to circulation among the lagoon alternatives. 4. For Upland Trail / Developed "years to full function" = 1. 5. Includes freshwater/brackish wetlands.

Additional habitat values were developed for this model to conservatively assess habitat improvements throughout the study area and within the limitations of the methodology. Partially functioning habitat conditions are developed to more accurately quantify that existing habitats in the study area are impacted, but still provide a moderate level of habitat functions greater than the degraded value of 0.1. To accurately reflect the impacts of constructing a low-impact recreation trail through a restored site, an additional habitat category was developed for elevated grated structures.

Although the model was developed to quantify habitat improvements within the study area, limitations remain. For example, conversion to estuarine marsh and intertidal habitat generated a higher value than conversion to riparian habitat in all cases. However, it is recognized that creation of additional riparian "edge" habitat along the highly modified shorelines of West Bay could provide enhanced habitat for nearshore fish and wildlife. Accounting for such complexity is a task best suited for detailed design efforts. Additional qualitative criteria were assessed as described in Section 3.4.2.

3.4.1.2 Assessment and Ranking Methodology

Existing habitat types and proposed restoration habitat types were mapped using GIS for each alternative. Polygons were generated to represent the difference between existing and proposed habitat (e.g. habitat shift) and the acreage of each habitat shift polygon was input into the West Bay habitat valuation model. The model then calculated the overall "Relative Habitat Score" for each alternative. This provided a quantified score by which habitat improvements anticipated from implementation of each alternative were ranked. By this method, larger sites have higher habitat scores due to their size. Therefore, sites were also ranked using the ratio of habitat points per acre, which normalized the habitat gains independent of the size of the site. The level of restoration activities required for each alternative also varies greatly. To provide a third ranking system, the cost estimate for each alternative was used to develop ratios of cost per habitat point.

3.4.1.3 Ranking Results

Multiple ranking methods were employed. Table 5 provides a brief summary of the pros and cons for the three ranking methods applied in the semi-quantitative assessment. Tables 6, 7and 8 present rankings by overall relative habitat score, habitat score per acre, and cost per habitat point, respectively.

Table 5. Table of Pro's and Con's for semi-quantitative ranking methods

Ranking Method	Pros	Cons
Relative Habitat Score	• Ranked restoration alternatives based on providing the most habitat lift • Provided a suitable ranking system for restoration independent of cost	• Biased toward largest sites • Did not identify which sites would be cost-prohibitive
Habitat Score/ Acre	• Ranked restoration alternatives based on providing the highest ratio habitat lift • Provided a suitable ranking system independent of size or cost	• Biased towards restoration of most degraded sites • Did not identify which sites would be cost-prohibitive
Cost/ Habitat Point	• Provided a cost/benefit ratio useful for planning restoration actions • Provided comprehensive habitat ranking including size, level of habitat lift, and cost • Identified which restoration alternatives would be excluded as cost prohibitive	• Includes estimated cost for restoration, which is not necessarily an ecological consideration

Table 6 represents the overall habitat gains anticipated from implementation of each restoration alternative. Lagoon Alternative 4 ranked highest with a relative habitat score of 270.39 and the Schneider alternative ranks lowest with a score of 47.25. It is important to note that the Lagoon site is the largest (approximately 15 acres) and the Schneider site is the smallest (approximately 3 acres). To account for overall restoration area size, the model results were processed as a ratio of habitat points relative to the size of the restoration area in acres. The results of this ranking by habitat score per acre are shown in Table 7 below.

While this ranking method removes the bias of size from the assessment, it generally provides higher ratios for sites which convert the most developed upland (often highly degraded) into high quality nearshore and shoreline habitat. Using this ranking method, the Reliable Alternative 1 site ranks highest and the Lagoon Alternative 1 ranks the lowest. The high rank of the Reliable Alternative 1 site relates to the relatively highly impacted nature of the existing site. The low rank of the Lagoon alternative is explained by the minor removal of berm material for this alternative and overall expected minimal improvement in habitat function.

Table 6. Alternatives ranked by relative habitat score

Rank	Site Alternative	Total Habitat Score (Restoration Only)	Total Habitat Score (Includes Recreation)
1	Lagoon Alt. 4	266.94	252.17
2	Lagoon Alt. 2	191.07	177.43
3	Lagoon Alt. 3	157.33	141.24
4	Schneider	127.17	117.73
5	Port Tidelands	118.91	107.96
6	West Bay Park Alt. 1	114.19	99.67
7	Reliable Alt. 2	89.18	82.55
8	Lagoon Alt. 1	81.34	69.62
9	Reliable Alt. 1	74.82	68.89
10	West Bay Park Alt. 2	71.97	59.05
11	Delta Illahee	64.43	56.91
12	Hardel	62.02	50.61

Table 7. Alternatives ranked by habitat points per acre for restoration only

Rank	Site Alternative	Habitat Points/Acre
1	Reliable Alt. 2	26.88
2	Reliable Alt. 1	25.07
3	Delta Illahee	24.99
4	Schneider	23.43
5	Hardel	21.84
6	Port Tidelands	21.08
7	Lagoon Alt. 4	17.37
8	West Bay Park Alt. 1	16.00
9	West Bay Park Alt. 2	14.97
10	Lagoon Alt. 2	12.29
11	Lagoon Alt. 3	10.18
12	Lagoon Alt. 1	5.43

A third ranking approach was used which incorporates the estimated cost of implementing each alternative into a ratio of cost per habitat point. Costs used to estimate this metric do not include recreation or stormwater improvements, only restoration. A more detailed description of cost is provided in the following section. This ranking method provides more practical information for evaluating the cost/benefit of the alternatives and site based on cost per habitat point, the Reliable Steel site has the highest rank, whereas the Lagoon Alternative 1 has the lowest rank (highest cost/acre of habitat improvement).

Table 8. Alternatives ranked by cost per habitat point for restoration only

Rank	Site Alternative	Cost / Habitat Point
1	Reliable Alt. 2	$25,399
2	Reliable Alt. 1	$26,062
3	Schneider	$27,372
4	Delta Illahee	$27,473
5	Port Tidelands	$28,728
6	West Bay Park Alt. 1	$31,307
7	Lagoon Alt. 2	$43,277
8	Lagoon Alt. 4	$52,884
9	West Bay Park Alt. 2	$53,689
10	Lagoon Alt. 3	$56,938
11	Hardel	$65,031
12	Lagoon Alt. 1	$78,707

3.4.1.4 Semi-quantitative Summary Discussion

Table 9 provides a summary of the unranked semi-quantitative results sorted by reach and alternative. This allows for an overall view of the ranking methods, where a rank of 1 is the highest (best) and 11 the worst. Key points of emphasis from the summary rankings are provided below:

- Lagoon Alternative 1 has a relatively low rank across all methods. This is due to the expected minimal improvement in habitat function combined with relative difficulty of performing construction work within the lagoon.
- Restoration at Reliable Alt. 1 and Delta Illahee rank relatively high in points per acre and cost per point due to conversion up degraded uplands and armored shorelines to intertidal beach and riparian areas. Thus the relative uplift is high and cost for these sites with focused beach nourishment placement along a degraded shore is relatively lower.
- Restoration at the Hardel site has a relatively high cost per acre, even though the proposed restoration action is similar to Reliable and Delta Illahee sites. This is due to the relatively deep water offshore of the armored shoreline that require substantial placement of fill and beach nourishment material to achieve intertidal elevations.

Table 9. Combined semi-quantitative rankings by reach and restoration alternative

Site Alternative	Total Habitat Score Rank	Habitat Points/Acre Rank	Cost / Habitat Point Rank
Lagoon Alt. 1	8	12	12
Lagoon Alt. 2	2	10	7
Lagoon Alt. 3	3	11	10
Lagoon Alt. 4	1	7	8
West Bay Park Alt. 1	6	8	6
West Bay Park Alt. 2	10	9	9
Port Tidelands	5	6	5
Reliable Alt. 1	9	1	2
Reliable Alt. 2	7	2	1
Hardel	12	5	11
Schneider	4	4	3
Delta Illahee	11	3	4

3.4.2 Qualitative Evaluation Framework

The qualitative evaluation framework provides the opportunity to consider important restoration elements that are difficult to quantify and not easily incorporated numerically. First, projects were evaluated against the established objectives in the opportunities matrices. Secondly, professional judgement was applied to establish the scale of value for qualitative metrics for each alternative. Qualitative metrics are scored on a linear scale of none (0), low (1), medium (2), high (3), exceptional (4). The exceptional rating was included to recognize restoration opportunities that are unique amongst the reaches and alternatives. The following metrics are considered:

- Sediment supply and transport: project provides the opportunity to increase the supply and transport of sediment in the project area.
- Tidal circulation & flushing: project increases tidal circulation and reduces residence time of tidal flushing.
- Connectivity: project links with other restoration opportunities and provides continuity with other restoration sites.
- Underrepresented habitats: project provides unique opportunity to restore unique habitat or historically lost habitat, such as freshwater wetlands, streams/creeks, etc.
- Resiliency: project enhances natural physical process and is capable to respond to rising sea levels through natural adaptation.
- Deschutes Estuary Restoration: project is compatible with the proposed Deschutes River Estuary restoration with respect to encouraging natural recovery through physical and biological processes.
- Phasing: project can be implemented in phases.
- Recreation compatibility: project provides for recreation uses, public access and educational opportunities.

Table 10 summarizes the results of the qualitative assessment for the qualitative metrics described above. A total score of 32 is possible, but few of the restoration alternatives are capable of achieving high scores in all metrics. The table is provided in unranked format by reach. The highest scoring alternative is the Lagoon Alternative 4, and the lowest is the Lagoon Alternative 1.

Table 10. Summary of qualitative scoring based on the above metrics

Site Alternative	Sediment Supply &Transport [SED]	Tidal Circulation + Flushing [CIRC]	Connectivity [CON]	Underrepresented habitats [HIS]	Resiliency [RES]	Deschutes Estuary Restoration [DES]	Phasing [PHS]	Recreation Compatibility [REC]	TOTAL
Lagoon Alt. 1	1	1	1	1	1	0	0	2	7
Lagoon Alt. 2	1	3	1	1	2	2	0	2	12
Lagoon Alt. 3	2	2	2	1	2	2	2	3	16
Lagoon Alt. 4	3	4	4	1	2	4	2	3	23
West Bay Park Alt. 1	2	1	2	1	3	2	1	3	15
West Bay Park Alt. 2	2	1	1	3	3	2	1	3	16
Port Tidelands	2	1	1	1	2	1	1	2	11
Reliable Alt. 1	2	1	1	1	2	1	2	2	12
Reliable Alt. 2	2	1	1	1	2	1	2	2	12
Hardel	2	1	1	2	2	1	3	2	14
Schneider	2	2	3	2	2	1	3	2	17
Detla Illahee	1	0	1	1	2	1	2	1	9

4 IMPLEMENTATION

4.1 Cost

Cost estimates were developed based on recent nearby projects and professional judgement. Cost estimate assumptions are summarized below. Table 11 provides conceptual cost estimates for each alternative by reach. Detailed conceptual cost estimate tables are included in Appendix F for restoration and recreation and Appendix C for stormwater. The table provides separate costs for restoration and recreation elements identified in the assessment. Restoration and recreation elements included an assumed 30% contingency and allowance of 25% for design and permitting. Because identified stormwater improvements span large upstream basins these are included in the table on a reach-by-reach basis and are somewhat independent of restoration alternatives. Stormwater improvements costs along West Bay Drive are excluded from the table and could total up to $280,000 (details provided separately in Appendix C). Because stormwater improvement costs vary widely, a range of costs was developed from low to high. In total, stormwater improvement opportunities may range from $11 million to $16 million in construction cost.

Note that various recreational options are possible for each lagoon alternative, including a multi-modal trail along West Bay Drive. City Public Works Engineering developed a conceptual Estimate of Probable Construction Cost based on Section 14 (see Appendix A) for a trail along West Bay Drive. The conceptual cost estimate range is $9,000,000 to $10,500,000 and includes right of way purchase, sales tax, engineering contingency, and overall contingency. The conceptual cost estimate includes a 12-foot multiuse trail on the east side of West Bay Drive, two 5-foot bike lanes, two 11-foot vehicle lanes, an 8-foot sidewalk on the west side of the road, and associated miscellaneous road elements for a total width of 56 feet. In order to build the conceptual roadway cross section, right of way would need to be purchased along both sides of the existing roadway. This may impact businesses, condos, and homes adjacent to the road. The sidewalk on the west side of the road will require shoring and concrete walls to ensure the high bank with homes above remains stable.

Table 11. Cost summaries for conceptual alternatives and reach

Reach	Alternative	Restoration Cost	Recreation Cost	Stormwater Opportunities Range
1	Lagoon Alt. 1	$6,402,000	$3,922,000 *	$2,943,000 to $4,414,000
	Lagoon Alt. 2	$8,269,000	$6,299,000 **	
	Lagoon Alt. 3	$8,958,000	$2,924,000 ***	
	Lagoon Alt. 4	$14,117,000	$9,073,000 ****	
2	WB Park Alt. 1	$3,575,000	$297,000	$1,300,000 to $1,950,000
	WB Park Alt. 2	$3,864,000	$289,000	
3	Port Tidelands	$3,416,000	$132,000	$1,642,000 to $2,462,000
4	Reliable Alt. 1	$1,950,000	$80,000	$423,000 to $634,000
	Reliable Alt. 2	$2,265,000	$80,000	
5	Hardel	$4,033,000	$142,000	$1,676,000 to $2,513,000
6	Schneider	$3,481,000	$119,000	$650,000 to $975,000
7	Delta Illahee	$1,770,000	$102,000	$1,229,000 to $1,843,000
8	Marina	-	-	$234,000 to $351,000
9	Logyard	-	-	$386,000 to $578,000

* Rec. cost assumes trail along remaining berm with two overwater spans
** Rec. cost assumes trail along remaining berm with four overwater spans
*** Rec. cost assumes mixed trail/boardwalk/overwater structure along shore
**** Rec. cost assumes full overwater structure on piles

4.1.1 Conceptual Cost Estimate Assumptions

General

- The estimates relied upon site topography from LiDAR and conceptual grading quantities.

- Remedial cleanup action costs are not included. Over excavation is limited to the placement thicknesses needed for restoration.
- Berm material excavated from the Lagoon is not considered for reuse outside Lagoon reach.
- All dredged material must be disposed in a confined upland facility.
- Marsh, beach, backshore, and beach toe substrate placement is assumed to be a minimum 1.5 feet thick.
- Concrete/rubble locations and areas are based on analysis of 2015 aerial photography.
- Habitat logs would be placed as four logs every 400 ft, with anchors.
- Approximately 75% of riparian areas would consist of riparian plantings and 25% would consist of natural meadow.
- Interpretive signage would be included at all reaches.
- Project monitoring after construction is not included.

Lagoon

- Material excavated from the berm may be reused where possible within Lagoon.
- Excavated upland material would not be reused.
- Concrete rubble in the existing lagoon openings is assumed to be 150’ long, 2’ thick, and 10’ wide.
- A railroad trestle is buried within berm along its entire length.
- Railroad trestle consists of 10 ties per bent, 5 piles per bent, and 15 feet spacing between pile bents.
- Timber piles from the railroad trestle would only be removed when berm is removed.
- Railroad ties and steel rail would be removed along the entire berm length.

West Bay Park

- Approximately 60 tons of concrete would be disposed of from 2 stormwater outfall pipes.

Stormwater Opportunities

- Stormwater treatment costs are based on both previous studies and local experience and do not include land acquisition costs.
- West Bay Drive costs are estimated based upon unit-area of treatment.
- Low cost range is based upon average stormwater retrofit costs plus 30% contingency per Puget Sound Stormwater Retrofit Cost Estimate (Puget Sound Partnership 2010).
- High cost range is based upon 1.5 times the estimated low cost range.

4.2 Funding Opportunities

Potential funding sources for proposed restoration alternatives would include restoration funding, recreation funding, stormwater improvement funding, and climate change adaptation funding. Potential Washington State Recreation and Conservation Office (RCO) grant funding opportunities for local agency (City, Port, or Tribe) restoration and recreation activities are summarized in Table 12.

Table 12. Potential grant funding opportunties through RCO.

Grant Program	Frequency	Match Required
Aquatic Land Enhancement Account (ALEA)	Even-numbered years	Yes. 50% min.
Estuary and Salmon Restoration Program (ESRP)	Annually	Yes. 33% min.
Land and Water Conservation Fund (LWCF)	Even-numbered years	Yes. 50% min.
Marine Shoreline Protection (MSP)	Typically even-numbered years	Yes. 50% min.
Puget Sound Acquisition and Restoration Fund (PSAR)	Annually	Yes. 15% min, except for design.
Recreation Trail Program (RTP)	Even-numbered years	Yes. 20% min.
Washington Wildlife and Recreation Program (WWRP)	Even-numbered years	Yes. 50% min.

4.3 Risks and Unknowns

This assessment and conceptual restoration concept development was conducted primarily at the desktop level based upon readily available existing information. To quantify unknowns and potential risks associated with the developed concepts, a risk register table was created and is provided as Appendix G. The table summarizes potential risks/unknowns and recommendations to address these in subsequent stages of analysis and design.

5 CONCLUSIONS

The shorelines and intertidal areas within West Bay have been heavily altered and ample opportunity exists for restoration. Analysis shows that existing ecological and physical processes have been significantly impacted compared to historical conditions. Critical issues include disconnection of riparian forest and freshwater habitats from the bay, conversion of shallow intertidal mudflats into navigable waters and uplands, loss of sediment and large wood inputs from bluffs and rivers/creeks, degradation of water quality by physical modification and untreated stormwater inputs, and degradation of intertidal areas by armoring, fill placement, and contamination.

The study area, which is characterized by a wide range of land uses and shoreline conditions, was partitioned into reaches based primarily on consideration of site physical characteristics and property ownership. Each reach presents unique opportunities for restoration based upon site conditions, site constraints and physical processes. However, limited restoration opportunities were identified in the northernmost reaches (Marina and Logyard) due to current degraded condition and land use.

The developed restoration strategy for West Bay primarily revolves around reconnection of riparian and intertidal habitats, restoration of intertidal areas through removal of historical fill, placement of natural beach substrates at appropriate slopes and elevations, creation of salt marsh in the upper intertidal zone, restoring pocket estuaries of small creeks, and limited freshwater marsh and upland meadow creation. Sediment and soil contamination is present throughout West Bay, and any potential restoration efforts must further consider and evaluate potential remediation efforts required to implement effective restoration. However, restoration efforts such as beach creation and creek daylighting may provide efficiencies for cleanup of soils and sediment needing remediation.

Taken as a whole, the suite of potential restoration projects and alternatives provide the opportunity to enhance disjointed pockets of existing functional habitat within West Bay through reconnection with adjacent sites and continuity of ecological functions from the lagoon to the West Bay Marina. Connectivity between restoration sites promotes improved natural coastal geomorphic processes and resiliency compared to piecemeal efforts at isolated sights.

In the Lagoon reach, it appears that Lagoon Alternative 4 provides the largest overall habitat improvement. This results primarily from removal of the berm and the resulting expected improvements in tidal circulation and sediment processes within the lagoon. Lagoon Alternative 1 provides relatively little value from a habitat perspective.

Fill beneath the 5th Ave. Bridge constrains tidal and freshwater flow from Capitol Lake to the north and east of the lagoon. It is expected that the constraining fill at the existing bridges would continue to constrain flows to the lagoon in the event that the Deschutes estuary were restored. The available modeling suggests that the lagoon alternative with the highest circulation and exchange for the existing condition would likely provide the same level of benefit for the restored estuary condition. Regardless of the alternative selected for the Lagoon, coordination of restoration and recreation elements during permitting, design and construction will be critical. Coupling restoration and recreation improvements provides an opportunity to leverage multiple funding sources. Additionally, construction access to the lagoon area will require a comprehensive constructability approach.

West Bay Park South Alternative 2 presents a unique opportunity to transition and provide connectivity between freshwater wetlands and salt marsh in the adjacent Lagoon area. This would create a diverse and resilient network of habitat types in the south part of the study area.

Due to diverse property ownership and land use in West Bay, implementation of holistic restoration that provides habitat connectivity and synergy requires private participation. Restoration concepts that include restored beaches, public access, and recreational amenities provide incentives and opportunity for private partnership and more rapid implementation as properties are re-developed.

Based upon limited field investigation and review of available data, the study identified numerous stormwater outfalls within the study area that discharge untreated into Budd Inlet, carrying pollutants detrimental to species utilizing the nearshore environment. The Conceptual Stormwater Analysis (see Appendix C) provides detailed evaluation of stormwater retrofit technologies and techniques that can be applied throughout West Bay, and identifies retrofit opportunities at stormwater outfalls, upland areas within the contributing basins, and reaches along West Bay Drive.

Many of the identified outfalls have constraints such as terrain slope, discharge rates, and available area for treatment, or other factors that make end-of-pipe retrofit challenging. Additionally, the scale of retrofits needed to treat stormwater flow rates from the large tributary basins along West Bay makes end-of-pipe retrofits impractical to implement. However, the study did identify a small number of outfalls with smaller drainages where end-of-pipe retrofits are feasible.

Upstream stormwater retrofits offer more feasible projects to treat sub-basins within larger basins that discharge into West Bay, particularly for Garfield Creek and Schneider Creek. Upstream retrofits can be scaled or replicated to achieve additional water quality benefits within other areas of these basins as feasible. Collection and treatment of stormwater from portions of West Bay Drive also provides retrofit opportunities throughout the project area. These opportunities focus on treating concentrated stormwater at the source locations within the watershed, as opposed to treating comingled stormwater and creek flows near the shoreline.

The identified alternative concepts may be useful for environmental mitigation planning in West Bay for public and private interests. The semi-quantitative analysis herein would require additional refinement and more detailed analysis at the project scale and coordination with resource agencies. The developed concepts also promote increased public use of the shoreline of West Bay through both improved access and restored shoreline areas.

Creating intertidal beach and marsh habitats connected with functional riparian upland areas is compatible with resilient design for sea level rise adaptation in West Bay. Such features provide a natural berm buffer that is adaptable and can be maintained through natural processes and nourishment augmentation rather than hard armoring. Incorporating sea level rise adaptation strategies within the restoration strategy for West Bay provides additional funding opportunities.

Due to the relatively disjointed nature of existing habitat along the shoreline implementation of the various projects can be accomplished independently and or in phases. Where recreation elements can be incorporated appropriately into the restoration designs, additional sources of public funding may be available for design and construction.

The estimated cost for the restoration of West Bay ranges from $24.7 million to $33 million, depending upon the alternatives selected for each shoreline area. Similarly, conceptual public access and recreation improvement costs range from about $3.8 million to $11 million. Finally, stormwater improvements in watersheds associated with the study area may range from $11 million to $16 million. Implementation and cost sharing could occur as part of restoration, mitigation, capital improvements, or private development activities along the shorelines of West Bay. Multiple grant funding sources may be available to help implement West Bay restoration. The identified restoration, recreation, and stormwater management opportunities broaden the number of potential funding sources.

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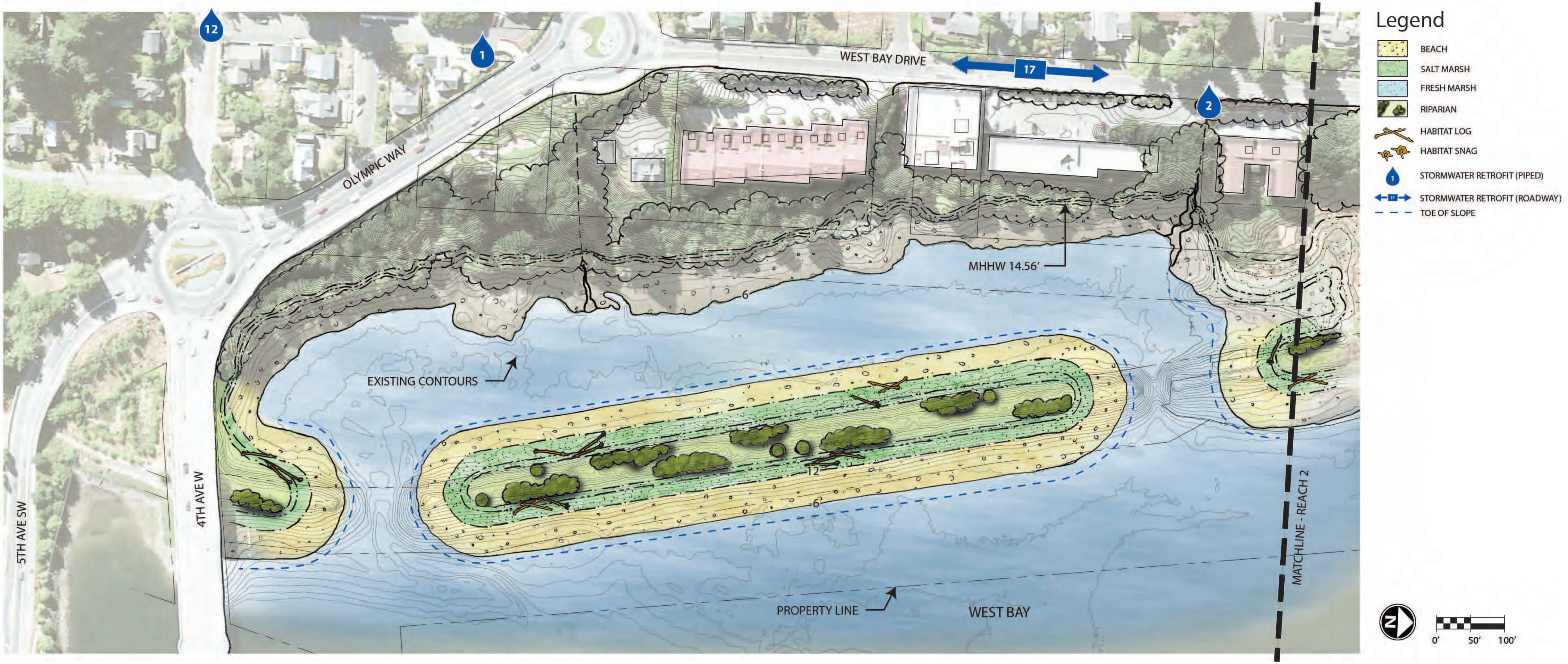
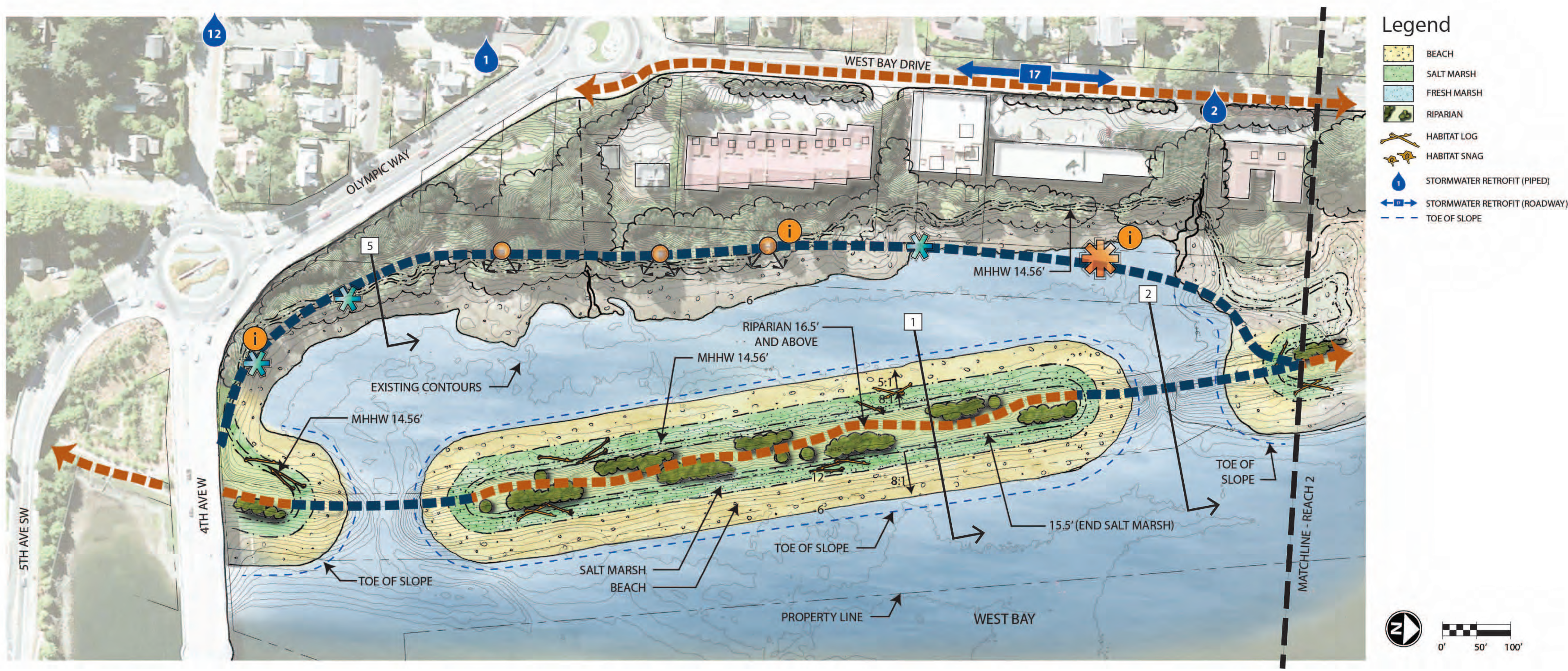
APPENDIX A

Illustrative Graphic Plans and Sections



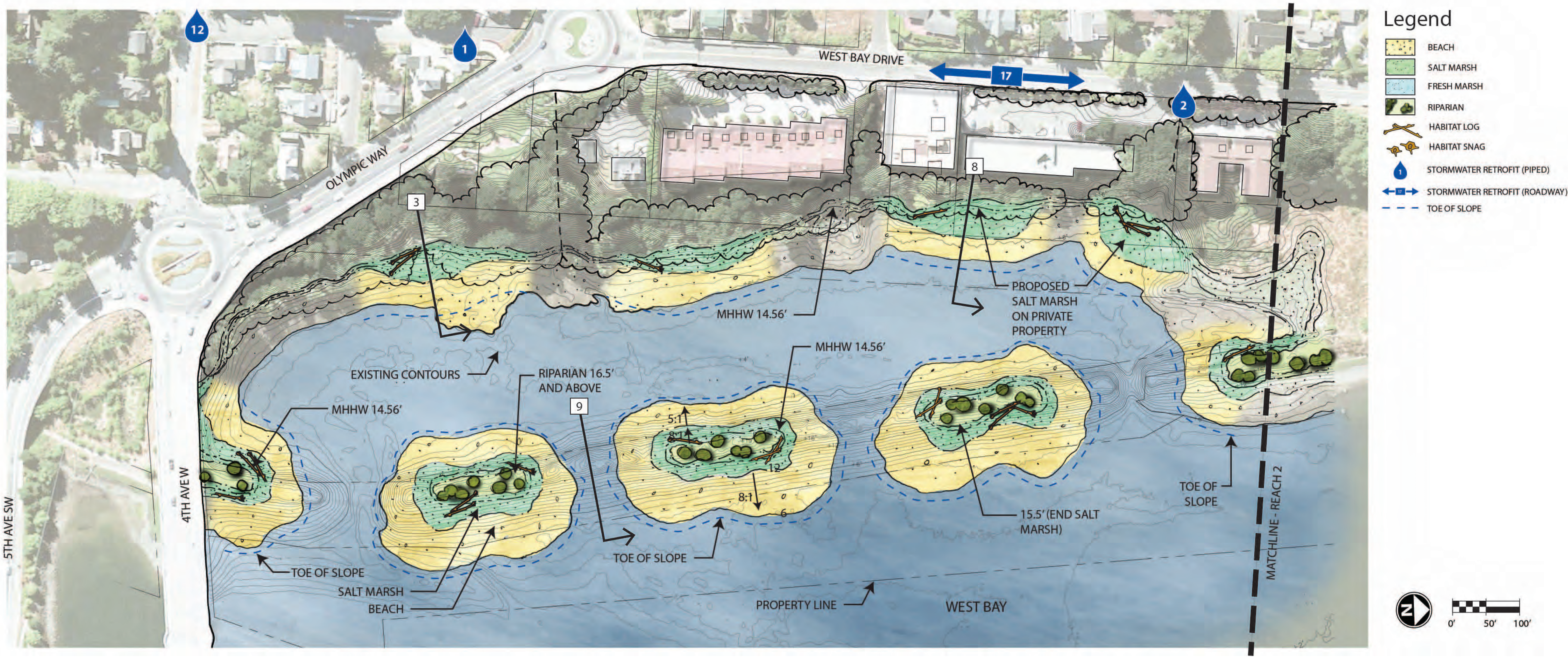
Alternative 1 - Restoration Options

Reach 1 - Lagoon



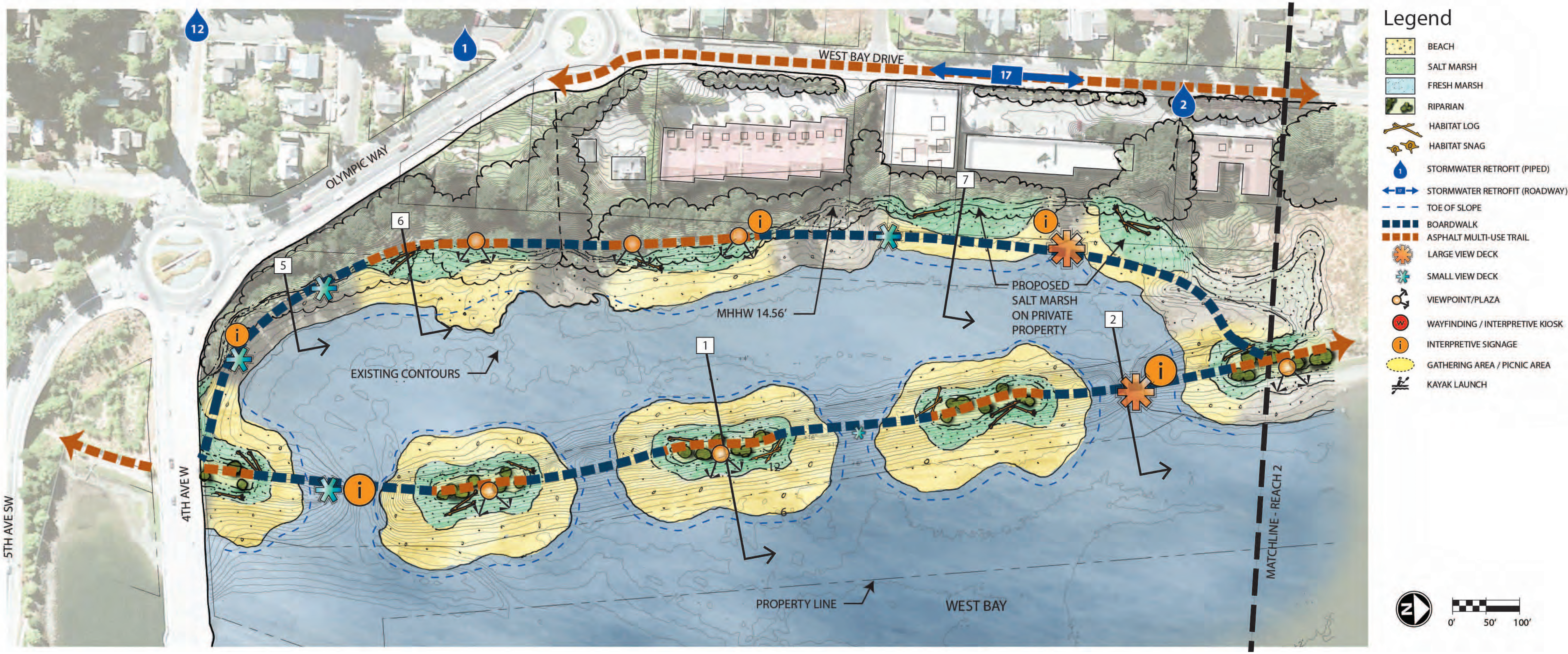
Alternative 1 - Recreation Options

Reach 1 - Lagoon



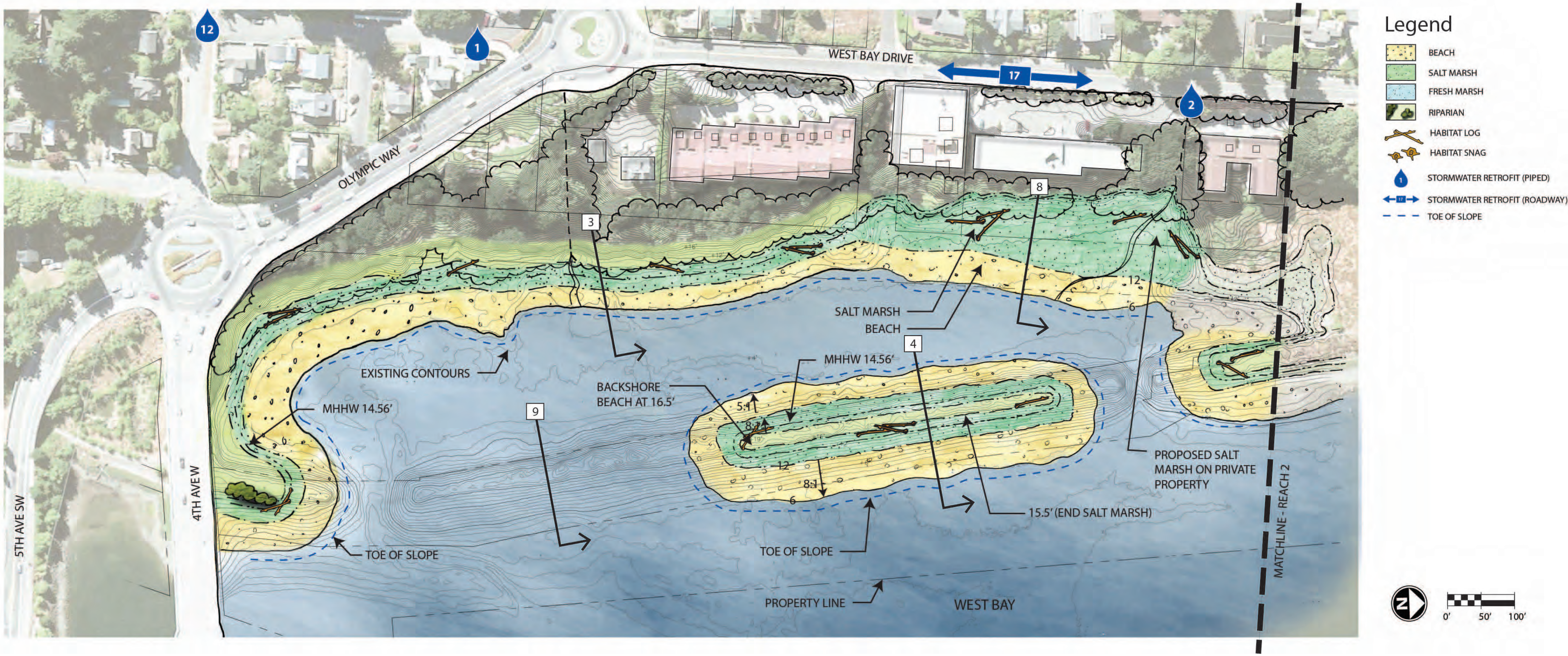
Alternative 2 - Restoration Options

Reach 1 - Lagoon



Alternative 2 - Recreation Options

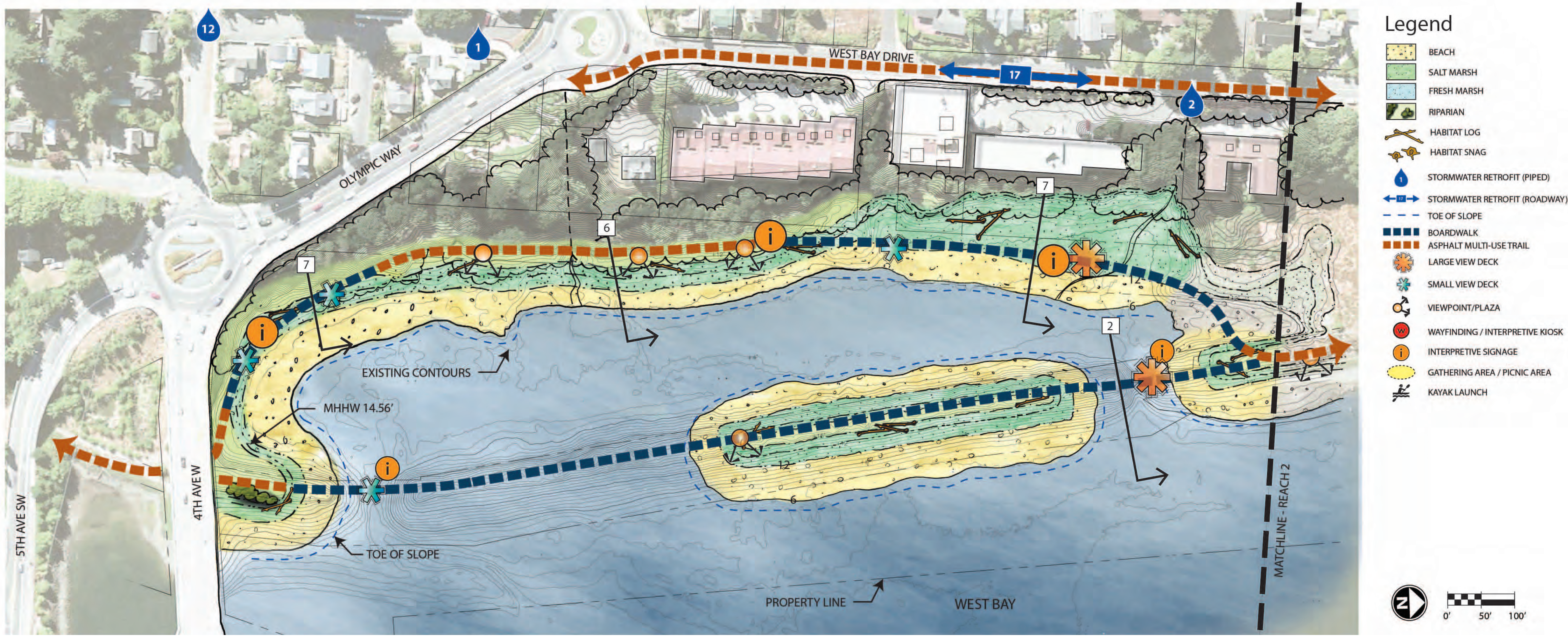
Reach 1 - Lagoon



Alternative 3 - Restoration Options

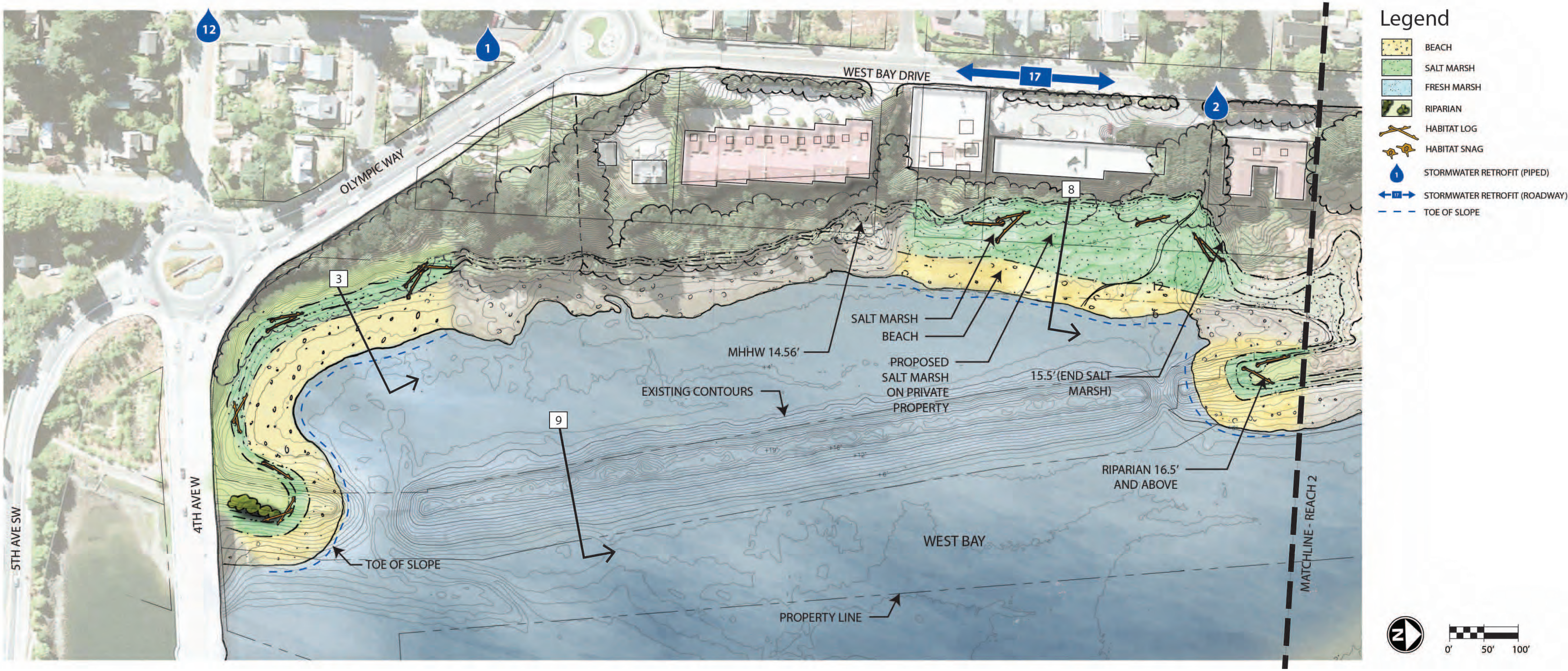
Reach 1 - Lagoon

j.a. brennan associates PLLC



Alternative 3 - Recreation Options

Reach 1 - Lagoon



Alternative 4 - Restoration Options

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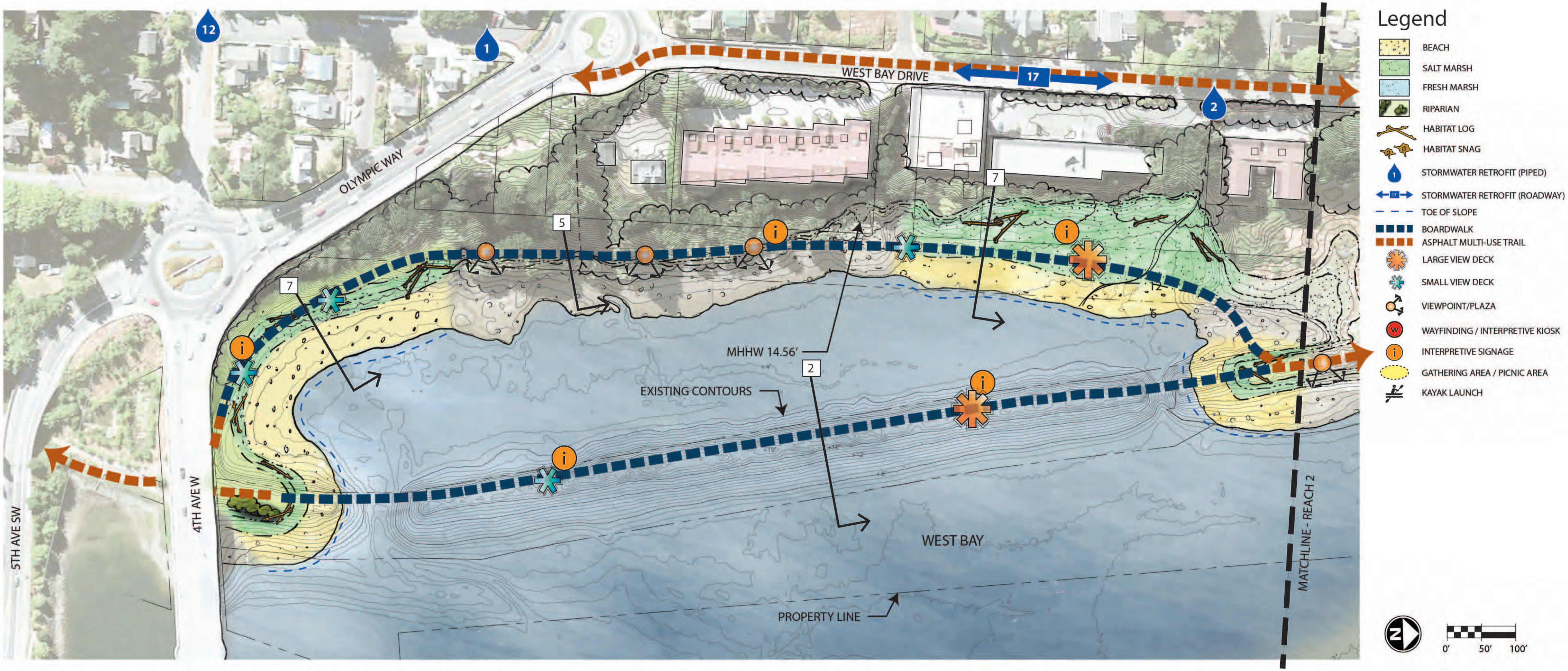


Alternative 4- Recreation Options

Reach 1 - Lagoon

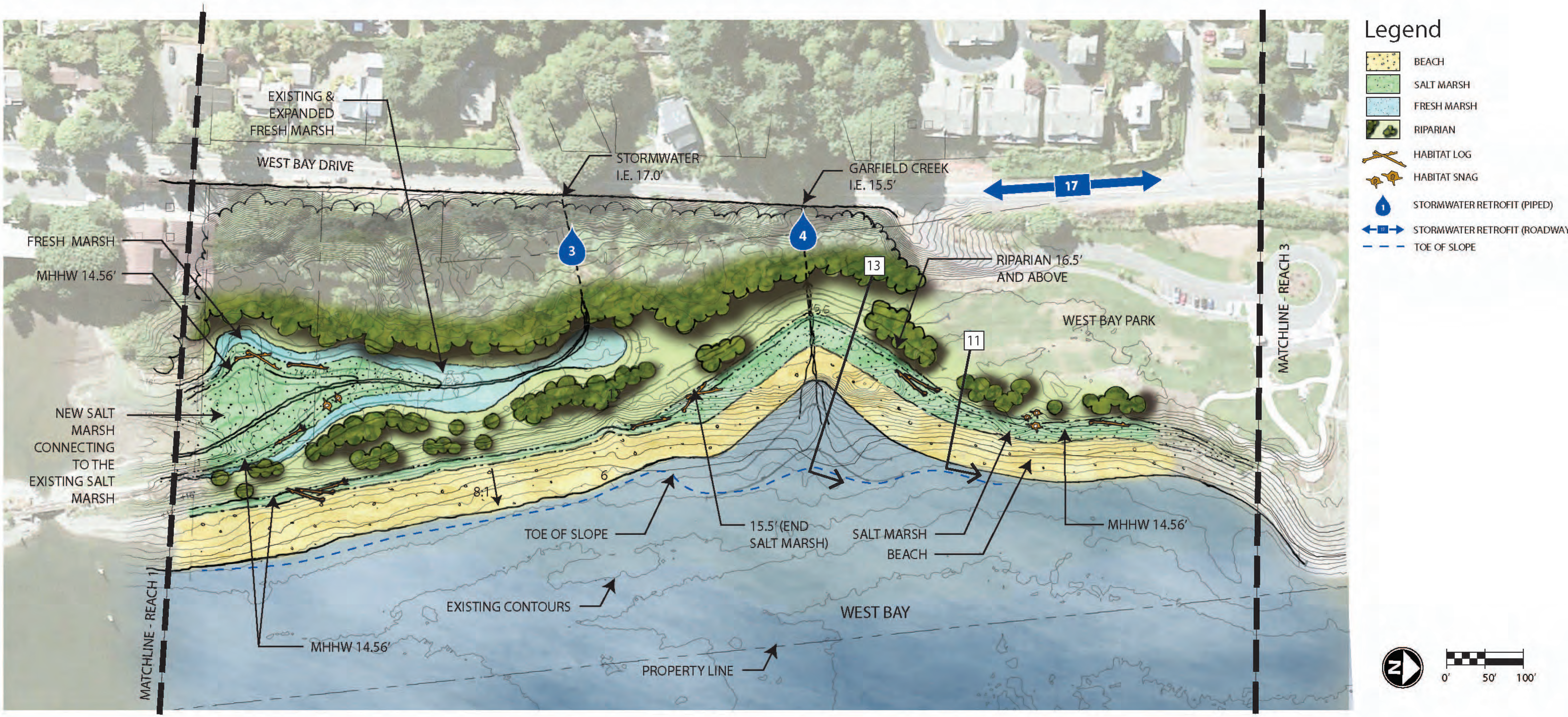
Alternative 1 - Restoration Options

Reach 2 - West Bay Park South

j.a. brennan associates PLLC

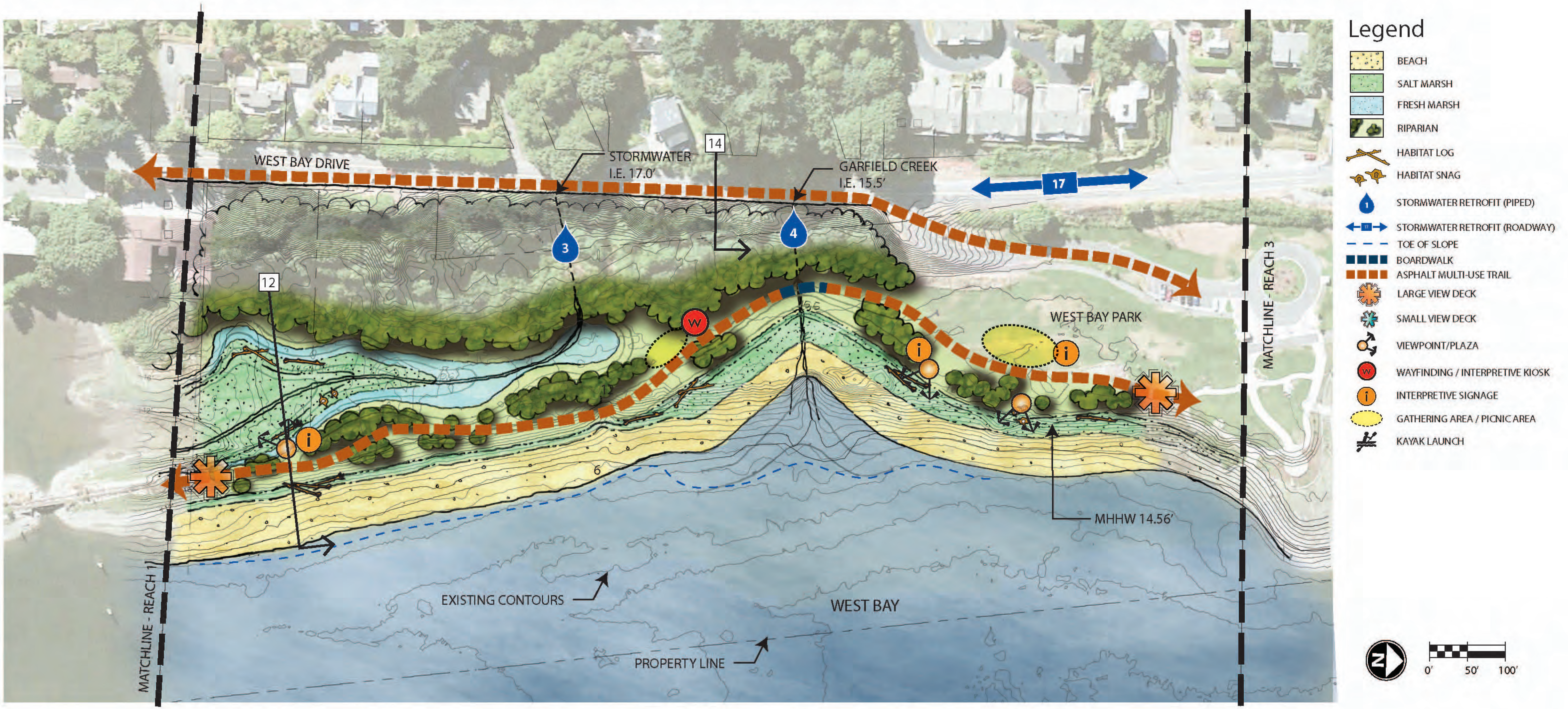
Alternative 1 - Recreation Options

Reach 2 - West Bay Park South



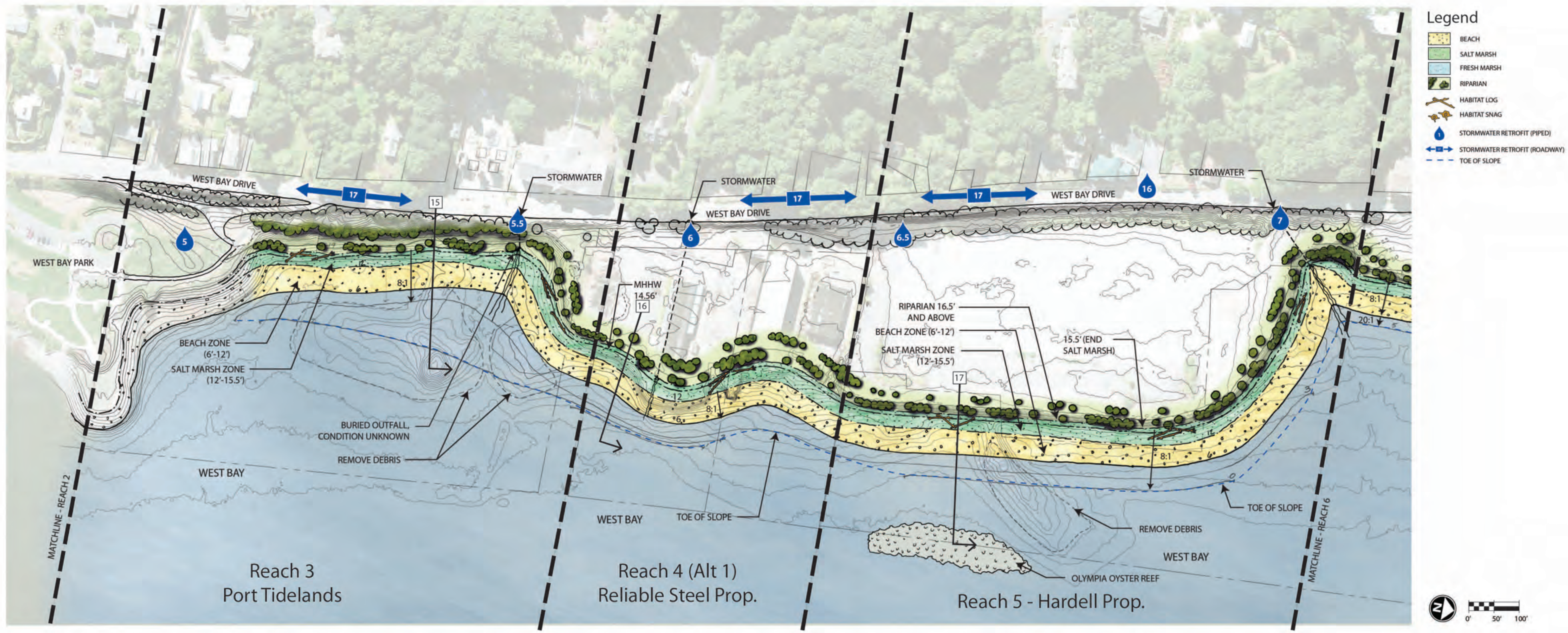
Alternative 2 - Restoration Options

Reach 2 - West Bay Park South



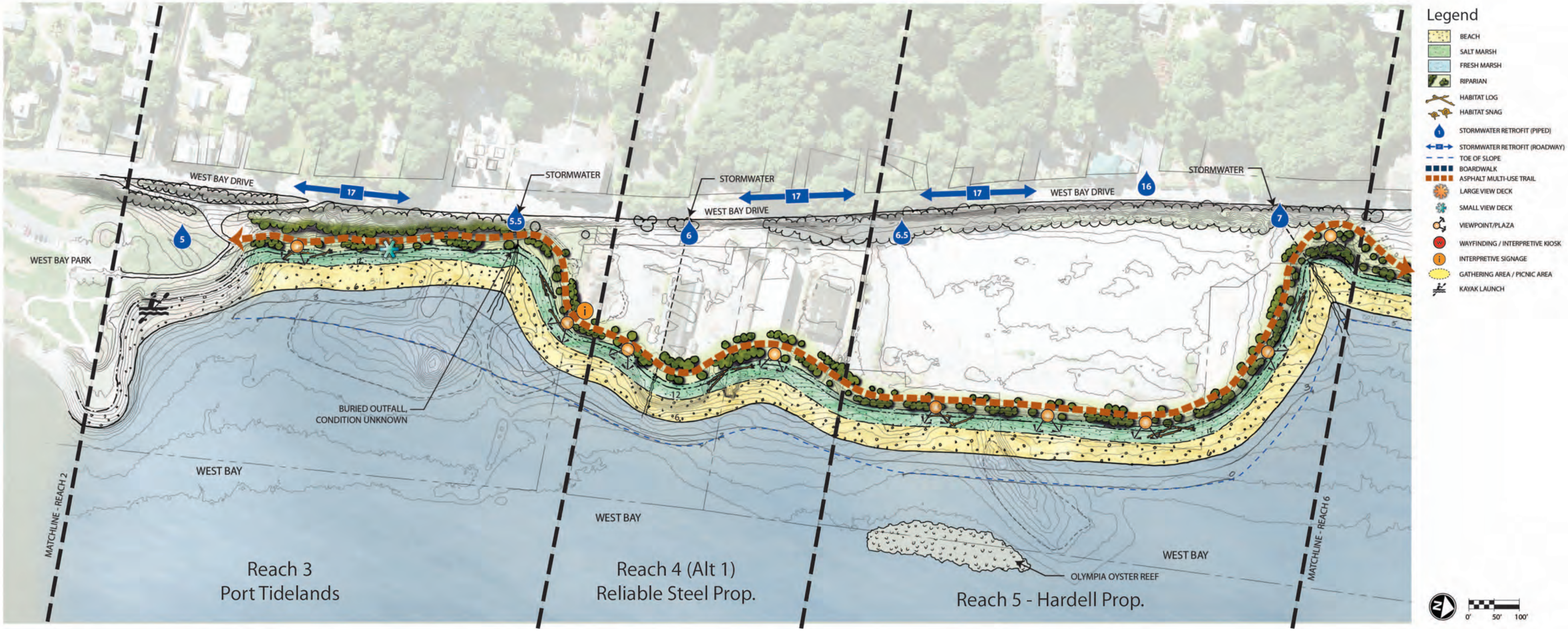
Alternative 2 - Recreation Options

Reach 2 - West Bay Park South



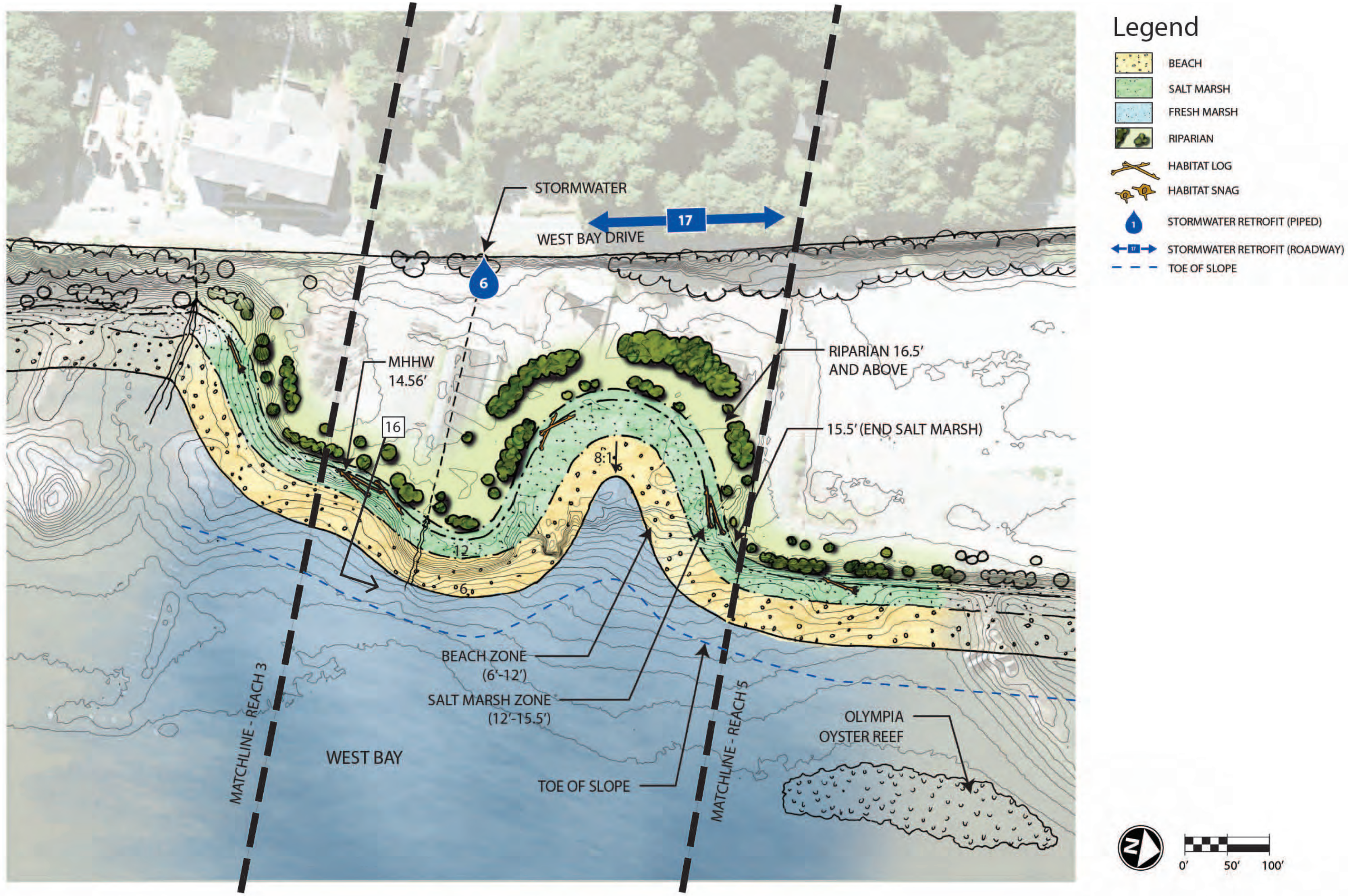
Restoration Options

Reaches 3, 4, 5



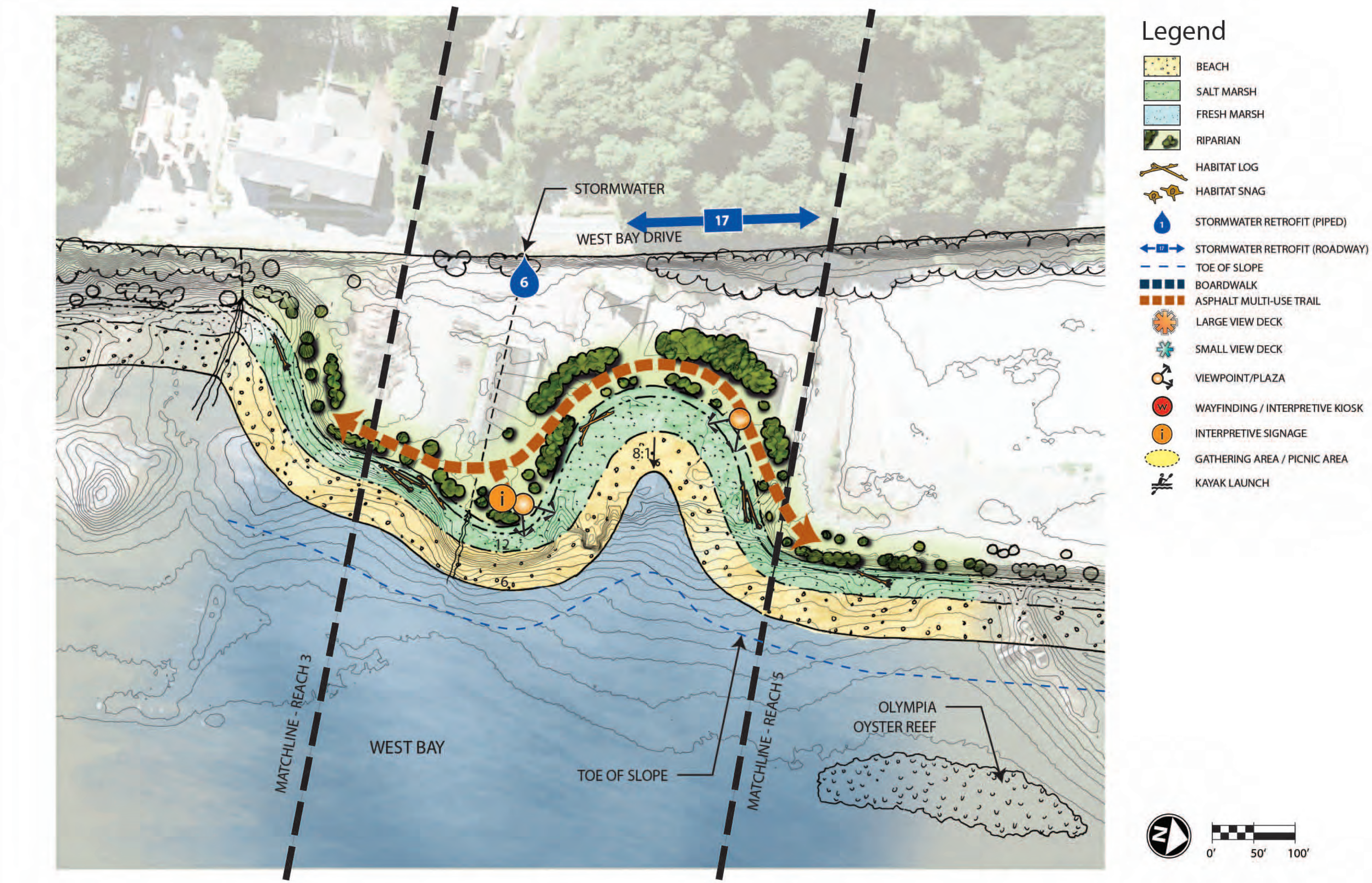
Recreation Options

Reaches 3, 4, 5



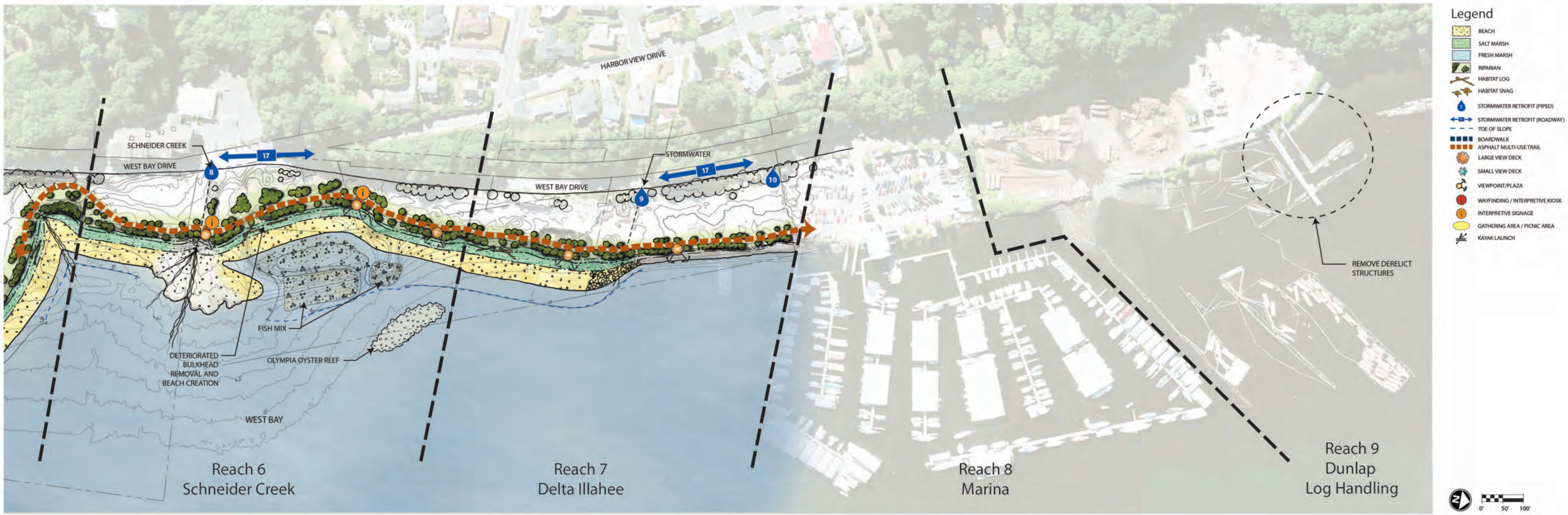
Alternative 2 - Restoration Options

Reach 4 - Reliable Steel Property



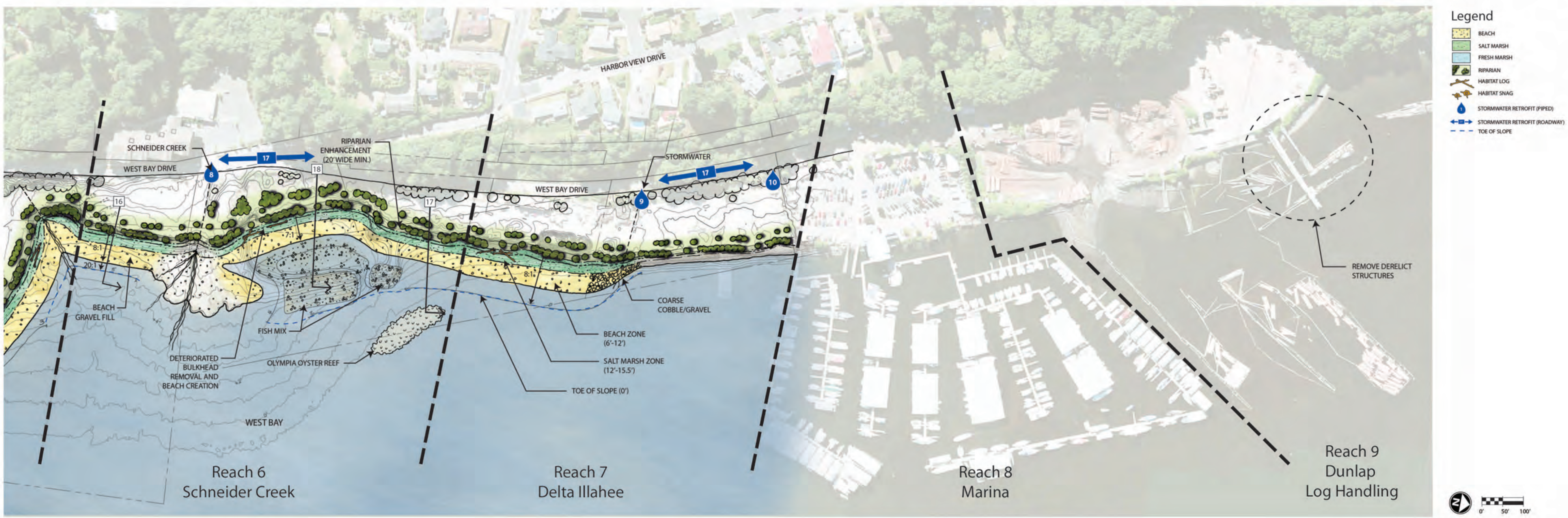
Alternative 2 - Recreation Options

Reach 4 - Reliable Steel Property



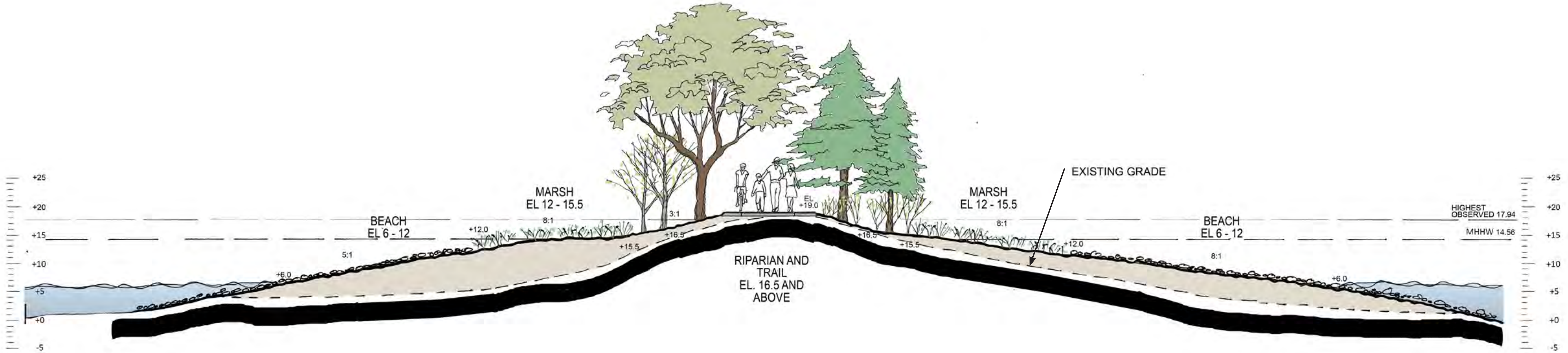
Recreation Options

Reaches 6, 7, 8, 9

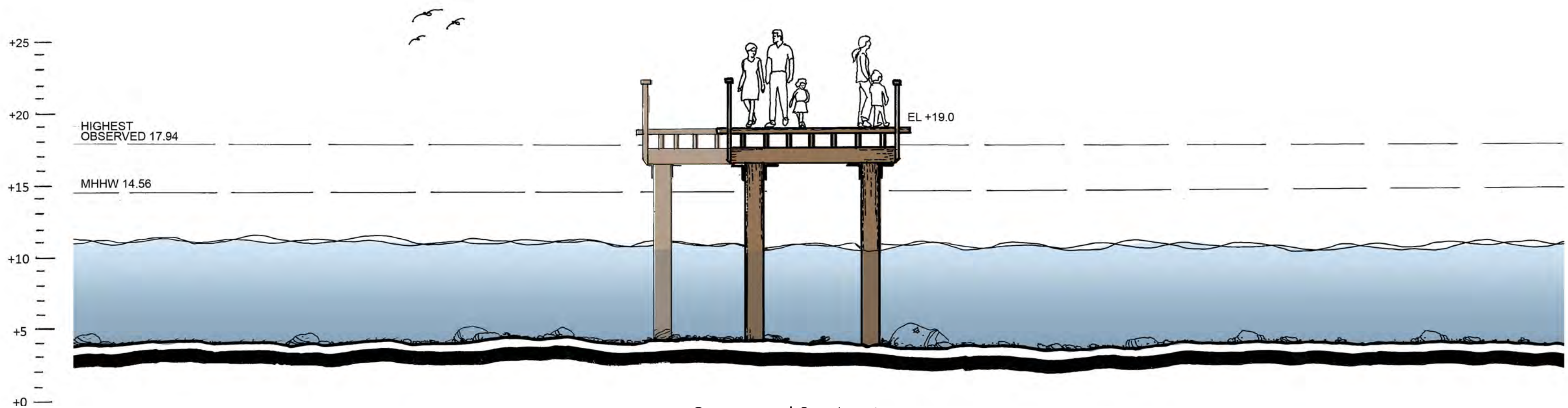


Restoration Options

Reaches 6, 7, 8, 9



Conceptual Section 1



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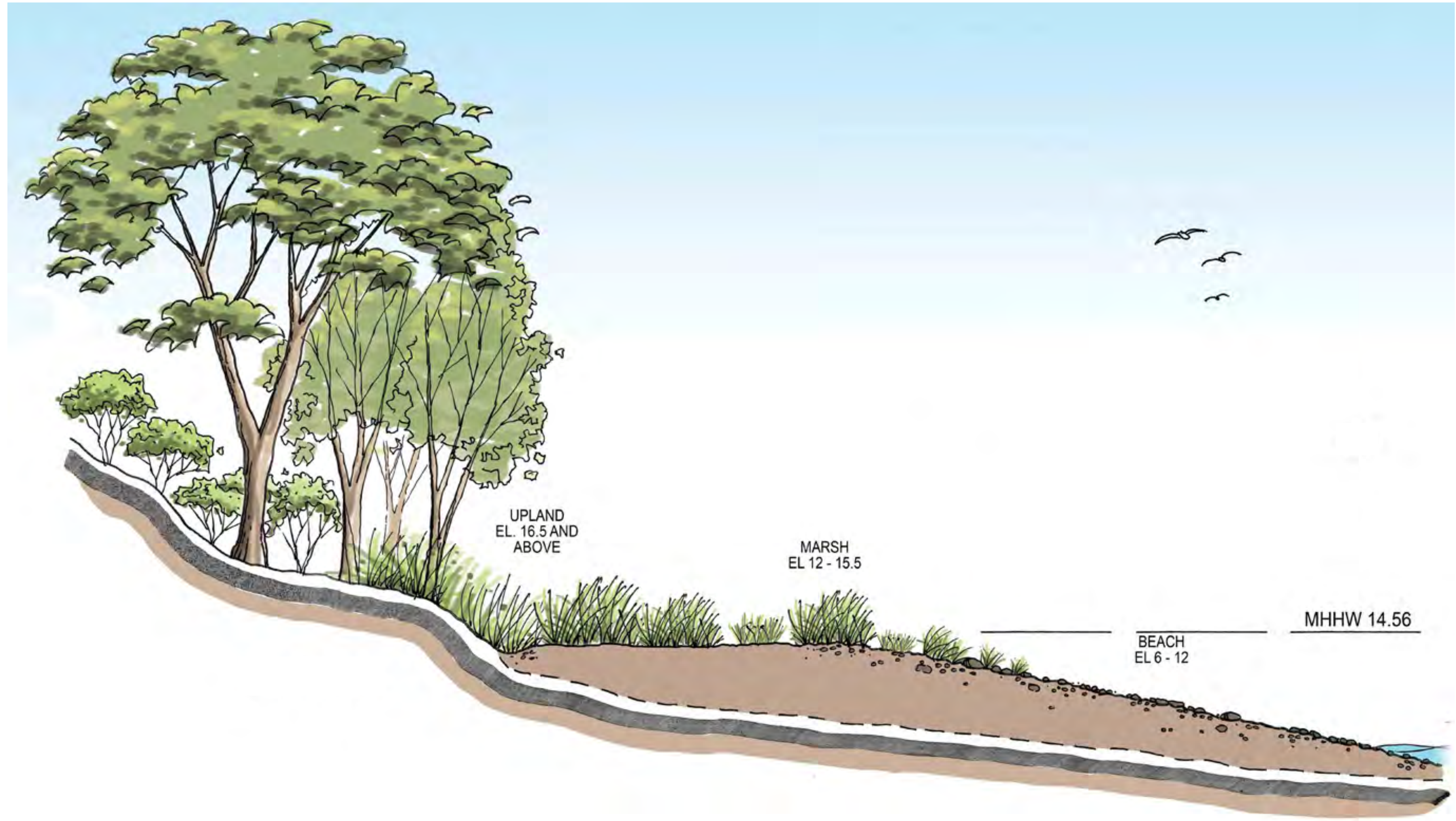

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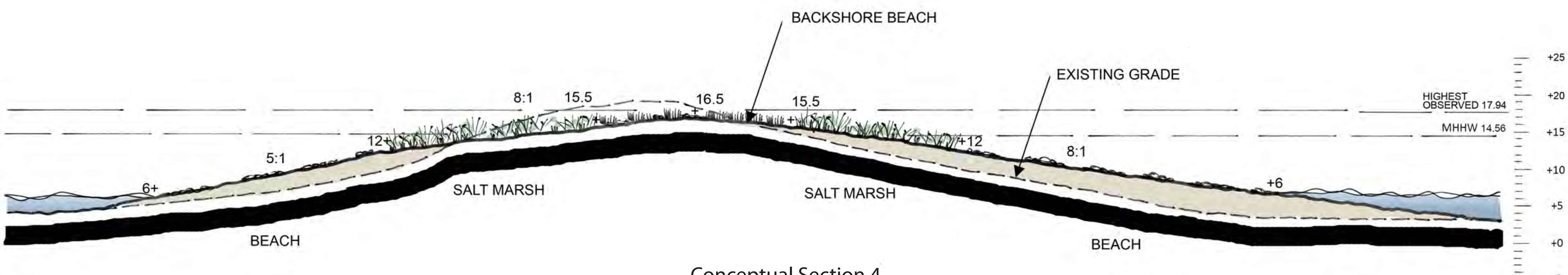

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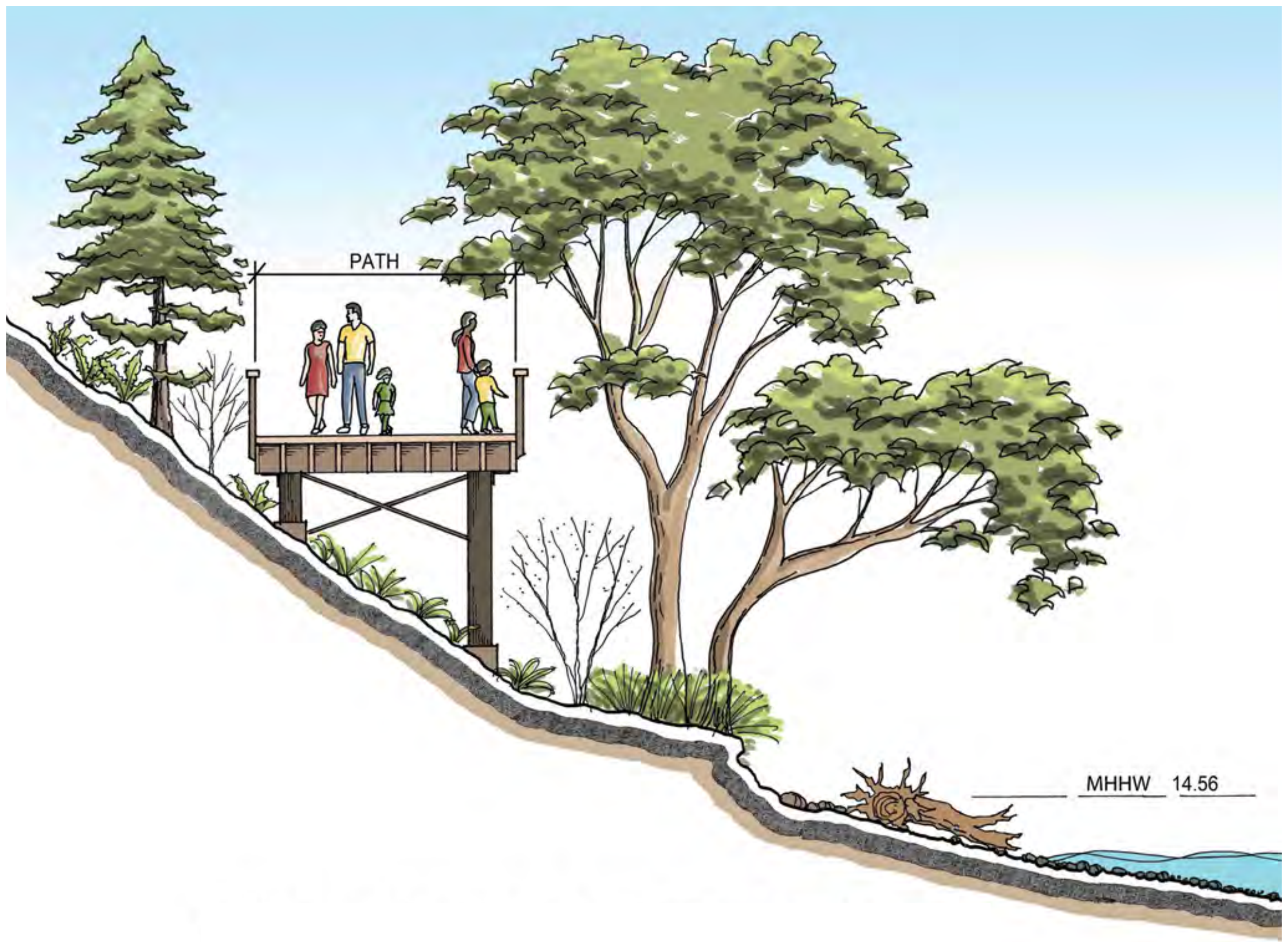

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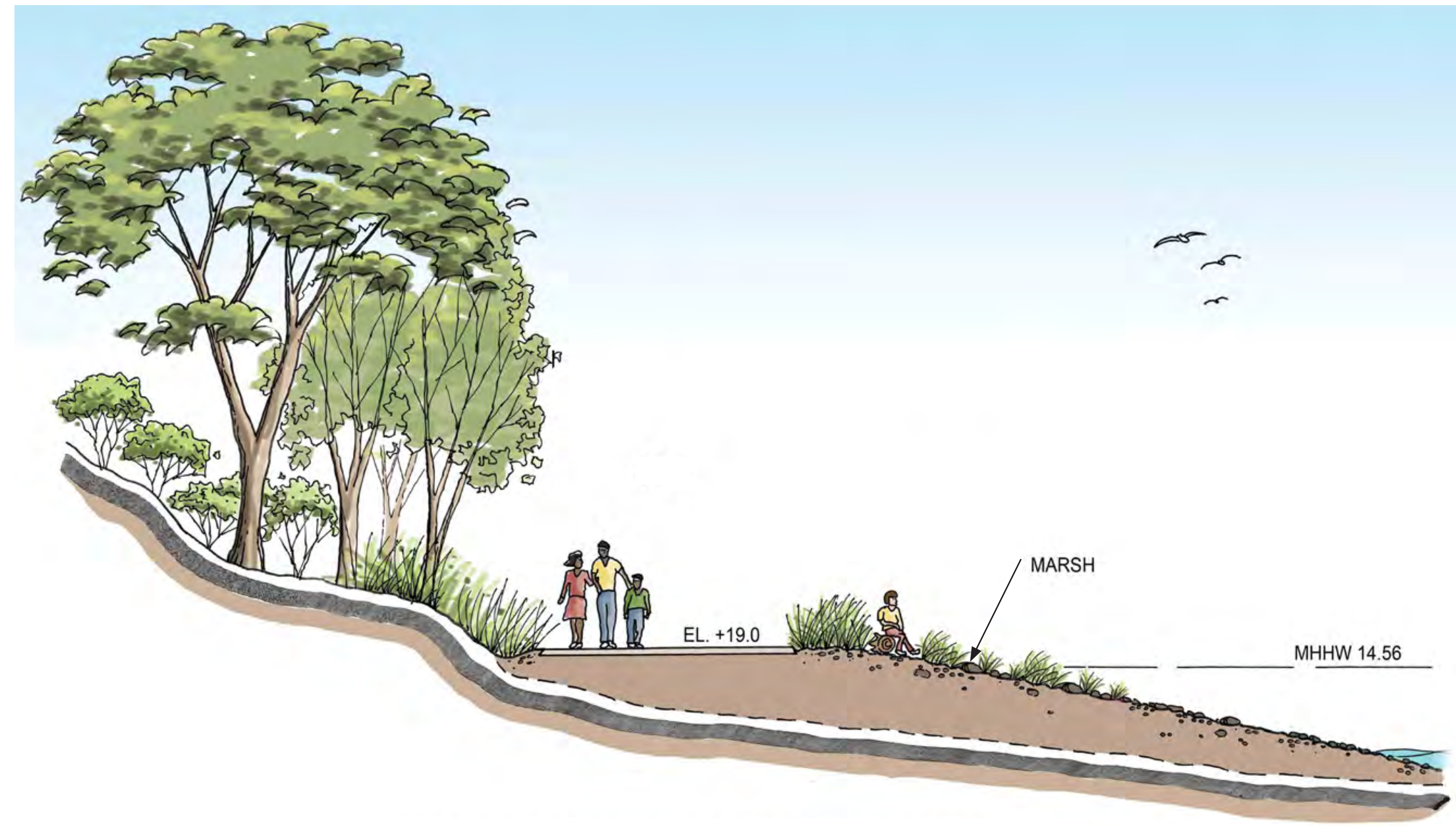

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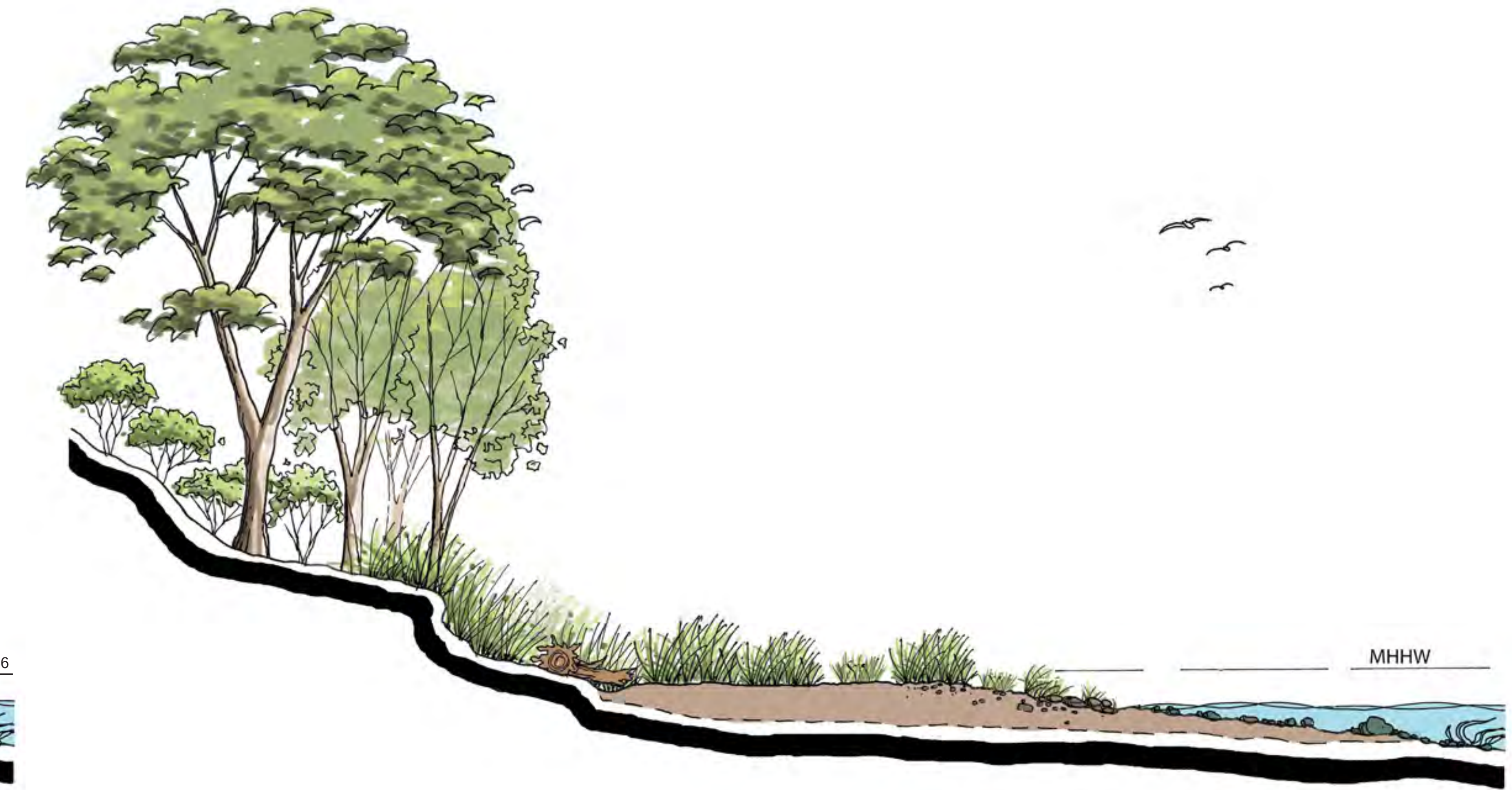
Conceptual Section 7



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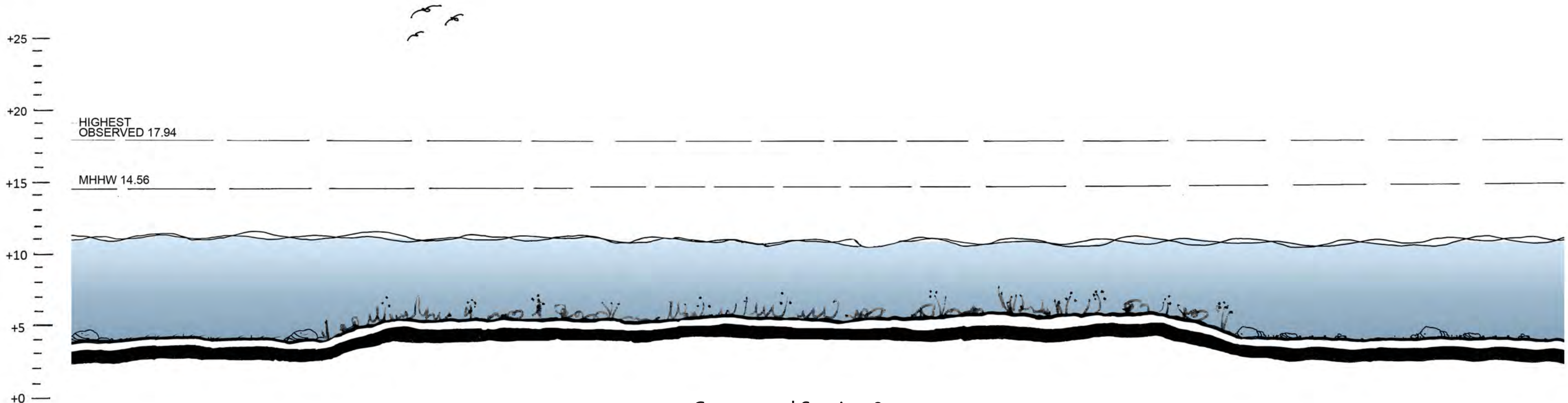

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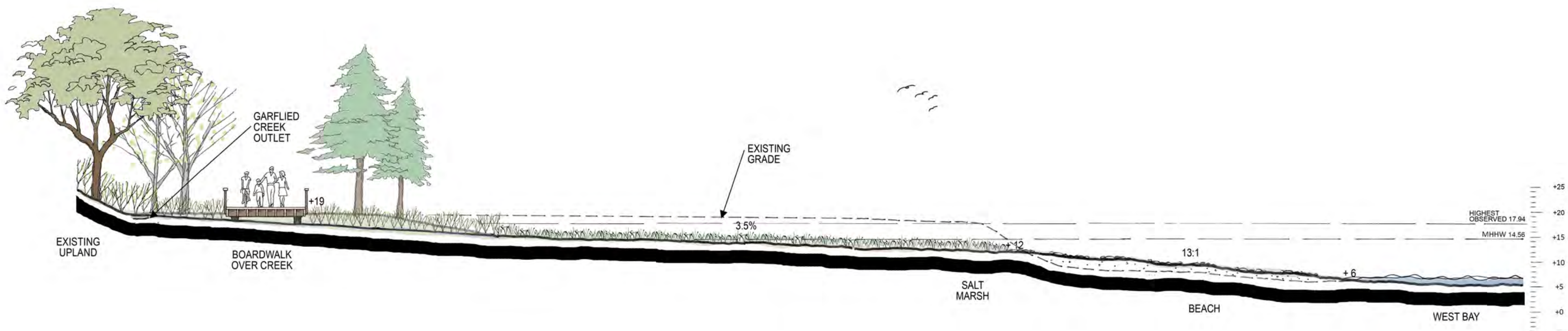

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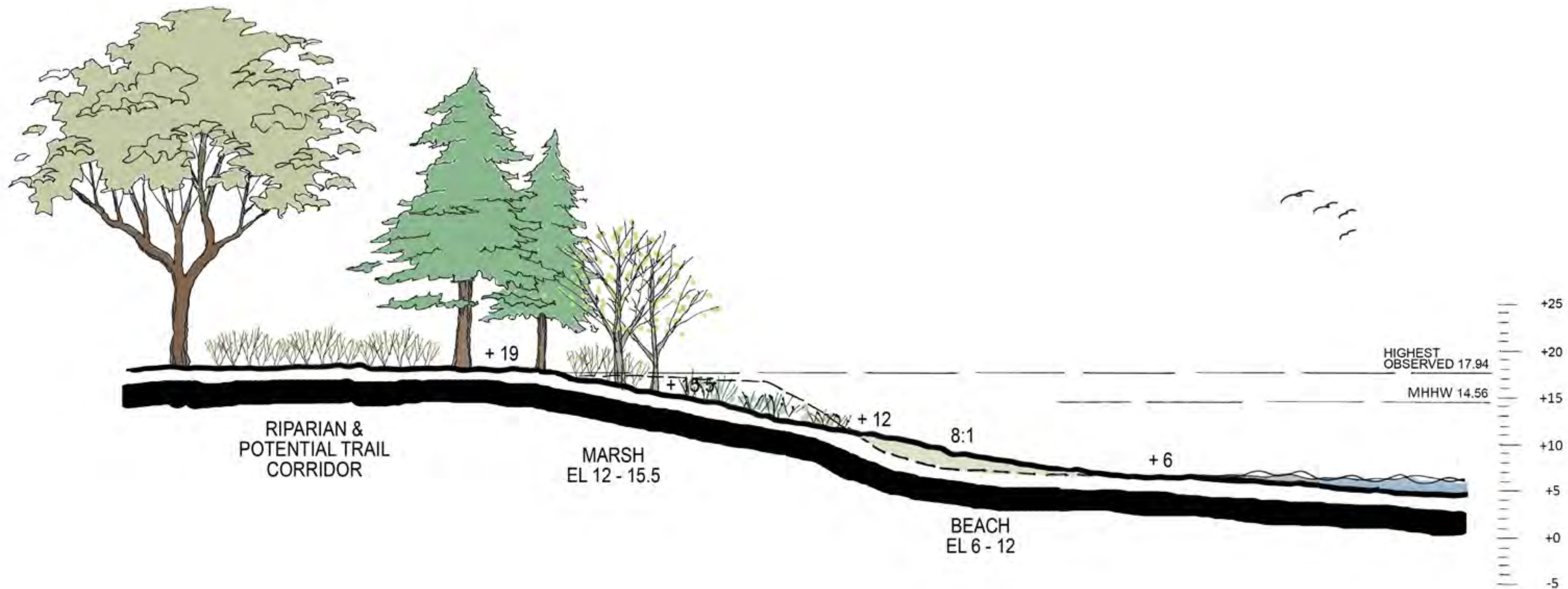

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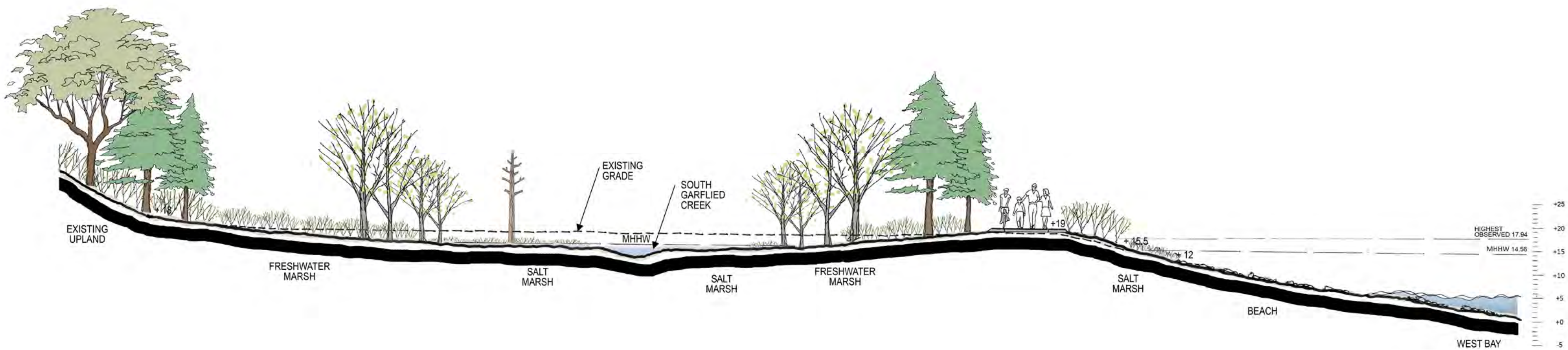

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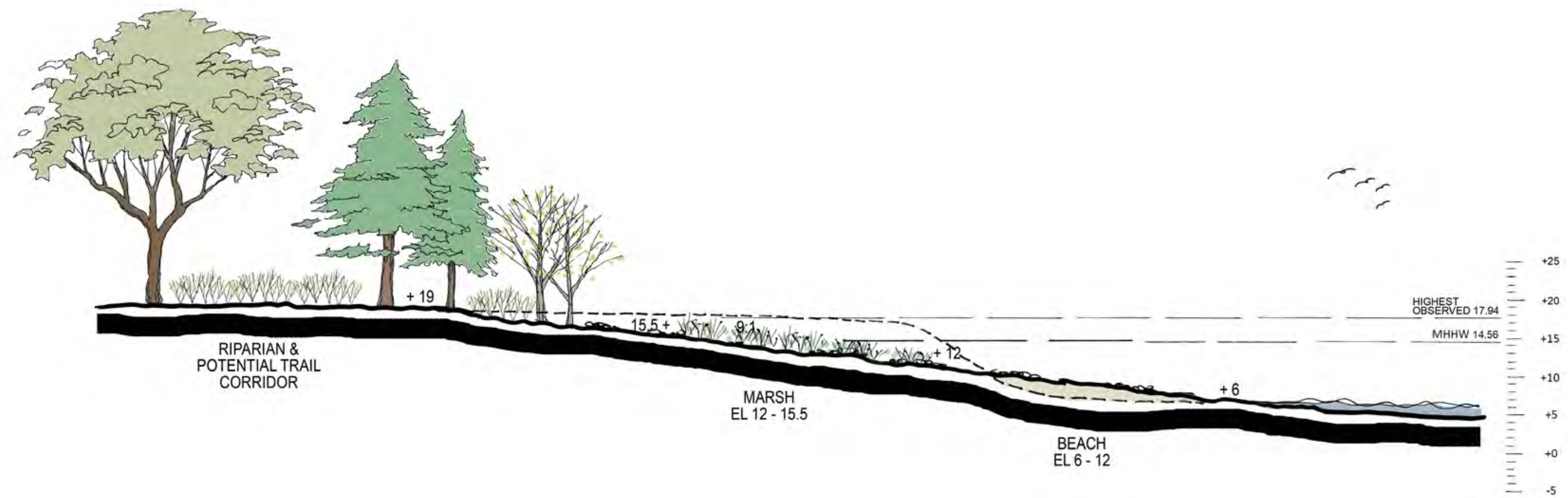

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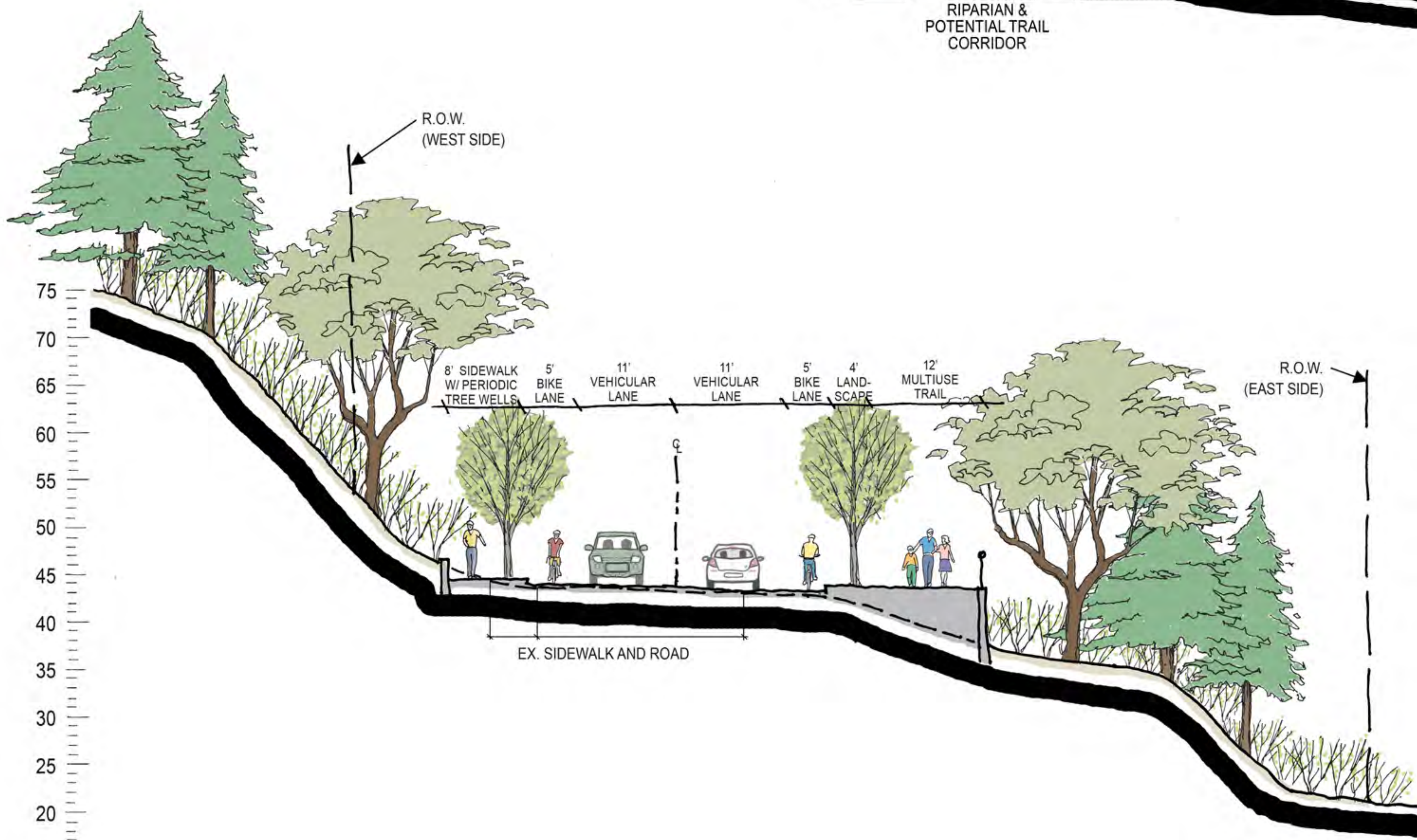
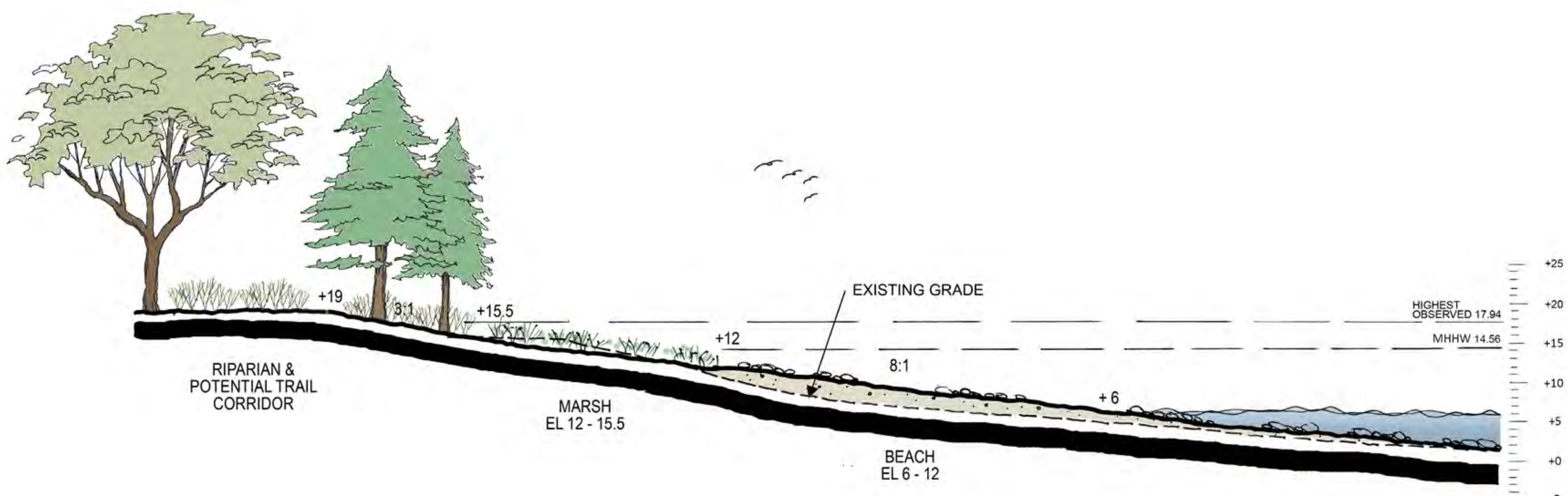


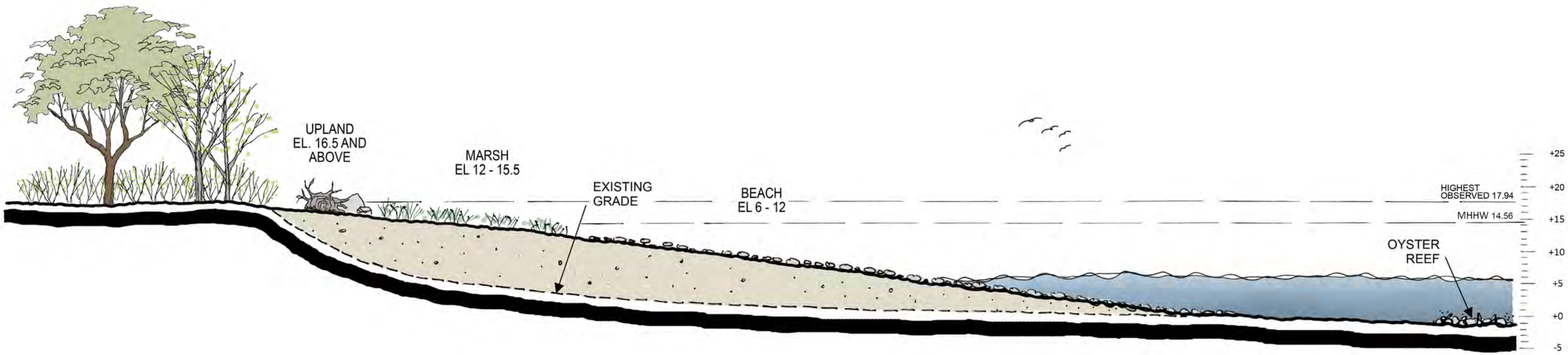
Conceptual Section 14

Conceptual Section 15



Conceptual Section 16

j.a. brennan associates PLLC



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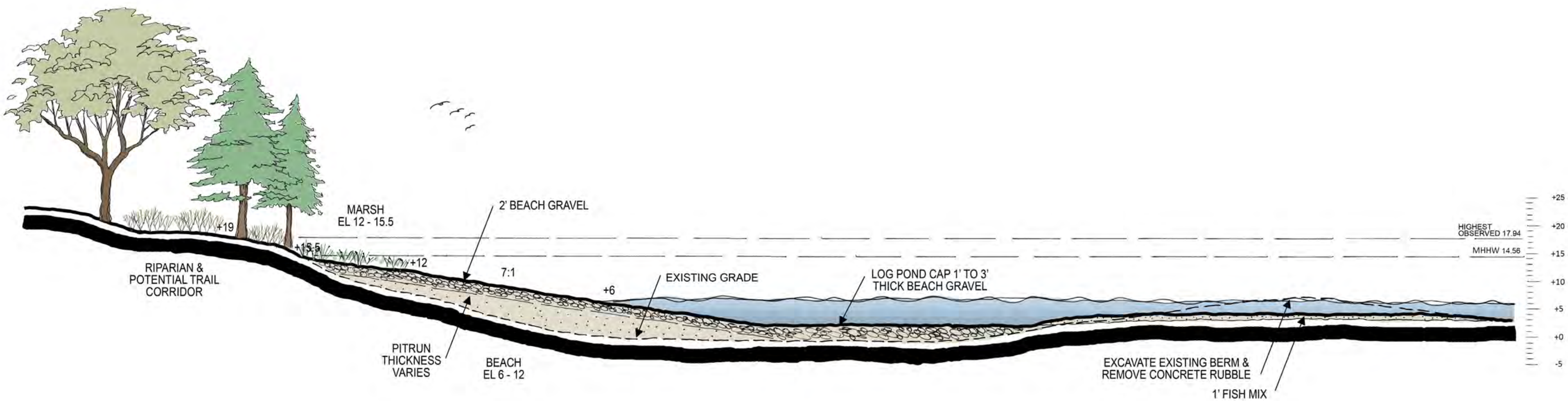


Conceptual Section 18

APPENDIX B

Historic and Existing Functions Analysis Memo

GeoEngineers

Memorandum

1101 South Fawcett Avenue, Suite 200, Tacoma, WA 98402, Telephone: (253) 383-4940, Fax: (253) 383-4923 www.geoengineers.com

To:	Jesse Barham, Andy Haub, and David Hannah – City of Olympia; Scott Steltzner and Jeff Dickison – Squaxin Island Tribe; Alex Smith– Port of Olympia
From:	Joe Callaghan and Shawn Mahugh – GeoEngineers; Joel Darnell, PE – Coast & Harbor Engineering; Tracey Belding, PE – Davido Consulting Group
Date:	October 16, 2015
File:	0415-066-00
Project Name:	West Bay Environmental Restoration Assessment
Subject:	Historic and Existing Functions Analysis Memorandum

INTRODUCTION

GeoEngineers biologists have prepared this Historic and Existing Functions Analysis Memorandum to document the results of our review of the historic habitat functions and physical processes within West Bay of Budd Inlet and the human actions that have altered the existing habitat functions within the Bay. This information will be used to support an ecosystem restoration approach for the West Bay Environmental Restoration Assessment Project. Analyses of the historic ecological processes will guide restoration efforts to restore or reestablish functioning habitat conditions in accordance with the project design criteria documented in the Criteria Development Memo (Coast & Harbor Engineering [CHE], 2015). The overall restoration goals identified in the Shoreline Restoration Plan appendix of the City of Olympia Shoreline Master Program (2012) are:

- Improve water quality in Budd Inlet and its tributaries,
- Improve natural sediment processes,
- Preserve and restore wildlife habitat, and
- Restore shorelines as opportunities for humans to connect with the natural environment.

The specific restoration objectives identified in City Plan (2012) for Budd Inlet include:

- Preserve and restore estuarine habitat for transition between fresh and saltwater environments,
- Preserve and restore subtidal and intertidal mudflats and salt marshes,
- Enable natural wave energy attenuation (remove or modify hard shoreline armoring),
- Improve sediment generation and transport (reconnect feeder bluffs to shoreline),
- Improve water quality (reduce or eliminate upland pollutant sources),
- Preserve and restore wildlife habitat,
- Increase sources and delivery of large woody debris (LWD).

The City's Shoreline Restoration Plan is one of several regional plans that identify restoration goals for Budd Inlet. Other plans include Puget Sound Partnership's 2014/2015 Action Agenda and the Water Resources Inventory Area (WRIA) 13 Salmon Habitat and Restoration Plan. Currently, the South Sound Ecosystem

Recovery Strategy is under development and will objectively assess which pressures and recovery target are most applicable to the South Puget Sound (PSP 2014).

METHODS

This memorandum has been prepared using information obtained from the City of Olympia, the Port of Olympia, other available documents, and through interpretation of photographs, topographic sheets (T-sheets), and historic charts and maps, as described below.

Literature Review

The following documents were reviewed for this assessment:

- *Shoreline Master Program – Appendix A: Restoration Plan*. City of Olympia (2012)
- *Budd Inlet Restoration Partnership Phase II Report.* Ross and Associates Environmental Consulting, LTD (RAEC) (2011)
- *The 2014/2015 Action Agenda for Puget Sound*. Puget Sound Partnership (PSP) (2014)
- *Salmon Habitat and Restoration Plan for Water Resources Inventory Area 13, Deschutes.* Thurston County Conservation District. (2005)
- *Conceptual Approach to Prioritization for Restoration and Conservation of Budd Inlet*. Squaxin Island Tribe Natural Resources (2010)
- *A Short History of Budd Inlet.* Thurston County Historic Commission (1992)
- *Deschutes Estuary Feasibility Study: Hydrodynamics and Sediment Transport Modeling*. United States Geologic Survey (USGS) (2006)
- *Coastal Atlas Map.* https://fortress.wa.gov/ecy/coastalatlas/tools/Map.aspx. Washington State Department of Ecology (2015)
- *Cultural Resources Assessment of West Bay Park, Phase I.* Northwest Archeological Associates, Inc. (2008)
- *West Bay Habitat Assessment Final Report*. R. W. Morse Company (2002)
- *Final Investigation Report: Port of Olympia Budd Inlet Sediment Site*. Port of Olympia – prepared by Anchor QEA (2014)
- *Sediment Characterization Study: Budd Inlet, Olympia, WA.* Washington Department of Ecology – prepared by SAIC (2008)
- *City of Olympia Storm and Surface Water Plan, Appendix D*. City of Olympia (2003)
- *City of Olympia GIS Basin Analysis 2010.* City of Olympia (2010)
- *DRAFT Water Quality Improvement Report and Implementation Plan–Deschutes River, Percival Creek, and Budd Inlet Tributaries Temperature, Fecal Coliform Bacteria, Dissolved Oxygen, pH, and Fine Sediment Total Maximum Daily Load Report.* Washington Department of Ecology (2015)

- *Deschutes River, Capitol Lake, and Budd Inlet Temperature, Fecal Coliform Bacteria, Dissolved Oxygen, pH, and Fine Sediment Total Maximum Daily Load Technical Report: Water Quality Study Findings*. Washington State Department of Ecology (2012)
- *Restoring the Olympia Oyster.* National Oceanic and Atmospheric Administration (NOAA) (2008)
- *Washington Department of Fish and Wildlife Plan for Rebuilding Olympia Oyster (Ostrea lurida) Populations in Puget Sound with a Historical and Contemporary Overview*. Blake and Bradbury (2012)
- *Marine Forage Fishes in Puget Sound.* Pentilla (2007)
- *Implications of Observed Anthropogenic Changes to the Nearshore Ecosystems in Puget Sound.* Fresh et al. (2011)
- *SalmonScape.* http://apps.wdfw.wa.gov/salmonscape/map.html. Washington Department of Fish and Wildlife (WDFW) (2015)
- *Tumwater Falls Park*. Walk Olympia (2012)
- *West Bay Environmental Restoration Assessment, Criteria Development Technical Memorandum.* Prepared by Coast & Harbor Engineering for City of Olympia *(2015)*

Photographs, T-Sheets, Maps and Charts Interpretation

- The 1873 T-sheet was reviewed.
- Maps and Charts were reviewed from 1855, 1856, 1895 and 1949.
- Aerial and oblique photographs were reviewed from 1947, 1956, 1961, 1965, 1970s, 1990s, 2006, and 2014.

Data Gaps

Information was limited or not readily available regarding historic distribution of forage fish spawning, Olympia oysters, salmonids, or tidal marsh habitat in the vicinity of West Bay.

RESULTS

West Bay provides habitat for many fish and wildlife species including great blue heron (*Ardea herodias*), grebes, cormorants, ducks, raptors, gulls, forage fish, flatfish, salmonids, harbor seals (*Phoca vitulina*), Dungeness crab (*Cancer magister*) and numerous other birds, fish, mammals and shellfish. Many of these species depend on the same habitat types and ecological processes for survival, growth and reproduction. The Squaxin Island Tribe identifies a common approach in defining and understanding ecosystems through an indicator species of interest and there are numerous instances of using salmonids, which have been argued to be a keystone species (Squaxin, 2010). The following section identifies the target species for this restoration alternatives analysis project.

Target Species and Habitats

This historic and existing functions analysis targets two keystone species, Chinook salmon (*Oncorhynchus tshawytscha*) and Olympia oyster (*Ostrea lurida*) and their habitats. This approach will also allow direct assessment of habitats used by other important species, such as forage fish, other shellfish, marine birds, and mammals using an ecosystem restoration approach.

Chinook Salmon

Chinook salmon was selected as the primary target species for three reasons: 1) Chinook is federally listed as threatened under the Endangered Species Act (ESA); 2) Chinook have multiple life history strategies, which include diverse habitat requirements; and 3) known Chinook utilization of Budd Inlet and West Bay. The diet of Chinook salmon varies widely ranging from invertebrates and crustaceans to small fish including Pacific herring (*Clupea pallasii*) and sandlance (*Ammodytes hexapterus*). In order to successfully restore habitat for Chinook, habitat must not only benefit this species directly, but must also be restored to benefit Chinook prey species. Therefore, using Chinook salmon as a target species will allow this assessment to focus on the overall ecological processes required by Chinook and their prey species.

The habitat requirements of Chinook salmon include both fresh and saltwater habitats and their associated riparian corridors. This assessment focuses on the marine environment of West Bay and estuarine habitat associated with the Deschutes River below Capitol Lake, Garfield and Schneider Creeks, and other small drainages. Although native Chinook salmon populations are not present in tributaries within the project area, the shallow, nutrient-rich waters of the South Sound are optimal rearing conditions for Chinook and are known to attract juvenile Chinook from waters as far north as the Green River (Thurston County Conservation District 2005). Estuaries are critical habitat features for both juvenile and adult Chinook, providing feeding opportunities as well as transition from freshwater to saltwater and back. In the marine environment Chinook utilize habitats ranging from shallow intertidal beaches and marshes used for foraging, migration and refuge by juveniles to deep-water marine areas used by resident and returning adults (Fresh et al., 2011).

Chinook prey species in estuarine and marine environments include terrestrial invertebrates, freshwater and marine invertebrates, and forage fish (Fresh et al., 2011). A diverse array of habitat types should be present within an ecosystem to support Chinook prey species. Terrestrial invertebrates depend on riparian vegetation, freshwater invertebrates need clean gravel and cobble substrate, while marine invertebrates require salt marsh, mudflats, sandy beaches and other suitable vegetation or substrate. Forage fish spawning requirements vary by species. Surf smelt (*Hypomesus pretiosus*) and sandlance require gravel and sand substrate, respectively, within the middle and upper intertidal ranges, while Pacific herring require macroalgae as substrate to attach their eggs (Pentilla, 2007).

Olympia Oyster

Olympia oysters were also selected as a target species because they are the only species of oyster native to Washington and were once prolific in the south Puget Sound. This species occupies lower intertidal and shallow subtidal habitat and requires suitable hard substrate such as shells, shell fragments and rock, generally found over sand and silt, for attachment and growth to maturity. Olympia oysters, and other shellfish, have multiple important ecosystem functions; they create hard shells that provide physical habitat structure for juvenile fish and crustaceans, they tend to stabilize substrate, and they also filter plankton and nutrients from the water (NOAA, 2008).

Historic Conditions

Prior to Euroamerican settlement of Olympia, Budd Inlet was the traditional territory of the Sahehwamish. Food sources included roots, shoots and berries in the uplands and along the shorelines and abundant marine food sources in West Bay and Budd Inlet. The local people depended on West Bay and Budd Inlet as a key location for resource procurement. They harvested salmon and other fish from Budd Inlet and West Bay, as well as shellfish including oysters, clams and crab. In the 1850s it was noted that "all along the beach [in Olympia] were Indian huts and the whole beach was lined with canoes" (NAA, 2008).

Limited information was available regarding the historic distributions of salmonids in tributaries to Budd Inlet. However, current documented salmonid populations and modeled salmon habitat suitability, suggest that fall Chinook salmon, coho salmon (*O. kisutch*), fall chum salmon (*O. keta*), and winter steelhead (*O. clarkii*) historically utilized the Deschutes River below Tumwater Falls, as well as Percival and Schneider Creeks in West Bay and Ellis, Mission, and Moxlie Creeks in East Bay. In addition to salmonids and Olympia oysters, historic documents suggest that West Bay was also habitat for numerous waterfowl, raptors, terrestrial and marine mammals and numerous other marine fish and shellfish.

The earliest charts of Budd Inlet indicate that West Bay was an expansive mudflat through which the Deschutes River flowed in a series of channels. The peninsula between East and West Bays was smaller in size and located further south. Both East and West Bays contained unimpeded estuaries for Moxlie Creek and the Deschutes River, respectively (T-sheet 1873). West Bay also contained small pocket estuaries associated with Percival Creek, Garfield Creek, Schneider Creek and other small drainages.

The west shoreline of West Bay historically abutted the adjacent steep slopes to form bluff-backed beaches. The slope was forested land dominated by coniferous trees including western hemlock (*Tsuga heterophylla*) and Douglas fir (*Pseudotsuga menziesii*). Little information was found regarding the presence or quantity of salt marsh habitat; however, the historic presence of the shallow gradient intertidal mudflats combined with the current abundance and distribution of tidal marsh along much of West Bay, suggest that West Bay may have historically had tidal fringe marsh habitat along much of the shoreline similar to what remains at Priest Point Park on the eastern shoreline of Budd Inlet.

Historic Ecological Processes and Habitat Functions

Historically, West Bay was an estuarine mudflat with unrestricted flows from the Deschutes River and numerous small pocket estuaries from Garfield Creek, Schneider Creek and other small drainages. West Bay was an important ecological connection between Budd Inlet and the adjacent freshwater and upland habitats. The estuarine conditions provided a transitional area critical for out-migrating juvenile salmon and returning adults. Without the presence of culverts, dams, extensive shoreline fill and armoring fish passage and sediment transport were unimpeded and functioned properly.

The vast mudflats supported key shellfish species including Olympia oysters, clams and crabs, and provided habitat for primary production of benthic and epibenthic invertebrates. Shellfish and other invertebrates provided a primary component for the diets of fish, birds and mammals and served to filter the sediment and water, thereby contributing to suitable water quality in the estuary. Furthermore, the intertidal mudflats were exposed during low tides, which allowed West Bay to flush on a frequent basis.

The bluff-backed shorelines were densely forested with coniferous species and likely a dense understory of smaller trees and shrubs, which provided overhanging vegetation for refuge habitat, shading, erosion control, detritus/nutrient export, and foraging opportunities on terrestrial invertebrates. The bluffs also contributed sediment ranging from fines to cobbles and boulders and LWD from shoreline erosion events. LWD served as refuge habitat for juvenile salmonids, other fish, birds and mammals in the nearshore environment and the eroded sediment provided suitable substrate for invertebrates and spawning habitat for forage fish.

Existing Conditions

The earliest “modern” development surrounding West Bay occurred along the east shore in the 1850s. One of the first major modifications to the west shore occurred in 1878 when the Olympia Railroad and Mining Company constructed a railroad spur along the shoreline between the 4th Avenue Bridge and Butler’s Cove (NAA, 2008). This action began a long series of shoreline modifications along the west shore of West Bay, which resulted in isolating the bluff-backed beaches from the shoreline with fill material. By the early 1970s[1] Burlington Northern Sante Fe (BNSF) rebuilt the railroad spur using rock and gravel fill, which created the existing lagoon north of the 4th Avenue Bridge.

Waterborne transportation was the primary form of travel in Olympia due to the thick forests that surrounded the area (TCHC, 1992). In 1853 the steamboat era began, which increased construction of docks and wharfs. The intertidal mudflats of West Bay were not conducive for vessel traffic, which was only possible for most vessels during high tides. Dredging was first attempted, unsuccessfully, in 1885 by the City of Olympia. Dredging conducted by the Army Corps of Engineers between 1893 and 1894, and again between 1909 and 1911, created a navigable channel (NAA, 2008). The T-sheet of Budd Inlet from 1895 identifies a dredged navigation channel in West Bay. Spoils from dredging events were used as fill to create additional uplands over existing mudflats. This resulted in creation of 29 city blocks, primarily expanding the peninsula between East and West Bays, using 2 million cubic yards of spoils. Some dredge spoils may have also created part of West Bay Park and other level uplands along the west shore (TCHC, 1992).

A primary cargo distributed from Olympia was the Olympia oyster, which is native to Budd Inlet. The first oyster processing plant was built on the waterfront in 1893 (TCHC, 1992). Demand for the oysters continued to grow and led to the depletion of wild stocks of oysters. Advanced cultivation techniques were introduced, which revitalized the oyster industry. As the demand for oysters continued to grow, Eastern oysters (*Crassostrea virginica*) and Pacific oysters (*C. gigas*) were introduced in the Puget Sound. These non-native oysters brought with them non-native invasive species including predatory oyster drill snails, which further impacted native oyster populations. In addition to overharvest and non-native invasive species, sulfite waste and other environmental factors associated with industrial development also contributed to the continued decline of the Olympia oyster (Blake and Bradbury, 2012).

[1] Oblique aerial photographs from Washington State archives show the unfilled trestle in existence as late as 1971, with complete fill placed by 1974.

The coniferous forests along the West Bay shoreline were logged in the late 1800s and by the late 1890s log mills lined the shoreline, built primarily on fill from dredging activities (TCHC, 1992). The earliest indications of West Bay Drive are visible on the 1895 "Olympia Harbor" nautical chart. Fill along the West Bay shoreline resulted in the addition of shoreline armoring, impervious surfaces and streams being buried underground in culverts. The mills and other industrial facilities also contributed pollutants including dioxins, heavy metals, and petroleum hydrocarbons to the water and sediments of West Bay. Log storage was a common use of West Bay throughout the years. Log storage resulted in the accumulation of wood debris, which has likely further degraded water quality in West Bay.

A sediment characterization study of Budd Inlet commissioned by the Washington State Department of Ecology (Washington Department of Ecology, 2008) identifies contaminated sites in West and East Bay. Samples taken around West Bay indicate high levels of dioxins throughout all of the former industrial areas, as well as high levels of heavy metals around West Bay Marina. Sediment quality standards for other chemicals of concern were also exceeded in the vicinity of the Hardel and Reliable Steel sites.

A sediment investigation report funded by the Port of Olympia (Port of Olympia, 2014) further identifies contaminated sites throughout West and East Bay. Testing confirmed the presence of high levels of dioxin and other chemicals at several sites within the project area near the Solid Wood Inc. site (part of which is currently occupied by West Bay Park), Reliable Steel Inc., Hardel Mutual Plywood, and West Bay Marina. The high levels of dioxins in these areas all appear to be primarily due to historical presence and use of wood waste burners. In addition to dioxins, relatively high levels of polycyclic aromatic hydrocarbons (PAHs) are present in the marina, and near the Reliable Steel and Hardel Mutual Plywood sites.

The Port of Olympia was officially formed in 1922 and wharf facilities were built throughout the 1920s. Economic development continued at the Port resulting in widening and additional dredging of the navigation channel, construction of bulkheads, and use of Port property for log processing and log booming (TCHC, 1992). Filling and dredging and the subsequent construction of wharfs and bulkheads resulted in the loss of intertidal mudflats within West Bay.

As the City of Olympia continued to grow, additional roads and buildings were constructed, creating impervious surfaces, generating stormwater runoff and requiring management of sanitary sewer and storm drainage flows (see Figure 2). The areas immediately adjacent to West Bay are largely developed with commercial and residential land use, the majority of which currently do not provide water quality treatment or flow control measures for stormwater discharges. The majority of sanitary sewer flows are treated by the LOTT Clean Water Alliance treatment plant, and subsequently discharged to Budd Inlet; areas not served by the municipal sewer system are served by on-site systems (e.g., septic). These factors, among others, result in diminished water quality within Budd Inlet and its tributaries including the Deschutes River, Capitol Lake and small stream systems within this study area.

The Washington State Department of Ecology (Ecology) completed a technical study in 2012 on the water quality of the Deschutes River, Capitol Lake and Budd Inlet. The findings indicated temperature, fecal coliform bacteria, dissolved oxygen, pH, and fine sediment levels violated Washington State surface water quality standards. Regarding bacteria and nutrients, Ecology notes: "Urban areas include a variety of potential sources, including cross-connected infrastructure, failing septic systems, domestic animals, recreational users, and homeless populations." Regarding dissolved oxygen (DO) Ecology's Water Quality

Study Findings report notes: "Marine DO levels in Budd Inlet are affected by point-source discharges from facilities covered by individual and general permits. Treated domestic wastewater adds nutrient loads to the marine waters, enhancing primary productivity, as occurs in the freshwater systems described above. Stormwater from combined areas can also decrease treatment efficiency at the facility. Combined Sewer Outflows (CSOs) are a source of biological, chemical, and aesthetic pollution. Marine DO levels also are affected by nonpoint-source nutrient loads from the Deschutes River and other direct tributaries, due to a combination of human and animal sources. In addition, high productivity within Capitol Lake – due to the combination of increased residence times compared with a free-flowing estuary, shallow water, warm water temperatures, and high nutrient loads from the Deschutes River and Percival Creek – produces high seasonal organic matter levels, particularly during algae blooms that occur in late summer." (Ecology, 2012).

Subsequently, Ecology prepared a draft Water Quality Improvement Report/Implementation Plan or Total Maximum Daily Load (TMDL) Report. The draft TMDL Report sets the load and waste load reductions needed to meet Washington State water quality standards, and describes recommended implementation actions to achieve those reductions for the fresh water bodies within the TMDL boundary. The report also estimates loads of dissolved inorganic nitrogen, but does not assign numeric load allocations for nitrogen in the freshwater section. The marine sections of the TMDL boundary, including Capitol Lake and Budd Inlet will be addressed at a later date when additional modeling is completed. Schneider Creek is identified as violating Part 2 of the standards but the estimated 90th percentile is below the target. Therefore, a nominal 10 percent reduction in bacteria loads is recommended to achieve compliance with Part 2[2] of the standards.

Streams within this study area that discharge to Budd Inlet include Schneider Creek (the largest) and Garfield Creek as well as smaller unnamed drainage courses. Schneider Creek is described (City of Olympia, 2003) as having:

- Overall poor to fair condition.
- Highly unstable, mobile substrate subject to erosion; severely scoured creek.
- Good buffer in downstream areas, and presence of LWD, pools, etc.
- Impervious surfaces cover 19 percent of the 634-acre basin, with approximately half of that area receiving some type of stormwater treatment (City of Olympia, 2010).
- Rural land use is 23 percent, with remainder as urban developed land use.
- On-site sewage systems, or septic systems, serve 154 acres of the Schneider Creek basin (approximately 24 percent of the basin), with the remainder of the area served by LOTT (City of Olympia, 2010).

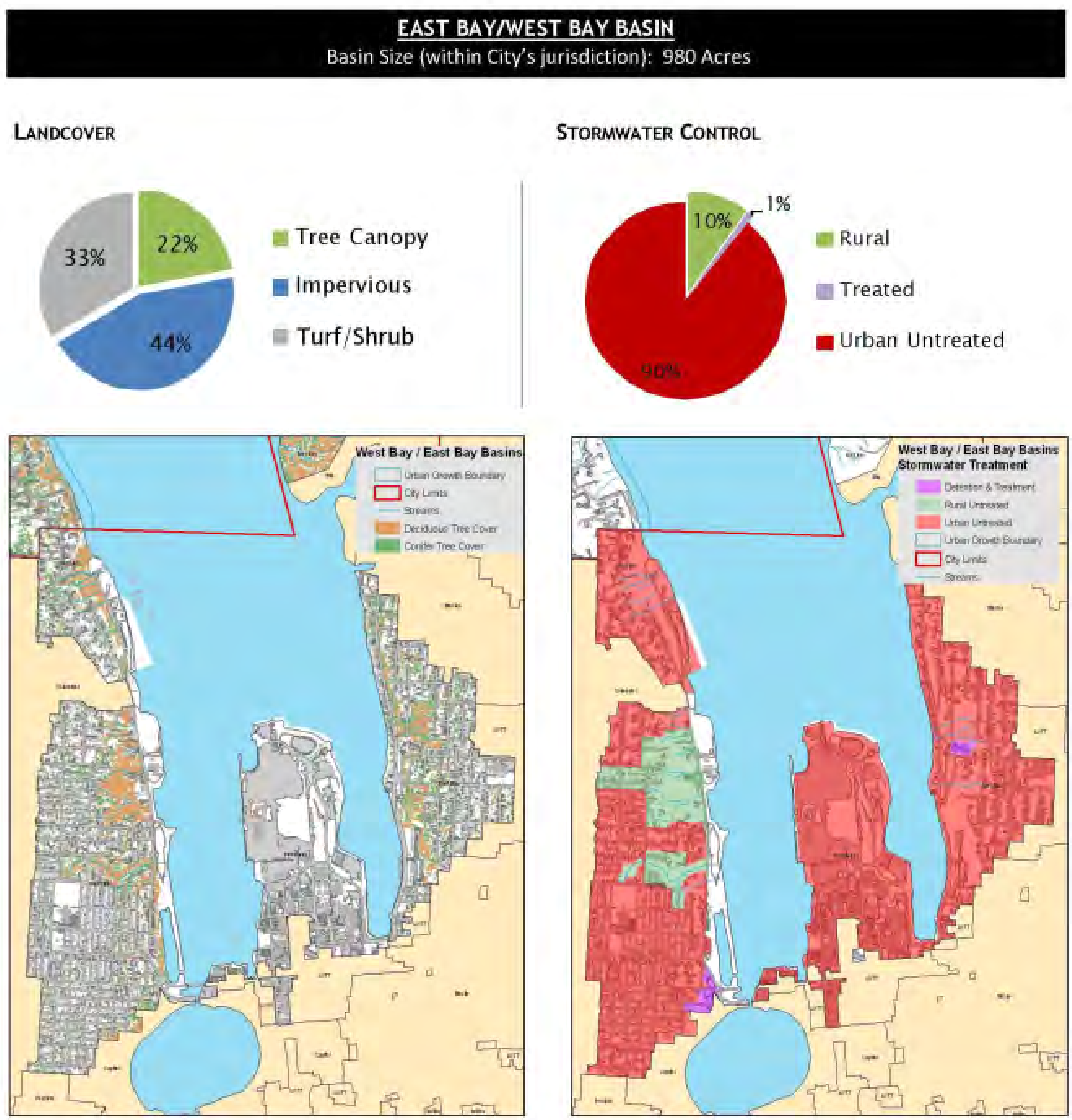
Water quality monitoring on Schneider Creek has been performed by Thurston County. The 2010-2011 Thurston County Water Resources Monitoring Report provides the following summary:

[2] The State water quality standard for fecal coliform bacteria has two parts: Part 1 - the geometric mean shall not exceed 100 colonies per 100 milliliters of sample and, Part 2 - no more than 10 percent of the samples shall exceed 200 colonies per 100 mL.

> "Monitoring began on Schneider Creek in 1993 as part of the long-term ambient monitoring program. It was discontinued in 1998, but resumed in water year 2002/03. Generally the creek meets water quality standards with the exception of part 2 of the fecal coliform standard. There were turbidity violations in November of each water year. The nitrate concentration in the creek is higher than impacted surface water levels, with an average concentration of 1.5 milligrams per liter. The nitrate concentrations in the creek are high year-round reflecting contamination in the shallow ground water, which provides base flow, as well as in surface runoff. During the winter months the creek channel is highly impacted by peak storm water flows which scour and alter the stream channel."

The City of Olympia also performed a Basin Analysis in 2010 using GIS information, water quality monitoring data and other published sources. The Basin Analysis contains physical drainage basin data such as impervious surface percentages, percent served by on-site sewage systems, and percentage of the basin for which stormwater treatment is provided. The Analysis also included conversion of water quality data into a Water Quality Index (WQI) using protocol developed by Ecology and an evaluation of biological health data (i.e., Benthic Index of Biotic Integrity [B-IBI]). The basin analysis found nitrogen loading from numerous sources including the Deschutes River, the LOTT Clean Water Alliance, and many of Olympia's streams, contribute to low dissolved oxygen problems in Budd Inlet. Also, the Thurston County data indicates B-IBI scores for Schneider Creek ranged from 18.0 in 2003 to 22.7 in 2008 (Scores 10-26 are in the very poor to poor range).

In addition to the streams, stormwater from the constructed storm drain system (pipes and catch basins, etc.) discharges via stormwater outfalls to the West Bay of Budd Inlet. Collectively, the constructed storm drain system that discharges directly to West Bay is referred to as the West Bay catchment. Mapped conditions as of 2010 are shown in the following image from the 2010 GIS Basin Analysis (COO) (2010), indicating that most of the basin is urban with high percentage of impervious and little to no stormwater controls.



GIS Image from COO 2010 GIS Basin Analysis

Water quality data for the storm drainage system and smaller streams in the study area is not available. However, urban stormwater runoff generally contributes to nonpoint source pollution such as: fine sediment; increased water temperatures; oil, grease, heavy metals, and toxic chemicals from vehicles; pesticides and nutrients from lawns and gardens; viruses, bacteria and nutrients from failing septic systems; and heavy metals from roofing systems or other sources. The increased flows from uncontrolled stormwater runoff also causes creek channel erosion, mass wasting and increased sediment transport/deposition, all of which degrades natural habitat conditions.

Capitol Lake was created in 1951 by damming the Deschutes River Estuary at the 5th Street Bridge (TCHC, 1992). The creation of Capitol Lake limited tidal flows and permanently inundated the mudflats of the Deschutes Estuary. Installation of the dam also prevented the transport of sediments from the estuary into West Bay, significantly altering the natural geomorphic processes (see subsequent section for discussion of processes). Other impacts from construction of the dam include impeded fish passage, nutrient and organic matter transport, loss of flushing, and alteration of the natural salinity gradient transition. In 1952, the hatchery and fish ladder were installed at Tumwater Falls to generate a Chinook salmon run on the Deschutes River and allow anadromous fish passage upstream. Current salmonid utilization of West Bay tributaries includes documented presence of fall Chinook, coho, and fall chum salmon in Percival Creek and the Deschutes River below Tumwater Falls. Steelhead are also documented in the Deschutes River below Tumwater Falls (Washington State Department of Fish and Wildlife [WDFW] 2015). Above Tumwater Falls, WDFW identifies "documented-artificial presence" of these species as well. Schneider Creek is documented to contain coho and WDFW indicates "modeled presence" of fall Chinook, fall chum and steelhead.

Modification of the Deschutes River Estuary into Capitol Lake resulted in the following impacts to the shoreline and nearshore habitats.

- Shoreline length has been reduced from 17.5 km to 9.0 km
- Wetlands have been reduced from 3.48 km^2 to 1.96 km^2
- Armoring is present for 94.2 percent of length
- Roads are present for 13.4 percent of length
- 75.5 percent of lands have been developed in nearshore. (Fresh et al., 2011)

Additionally, dredge and fill activities in West Bay have resulted in the following impacts.

- Mudflats have been converted to uplands
- Mudflats have been converted to subtidal
- Pocket estuaries have been removed
- Feeder bluffs have been disconnected from the shoreline
- Riparian forests have been disconnected from the shoreline

Deschutes River Estuary has been converted to a freshwater lake. Figure 1 shows how West Bay has been altered over time including the loss of intertidal mudflats and pocket estuaries.

Current wildlife use of West Bay includes at least 39 species of waterbirds and six species of raptors (R.W. Morse Company, 2002). The 2002 habitat study report documented observations made between October

2001 and June 2002 which mainly included observations of herons, grebes, cormorants, geese, ducks, shorebirds and gulls feeding on small fish and invertebrates. The study identified that preferred feeding and resting spots for waterbirds within the project area are the Port lagoon, the cove south of Reliable Steel and other undeveloped portions of the west shoreline. Incidental wildlife observations made during the study included terrestrial and marine mammals including harbor seals, river otter, mink and black-tailed deer.

Existing Ecological Processes and Habitat Functions

Development of West Bay and the surrounding vicinity over the last 150 years has degraded the ecological functions of the bay in numerous ways. Riparian habitat has been disconnected from the shoreline along much of the shore of West Bay. Fill placed along the shoreline for the railroad grade and industrial facilities has eliminated the potential for the adjacent bluffs to provide sediment to nourish the beaches. The buried stream outfalls of Garfield Creek, Schneider Creek, and other small tributaries and the construction of the dam at Capitol Lake have substantially reduced the amount of available estuarine habitat and the input of sediment from these freshwater sources into West Bay. These modifications have also altered the natural salinity transition zone for out-migrating juvenile salmonids.

By removing the connection between these freshwater features and West Bay, the area now functions poorly for estuarine ecological functions. Juvenile salmon depend on properly functioning pocket estuaries as they leave their natal streams to adjust from freshwater to saltwater and continue to use pocket estuaries to forage and grow throughout their migration to the Pacific Ocean. Another important function lost by impeding the outfalls of the Deschutes River and other creeks is the loss of sediment sources. Sediment inputs are a critical component to healthy beaches and provide suitable substrate for forage fish spawning and invertebrate production. Few patches of beach substrate suitable for forage fish spawning are available within the project area and, in turn, no sandlance spawning is documented in West Bay and surf smelt spawning is only mapped in one location along the north end of West Bay Park. The presence of surf smelt spawning in one of the few areas with suitable substrate infers that more forage fish spawning would occur in the project area if additional spawning substrate was available. Moving north along the west shore of West Bay, suitable coarse spawning substrate is expected to persist longer-term due to more exposure to wave action in the northernmost portions of the project area.

Additional impacts to riparian habitat along the west shore of West Bay include the removal of coniferous forests, which have transitioned to deciduous-dominated forests and are now largely isolated from the West Bay shoreline by roads and fill material. Adjacent riparian forests provide important ecological functions including overhanging vegetation, recruitment of LWD along the shoreline, organic matter and terrestrial insect inputs, and habitat structure for a variety of wildlife. Without adjacent coniferous forests, the project area shoreline is largely devoid of properly functioning LWD habitat structures and overhanging vegetation to provide shade on the upper beach. However, much of the western shoreline of West Bay contains a narrow strip of salt marsh wetland habitat and the innermost portion of the lagoon contains a large salt marsh component.

Mudflat habitat in West Bay has been significantly reduced over the last 150 years (T-Sheet 1873). This is a direct result of dredge and fill activities in West Bay and the construction of Capitol Lake. The reduction in the amount of mudflat habitat has resulted in reduced habitat for critical juvenile salmonid food sources and Olympia oysters. Fill placed between the East and West Bays of Budd Inlet and associated bulkheads and overwater structures have displaced mudflat habitat and created new degraded upper intertidal habitat. Dredging has also transformed West Bay from a vast intertidal mudflat into deeper subtidal marine habitat. This has increased the volume of water present in West Bay and reduced the percentage of water that is flushed out of the Bay during each tidal cycle.

Water quality is a concern in West Bay and has been influenced by many of the factors described above. Portions of the Deschutes River, Capitol Lake, and Budd Inlet do not meet current water quality standards and are listed on the Clean Water Act Section 303(d) list for one or more of the following parameters: fecal coliform, temperature, dissolved oxygen, pH, or fine sediment.

Additional factors that have degraded water quality in West Bay include the development of uplands with impervious surfaces and the lack of treatment and flow control for stormwater generated on these surfaces. Figure 2 identifies known outfalls within the project area. Poor water quality limits the habitat functions of all marine habitat types and can lead to bioaccumulation of toxins in marine life or mortality. For example, poor water quality has contributed to the depletion of local stocks of Olympia oysters, in combination with habitat loss/degradation, overharvest and introduction of non-native invasive species.

Water and sediment quality in West Bay have also been affected by industrial development including log processing facilities, steel manufacturing, and ship building/repair facilities. These facilities were an important component of the development of Olympia, but also were point sources for harmful chemical pollutants to enter the waters of West Bay and potentially accumulate in the sediments of the Bay. In the 2008 Sediment Characterization Study of Budd Inlet, historic pollutants were identified including petroleum hydrocarbons, dioxin/furan, arsenic, copper and other heavy metals (Ecology, 2008). Log storage has also degraded the sediments within West Bay through accumulation of wood debris, which degrades the ecological functions of the substrate for benthic and epibenthic production. Bacteria related to the breakdown of wood waste also increases the demand for dissolved oxygen during the decomposition process of the wood debris further impacting benthic and epibenthic organisms.

Existing and Historic Shoreline Physical Processes

Shoreline and nearshore physical processes in West Bay are predominantly driven by wind-waves, salinity gradients (e.g., freshwater input), and tidal circulation. Sediments in West Bay generally consist of fine, silty materials historically sourced from upstream terrestrial areas (Port of Olympia, 2014). Although historically consisting predominantly of inter-tidal mudflats (as determined from historic T-sheets), about 100 acres of mudflats in West Bay have been lost to deepening. Deepening is caused by the combined effects of dredging (on the east side of the bay in particular), scouring due to concentrated flows from 5th Avenue Dam, and constrained sediment supply from sediment impoundment behind the dam. Nearshore bathymetry on the west side of West Bay, however, appears to have been minimally impacted by mudflat deepening, though historic tidal channels are no longer prevalent.

Sediment supply to West Bay shorelines is very limited, due to the armoring of shoreline, disconnection from adjacent bluffs, and reduction of sediment input from the historic Deschutes River Estuary. Sources of coarse sediment to the northern portion of the project site comes from feeder bluffs to the north, near the City limit. Most of West Bay, however, experiences no appreciable sediment drift laterally (Ecology, 2015). The heavily armored shoreline and absence of intertidal beaches makes it difficult to assess actual shoreline drift in West Bay. Based on observed patterns and existing developed conditions, shoreline drift through West Bay appears highly segmented by artificial features that prevent shoreline sediments from being transported between adjacent areas. In addition to loss of historic mudflats, much of the shoreline throughout West Bay has been filled for development. Approximately 40 acres of subtidal and intertidal habitat area has been reclaimed for development along the west side of West Bay since the late 19th Century.

Waves in West Bay are produced from wind blowing along Budd Inlet from the north and through West Bay, from the south. The strongest winds typically blow from the south. The fetch to the north, however, is considerably longer and produces larger waves. Still, shorelines along West Bay are relatively sheltered and low energy, with 1- to 2-foot wind-waves during a 50-year return period wind storm event. With no tidal exchange between the Deschutes River Estuary and Bay, circulation through the Bay is severely constrained. Pre-dam conditions exhibited considerably more circulation and mixing than current conditions (USGS, 2006).

Prior to impoundment of Capitol Lake Dam, the head-of-tide for the Deschutes River extended all the way up to the base of Tumwater Falls. At low tide what is now Capitol Lake was composed almost entirely of mudflats. Following construction of the dam, salt water was incapable of entering the southern Deschutes River Estuary and now a large portion of the estuary is a freshwater lake and freshwater flows into West Bay from Deschutes River became significantly more concentrated. In addition to deepening West Bay as discussed above, this has the effect of producing sharper salinity gradients in the bay through deeper channels and concentrated flow.

SUMMARY

In summary, the West Bay of Budd Inlet has undergone substantial modification over the last 150 years. Impacts to the ecological functions of the bay include:

- Conversion of coniferous riparian forests to deciduous forests.
- Disconnection of riparian forest and freshwater habitats from West Bay.
- Conversion of shallow intertidal mudflats into navigable waters and uplands.
- Loss of sediment and large wood inputs from bluffs and rivers/creeks.
- Degradation of intertidal beaches from armoring.
- The loss of pocket estuary habitat.
- Water quality impacts from deepening the bay and from pollution sources including untreated stormwater from impervious surfaces.
- Increased erosion and scour in small tributary creeks

These impacts have degraded habitat for marine-dependent species including Chinook salmon and Olympia oysters. Future restoration alternatives should focus on improving ecological functions for:

- Intertidal and nearshore salmonid habitat
- Forage fish spawning habitat
- Olympia oyster and other shellfish habitat
- Estuarine habitat and pocket estuaries
- Freshwater streams and wetlands
- Marine bird/mammal habitat
- Marine and freshwater riparian establishment/connectivity
- Salt marsh habitats
- Tidal circulation and flushing
- Sediment transport along the shoreline
- Stormwater flow control and water quality treatment, possibly through implementation of Low Impact Development (LID) strategies

This memorandum serves to identify the historic ecological functions of West Bay, the human actions that have altered the functions of the Bay, and the current ecological functions/limiting factors within the Bay. Numerous documents have been prepared, which outline potential restoration projects in Budd Inlet and West Bay. Two restoration projects identified in the *Budd Inlet Restoration Partnership Phase II Report* are Schneider Creek Culvert Replacement and West Bay Park Shoreline Enhancements (RAEC, 2011). These projects as well as others will be identified and assessed for restoration potential using information contained in this report and the criteria development memorandum (CHE, 2015).

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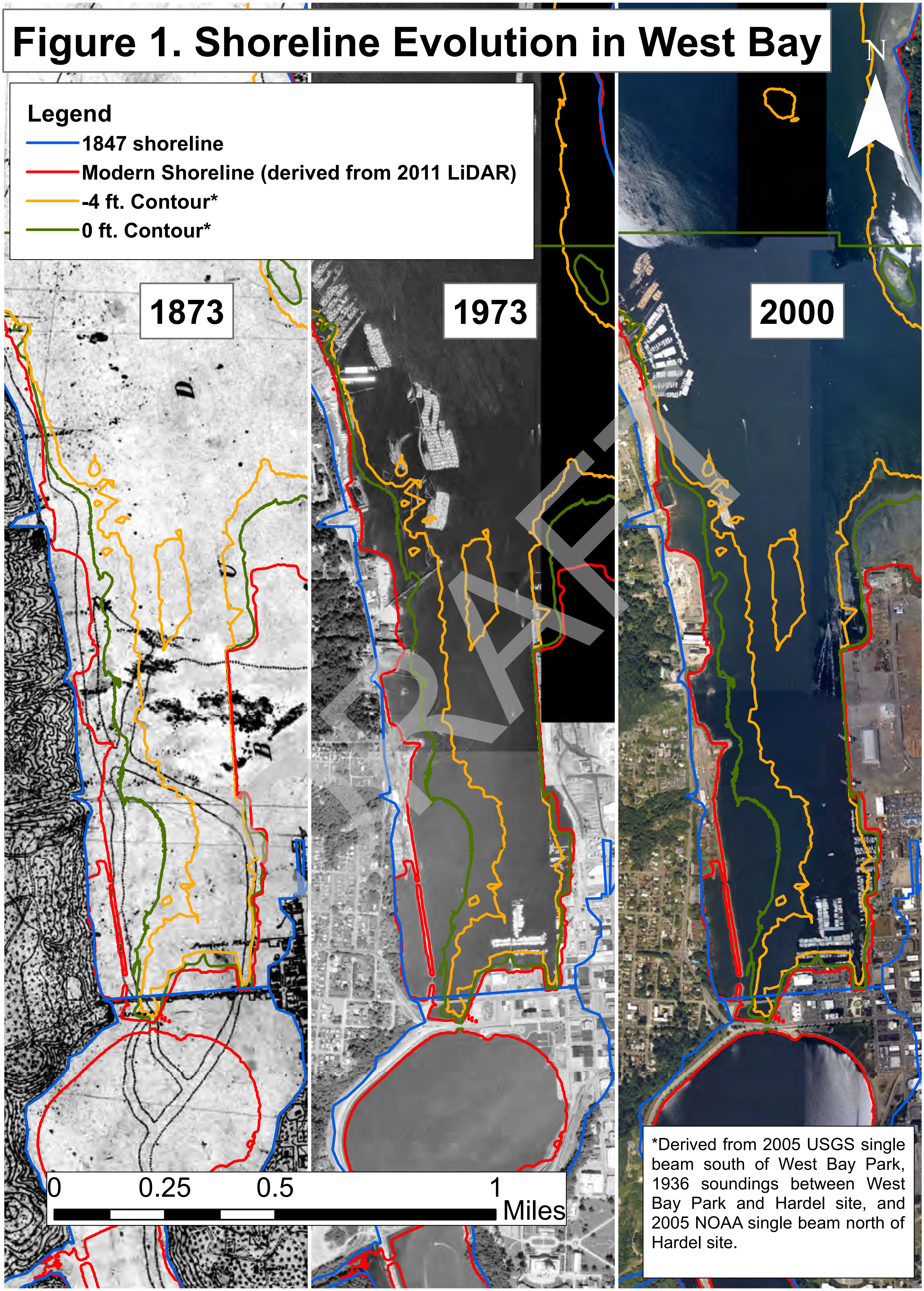
Attachments:
Figure 1. Shoreline Evolution in West Bay
Figure 2. Stormwater Outfalls in West Bay

Figure 1. Shoreline Evolution in West Bay



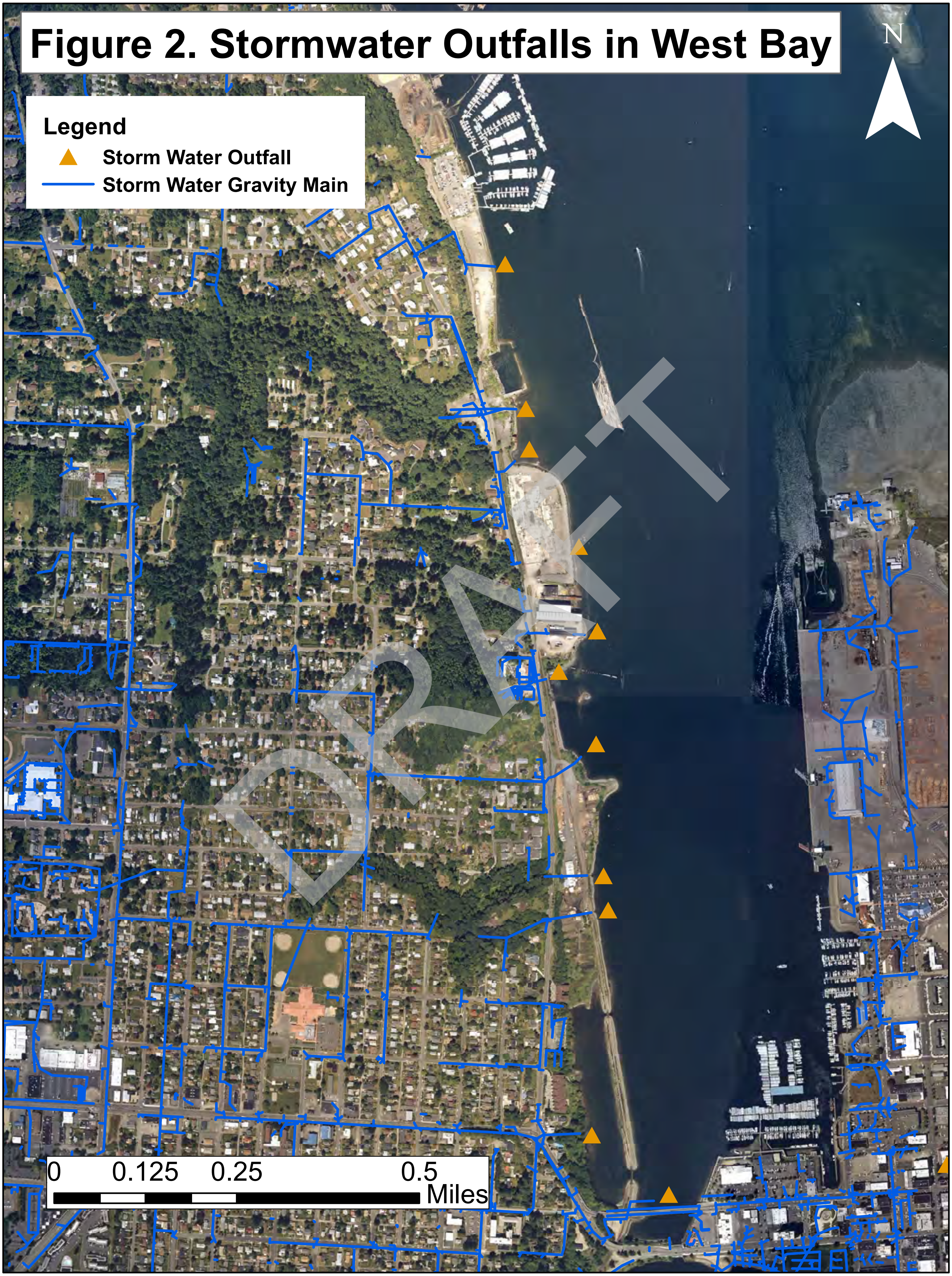


Figure 2. Stormwater Outfalls in West Bay
N
Legend
Storm Water Outfall
Storm Water Gravity Main
0 0.125 0.25 0.5
Miles
DRAFT

APPENDIX C

Conceptual Stormwater Analysis Memo

TO: Jesse Barham, Habitat Planner, City of Olympia Public Works

FROM: Tracey Belding, P.E.
Aaron Bowman, P.E.

DATE: February 18, 2016

RE: West Bay Environmental Restoration Assessment – Conceptual Stormwater Analysis TM

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1. Introduction

The City of Olympia (City) contracted with a consulting team led by Coast & Harbor Engineering, a Division of Hatch Mott MacDonald, to complete a science-based environmental restoration assessment for the West Bay of Budd Inlet, in southern Puget Sound. The assessment is intended to support the implementation of water quality and habitat restoration strategy, including the prioritization of restoration projects for planning and management by the City, Port of Olympia (Port), Squaxin Island Tribe (Tribe) and other public entities.

One objective of the environmental restoration assessment is to identify potential stormwater improvement opportunities to enhance restoration sites identified in the overall assessment, with a focus on potential retrofit projects to improve water quality in the existing stormwater system. The expectation is that these potential retrofit projects will be further evaluated and ranked, and can be implemented in coordination with redevelopment, cleanup, public works or restoration projects to further enhance habitat quality in Budd Inlet. This technical memo summarizes the identification and analysis of conceptual stormwater quality treatment opportunities and documents the findings and recommendations.

The stormwater assessment was accomplished through review of stormwater pollution documented in previous studies, limited field investigations and desktop analysis to identify sources of stormwater to the shorelines of West Bay, screening of potential sites, and development of conceptual level stormwater treatment opportunities and costs. The approach and methodology used in this stormwater analysis are discussed further in Section 5, while the results are presented in Section 6.

Key findings include:

- New restoration or redevelopment projects along the West Bay shoreline provide opportunities to partner with property owners to go above and beyond code-required stormwater treatment, or to provide stormwater retrofits along with site development.
- Many of the identified outfalls have constraints that preclude practical end-of-pipe retrofits, including the slope of the terrain, available area for treatment, etc. Additionally, the scale of retrofits needed to treat stormwater flowrates from the large tributary basins along West Bay makes end-of-pipe retrofits impractical to implement for several of the sites. However, the study did identify certain stormwater outfalls with smaller drainage basins that have the potential for end-of-pipe, or near end-of-pipe, water quality retrofits.
- Upland stormwater retrofits offer more feasible scale projects to treat sub-basins within larger basins that discharge into West Bay, particularly for Garfield Creek and Schneider Creek. Upland retrofits can be scaled or replicated to achieve additional water quality benefits within other areas of the basin as feasible.
- Collection and treatment of stormwater from portions of West Bay Drive also provides retrofit opportunities throughout the project area. These opportunities focus on treating concentrated stormwater at the source locations within the basin, as opposed to treating comingled stormwater and creek flow.

2. Previous Studies and Data

Many previous and on-going studies have documented water quality and habitat in Budd Inlet and adjacent water bodies. The sections below summarize a limited selection of recent studies related to potential stormwater projects to improve the water quality of urban runoff. A more complete list of the studies and resources that were reviewed for this project is included in the Historic and Existing Functions Analysis Memorandum, dated October 16, 2015.

City of Olympia GIS Basin Analysis 2010

The City has published a detailed characterization of the watersheds within its boundaries. The purpose of this work was to inventory and understand the condition of the City's aquatic resource base and the stormwater infrastructure system, then use the information we gain to better direct Storm and Surface Water program focus and resource allocation. (Olympia. 2010). GIS data and water quality monitoring data were used in this analysis. Basins were characterized and compared to the corresponding environmental monitoring data for streams within each basin. The City performed statistical analysis to identify if there were relationships between basin attributes, (e.g. basin land cover, riparian cover, onsite sewage systems, stormwater controls) and water quality or stream biologic health.

Study Area Drainage Basin Characteristics

A general description of the areas that drain to the West Bay Environmental Restoration Assessment study area, gleaned from the City of Olympia GIS Basin Analysis 2010 and other studies, City staff knowledge, and direct observations, includes:

- Topography is fairly steep (up to 38%) in areas near West Bay, with slopes decreasing to fairly flat at the top of the hill and the upper areas of the drainage basin

- Impervious surface coverage is fairly typical for each represented land use, except in the steep bluff and ravines which are predominantly forested and undeveloped
- Residential; much of it single family, but with some areas of multifamily residential and commercial
- Areas of commercial development, including car repair shops that may be a source of oil/grease, and some large at-grade parking areas (not covered)
- Generally older cars that may be more likely to deposit oils and metals on roadways and parking lots
- Majority of area was built before property developers and landowners were required to install stormwater treatment facilities. It is estimated that, in general, approximately 50% to 99% of the area that is already developed as urban land use lacks stormwater treatment. (City of Olympia, 2010)
- Steep hills near West Bay Drive that may receive sand and/or other de-icing treatment in winter months

Port of Olympia Investigation Report, Port of Olympia Budd Inlet Sediment Site

A sediment investigation report funded by the Port of Olympia (Port of Olympia, 2014) further identifies contaminated sites throughout West and East Bay. Testing confirmed the presence of high levels of dioxin and other chemicals at several sites within the project area near the Solid Wood Inc. site (part of which is currently occupied by West Bay Park), Reliable Steel Inc., Hardel Mutual Plywood, and West Bay Marina. The high levels of dioxins in these areas all appear to be primarily due to historical presence and use of wood waste burners. In addition to dioxins, relatively high levels of polycyclic aromatic hydrocarbons (PAHs) are present in the marina, and near the Reliable Steel and Hardel Mutual Plywood sites. The study also cited a potential source of ongoing Dioxin/Furans to be via stormwater inputs from urban outfalls, likely from historic wood treating activities and atmospheric deposition from wood waste burners in and around the Study Area:

> "Typical activities contributing to stormwater inputs may include vehicle emissions and other urban combustion activities as well as erosion of soil containing elevated Dioxin/Furan concentrations potentially associated with historical activities, such as wood waste burners."

The study also found elevated polycyclic aromatic hydrocarbons (PAHs) localized near outfalls, citing the potential source: "may be the result of stormwater/Combined Sewer Overflow (CSO) releases and runoff from motor oil and urban combustion sources." (Port of Olympia, 2014).

The Port of Olympia sediment report mentions future work could include collecting additional source characterization samples at several locations in the vicinity of the Study Area based on the presence of elevated surface concentrations near outfalls, which may include catch basin solids or sediment traps to determine if suspended solids with elevated pollutant concentrations are entering Budd Inlet from the stormwater system. (Port of Olympia, 2014). The City is currently implementing an effort to install sediment traps to enable further sampling in the storm drain system.

Ecology Water Quality Studies for Deschutes Watershed and Budd Inlet

The water quality concerns of Budd Inlet have been acknowledged and documented by the Department of Ecology (DOE). Budd Inlet has been listed on the 2008 Clean Water Act 303(d) list of Impaired Waters for violations to the following water quality constituents: dissolved oxygen (DO), fecal coliform, Copper, Lead, Zinc, PCBs, Phenol, Chrysene, Cadmium, Chromium, Benzo[b]flourene, Benzo[k]flourene, Benzo[a]flourene, 2,4-Dimethylphenol, 2-Methylphenol, 4-Methylphenol, and Pentachlorophenol. (Ecology, 2012).

A water cleanup plan, also referred to as a Total Maximum Daily Load (TMDL), has been initiated for the Deschutes River, Capitol Lake, and Budd Inlet; specifically for Budd inlet, the TMDL addresses dissolved oxygen. Constituents addressed by the draft TMDL Report include:

- Fecal coliform bacteria
- Temperature
- Fine sediments
- Dissolved oxygen
- pH

A technical report documenting the technical basis for the water cleanup plan, was prepared in 2012 by Ecology, and was followed in 2015 by a draft Water Quality Improvement Report and Implementation Plan (IP), or TMDL Report (see below). Other parameters were addressed in the TMDL for other waterbodies within the study area. A TMDL identifies how much pollution needs to be reduced or eliminated to achieve clean water. The TMDL Technical Report points out potential sources of fecal coliform bacteria and nutrients that could affect dissolved oxygen (DO) including point sources as well as non-point sources:

> "Potential sources of fecal coliform bacteria and nutrients that could affect DO and pH include humans, domestic animals, agricultural activities, and wildlife."
>
> "Marine DO levels in Budd Inlet are affected by point-source discharges from [wastewater] facilities covered by individual and general permits. … Marine DO levels also are affected by nonpoint-source nutrient loads from the Deschutes River and other direct tributaries, due to a combination of human and animal sources."

Table 1 shows the recommended items identified in the draft Implementation Plan for the City of Olympia.

Table 1 - TMDL Implementation Plan BMP Recommendations for the City of Olympia

Action	Comments
Stormwater control and management: Develop a plan to reduce, bacteria and sediment loading with a schedule of prioritized projects prior to expiration of the permit on July 31. 2018. The prioritized projects will need to be implemented during subsequent permit cycles.	Implement projects as funds are available. Projects could include: Provide stormwater treatment for currently untreated impervious surfaces; require stormwater retrofits as a condition of property development; develop targeted pollutant source control program; develop a street sweeping program. Priority areas: Budd Inlet tributaries: Ellis, Indian, Mission, Moxlie, and Schneider Creeks; Percival Creek watershed: Percival Creek
Continue to develop and implement pet waste reduction programs through existing education and outreach efforts, including installing pet waste stations at established pet recreation areas to prevent or reduce bacteria released into local water bodies. Work with other jurisdictions on a regional pet waste control program.	Priority areas: Ellis, Indian, Mission, Moxlie, and Schneider Creeks

Schneider Creek is within the West Bay Environmental Restoration Assessment study area, and was monitored for the TMDL technical report. Because Schneider Creek (13-SCH-00.1) violates Part 2 of the standards but the estimated 90th percentile is below the target, a nominal 10% reduction in bacteria loads are recommended to achieve compliance with Part 2 of the standards (Ecology, 2015).

The remaining water quality constituents are to be addressed in future TMDLs. The Draft Water Quality Improvement Report and Implementation Plan (IP), also known as the TMDL Report, was prepared in 2015 to include Budd Inlet tributaries including Schneider Creek. The TMDL Report sets the waste load reductions needed to meet Washington State water quality standards, and describes implementation actions to achieve those reductions (Ecology, 2015).

The TMDL Report is not setting a wasteload allocation (WLA) for phosphorus but recognizes that if the turbidity surrogate measure target is met, then phosphorus bound to suspended particles will also be reduced to the lowest level possible for offsite transport (Ecology, 2015).

Refer to Section 3 for a discussion of contaminants targeted in the proposed stormwater retrofit opportunities.

3. Stormwater Pollutants and Habitat Benefits of Treatment

Typical Constituents of Urban Stormwater Runoff

Water quality data for the urban stormwater runoff has not been collected for the entire study area. However, typical pollutant constituents in runoff have been documented in various research studies. Data from one runoff pollutant monitoring study performed in Oregon is presented in Table 2. The study provided comparisons to national data, which are also listed below.

Table 2 - Pollutant Median Concentrations from Monitoring in Oregon[1]

	Transportation		Commercial		Residential		Open Space	
	ACWA[1]	FHWA[3]	ACWA[1]	NURP[2]	ACWA[1]	NURP[2]	ACWA[1]	NURP[2]
TSS (mg/L)	132.4	142	55.6	69	43.2	101	24.7	70
BOD5 (mg/L)	8.9	-	7.4	9	5.8	10	3.7	-
COD (mg/L)	59	114	47.2	57	33.4	73	19.1	40
Total P (mg/L)	0.33	0.4	0.21	0.2	0.15	0.38	0.16	0.12
TKN (mg/L)	1.51	1.8	1.00	1.2	0.84	1.9	0.69	1.0
Total Cu (mg/L)	0.028	0.054	0.022	0.029	0.010	0.033	0.004	-
Total Pb (mg/L)	0.043	0.400	0.026	0.104	0.010	0.144	0.002	0.030
Total Zn ((mg/L)	0.197	0.329	0.115	0.172	0.069	0.135	0.012	0.195

[1] Oregon Association of Clean Water Agencies (ACWA). 1997. Analysis of Oregon Urban Runoff Water Quality Monitoring Data Collected from 1990-1996, by Woodward-Clyde Consultants.
[2]Median values reported for the National Urban Runoff Program (EPA, 1983) as cited in the 1997 ACWA Analysis of Oregon Urban Runoff Water Quality Monitoring Data Collected from 1990-1996.
[3] Median values reported for urban highways (Federal Highway Administration, 1990) as cited in the 1997 ACWA Analysis of Oregon Urban Runoff Water Quality Monitoring Data Collected from 1990-1996.

Other studies have found that residential areas may transport as much or more contaminants than other land uses. Another source for stormwater pollutants and removal efficiencies is the International Stormwater BMP Database (http://bmpdatabase.org/).

Stormwater Treatment Habitat Benefits

Urban runoff is one of the leading sources of water quality degradation in surface waters. Untreated or inadequately treated stormwater from urban environments can negatively impact water quality in estuaries and other marine environments by lowering dissolved oxygen levels and increasing levels of harmful pollutants including nutrients, metals, hydrocarbons, bacteria and other constituents (EPA 2005). These pollutants have a significant impact on marine organisms ranging from reduced productivity to mortality. Pollutants bioaccumulate over time in organisms exposed to them. Shellfish, for example, are highly susceptible to bioaccumulation as they filter large amounts of water on a daily basis. Poor water quality results in closures of recreational and commercial harvest of shellfish each year (DOH 2015). At higher trophic levels, biomagnification occurs when top predators, such as killer whales or humans consume lesser predators, resulting in extremely high concentrations of pollutants at the top of the food chain. Therefore, stormwater treatment has been included as a metric in this assessment to improve habitat in West Bay for Marine species including Chinook salmon and Olympia oysters.

4. Treatment Technologies and Applications

Stormwater treatment, when required, is guided by Ecology's Stormwater Management Manual for Western Washington, or equivalent manuals as adopted by local jurisdictions. Ecology and the City require water quality treatment of 91% of the average annual volume of runoff from PGIS, when water quality treatment is triggered. For this analysis, conceptual sizing of facilities is based on a rough estimate of sizing informed by the sizing used for similar projects. Modeling and sizing for each facility was not performed, and should be done in future phases of implementation.

New development and re-development projects are required by local codes and state-mandated regulations to provide stormwater treatment for pollution generating impervious surfaces (PGIS). While there is existing stormwater treatment on some parcels in the study area, such as newer commercial development along West Bay Drive and Jefferson Middle School, much of the study area was constructed before stormwater treatment was required. Treatment of runoff from those areas with existing development is therefore the focus of the analysis for stormwater retrofit project identification. Further, the emphasis is on constructed Best Management Practices (BMPs) (physical, constructed facilities) rather than on non-structural BMPs such as street sweeping, pet waste reduction programs, or educational programs.

While there is no single solution for stormwater retrofits within the West Bay Environmental Restoration Assessment study area, there are a range of stormwater treatment technologies that can be applied including various BMPs that fall into the categories of Green Stormwater Infrastructure (GSI) and emerging technologies. Those two categories of stormwater treatment BMPs are discussed in the following sections.

Low Impact Development (LID)/ Green Stormwater Infrastructure (GSI)

Low Impact Development stormwater techniques such as bioretention (rain gardens) and other techniques such as treatment wetlands are designed to mimic the benefits of the natural environment to achieve stormwater treatment and other benefits. These approaches generally use more real-estate than the emerging technologies which are mostly underground facilities. Therefore, LID type approaches are generally better suited for sites that will be redeveloped, or where the LID feature can be incorporated into the landscaping of a development or habitat restoration project. Bioretention areas can also be retrofitted in the shoulder or planting area adjacent to existing roads, as shown in Figure 1.

Figure 1 - Bioretention Area installed on existing landscape strip to treat roadway runoff

A stormwater treatment wetland is a conventional stormwater treatment BMP that is designed to mimic the benefits of natural wetlands, by treating stormwater through the biological processes associated with emergent aquatic plants. These type of wetlands consist of shallow man-made ponds that typically consist of a pre-settling cell and a wetland cell which is planted with emergent wetland plants. An image of a stormwater wetland is shown in Figure 2. Stormwater wetlands perform well to remove sediment, metals, and pollutants that bind to humic or organic acids. Phosphorus removal in stormwater wetlands is highly variable.

Figure 2 - Treatment Wetland

Emerging Technologies

Stormwater treatment retrofit opportunities for most of the identified sites in this study include Emerging Technologies, or manufactured treatment devices because they generally have a small footprint and many can be installed underground. These Emerging Technologies are reviewed and approved by Ecology as functionally equivalent to the standards required by the Stormwater Management Manual for Western Washington. They are approved through the Department of Ecology (Ecology) Technology Assessment Protocol - Ecology (TAPE) program.

Table 3 shows the treatment types for several stormwater treatment technologies under the General Use Level Designation (GULD), as approved through Ecology's TAPE program. These technologies are used as example technologies for this stormwater analysis due to their GULD designation and their prior use in Western Washington, including within the City of Olympia.

Table 3 - Treatment Types for Various GULD Approved Treatment Technologies

Stormwater Treatment Technology	Pretreatment	Oil Treatment	Basic Treatment	Enhanced Treatment	Phosphorus Treatment
CDS (Continuous Deflective Separation)	X				
StormFilter - ZPG Media			X		
StormFilter - Phosphosorb Media			X		X
MWS-Linear Modular Wetland			X	X	X
Filterra		X	X	X	X

For the purposes of this technical memorandum, emerging technologies were split into two categories:

1) Pretreatment and Filtration, which are underground facilities that work well as retrofits to treat concentrated pipe flows on a parcel or under a roadway

2) Manufactured Biological Filtration Devices, such as Filterra or Modular Wetland Systems, which are often installed on existing roadways in lieu of catch basins, and which provide a high level of treatment for a very small footprint.

Ecology's emerging technologies criteria for removal of pollutants are shown in Table 4. It should be noted that standard stormwater BMPs are not targeted to remove contaminants such as Dioxin/Furan or polycyclic aromatic hydrocarbons (PAHs). If these contaminants are found to be in the stormwater runoff and are targeted for removal, careful selection of the treatment will be required.

Actual removal efficiency depends on a number of factors, which have not been identified for the project area, including:

- Particle size distribution of sediment in stormwater runoff
- Concentrations of individual contaminants
- pH
- Type and concentration of organics in stormwater, and seasonal variation

Table 4 - Ecology's Emerging Technologies Criteria

Table 2. Basic, dissolved metals, phosphorus, and oil treatment and pretreatment performance goals and required water quality parameters for TAPE monitoring.

Performance Goal	Influent Range	Criteria	Required Water Quality Parameters
Basic Treatment	20-100 mg/L TSS	Effluent goal ≤ 20 mg/L TSS [a]	TSS
	100-200 mg/L TSS	≥ 80% TSS removal [b]	
	> 200 mg/L TSS	> 80% TSS removal [b]	
Dissolved Metals Treatment [c]	Dissolved copper 0.005 – 0.02 mg/L	Must meet basic treatment goal and better than basic treatment currently defined as > 30% dissolved copper removal [b,d]	TSS, hardness, total and dissolved Cu and Zn
	Dissolved zinc 0.02 – 0.3 mg/L	Must meet basic treatment goal and better than basic treatment currently defined as > 60% dissolved zinc removal [b,d]	
Phosphorus Treatment	Total phosphorus (TP) 0.1 to 0.5 mg/L	Must meet basic treatment goal and exhibit ≥ 50% TP removal [b]	TSS, TP, orthophosphate
Oil Treatment	Total petroleum hydrocarbons (TPH) > 10 mg/L [e]	1) No ongoing or recurring visible sheen in effluent 2) Daily average effluent TPH concentration < 10 mg/L [a,e] 3) Maximum effluent TPH concentration of 15 mg/L [a,e] for a discrete (grab) sample	NWTPH-Dx, visible sheen
Pretreatment [f]	50-100 mg/L TSS	Effluent goal ≤ 50 mg/L TSS [a]	TSS
	≥ 100 mg/L TSS	> 50% TSS removal [b]	

mg/L – milligrams per liter
Cu – copper
NWTPH-Dx – Northwest Total Petroleum Hydrocarbons-Motor Oil and Diesel fractions
TP – total phosphorus
TPH – total petroleum hydrocarbons
TSS – total suspended solids
Zn – zinc

Emerging Technologies – Pretreatment and Filtration

Manufactured filtration products filtration media that absorb and retain pollutants from stormwater. An example is the StormFilter® by Contech Engineered Solutions, which uses rechargeable, self-cleaning, media-filled cartridges to absorb and retain the most challenging pollutants from stormwater runoff including total suspended solids, hydrocarbons, nutrients, metals, and other common pollutants. Regular maintenance for StormFilter® installations include removal of sediment with an educator (vactor) truck and replacement of filter cartridges. StormFilter® cartridges are commonly installed underground in concrete vaults, which provide maintenance access.

Pretreatment to remove larger particles, dirt and floatables, is recommended to extend the replacement frequency for the filter cartridges. For this study, pretreatment using CDS is used for conceptual treatment opportunities and cost estimating. The CDS unit is a manufactured device that uses a swirl concentrator action and screening to separate and trap debris, sediment and hydrocarbons from piped stormwater systems. They can be retrofitted into existing storm drainage systems with adequate depth, and are relatively simple to maintain.

The City of Olympia has an existing StormFilter® facility with pretreatment (CDS) at the Giles Avenue treatment facility, which is in the Schneider Creek basin. That facility, as shown in Figure 3, is installed without the concrete lid, allowing a view of the cartridges within.

Figure 3 - Stormwater Filtration at the City of Olympia's Giles Avenue Facility

A typical configuration for pretreatment plus filtration could include a CDS (for pretreatment) followed by a StormFilter® vault, or similar stormwater treatment unit for "filtration". Stormwater flows could be split at the upstream conveyance pipe, directing low flows to be treated by the BMP, while larger flows would bypass the system. Feasible retrofit locations meet the following constraints:

- adequate area
- slopes which are not too steep for installation
- adequate elevation drop (1.8 to 3 foot drop across the StormFilter® vault required)
- adequate maintenance access (or potential for it to be constructed)
- where existing pipes can be accessed and the pipe network requires minimal adjustments or expansions

Table 5 - Example removal efficiencies for a StormFilter Vault (per Contech) [1]

Constituent	Average removal percentage
Total Suspended Solids (TSS)	80%
Total Phosphorus	50%
Total Copper	40%
Total Zinc	40%
Total Nitrogen	30%

[1]Actual removal is highly variable depending on basin characteristics, season, particle size distribution, organics, etc. (Source: Contech)

Using emerging technologies to provide pretreatment and filtration are good applications for retrofits because these BMPs can be installed below the ground surface and take up a relatively small area. These below ground type of facilities can be installed with almost no noticeable elements, resulting in only manhole lids visible at the ground surface, meaning the space above the BMP is unobstructed and can still be used for passive recreation.

Emerging Technologies – Manufactured Biological Filtration Devices

Manufactured biological filtration devices are Media filtration devices that support plants or bacterial biofilms. Examples that have been approved by Ecology for use in Washington include Filterra® tree box units and Modular Wetland System®. Filterra® tree box units have been used in Olympia and throughout western Washington, and are GULD approved for oil treatment in addition to enhanced and phosphorous. Therefore, the Filterra® system has been used for cost estimating the conceptual opportunities in this study. A diagram of the Filterra® tree box components is shown in Figure 4. An image of a Filterra® tree box installed adjacent to a sidewalk is shown in Figure 5.

A Filterra® tree box units is essentially a containerized biofiltration stormwater treatment technology that exists mostly below the surface, except for the tree that grows within the media. They are typically installed at the gutter line of a roadway or parking lot to replace a catch basin, or intercept flow before it reaches the next downstream catch basin.

The Filterra® tree box units treat runoff by infiltrating stormwater through a proprietary media mixture. As stormwater flows through the system the filter media captures pollutants, which are decomposed, volatilized, and incorporated into the biomass of the Filterra® system. Treated water is collected in the Filterra® underdrain system in the bottom of the concrete vault, and then discharged to the storm drain system. Table 6 shows removal efficiencies for a Filterra® unit (per Contech).

Filterra® tree box units are approved in Washington for basic, phosphorus, oil and enhanced (metals) at varying flow rates. Standard Filterra® tree box units vary in size from 4’ by 4’ to 6’ by 12’ and are about 4 feet deep. They come in several configurations for installation in or adjacent to sidewalks.

The Modular Wetland System® is a similar device that has been installed recently by the City of Olympia along a portion of West Bay Drive, as shown in Figure 6.

To: Jesse Barham, City of Olympia
Date: February 18, 2016

Table 6 - Removal efficiencies for a Filterra® (per Contech)[1]

Constituent	Average removal percentage
Total Suspended Solids (TSS)	85%
Phosphorus	70%
Nitrogen	43%
Total Copper	58%
Dissolved Copper	46%
Total Zinc	66%
Dissolved Zinc	58%
Oil & Grease	93%

[1] Ranges varying with particle size, pollutant loading and site conditions. (Source: Contech)

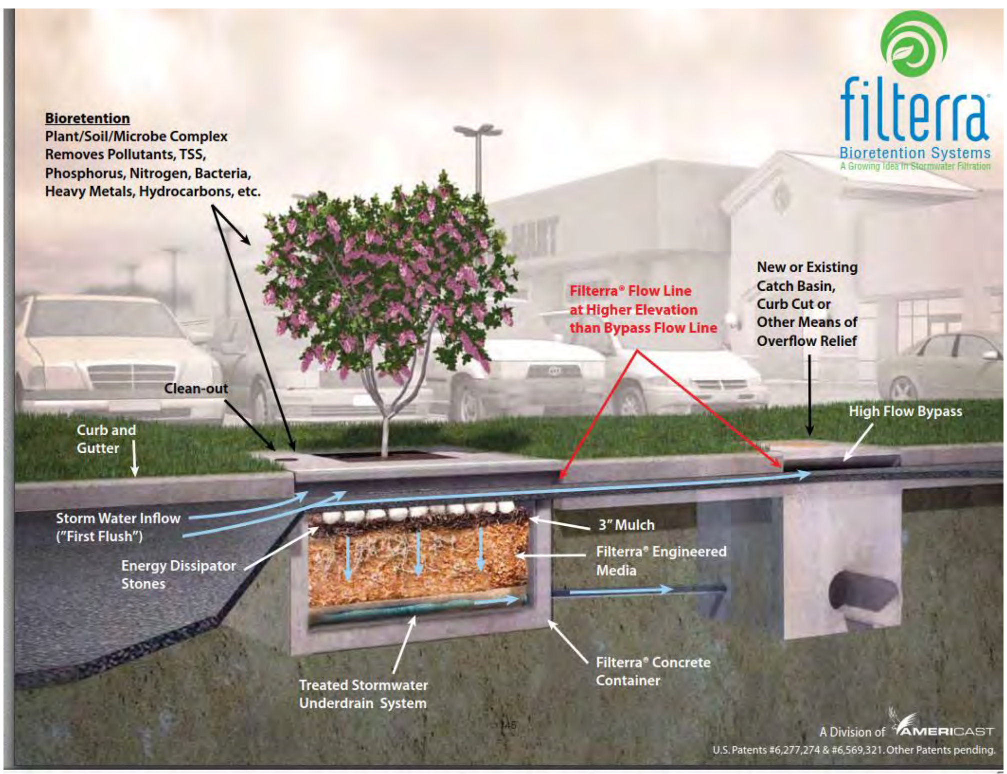


Figure 4 - Diagram of Filterra® Bioretention System

Figure 5 - Filterra® Bioretention System installed adjacent to sidewalk

Figure 6 - Modular Wetland System (MWS)® installed on West Bay Drive

5. Stormwater Analysis

Goals & Methodology

The conceptual stormwater analysis portion of the West Bay Environmental Restoration Assessment was prepared to identify sources and potential stormwater improvement opportunities that can be applied throughout West Bay. The analysis included looking for potential opportunities among the stormwater outfalls to Budd Inlet, potential opportunities to treat stormwater along West Bay Drive before it is conveyed to the outfalls, and additional upland opportunities within the upper areas of the basins. Potential opportunity sites were identified and analyzed for various criteria to target sites that provide feasible and cost-effective stormwater treatment opportunities.

The extent of the evaluation was a “desktop scale” analysis, using available data including Geographic Information System (GIS) data, surveys, and reports, including sub-basin delineations. The desktop study was supplemented with limited site visits. More detailed studies may be needed prior to design and implementation of stormwater retrofits.

Screening Stormwater Opportunities

Outfall locations

Each outfall to Budd Inlet from the West Bay piped stormwater network was assessed as a potential opportunity for stormwater treatment. First each outfall was characterized by the extent of the stormwater pipe network and its tributary basin area. Outfalls were then evaluated for treatment feasibility using engineering judgement to select cost-effective stormwater opportunities.

Opportunities were targeted based on areas with little or no existing treatment, areas more likely to have increased contaminants in runoff (e.g. areas with more impervious surface such as roadways and parking lots). For this analysis, it was assumed that reasonable contributing basin area for a pretreatment plus filtration type of retrofit is on the order of 20 to 25 acres. For larger areas, it is likely that any feasible emerging technology installation would treat to a threshold lower than the 91% average annual volume. However, there are installations of larger filtration facilities, such as the Port of Seattle facility, but those are generally above ground or open installations that preclude other uses of the land.

A table was compiled including relevant basin, stormwater, and outfall characteristics for each stormwater treatment opportunity to assist in analyzing applicable BMPs. The characteristics included:

- Size of Basin
- Discharge location (lagoon or West Bay)
- Basin Zoning
- Space for Maintenance Access
- Predominant flow (concentrated stormwater flow vs creek/springs)
- Available space
- Areas with little or no existing treatment
- Slope/topography at the outfall location

- Land use/street use

The purpose of the table was to help assess the applicability of the BMPs to each stormwater treatment opportunity. Based on the assessment a potential water quality BMP was chosen for the opportunity (e.g. emerging technology, green BMP, etc), or a recommendation for related upland opportunities was noted.

Through the initial screening of outfalls, it was found that many outfalls in the study area have constraints that preclude practical end-of-pipe retrofits, including terrain slope, available area for treatment, etc. Additionally, the scale of retrofits needed to treat stormwater flowrates from the large tributary basins along West Bay makes end-of-pipe retrofits impractical to implement for several of the sites. However, several stormwater outfalls with smaller drainage basins do have the potential for end-of-pipe, or near end-of-pipe, water quality retrofits.

As a result of the screening of the outfalls, upland areas and smaller sub-basins within larger basins were evaluated further. Upland stormwater retrofits offer more feasible scale projects to treat sub-basins within larger basins that discharge into West Bay, particularly for Garfield Creek and Schneider Creek. Upland retrofits can be scaled or replicated to achieve additional water quality benefits within other areas of the basin as feasible.

In addition, it was found that there are opportunities along West Bay Drive to treat concentrated roadway runoff without significant additional stormwater infrastructure or real estate.

"Upland" Locations

In the upland areas of the basins, opportunities can be focused on stormwater retrofits at strategic treatment opportunities. Through discussions and a site visit with City of Olympia representatives, several potential upland retrofit opportunities were determined. These locations include areas where a portion of the tributary basin can be intercepted or split-off from a conveyance pipe and treated, prior to being released to the downstream conveyance or streams. These opportunities take advantage of the benefits of treating the concentrated stormwater at locations within the basin, as opposed to trying to treat larger flowrates at the outfall which are often made up of comingled stormwater and creek flow.

This upland category includes the potential to treat stormwater runoff from West Bay Drive. Many untreated segments of West Bay Drive can be treated, reducing the pollutants that reach the outfalls. Opportunity #17 covers the West Bay Drive possibilities.

Additionally, there are other non-structural Best Management Practices (BMPs) that can be employed to reduce target water quality pollutants throughout the basin. These non-structural BMPs include pet waste education programs, increased street sweeping, and encouragement of Low Impact Development (LID) stormwater BMPs. Pet waste education programs encourage pet owners to pick up after their pets to reduce the fecal coliform and nutrient loads to stormwater. Increased street sweeping collects roadway pollutants at the source, keeping them out of stormwater runoff. Encouragement of Low Impact Development (LID) stormwater BMPs, helps stormwater to be reintroduced into the groundwater and reduces stormwater volumes and erosive flowrates that drive erosion and sediment transportation in stream channels such as Schneider Creek.

6. Representative Stormwater Improvement Opportunities

The following sections describe the conceptual stormwater treatment retrofit opportunities that have been identified. For this analysis, conceptual sizing of facilities is based on a rough estimate of sizing informed by the sizing used for similar projects. Modeling and sizing for each facility was not performed, and should be done in future phases of implementation. A matrix showing the Conceptual Stormwater Treatment Opportunities, along with preliminary capital cost estimate ranges, is included as Attachment 1.

Pretreatment and Filtration

To assess the practicality and feasibility of an emerging technology BMP at the opportunity sites, a relative footprint of the BMP was estimated by taking a StormFilter® vault area and its tributary area (from a past City of Olympia project), and scaling the resulting BMP footprint for each outfall, based on the size of the tributary area. This relative BMP size was used to gauge the practicality of an emerging technology BMP at the outfall location.

When scaled based on the tributary basin size, a BMP could be too large or just impractically large for the site. In these cases the facility could potentially be sized to treat lower flows from the basin by configuring the flow splitter to direct only flowrates up to a set maximum to the stormwater treatment BMP, allowing lower flows to be treated while larger flows are bypassed.

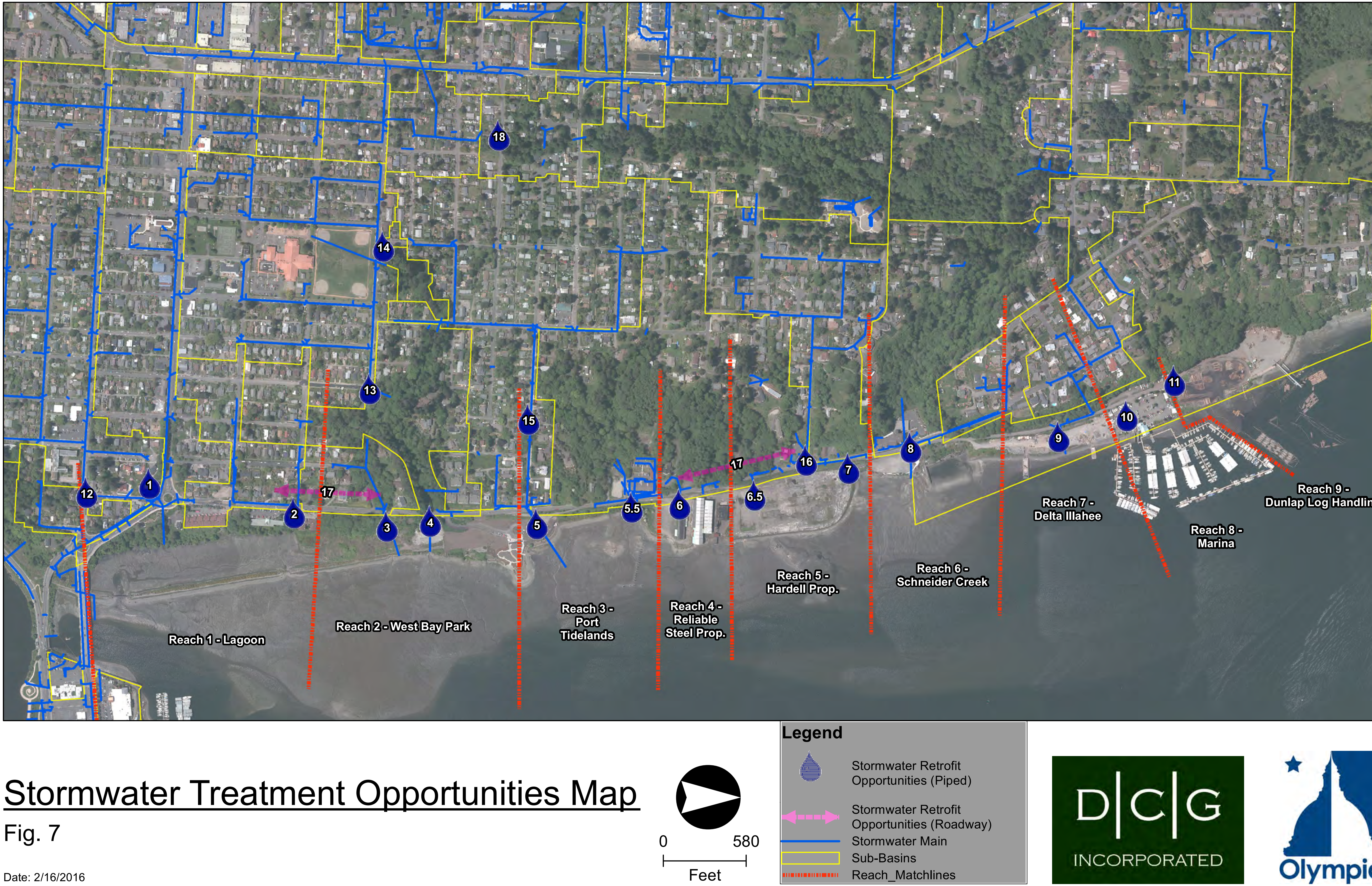
This basic configuration can be adapted to any site that meets basic physical constraints at the proposed location (e.g. available area, elevation drop, etc). The arrangement can vary some and the BMPs can be interchanged with other BMP treatment technologies depending on treatment goals. An exhibit of this conceptual layout showing what a typical emerging technology BMP could include, is shown as Figure 8. This figure shows an example potential retrofit for Opportunity #5. The example layout can be scaled based on contributing drainage area for other potential treatment sites.

Site Narratives

Each opportunity location was assigned a number identifier, as seen on the Stormwater Opportunity Map, included as Figure 7. The characteristics, constraints, and potential of each stormwater opportunity is discussed below, and summarized in the Conceptual Stormwater Treatment Opportunities Matrix, Attachment 1.

Opportunity # 1

This outfall receives runoff from a 107-acre catchment area, and discharges to the lagoon between West Bay Park and the 4th Avenue Bridge. This outfall is characterized by steep slopes, private parcel ownership, and lack of maintenance access at the end of the outfall. Therefore stormwater treatment at the outfall is not feasible. A portion of the pipe crosses a city park, but steep slopes and maintenance access complications make the placement of a BMP at that location difficult. Therefore, upland treatment opportunities in the contributing basin are the best option for this large basin (107 acres). One opportunity is discussed here as Opportunity #1, while the other is presented as Opportunity # 12 and discussed separately.



Stormwater Treatment Opportunities Map

Fig. 7

Date: 2/16/2016

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Olympia

During discussions with City of Olympia representatives while on site, an upland opportunity was identified that has been previously evaluated by the City. This opportunity is located near the traffic circle at Harrison Ave NW and West Bay Dr, and would treat a significant portion (24 acres) of the basin, including roadway runoff from Harrison Ave NW. The conceptual design includes a flow splitter along the pipes in Harrison Ave NW to redirect flow to a CDS before routing flows back to Outfall #1. Another potential design variation, or a future expansion, could include adding a StormFilter treatment vault after the CDS pretreatment unit for added stormwater treatment.

Opportunity # 2

This outfall receives runoff from a basin of approximately 13 acres, and discharges to the lagoon between West Bay Park and the 4th Avenue Bridge. This outfall is characterized by steep slopes, private parcel ownership, and complications of maintenance access, so stormwater treatment at the outfall is not feasible. However, with an easement, an emerging technology BMP such as a CDS and/or Stormfilter, could be located under the parking area in the NW corner of the lot to treat flows separated from stormwater pipes. Placement on private property is contingent upon proper easement and maintenance agreements. Locating the BMP within the right-of-way may make maintenance difficult. A facility in this location would treat the majority of the 13 acre basin. Alternatively the BMP could be located further up in the basin where space is available, but that would treat a smaller tributary area.

Opportunity # 3

This outfall is made up of a piped segment of the south stem of Garfield Creek which is routed under West Bay Drive to outfall to Budd Inlet at the City-owned West Bay Park property. A basic feasibility analysis was done to evaluate if the required footprint of a stormwater treatment wetland would fit on this parcel, sized for the relatively small tributary area of 14 acres. That evaluation showed that a treatment wetland could fit on the parcel, however site elevations are not conducive to typical freshwater wetland and stream establishment due to proximity to salt water and stream dynamics. If a wetland that is not designed for stormwater treatment is feasible and desired for habitat enhancement purposes, it may still be a viable option. Additionally, treatment of stormwater runoff after it is combined with stream/seepage flows (base flows) is not as efficient as treating concentrated runoff directly from impervious surfaces.

Perhaps the most feasible option to treat higher concentration flows, is an opportunity to treat a large segment of West Bay Drive in this vicinity that currently drains untreated to the south stem of Garfield Creek. Stormwater from the northbound and southbound lanes can be diverted to an emerging technology BMP such as a Filterra Tree Box system, potentially one on either side of the street, which would treat the stormwater as it flows through the BMP, and release the treated flows back into downstream conveyance pipes. The treatment of this target area reduces road related pollution prior to flowing to the outfall. This type of road stormwater treatment opportunity takes advantage of the benefits of treating the lower flowrates of the concentrated stormwater, prior to the stormwater becoming comingled with creek flow. See also - Opportunity #17b regarding potential stormwater treatment along West Bay Drive.

Opportunity #4

This is the Garfield Creek outfall at the City-owned West Bay Park property. The catchment area is approximately 74 acres of riparian vegetated area plus primarily residential land use. A treatment wetland geometry was considered at this location as well, however, given that this is mapped as a fish-bearing stream, any BMP that would obstruct fish passage is precluded. The 74-acre tributary basin is also too large for a practically sized emerging technology BMP at the outfall, so upland BMP applications to treat concentrated urban runoff is the recommended strategy.

There is an opportunity to treat a segment of West Bay Drive in this vicinity by collecting and treating stormwater runoff with an emerging technology BMP such as a Filterra Tree Box system or similar BMP, prior to the stormwater being conveyed to be comingled with the creek flow. See also - Opportunity #17b regarding potential stormwater treatment along West Bay Drive, which would take advantage of the benefits of treating the lower flowrates of the concentrated stormwater, prior to the stormwater becoming comingled with creek flow. Additionally, there are two upland opportunities to treat stormwater at the point where the stormwater is discharged to the creek, up within the basin. Refer to opportunities 13 and 14.

Opportunity # 5

This outfall outlets to Budd Inlet at the City-owned West Bay Park property. The tributary basin is large (55 acres), therefore an emerging technology BMP to treat the full basin is feasible, but would be large. However, a retrofit facility could be sized to treat lower flows from the basin by configuring a flow splitter to direct only flowrates up to a set maximum to the stormwater treatment BMP, allowing lower flows to be treated while larger flows are bypassed.

A conceptual layout of a facility treating approximately 33% of the catchment area is shown as Figure 8. This figure shows an example retrofit for Opportunity #5, which includes a flow splitter, CDS unit, and a StormFilter installed below grade, under the pathway and lawn area at the north end of West Bay Park. This type of installation could be scaled up to treat more of the catchment area. Early input indicated that the Olympia Parks Department preferred to not have an above ground treatment facility in this area. An emerging technology BMP that is installed underground with the area restored to existing condition, may be a feasible alternative that would not impact the recreational opportunities or visual aesthetics of the existing park facility. Alternatively, the City could explore locations in the right of way, but maintenance access would be more limited, and capture of roadway runoff would be reduced if the facility were placed uphill from West Bay Drive.

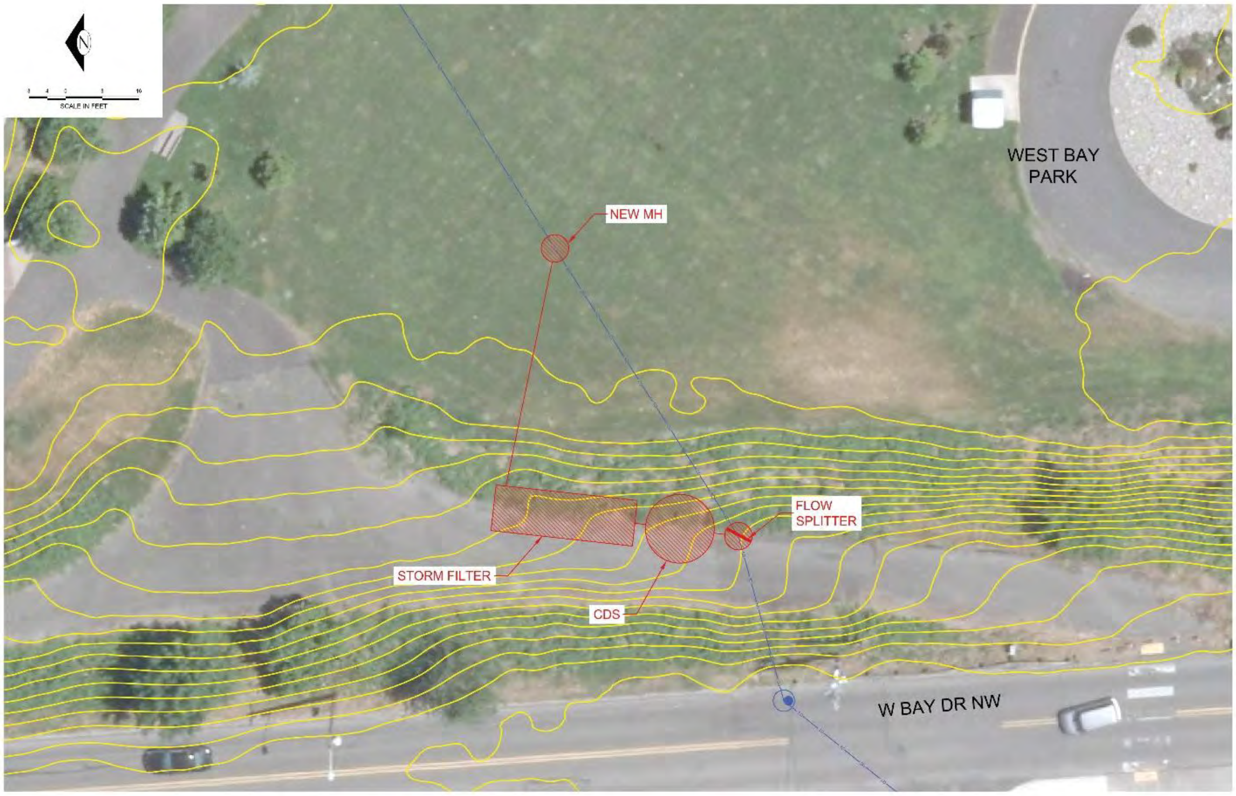

Figure 8 - Example Underground Pretreatment and Filtration Concept at West Bay Park north

Opportunity # 5.5

This outfall drains directly to Budd Inlet on property owned by the Port of Olympia. There is no space at the outlet for BMP retrofits. It should be noted that the actual tributary area to this outfall is smaller than the mapped basin (per GIS) in which it is located, so a more accurate delineation would be needed prior to any design based on the outfall flows. It appears that majority of the tributary area is forested and most of conveyance is within the stream, except for some developed areas adjacent to West Bay Drive and a segment of West Bay Drive itself that drains to the outfall. The developed areas adjacent to West Bay Drive already have stormwater treatment facilities to treat the on-site PGIS. Therefore, the primary retrofit opportunity is to treat a portion of West Bay Drive adjacent to the outfall to with an emerging technology BMP such as a Filterra or Linear Modular Wetland facility prior to the stormwater flowing to the outfall pipe. See also - Opportunity #17c regarding potential stormwater treatment along West Bay Drive.

Opportunity # 6

An existing outfall is located on the former Reliable Steel site, and drains an area of approximately 13 acres, much of which is forested and undeveloped. A portion of West Bay Drive in this area does have existing stormwater treatment for the roadway runoff. This treatment was installed by the City of Olympia with a roadway and sidewalk project that was completed in 2015 (see also Figure 6).

The outfall parcel does not have enough elevation drop for a StormFilter facility, so an emerging technology BMP may be challenging at this location. This is a contaminated site that will require a cleanup effort prior to any redevelopment or habitat restoration projects. Potentially an above ground facility could be placed here to coincide with site restoration efforts, as considerable excavation would be presumably be part of that restoration. If any stormwater BMP involving infiltration (such as LID) is proposed for this site, full removal of contaminated soils would be required.

This opportunity is also contingent upon other factors such as property ownership. Furthermore, it should be noted that the actual tributary area to this outfall is smaller than the basin (per GIS) in which it is located, so a more accurate delineation would be needed prior to any design based on the outfall flows.

Opportunity # 6.5

This outfall is on the former Hardell Mutual Plywood site which is privately owned. The outfall location is not well documented in the City of Olympia GIS data, but it is known to exist based on the stormwater pipes in the area and that the outlet is visible in Aerial photos. It is believed that a portion of this outfall pipe was removed during demolition of the prior site, and there are reports that stormwater from the remaining pipe flows from the site to Budd Inlet.

It should be noted that the actual tributary area to this outfall is smaller than the sub-basin in which it is located, so a more accurate delineation would be needed prior to any design based on the outfall flows. The tributary area to this outfall appears to be small, the majority of the tributary area is forested, and most of conveyance is within the stream until it reaches and crosses West Bay Drive. Depending on the future use and ownership of the site a GSI BMP or an emerging technology BMP could potentially be implemented on the site.

Opportunity # 7

This outfall is on the northern end of the former Hardell Mutual Plywood site which is privately owned. A StormFilter could potentially fit near the outfall, if the outfall pipe was realigned to allow for the utilization of more space on the parcel. Given the basin size, it would require relatively large StormFilter vault, or the BMP could be sized to treat lower flows from the basin by configuring the flow splitter to direct only flowrates up to a set maximum to the stormwater treatment BMP. Upland opportunities in this basin are another option. See also - Opportunity #16, for an upland BMP location within the basin.

Opportunity # 8

This outfall is the location where Schneider Creek flows into Budd Inlet across property owned by the Squaxin Island Tribe. The Schneider Creek watershed is very large (662 acres), and is the largest of the West Bay outfalls. Given this, a treatment facility at or near the end of pipe is not feasible. The creek could be daylighted for the portion of the creek that flows through a culvert at the mouth of the creek, need to be the subject of future study, as no investigation into the feasibility of this option was pursued in this evaluation.

Upland opportunities within the watershed are the only option related to stormwater quality for this outfall. Stormwater BMPs that also have a flow control component are recommended to reduce the effects of urbanization upon downcutting and erosion of the creek corridor.

There is an opportunity to treat a segment of West Bay Drive in this vicinity by collecting and treating stormwater runoff with a Filterra or similar BMP, prior to the stormwater being conveyed to be comingled with the creek flow. See also - Opportunity #17f regarding potential stormwater treatment along West Bay Drive. See also - Opportunity #18, relating to the existing Giles Ave NW stormwater treatment facility.

Opportunity # 9

This outfall is on property which is privately owned. The outfall parcel does not have enough elevation drop for a StormFilter facility, so an emerging technology BMP may be challenging at this location. Upland opportunities in this basin are the most likely option. If and when the parcel is developed, stormwater treatment will be required in accordance with the then-current code. See also - Opportunity #17g regarding potential stormwater treatment along West Bay Drive.

Opportunity # 10

The existing West Bay Marina parcel presents an opportunity for improved stormwater treatment in and when it is redeveloped or improved. The parcel is the marina property which is privately owned. There is potential for onsite improvements to stormwater quality here, as the parking lot catch basins drain untreated directly to Budd Inlet, however onsite stormwater treatment BMPs will likely coincide with future site improvements or redevelopment.

Opportunity # 11

There is an outfall just north of the marina which conveys a stream under West Bay Drive, around the edge of the log yard, and to Budd Inlet. The tributary area of the stream contains a residential neighborhood. There is not enough space at the outfall for a treatment BMP, so upland opportunities for this basin could be explored.

There is an opportunity to provide treatment on the log yard site or just off site to reduce sediment loading to the roadside ditch and Budd Inlet. The log yard property is privately owned, and there is no piped stormwater outfalls, but several open conveyance systems are routed around the central portion of the site. City of Olympia reports that the log yard has an oil water separator installed, but other stormwater BMP's are limited. During the site visit it was noted that large amounts of sediment are tracked onto West Bay Drive from the Log Yard site. Stormwater then carries that sediment into Budd Inlet.

Potential opportunities for addressing this sediment tracking problem could involve a wheel-wash to remove sediment from the vehicles as they leave the site, other stormwater retrofits along West Bay Drive to treat the sediment laden stormwater, or potential onsite improvements to reduce sediment track-off. The City of Olympia could explore options and coordinate with the property owner for reducing sediment track-off.

Opportunity # 12

This is a potential upland opportunity to treat stormwater contained in the storm drainage pipes that flow down 4th Ave, and eventually discharges to the Lagoon. The area is approximately 70 acres of residential neighborhoods. This would be an emerging technology BMP likely involving a flow splitter, CDS unit, and potentially a StormFilter, which could be installed in the right of way.

Opportunity # 13

This is a potential upland opportunity to treat stormwater contained in the storm drainage pipes at the intersection of Madison Ave NW & Percival St NW, before they outlet into and become comingled with Garfield Creek. There is a small pocket park in the right-of-way with two of the surrounding parcels owned by the City of Olympia. This would be an emerging technology BMP likely involving a below ground stormwater treatment facility installed in the right of way.

Opportunity # 14

This is a potential upland opportunity to treat stormwater contained in the storm drainage pipes at the intersection of Madison Ave NW & Thomas St NW, before they outlet into and become comingled with Garfield Creek. This is the location of NW Volunteer Park, which is City of Olympia property. This would be an emerging technology BMP likely involve a below ground stormwater treatment facility installed in the right of way.

Opportunity # 15

This is a potential upland opportunity to treat stormwater contained in the storm drainage pipes at the intersection of Brawne Ave NW & Foote St NW. This would be an emerging technology BMP likely involving a flow splitter, CDS unit, and potentially a StormFilter to treat at least the lower flows from the conveyance pipes.

Opportunity # 16

This potential upland opportunity is essentially an alternative to the Outfall # 7 site, as this location would to treat the majority of the outfall 7 basin (with the exception of a few smaller streams and the portion of West Bay Drive that flows to outfall 7). Stormwater contained in the storm drainage pipes at the intersection of Woodard Ave NW & West Bay Dr (or a portion of the flows up to maximum flowrate) could be separated and treated. This would be an emerging technology BMP likely involving a flow splitter, CDS unit, and potentially a StormFilter to treat at least the lower flows from the conveyance pipes.

Opportunity # 17 (17a -17h)

During the site visit to the various outfall and upland opportunity sites, it became apparent that there is a lot of potential to treat stormwater runoff from West Bay Drive. Many untreated segments of West Bay Drive can be treated, reducing the pollutants that reach the outfalls. In several areas, the stormwater can treated prior to it being comingled with stream baseflow.

The treatment can be accomplished with the addition of a roadside BMP such as Filterra unit or Linear Modular Wetland to collect the runoff from a segment of street, treat the stormwater as it flows through the BMP, and release the treated flows into downstream conveyance pipes. Overflows from larger storms would bypass the facility and end up at the outfall locations.

In many portions of West Bay Drive stormwater is already collected in street catch basins and piped towards the outfall. In these locations there is the potential to divert the flows, or separate the flows with a flow splitter, and redirected them to the BMP, and the outlet the BMP back to the original pipe, to drain to the outfall.

There are a few segments of West Bay Drive that are currently being treated by Linear Modular Wetlands such as the southbound lanes of West Bay Drive between the Hardell Plywood and Reliable Steel sites. The remaining segments of West Bay Drive can be evaluated for the potential for this collection/separation and treatment. Several potential sites, adjacent to the Outfall opportunities listed above, have been highlighted in this report.

Opportunity 17 is further broken-down into sub-areas (17a-17h) within the Stormwater Opportunities Table, representing a segment of West Bay Drive corresponding to each reach of the restoration assessment reaches along the shoreline. The West Bay Drive area for each reach, as shown in the Stormwater Opportunities Table, was calculated by multiplying the length of West Bay Drive along the reach by an assumed road width of 30 LF.

Opportunity # 18

The existing Giles Ave NW stormwater treatment facility consists of a 12' diameter CDS unit and a StormFilter with 80 18" ZPG cartridges. This facility treats a large portion of the upper Schneider Creek watershed. The outlet of this facility is essentially the upstream end of Schneider Creek. Although the facility is undersized per current standards for the basin it serves, it provides significant removal of Total Suspended Solids. The facility could be expanded to treat more of the contributing drainage basin, by adding more StormFilter vaults at this same site, or at an adjacent location.

7. Implementation

Costs

Part of the evaluation included assessing the cost of implementing the BMPs. Due to the scope of the evaluation, costs data collected in a literature review of published information was used as the basis for the BMP cost estimate. The sources of the cost data include documents titled “Puget Sound Stormwater Retrofit Cost Estimate” (PSP 2010) and “Costs of Stormwater Management Practices In Maryland Counties” which contain installation costs for BMPs for treating a unit impervious acre. Costs from similar projects in western Washington were also used. The summary of this data is presented in the Stormwater Retrofit Treatment Opportunities Cost Ranges in Attachment 2. The cost per impervious surface ranges that were used are summarized in Table 7.

Table 7 - Construction Cost Ranges for Stormwater Retrofits

	Cost Per Impervious Acre Treated	
Technology	Low	High
StormFilter + CDS (1)(2)	$26,000.00	$39,000.00
Filterra (3)(4)	$28,000.00	$58,000.00
Bioretention/LID (1)(2)	$32,500.00	$48,750.00

(1)Low Range Based on Average Stormwater Retrofit costs plus 30% from the DRAFT - Puget Sound Stormwater Retrofit Cost Estimate Appendix A
(2)High Range Based on 1.50 times the low cost

(3)Filterra Cost Low Range cost based on 2014 projects sized for Basic Treatment (70.92 In/hr sizing)

(4)Filterra High Cost Range based on similar projects sized for Enhanced Treatment (24.82 in/hr); also meets phosphorus and oil treatment

Cost ranges were calculated for each stormwater opportunity and are included in the Stormwater Opportunity Table.

A cost for treatment of each segment of West Bay Drive, correlating to each of the restoration assessment reaches, was also calculated. The road area of each of these segments was found by multiplying the road segment length by a 30 feet assumed road width. This area was then multiplied by the cost per impervious area treated for Filterra treatment, to arrive at an estimate of the cost to treat each segment of West Bay Drive. There are many assumptions built into this estimate that were not further evaluated, such as how the topography of each segment of West Bay Drive correlates with the reach boundaries. These costs are calculated per unit area and represent the relative cost for treatment of each segment of West Bay Drive. Further evaluation would be needed to achieve more precise costs. The cost of roadside BMPs also assumes there is existing stormwater infrastructure to split the stormwater flow from and/or tie the BMP outlets into. This assumption was not further evaluated for this cost estimate, however there appears to be many locations along West Bay Drive where stormwater infrastructure is available for potential connections. These costs are presented in the Conceptual Stormwater Treatment Opportunities Matrix, Attachment 1.

Recommendations for Future Analysis

Properties that are redeveloped will be required to meet stormwater requirements for the redevelopment sites. As restoration, cleanup, re-development, and/or public works projects are implemented, the City and other parties should collaborate on potential joint water quality treatment opportunities that can benefit both parties. This is not to preclude onsite stormwater treatment requirements, but to encourage projects where the private and public water quality needs can be achieved together, such as easement or maintenance agreements for stormwater treatment facilities.

- Data needs
  - The Port of Olympia sediment report mentions future work could include collecting additional source characterization samples at several locations in the vicinity of the Study Area based on the presence of elevated surface concentrations near outfalls, which may include catch basin solids or sediment traps to determine if suspended solids with elevated pollutant concentrations are entering Budd Inlet from the stormwater system. (Port of Olympia, 2014).
  - Additional sampling may be appropriate to identify specific pollutants at specific sites
- During the desktop analysis errors in the delineations were noticed which result in incorrect sub-basin tributary areas. If further design for BMPs is planned on a sub-basin level, the sub-basin delineations will need to be verified to be sure the tributary areas are correct for sizing BMPs.
- Preliminary Engineering for site-specific retrofit opportunities should consider:
  - Availability of existing stormwater infrastructure, depth, etc.
  - Maintenance access and safety
  - Permitting
- Other strategies to improve water quality could include Basin-wide and non-structural programs such as:
  - Pet waste
  - Street sweeping
  - Encourage property owners to install bioretention systems to reduce runoff volumes, particularly in Schneider Creek Basin

Conclusions and Findings

Based upon limited field investigation and review of available data, the study identified numerous stormwater outfalls within the study area that discharge untreated into Budd Inlet, carrying pollutants which are detrimental to the species in that nearshore environment. The Conceptual Stormwater Analysis evaluated stormwater retrofit technologies and techniques that can be applied throughout West Bay, and identifies retrofit opportunities at stormwater outfalls, upland areas within the basin, and reaches along West Bay Drive.

Many of the identified outfalls have constraints that preclude practical end-of-pipe retrofits, including terrain slope, available area for treatment, etc. Additionally, the scale of retrofits needed to treat stormwater flowrates from the large tributary basins along West Bay makes end-of-pipe retrofits impractical to implement. However, the study did identify certain stormwater outfalls with smaller drainage basins that have the potential for end-of-pipe, or near end-of-pipe, water quality retrofits.

Upland stormwater retrofits offer more feasible scale projects to treat sub-basins within larger basins that discharge into West Bay, particularly for Garfield Creek and Schneider Creek. Upland retrofits can be scaled or replicated to achieve additional water quality benefits within other areas of the basin as feasible.

Collection and treatment of stormwater from portions of West Bay Drive also provides retrofit opportunities throughout the project area. These opportunities focus on treating concentrated stormwater at the source locations within the basin, as opposed to treating comingled stormwater and creek flow.

8. Glossary & Acronyms

Acronyms

BMP	Best Management Practice
CDS	Continuous Deflective Separation
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DO	Dissolved Oxygen
DOE	Department of Ecology
EPA	Environmental Protection Agency
GSI	Green Stormwater Infrastructure
GIS	Geographical Information System
GULD	General Use Level Designation
IP	Implementation Plan
LID	Low Impact Development
MWS	Modular Wetland System
NPDES	National Pollution Discharge Elimination System
PAHs	Polyaromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PSP	Puget Sound Partnership
TAPE	Technology Assessment Protocol - Ecology
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
WLA	Waste Load Allocation
ZPG	Zeolite, Perlite, and Granular Activated Carbon (GAC) Media

Glossary

303(d) List
The 303(d) List refers to a section of the Clean Water Act that comprises of impaired waterways. Pollution in these bodies of water impacts the applicable water quality standard for its designated use, such as drinking, aquatic habitat, or recreation. Bodies of water can eventually be removed from the list after a TMDL is developed, or changes are implemented to positively affect the water quality.

Best Management Practices (BMPs)
Includes schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent, eliminate, or reduce the pollution of waters of the receiving waters. BMPs also include treatment requirements, operating procedures, and practices to control runoff, spillage, or leaks.

Nonpoint Source Pollution
Pollution that does not come from a point source. Nonpoint source pollution originates from diffuse sources that are mostly related to land use.

Outfall
The end point where storm drains discharge water into a waterway.

Point Source
Any discernible, confined, and discrete conveyance from which pollutants are or may be discharged.

TMDL – Total Maximum Daily Load
The TMDL program was specifically developed to restore impaired waterways. It is used to describe the maximum amount of a pollutant a waterbody can receive and still meet water quality standards. TMDL's are developed for a number of water quality impairments including fecal/bacteria, sediment, nutrients (such as Phosphorus and Nitrogen), metals (such as Copper and Zinc), temperature, and pH.

TSS – Total Suspended Solids
Used to describe the amount of solids suspended/transported in runoff. TSS is currently the most commonly regulated stormwater pollutant.

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Attachments

Attachment 1 - Conceptual Stormwater Treatment Opportunities Matrix
Attachment 2 - Stormwater Retrofit Treatment Opportunities Cost Ranges

ATTACHMENT 1 - CONCEPTUAL STORMWATER TREATMENT OPPORTUNITIES MATRIX

Project: West Bay Environmental Restoration Assessment
Owner: City of Olympia
Consultant: Davido Consulting Group, Inc
Description: Matrix of conceptual stormwater treatment opportunities
Date Revised: 2/17/2016
Revised By: AB, TB

	Cost Per Impervious Acre Treated	
Technology	Low	High
StormFilter + CDS [(1)(2)]	$ 26,000.00	$ 39,000.00
Filterra [(3)(4)]	$ 28,000.00	$ 58,000.00
Bioretention/LID [(1)(2)]	$ 32,500.00	$ 48,750.00

[(1)] Low Range Based on Average Stormwater Retrofit costs plus 30% from the DRAFT - Puget Sound Stormwater Retrofit Cost Estimate Appendix A

[(2)] High Range Based on 1.50 times the low cost
[(3)] Filterra Cost Low Range cost based on 2014 projects sized for Basic Treatment (70.92 In/hr sizing)

[(4)] Filterra High Cost Range based on similar projects sized for Enhanced Treatment (24.82 in/hr); also meets phosphorus and oil treatment

SW Opp #	Reach Area Label	Total Trib Area to outfall (acres)	Tributary Area for Treatment (acres)	Basin Zoning Type (per 2015 Zoning Map)	Area of Parcel (acres)	Outfall or BMP Location Property Owner	Predominant Flow	Potential WQ BMP	Maintenance Access	Planning Level Cost Estimate Range - Low	Planning Level Cost Estimate Range - High	Notes
1	Reach 1 - Lagoon [(a)]	107.40	24.09	SF Residential, High Density Corridor, Office/Multi-family	0.24	City of Olympia	Storm	Emerging Technology	Yes. Right of Way in upland location	$ 627,000	$ 940,000	The City of Olympia has applied for grant funding for a retrofit to treat 24 acres of the basin at this location. See also Opportunity # 12, another upland retrofit location for portions of basin as separate project.
2	Reach 1 - Lagoon	12.83	12.83	SF Residential, Office/Multi-family, High Density Corridor	1.90	Fourth Street Investors LLC	Storm	Emerging Technology	Yes. If BMP is near West Bay Dr	$ 334,000	$ 501,000	
3	Reach 2 - West Bay Park (South stem of Garfield Creek)	14.25	Refer to Opportunity 17b	SF Residential, Multi-family Residential	12.75	City of Olympia	Storm and some base flow	Emerging Technology in upland area and West Bay Drive.	Feasible	Refer to Opportunity 17b	Refer to Opportunity 17b	
4	Reach 2 - West Bay Park (Garfield Creek) [(a)]	73.93	Refer to Opportunities 13, 14, and 17b	SF Residential,	12.75	City of Olympia	Creek and Storm	Emerging Technology in upland area and West Bay Drive.	Feasible	Refer to Opportunities 13, 14, and 17b	Refer to Opportunities 13, 14, and 17b	
5	Reach 3 - Port Tidelands (West Bay Park North) [(a)]	54.97	18.14	SF Residential, Office/Multi-family	12.75	City of Olympia	Storm	Emerging Technology (under ground) at West Bay Park to treat a portion of basin.	Yes	$ 472,000	$ 708,000	Conceptual layout for this location shows a BMP scaled for treatment of 33% of the basin. Alternatively, upland treatment retrofit for portions of the basin could be implemented.
5.5	Reach 3 - Port Tidelands (Outfall South of Reliable Steel) [(a) (b)]	31.00	Refer to Opportunity 17c	SF Residential, Office/Multi-family	1.28	Port of Olympia	Storm & Creek	Likely upland treatment or West Bay Drive Treatment.	No	Refer to Opportunity 17c	Refer to Opportunity 17c	The tributary area assigned to this outfall is a portion of the 61 acre sub-basin from GIS, which is more representative of the actual tributary area to this outfall.
6	Reach 4 - Reliable Steel	13.00	13.00	SF Residential, Office/Multi-family	3.53	Drogba LLC	Storm & Creek	Potential Green BMP with Restoration Project	Feasible. Dependant on future development.	$ 423,000	$ 634,000	The tributary area assigned to this outfall is a portion of the 61 acre sub-basin from GIS, which is more representative of the actual tributary area to this outfall.
6.5	Reach 5 - Hardell (missing outfall)	9.00	9.00	SF Residential, Office/Multi-family	7.00	Hardel Mutual Plywood Corp	Storm & Creek	Emerging Technology or Green BMP	Feasible. Dependant on future development.	$ 234,000	$ 351,000	The tributary area assigned to this outfall is a portion of the 61 acre sub-basin from GIS, which is more representative of the actual tributary area to this outfall.
7	Reach 5 - Hardell (a) (b)	30.71	30.71	SF Residential, Office/Multi-family	7.00	Hardel Mutual Plywood Corp	Storm & Creek	Emerging Technology or Upland BMPs	Feasible. Dependant on future development.	$ 799,000	$ 1,198,000	

SW Opp #	Reach Area Label	Total Trib Area to outfall (acres)	Tributary Area for Treatment (acres)	Basin Zoning Type (per 2015 Zoning Map)	Area of Parcel (acres)	Outfall or BMP Location Property Owner	Predominant Flow	Potential WQ BMP	Maintenance Access	Planning Level Cost Estimate Range - Low	Planning Level Cost Estimate Range - High	Notes
8	Reach 6 - Schneider Creek (a)	662.00	20.00	SF Residential, Multi-family, High Density Corridor, Office/Multi-family	1.35	Squaxin Island Tribe	Creek with Storm outfalls in upper basin	Due to subbasin size, upland treatment for water quality. Recommend BMPs that also address flow control. Emerging Technology or Green BMP	Yes	$ 650,000	$ 975,000	Cost reflects a potential water quality retrofit for a 20 acre basin within watershed; location not identified. This could be scaled/replicated within other areas of the watershed. Potential creek daylighting or creek channel improvements not included in cost. Cost based on LID.
9	Reach 7 - Delta Illahee	20.32	20.32	SF Residential,	2.33	Delta Illahee Limited Partnership	Storm	Upland treatment	Yes	$ 529,000	$ 793,000	
10	Reach 8 - Marina	9.00	9.00	SF Residential, Industrial	9.00	Dunlap Towing Co	Storm & Creek	Future onsite BMPs	Yes	$ 234,000	$ 351,000	On-site treatment by developer when/if redevelopment occurs.
11	Reach 9 - Dunlap Log Handling	14.81	14.81	SF Residential, Industrial	14.81	Dunlap Towing Co	Storm & Creek	West Bay Drive Treatment or future onsite BMPs	Yes	$ 386,000	$ 578,000	Potential to reduce sediment track-out from parcel onto publicly-owned roadways.
12	Reach 1 (upland) - 4th Ave	76.22	76.22	SF Residential, Office/Multi-family, Multi-family,	ROW	ROW - City of Olympia	Storm	Emerging Technology	Yes	$ 1,982,000	$ 2,973,000	
13	Reach 2 (upland) - Madison Ave NW & Percival St NW	28.00	28.00	SF Residential, Office/Multi-family, Multi-family,	ROW	ROW/Park - City of Olympia	Storm	Emerging Technology	Yes	$ 728,000	$ 1,092,000	
14	Reach 2 (upland) - Madison Ave NW & Thomas St NW	22.00	22.00	SF Residential,	0.38	ROW/Park - City of Olympia	Storm	Emerging Technology	Yes	$ 572,000	$ 858,000	
15	Reach 3 (upland) - Brawne Ave NW & Foote St NW	44.97	44.97	SF Residential,	ROW	ROW - City of Olympia	Storm	Emerging Technology	Yes	$ 1,170,000	$ 1,754,000	
16	Reach 5 (upland) Woodard Ave NW & West Bay Dr	24.71	24.71	SF Residential,	ROW	ROW - City of Olympia	Storm	Emerging Technology	Yes	$ 643,000	$ 964,000	
17	West Bay Drive	ROW	Refer to Opportunities 17a-17h	SF Residential, Office/Multi-family, Industrial	ROW	ROW - City of Olympia	Storm	Emerging Technology or Green BMP	Yes	Refer to Opportunities 17a-17h	Refer to Opportunities 17a-17h	
17a	Reach 1 - Lagoon (West Bay Drive Roadway)	ROW	0.67	SF Residential, Office/Multi-family, Industrial	ROW	ROW - City of Olympia	Storm	Emerging Technology or Green BMP	Yes	$ 19,000	$ 39,000	
17b	Reach 2 - West Bay Park (West Bay Drive Roadway)	ROW	0.97	SF Residential, Office/Multi-family, Industrial	ROW	ROW - City of Olympia	Storm	Emerging Technology or Green BMP	Yes	$ 28,000	$ 57,000	
17c	Reach 3 - Tidelands (West Bay Drive Roadway)	ROW	0.74	SF Residential, Office/Multi-family, Industrial	ROW	ROW - City of Olympia	Storm	Emerging Technology or Green BMP	Yes	$ 21,000	$ 44,000	
17d	Reach 4 - Reliable Steel Prop. (West Bay Drive Roadway)	ROW	0.35	SF Residential, Office/Multi-family, Industrial	ROW	ROW - City of Olympia	Storm	Emerging Technology or Green BMP	Yes	$ 10,000	$ 21,000	
17e	Reach 5 - Hardell Prop. (West Bay Drive Roadway)	ROW	0.68	SF Residential, Office/Multi-family, Industrial	ROW	ROW - City of Olympia	Storm	Emerging Technology or Green BMP	Yes	$ 20,000	$ 40,000	
17f	Reach 6 - Schneider Creek (West Bay Drive Roadway)	ROW	0.65	SF Residential, Office/Multi-family, Industrial	ROW	ROW - City of Olympia	Storm	Emerging Technology or Green BMP	Yes	$ 19,000	$ 38,000	
17g	Reach 7 - Delta Illahee (West Bay Drive Roadway)	ROW	0.51	SF Residential, Office/Multi-family, Industrial	ROW	ROW - City of Olympia	Storm	Emerging Technology or Green BMP	Yes	$ 15,000	$ 30,000	
17h	Reaches 8, 9 (West Bay Drive Roadway North of Schnieder Hill Road NW)	ROW	0.18	SF Residential, Office/Multi-family, Industrial	ROW	ROW - City of Olympia	Storm	Emerging Technology or Green BMP	Yes	$ 5,000	$ 11,000	

SW Opp #	Reach Area Label	Total Trib Area to outfall (acres)	Tributary Area for Treatment (acres)	Basin Zoning Type (per 2015 Zoning Map)	Area of Parcel (acres)	Outfall or BMP Location Property Owner	Predominant Flow	Potential WQ BMP	Maintenance Access	Planning Level Cost Estimate Range - Low	Planning Level Cost Estimate Range - High	Notes
18	Giles stormwater treatment facility (a)	196.05	196.05 (a)	SF Residential, Multi-family, High Density Corridor, Office/Multi-family	Location TBD	Location TBD	Storm	Additional StormFilter or other Emerging Technology	Yes	$ 700,000	$ 1,050,000	Potentially doubling the existing BMPs at the Giles Facility. Since there is an exisiting BMP in place, the portion of the tributary area for which the existing CDS + StormFilter BMP currently treats is credited towards tributary area upland of this BMP location, and can be deducted from the tributary area to this location. Cost based on doubling the bid price for the Pacific Avenue stormwater facility, and does not correspond to treatment of the entire basin to 91% average annual volume.

[a] Drainage basin too large for treatment with one retrofit project; treatment of a portion of flows, or treatment at multiple sites with smaller catchment areas recommended

[b] Outfall flows include concentrated stormwater runoff and other sources such as seasonal streams and/or seeps; treatment of concentrated stormwater runoff at other (upland or roadway) sites recommended

ATTACHMENT 2 - SUPPORTING INFORMATION FOR CONCEPTUAL COST ESTIMATE RANGES

SUPPORTING INFORMATION FOR CONCEPTUAL COST ESTIMATE RANGES

Project: West Bay Environmental Restoration Assessment
Owner: City of Olympia
Consultant: Davido Consulting Group, Inc
Description: Average cost from research for stormwater treatment BMPs
Date Revised: 12/11/2015
Revised By: AB, TB

Stormwater Retrofit Treatment BMP	End of Pipe Retrofit	Upland Basin Retrofit	Point Source BMP	Type (above or below ground)	Cost Per Impervious Acre Treated	Cost Estimate Source
Infiltration		X		b	-	
Biofiltration Swale or Filter Strip		X		a	-	
Filtration Media	X	X	x	b	-	
Rain Gardens or Bioretention		X	x	a	$ 25,000.00	1
Wetponds	X	X	x	a	$ 28,000.00	1
Wetvaults	X	X	x	b	$ 61,000.00	1
Stormwater Treatment Wetland	X	X	x	a	$ 65,998.00	2
BayFilter®	X	X	x	b	$ 26,000.00	1
MWS - Linear Modular Wetland	X	X	x	a	-	
Filterra® System	X	X	x	b	$ 23,000.00	1
Filterra® Boxless™	X	X	x	b	-	
Media Filtration System (MFS)	X	X	x	b	$ 20,000.00	1
Stormfilter® using ZPG Media	X	X	x	b	$ 20,000.00	1
FloGard Perk Filter®	X	X	x	b	$ 41,000.00	1
ecoStorm plus®	X	X	x	b	$ 52,000.00	1
Compost-Amended Biofiltration Swale		X	x	b	-	
Media Filter Drain		X		b	-	
Sand Filter	X	X	x	b	-	
Porous Pavement		X		b	-	
Street Sweeping		X		a	-	

Source Documents
1 - DRAFT - Puget Sound Stormwater Retrofit Cost Estimate Appendix A
2 - Costs of Stormwater Management Practices In Maryland Counties

APPENDIX D

Lagoon Area Alternatives Summary Memo

City of Olympia, West Bay Environmental Restoration Assessment
Lagoon Alternatives Summary Memo

1 INTRODUCTION

This memorandum summarizes the development of four conceptual restoration alternatives and the evaluation of ecological and physical processes at the West Bay Lagoon as part of the West Bay Environmental Restoration assessment and in support of the West Bay Park Master Plan. Two of the restoration alternatives (Alt. 1 and Alt 2) were based upon modification of internal unpublished concepts previously developed by the City and provided to Coast & Harbor Engineering (CHE). Two other restoration alternatives (Alt. 3 and Alt. 4) were developed that envision a greater level of restoration and berm removal than previous concepts. Various alternatives for connecting recreational activity between Capitol Lake and West Bay Park were considered during conceptual design development and are presented herein.

The alternatives were evaluated using semi-quantitative and qualitative methods consistent with the overall restoration assessment for West Bay. In addition, a two-dimensional hydrodynamic model was developed and applied to allow for relative comparison of tidal circulation and exchange patterns between existing conditions and proposed conceptual design alternatives.

2 HISTORICAL AND EXISTING FUNCTIONS ANALYSIS

Analysis of historical and existing functions within the Lagoon was performed in parallel with review of the study along the west shore of West Bay. Primary sources of information included review of historical charts, maps, and oblique aerial photography available from the Port of Olympia (Port) and the Washington State archives. Key conclusions specific to the Lagoon area are provided below. Refer to the overall assessment report, Appendix B, for more detailed information.

- The railroad trestle along West Bay (including the current lagoon berm) changed hands several times, was abandoned in 1894, rebuilt by BNSF and rock/gravel fill placed to form the existing berm in the early 1970's. The railroad trestle/berm was not in industrial use after 1996.
- The lagoon area historically contained channels that drained the shallow Deschutes Estuary (now Capitol Lake).
- Modifications and fill along the west shore of the lagoon in the vicinity of the 4th and 5th avenue bridges have significantly altered tidal flow and circulations patterns.
- Areas located offshore of the lagoon (to the east) are significantly deeper than historic conditions.

3 RESTORATION ASSESSMENT

3.1 Habitat Restoration Alternatives Development

Per the scope of work, four lagoon alternatives were developed. For the first two alternatives, CHE reviewed and refined previous unpublished draft alternative configurations developed for the City by Anchor QEA. The second two alternatives were developed based upon new analysis and design concepts. The following summarizes the scope of work for developing lagoon alternatives. High resolution illustrative conceptual graphic plans showing restoration and recreation elements and sections of the lagoon concepts are included in Appendix A of the overall assessment report.

- Alt. 1. Current lagoon configuration with trail added on the existing berm and the two overwater spans.
- Alt. 2. Partial berm removal with new trail added on the remaining berm and new overwater sections.
- Alt. 3. Complete berm removal with new trail added on an overwater structure.
- Alt. 4. Complete berm removal with no overwater trail.

Note that based upon feedback and discussion with stakeholders (Port, City, Tribe) the assessment developed a slight variation of Alternative 3, where a portion of the berm remained but the top elevation was removed down to the intertidal zone to allow for marsh development and tidal exchange.

Multi-modal trail options compatible with the restoration alternatives were also developed. These include: route along the existing railroad berm with varying type depending on restoration work, route along the west shoreline bluff and adjacent toe of slope in existing city ROW, and routing the trail entirely along West Bay Drive with appropriate ROW improvements. Trail options are discussed in more detail in Section 3.3.1.

Like the overall assessment, concepts were developed to respond to the ecological needs identified by review of historic and existing conditions and as identified in the project criteria (see Appendices of the overall assessment report). At the lagoon, this strategy revolves around reconnection of riparian and intertidal habitats, restoration of intertidal areas through removal of historical fill, placement of natural beach substrates at appropriate slopes and elevations, and creation of salt marsh in the upper intertidal zone. Additionally, the lagoon area presents a unique opportunity to improve tidal flushing and circulation.

Primary opportunities for restoration in the lagoon include removal of historic fill to improve tidal circulation and flushing, beach creation, salt marsh creation, and stormwater quality improvements. The Shoreline Restoration Plan (City of Olympia 2012) identifies West Bay Project No. 9 in this reach as potential restoration of functional riparian area along the existing berm.

3.2 Description of Lagoon Concepts

3.2.1 Existing Conditions

The Lagoon reach is located at the southern extent of the study area and is characterized by a former railroad trestle and gravel berm that separates the shallow lagoon from West Bay. The west shore contains steep slopes and intact riparian areas, fronted by sparse salt marsh. Tidal communication between West Bay and the lagoon currently occurs via two openings in the berm. Property ownership includes the Port, City, and private landowners. The lagoon supports a wide variety of shorebirds and waterfowl (Morse 2002). Due to its shallow nature, the lagoon wets and dries during the tidal cycle and is filled and drained by a small number of tidal channels that communicate through the berm openings. Figure 1 shows the existing lagoon conditions from aerial photography.

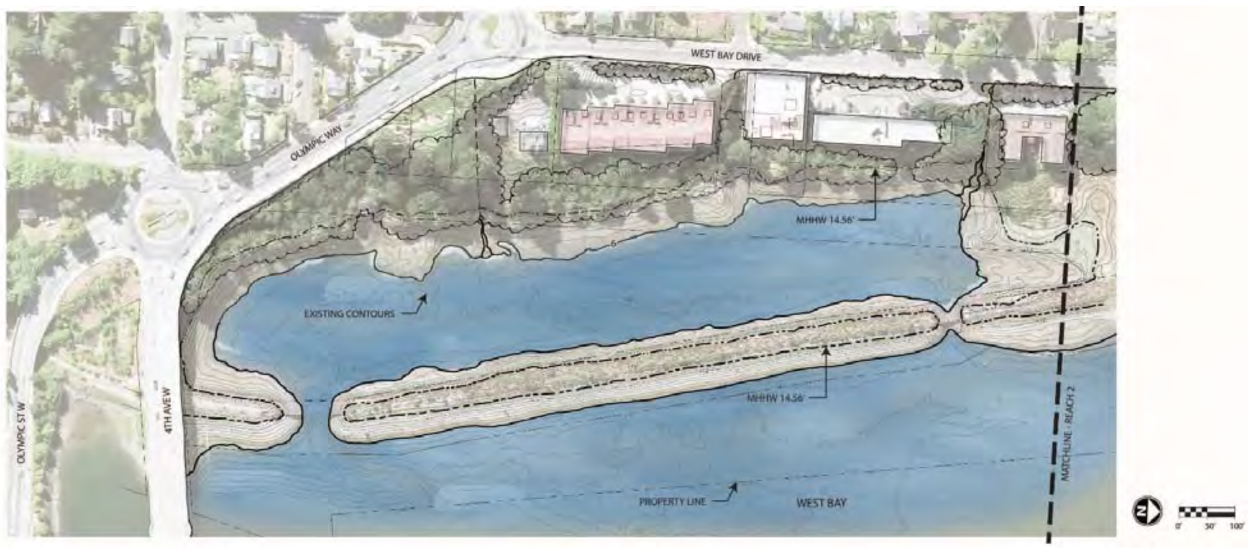

Figure 1. Existing Lagoon conditions.

3.2.2 Alternative 1

Alternative 1 seeks to remove a minor amount of historic fill from the berm and expand the existing north and south openings to approximately 100 feet wide at the mudflat elevations. In this alternative, the existing beach and marsh along the berm would be enhanced through natural beach substrate placement, grading, and plantings. Nearly all of the excavated berm material would be reused in the lagoon. Additionally, riparian areas would be enhanced and expanded and the upland nature of the existing berm would remain essentially intact. Figure 2 below provides a snapshot of the alternative; high quality graphics are found in Appendix A.

Figure 2. Lagoon Alternative 1.

3.2.3 Alternative 2

Alternative 2 seeks to remove a moderate amount of historic fill from the berm by two creating additional openings (approximately 50 feet wide at mudflat elevations) and expanding the existing openings in the berm to approximately 100 feet wide. In this alternative, the existing beach and marsh along the remaining berm would be enhanced and expanded through natural beach substrate placement, reuse of approximately 30% of excavated berm materials, grading, and plantings. Additionally, riparian areas on the berm would be enhanced and expanded and the upland nature of the remaining existing berm segments would remain essentially intact. Shoreline edge length and berm complexity would increase and support improved fish and wildlife use. Finally, excess materials removed from the berm and imported habitat substrate would be placed along the west shore to enhance beach and marsh areas. Figure 3 below provides a snapshot of the alternative; high quality graphics are found in Appendix A. About 13,000 CY of excavated berm material would be available for reuse elsewhere within the project areas.

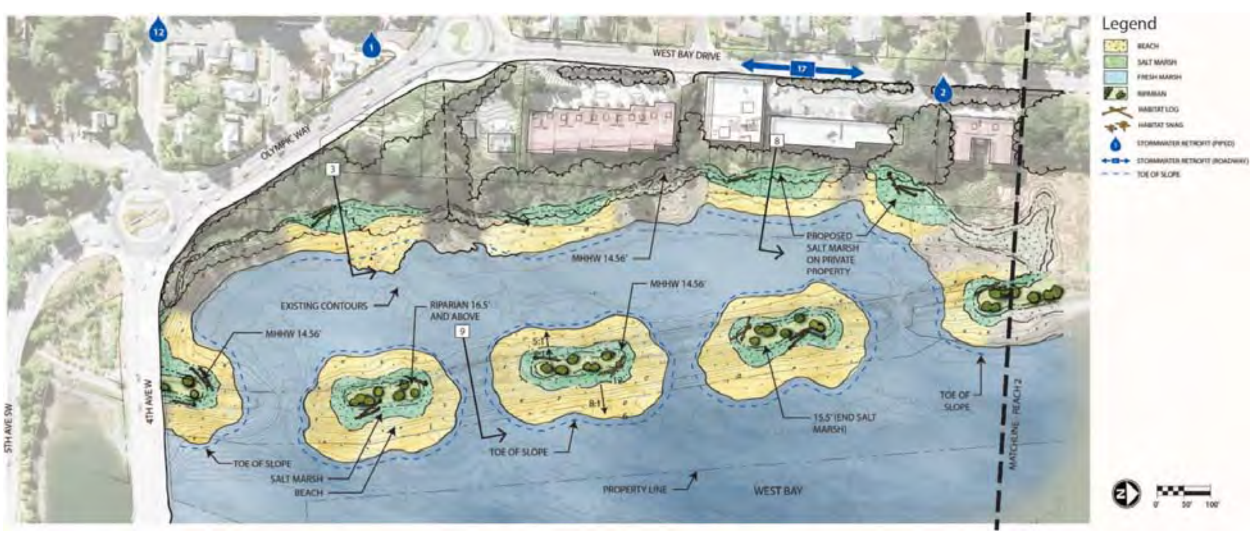

Figure 3. Lagoon Alternative 2.

3.2.4 Alternative 3

Alternative 3 seeks to remove approximately 500 feet of the southern berm down to existing mudflats elevations and cut down the elevation of the remaining berm to intertidal elevation range to support salt marsh development. The existing northern berm opening would be enlarged to approximately 100 feet at mudflat elevations. In this alternative, the existing beach and marsh along the south and west shore would be significantly enhanced and expanded through natural beach substrate placement, reuse of approximately 20% of the excavated berm materials, imported habitat substrate, and plantings. Materials would also be placed along the southern portion of the lagoon to expand intertidal beach and marsh habitat, while buffering potentially increased wave erosion due to berm removal. If material cannot be placed to create marsh along the northwest shore (privately held), material could be placed at the southern end of the lagoon alternatively. Figure 4 below provides a snapshot of the alternative; high quality graphics are found in Appendix A. About 14,500 CY of excavated berm material would be available for reuse elsewhere within the project areas.

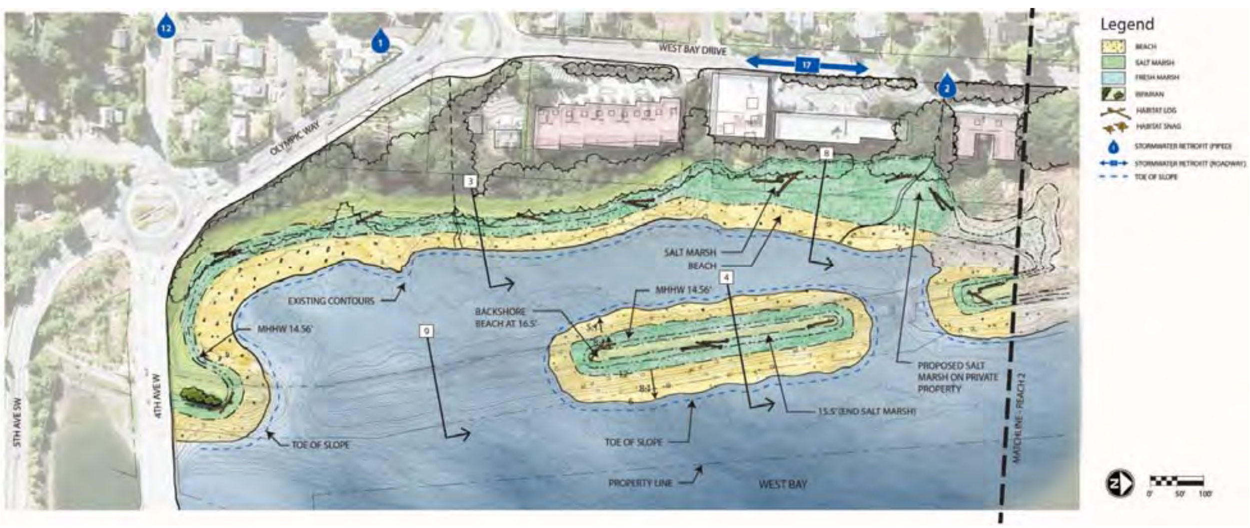

Figure 4. Lagoon Alternative 3.

3.2.5 Alternative 4

Alternative 4 removes the entire existing berm (approximately 1,100 feet) down to existing mudflats elevations to fully reconnect the mudflats and shorelines with West Bay. In this alternative, the existing beach and marsh along the south and west shore would be enhanced and expanded through natural beach substrate placement, reuse of a very small amount (less than 5%) of the excavated berm materials, and plantings. Materials would also be placed along the southern portion of the lagoon to expand intertidal beach and marsh habitat, while buffering potentially increased wave erosion due to berm removal. If material cannot be placed to create marsh along the northwest shore (privately held), material could be placed at the southern end of the lagoon alternatively. Figure 5 below provides a snapshot of the alternative; high quality graphics are found in Appendix A. Significant excess berm material (about 50,000 CY) would be available for reuse elsewhere within the project areas.

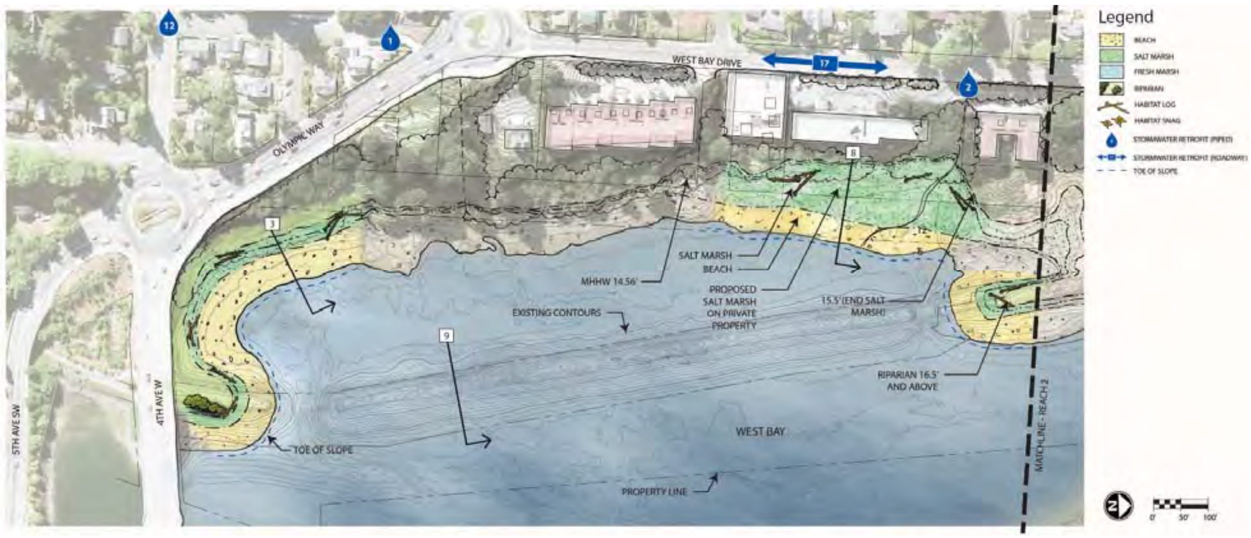

Figure 5. Lagoon Alternative 4.

3.3 Public Access and Recreation

Based on feedback from stakeholders, the restoration and recreation elements were partially de-coupled to allow for a direct assessment of restoration value. Additionally, multiple trail opportunities were developed that are compatible, conceptually, with multiple restoration alternatives. For Alternatives 3 and 4, where no upland berm remains, numerous trail options are feasible including land-based trails along the roadway, fully overwater spans along the existing berm alignment, and trails along the west shore of the lagoon. Illustrative plans and sections of recreation elements, including trail options, are included in Appendix A of the overall assessment report.

3.3.1 Potential Trail Options

There are a variety of trail options are possible for linking the Capitol Lake Trail and/or downtown with West Bay Park. The following alternative trail types and alignments can be mixed and matched with the four lagoon restoration options. The lagoon restoration designs may require modification of the extent and type of trail, if any.

- Trail within the old rail line corridor (e.g. berm): This alignment can be a combination of at-grade asphalt trail and over-water boardwalk/structure or only over-water boardwalk depending on restoration work.
- Trail along the western perimeter of the lagoon: This alignment may combine boardwalk in uplands or over marsh with an at-grade asphalt trail on top of riparian and beach substrate at the base of the bluff. If no riparian and beach substrate is placed at the base of the bluff, this portion of the trail would also be a boardwalk. This trail alignment is located in the City ROW along the west and northwest margin of the lagoon.
- Trail from 4th Ave. Bridge along West Bay Drive: connecting to West Bay Park with stairs and an expanded sidewalk connection. This alignment requires significant ROW improvements (buffered multi-use path, bike lanes, planting strip, and retaining walls), possibly additional ROW in some sections, and transportation infrastructure related funding and planning. Details of the connection to downtown south of the Harrison Roundabout are beyond the scope of this study.

Figure 6 illustrates the range of conceptual trail options developed for Alt. 2, where blue indicates elevated boardwalk or elevated overwater structures, and orange illustrates at grade trails. Illustrative plans and sections of recreation elements, including trail option overlays for each restoration alternative, are included in Appendix A of the overall assessment report.

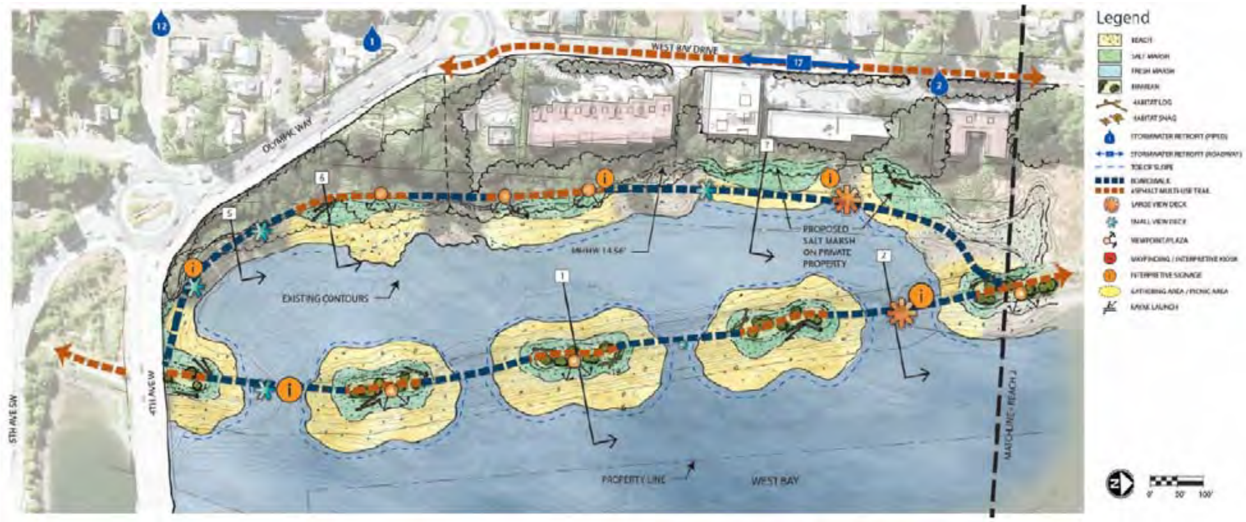

Figure 6. Illustration of potential lagoon trail options for Alternative 2.

4 COMPARISON OF ALTERNATIVES

Evaluation of potential restoration alternatives for the lagoon included semi-quantitative and qualitative measures. When taken together, these evaluation measures provide a science-based approach to facilitate discussion and decision-making, while also considering the inherent uncertainties, stakeholder experience, and professional judgement that are needed to produce a restoration strategy for West Bay. Methodologies were the same as applied for the overall West Bay assessment. Conceptual costs were developed for conceptual restoration, recreation, and potential stormwater improvements.

4.1 Semi-Quantitative Evaluation Framework

The Semi-Quantitative evaluation and ranking of the habitat benefits for each conceptual alternative was accomplished using a habitat value quantification model based on existing marine and estuarine habitat equivalency analysis methodologies. Refer the overall assessment report for more information on the methodologies applied. The following Table 1 summarizes the result of the analysis for only the lagoon alternatives. The entirety of the lagoon area, including existing mudflats, were considered as part of affected area to account for improvements to circulation and sediment processes over this area. Note that cost per habitat point metric includes only restoration elements. Alternative 4 ranks consistently highest (Rank 1) while Alternative 1 ranks consistently lowest (Rank 4) across all methodologies. This is due in large part to the improved function in the shallow intertidal areas related to removal of the berm and anticipated improvement in tidal circulation, sediment flux, exchange, and connectivity described below.

Table 1. Combined semi-quantitativeresults for lagoon restoration alternatives.

Alternative	Total Habitat		Habitat Points/Acre		Cost / Habitat Point	
	Score	Rank	Score	Rank	Score	Rank
Alt. 1	81.34	4	5.43	4	$ 78,707	4
Alt. 2	191.07	2	12.29	2	$ 43,277	1
Alt. 3	157.33	3	10.18	3	$ 56,938	3
Alt. 4	266.94	1	17.37	1	$ 52,884	2

4.2 Qualitative Evaluation Framework

4.2.1 Qualitative Metrics

The qualitative evaluation framework provides the opportunity to consider important restoration elements that are difficult to quantify and not easily incorporated numerically. Refer the overall assessment report for more information on the methodologies applied. Qualitative metrics established for the overall assessment were adopted, and scored on a linear scale of none (0), low (1), medium (2), high (3), exceptional (4). The exceptional rating was included to recognize restoration opportunities that were unique amongst the reaches and alternatives. Table 2 summarizes results for the lagoon analysis.

Table 2. Summary of qualitative scoring based on the above metrics.

Site Alternative	Sediment Supply &Transport [SED]	Tidal Circulation + Flushing [CIRC]	Connectivity [CON]	Underrepresented habitats [HIS]	Resiliency [RES]	Deschutes Estuary Restoration [DES]	Phasing [PHS]	Recreation Compatibility [REC]	TOTAL
Lagoon Alt. 1	1	1	1	1	1	0	0	2	7
Lagoon Alt. 2	1	3	1	1	2	2	0	2	12
Lagoon Alt. 3	2	2	2	1	2	2	2	3	16
Lagoon Alt. 4	3	4	4	1	2	4	2	3	23

4.2.2 Hydrodynamic Modeling

Tidal flow hydrodynamic modeling was conducted to determine possible effects of proposed lagoon alternative design concepts on changes to circulation, velocity, inundation frequency, inundation duration, and overall flushing of the lagoon. Existing conditions and the four alternative conceptual design alternatives were evaluated. Modeling included restoration elements, but did not include the potential effects (likely minor) of overwater structures on tidal hydrodynamics. Modeling was conducted for existing Capitol Lake conditions and was reviewed for accuracy based on known tide levels, but was not calibrated with site specific measurements. Therefore, the value of the modeling application is greatest for evaluating the relative differences between alternatives and existing conditions.

4.2.2.1 Modeling Methodology

Numerical modeling of tidal flow circulation was conducted in two steps: (1) large (regional) grid numerical modeling; and (2) nested (local scale) grid numerical modeling. Step 1 modeling was conducted usingn a large scale three-dimensional (3-D) numerical model of the Puget Sound and adjacent Pacific Ocean. This modeling grid was previously developed and used by CHE for modeling and analysis of numerous projects throughout the Puget Sound. The model simulates tidal-driven circulation on a large modeling grid (see Figure) with 3-D SELFE numerical modeling code (Kivva et. al. 2006).

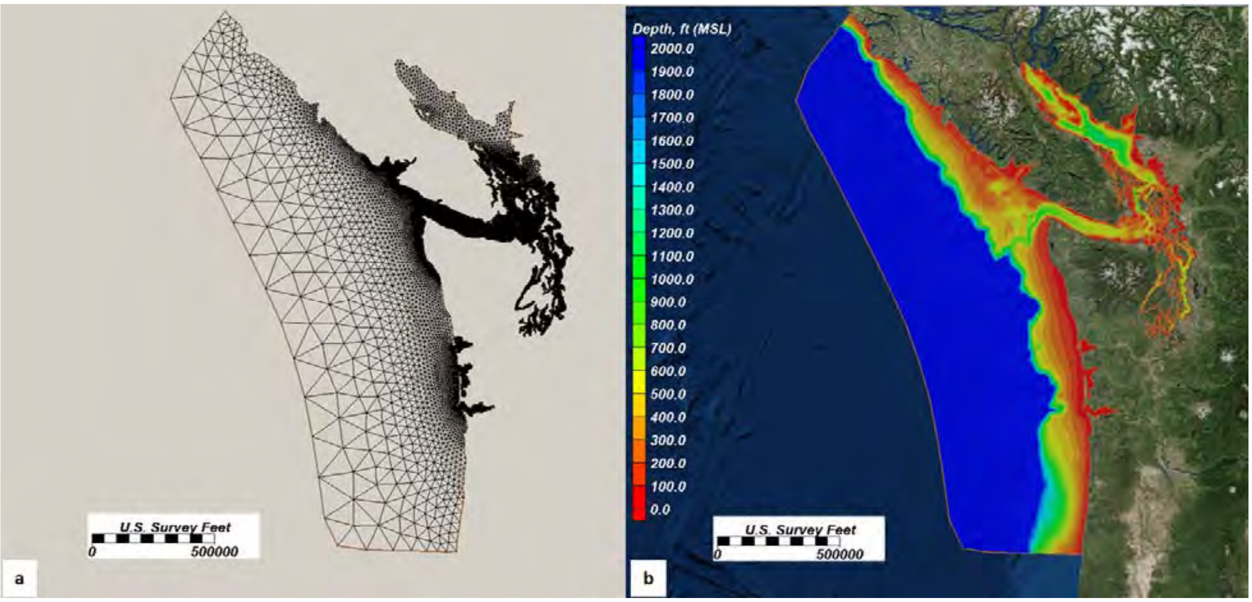

Figure 7. SELFE (a) numerical modeling grid and (b) bathymetry

The refined nested modeling grid was built from data sources including USGS digital elevation models (DEM), LiDAR surveys from 2011 obtained from the Puget Sound LiDAR Consortium, and NOAA navigation soundings from 1936, 1996, and 2005. Great care was taken to adequately resolve the modeling grid key features such as the lagoon, the berm, the adjacent channel from of Capitol Lake dam, and the shoreline along the proposed restoration area up to West Bay Marina. The model grid element resolution varies from approximately 4 feet along the lagoon berm and throughout the project area up to element size of approximately 315 feet at the mouth of Budd Inlet. Figure shows the complete nested modeling grid bathymetry in the project area.

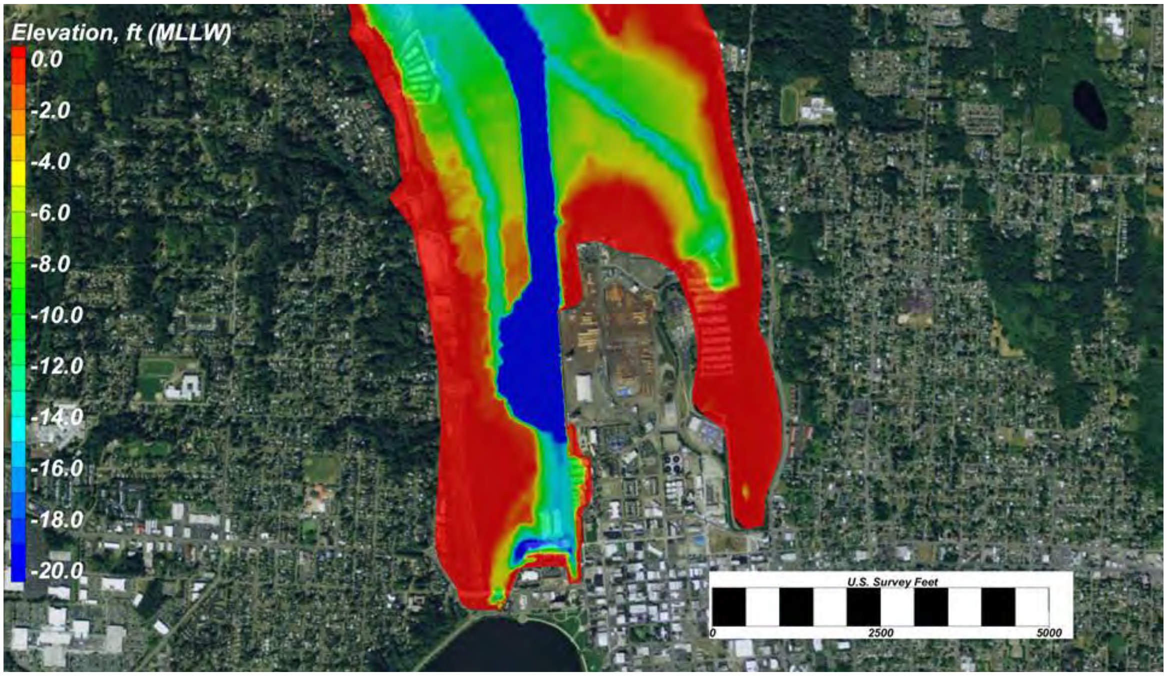

Figure 8. Nested local scale numerical model grid bathymetry; color indicates elevation.

Tidal flow circulation numerical modeling on the local scale grid was conducted with 2-D MORPHO numerical modeling code (Kivva *et al*. 2006). The output from the large numerical modeling with SELFE (Step 1) was applied as a boundary condition input to the nested model.

To model the proposed lagoon design alternatives, the existing conditions topographic and bathymetric model was modified to the proposed alternatives. Figure illustrates the geometry that was used to construct the typical beach and marsh profile into the topographic model and subsequently used for hydrodynamic modeling of the proposed alternative lagoon design conditions. The modeled footprints of the proposed riparian, marsh, and beach sections vary slightly with local elevations along the existing berm alignment. Elevations reference MLLW datum.

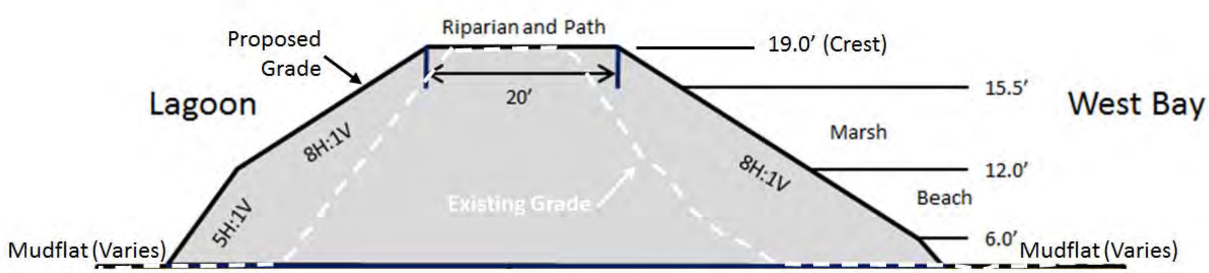

Figure 9. Typical cross-section of proposed berm for model grid (not to scale).

To represent berm removal, the model bathymetry was modified to match existing mudflat elevations, approximately 5 ft MLLW. Figure shows Lagoon Alternative 2 model bathymetry.

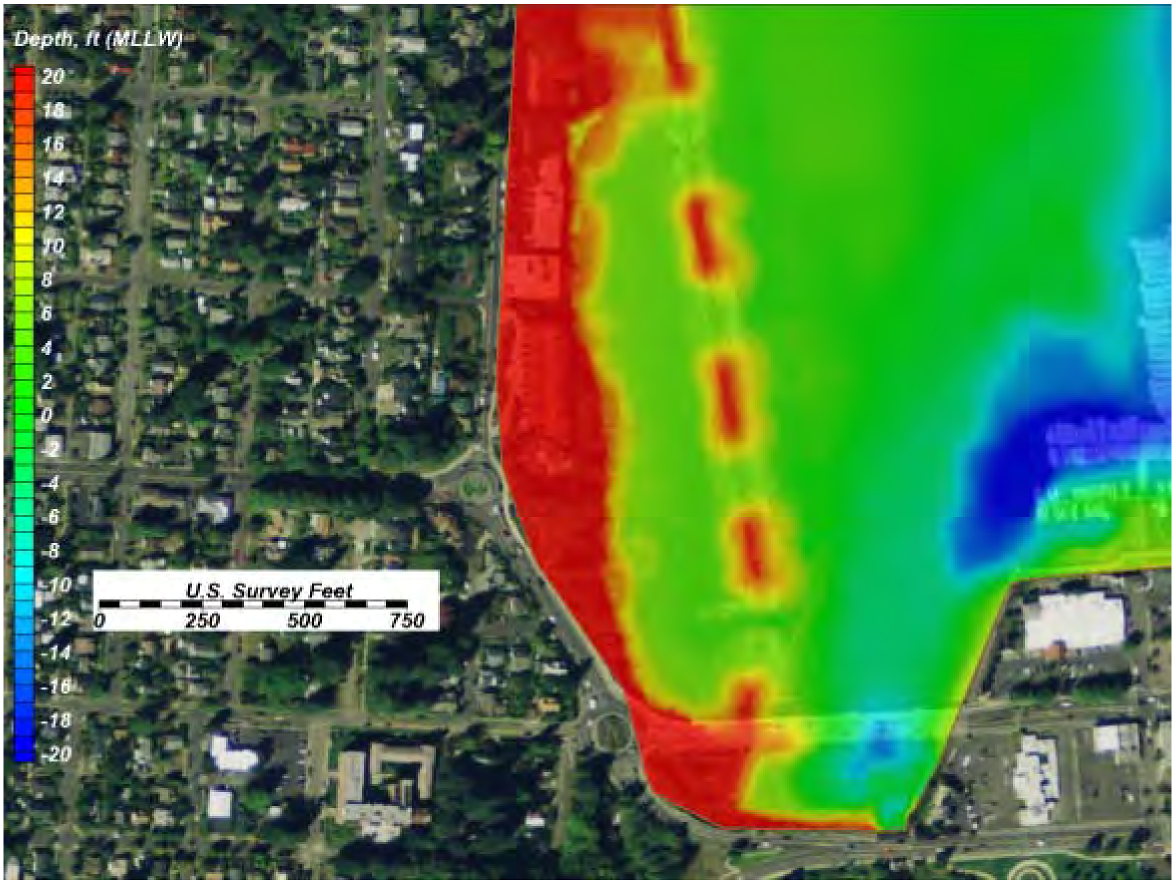

Figure 10. Model bathymetry for Lagoon Alternative 2.

4.2.2.2 Modeling Scenarios

Hydrodynamic modeling was conducted for existing conditions and four lagoon alternative conceptual designs. Each scenario included a 31 day simulation of a typical spring/neap tidal cycle.

Existing freshwater input from Capitol Lake was simulated as constant flow from the dam. The size and dimensions of the existing dam were determined from a USGS report that evaluated the impacts of dam removal on the lake and Budd Inlet (USGS 2006). The rate of flow was also taken from the USGS report and was assigned a constant value of 392 cubic feet /sec. (11.1 m^3/sec).

4.2.2.3 Modeling Results and Analysis

The output from local scale numerical model simulations included water surface elevations, depth-averaged flow velocities. Results were evaluated by analysis of changes in velocities throughout the lagoon and numerical dye tracer propagation in response to changes in the lagoon configuration. The flow velocity analysis included extraction and comparison analysis of modeling results at controlling stations. For all modeling scenarios, model stations were specified in the modeling domain at locations that are considered representative for analysis of potential changes and for evaluation of the conceptual design alternatives. The locations of the representative stations are shown and labeled in Figure .

Figure 11. Location of model stations used for stationary analysis.

4.2.2.4 Velocity Analysis

Figure 12 provides snapshots of depth-averaged velocities during a typical ebb tide for each alternative. Color indicates velocity magnitude and the arrow indicate direction of flow.

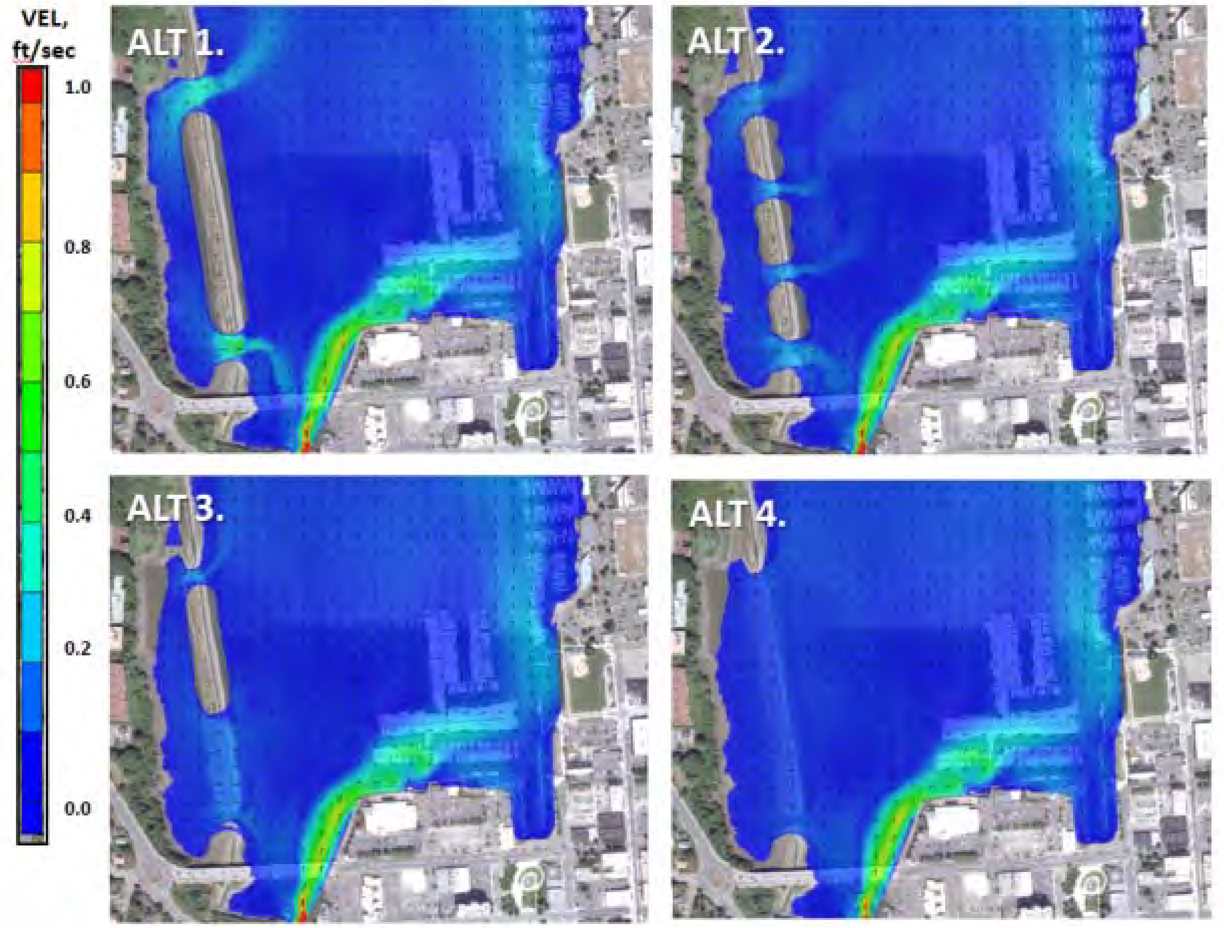

Figure 12. Snapshot of velocities for each alternative during ebb tide

Time series of velocities were extracted from the modeling results at the points shown in Figure . The extracted velocities as time-series are shown in Figure . Figure 12 and 13 show that velocities at locations 1 and 2 are much higher for the existing conditions and Alternative 1, 2, and 3 that have smaller gaps in berm. Figure 13 also show that Alternatives 2, 3, and 4 produce higher velocities in the middle of the lagoon, and that the flow velocities are more spatially uniform across the lagoon than for existing conditions and Alternative 1. Higher velocities may result in redistribution of fine sediment and slight coarsening of surface sediment.

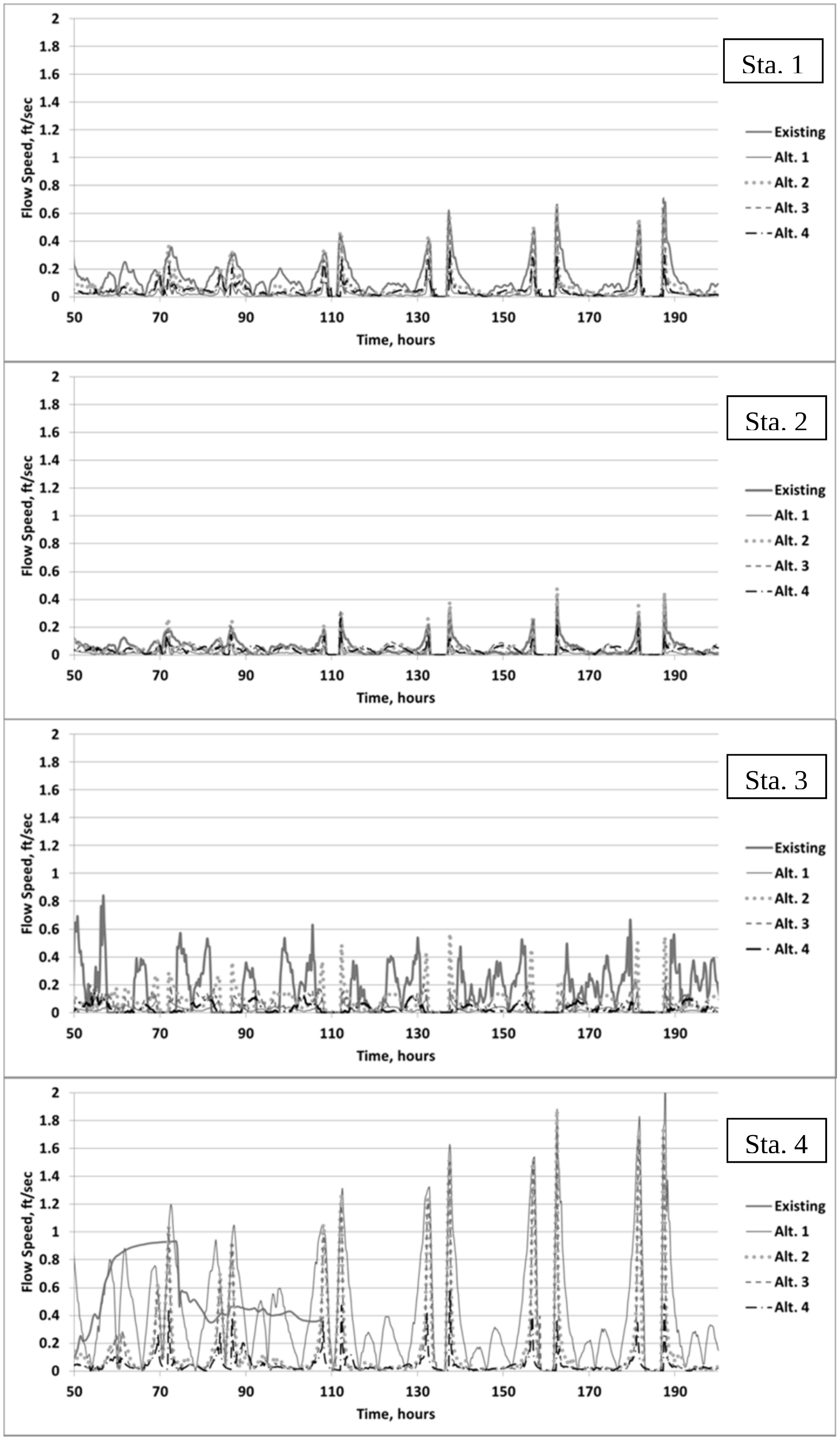

Figure 13. Time series of extracted model velocities at four stations.

Analysis of flow velocities indicates that velocities are higher at the openings of the berm for alternatives where much of the berm remains (Alt. 1, 2, and 3). Opening up more of the berm to flow between the lagoon and West Bay provides a greater degree of flushing and circulation throughout the lagoon, and more uniform velocities in the lagoon overall.

4.2.2.5 Dye Propagation Analysis

Numerical dye as a concentration tracer modeling was conducted to determine the residence time for each of the alternative lagoon design options. Residence time was used as a proxy for circulation and flushing of each of the alternative designs. The residence time in a body of water is typically defined as the amount of time required for the concentration of some suspended material – non-settling dye in this case – to drop down to 37% of its initial concentration. The faster that it takes to decrease the initial concentration to the reference concentration, the more circulation is taking place in the body of water.   A non-settling constituent (e.g. numerical dye) was integrated into the modeling grid around the alternative lagoon designs. Circulation models were run for existing conditions and each of the alternatives. The initial concentration conditions within the was set to 2.14 kg/m^3 and residence time was determined when the average concentration in the lagoon reduced to 0.79 kg/m^3. Figure 14 shows the modeling grid for existing conditions with the initial concentration of the lagoon at 2.14 kg/m^3. As the models run, tidal flow through the lagoon and flow from the dam results in the dispersal of the initial concentration condition prior to dispersal.

Figure 14. Initial concentration around the lagoon for evaluation of residence time in the lagoon for existing conditions.

The concentrations in various parts of the lagoon were extracted from the modeling grid at the points shown in Figure for existing and alternative conditions and plotted as time-series. Figure 14 shows time series plots of the concentration of dye in the lagoon for existing and proposed conditions. Figure 14 shows that Alternatives 2 and 4 consistently provide the best circulation and flushing through the lagoon.

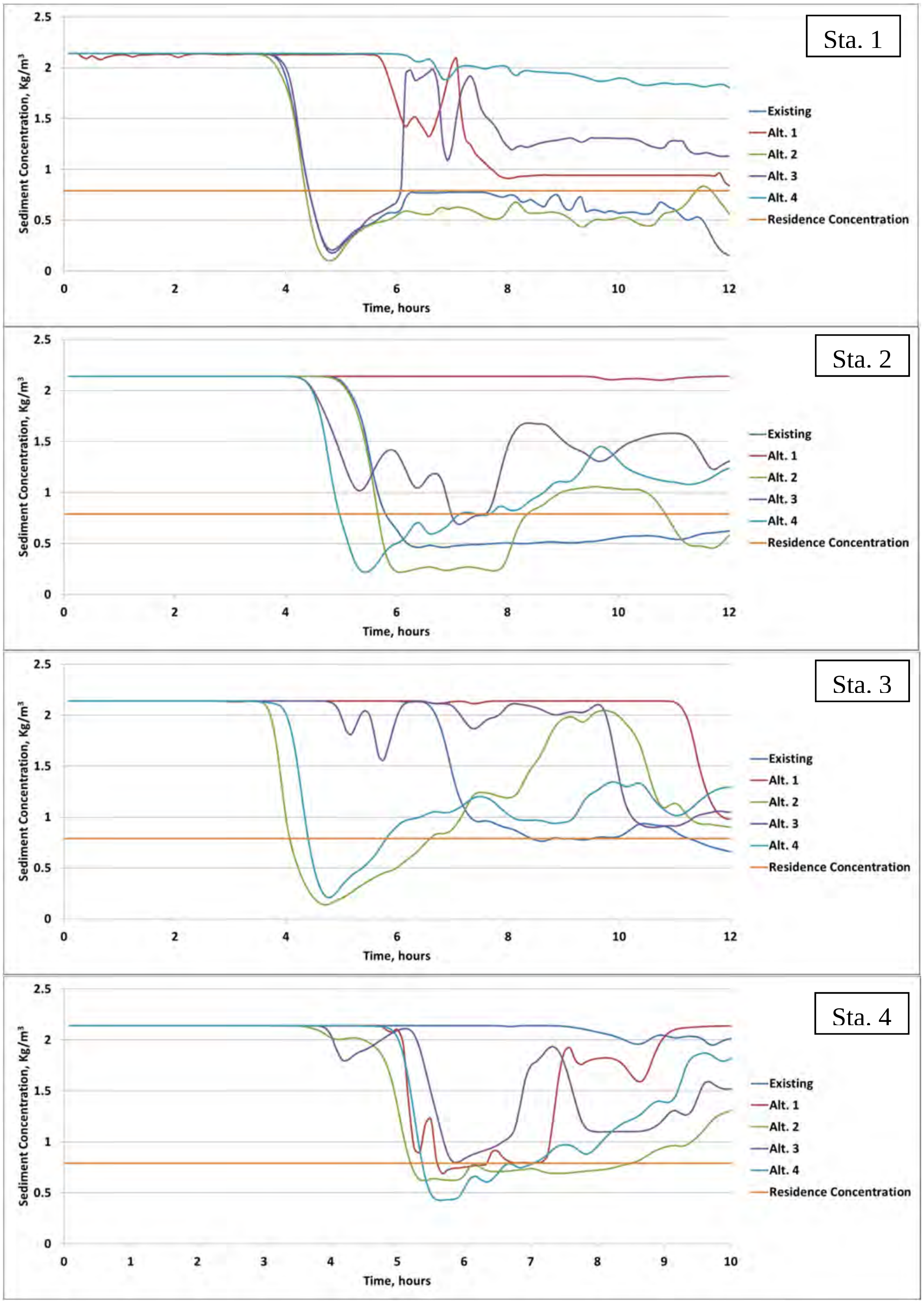

Figure 14. Time series of dye concentration at model stations.

The modeling results indicate that Alternatives 2 and 4 provided the greatest degree of circulation through the lagoon because these result in the greatest amount of exchange between the lagoon and West Bay across the entire lagoon. This results from larger berm openings spread evenly across the lagoon area. The degree of circulation through the lagoon roughly correlates to the amount of berm removal within the intertidal zone – the more berm that is removed, the greater the amount of circulation through the lagoon. The results for Alternative 3 are unique, however, because although a large part of the berm is removed much would remain in place above MHHW at the north end. This minimizes tidal exchange in the northern part of the lagoon except during very high tides for short periods of time.

Removal of the lagoon berm will likely benefit coastal geomorphic processes by promoting more natural sediment exchange and deposition. Improved sediment exchange would support expanded salt marsh habitat, mudflat health, and water quality.

5 COST

Lagoon costs were evaluated in parallel with the overall West Bay assessment (see main report and Appendix F). Table 3 summarizes the conceptual level costs for the lagoon alternatives. Recreation and restoration elements are separated for comparison and notes are provided to explain the recreation trail option included. Note that the City estimated the conceptual cost for constructing road improvements and a trail in the uplands along West Bay Drive could range from $9.0 to $10.5 million and may be applicable to any alternative.

Table 3. Summary of lagoon alternative costs.

Alternative	Restoration Cost	Recreation Cost	Notes
Lagoon Alt. 1	$6,402,000	$3,922,000	Rec. cost assumes trail along remaining berm with two overwater spans
Lagoon Alt. 2	$8,269,000	$6,299,000	Rec. cost assumes trail along remaining berm with four overwater spans
Lagoon Alt. 3	$8,958,000	$2,924,000	Rec. cost assumes trail/boardwalk & overwater structure along shore
Lagoon Alt. 4	$14,117,000	$9,073,000	Rec. cost assumes full overwater structure on piles

6 RESILIENCY

6.1 Sea Level Rise

Rising sea levels in the lagoon area will tend to cause shorelines to migrate landward and mudflat areas to deepen, compared to existing conditions.

Alternative 1 provides little to no sea level rise resiliency improvements because this alternative does not effectively change physical process or address the shoreline migration.

Alternative 2 would promote greater sediment and tidal exchange between the lagoon and West Bay and provide increased shoreline edge complexity. Improved sediment exchange would promote marsh growth and overall add resiliency for future conditions. Placement of habitat substrates and establishment of marsh along the west shore would buffer shoreline migration and provide an additional source of sediment to the lagoon which has been absent for many decades.

Alternative 3 would promote greater sediment and tidal exchange between the lagoon and West Bay, but not to the extent of Alternatives 2 or 4. Placement of habitat substrates and establishment of marsh along the west shore and south shore would buffer shoreline migration and potential for increased wave erosion, and provide an additional source of sediment to the lagoon which has been absent for many decades.

Alternative 4 would promote greater sediment and tidal exchange between the lagoon and West Bay. Improved sediment exchange would promote marsh growth and overall add resiliency for future conditions. Placement of habitat substrates and establishment of marsh along the west shore and south would buffer shoreline migration and potential for increased wave erosion, and provide an additional source of sediment to the lagoon which has been absent for many decades.

6.2 Deschutes Estuary Restoration

It is noted that fill beneath the 5th Ave. bridge constrains tidal and freshwater flow from Capitol Lake to the north and east of the lagoon. Although numerical modeling for full Deschutes Estuary restoration was not performed, it is expected that the constraining fill at the existing bridges would continue to constrain flows to the lagoon. Restoration of historical connectivity between the existing lagoon and estuary/lake would therefore require more than berm modifications.

Modeling performed for existing conditions provides a representative concept of flow patterns for the restored estuary condition. Therefore, the available modeling suggests that the lagoon alternative with the highest circulation and exchange (Alt. 2, Alt. 4) for the existing Capitol Lake conditions would likely provide the same for the restored estuary condition. Restoration of historical connectivity between the existing lagoon and estuary/lake would require more than berm modifications such as modifications to fill in the vicinity of the existing bridges and a larger opening at the dam to promote wider flow and sediment distribution.

7 Conclusions

Four lagoon concepts were developed and compared using semi-quantitative and qualitative metrics, included two-dimensional hydrodynamic modeling. The results indicate that Lagoon Alternative 4 provides the greatest overall habitat score, highest score per acre and second lowest cost per habitat point amongst the lagoon alternatives. This outcome is primarily related to the opportunity to create marsh using berm material and overall improvements in the function of the mudflat areas that would be expected with removal of the berm based on the outcome of the numerical modeling and qualitative analysis. Alternative 2 ranks well due to its lower cost, relative improvements to tidal exchange in the lagoon, and shoreline edge increase.

At least five recreational trail options were developed for the lagoon, including options that route recreation into adjacent upland areas along West Bay Drive. Many of the trail options can be overlaid with multiple restoration alternatives allowing for a large number of combinations of restoration and recreation design options. Costs for an upland trail along improved West Bay Drive are in a similar range to the full overwater trail option for Alternative 4.

Berm removal and overall restoration costs are high, due to the volume of material and quantity of trestle to be removed to restore physical and biological processes. Due to difficult construction access, constructing restoration and recreation elements concurrently would likely be most cost-efficient if accomplished together.

Fill beneath the 5th Ave. Bridge constrains tidal and freshwater flow from Capitol Lake to the north and east of the lagoon. It is expected that the constraining fill at the existing bridges would continue to constrain flows to the lagoon in the event that the Deschutes Estuary restoration were performed. The available modeling suggests that the lagoon alternative with the highest circulation and exchange for the existing condition would likely provide the same for the restored estuary condition.

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APPENDIX E

Criteria Development Memo

Technical Memorandum

City of Olympia West Bay Environmental Restoration Assessment

Criteria Development

1. Introduction

Coast & Harbor Engineering (CHE), a division of Hatch Mott MacDonald, prepared this document for the City of Olympia (City) West Bay Environmental Assessment. The purpose of the project is to complete a science based environmental restoration assessment for West Bay, Budd Inlet, located in Olympia, WA, to support the implementation of a water quality and habitat restoration strategy, including the prioritization of restoration projects for planning and managing by the City of Olympia, Port of Olympia (Port), Squaxin Island Tribe (Tribe), and other public entities.

This criteria development document seeks to guide the approach for developing restoration concepts by summarizing the project area, criteria, known limitations and constraints, habitat improvement and public accessibility goals, and the framework for evaluation and prioritization of restoration alternatives.

2. Assessment Area

2.1. Extents

The project study area is located along the west shorelines of West Bay within Budd Inlet, including associated upland drainages and adjacent intertidal and subtidal areas. The assessment area is bounded to the south by the 5th Avenue Dam and to the north by the City limit. While the restoration assessment effort is focused along shorelines and nearshore zone within the stated area, analysis will include watersheds that flow into West Bay and evaluation of physical and biological processes throughout Budd Inlet to understand the adjacent areas affecting habitat connectivity, restoration opportunities, and large scale processes within the assessment area.

2.2. Property Ownership

This restoration assessment focuses on City, Port and Tribe owned properties along West Bay. However, private properties located within the project area will be considered for typical restoration treatments (such as beach nourishment seaward of revetments, or balanced cut fill) that may be implemented as these parcels are redeveloped and that minimize loss of existing upland areas. Thurston County parcel data provided by the City will be the primary basis for identifying approximate property boundaries and ownership.

2.3. Topographic Data & Vertical Datums

LiDAR derived contour data provided by the City will serve as the basis for defining existing topographic features in the assessment area. Given the ecological nature of the assessment, the project vertical datum will be Mean Lower Low Water (MLLW), and the horizontal coordinate system will be NAD'83 Washington State Plane South Zone. Tidal datum relationships to geodetic survey datums are provided below for reference below:

	MLLW DATUM (feet)	NAVD88 DATUM (feet)
Highest Observed[2]	17.94	13.91
Mean Higher High Water (MHHW)	14.56	10.53
Mean High Water (MHW)	13.55	9.52
Mean Sea Level (MSL)	8.35	4.32
Mean Tide Level (MTL)	8.31	4.28
National Geodetic Vertical Datum of 1929[1]	7.47	3.44
North American Vertical Datum of 1988[4]	4.03	0.00
Mean Low Water (MLW)	3.07	-0.96
Mean Lower Low Water (MLLW)	0.00	-4.03
Lowest Observed[2]	-4.33	-8.36

Notes:
[1] Per Standard City of Olympia standard relationship, 0.00' NGVD29 = +3.44' NAVD88
[2] As observed at NOAA Station 9446969 between 4/1977 and 4/1978
[3] Tidal datum relationships per NOAA Station 9446969, Epoch 1983-2001
[4] To convert an elvation from MLLW to NAVD88 Datum, subtract 4.03'

2.4. Other Assumptions

- West Bay Drive will remain in its current alignment.
- Private property owners may be willing participants in typical shoreline treatments / improvements, but not full scale restoration of upland properties.
- Both restoration and recreation will be accommodated in West Bay, requiring a range of design solutions that allow for tradeoffs regarding future access and meaningful science-based restoration.

2.5. Existing Limiting Factors

These following limiting factors are provided to outline the existing ecological issues and constraints in West Bay and the project area. Solutions to address and reduce these limiting factors are provided in Section 3 of this memo.

2.5.1. Bulkheads/Armoring

- Over-steepened beach slopes
- Oversized substrate
- Lack of upper intertidal habitat (forage fish spawning and macroinvertebrates)
- Lack of backshore/dune habitat
- Lack of wood structures
- Limited recreation access along shore at high tide
- Reduced shoreline vegetation
- Sediment recruitment to beach

2.5.2. Dredge/Fill/Wood Waste/Contaminants

- Lost intertidal habitat (nearshore vegetation/forage fish spawning)
- Lost riparian functions
- Potential pollution sources
- Introduces non-native substrate to beach
- Beach slope adjustment
- Distribution and pattern of habitat types (e.g. lack of salt marsh in lower Budd Inlet)

2.5.3. In-water/Overwater Structures

- Lost intertidal/shallow subtidal habitat
- Alters natural shore drift and currents
- Increase predator habitat
- Potential barriers to migrant juvenile salmonids

2.5.4. Non-native Species

- Forms monoculture with low habitat value
- Limits recreational access to shoreline
- Reduces overhanging vegetation
- Limits recruitment of large wood to shoreline

2.5.5. Stream channelization and culverts

- Eliminates natural stream processes
- Failed outfall structures contribute fine sediment, rubble and debris
- Eliminated estuary habitat and reduced habitat complexity
- Fish passage/attractive nuisance
- Alters sediment transport from drainages to the beach and nearshore
- Reduced function and capacity as sea levels rise

2.5.6. Deschutes Estuary/ Capitol Lake

- Reduced sediment supply and inflows
- Limited circulation/flushing
- Degraded water quality
- Fish passage barrier
- Altered salinity mixing zone
- Reduced refugia and transition zones between fresh/marine systems

2.5.7. Stormwater

- Untreated water contributes to reduced water quality (low DO, temperature, organics, hyrdocarbons, fertilizers, and other chemicals)
- Outfalls located on the upper beach may erode and contaminate beach substrate

2.5.8. Railroad Fill/Trestle

- Reduced flushing (higher temperature/ lower dissolved oxygen)
- Potential fish stranding and fish access impairments
- Altered sediment dynamics in existing and potential future Deschutes estuary restoration scenario
- Contaminants in trestle & ties (creosote timber)
- Reduced intertidal habitat area

2.6. Historic Conditions

The following broadly summarizes the historic conditions in the assessment area. A more detailed summary of historical and existing function analysis will be provided in the forthcoming *Historical and Existing Function Analysis Memo.*

- Deschutes River estuary was modified to form Capitol Lake, which resulted in:
  - Historic shoreline length was 17.5 km, now 9.0 km
  - Historic wetlands were 3.48 km^2, now 1.96 km^2
  - Armoring present for 94.2 percent of length
  - Tidal barriers are present for 46 percent of length
  - Roads are present for 13.4 percent of length
  - 75.5 percent developed lands in nearshore

- Shallow intertidal zone (mud flats) dominated, with few and very shallow subtidal channels
- Riparian vegetation was conifer dominant (Douglas fir, western hemlock)
- LWD was incorporated in shoreline banks and backshore habitat
- Bluff backed beaches were more prevalent
- Intertidal salt marsh and oyster reef were common place
- Creeks and streams provided connectivity to upland drainages
- Sediment was supplied from creeks, bluffs, and river flows
- Areas was a key location for resource procurement (oysters, clams, crabs, other shellfish, salmon and other fish.)

2.6.1. Historic Modifications

- Earliest "modern" development occurred in the 1850's
- Railroad spur along West Bay was built in 1878
- Dredging was first attempted unsuccessfully in 1885 to deepen the channel.
- Dredging deepened channel between 1893 and 1894 and again between 1909 and 1911 resulting in creation of 29 city blocks using two million cubic yards of spoils. Some dredge spoils may have also created part of West Bay Park.
- The bluff and shoreline along West Bay was modified by regrading and fill placed at base of West Bay bluff to create land for sawmills in the late 1800's.
- The railroad trestle along West Bay (including the current lagoon berm) changed hands several times, was abandoned in 1894, rebuilt by BNSF and rock/gravel fill placed to form the existing berm in the early 1970's[1]. The railroad trestle was not in use after 1996.
- The West Bay Marina was established on former sawmill/log storage area by the early 1960's.
- At least four sawmills existed along West bay, many constructed on fill generated from regrading of the shoreline and bluffs to create West Bay Dr. The mill at West Bay Park was removed in 1963 and land use was converted to log storage.
- Budd Inlet was used as a natural log pond, with log rafts along the entire length of West Bay through the 1970's.
- City purchased land form the Port of Olympia for West Bay Park in 2004. Phase 1 of park improvements were constructed in the summer of 2010.

2.7. Future Conditions

This assessment acknowledges that future conditions may differ from historical and existing conditions, as summarized below

[1] Oblique aerial photographs from Washington State archives show the unfilled trestle in existence as late as 1971, with complete fill placed by 1974.

2.7.1. Deschutes River Estuary Restoration

- Restoration of the estuary is being evaluated by other entities, and various technical studies have documented potential alternatives for removal of the Fifth Avenue Dam as part of the Deschutes River estuary restoration
- If restoration occurs, the future conditions considered will be as described in the Deschutes Estuary Feasibility Study Reports (2006). http://www.des.wa.gov/about/pi/CapitolLake/Pages/CapitolLakeReports.aspx

2.7.2. Sea Level Rise

- It is well documented that sea levels are rising, relative to the land, within the assessment area and that resilient designs are needed for long lasting ecosystem restoration. Resilient designs will promote natural adaptation to changing sea level conditions and promote restoration of physical processes.
- Future sea level rise scenarios will be as described in the latest published scientific literature [IPCC (2013), UW Climate Impacts Group (Mote et. al 2008), National Academies (2012), NOAA(2012)] for West Bay, considering existing sea level trends and medium-rise scenarios.

3. Objectives & Opportunities

3.1. Reference Documents

Other existing studies, plans, regulations and standards may apply to project area, and are listed below. Relevant criteria from the references will be considered in developing the restoration alternatives.

- City of Olympia Shoreline Master Program (latest version)
- City of Olympia Comprehensive Plan (latest version)
- City of Olympia Engineering Development & Design Standards
- City of Olympia Critical Areas Ordinance
- City of Olympia Capital Facilities Plan
- City of Olympia 2010 Parks, Arts and Recreation Plan
- City of Olympia West Bay Drive Corridor Study
- Accessibility Guidelines for Outdoor Developed Areas
- Thurston Regional Trails Plan
- 2010 ADA Guidelines for Accessible Design

3.2. Restoration

A variety of restoration opportunities are possible at sites along West Bay. Table 1 summarizes overall restoration objectives and opportunities that will guide the development and evaluation of alternatives. The notes provide more detailed criteria associated with each opportunity to be used in developing concepts.

3.3. Recreation

A variety of recreation opportunities are possible at sites along West Bay, many of which are compatible with restoration objectives. Table 2 summarizes overall recreation objectives and opportunities that will guide the development and evaluation of alternatives. The notes provide more detailed criteria associated with each opportunity to be used in developing concepts.

Objective	Remove/reduce or setback bulkheads 1	Remove/reduce intertidal fill 2	Remove in-water/overwater structures	Beach nourishment 3	Regrading shorelines to natural slopes 4	Expand salt marsh prevalence 5	Enhance existing freshwater wetland 6	Riparian corridors 7	Backshore dune and riparian habitat 8	Large wood structures	Daylight creeks/streams to create pocket estuary	Beneficial use of clean dredge spoils 9	Remove creosote trestle structures	Olympia oyster habitat/substrate enhancement 10	Signage	Water Quality Treatment Facilities11
	Restoration Opportunities															
Intertidal and nearshore juvenile salmon habitat	x	x	x	x	x	x	x	x		x	x	x	x	x		x
Forage fish spawning habitat	x	x	x	x	x	x	x	x		x	x	x	x	x		x
Olympia oyster and shellfish habitat (non-harvest)	x	x	x	x	x		x	x			x	x	x	x		x
Estuary functions	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Marine bird/mammal habitat	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Nearshore vegetation abundance	x	x	x	x	x	x					x	x	x	x		x
Tidal circulation/flushing/water quality		x	x		x						x	x	x			x
Climate Change Resiliency	x	x				x	x	x	x	x	x	x				
Public Education	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Connectivity and migration corridor	x	x	x	x	x	x	x	x		x	x	x	x	x		x
Restore underrepresented/lost habitat types	x	x		x	x	x	x	x	x	x	x	x		x		x
Sediment sources and beach substrate	x			x	x				x		x	x		x		
Compatibility with future estuary restoration	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stormwater quality improvements	x	x	x		x	x	x	x			x					x

1. Target structures at or below EL. 16 ft MLLW.
2. Lower elevations to below EL. 16 ft MLLW.
3. Beach target range EL. 6.0 to EL. 16 ft MLLW. Substrate sandy gravel fish mix.
4. Both cut and fill may be required to achieve target intertidal elevations, maximize reuse of clean local materials for bulk fill. Import surface fish mix materials. Use local referenc site elevations.
5. Salt marsh target range EL. 12 to 15.5 ft MLLW, silt sandy gravel substrate, and should include tidal channels for fish access and tidal circulation.
6. Pre-treatment option prior to discharge into West Bay.
7. Target conifiers such as Douglas Fir, Western Hemlock, and Sitka Spruce.
8. Backshore Target above EL. 16.0 ft MLLW to 17.5 ft MLLW.
9. Depending on grain size, as beach fill (sand/gravel), bulk fill base layer (misc) or for intertidal marsh (silt/sand).
10. Oyster substrate silty sand with shell/gravel/cobble. Salinity above 24 PPM. Elevation range below -1.0 ft MLLW is ideal.
11. May include wetlands or other physical treatment alternatives.

Table 1. Restoration objectives and opportunities matrix.

Objective	Elevated corridors and structures 1	Pedestrians and bicycles trails 2	ADA accessible touchpoints 3	New backshore and upper intertidal beach 4	Kayak/Water trail landings & launches 5	Restroom 6	Parking 6	Shelters/tables/gathering areas 6	Fishing 7	Nature viewing & interpretive areas 8
Non-motorized corridor connecting Capitol Lake to West Bay Park	x	x	x		x	x	x	x	x	x
Passive recreation	x	x	x	x	x	x	x	x	x	x
Visual acces through view preservation	x	x	x							x
Non-motorized corridor connectivity from West Bay Park north to Raft Ave. [A]	x	x	x	x	x		x	x	x	x
Preserve & enhance natural shoreline aesthetics (from water and land)	x			x	x					x
Preserve critical public infrastructure (roads, utilities)		x	x	x	x	x	x			
Provide physical public access to beach/West Bay	x	x	x	x	x		x		x	x
Compatible with Restoration	x	x	x	x	x				x	x

Recreation Opportunities

1. Elevated corridor at or above EL. 19.0 ft MLLW. Will not cause a net loss of shoreline ecological functions, processes, adverse impacts on other shoreline uses.

2. Corridor options: 3' wide soft – pedestrian, more rustic 5' wide crushed rock – pedestrian and off road bicycle 10' wide multi-use twith 2' shoulders – more formal, ABA friendly; subject to the mitigation sequencing process and shall be designed to minimize impacts to the ecological functions of the shoreline while providing access and waterfront enjoyment to the public.
3. Slope, rise, run and material surfaces must meet ADA and applicable design codes for use and experience.
4. Target elevations above EL. 15.0 ft MLLW at appropriate areas (sediment source, wave energy, geomorphology).
5. Firm substrate at moderate slopes. Motorized launches are not included.
6. Refer to City SMP requirements.
7. Intentional water access for fishing will require determine specific locations and access points, including closures and exclusion in restoration areas until establishment.
8. Refer to City SMP requirements.

A. May include or consider neighborhood connections to upland recreation areas.

Table 2. Recreation objectives and opportunities matrix.

4. Evaluation Framework

Evaluation of potential restoration alternatives and scenarios will include semi-quantitative and qualitative measures based on input from stakeholders, as well as costs. When taken together, these evaluation measures will provide a science-based approach to facilitate discussion and decision-making, while also considering the inherent uncertainties, stakeholder experience, and professional judgement that are needed to produce a restoration plan for West Bay.

The semi-quantitative evaluation framework will provide numerical scores for restoration alternatives, which will allow for relative comparison of the habitat value delivered on a quantitative basis for measureable items (such as acreage of certain habitat zones and function of that habitat). Since the goal is to perform a streamlined assessment over a large study, some judgement is required to assign values to habitat zones and functions. Thus the outcome will be semi-qualitative, with emphasis on the relative differences between alternatives.

The qualitative evaluation framework will provide the opportunity to consider important restoration elements that are difficult to quantify and not easily incorporated numerically. Professional judgement and discussion will be required to establish the scale of value for these elements for each alternative.

Finally, costs will be provided for an understanding of the cost/benefit of the alternatives relative to the semi-quantitative and qualitative. More details for each evaluation method are provided below.

4.1. Semi-Quantitative Evaluation Framework

A semi-qualitative approach, similar to Habitat Equivalency Analysis (HEA), is proposed for assigning numerical scores to quantitative elements of restoration such as area, habitat type, functional importance to target species, etc. This has been used for over 30 years to evaluate habitats. Similar concepts include the US Fish and Wildlife Services (USFWS) Habitat Suitability Indices (HSI) from 1980. The approach will use values obtained from existing literature from Puget Sound assessments including Iadanza (2001) and will also develop new or modified habitat types and values specific to the West Bay of Budd Inlet based on input from local experts and key project stakeholders. An example of our proposed evaluation framework is shown below, followed by a description of the evaluation framework development process.
i

4.1.1. Framework

The following list describes the proposed process to develop a streamlined evaluation framework for the West Bay restoration assessment.

1. Identify existing and proposed habitat zones (i.e. Intertidal, Subtidal, Backshore, Saltmarsh, Riparian, Upland, etc.)

2. Identify minimum and maximum values for each habitat type based on level of function performed (i.e. Not functioning = 0, partially functioning = 0.5, fully functioning = 1.0). This can be a combination of using values from existing models and developing site specific values based on habitat needs of West Bay.
3. Measure areas of existing habitat types and identify current levels of functions to establish baseline habitat functional values.
4. Compare existing conditions to historic matrix/pattern of habitat types to identify missing or under represented habitat types that may be critical to juvenile salmon migration and other species.
5. Conduct streamlined assessment of proposed habitat types for alternatives and identify area and proposed level of function.
6. The difference (Δ) between proposed habitat value and existing habitat value will provide a semi-quantitative value which will represent the habitat functional lift.
7. Multiply Δ value from Item 5 above by the area to get semi-quantitative value that combines functional lift and the size of the potential restoration area.
8. Identify other qualitative attributes such as potential for tidal flushing and sediment transport and identify appropriate multipliers for these attributes.
9. Multiply values identified in Item 6 by the multipliers identified in Item 7 to get a streamlined, semi-quantitative prioritization value for habitat restoration alternatives.

4.1.2. Example

Consider a lawn adjacent to a bulkhead may be assigned a habitat value of 0.1 for Chinook salmon because a lawn provides minimal support for Chinook survival and growth. However, if the bulkhead and lawn are removed and the area is restored to upper intertidal riparian habitat suitable for forage fish spawning, then the value of this area could be increased to 0.9 and may also include multipliers for forage fish spawning occurrence or potential. If tidal marsh is created at the upper end of the new intertidal area, this habitat could be assigned the maximum value of 1.0.

4.2. Qualitative Evaluation Framework

For restoration elements that are difficult to quantify, such as improvements to physical processes, a more qualitative framework is needed in parallel with the semi-quantitative framework. Assignment of scoring for qualitative elements will require the use of judgment and will be performed on a three tier scale, such as low, medium, high, or similar. Elements may include:

- Sediment Supply and Transport (increase/decrease/neutral)
- Water Quality (residence time)
- Stormwater (daylighting, water quality improvements)
- Tidal Circulation & Flushing (using limited two-dimensional modeling)
- Connectivity to other restoration opportunities (proximity, continuity)
- Historic/underrepresented habitats
- Resiliency over time (sea level rise, enhances natural physical process)
- Compatibility with potential Deschutes Estuary restoration
- Ability to phase projects
- Compatibility with recreation uses, public access (as defined in Reference Documents), and educational opportunities

4.3. Cost/Feasibility (Secondary)

Conceptual level costs will be developed for consideration and comparison amongst the restoration scenarios and alternatives. This will be secondary to the semi-quantitative and qualitative scientific assessment providing cost context for the proposed projects and actions.

5. References

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APPENDIX F

Conceptual Cost Estimates

City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - Lagoon Alternative No. 1

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	600,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	2	AC	$	8,000	$	16,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	630	TON	$	50	$	31,500
6	Berm Excavation and Off-site Disposal	0	CY	$	50	$	-
7	Misc. Excavation and Off-site Disposal	3,820	CY	$	35	$	133,700
8	Misc. Excavation, Grading and On-site Reuse	4,420	CY	$	15	$	66,300
9	Pit Run Fill	9,720	TON	$	20	$	194,400
10	Demolish and Dispose Creosote Railroad Ties	1,140	EA	$	400	$	456,000
11	Demolish and Dispose Creosote Piles	200	EA	$	700	$	140,000
12	Demolish and Dispose Steel Rails	3,400	LF	$	15	$	51,000
13	Dredging and Upland Disposal	2,460	CY	$	175	$	430,500
14	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
15	Cobble Fill	0	TON	$	40	$	-
16	Fish Mix for Beach	13,000	TON	$	50	$	650,000
17	Gravel Beach Material	2,780	TON	$	40	$	111,200
18	Site Restoration - Riparian Planting	58,620	SF	$	8	$	468,960
19	Habitat Log	22	EA	$	2,100	$	46,200
20	Site Restoration - Topsoil Cover (for marsh/upland riparian)	1,330	CY	$	47	$	62,510
21	Site Restoration - Marsh Planting	49,100	SF	$	5	$	245,500
22	Habitat Snag	0	EA	$	2,200	$	-
23	Path - Asphalt (CSBC) along berm	2,322	SY	$	24	$	55,728
24	Board Walk - View Deck with Railing and 2 benches - Large	1	EA	$	14,000	$	14,000
25	Board Walk - View Deck with Railing and 1 bench - Small	1	EA	$	7,000	$	7,000
26	Board Walk - Elevated w railing (12' wide)	0	LF	$	750	$	-
27	Interpretive Signage	1	EA	$	3,000	$	3,000
28	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
29	Overwater Trail (Decking on piles) from berm to uplands	7320	SF	$	300	$	2,196,000
	Construction Cost Subtotal					$	6,026,538
	Washington State Sales Tax (8.8%)					$	530,335
	Engineering/Design & Permitting (25%)					$	1,506,635
	Contingency (30%)					$	2,259,952
			TOTAL COST			**$**	**10,324,000**

COAST & HARBOR ENGINEERING
A Division of Hatch Mott MacDonald

j.a. brennan associates pllc

City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - Lagoon Alternative No. 2

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	850,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	2	AC	$	8,000	$	16,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	630	TON	$	50	$	31,500
6	Berm Excavation and Off-site Disposal	5,020	CY	$	50	$	251,000
7	Misc. Excavation and Off-site Disposal	4,150	CY	$	35	$	145,250
8	Misc. Excavation, Grading and On-site Reuse	1,500	CY	$	15	$	22,500
9	Pit Run Fill	6,070	TON	$	20	$	121,400
10	Demolish and Dispose Creosote Railroad Ties	1,140	EA	$	400	$	456,000
11	Demolish and Dispose Creosote Piles	350	EA	$	700	$	245,000
12	Demolish and Dispose Steel Rails	3,400	LF	$	15	$	51,000
13	Dredging and Upland Disposal	5,790	CY	$	175	$	1,013,250
14	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
15	Cobble Fill	0	TON	$	40	$	-
16	Fish Mix for Beach	18,710	TON	$	50	$	935,500
17	Gravel Beach Material	3,120	TON	$	40	$	124,800
18	Site Restoration - Riparian Planting	18,680	SF	$	8	$	149,440
19	Habitat Log	14	EA	$	2,100	$	29,400
20	Site Restoration - Topsoil Cover (for marsh/upland riparian)	990	CY	$	47	$	46,530
21	Site Restoration - Marsh Planting	61,040	SF	$	5	$	305,200
22	Habitat Snag	0	EA	$	2,200	$	-
23	Path - Asphalt (CSBC)	1,350	SY	$	24	$	32,400
24	Board Walk - View Deck with Railing and 2 benches - Large	1	EA	$	14,000	$	14,000
25	Board Walk - View Deck with Railing and 1 bench - Small	2	EA	$	7,000	$	14,000
26	Board Walk - Elevated w railing (12' wide)	0	LF	$	750	$	-
27	Interpretive Signage	1	EA	$	3,000	$	3,000
28	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
29	Overwater Trail (Decking on piles) between islands	12000	SF	$	300	$	3,600,000
	Construction Cost Subtotal					$	8,504,210
	Washington State Sales Tax (8.8%)					$	748,370
	Engineering/Design & Permitting (25%)					$	2,126,053
	Contingency (30%)					$	3,189,079
			TOTAL COST			**$**	**14,568,000**

COAST & HARBOR ENGINEERING
A Division of Hatch Mott MacDonald

j.a. brennan

City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - Lagoon Alternative No. 3

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	700,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	2	AC	$	8,000	$	16,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	630	TON	$	50	$	31,500
6	Berm Excavation and Off-site Disposal	6,390	CY	$	50	$	319,500
7	Misc. Excavation and Off-site Disposal	4,540	CY	$	35	$	158,900
8	Misc. Excavation, Grading and On-site Reuse	1,720	CY	$	15	$	25,800
9	Pit Run Fill	8,540	TON	$	20	$	170,800
10	Demolish and Dispose Creosote Railroad Ties	1,140	EA	$	400	$	456,000
11	Demolish and Dispose Creosote Piles	300	EA	$	700	$	210,000
12	Demolish and Dispose Steel Rails	3,400	LF	$	15	$	51,000
13	Dredging and Upland Disposal	5,740	CY	$	175	$	1,004,500
14	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
15	Cobble Fill	0	TON	$	40	$	-
16	Fish Mix for Beach	21,020	TON	$	50	$	1,051,000
17	Gravel Beach Material	3,450	TON	$	40	$	138,000
18	Site Restoration - Riparian Planting	11,710	SF	$	8	$	93,680
19	Habitat Log	16	EA	$	2,100	$	33,600
20	Site Restoration - Topsoil Cover (for marsh/upland riparian)	1,760	CY	$	47	$	82,720
21	Site Restoration - Marsh Planting	130,580	SF	$	5	$	652,900
22	Habitat Snag	0	EA	$	2,200	$	-
23	Path - Asphalt (CSBC)	1,115	SY	$	24	$	26,760
24	Board Walk - View Deck with Railing and 2 benches - Large	1	EA	$	14,000	$	14,000
25	Board Walk - View Deck with Railing and 1 bench - Small	1	EA	$	7,000	$	7,000
26	Board Walk - Elevated w railing (12' wide)	750	LF	$	750	$	562,500
27	Interpretive Signage	1	EA	$	3,000	$	3,000
28	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
29	Overwater Trail (Decking on piles) along shoreline and bluff	3600	SF	$	300	$	1,080,000
	Construction Cost Subtotal					$	6,936,200
	Washington State Sales Tax (8.8%)					$	610,386
	Engineering/Design & Permitting (25%)					$	1,734,050
	Contingency (30%)					$	2,601,075
			TOTAL COST			**$**	**11,882,000**

City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - Lagoon Alternative No. 4

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	1,350,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	2	AC	$	8,000	$	16,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	630	TON	$	50	$	31,500
6	Berm Excavation and Off-site Disposal	25,450	CY	$	50	$	1,272,500
7	Misc. Excavation and Off-site Disposal	8,090	CY	$	35	$	283,150
8	Misc. Excavation, Grading and On-site Reuse	450	CY	$	15	$	6,750
9	Pit Run Fill	1,520	TON	$	20	$	30,400
10	Demolish and Dispose Creosote Railroad Ties	1,140	EA	$	400	$	456,000
11	Demolish and Dispose Creosote Piles	570	EA	$	700	$	399,000
12	Demolish and Dispose Steel Rails	3,400	LF	$	15	$	51,000
13	Dredging and Upland Disposal	17,730	CY	$	175	$	3,102,750
14	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
15	Cobble Fill	0	TON	$	40	$	-
16	Fish Mix for Beach	12,510	TON	$	50	$	625,500
17	Gravel Beach Material	1,620	TON	$	40	$	64,800
18	Site Restoration - Riparian Planting	11,320	SF	$	8	$	90,560
19	Habitat Log	4	EA	$	2,100	$	8,400
20	Site Restoration - Topsoil Cover (for marsh/upland riparian)	1,050	CY	$	47	$	49,350
21	Site Restoration - Marsh Planting	74,000	SF	$	5	$	370,000
22	Habitat Snag	0	EA	$	2,200	$	-
23	Path - Asphalt (CSBC)	1,900	SY	$	24	$	45,600
24	Board Walk - View Deck with Railing and 2 benches - Large	0	EA	$	14,000	$	-
25	Board Walk - View Deck with Railing and 1 bench - Small	0	EA	$	7,000	$	-
26	Board Walk - Elevated w railing (12' wide)	0	LF	$	750	$	-
27	Interpretive Signage	1	EA	$	3,000	$	3,000
28	Wayfinding/Interpretive Kiosk	2	EA	$	14,000	$	28,000
29	Overwater Trail (Decking on piles)	17400	SF	$	300	$	5,220,000
	Construction Cost Subtotal					$	13,537,300
	Washington State Sales Tax (8.8%)					$	1,191,282
	Engineering/Design & Permitting (25%)					$	3,384,325
	Contingency (30%)					$	5,076,488
			TOTAL COST			**$**	**23,190,000**

COAST & HARBOR ENGINEERING
A Division of Hatch Mott MacDonald

j.a. brennan

City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - West Bay Park South Alternative No. 1

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	220,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	2	AC	$	8,000	$	16,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	60	TON	$	50	$	3,000
6	Misc. Excavation and Off-site Disposal	12,010	CY	$	35	$	420,350
7	Pit Run Fill	0	TON	$	20	$	-
8	Dredging and Upland Disposal	710	CY	$	175	$	124,250
9	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
10	Cobble Fill	40	TON	$	40	$	1,600
11	Fish Mix for Beach	7,120	TON	$	50	$	356,000
12	Gravel Beach Material	1,260	TON	$	40	$	50,400
13	Site Restoration - Riparian Planting	61,353	SF	$	8	$	490,824
14	Habitat Log	15	EA	$	2,100	$	31,500
15	Site Restoration - Topsoil Cover (for marsh/upland riparian)	1,350	CY	$	47	$	63,450
16	Site Restoration - Marsh Planting	47,790	SF	$	5	$	238,950
17	Habitat Snag	3	EA	$	2,200	$	6,600
18	Site Restoration - Natural Meadow	20,460	SF	$	2	$	30,690
19	Site Restoration - Lawn	0	SF	$	1	$	-
20	Path - Asphalt (CSBC)	3,190	SY	$	24	$	76,560
21	Board Walk - Elevated w railing (12' wide)	80	LF	$	750	$	60,000
22	Gathering Area/Picnic Area	1	EA	$	20,000	$	20,000
23	Interpretive Signage	1	EA	$	3,000	$	3,000
24	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
	Construction Cost Subtotal					$	2,260,214
	Washington State Sales Tax (8.8%)					$	198,899
	Engineering/Design & Permitting (25%)					$	565,054
	Contingency (30%)					$	847,580
		TOTAL COST				**$**	**3,872,000**

COAST & HARBOR ENGINEERING
A Division of Hatch Mott MacDonald

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City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - West Bay Park South Alternative No. 2

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	100,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	2	AC	$	8,000	$	16,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	30	TON	$	50	$	1,500
6	Misc. Excavation and Off-site Disposal	11,460	CY	$	35	$	401,100
7	Pit Run Fill	0	TON	$	20	$	-
8	Dredging and Upland Disposal	600	CY	$	175	$	105,000
9	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
10	Cobble Fill	40	TON	$	40	$	1,600
11	Fish Mix for Beach	6,040	TON	$	50	$	302,000
12	Gravel Beach Material	1,320	TON	$	40	$	52,800
13	Site Restoration - Riparian Planting	103,540	SF	$	8	$	828,320
14	Habitat Log	15	EA	$	2,100	$	31,500
15	Site Restoration - Topsoil Cover (for marsh/upland riparian)	1,870	CY	$	47	$	87,890
16	Site Restoration - Marsh Planting	47,260	SF	$	5	$	236,300
17	Habitat Snag	3	EA	$	2,200	$	6,600
18	Site Restoration - Natural Meadow	34,520	SF	$	2	$	51,780
19	Site Restoration - Lawn	0	SF	$	1	$	-
20	Path - Asphalt (CSBC)	2,990	SY	$	24	$	71,760
21	Board Walk - Elevated w railing (12' wide)	80	LF	$	750	$	60,000
22	Gathering Area/Picnic Area	1	EA	$	20,000	$	20,000
23	Interpretive Signage	1	EA	$	3,000	$	3,000
24	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
	Construction Cost Subtotal					$	2,424,190
	Washington State Sales Tax (8.8%)					$	213,329
	Engineering/Design & Permitting (25%)					$	606,048
	Contingency (30%)					$	909,071
			TOTAL COST			**$**	**4,153,000**

COAST & HARBOR ENGINEERING
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City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - Port Tidelands

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	200,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	2	AC	$	8,000	$	16,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	380	TON	$	50	$	19,000
6	Misc. Excavation and Off-site Disposal	3,750	CY	$	35	$	131,250
7	Pit Run Fill	710	TON	$	20	$	14,200
8	Dredging and Upland Disposal	2,070	CY	$	175	$	362,250
9	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
10	Cobble Fill	0	TON	$	40	$	-
11	Fish Mix for Beach	6,090	TON	$	50	$	304,500
12	Gravel Beach Material	6,760	TON	$	40	$	270,400
13	Site Restoration - Riparian Planting	50,290	SF	$	8	$	402,320
14	Habitat Log	13	EA	$	2,100	$	27,300
15	Site Restoration - Topsoil Cover (for marsh/upland riparian)	980	CY	$	47	$	46,060
16	Site Restoration - Marsh Planting	28,440	SF	$	5	$	142,200
17	Habitat Snag	0	EA	$	2,200	$	-
18	Site Restoration - Natural Meadow	16,770	SF	$	2	$	25,155
19	Site Restoration - Lawn	0	SF	$	1	$	-
20	Path - Asphalt (CSBC)	2,510	SY	$	24	$	60,240
21	Gathering Area/Picnic Area	0	EA	$	20,000	$	-
22	Interpretive Signage	1	EA	$	3,000	$	3,000
23	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
	Construction Cost Subtotal					$	2,070,915
	Washington State Sales Tax (8.8%)					$	182,241
	Engineering/Design & Permitting (25%)					$	517,729
	Contingency (30%)					$	776,593
			TOTAL COST			**$**	**3,548,000**

COAST & HARBOR ENGINEERING
A Division of Hatch Mott MacDonald

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City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - Reliable Steel Alt. 1

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	118,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	4	AC	$	8,000	$	32,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	500	TON	$	50	$	25,000
6	Misc. Excavation and Off-site Disposal	4,410	CY	$	35	$	154,350
7	Pit Run Fill	0	TON	$	20	$	-
8	Dredging and Upland Disposal	850	CY	$	175	$	148,750
9	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
10	Cobble Fill	0	TON	$	40	$	-
11	Fish Mix for Beach	2,620	TON	$	50	$	131,000
12	Gravel Beach Material	4,370	TON	$	40	$	174,800
13	Site Restoration - Riparian Planting	25,240	SF	$	8	$	201,920
14	Habitat Log	5	EA	$	2,100	$	10,500
15	Site Restoration - Topsoil Cover (for marsh/upland riparian)	500	CY	$	47	$	23,500
16	Site Restoration - Marsh Planting	14,490	SF	$	5	$	72,450
17	Habitat Snag	0	EA	$	2,200	$	-
18	Site Restoration - Natural Meadow	8,420	SF	$	2	$	12,630
19	Site Restoration - Lawn	0	SF	$	1	$	-
20	Path - Asphalt (CSBC)	1,246	SY	$	24	$	29,904
21	Gathering Area/Picnic Area	0	EA	$	20,000	$	-
22	Interpretive Signage	1	EA	$	3,000	$	3,000
23	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
	Construction Cost Subtotal					$	1,184,844
	Washington State Sales Tax (8.8%)					$	104,266
	Engineering/Design & Permitting (25%)					$	296,211
	Contingency (30%)					$	444,317
			TOTAL COST			**$**	**2,030,000**

City of Olympia 2/22/2016

West Bay Environmental Restoration Assessment - Reliable Steel Alt. 2

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	136,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	4	AC	$	8,000	$	32,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	500	TON	$	50	$	25,000
6	Misc. Excavation and Off-site Disposal	4,740	CY	$	35	$	165,900
7	Pit Run Fill	0	TON	$	20	$	-
8	Dredging and Upland Disposal	870	CY	$	175	$	152,250
9	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
10	Cobble Fill	0	TON	$	40	$	-
11	Fish Mix for Beach	2,620	TON	$	50	$	131,000
12	Gravel Beach Material	4,370	TON	$	40	$	174,800
13	Site Restoration - Riparian Planting	35,420	SF	$	8	$	283,360
14	Habitat Log	5	EA	$	2,100	$	10,500
15	Site Restoration - Topsoil Cover (for marsh/upland riparian)	750	CY	$	47	$	35,250
16	Site Restoration - Marsh Planting	25,010	SF	$	5	$	125,050
17	Habitat Snag	0	EA	$	2,200	$	-
18	Site Restoration - Natural Meadow	11,810	SF	$	2	$	17,715
19	Site Restoration - Lawn	0	SF	$	1	$	-
20	Path - Asphalt (CSBC)	1,246	SY	$	24	$	29,904
21	Gathering Area/Picnic Area	0	EA	$	20,000	$	-
22	Interpretive Signage	1	EA	$	3,000	$	3,000
23	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
	Construction Cost Subtotal					$	1,368,769
	Washington State Sales Tax (8.8%)					$	120,452
	Engineering/Design & Permitting (25%)					$	342,192
	Contingency (30%)					$	513,288
			TOTAL COST			**$**	**2,345,000**

COAST & HARBOR ENGINEERING
A Division of Hatch Mott MacDonald

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City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - Hardel

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	240,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	9	AC	$	8,000	$	72,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	800	TON	$	50	$	40,000
6	Misc. Excavation and Off-site Disposal	1,900	CY	$	35	$	66,500
7	Pit Run Fill	18,820	TON	$	20	$	376,400
8	Dredging and Upland Disposal	1,580	CY	$	175	$	276,500
9	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
10	Cobble Fill	0	TON	$	40	$	-
11	Fish Mix for Beach	5,930	TON	$	50	$	296,500
12	Gravel Beach Material	8,880	TON	$	40	$	355,200
13	Site Restoration - Riparian Planting	45,690	SF	$	8	$	365,520
14	Habitat Log	13	EA	$	2,100	$	27,300
15	Site Restoration - Topsoil Cover (for marsh/upland riparian)	910	CY	$	47	$	42,770
16	Site Restoration - Marsh Planting	27,900	SF	$	5	$	139,500
17	Habitat Snag	0	EA	$	2,200	$	-
18	Site Restoration - Natural Meadow	15,230	SF	$	2	$	22,845
19	Site Restoration - Lawn	0	SF	$	1	$	-
20	Path - Asphalt (CSBC)	2,745	SY	$	24	$	65,880
21	Gathering Area/Picnic Area	0	EA	$	20,000	$	-
22	Interpretive Signage	1	EA	$	3,000	$	3,000
23	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
	Construction Cost Subtotal					$	2,436,955
	Washington State Sales Tax (8.8%)					$	214,452
	Engineering/Design & Permitting (25%)					$	609,239
	Contingency (30%)					$	913,858
			TOTAL COST			**$**	**4,175,000**

COAST & HARBOR ENGINEERING
A Division of Hatch Mott MacDonald

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City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - Schneider

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	210,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	3	AC	$	8,000	$	24,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	150	TON	$	50	$	7,500
6	Misc. Excavation and Off-site Disposal	3,270	CY	$	35	$	114,450
7	Pit Run Fill	1,370	TON	$	20	$	27,400
8	Dredging and Upland Disposal	3,590	CY	$	175	$	628,250
9	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
10	Cobble Fill	0	TON	$	40	$	-
11	Fish Mix for Beach	5,830	TON	$	50	$	291,500
12	Gravel Beach Material	6,540	TON	$	40	$	261,600
13	Site Restoration - Riparian Planting	34,170	SF	$	8	$	273,360
14	Habitat Log	10	EA	$	2,100	$	21,000
15	Site Restoration - Topsoil Cover (for marsh/upland riparian)	650	CY	$	47	$	30,550
16	Site Restoration - Marsh Planting	18,400	SF	$	5	$	92,000
17	Habitat Snag	0	EA	$	2,200	$	-
18	Site Restoration - Natural Meadow	11,390	SF	$	2	$	17,085
19	Site Restoration - Lawn	0	SF	$	1	$	-
20	Path - Asphalt (CSBC)	2,187	SY	$	24	$	52,488
21	Gathering Area/Picnic Area	0	EA	$	20,000	$	-
22	Interpretive Signage	1	EA	$	3,000	$	3,000
23	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
	Construction Cost Subtotal					$	2,101,223
	Washington State Sales Tax (8.8%)					$	184,908
	Engineering/Design & Permitting (25%)					$	525,306
	Contingency (30%)					$	787,959
		TOTAL COST				**$**	**3,600,000**

Coast & Harbor Engineering
A Division of Hatch Mott MacDonald

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City of Olympia

2/22/2016

West Bay Environmental Restoration Assessment - Delta Illahee

Final Estimate of Probable Construction Cost - Conceptual

Item No.	Item Description	Quantity	Unit	Unit Cost		Total Cost	
1	Marine Mobilization/Demobilization	1	LS	10% of Construction Costs		$	108,000
2	Construction Surveying	1	LS	$	25,000	$	25,000
3	Clearing and Grubbing	3	AC	$	8,000	$	24,000
4	Temporary Erosion and Water Pollution Control	1	LS	$	8,000	$	8,000
5	Demolish and Dispose Rubble and Concrete Debris	500	TON	$	50	$	25,000
6	Misc. Excavation and Off-site Disposal	2,320	CY	$	35	$	81,200
7	Pit Run Fill	10,630	TON	$	20	$	212,600
8	Dredging and Upland Disposal	160	CY	$	175	$	28,000
9	Stormwater Treatment and Drainage System	10	SF	$	4	$	40
10	Cobble Fill	250	TON	$	40	$	10,000
11	Fish Mix for Beach	2,410	TON	$	50	$	120,500
12	Gravel Beach Material	1,740	TON	$	40	$	69,600
13	Site Restoration - Riparian Planting	26,900	SF	$	8	$	215,200
14	Habitat Log	8	EA	$	2,100	$	16,800
15	Site Restoration - Topsoil Cover (for marsh/upland riparian)	470	CY	$	47	$	22,090
16	Site Restoration - Marsh Planting	10,670	SF	$	5	$	53,350
17	Habitat Snag	0	EA	$	2,200	$	-
18	Site Restoration - Natural Meadow	8,970	SF	$	2	$	13,455
19	Site Restoration - Lawn	0	SF	$	1	$	-
20	Path - Asphalt (CSBC)	1,774	SY	$	24	$	42,576
21	Gathering Area/Picnic Area	0	EA	$	20,000	$	-
22	Interpretive Signage	1	EA	$	3,000	$	3,000
23	Wayfinding/Interpretive Kiosk	1	EA	$	14,000	$	14,000
	Construction Cost Subtotal					$	1,092,411
	Washington State Sales Tax (8.8%)					$	96,132
	Engineering/Design & Permitting (25%)					$	273,103
	Contingency (30%)					$	409,654
			TOTAL COST			**$**	**1,872,000**

Coast & Harbor Engineering
A Division of Hatch Mott MacDonald

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APPENDIX G

Risk Register Table

City of Olympia 2/26/2016

West Bay Environmental Restoration Assessment

Risk Register Table

Reach / Topic	Reach Number	Alternative	Identified Risk	Consequence	Importance	Recommendation
General	All	All	Cultural resources may exist throughout the project area.	Discovery of cultural resources may affect the extent, cost, and type of restoration possible.	Med	Perform focused cultural resource investigations for each reach prior to permitting.
General	All	All	Restoration strategy relies on both removal and placement of fill below MHHW; requires regulatory approval from permitting and resource agencies.	Without fill placement, many areas cannot feasibly receive restoration treatment.	Med	Consult with regulatory and permitting agencies for approval of strategy prior to permitting design.
Lagoon	1	All	Testing of existing berm materials is limited and reuse below MHHW uncertain.	Potential large cost increase if berm materials cannot be reused.	High	Extensive testing program needed in next phase of design.
Lagoon	1	2,3,4	Creosote treated piles, stringers, tiebacks, and headers. Extent of deterioration and potential contamination of adjacent soil not known.	Potential large cost increase if berm materials cannot be reused.	Med	Extensive testing program needed in next phase of design.
Lagoon	1	3,4	Private property along the northwest shoreline and mudflat. Fill in this area would need to be approved by the property owner.	Reduced habitat score and less marsh creation. Included alternate salt marsh in southern part of lagoon.	Med	Confer with private property owner prior to next phase of design.
Lagoon	1	All	Mitigation sites are present and cannot be negatively impacted.	Perceived impacts to mitigation area may alter site layouts.	Low	Assess potential positive impact on mitigation sites and confer with agencies.
Lagoon	1	All	USFWS restrictive conservation easement on lagoon, must be maintained as habitat. Any restoration conditional on USFWF service approval.	Perceived impacts to covenant lands may alter site layouts.	Med	Confer with USFWS prior to next phase of design.
Lagoon	1	3,4	Steep slopes are present along the west shore of the lagoon and require geotechnical investigations to substantiate design details and cost for trail improvements.	Trail options that rely upon use of bluff slope or toe may require significant engineering.	Med	Depending upon preferred lagoon alternative, perform geological/geotechnical studies for trail alignment.
Lagoon	1	All	Railroad trestle is old enough to be considered an historic structure.	Removal may require mitigation, such as interpretive signage, etc.	Low	Perform cultural resources investigation and confer with agencies on potential mitigation for removal.
Lagoon	1	2,3,4	Existing West Bay Drive ROW may not accommodate adequate multi-modal cooridor with trail and needed frontage improvements. Details of trail connection from Harrison Ave. to downtown or Capital Lake is unclear and may require substantial infrastructure improvements.	ROW acquisition may be needed in some sections, namely south of Jackson Ave. Additional transportation planning and engineering needed at roundabouts and connections.	Med	Initiate ROW scoping and planning if this alternative becomes preferred alternative through decision making processes.
West Bay Park South	2	All	West Bay Park low quality wetlands likely present, but not delineated. Perched above layers of wood waste and unknown soil fill properties.	Wetlands present may require mitigation. Replacement with suitable soils could increase cost.	Low	Delineate wetlands and confer with agencies. Perform geological/geotechnical studies of subsurface soils for design.
West Bay Park South	2	All	Buried railroad grade and structures may be present along the shoreline, though not visible from field investigations.	Potential cost increase to remove and dispose of trestle.	Low	Limited subsurface investigations to confirm trestle extents.
West Bay Park South	2	All	Cleanup actions are required in portions of the upland areas to remediate former Solid Wood, Inc. contamination.	Potential to delay implementation or discovery of contaminants during construction.	Low	Coordinate with remediation efforts.
Port Tidelands	3	All	Historic masonry kiln structure is old enough to be considered an historic structure.	Removal may require mitigation, such as interpretive signage, etc.	Low	Perform cultural resources investigation and confer with agencies on potential mitigation for removal.
Port Tidelands	3	All	Drainage is apparent beneath West Bay Drive, but no obvious culverts were located.	Relic railroad bridge may be present beneath the roadway and require shoring or drainage improvements.	Low	Perform site investigations to locate source or drainage and sub-surface structures.
Port Tidelands	3	All	Potential sediment and soil contamination from historic Industrial Petroleum Distributors operations.	Potential to delay implementation or discovery of contaminants during construction.	Med	Coordinate with remediation efforts.
Reliable Steel	4	All	Known contaminants in soil, sediment, and groundwater requires extensive remediation.	Potential to delay implementation or discovery of contaminants during construction.	High	Coordinate with remediation efforts.
Reliable Steel	4	All	Future SLR mitigation measures along some shoreline sites (berm/levees)could be incorporated along shoreline, possibly under trail corridor.	Cost not included.	Low	Coordinate during redevelopment efforts.
Reliable Steel	4	All	Uncertainty remains regarding property ownership and development potential. Agreement from landowner prior to design and implementation of restoration along this reach.	This may delay or preclude restoration implementation and reconnection along the shoreline.	Med	Confer with landowner.
Hardel	5	All	Formerly contaminated upland site has been remediated, but potential contamination in nearshore sediments remains.	Potential to delay implementation or discovery of contaminants during construction.	Med	Coordinate with remediation efforts.
Hardel	5	All	Future SLR mitigation measures along some shoreline sites (berm/levees)could be incorporated along shoreline, possibly under trail corridor. Cost not included.	Cost not included.	Low	Coordinate during redevelopment efforts.
Hardel	5	All	Private property require agreement from landowner prior to design and implementation of restoration along this reach.	This may delay or preclude restoration implementation and reconnection along the shoreline.	Med	Confer with landowner.
Schneider Creek	6	All	Private and Tribe help tidelands require agreement prior to design and implementation of restoration along this reach.	This may delay or preclude restoration implementation and reconnection along the shoreline.	Low	Confer with landowner.
Schneider Creek	6	All	Full scale replacement of Schneider Creek culvert or other restoration work (e.g. daylighting)is not included.	Cost for replacement would be very high and technically challenging.	Med	Evaluate potential modifications in a detailed study.
Schneider Creek	6	All	Future SLR mitigation measures along some shoreline sites (berm/levees)could be incorporated along shoreline, possibly under trail corridor. Cost not included.	Cost not included.	Low	Coordinate during redevelopment efforts.
Delta Ilahee	7	All	Private property require agreement from landowner prior to design and implementation of restoration along this reach.	This may delay or preclude restoration implementation and reconnection along the shoreline.	Med	Confer with landowner.
Delta Ilahee	7	All	Relatively narrow parcel may complicate implementation of a functional riparian corridor.	This may could disconnect the continuous riparian shoreline band.	High	Confer with landowner.
Delta Ilahee	7	All	Future SLR mitigation measures along some shoreline sites (berm/levees)could be incorporated along shoreline, possibly under trail corridor. Cost not included.	Cost not included.	Low	Coordinate during redevelopment efforts.
Marina	8	NA	Few restoration opportunities unless shoreline use changes from existing marina.	No restoration occurs.	Low	Monitor marina use and opportunity to restore.
Logyard	9	NA	Active industrial site with little opportunity for restoration, except in offshore areas and north end of the site. Additional restoration opportunities may be possible if land use or ownership change.	No restoration occurs in offshore areas.	Low	Confer with landowner and monitor land use for opportunity to restore.

APPENDIX H

Comparative Assessment Graphics

RESTORATION	RECREATION
10/14	6/8

CRITERIA OBJECTIVES

81.34 points
5.43 points/ac
$78,707 /point

SEMI-QUANTITATIVE

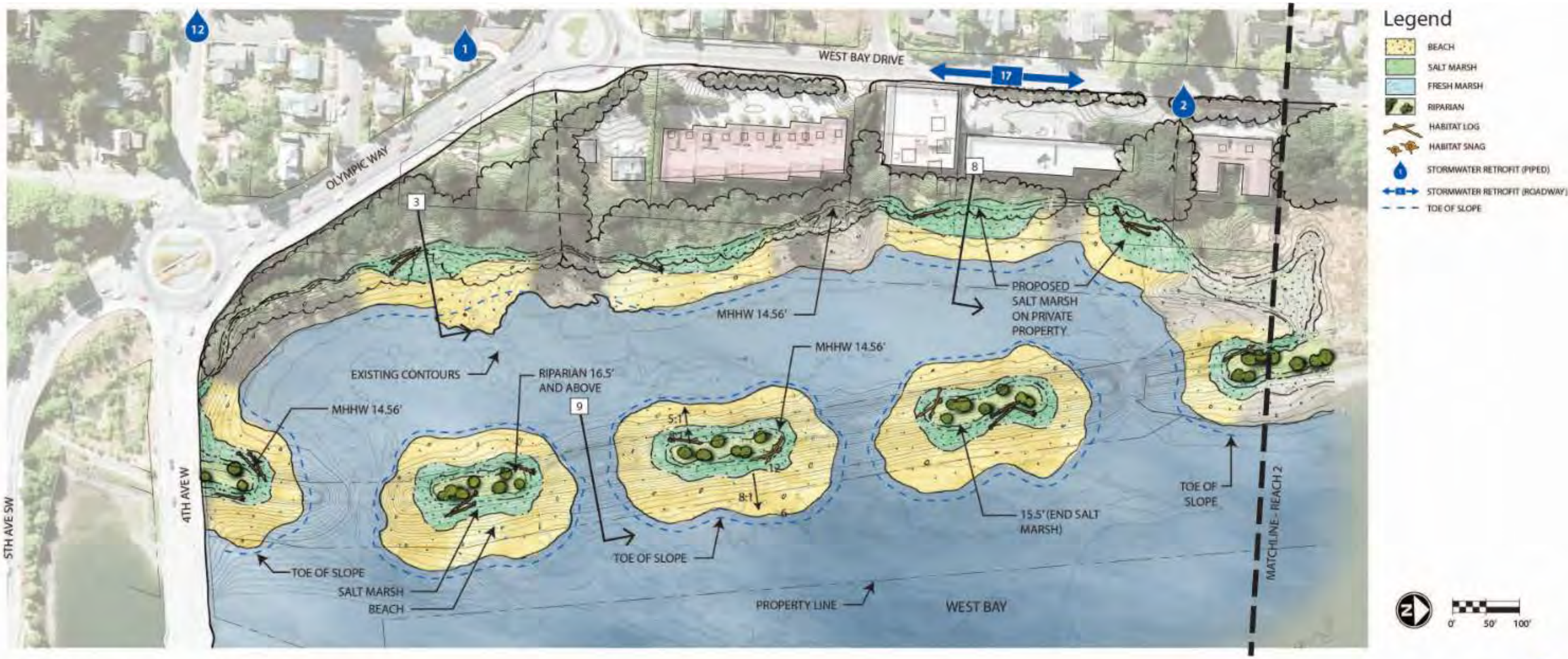
SED	CIRC	CON	HIS	RES	DES	PHS	REC
1	1	1	1	1	0	0	2

QUALITATIVE EVALUATION

$6,402,000 **REST.**
$3,922,000 **REC.**

COST

NOTES:
1. Cost /point reflects restoration costs only. 2. Rec. cost assumes trail along remaining berm with two overwater spans



Reach 1 - Lagoon Alternative 2

West Bay Environmental Restoration Assessment

December 10, 2015

j.a. brennan associates PLLC

RESTORATION	RECREATION
12/14	6/8

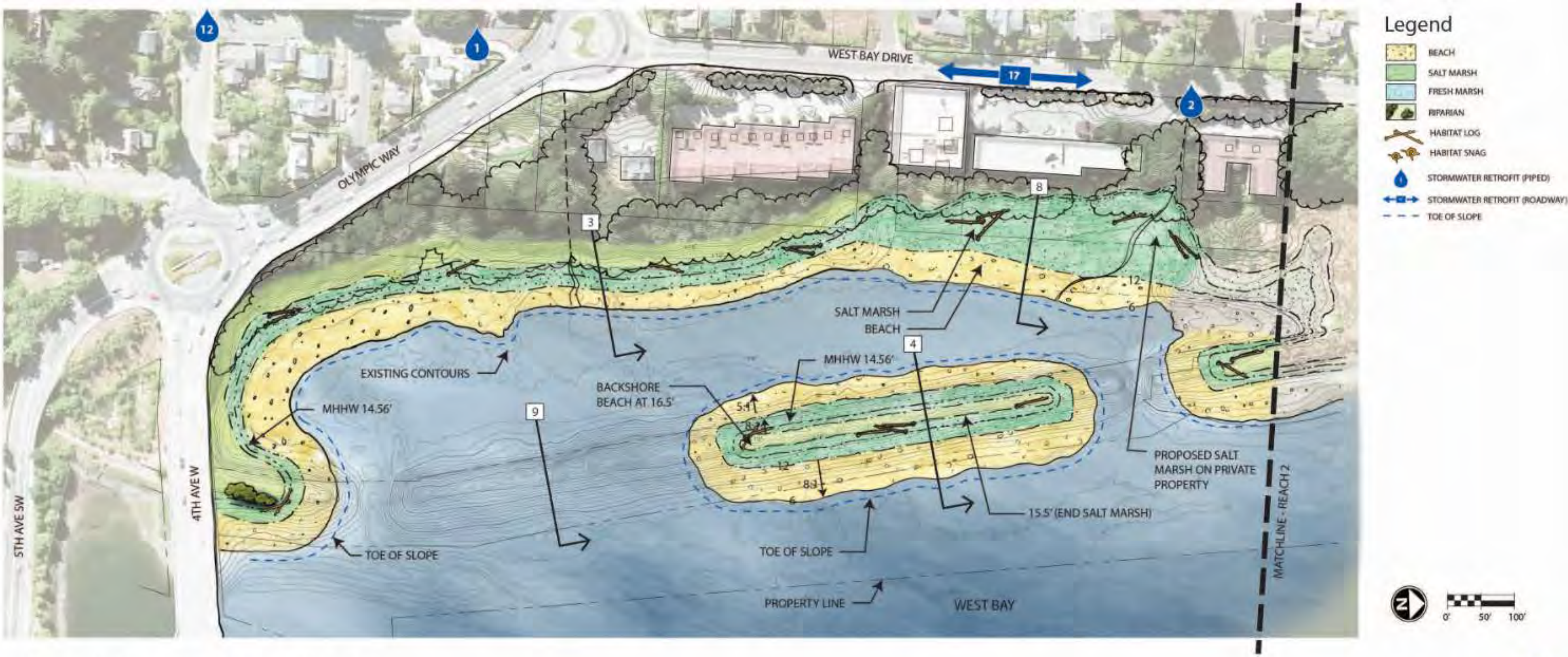
191.07 points
5.43 points/ac
$43,277 /point

SED	CIRC	CON	HIS	RES	DES	PHS	REC
1	3	1	1	2	2	0	2

$8,269,000 **REST.**
$6,299,000 **REC.**

CRITERIA OBJECTIVES — SEMI-QUANTITATIVE — QUALITATIVE EVALUATION — COST

NOTES:
1. $ per point reflects restoration costs only 2. Rec. cost assumes trail along remaining berm with four overwater spans



Reach 1 - Lagoon Alternative 3

West Bay Environmental Restoration Assessment

December 10, 2015

j.a. brennan associates PLLC

RESTORATION	RECREATION	SEMI-QUANTITATIVE
12/14	6/8	157.33 points 10.18 points/ac $56,938 /point

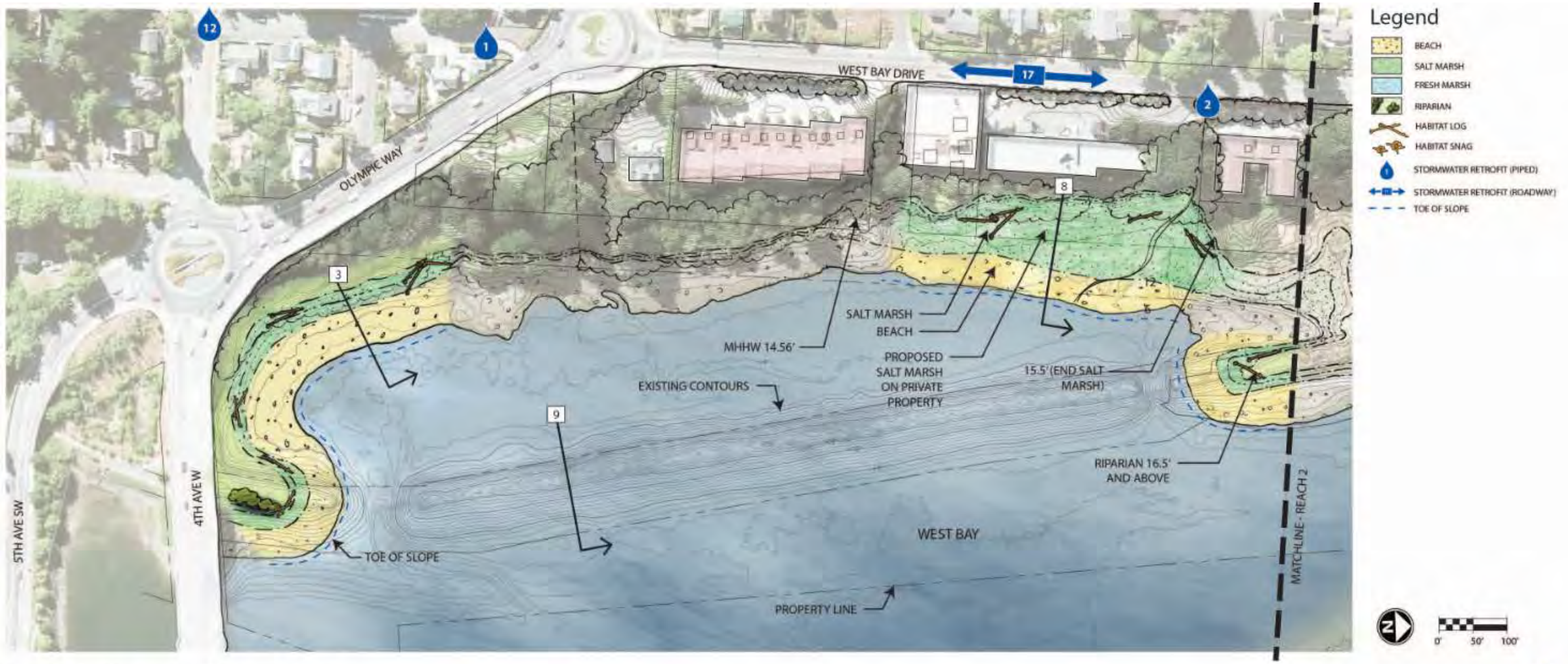
SED	CIRC	CON	HIS	RES	DES	PHS	REC
2	2	2	1	2	2	2	3

$8,958,000 **REST.**

$2,924,000 **REC.**

CRITERIA OBJECTIVES SEMI-QUANTITATIVE QUALITATIVE EVALUATION COST

NOTES:
1. $ per point reflects restoration costs only 2. Rec. cost assumes mixed trail/boardwalk/overwater structure along shore



Reach 1 - Lagoon Alternative 4

West Bay Environmental Restoration Assessment

December 10, 2015

j.a. brennan associates PLLC

RESTORATION	RECREATION
12/14	6/8

CRITERIA OBJECTIVES

266.94 points
17.37 points/ac
$52,884 /point

SEMI-QUANTITATIVE

SED	CIRC	CON	HIS	RES	DES	PHS	REC
3	4	4	1	2	4	2	3

QUALITATIVE EVALUATION

$14,117,000 **REST.**
$9,073,000 **REC.**

COST

NOTES:
1. $ per point reflects restoration costs only 2. Stormwater opportunities 13 & 14 not shown.

Reach 2 - West Bay Park South Alternative 1

December 10, 2015

West Bay Environmental Restoration Assessment

j.a. brennan associates PLLC

RESTORATION	RECREATION
13/14	7/8

114.19 points
16.00 points/ac
$31,307 /point

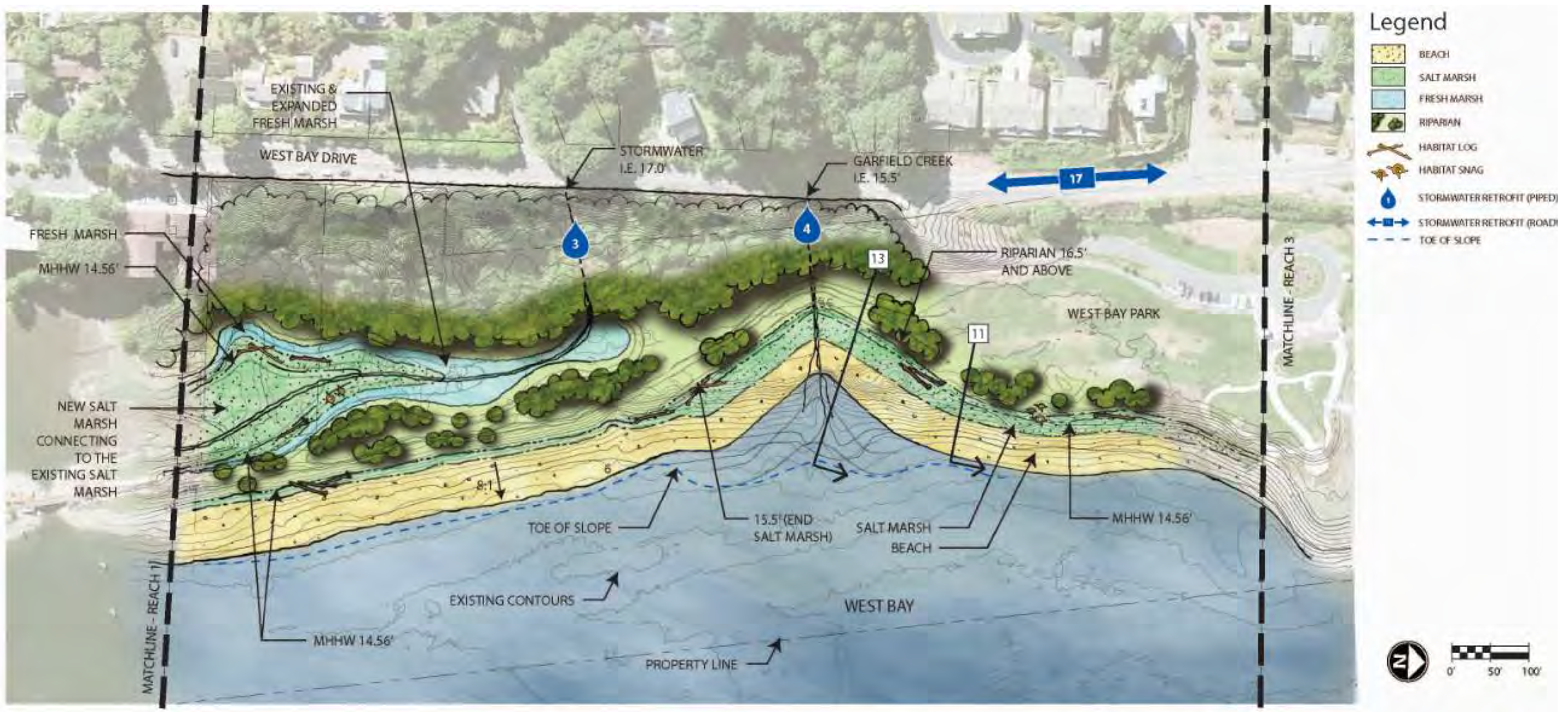
SED	CIRC	CON	HIS	RES	DES	PHS	REC
2	1	2	1	3	2	1	3

$3,575,000 **REST.**

$297,000 **REC.**

CRITERIA OBJECTIVES SEMI-QUANTITATIVE QUALITATIVE EVALUATION COST

NOTES:
1. $ per point reflects restoration costs only 2. Stormwater opportunities 13 & 14 not shown.



Reach 2 - West Bay Park South Alternative 2

December 10, 2015

West Bay Environmental Restoration Assessment

j.a. brennan associates PLLC

RESTORATION	RECREATION
13/14	7/8

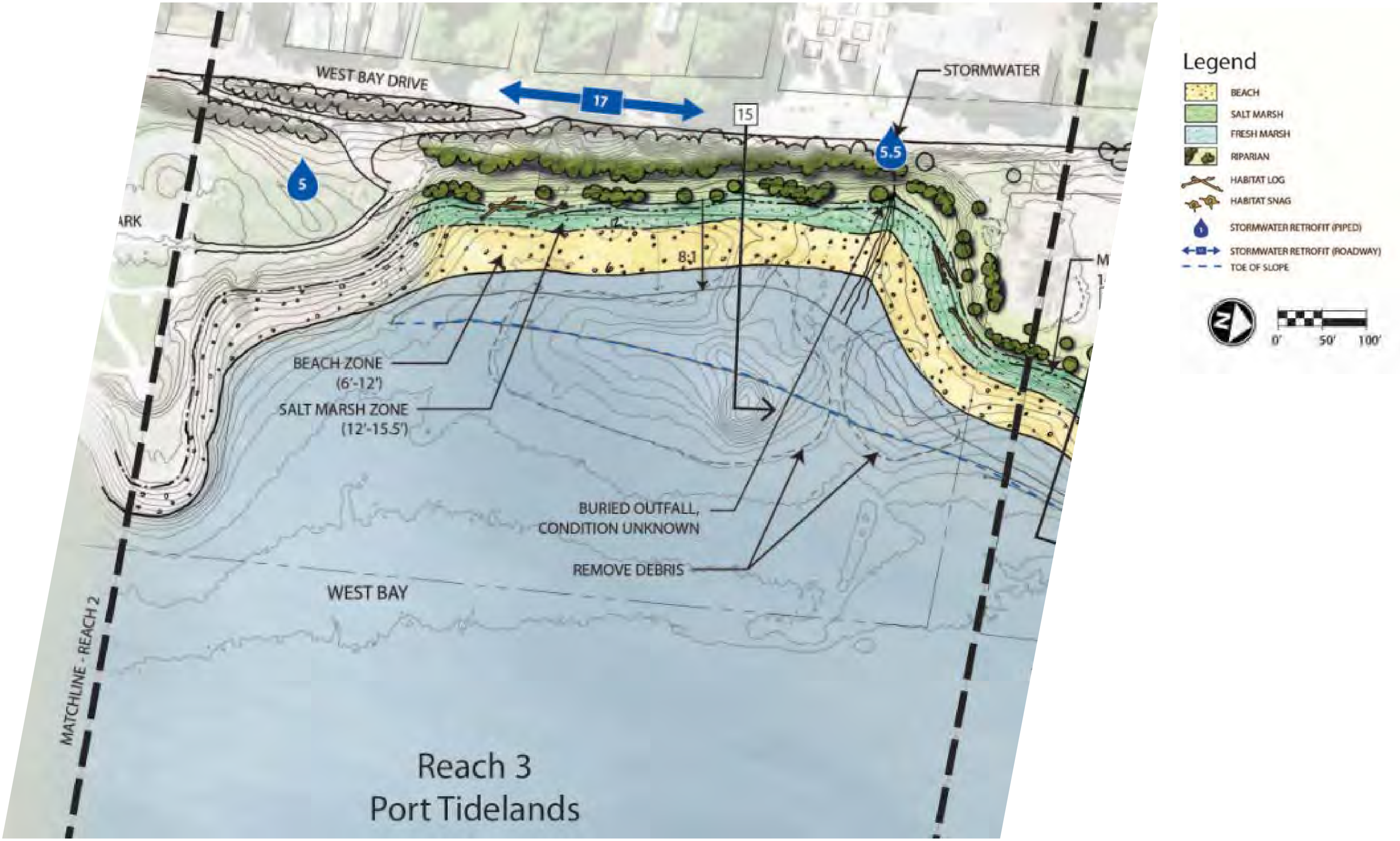
71.97 points
14.97 points/ac
$53,689 /point

SED	CIRC	CON	HIS	RES	DES	PHS	REC
2	1	1	3	3	2	1	3

$3,864,000 **REST.**
$289,000 **REC.**

CRITERIA OBJECTIVES SEMI-QUANTITATIVE QUALITATIVE EVALUATION COST

NOTES:
1. $ per point reflects restoration costs only 2. Stormwater opportunities 13 & 14 not shown.



RESTORATION	RECREATION
10/14	6/8

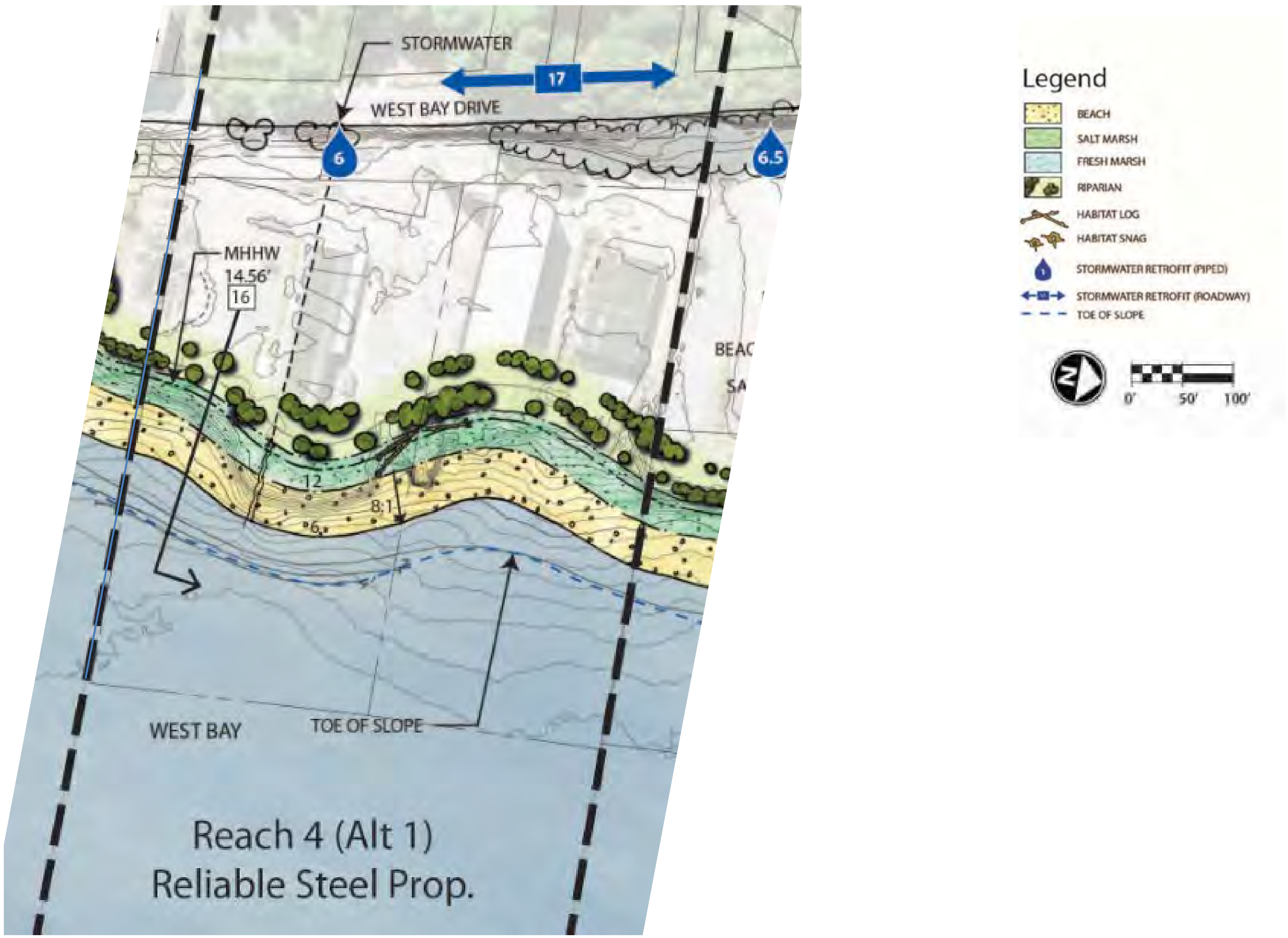
118.91 points
21.08 points/ac
$28,728 /point

SED	CIRC	CON	HIS	RES	DES	PHS	REC
2	1	1	1	2	1	1	2

$3,416,000 **REST.**
$132,000 **REC.**

CRITERIA OBJECTIVES   SEMI-QUANTITATIVE   QUALITATIVE EVALUATION   COST

NOTES:
1. $ per point reflects restoration costs only 2. Stormwater opportunity 15 not shown.



RESTORATION	RECREATION
9/14	4/8

CRITERIA OBJECTIVES

74.82 points
25.07 points/ac
$26,062 /point

SEMI-QUANTITATIVE

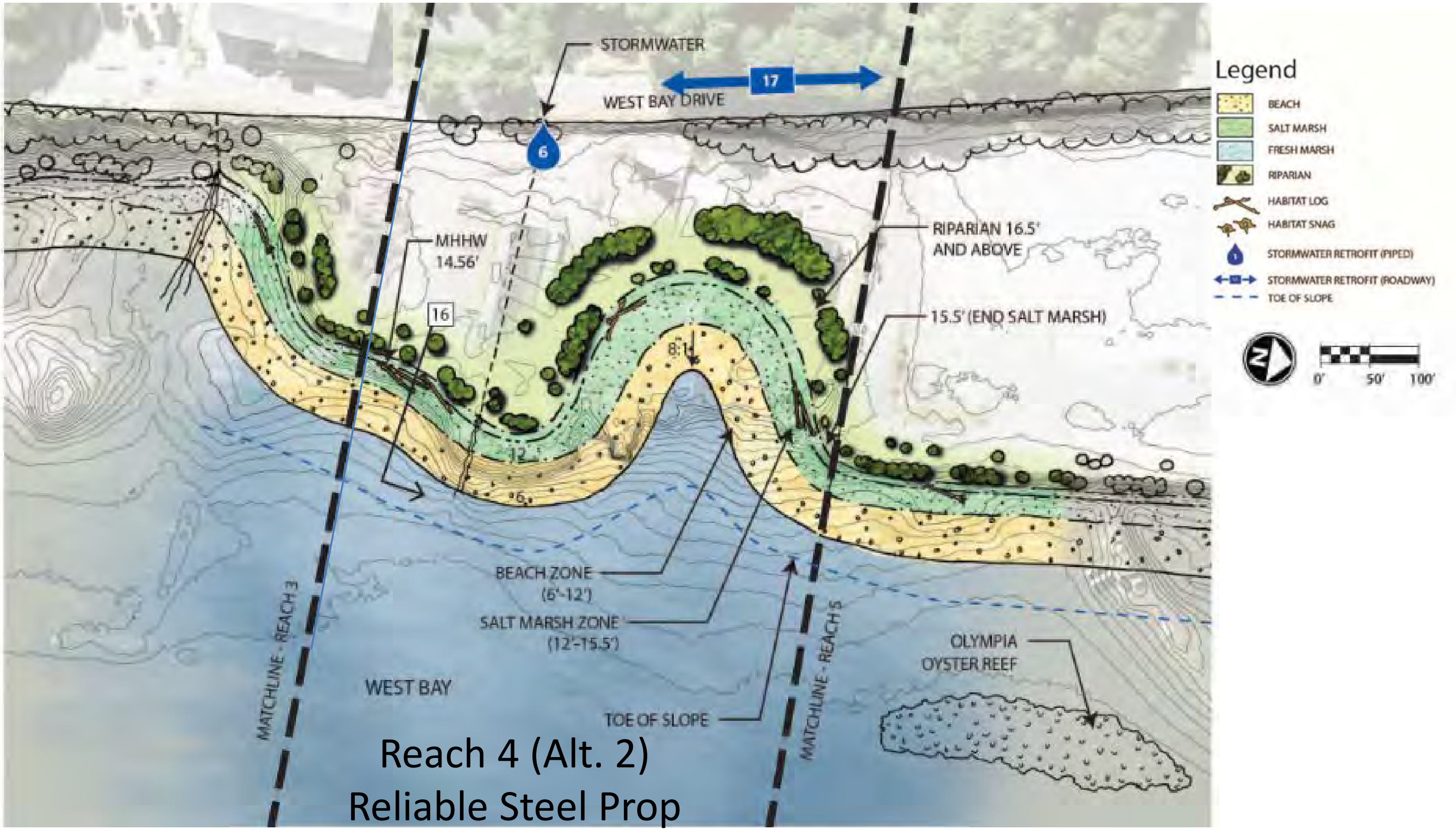
SED	CIRC	CON	HIS	RES	DES	PHS	REC
2	1	1	1	2	1	2	2

QUALITATIVE EVALUATION

$1,950,000 **REST.**
$80,000 **REC.**

COST

NOTES:
1. $ per point reflects restoration costs only



RESTORATION	RECREATION
9/14	4/8

CRITERIA OBJECTIVES

89.18 points
26.88 points/ac
$25,399 /point

SEMI-QUANTITATIVE

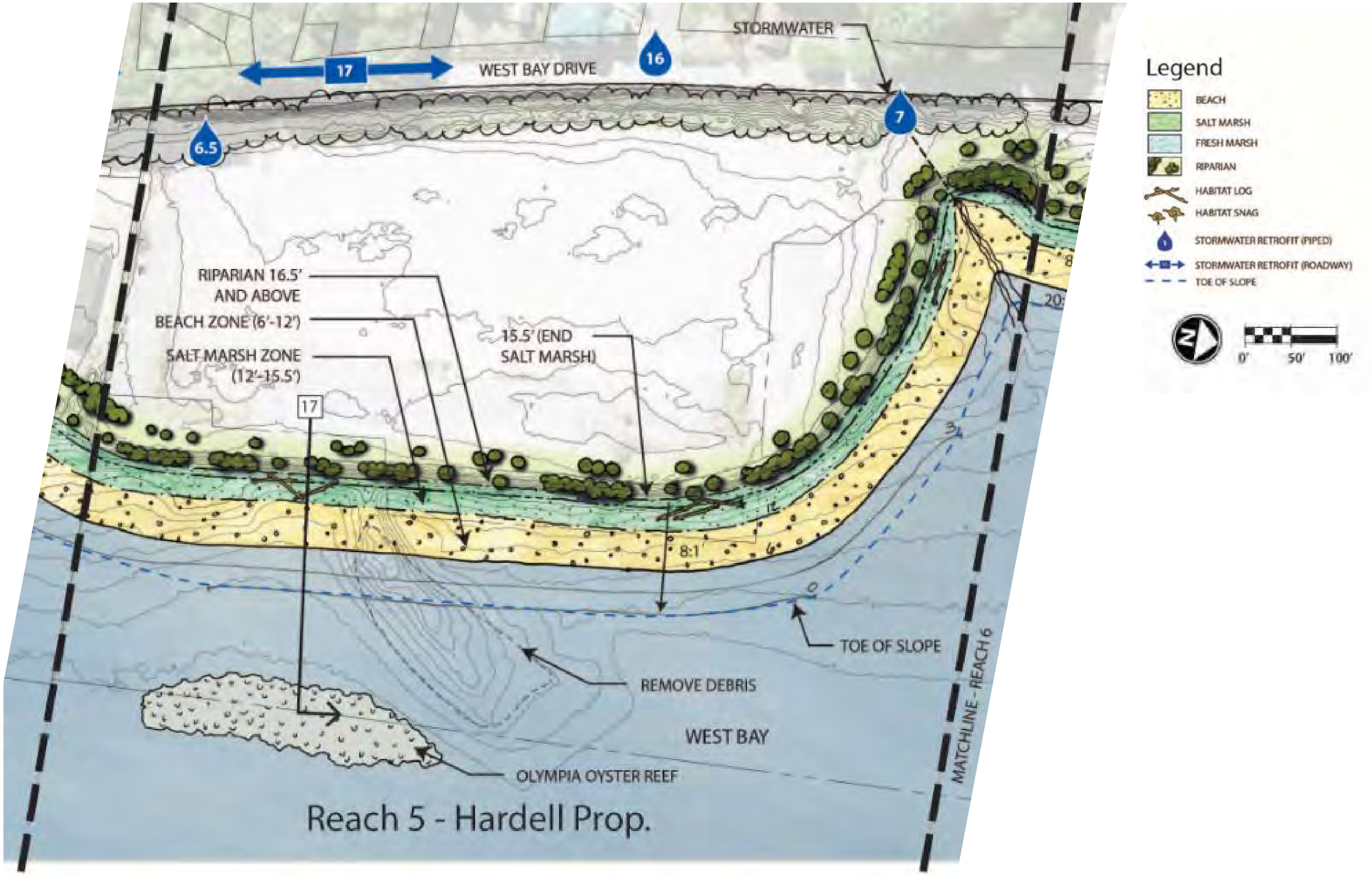
SED	CIRC	CON	HIS	RES	DES	PHS	REC
2	1	1	1	2	1	2	2

QUALITATIVE EVALUATION

$2,265,000 **REST.**
$80,000 **REC.**

COST

NOTES:
1. $ per point reflects restoration costs only



RESTORATION	RECREATION
10/14	4/8

CRITERIA OBJECTIVES

62.02 points
21.88 points/ac
$65,031 /point

SEMI-QUANTITATIVE

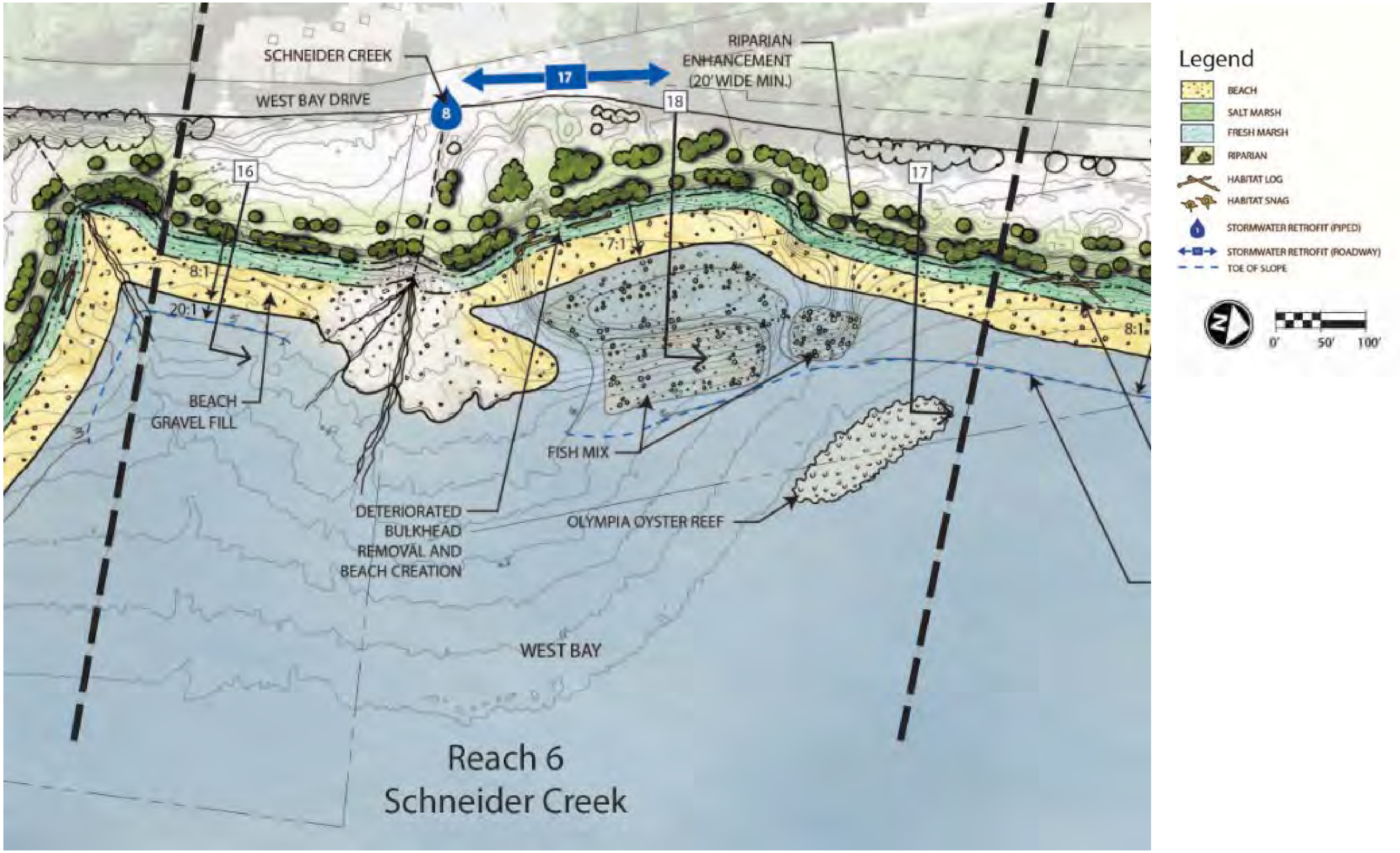
SED	CIRC	CON	HIS	RES	DES	PHS	REC
2	1	1	2	2	1	3	2

QUALITATIVE EVALUATION

$4,033,000 **REST.**
$142,000 **REC.**

COST

NOTES:
1. $ per point reflects restoration costs only



RESTORATION	RECREATION
14/14	6/8

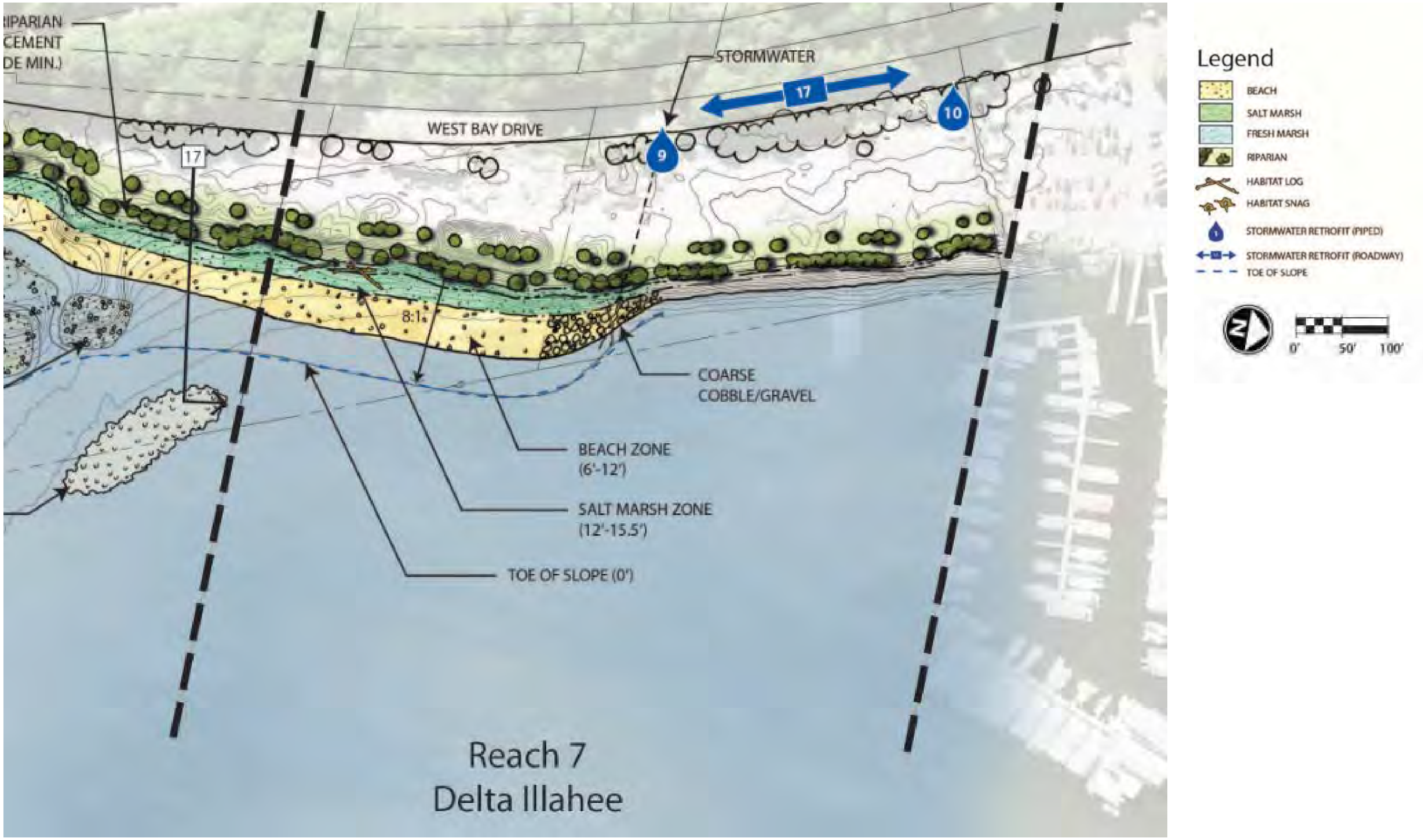
127.17 points
23.43 points/ac
$27,372 /point

SED	CIRC	CON	HIS	RES	DES	PHS	REC
1	0	1	1	2	1	2	1

$3,481,000 **REST.**
$119,000 **REC.**

CRITERIA OBJECTIVES SEMI-QUANTITATIVE QUALITATIVE EVALUATION COST

NOTES:
1. $ per point reflects restoration costs only 2. Stormwater opportunity 18 not shown.



RESTORATION	RECREATION
8/14	4/8

CRITERIA OBJECTIVES

64.43 points
24.99 points/ac
$27,473 /point

SEMI-QUANTITATIVE

SED	CIRC	CON	HIS	RES	DES	PHS	REC
1	0	1	1	2	1	2	1

QUALITATIVE EVALUATION

$1,770,000 **REST.**
$102,000 **REC.**

COST

NOTES:
1. $ per point reflects restoration costs only

APPENDIX I

Semi-quantitative Habitat Score Tables

West Bay Environmental Restoration Assessment - Lagoon Alt. 1

Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2 (0.55)	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	-0.728449067	0	0	0	0	0	0	0	0	0	0	0	-0.72844907
Partially Functioning Intertidal	20.22476177	0	-0.014781545	0	0	45.48153757	0	-0.372880674	0	0	0	0	2.560543955	0	-0.011800964	0	-3.812827178	64.0545529
Degraded Intertidal	0.117523019	0	0.015766844	0	0	0.191630303	0	0.063444947	0	0	0	0	1.229806888	0	0.0161308	0	-0.233167403	1.4011354
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0.006746979	0	0	0	0	0	0	0	0	0	0	0	0.00674698
Degraded Freshwater Wetland	0	0	0	0	0	0.525362574	0	0	0	0	0	0	0	0	0	0	0	0.52536257
Partially Functioning Riparian	0.074919287	0	0.00669106	0	0	0.110471394	0	0.005198255	0	0	0	0	0.046641517	0	-7.58494E-05	0	-0.1762765	0.06756916
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	0.098295538	0	0.257617411	0	0	0.482032844	0	1.166987257	0	0	0	0	1.510495212	0	0.045882282	0	0	3.56131054
Totals	20.51549962	0	0.26529377	0	0	46.0693326	0	0.862749784	0	0	0	0	5.347487574	0	0.050136269	0	-4.222271082	68.8882285

Total Relative Habitat Score: 68.88822853

Relative Habitat Score/Acre: 4.599287212

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2 (0.55)	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	-0.728449067	0	0	0	0	0	0	0	0	0	0	0	-0.72844907
Partially Functioning Intertidal	20.5612607	0	0	0	0	45.99362897	0	0	0	0	0	0	3.292879711	0	0	0	0	69.8477694
Degraded Intertidal	0.161184064	0	0	0	0	0.30375484	0	0	0	0	0	0	2.202055537	0	0	0	0	2.66699444
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0.006746979	0	0	0	0	0	0	0	0	0	0	0	0.00674698
Degraded Freshwater Wetland	0	0	0	0	0	0.525362574	0	0	0	0	0	0	0	0	0	0	0	0.52536257
Partially Functioning Riparian	0.107262895	0	0	0	0	0.126486028	0	0	0	0	0	0	0.200123152	0	0	0	0	0.43387207
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	0.751413014	0	0	0	0	2.277175041	0	0	0	0	0	0	5.558795627	0	0	0	0	8.58738368
Totals	21.58112068	0	0	0	0	48.50470536	0	0	0	0	0	0	11.25385403	0	0	0	0	81.3396801

Total Relative Habitat Score: 81.33968007

Relative Habitat Score/Acre: 5.431527322

West Bay Environmental Restoration Assessment - Lagoon Alt. 2

Trail

Habitat Type	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0.05500452	0	0	0	0	0	0	0	0.17510904	0	0	0	0	0	0	0	0	0.23011356
Partially Functioning Intertidal	24.3178999	0	-0.02255603	0	0	0	0	-0.61087987	147.460793	0	0	0	0.4508632	0	-0.00254498	0	-2.26078885	169.332787
Degraded Intertidal	0.14067189	0	0.10547826	0	0	0	0	0.45224864	0.91502816	0	0	0	0.22970774	0	0.00011459	0	-0.20219082	1.64105848
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0.15147667	0	0	0	0	0	0	0	0.84176735	0	0	0	0.02685684	0	0	0	-0.00036723	1.01973363
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	0.29617956	0	0.34774598	0	0	0	0	1.68481907	2.36082725	0	0	0	0.51464319	0	0.00034882	0	0	5.20456387
Totals	24.9612326	0	0.43066821	0	0	0	0	1.52618784	151.753525	0	0	0	1.22207097	0	-0.00208158	0	-2.46334689	177.428256

Total Relative Habitat Score: 177.428256

Relative Habitat Score/Acre: 11.4068687

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0.05500452	0	0	0	0	0	0	0	0.17510904	0	0	0	0	0	0	0	0	0.23011356
Partially Functioning Intertidal	24.879366	0	0	0	0	0	0	0	150.072611	0	0	0	0.80170326	0	0	0	0	175.75368
Degraded Intertidal	0.49127466	0	0	0	0	0	0	0	2.16024007	0	0	0	0.87226398	0	0	0	0	3.52377871
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0.15147667	0	0	0	0	0	0	0	0.84176735	0	0	0	0.02717948	0	0	0	0	1.0204235
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	1.33464212	0	0	0	0	0	0	0	6.19310418	0	0	0	3.01660835	0	0	0	0	10.5443547
Totals	26.911764	0	0	0	0	0	0	0	159.442832	0	0	0	4.71775507	0	0	0	0	191.072351

Total Relative Habitat Score: 191.072351

Relative Habitat Score/Acre: 12.2903891

City of Olympia

2/26/2016

West Bay Environmental Restoration Assessment - Lagoon Alt. 3

Up Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0.00015447	0	0	0	-0.23375821	0	0	-0.06513289	0	0	0	0	0	0	0	0	0	-0.29873663
Partially Functioning Intertidal	47.7817454	0	-0.30298843	0	85.5324701	0	0	-0.34005721	0	0	0	0	0.52039579	0	-0.07132105	0	-4.46604513	128.654199
Degraded Intertidal	0.30005988	0	0	0	2.89245642	0	0	0	0	0	0	0	0.1579291	0	0	0	-0.00652916	3.34391624
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0.10086548	0	0	0	0.20768537	0	0	0	0	0	0	0	0	0	0	0	0	0.30855085
Partially Functioning Riparian	0.09956512	0	0	0	0.12852824	0	0	0	0	0	0	0	0.19763035	0	-0.02573582	0	-1.16043583	-0.76044793
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	0.85335088	0	0	0	8.48884483	0	0	0	0	0	0	0	0.64590656	0	0	0	0	9.98810227
Totals	49.1357413	0	-0.30298843	0	97.0162267	0	0	-0.40519011	0	0	0	0	1.5218618	0	-0.09705686	0	-5.63301012	141.235584

Total Relative Habitat Score: 141.235584

Relative Habitat Score/Acre: 9.03911856

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0.00015447	0	0	0	-0.24378073	0	0	0	0	0	0	0	0	0	0	0	0	-0.24362626
Partially Functioning Intertidal	55.568393	0	0	0	87.1063237	0	0	0	0	0	0	0	0.64017749	0	0	0	0	143.314894
Degraded Intertidal	0.30005988	0	0	0	2.89245642	0	0	0	0	0	0	0	0.18374325	0	0	0	0	3.37625955
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0.10086548	0	0	0	0.20768537	0	0	0	0	0	0	0	0	0	0	0	0	0.30855085
Partially Functioning Riparian	0.09956512	0	0	0	0.12977032	0	0	0	0	0	0	0	0.19763035	0	0	0	0	0.42696579
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	0.85335088	0	0	0	8.48884483	0	0	0	0	0	0	0	0.80463918	0	0	0	0	10.1468349
Totals	56.9223888	0	0	0	98.5812999	0	0	0	0	0	0	0	1.82619027	0	0	0	0	157.329879

Total Relative Habitat Score: 157.329879

Relative Habitat Score/Acre: 10.1835272

City of Olympia 2/26/2016

West Bay Environmental Restoration Assessment - Lagoon Alt. 4

Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	1.50885206	0	0	1.28803062	0	0	0	0	0	0	0	0	0	0	0	0	0	2.79688268
Partially Functioning Intertidal	28.1786032	0	-0.01116071	207.5731	0	0	0	-1.33055827	0	0	0	0	0.51484065	0	-0.05876066	0	-0.38063751	234.485427
Degraded Intertidal	0	0	0.00345308	2.61039347	0	0	0	0.61585312	0	0	0	0	0.05932054	0	0.00058582	0	-0.04153661	3.24806942
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0.14204669	0	0	0	0	0	0	0	0	0	0	0	0	0	0.14204669
Degraded Freshwater Wetland	0.09901141	0	0	0.86478488	0	0	0	0	0	0	0	0	0	0	0	0	0	0.96379629
Partially Functioning Riparian	0.10332124	0	0.00025245	0.20914667	0	0	0	0.00038825	0	0	0	0	0.13464011	0	-0.00338734	0	-0.06309799	0.3812634
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	0.05930151	0	0.14627586	8.31422579	0	0	0	1.5399948	0	0	0	0	0.01431369	0	0.07715907	0	0	10.1512707
Totals	29.9490894	0	0.13882068	221.001728	0	0	0	0.8256779	0	0	0	0	0.72311499	0	0.01559688	0	-0.4852721	252.168756

Total Relative Habitat Score: 252.168756

Relative Habitat Score/Acre: 16.4103798

No Trail

Habitat Type	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	1.50885206	0	0	1.28803062	0	0	0	0	0	0	0	0	0	0	0	0	0	2.79688268
Partially Functioning Intertidal	28.4242828	0	0	215.589785	0	0	0	0	0	0	0	0	0.60526236	0	0	0	0	244.61933
Degraded Intertidal	0.00975389	0	0	4.40286968	0	0	0	0	0	0	0	0	0.19719525	0	0	0	0	4.60981882
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0.14204669	0	0	0	0	0	0	0	0	0	0	0	0	0	0.14204669
Degraded Freshwater Wetland	0.09901141	0	0	0.86478488	0	0	0	0	0	0	0	0	0	0	0	0	0	0.96379629
Partially Functioning Riparian	0.10454157	0	0	0.21157334	0	0	0	0	0	0	0	0	0.20249884	0	0	0	0	0.51861374
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	0.41310282	0	0	12.0417832	0	0	0	0	0	0	0	0	0.83892033	0	0	0	0	13.2938063
Totals	30.5595445	0	0	234.540873	0	0	0	0	0	0	0	0	1.84387678	0	0	0	0	266.944295

Total Relative Habitat Score: 266.944295

Relative Habitat Score/Acre: 17.3749187

City of Olympia 2/26/2016

West Bay Environmental Restoration Assessment - West Bay Park Alt. 1

Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0.88300014	0	0	0.48062025	0	0	0	0	0	0.45211949	0	0	0	0	0	0	0	1.81573988
Partially Functioning Intertidal	9.2696501	0	0	36.5602144	0	0	0	0	0	1.30264084	0	0	0.92830213	0	0	0	-0.25423986	47.8065676
Degraded Intertidal	0	0	0	0	0	0	0	0	0	0	0	0	0.11689835	0	0	0	-0.11523529	0.00166307
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0.72478021	0	0	0.78832736	0	0	0	0	0	5.39144747	0	0	1.06036363	0	0	0	-3.54735035	4.41756832
Degraded Freshwater Wetland	7.32960494	0	0	2.93940245	0	0	0	0	0	2.11420038	0	0	12.7826044	0	0	0	-0.31236319	24.853449
Partially Functioning Riparian	3.70027625	0	0	1.22826026	0	0	0	0	0	0.00755726	0	0	3.17352483	0	0	0	-1.78880385	6.32081474
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	4.58536523	0	0	1.87427322	0	0	0	0	0	0	0	0	7.99123236	0	0	0	0	14.4508708
Totals	26.4926769	0	0	43.871098	0	0	0	0	0	9.26796543	0	0	26.0529257	0	0	0	-6.01799254	99.6666735

Total Relative Habitat Score: 99.6666735

Relative Habitat Score/Acre: 13.9677644

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0.88300014	0	0	0.48062025	0	0	0	0	0	0.45211949	0	0	0	0	0	0	0	1.81573988
Partially Functioning Intertidal	9.2696501	0	0	36.5602144	0	0	0	0	0	1.30264084	0	0	0.97793769	0	0	0	0	48.1104431
Degraded Intertidal	0	0	0	0	0	0	0	0	0	0	0	0	0.57250094	0	0	0	0	0.57250094
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0.72478021	0	0	0.78832736	0	0	0	0	0	5.39144747	0	0	1.37201275	0	0	0	0	8.27656779
Degraded Freshwater Wetland	7.32960494	0	0	2.93940245	0	0	0	0	0	2.11420038	0	0	14.0175862	0	0	0	0	26.400794
Partially Functioning Riparian	3.70027625	0	0	1.22826026	0	0	0	0	0	0.00755726	0	0	4.74514912	0	0	0	0	9.68124289
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	4.58536523	0	0	1.87427322	0	0	0	0	0	0	0	0	12.8751633	0	0	0	0	19.3348017
Totals	26.4926769	0	0	43.871098	0	0	0	0	0	9.26796543	0	0	34.56035	0	0	0	0	114.19209

Total Relative Habitat Score: 114.19209

Relative Habitat Score/Acre: 16.0034258

City of Olympia

2/26/2016

West Bay Environmental Restoration Assessment - West Bay Park Alt. 2

Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	1.72158158	0	0	0.06845123	0	0	0	0	0	0.10426484	0	0	0	0	0	0	0	1.89429765
Partially Functioning Intertidal	8.89084388	0	0	0	0	0	0	0	0	0.41576746	0	0	1.33500119	0	0	0	-1.3424836	9.29912893
Degraded Intertidal	0.07329694	0	0	0.14166986	0	0	0	0	0	0.28246881	0	0	0.1005799	0	0	0	-0.03756109	0.56045441
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	2.75114583	0	0	0.27623887	0	0	0	0	0	4.91654276	0	0	1.29203482	0	0	0	-0.34100648	8.89495581
Degraded Freshwater Wetland	6.78152757	0	0	3.46525523	0	0	0	0	0	3.76059354	0	0	10.2450092	0	0	0	-0.18603398	24.0663516
Partially Functioning Riparian	1.21848343	0	0	0	0	0	0	0	0	0.14182071	0	0	2.78176936	0	0	0	-2.38030503	1.76176847
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	1.894652	0	0	2.38727591	0	0	0	0	0	0.07504927	0	0	8.21570803	0	0	0	0	12.5726852
Totals	23.3315312	0	0	6.3388911	0	0	0	0	0	9.6965074	0	0	23.9701025	0	0	0	-4.28739018	59.0496421

Total Relative Habitat Score: 59.0496421

Relative Habitat Score/Acre: 12.2843503

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	1.72158158	0	0	0.06845123	0	0	0	0	0	0.10426484	0	0	0	0	0	0	0	1.89429765
Partially Functioning Intertidal	8.89084388	0	0	0	0	0	0	0	0	0.41576746	0	0	1.59709592	0	0	0	0	10.9037073
Degraded Intertidal	0.07329694	0	0	0.14166986	0	0	0	0	0	0.28246881	0	0	0.24908414	0	0	0	0	0.74651974
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	2.75114583	0	0	0.27623887	0	0	0	0	0	4.91654276	0	0	1.32199363	0	0	0	0	9.26592109
Degraded Freshwater Wetland	6.78152757	0	0	3.46525523	0	0	0	0	0	3.76059354	0	0	10.9805267	0	0	0	0	24.987903
Partially Functioning Riparian	1.21848343	0	0	0	0	0	0	0	0	0.14182071	0	0	4.87308039	0	0	0	0	6.23338454
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Developed	1.894652	0	0	2.38727591	0	0	0	0	0	0.07504927	0	0	13.5817005	0	0	0	0	17.9386777
Totals	23.3315312	0	0	6.3388911	0	0	0	0	0	9.6965074	0	0	32.6034813	0	0	0	0	71.970411

Total Relative Habitat Score: 71.970411

Relative Habitat Score/Acre: 14.9723132

West Bay Environmental Restoration Assessment - Port Tidelands

Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	5.79338211	0	0	25.3184067	0	0	0	0	0	0	0	0	0.15744265	0	0	0	-0.0003748	31.2688567
Degraded Intertidal	8.87666498	0	0	51.8805154	0	0	0	0	0	0	0	0	2.32479995	0	0	0	-0.1683131	62.9136672
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0.14809433	0	0	0.49982176	0	0	0	0	0	0	0	0	7.01334618	0	0	0	-3.90354388	3.7577184
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	1.47075816	0	0	1.44420409	0	0	0	0	0	0	0	0	0.73415605	0	0	0	-0.09237789	3.55674042
Developed	0.12415942	0	0	2.93327983	0	0	0	0	0	0	0	0	3.40905628	0	0	0	0	6.46649553
Totals	16.413059	0	0	82.0762278	0	0	0	0	0	0	0	0	13.6388011	0	0	0	-4.16460967	107.963478

Total Relative Habitat Score: 107.963478

Relative Habitat Score/Acre: 19.1403061

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	5.79338211	0	0	25.3184067	0	0	0	0	0	0	0	0	0.15751582	0	0	0	0	31.2693047
Degraded Intertidal	8.87666498	0	0	51.8805154	0	0	0	0	0	0	0	0	2.99025485	0	0	0	0	63.7474352
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0.14809433	0	0	0.49982176	0	0	0	0	0	0	0	0	10.4429589	0	0	0	0	11.090875
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	1.47075816	0	0	1.44420409	0	0	0	0	0	0	0	0	1.09938797	0	0	0	0	4.01435023
Developed	0.12415942	0	0	2.93327983	0	0	0	0	0	0	0	0	5.7303569	0	0	0	0	8.78779615
Totals	16.413059	0	0	82.0762278	0	0	0	0	0	0	0	0	20.4204744	0	0	0	0	118.909761

Total Relative Habitat Score: 118.909761

Relative Habitat Score/Acre: 21.080918

City of Olympia

2/26/2016

West Bay Environmental Restoration Assessment - Reliable Alt. 1

Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	0	0	0	9.18946679	0	0	0	0	0	0	0	0	0	0	0	0	0	9.18946679
Degraded Intertidal	7.4025807	0	0	32.0596166	0	0	0	0	0	0	0	0	0.67645628	0	0	0	-0.05494158	40.083712
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0.02270119	0	0	0.12223307	0	0	0	0	0	0	0	0	0.16860887	0	0	0	-0.07179984	0.24174329
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	1.30766621	0	0	1.87309219	0	0	0	0	0	0	0	0	0.0394151	0	0	0	0	3.2201735
Developed	1.64920958	0	0	4.77707839	0	0	0	0	0	0	0	0	10.4543761	0	0	0	0	16.880664
Totals	10.3821577	0	0	48.021487	0	0	0	0	0	0	0	0	11.3388563	0	0	0	-0.12674142	69.6157596

Total Relative Habitat Score: 69.6157596

Relative Habitat Score/Acre: 23.3217676

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	0	0	0	9.18946679	0	0	0	0	0	0	0	0	0	0	0	0	0	9.18946679
Degraded Intertidal	7.4025807	0	0	32.0596166	0	0	0	0	0	0	0	0	0.89367728	0	0	0	0	40.3558745
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0.02270119	0	0	0.12223307	0	0	0	0	0	0	0	0	0.23169146	0	0	0	0	0.37662571
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	1.30766621	0	0	1.87309219	0	0	0	0	0	0	0	0	0.0394151	0	0	0	0	3.2201735
Developed	1.64920958	0	0	4.77707839	0	0	0	0	0	0	0	0	15.2529869	0	0	0	0	21.6792748
Totals	10.3821577	0	0	48.021487	0	0	0	0	0	0	0	0	16.4177707	0	0	0	0	74.8214154

Total Relative Habitat Score: 74.8214154

Relative Habitat Score/Acre: 25.0656988

West Bay Environmental Restoration Assessment - Reliable Alt. 2

Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	0	0	0	1.70481939	0	0	0	0	0	0	0	0	0	0	0	0	0	1.70481939
Degraded Intertidal	5.90254063	0	0	32.160036	0	0	0	0	0	0	0	0	2.08079911	0	0	0	-0.143569	39.9998067
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0	0	0	2.4929E-05	0	0	0	0	0	0	0	0	0.22972238	0	0	0	-0.14576078	0.08398653
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	1.07652229	0	0	1.83475204	0	0	0	0	0	0	0	0	0.13179042	0	0	0	-0.00546425	3.03760051
Developed	11.8515137	0	0	12.671705	0	0	0	0	0	0	0	0	13.2032809	0	0	0	0	37.7264996
Totals	18.8305767	0	0	48.3713374	0	0	0	0	0	0	0	0	15.6455928	0	0	0	-0.29479403	82.5527128
													Total Relative Habitat Score:				82.5527128	

Relative Habitat Score/Acre:	24.88419

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	0	0	0	1.70481939	0	0	0	0	0	0	0	0	0	0	0	0	0	1.70481939
Degraded Intertidal	5.90254063	0	0	32.160036	0	0	0	0	0	0	0	0	2.64842394	0	0	0	0	40.7110005
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0	0	0	2.4929E-05	0	0	0	0	0	0	0	0	0.35778627	0	0	0	0	0.3578112
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	1.07652229	0	0	1.83475204	0	0	0	0	0	0	0	0	0.15339426	0	0	0	0	3.06466859
Developed	11.8515137	0	0	12.671705	0	0	0	0	0	0	0	0	18.8141935	0	0	0	0	43.3374123
Totals	18.8305767	0	0	48.3713374	0	0	0	0	0	0	0	0	21.973798	0	0	0	0	89.175712
													Total Relative Habitat Score:				89.175712	

Relative Habitat Score/Acre:	26.8805868

City of Olympia

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West Bay Environmental Restoration Assessment - Hardel

Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	3.73366459	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.73366459
Degraded Intertidal	10.8212308	0	0	0	0	0	0	0	0	0	0	0	0.19278545	0	0	0	-0.00462326	11.009393
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0.4204393	0	0	0	-0.02604231	0.39439699
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	2.75104767	0	0	7.15333473	0	0	0	0	0	0	0	0	6.26198091	0	0	0	-0.06929021	16.0970731
Developed	0	0	0	0	0	0	0	0	0	0	0	0	19.3789142	0	0	0	0	19.3789142
Totals	17.3059431	0	0	7.15333473	0	0	0	0	0	0	0	0	26.2541199	0	0	0	-0.09995578	50.6134419

Total Relative Habitat Score:	50.6134419

Relative Habitat Score/Acre:	17.8221868

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	3.73366459	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.73366459
Degraded Intertidal	10.8212308	0	0	0	0	0	0	0	0	0	0	0	0.21106433	0	0	0	0	11.0322952
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0.4433198	0	0	0	0	0.4433198
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	2.75104767	0	0	7.15333473	0	0	0	0	0	0	0	0	6.53593169	0	0	0	0	16.4403141
Developed	0	0	0	0	0	0	0	0	0	0	0	0	30.3666139	0	0	0	0	30.3666139
Totals	17.3059431	0	0	7.15333473	0	0	0	0	0	0	0	0	37.5569297	0	0	0	0	62.0162075

Total Relative Habitat Score:	62.0162075

Relative Habitat Score/Acre:	21.8373695

West Bay Environmental Restoration Assessment - Schneider Creek

Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	0.22927764	0	0	16.6148479	0	0	0	0	0	0	0	0	0	0	0	0	0	16.8441256
Degraded Intertidal	10.8025199	0	0	64.7825956	0	0	0	0	0	0	0	0	2.09067853	0	0	0	-0.30711649	77.3686775
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0.001359	0	0	0.03965819	0	0	0	0	0	0	0	0	4.58348113	0	0	0	-2.58925937	2.03523895
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	1.76774141	0	0	9.54672176	0	0	0	0	0	0	0	0	1.43442874	0	0	0	-0.17283204	12.5760599
Developed	0.03539283	0	0	0.26118442	0	0	0	0	0	0	0	0	8.61391754	0	0	0	0	8.9104948
Totals	12.8362907	0	0	91.2450079	0	0	0	0	0	0	0	0	16.7225059	0	0	0	-3.0692079	117.734597

Total Relative Habitat Score: 117.734597

Relative Habitat Score/Acre: 21.6922242

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	0.22927764	0	0	16.6148479	0	0	0	0	0	0	0	0	0	0	0	0	0	16.8441256
Degraded Intertidal	10.8025199	0	0	64.7825956	0	0	0	0	0	0	0	0	3.30491657	0	0	0	0	78.890032
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0.001359	0	0	0.03965819	0	0	0	0	0	0	0	0	6.85837725	0	0	0	0	6.89939444
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	1.76774141	0	0	9.54672176	0	0	0	0	0	0	0	0	2.11775004	0	0	0	0	13.4322132
Developed	0.03539283	0	0	0.26118442	0	0	0	0	0	0	0	0	10.8095465	0	0	0	0	11.1061238
Totals	12.8362907	0	0	91.2450079	0	0	0	0	0	0	0	0	23.0905904	0	0	0	0	127.171889

Total Relative Habitat Score: 127.171889

Relative Habitat Score/Acre: 23.4310152

City of Olympia 2/26/2016

West Bay Environmental Restoration Assessment - Delta Illahee

Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Intertidal	2.43628022	0	0	23.2235031	0	0	0	0	0	0	0	0	0.8088184	0	0	0	-0.21092797	26.2576738
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0	0	0	0.00278299	0	0	0	0	0	0	0	0	0.39796706	0	0	0	-1.04259246	-0.64184241
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	4.4313795	0	0	8.32989542	0	0	0	0	0	0	0	0	1.00943416	0	0	0	-0.04054805	13.730161
Developed	0.72854012	0	0	3.25421716	0	0	0	0	0	0	0	0	13.5804283	0	0	0	0	17.5631856
Totals	7.59619983	0	0	34.8103987	0	0	0	0	0	0	0	0	15.7966479	0	0	0	-1.29406848	56.909178
													Total Relative Habitat Score:				56.909178	

Relative Habitat Score/Acre:	22.0701762

No Trail

Habitat Type (Proposed to right, existing below)	Fully Functioning Estuarine Marsh	Baseline Adjusted Estuarine Marsh	Grated Structure Estuarine Marsh (FF)	Fully Functioning Intertidal	Partially Functioning Intertidal 3 (0.65)	Baseline Adjusted Shallow Subtidal/ Partially Functioning Intertidal 2	Partially Functioning Intertidal 1	Grated Structure Intertidal (FF)	Baseline Adjusted Intertidal	Fully Functioning Freshwater Wetland	Baseline Adjusted Freshwater Wetland	Grated Structure Freshwater Wetland (FF)	Fully Functioning Riparian	Baseline Adjusted Riparian	Grated Structure Riparian (FF)	Fully Functioning Shallow Subtidal	Upland Trail/ Developed	Totals
Partially Functioning Estuarine Marsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Intertidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Intertidal	2.43628022	0	0	23.2235031	0	0	0	0	0	0	0	0	1.64275852	0	0	0	0	27.3025419
Partially Functioning Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Shallow Subtidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Degraded Freshwater Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Partially Functioning Riparian	0	0	0	0.00278299	0	0	0	0	0	0	0	0	1.31397786	0	0	0	0	1.31676085
Degraded Riparian	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armoring	4.4313795	0	0	8.32989542	0	0	0	0	0	0	0	0	1.16974786	0	0	0	0	13.9310228
Developed	0.72854012	0	0	3.25421716	0	0	0	0	0	0	0	0	17.8928949	0	0	0	0	21.8756522
Totals	7.59619983	0	0	34.8103987	0	0	0	0	0	0	0	0	22.0193792	0	0	0	0	64.4259777
													Total Relative Habitat Score:				64.4259777	

Relative Habitat Score/Acre:	24.9852964