Final

HERRING'S HOUSE SHORELINE RESTORATION

Feasibility Study Report

Prepared for
City of Seattle Parks & Recreation Dept.

October 2024

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Acronyms and Other Abbreviations

Abbreviation	Definition
ESA	Environmental Science Associates
SPR	Seattle Parks and Recreation Department
GEV	Generalized Extreme Value Distribution
NAVD88	North American Vertical Datum of 1998
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
RSP	Rock Shore Protection
NOAA	National Oceanic and Atmospheric Administration
USGS	United States Geological Survey
NDBC	National Data Buoy Center
PSLC	Puget Sound LiDAR Consortium
FEMA	Federal Emergency Management Agency
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
UAV	Unmanned Aerial Vehicle
LiDAR	Light Detection and Ranging

EXECUTIVE SUMMARY

This report presents the findings of the *Herring's House Shoreline Restoration Feasibility Study* conducted by Environmental Science Associates (ESA) for Seattle Parks and Recreation Department (SPR). The study's purpose was to evaluate current site conditions, conduct a comprehensive hydrologic study, and develop and propose preliminary alternative design concepts to restore the marsh and improve upland areas.

The study's primary objective is to provide SPR with viable alternatives to enhance the site's ecological performance by expanding the tidal channel to bolster estuarine habitats for Chinook salmon.

The feasibility study revealed a number of key considerations and findings that serve as the basis for the proposed conceptual alternatives. **Table ES-1** provides a summary of the study's findings and recommendations.

TABLE ES-1
SUMMARY OF KEY FINDINGS

Design Parameter	Description / Recommendations
Inlet Stability	• The inlet was found to be too narrow and too long relative to similar sites connected to Puget Sound. To restore the natural processes to the site, the inlet should be shortened and widened to a minimum of 50 ft wide to meet hydrology requirements and widen it to at least 120 ft for salmon habitat requirements. • Additionally, it is recommended to over-excavate the inlet channel to provide additional accommodation space for sedimentation.
Channel Geomorphology	• Rotate the channel alignment to be perpendicular to the existing shoreline. • Dredge pilot channels to an elevation of 4 ft NAVD88 or lower within the marsh. This will allow the site to increase regular tidal inundation and "washing" of the imported soil, which is needed to alter the soil's physical and chemical components that support wetland vegetation.
Riparian and Wetland Vegetation	Riparian and wetland re-vegetation is recommended: • Plant riparian and wetland vegetation between elevations of 8 ft to 10 ft NAVD88. • Seeding on the existing estuary, situated between elevations of 5 to 8 feet NAVD88, once tidal flow is established.
Sea Level Rise	• By 2030-2050, 2 to 5 years water levels events are projected to exceed 12.5 feet NAVD. These events will result in the inundation of certain upland areas within the park and are anticipated to become annual incidents by 2050-2070. • It is recommended to take into account the impact of rising sea levels on the design and elevation of upland areas within the park. This can be achieved through a phased approach; wherein upland areas can be created with a gradual transition from the marsh to higher elevations.
Upland Improvements and Park Use Opportunities	The proposed inlet modifications and the corresponding enhancements will enable park visitors to observe and monitor the restoration progress of this shoreline segment. Several actions are recommended to facilitate this: • Selectively trim and thin existing vegetation to provide visual access to the park. • Install bird blinds at locations where overlooks are provided for views into the wetland. • Establish clear demarcations of navigation routes to direct visitors away from critical habitat and restoration areas. This may involve the use of split-rail fencing, signage, and strategic planting. • Install signage to identify habitat planting locations.

Design Parameter	Description / Recommendations
Permitting Requirements	• A comprehensive review of the permitting requirements is needed. This should include any potential permitting issues. The project will likely require federal, state and local permits. • The location is marked to have high sensitivity for cultural resources. Additional review will be necessary to identify and evaluate the potential impacts of cultural resources
Contaminated Soil	• Historical records suggest the presence of contaminated soils below grade at the project site. Further investigation of the soils within the proposed excavated and regrading area will be needed to inform future plans and decisions.
Cost Estimate	Total costs were estimated on a first order of magnitude at the concept level. • The total cost of the marsh restoration alternatives is estimated at $800 K to $900 K. • The Upland Improvements cost estimate for the evaluated alternatives fluctuates between $900 K to $3.6 M depending on the chosen alternative.

CHAPTER 1
Introduction

Environmental Science Associates (ESA) conducted this feasibility study on behalf of Seattle Parks and Recreation Department (SPR) to assess site conditions and propose alternative design concepts for improving the site's ecological performance and park use at Herring's House Park. The conceptual alternatives developed and described herein are intended for planning purposes and will require additional analysis, permitting, and design in future phases of the project.

Report Overview:

- ***Chapter 1 Introduction:*** Summarizes the study's scope, highlighting key opportunities and constraints, along with an overview of the project setting and historical background.
- ***Chapter 2 Site Investigation:*** Describes the site investigation and existing condition, including previous restoration efforts, aerial data acquisition, topography and bathymetry data collection, and water level measurements.
- ***Chapter 3, Estuarine Processes:*** Focuses on the Estuarine Processes study, which serves as the foundation for developing marsh restoration concept design.
- ***Chapter 4: Development of Alternatives:*** Provides a comprehensive summary of the alternatives development and a detailed description of the concept design alternatives developed for marsh restoration and upland areas.
- ***Chapter 5 Evaluation of Alternatives:*** Evaluate each conceptual alternative, weighing their benefits, trade-offs, and potential impacts.
- ***Chapter 6 Discussion:*** Provides a summary of the inlet design recommendations and outlines the proposed and recommended future work, including permitting requirements, cultural resources, contaminated soils, marsh and upland vegetation, and coastal resilience.
- ***Appendices:*** Includes the conceptual restoration and upland design renderings, as well as concept-level estimates of quantities and costs for each of the proposed alternatives.

1.1 Scope of Work

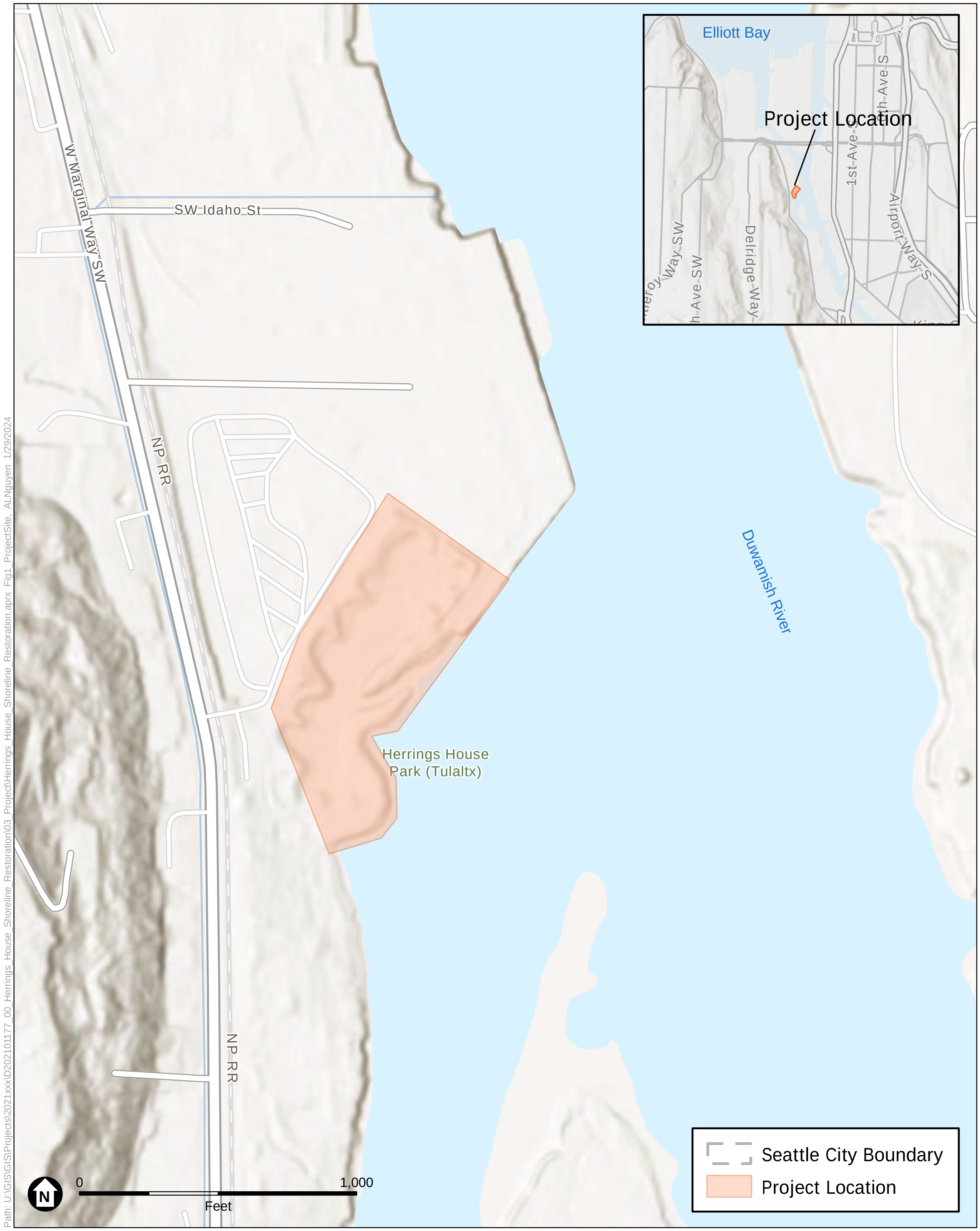
This Feasibility Study Report adheres to the scope of work outlined by ESA and authorized by SPR on June 7, 2023, as specified in contract agreement No. PRK730300-117 with SPR. The study aims to present SPR with a set of alternatives to enhance the site's ecological performance and enhance its usability.

The proposed solutions involve widening and realigning the existing tidal channel to enhance the tidal connection between the marsh and the adjacent Duwamish River channel. These actions are designed to restore natural hydrologic processes, including sediment transport, tidal channel formation, detritus exchange, and exchange of aquatic organisms.

1.2 Project Setting

Herring's House Park is situated on the Puget Sound along the Duwamish Waterway in South Elliott Bay. To the north, it is bordered by the Seattle Public Utilities (SPU) offices, while to the south lies the həʔapus Village Park and Shoreline Habitat (formerly Terminal 107 Park). Its western boundary is marked by W Marginal Way SW, and to the east is the industrial Duwamish Waterway (refer to **Figure 1-1**).

The current layout of Herring's House Park was established in 2000, and it was purposefully designed primarily as a habitat for juvenile Chinook salmon. The park comprises an intertidal estuary surrounded by an upland area adorned with native vegetation and a trail. The shoreline was fortified with quarry stone 8 to 9 inches in diameter, initially filled with fine/medium gravel and coarse sand. However, over time, these materials have been lost or are now located beneath the existing rock. Certain sections of the armored shoreline were constructed to contain low-level industrial contaminants (NOAA 1998).



Basemap: Esri; County Boundaries: WA DNR; City Boundary: ArcGIS; Study Area: ESA

Herrings House Shoreline Restoration

Figure 1-1
Project Location and Vicinity Map

ESA

1.3 Historical Background

Herring's House Park, situated along the Duwamish Waterway in South Elliot Bay, holds historical significance as a site deeply rooted in the cultural heritage of the *dxʷdəwʔabš* Duwamish ("people of the inside") (Duwamish Tribal Services 2018; Lane 1975; Suttles and Lane 1990). The Duwamish are part of the larger Southern Coast Salish cultural group that has inhabited this portion of Puget Sound since time immemorial (Duwamish Tribal Services 2018; Kopperl et al. 2016; Suttles and Lane 1990). There are numerous recorded villages and use areas along the shoreline of the Duwamish Waterway (Hilbert et al. 2001; Thrush 2007). The park's name is derived from the Duwamish village located downstream from the park's location near the mouth of the Duwamish, known as *túʔulʔaltxʷ*, meaning "herring's house" (Thrush 2007:234). Another Duwamish village *yəlíqʷad*, meaning "basketry hat" was located at the site of today's Herring's House Park (Thrush 2007:236-237). This location has high sensitivity for cultural resources (DAHP 2024).

The Duwamish/Green River system is culturally significant as a traditional fishing ground for the Squamish and Muckleshoot tribes, and it also houses numerous fish hatcheries that release approximately 10 million juvenile salmon annually (L.M. Doty 2015). Historically, this area served as a vital hub for sustenance, trade, and communal gathering for the Duwamish people (Duwamish Alive Coalition). With the arrival of non-Indigenous people to the area in the 1850s, traditional cultural practices carried out at this location since time immemorial were disrupted, and the location's ecological balance was impacted.

Due to historical industrial use and development of the site, the Duwamish Waterway was filled with waste-bearing fill material consisting of silt, sand, and gravel mixtures with broken asphalt, rock, concrete, brick, wood, and metal debris (NOAA 1998). Investigations revealed soils with concentrations of TPH, lead, mercury, and polycyclic aromatic hydrocarbons (PAHs) that exceeded Washington State Model Toxics Control Act cleanup criteria (Conn et al. 2018). In the mid-1990s, the Port of Seattle cleaned up the site as a part of the Super Fund cleanup effort, which covers the first 5 miles of the river basin (Duwamish Alive Coalition).

1.4 Current Park Use

Presently, the park is utilized for various recreational activities. Park amenities encompass a picnic area and three viewpoints offering panoramic vistas of the Duwamish River and the estuary, along with trails winding through the adjacent upland. Moreover, interpretative signs are placed throughout the park to educate visitors about the local ecosystem. Common activities observed in the park include leisurely walks, nature viewing, and cycling along the Duwamish trail.

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CHAPTER 2
Site Investigation

ESA investigated existing site conditions to provide a foundation for developing conceptual alternatives for the restoration of Herring's House Park. The following sections outline the methodology employed and the outcomes derived from this investigation.

2.1 Previous Restoration Efforts

2.1.1 Restoration Efforts

The initial restoration of Herring's House Park and its intertidal habitat was completed in 2000 as part of the *Herring's House Park and Intertidal Habitat Restoration Project* (SRP, 2023). Key elements of this project included the demolition and removal of former mill structures, a 9,200-square-foot shoreline dock, and highly contaminated upland soil. These soils, which were contaminated with Low-level petroleum hydrocarbons (TPH's), were capped and contained with two feet of clean soil and erosion control features.

As part of the restoration, a 1.8-acre intertidal bay was created with the limit contours ranging from 6 to 12 feet MLLW, shielded by two armored spits opening to the Duwamish River. An on-site soil mixture with high organic content was spread to a depth of 18 inches over the basin, designed to support wetland habitat development. Emergent marsh vegetation was planted along the sloping areas at varying elevations, creating a gradient of wetland habitat. Additionally, a transitional shrub habitat was planted to connect the intertidal marsh with upland meadow and forested areas, promoting ecological diversity across the site.

2.1.2 Duwamish Waterway Water Quality

The Duwamish Waterway, which flows into the Puget Sound at Elliott Bay, has been significantly impacted by anthropogenic activities throughout its history, resulting in the presence of polluted sediments (Conn et al. 2018; L.M. Doty 2015; W. Eash-Loucks 2014). With 91 percent of the Duwamish estuary being urbanized and serving as an important commercial and industrial corridor, including a complex network of storm drains from the Howard A Hanson Dam, which has contributed to the contamination of the river with overland runoff of water, particulates, and chemicals (Conn et al. 2018).

Due to concerns about potential health risks posed by exposure to these contaminated sediments, the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) mandated remedial investigations and feasibility studies under the Federal Superfund law and the Washington Model Toxics Control Act in 2001-02 (Conn et al. 2018; EPA 2014; L.M. Doty 2015; W. Eash-Loucks 2014).). Over the past century, heavy industrial and maritime activities have left area soils, groundwater, and river sediments contaminated with harmful substances such as polychlorinated biphenyls (PCBs), carcinogenic polycyclic aromatic hydrocarbons (cPAHs), dioxins/furans, arsenic, and other heavy metals (Conn et al. 2018; L.M. Doty 2015). Highlighting the ecological impact of the pollution, approximately 41 compounds (including individual metals, PCBs, polycyclic aromatic hydrocarbons [PAHs], phthalates, and other semi-volatile organic compounds) have been identified as contaminants of concern for the protection of the benthic community (Conn et al. 2018). To address these issues, the EPA released a final cleanup plan in November 2014, outlining a combination of strategies such as dredging, capping, natural sedimentation, and enhanced natural recovery (Conn et al. 2018; EPA 2014). These measures aim to protect and restore benthic organisms and resident fish populations, as well as safeguard the well-being of those who rely on these species as a food source.

2.2 Aerial Data Acquisition

The publicly available aerial imagery of the site lacked the necessary quality and scale required for future design plans, map production, and public presentation of conceptual alternatives. To address this, ESA utilized a small Unmanned Aerial Vehicle (UAV) to generate a high-resolution Georectified Aerial Orthophoto of the project area (refer to **Figure 2-1**). Ground control points (GCP) were established by both the SPR survey team and ESA to ensure the aerial data's alignment with the appropriate grid coordinate system (U.S State Plane, Washington North Zone) and the North American Vertical Datum of 1998 (NAVD88). The constructed and completed Orthoimage of the site is depicted in **Figure 2-2**.

Figure 2-1
Survey and Aerial Data Acquisition. a. Drone, b. Ground control points for aerial correction. c. Herring's House South View

Herring's House Shoreline Restoration

Figure 2-2
Aerial Image

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2.3 Topography and Bathymetry

ESA relied upon existing public data and topographic surveys conducted by both SPR and ESA[1]. These surveys focused on the park area and immediately adjacent properties. These surveys extended from the upland areas to offshore locations, covering elevations down to the -5 feet NAVD88 contour.

Light Detection and Ranging (LiDAR) data from 2016-2017 was collected, though the coverage does not include elevations beneath dense vegetation in the area (refer to **Figure 2-3**). LiDAR data typically have a vertical accuracy of approximately ±0.5 feet and are generally less precise than traditional field surveys. The topography and bathymetry data available and collected for this project are summarized in **Table 2-1.**

TABLE 2-1
AVAILABLE AND COLLECTED TOPOGRAPHY AND BATHYMETRY

Name	Publishing Agency	Type of Data	Date of Collection
2016-2017 Puget Sound LiDAR Consortium (PSLC) - King County, WA	NOAA	Topographic Surface	Feb. 2016 through May 2017
Puget Sound TBDEM (digital elevation model)	USGS Coastal National Elevation Database (CoNED)	Topo and bathymetry Surface	Topography surveys range from 2005-2017, and bathymetry surveys range from 1887 and 2015
GPS Topographic Survey	SPR	Topographic Survey	July. 27th, 2023
2023 ESA Survey	ESA	Elevation Points	July. 31st, 2023

SOURCE: Compiled by ESA, 2023

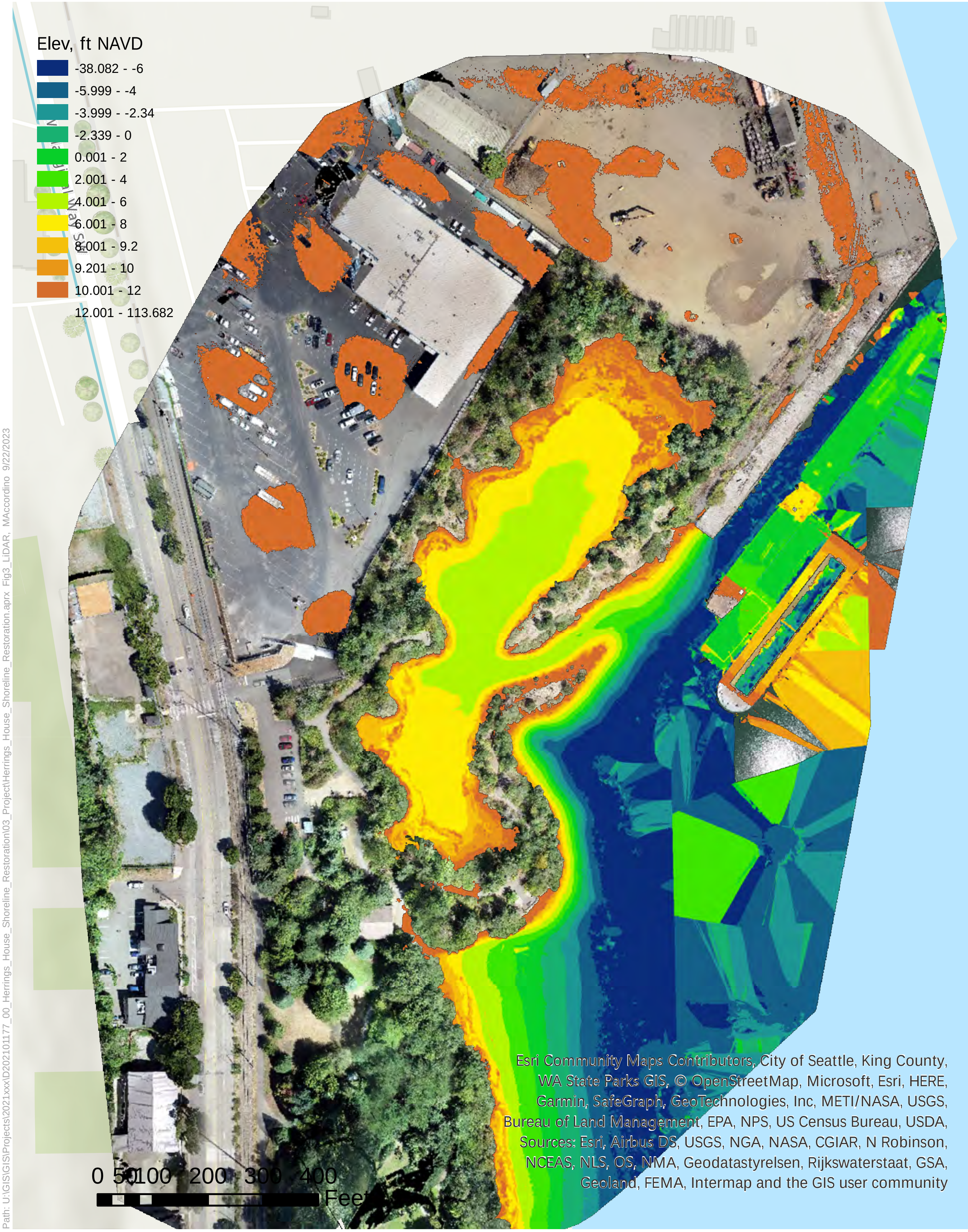
A combination of SPR and ESA surveys, along with LiDAR data, was utilized to create a comprehensive elevation model of the project site's existing conditions. Figures 2-4 display the elevation base map developed by ESA.

2.4 Water Levels

2.4.1 Water Level Data

This section presents the findings from the ESA water level monitoring and compares them with water level measurements obtained from the nearby National Oceanic and Atmospheric Administration (NOAA) tide gauge at the Seattle station (Sta. 9447130). Figures 2-5 show the locations of both the NOAA tide gauge from Seattle and the ESA water level gauge installed at the project site.

[1] ESA performs land surveys and collects hydrographic data to augment traditional surveying services for the purposes of engineering, geomorphic interpretation, monitoring of project performance, and other specific uses consistent with the Policy on Incidental Surveying Practice (Washington Board of Registration for Professional Engineers and Land Surveyors, Board Journal). ESA does not provide traditional land survey services such as property boundaries and maps for general use by others. ESA recommends that these traditional surveying services be accomplished by a licensed, professional land surveyor either under direct contract with the client or as a sub-consultant to ESA.



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SOURCE: Basemap: Esri; LiDAR:2016-2017 PSLC LiDAR: King County, WA

Herrings House Shoreline Restoration

Figure 2-3
Existing LiDAR Data

ESA

NOTES

1. ALL ELEVATIONS ARE IN THE VERTICAL DATUM NAVD88. THE HORIZONTAL DATUM IS NAD83 WASHINGTON STATE PLANE ZONE NORTH

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Herring's House Shoreline Restoration

Figure 2-4
Project Basemap

ESA

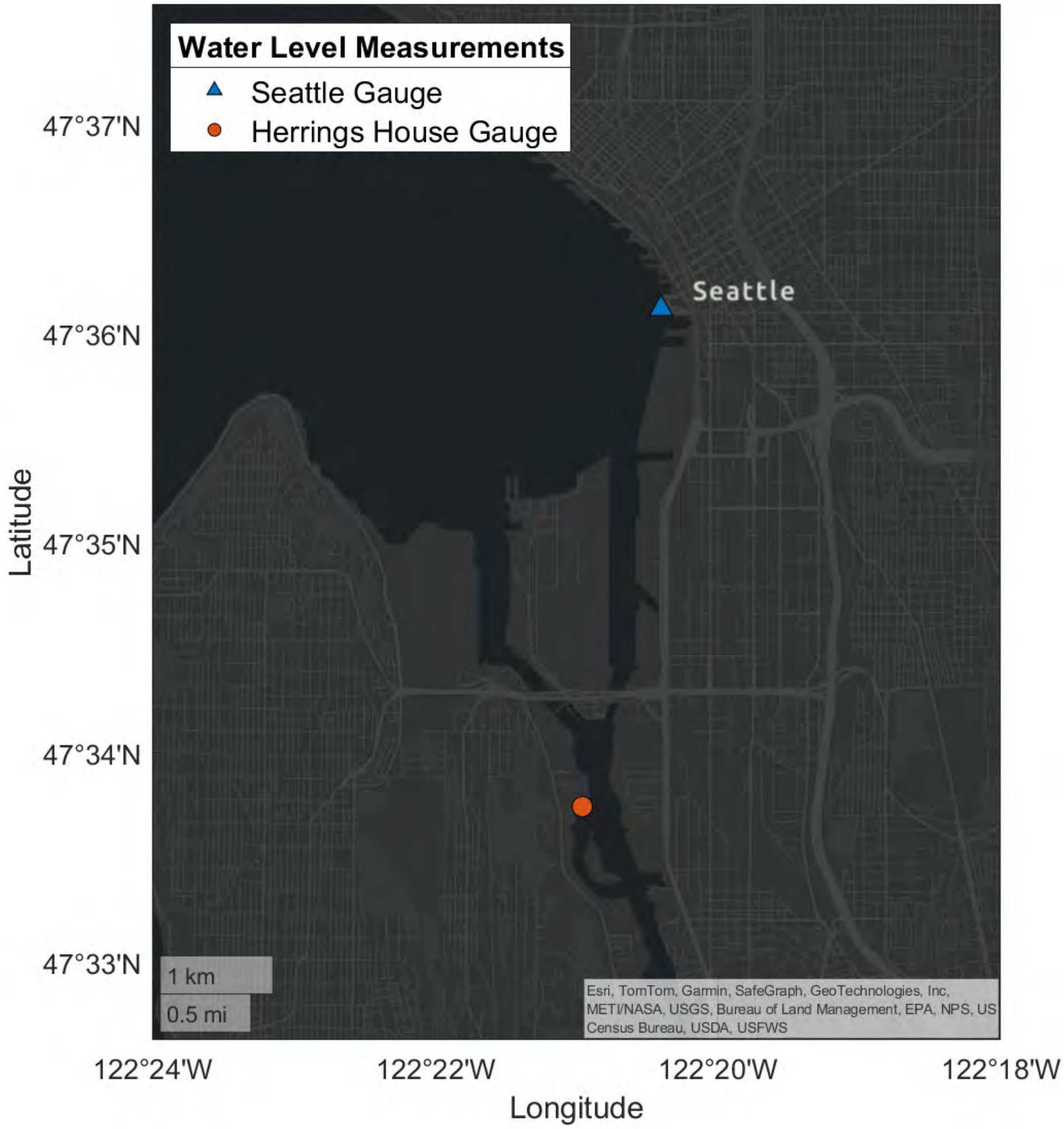

Figure 2-5
Tide Gauge Locations

ESA deployed a water level gauge at Herring's House Park between July 31st and October 26th, 2023, at the adjacent abandoned pier northeast of the site. The sensors collected data at 10-minute intervals. Upon deployment, the tide gauge was surveyed using a Real-Time Kinematic Global Positioning System, and water levels were adjusted for local barometric pressure using a barometric logger (refer to **Figure 2-6**). **Figure 2-7** displays the records of water level measurements obtained from July 31st to October 26th at both the Seattle tide gauge and the Herring's House tide gauge.

Figure 2-6
Tide Gauge Setup

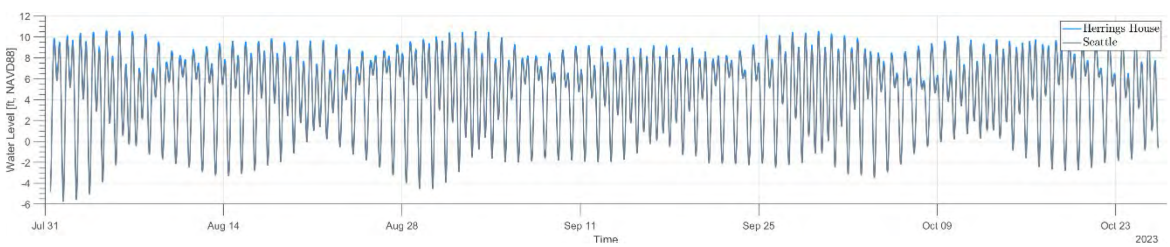

Figure 2-7
Water Level Measurements at Seattle Gauge (NOAA) and Herring's House From 07/31/2023 10:00 to 10/26/2023 08:20

For a closer examination, **Figure 2-8** provides a focused view of the water level record at the two stations from August 14th to 16th, 2023. The measurements at the Herring's House tide gauge show higher water level elevations during high tides.

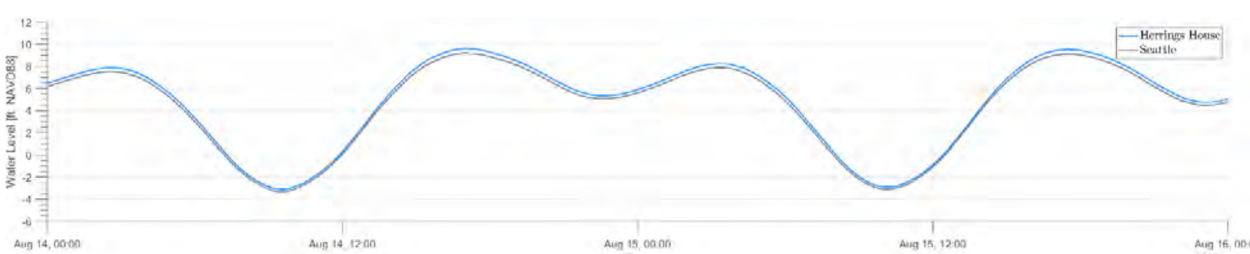

Figure 2-8
Water Level Measurements at Seattle Gauge (NOAA) and Herring's House From 08/14/2023 to 08/16/2023

2.4.2 Tide Datums

Table 2-2 presents a comparative analysis of tidal datum relationships between Seattle and Herring's House. Contrary to Seattle, which exhibits a smaller diurnal tide range, measuring 11.36 feet from mean higher high water to mean lower low water, Herring's House records a slightly larger range at 11.55 feet. Notably, Herring's House showcases higher values for most datum points, with a maximum difference of +0.36 foot for the mean higher high water (MHHW). Conversely, the variation is less pronounced for lower tides, with Herring's House registering a 0.18 foot elevation higher for the Mean Lower Low Water (MLLW).

TABLE 2-2
TIDAL DATUMS SEATTLE AND HERRING'S HOUSE

Tidal Datum	Abbrev.	Seattle[2] Elevation, ft NAVD88	Herring's House Elevation, ft NAVD88
Highest Observed (1/27/1983)[1]	HOT	12.14 (4:36 a.m.)	–
Highest Astronomical Tide	HAT	10.92	–
Mean Higher High Water	MHHW	9.02	9.4
Mean High Water	MHW	8.15	8.5
Mean Tide Level	MTL	4.32	4.56
Mean Sea Level	MSL	4.3	4.54
Diurnal Tide Level	DTL	3.34	3.61
Mean Low Water	MLW	0.49	0.63
North American Vertical Datum	NAVD	0.00	0.00
Mean Lower Low Water	MLLW	-2.34	-2.16
Lowest Astronomical Tide (6/22/1986)	LAT	-6.64	–
Lowest Observed (1/4/1916)[1]	LOT	-7.38 (0:00 a.m.)	–

SOURCE: Data compiled by Environmental Science Associates in 2023 from NOAA and Measured by ESA at the Project Site

NOTES:

Abbrev. = abbreviation for tidal datum; NAVD88 = North American Vertical Datum of 1988

1. The highest and lowest observed tide data are based on the recorded six-minute measurements.
2. Seattle Tidal Datums (EPOCH 1983-2001).

2.4.3 Water Level Distribution

Table 2-3 presents the water level percentiles recorded at the NOAA Seattle and ESA tide gauge during the monitoring period at Herring's House. Figure 2-9 provides a graphical depiction of the water level distribution. The findings reveal a discernible amplification of the highest tide signals at Herring's House compared to the Seattle tide gauge. Amplification of low tides is also observed but to a lesser extent.

TABLE 2-3
WATER LEVEL PERCENTILES FOR SEATTLE AND HERRING'S HOUSE

Percentile (%)	Seattle Gauge (ft, NAVD88)	Seattle Gauge 7/31/23 to 10/26/23 (ft, NAVD88)	Herring's House Gauge (ft, NAVD88)
0.1	11.15	10.14	10.53
1	10.05	9.74	10.13
2	9.65	9.44	9.83
5	9.2	8.99	9.38
10	8.65	8.49	8.83
25	7.3	7.29	7.58
50	5.3	5.44	5.68
75	2	2.04	2.23
90	-0.9	-0.91	-0.72
99	-3.95	-3.36	-3.22
99.9	-5.65	-5.41	-4.37

SOURCE: Data compiled by Environmental Science Associates in 2023
NOTE: ft, NAVD88 = feet, North American Vertical Datum of 1988.

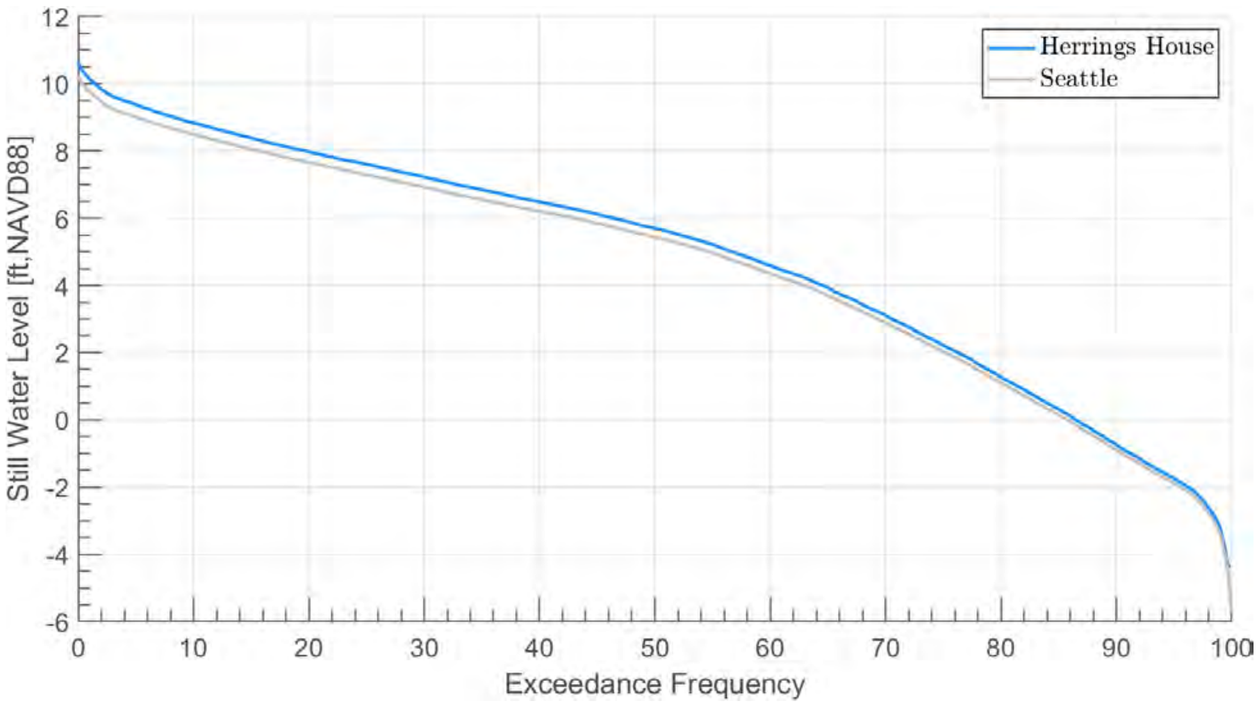

Figure 2-9
Still Water Level Distribution for Seattle and Herring's House

Table 2-4 shows selected high still-water elevations recorded at both the NOAA Seattle gauge and the ESA Herring's House tide gauge during the monitoring period from July 31st to October 26th. In most instances, the Herring's House gauge recorded water elevations ranging from +0.31 feet to +0.42 feet higher than those measured in Seattle. On average, these larger events are approximately +0.4 feet higher than the high tide events observed in Seattle.

TABLE 2-4
PEAK STILL WATER ELEVATIONS OBSERVED AT THE NOAA SEATTLE GAUGE AND THE HERRINGS HOUSE GAUGE FROM JULY 31ST TO OCTOBER 26TH, 2023

Event No.	Date (GMT)	Seattle Gauge (ft, NAVD88)	Herring's House Gauge (ft, NAVD88)	Difference (ft)
1	2023/08/14	9.20	9.62	0.42
2	2023/08/15	9.13	9.55	0.42
3	2023/08/16	9.20	9.60	0.40
4	2023/08/17	9.49	9.88	0.39
5	2023/08/18	9.14	9.51	0.37
6	2023/08/19	9.25	9.66	0.41
7	2023/08/20	9.26	9.65	0.39
8	2023/08/21	9.30	9.70	0.40
9	2023/08/22	8.90	9.26	0.36
10	2023/08/23	8.48	8.84	0.36
11	2023/08/24	8.29	8.66	0.37
12	2023/08/25	7.91	8.24	0.33
13	2023/08/26	7.83	8.17	0.34
14	2023/08/27	8.94	9.30	0.36
15	2023/08/28	9.19	9.57	0.38
16	2023/08/29	9.41	9.82	0.41
17	2023/08/30	9.62	10.03	0.41
18	2023/08/31	10.04	10.42	0.38
19	2023/09/01	10.11	10.48	0.37
20	2023/09/02	10.21	10.52	0.31
			Mean Difference	0.38

SOURCE: Data compiled by Environmental Science Associates in 2023
NOTE: ft, NAVD88 = feet, North American Vertical Datum of 1988.

2.4.4 Extreme Still-Water Level

Sea Level Trends

NOAA calculated long-term mean sea-level trends at the Seattle tide gauge from 1899 to 2021. The trend indicates a relative sea level increase of approximately 2.07 ± 0.14 millimeters per year, equivalent to a relative rise of 0.68 feet over a century. Using the available tidal data, ESA developed a tide time series normalized to account for historic sea level rise. To accurately assess present-day flood risk, the historical water level data was adjusted according to this rate of absolute sea level rise (refer to **Figure 2-10**).

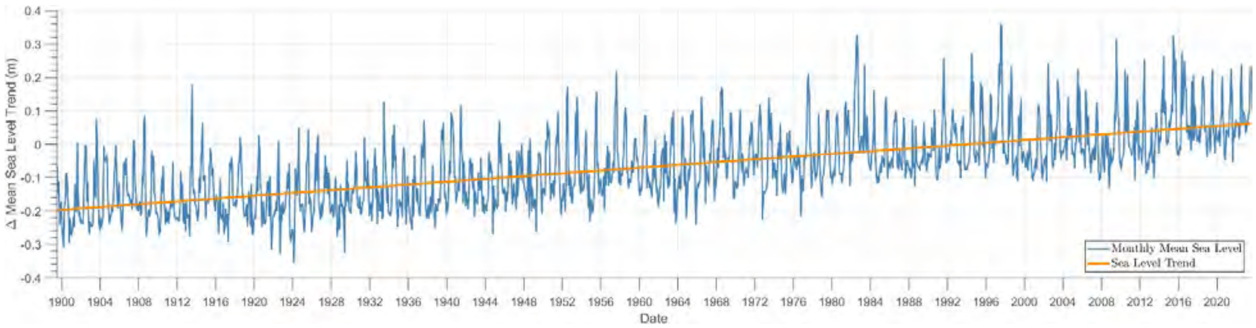

Figure 2-10
Monthly Mean Sea Level Trend from 1899 to 2021 at the Seattle Station. Source: NOAA, 2024

Extreme Analysis

Long-term water level records retrieved from the Seattle tide station serve as a representative dataset for long-term tide levels at the project site once adjusted to account for the tide amplification highlighted in the preceding section.

NOAA's Seattle tide gauge (Sta. 9447130), situated in Elliot Bay (refer to Figure 2-5), provides records of representative long-term water levels. While water level records at the Seattle Tide Station date back to January 1989, this study focused exclusively on the last sixty-two years (1961 to 2022) of data to establish more recent water level distributions and extreme events. The maximum still-water level elevation from each year was extracted from the detrended time series and fitted to various statistical distributions, including the Gumbel distribution, Weibull distribution, and the Generalized Extreme Value Distribution (GEV), as illustrated graphically in **Figure 2-11**.

Several distributions were scrutinized to identify the best fit for the dataset, with the GEV distribution emerging as the most suitable for the majority of extreme events. **Table 2-5** provides a summary of the extreme still-water levels derived from the GEV distribution, based on the detrended tide data for both the Seattle tide gauge and the project site at Herring's House Park by adding the +0.4 ft observed on the previous sections.

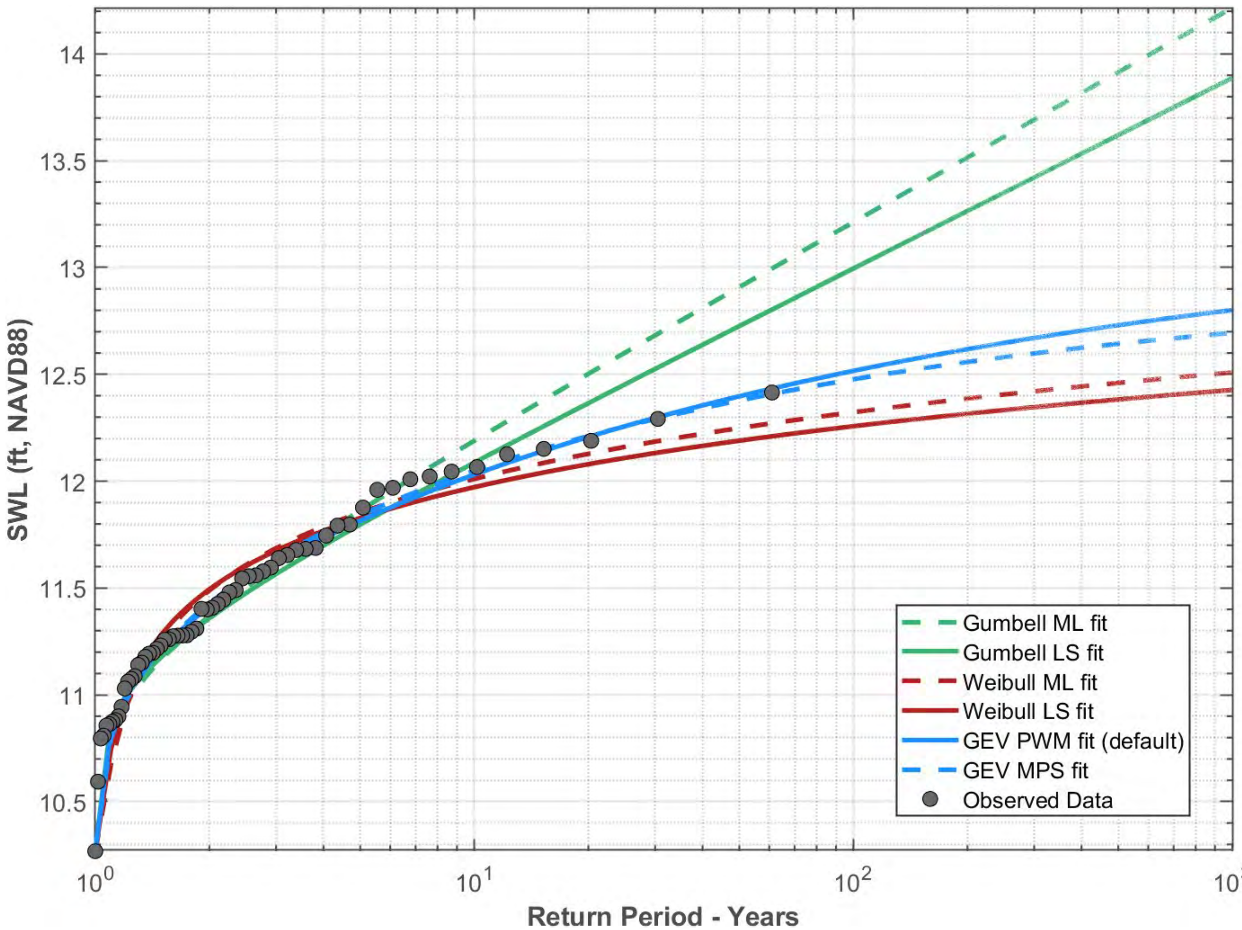

Figure 2-11
Detrended Still-Water Level Extreme Value Analysis for Seattle Station

TABLE 2-5
EXTREME STILL-WATER LEVEL VALUES FOR PRESENT-DAY SEA LEVELS

Return Period (years)	Seattle Elevation (ft, NAVD88)	Herring's House Elevation (ft, NAVD88)
1	10.3	10.7
2	11.5	11.9
5	11.9	12.3
10	12.1	12.5
20	12.3	12.7
50	12.5	12.9
100	12.6	13.0

SOURCE: Data compiled by Environmental Science Associates in 2023
NOTES: GEV = Generalized Extreme Value Distribution; NAVD88 = North American Vertical Datum of 1988.

2.4.5 Projected Sea Level Rise

Table 2-6 presents a summary of the projected sea level rise at the site sourced from the Washington Coastal Resilience Project and the *Projected Sea Level Rise for Washington State—A 2018 Assessment* (Miller et al., 2019). The table delineates sea level rise projections for the years 2030, 2050, 2070, and 2100, encompassing both Low Emissions and High Emissions scenarios.

TABLE 2-6
LIKELIHOOD (IN PERCENTAGES) OF SEA LEVEL RISE FOR HERRING'S HOUSE

Year	Low Emissions (RCP 4.5), ft						High Emissions (RCP 8.5), ft					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
2030	21	–	–	–	–	–	19	–	–	–	–	–
2050	89	17	1	–	–	–	92	23	1	–	–	–
2070	98	72	22	3	1	–	99	84	36	7	1	–
2100	99	93	74	43	18	7	100	98	90	69	42	20

SOURCE: Miller et al. 2019
NOTES: ft = feet; RCP = Representative Concentration Pathway, blue medium risk, yellow high risk.

According to the projections, there is a medium to moderate risk (greater than 10 percent) of a 0.5-foot increase in sea level rise by 2030, with a similar risk of a 1.0-foot rise by 2050. Anticipated sea level rise reaches 2-2.5 feet by 2100, with a medium to moderate risk, under high emissions projections, of this increase escalating to 3 feet.

Based on the sea level rise projections outlined in Table 2-6 and the extreme water level elevations detailed in Table 2-5 **and** Figure 2-11, water level estimates for various return periods and future years are presented below for both low emission projections (**Table 2-7**) and high emission projections (**Table 2-8**).

The results indicate that daily Mean Higher High Water (MHHW) levels are expected to transition from present-day to one-year events sometime between 2050-2060. Furthermore, present-day 10-year events are projected to occur annually by the years 2060-2070. For high emission projections (RCP 8.5), present-day 100-year events are anticipated to become one-year events in 2070, whereas, under low emission projections, they are not expected to become annual events until 2100.

Figures 2-12 and **2-13** depict a bathtub model using the current topographic conditions of the area under a one-year event, based on low and high emissions projections, respectively. Under low emissions projections, annual inundation events are expected to begin by 2060, primarily impacting localized areas such as the southern portion of the park. In contrast, high emissions projections indicate more widespread inundation across the park, extending northwest beyond the park boundaries by 2060.

Furthermore, water level events exceeding 12.5 feet NAVD are forecasted to inundate the upland areas of the park, with upland inundation becoming increasingly common between 2030 and 2050 for the 2-5 year events.

TABLE 2-7
WATER LEVEL DUE TO SEA LEVEL RISE LOW EMISSIONS (RCP 4.5)

Return Period (years)	Annual Probability of Occurrence	SWL Present (ft)	SWL 2030 (ft) 0.5 ft	SWL 2040 (ft) 0.75 ft	SWL 2050 (ft) 1.0 ft	SWL 2060 (ft) 1.25 ft	SWL 2070 (ft) 1.5 ft	SWL 2100 (ft) 2.5 ft
MHHW	Daily	9.4	9.9	10.15	10.4	10.65	10.9	11.9
1	100%	10.7	11.2	11.45	11.7	11.95	12.2	13.2
2	50%	11.9	12.4	12.65	12.9	13.15	13.4	14.4
5	20%	12.3	12.8	13.05	13.3	13.55	13.8	14.8
10	10%	12.5	13	13.25	13.5	13.75	14	15
20	5%	12.7	13.2	13.45	13.7	13.95	14.2	15.2
50	2%	12.9	13.4	13.65	13.9	14.15	14.4	15.4
100	1%	13.0	13.5	13.75	14	14.25	14.5	15.5

NOTES: ft = feet; MHHW = mean higher high water; TWL = total water level.

TABLE 2-8
WATER LEVEL DUE TO SEA LEVEL RISE LOW EMISSIONS (RCP 8.5)

Return Period (years)	Annual Probability of Occurrence	SWL Present (ft)	SWL 2030 (ft) 0.5 ft	SWL 2040 (ft) 0.75 ft	SWL 2050 (ft) 1.0 ft	SWL 2060 (ft) 1.5 ft	SWL 2070 (ft) 2.0 ft	SWL 2100 (ft) 3.0 ft
MHHW	Daily	9.4	9.9	10.15	10.4	10.9	11.4	12.4
1	100%	10.7	11.2	11.45	11.7	12.2	12.7	13.7
2	50%	11.9	12.4	12.65	12.9	13.4	13.9	14.9
5	20%	12.3	12.8	13.05	13.3	13.8	14.3	15.3
10	10%	12.5	13	13.25	13.5	14	14.5	15.5
20	5%	12.7	13.2	13.45	13.7	14.2	14.7	15.7
50	2%	12.9	13.4	13.65	13.9	14.4	14.9	15.9
100	1%	13.0	13.5	13.75	14	14.5	15	16

NOTES: ft = feet; MHHW = mean higher high water; TWL = total water level.

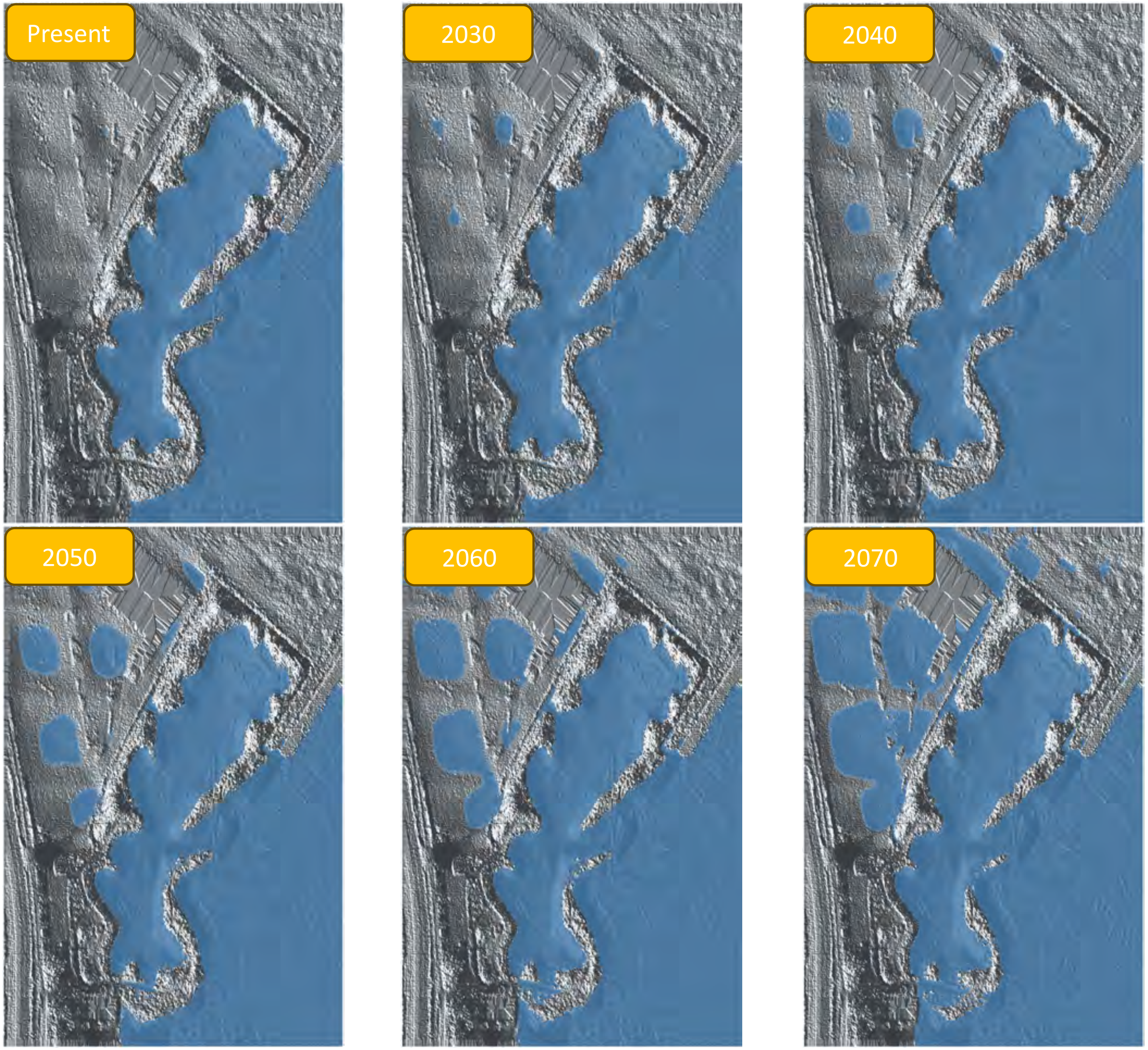

Figure 2-12 One-Year SWL Event for Low Emissions (RCP 4.5)

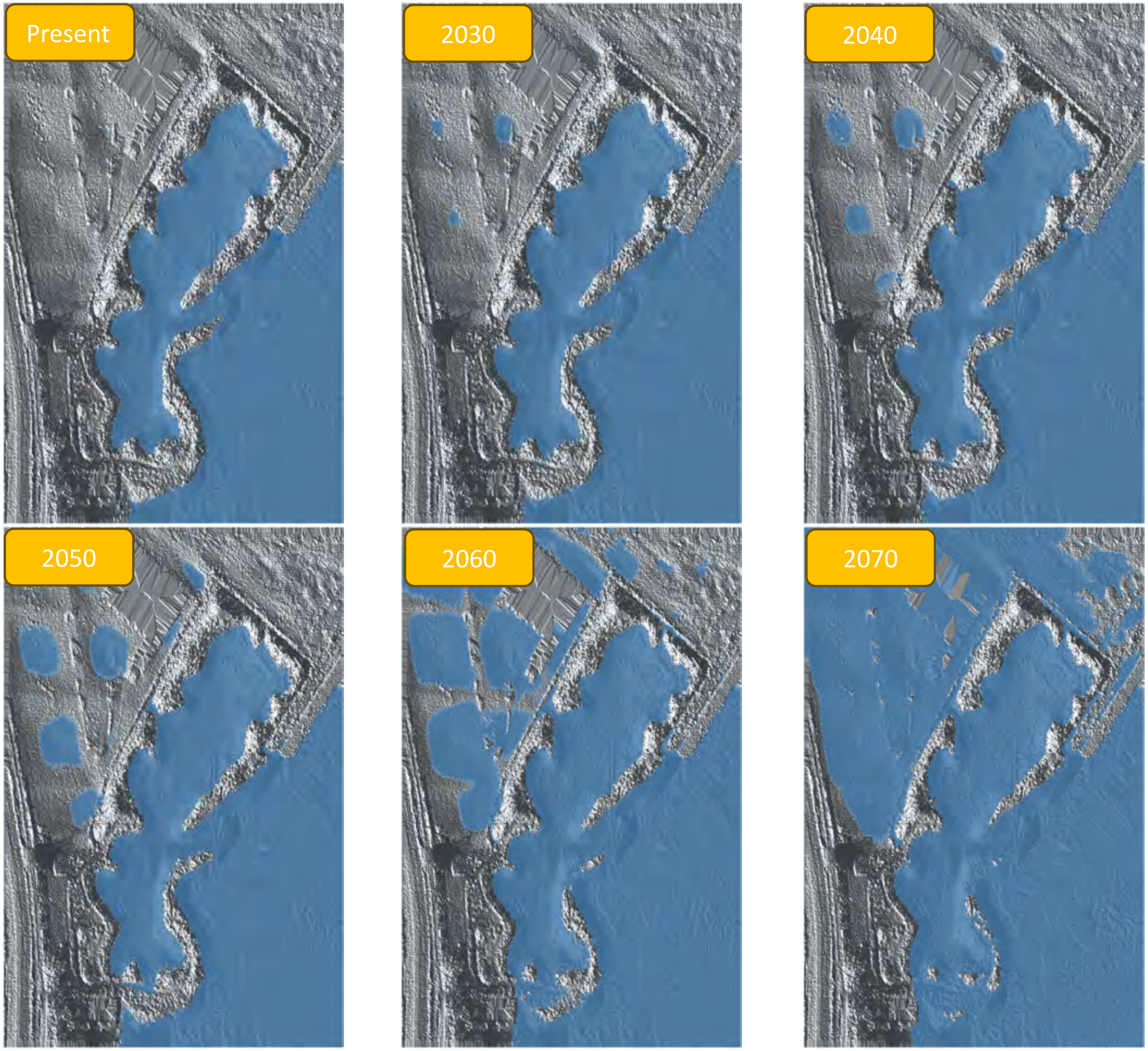

Figure 2-13 One-Year SWL Event for High Emissions (RCP 8.5)

CHAPTER 3
Estuarine Processes

3.1 Geomorphic Setting

As described in Chapter 1, the Herrings House Park site has experienced significant changes over the past several centuries, primarily due to urbanization and the repurposing of the Duwamish River for industrial uses. Historically, the site was previously situated on the western side of the alluvial floodplain of the Duwamish River, in the tidally influenced portion of the river close to its mouth. The geological setting would have previously consisted of alluvial (mud, silt, and sand) material originating from the upper watershed and recirculated material from the offshore (northerly) mudflats. Much of this was moved or buried with waste-bearing fill material in the last century (NOAA 1998), and the current site consists largely of material placed during the 2000 restoration efforts.

Figure 3-1 illustrates the site's location in 1900 and 2023. Despite substantial changes in the size and alignment of the Duwamish River (now the Duwamish Waterway), the site remains connected to the adjacent tidal channel, receiving sediment from both the watershed and adjacent channels and mudflats.

The present-day Herring's House Park shoreline (outside of the lagoon) is armored with 8-9 inch quarry stone, with a slope of approximately 3:1 (H:V) from El -3 ft to El 10 ft NAVD88. From El. -3 ft to El. -5 ft NAVD88 the site has gentler slopes of 5:1 (H:V) composed of mud and fine sands. Below -5 ft the shore steps down rapidly to elevations below -12 ft NAVD88.

The marsh is a tidal lagoon connected to the Duwamish Waterway via a single-thread inlet channel. This channel is characterized by a bottom depth that transitions downward from El 5 ft NAVD88 at the upstream end of the channel to El 2 ft NAVD88 at the downstream end. The thalweg width of the channel varies between 5 ft in the narrow areas to 8 ft on the wider areas. The channel is approximately 190 ft long. The existing marsh varies in elevation from 5 ft on the lowest area to 10 ft NAVD88. The vegetated area of the marsh goes from elevation 8 ft to elevation 10 ft NAVD88. The marsh is approximately 2.16 acres (Refer to Figure 1-1 and Figure 2-4).

3.2 Inlet Stability Approach

Tidal inlets are highly dynamic systems, shaped by the complex interactions of tides, waves, and sediment transport. Due to the bidirectional nature of tidal flows and the continuous interaction between water movement and the channel bed, assessing long-term inlet stability presents significant challenges. While hydrodynamic modeling, or even coupled hydrodynamic and sediment transport models, can offer insights into these processes, they often fall short of fully capturing the long-term geomorphic evolution of inlets.

For this reason, inlet stability assessments typically rely on applied geomorphological techniques, which consider both physical processes and historical changes to better predict the long-term behavior of the system.

Figure 3-1
Comparison of the lower Duwamish River and project site (left) in 1900 and (right) in 2023

One of the most commonly applied geomorphological techniques for understanding inlets is the relationship between the inlet cross-sectional area and the tidal prism in the lagoon behind it. The tidal prism is the volume of water that enters and exits the lagoon through the inlet in a given tidal cycle. It depends on the local tide range, the elevation of the lagoon bed, and the friction induced by the inlet. For lagoons with larger tidal prisms, more water passes through the inlet within the tidal cycle, leading to higher velocities in the channel. When the inlet exists within a bed of erodible material, the cross-sectional area of the inlet will typically adjust to these tidal flows by widening and/or deepening until they reach an equilibrium size that can pass the flows while causing minimal erosion. Thus, equilibrium in these systems can often be considered a pairing between the lagoon shape and the inlet shape. If the lagoon changes shape (e.g. from grading during a restoration project, from long-term sedimentation, or other events), the altered inlet shape can be predicted using this relationship.

Predictive relationships for inlet shape are well-established for lagoons and embayments on the open Pacific coast (e.g. O'Brien 1960). Williams et al. (2002) developed a similar relationship using ancient marshes within San Francisco Bay for marsh systems with embayments. This was an important advancement because systems interior to bays or estuaries often have different geological settings and wave exposure than open coast systems. More recently, Côté et al. (2023) developed a relationship for lagoons and marshes within Puget Sound. They reviewed several dozen sites to develop empirical relationships between the tidal prism of each site and the mean depth, width, and cross-sectional area. This is illustrated in **Figure 3-2**, which was modified from Côté et al. (2023) to include Herring's House.

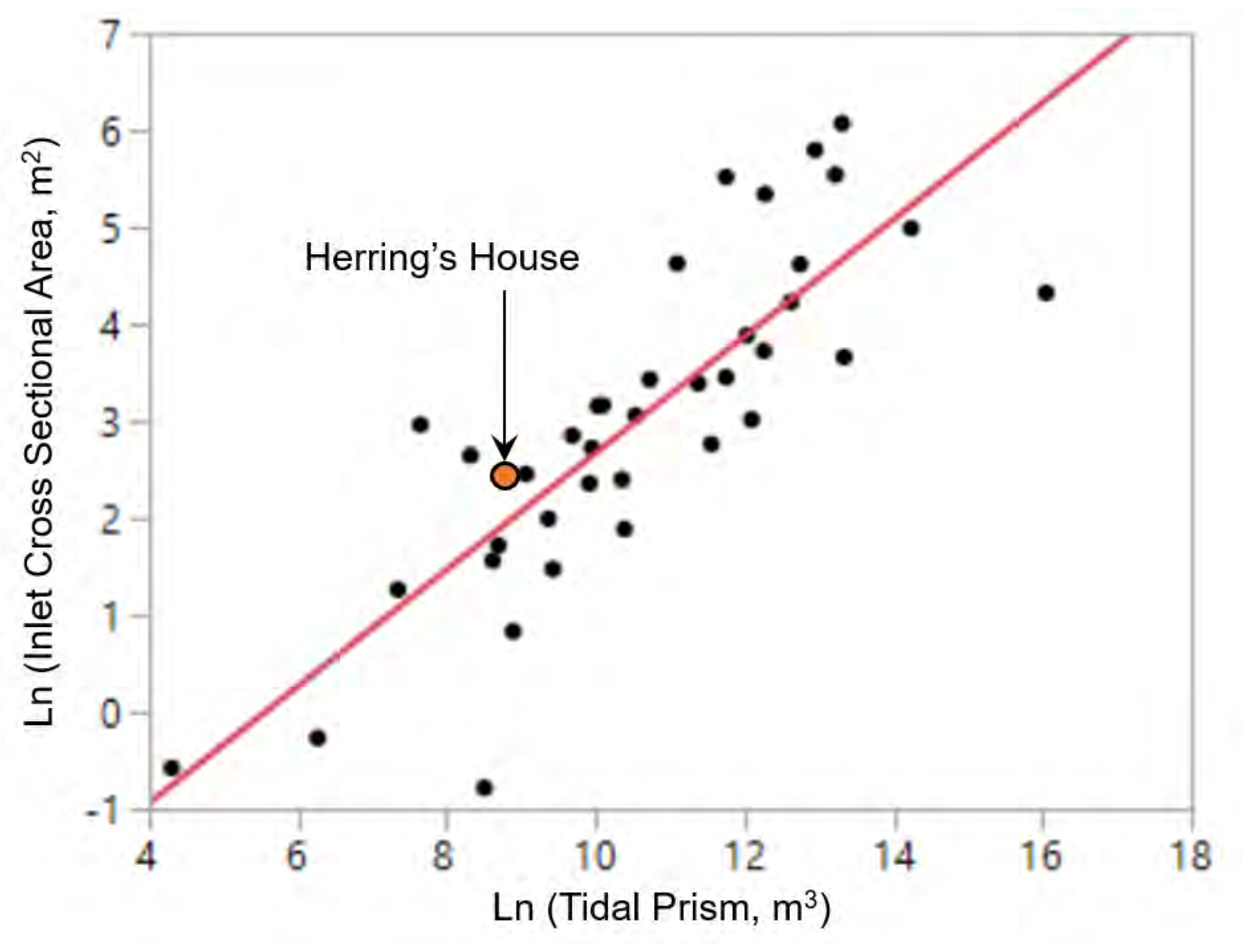

Figure 3-2
Inlet cross sectional area vs lagoon tidal prism from Puget Sound systems, from Côté et al. 2023

3.3 Tidal Channels

3.3.1 Tidal Channel Geometry

Table 3-1 compares the observed and predicted shape of the inlet channel at Herrings House with predictions based on Côté et al. 2023. The tidal prism (used to develop the predictions) was estimated using geographical information system (GIS) software based on topographic data collected by ESA in 2023. The inlet cross-sectional area, width, and depth were estimated as the average values from five sections across the inlet. Overall, the inlet at the site is deeper than the predicted value, but the width is significantly smaller than the predicted value. Although empirical relationships do not exist for inlet length, the inlet at the site is also longer than typical for such a small site. In research on salmonid use of systems throughout the Duwamish Channel, the inlet was noted by Toft et al. (2016) to be relatively narrow and long compared to other systems, and that this was a potential impediment to fish use of the site.

TABLE 3-1
HERRINGS HOUSE OBSERVED AND PREDICTED INLET CHANNEL DIMENSIONS

	Observed[1]		Predicted[2]	
Area	Mean	95% confidence range	Mean	95% confidence range
Tidal Prism (ft^3)	223,000	--	--	--
Cross Sectional Area[3] (ft^2)	116	101-127	80	0-240
Mean Width[4] (ft)	33	28-37	50	23-90
Mean Depth[5] (ft)	3.6	3.2-3.7	1.3	0.7-2.0

NOTES:

1. Source: ESA 2023 topographic survey.
2. Source: Côté et al. 2023.
3. defined as the wetted area below MHHW datum.
4. defined as the width at MHHW datum.
5. defined as the mean depth below MHHW datum.

3.3.2 Pilot Channel

The time scale for the outboard channel to scour to an equilibrium dimension that does not induce tidal muting of the site could extend over several years, even with the widening of the channel. As indicated in **Table 3-2**, most of the marsh experiences inundation only about 30 percent of the time, with some areas below 20 percent. This suggests that tidal action at the project site, particularly during tides lower than 7 ft NAVD, may remain muted for several years following the opening of the channel, potentially influencing the rate of habitat establishment. To expedite this process, dredging of pilot channels through the mudflat to a depth of at least 4 ft NAVD88 is proposed.

TABLE 3-2
EXCEEDING PERCENTAGE OF TIDES

Elevation (ft, NAVD88)	Exceeding Percentage
8	19.4
7	32.5
6	46.1
5	56.4
4	64.3
3	70.4

Dredging of pilot channels through the mudflat to a depth of at least 4 ft NAVD88 is proposed to help accelerate this process. This measure aims to facilitate an increase in regular tidal inundation at the project site, promoting the "washing" of imported soil. Such soil alteration is crucial for modifying the physical and chemical components necessary to support wetland vegetation. Additionally, the elevation variation introduced on the project site will accommodate different types of vegetation while also allowing for vertical uncertainties in tidal hydraulics effects and vegetation establishment elevations.

3.3.3 Inlet Design Recommendations

Based on the findings from the analyses described above, as well as the project team’s experience with the management and restoration design of other tidal inlets, ESA recommends that the design of the Herrings House inlet consider the following refinements:

- Over-excavate the inlet channel to provide additional accommodation space for sedimentation. Over-excavation will likely induce sediment capture until an equilibrium condition is attained.
- Widen the channel to at least 50 feet to restore hydraulic function and up to 120 feet for Salmon Habitat requirements.
- Rotate the channel alignment to be perpendicular to the existing shoreline to allow for a shorter overall channel length.
- Dredge pilot channels through the marsh to increase tidal inundation and tidal interaction at the project site.

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CHAPTER 4
Development of Alternatives

4.1 Opportunities and Constraints

The shoreline restoration project at Herring's House Park presents a unique opportunity to offer park visitors an immersive experience centered around a riparian habitat, all within a highly urban and industrialized environment.

Upland park enhancements necessitate thoughtful deliberation due to several park characteristics that converge to create a dynamic setting. Notably, the park's southeastern quadrant falls within the 100-year floodplain, introducing maintenance and safety considerations and specific criteria for determining the optimal location and design of valuable park improvements.

4.2 Estuarine Restoration

Informed by the technical studies, two conceptual alternatives (detailed in Appendix A) were developed to enhance the marsh ecosystem and reinstate tidal flow within the estuary. These conceptual alternatives consider enhancements in the site's hydrodynamics, ecological benefits, alterations to coastal geomorphology, potential impacts, future recreational usage of the park, constructability, and cost.

First-order magnitude construction costs were calculated for each concept. The total costs are outlined in Table 5-1 and provided in further detail in Appendix B.

4.2.1 Concept 1

In Concept 1 (refer to Appendix A), we propose widening the current channel inlet and realigning it to the shoreline by extracting material from the adjacent upland area. The channel will be excavated to an elevation of 2-3 ft NAVD88, with the riprap removed from the upland being reused as scour protection along the channel. Additionally, a topsoil layer with a minimum thickness of 1 ft will be applied. Planting low and high marsh vegetation will be implemented along the channel's sides, enhancing the site's ecological value, stabilizing the channel, and mitigating the risk of park users encroaching into the channel.

High marsh planting will extend along the estuary from elevations of 8 to 10 ft NAVD, while seeding of the estuary will cover elevations ranging from 6 ft to 8 ft NAVD88. Pilot channels along the estuary will be excavated to an elevation of up to 3-4 ft NAVD to reinstate a tidal flow regime.

This option offers several advantages. Firstly, it maximizes the utilization of the existing channel alignment, thereby reducing the amount of excavation required. Additionally, it minimizes disruption to access along the existing shoreline trail. However, it is important to note that excavated material may necessitate hauling offsite.

4.2.2 Concept 2

Concept 2 (refer to Appendix A) proposes excavating a new inlet channel northeast of the existing channel. This alignment capitalizes on a narrow segment of the shoreline to create a more direct, shoreline-aligned, and wider opening to the Duwamish River channel. The characteristics of the inlet channel will resemble those of Concept 1, but with gentler slopes, providing additional space for high and low marsh planting. Planting and excavation of pilot channels are also included in this concept.

Similar to Concept 1, this concept enables the reuse of excavated material onsite for constructing neighboring upland areas. The primary advantage of Concept 2 lies in creating a shorter and wider channel. However, since it would occupy an existing shoreline area, it would require larger excavation volumes and likely larger volume that might be required hauling offsite if is discover that the soil is contaminated.

4.3 Upland Improvements

Although the project focuses on marsh restoration, ESA also considered the implications of the different concepts on upland areas of the park. Combining the tidal inlet, marsh, and upland improvements will create a more holistic restoration project and a more coherent improvement of the park amenities and park-user experience. This approach will help SPR take into account not only the marsh ecology but also other factors like cultural resources, construction costs, improvements and phasing of upland ecology, coastal resilience, and use of the park.

ESA proposes three varying alternatives (Appendix C) that can be divided into two categories. Radial improvements (Alternative A) and Circuit Improvements (Alternative B and C).

Construction cost estimates were developed for each alternative and are summarized in Table 5-1 and shown in detail in Appendix D.

The park currently features existing riparian vegetation, ongoing planting restoration, and mature tree canopy. Together, these features limit sight lines into the property, limit views to the water and present considerations for maintenance and safety. The northern half of the property exhibits undulating topography, which, when paired with limitations associated with tree preservation, may limit accessible routes in this area.

The proposed inlet alterations and associated habitat improvements will offer Park visitors the opportunity to witness and track the restoration of this segment of shoreline.

It is recommended that selective trimming and thinning of existing vegetation be considered in order to provide visual access into the Park from the parking lot for safety monitoring. At locations where overlooks are provided for views into the wetland, it is recommended that bird blinds be considered.

For both schemes (Radial Improvements or Circuit Improvements), it is recommended that steps be taken to guide visitors away from critical habitat and restoration areas and clearly demarcate navigation routes appropriate for enjoying the park. This will avoid the current practice wherein visitors carve desire lines through vegetation and along the bank in order to reach desired viewpoints. Split-rail fencing, signage and strategic planting may all be employed to clarify appropriate park navigation routes.

Both schemes will also feature native plant palettes appropriate for upland and wetland restoration plantings. Planting areas will be proposed for areas of disruption, areas requiring screening, identified habitat planting locations and in locations that enhance visitor experience of navigation routes and seating areas.

4.3.1 Alternative A

The radial improvements scheme places a focus on park improvements that provide enhanced accessible circulation routes originating from the parking area to focus points within the park where visitors are afforded view of the restoration area and the Duwamish Waterway as well as connection points to həʔapus Village Park.

The radial improvements scheme places a focus on park improvements that provide enhanced accessible circulation routes originating from the parking area to focus points within the park where visitors are afforded a view of the restoration area and the Duwamish Waterway as well as connection points to həʔapus Village Park. This option considers limiting access to the Park so large areas of the Park will have limited human intervention.

4.3.2 Alternative B

Circulation routes will be enhanced with a focus on accessibility through a combination of surface replacement and selective re-alignment. Circulation routes that navigate through dynamic topography and amidst mature trees on the northern half of the site will rely on natural trail surfacing and boardwalks to bring visitors to a waterway overlook. Existing overlook locations will receive updates for structural integrity and safety which may require replacement. It is further recommended that waterway overlooks be revised to include bird blinds where they may impact wildlife.

Circulation routes will be enhanced with a focus on accessibility through a combination of surface replacement and selective re-alignment. Circulation routes that navigate through dynamic topography and amidst mature trees on the northern half of the site will rely on natural trail surfacing and boardwalks to bring visitors to a waterway overlook. Existing overlook locations will receive updates for structural integrity and safety, which may require replacement. It is further recommended that waterway overlooks be revised to include bird blinds where they may impact wildlife.

4.3.3 Alternative C

The circuit improvements scheme will focus on park improvements that allow visitors to circumnavigate the wetland restoration via accessible paths originating at the parking lot and connecting to həʔapus Village Park to the south. Visitors will be routed around the wetland including navigation of a bridge spanning the re-aligned inlet. Further study will be required for design and positioning of the bridge. The provision of accessible paths on the northern half of the site will require selective grading which may require some tree removal. It is recommended that plantings be provided along the property fence lines to assist with screening the adjacent industrial properties. Path surfacing on the southern half of the site will require some consideration for materials that are most appropriate for development within the 100yr floodplain.

The circuit improvements scheme will focus on park improvements that allow visitors to circumnavigate the wetland restoration via accessible paths originating at the parking lot and connecting to həʔapus Village Park to the south. Visitors will be routed around the wetland, including navigation of a bridge spanning the re-aligned inlet. Further study will be required for the design and positioning of the bridge. The provision of accessible paths on the northern half of the site will require selective grading which may require some tree removal. It is recommended that plantings be provided along the property fence lines to assist with screening the adjacent industrial properties.

4.4 No Action Alternative

The No Action alternative is included as a basis for understanding the benefits of the restoration alternatives. We expect that this alternative would result in the following:

- Degradation and instability of the existing inlet channel.
- Deterioration of existing trails and lookouts
- Continued lack of functionality of existing ecology, especially for Chinook salmon.
- Projected sea level rises will change the vegetation without planned or phased changes. This will also mean an increase in coastal flooding frequency by 2050.

This alternative is not preferred and does not provide benefits compared to the other alternatives. No cost estimate was developed for this alternative.

CHAPTER 5
Evaluation of Alternatives

This section compares the various alternatives with respect to key criteria, opportunities, and constraints and is intended to start a conversation with SPR about the preferred alternative.

5.1 Estuarine Processes

Both concept marsh restoration alternatives will yield comparable hydraulic responses and rejuvenation of estuarine processes. Concept 2 presents a more direct and shoreline-aligned inlet in contrast to Concept 1. However, Concept 2 necessitates a greater volume of excavation, particularly on unfamiliar soils that will require further exploration in subsequent studies. The potential need for hauling excavated material, especially if it is found that there is contaminated soil, this could significantly influence the decision-making process between Concept 1 and Concept 2.

5.2 Resilience to Sea Level Rise

Marsh Restoration

The conceptual alternatives for marsh restoration aim to establish a tidal influence system that fosters the development of a healthy marsh capable of increasing elevation in response to rising sea levels. However, both alternatives are vulnerable to potential marsh encroachment in the future. SPR should consider the expansion of the marsh north of the site before 2070 (for high emissions scenarios) or before 2100 (for low emissions scenarios).

Upland Alternatives

As shown in Figures 2-12 and 2-13, Upland improvements on exposed areas should be evaluated for all three upland alternatives. These improvements may involve elevating trails, filling lower areas, incorporating boardwalks, and contemplating future expansion or levee construction north of the site.

Among the three upland alternatives, Alternative C demonstrates the highest resilience to future sea level rise, while Alternative A exhibits the least resilience. This distinction arises primarily from the utilization of elevated boardwalks in Alternative C.

5.3 Nearshore Habitat

Marsh Restoration

Both marsh restoration concepts create healthy marshes with similar characteristics. Concept 2 offers more gentle slopes on the inlet channel, providing more area for low and upland marsh planting.

Upland Alternatives

Alternative A offers views of the restored marsh and the possibility of creating larger areas of nearshore and upland vegetation inside the marsh. Alternative B can be seen as a middle point, and Alternative C offers fewer habitat improvements compared with Alternatives B and A.

Alternative A provides scenic views of the restored marsh while limiting access to it. This offers the opportunity to establish expansive areas of nearshore and upland vegetation within the marsh. In contrast, Alternative B represents a middle ground between the alternatives, while Alternative C offers comparatively fewer habitat improvements than Alternative B and Alternative A.

5.4 Recreation

Marsh Restoration

Both concept alternatives offer similar recreation value, while Concept 1 offers a better aesthetic look for the inlet channel.

Upland Alternatives

Alternative C offers the most recreation use since it includes higher boardwalks around the marsh, multiple points of view of the marsh and the Duwamish River, a crossing over the inlet, and bird blinds. Comparatively, Alternative A has limited access to the park and will be limited in use for people wanting to use the park for walks or cycling.

5.5 Constructability

Marsh Restoration

Both marsh restoration concepts are expected to have a similar level of constructability, provided that uncontaminated soils are present at the site. However, if contaminated soils are discovered beneath the area slated for excavation, Concept 1 emerges as the more favorable option in terms of constructability.

Upland Alternatives

Constructability complexity escalates from Alternative A to C, primarily due to the incorporation of elevated boardwalks and the expansion of proposed overlook areas. However, the construction of a bridge within Alternative C renders it the most challenging option in terms of constructability.

5.6 Maintenance

Marsh Restoration

The marsh restoration concepts are anticipated to require equivalent levels of maintenance. Initially, fencing for seeding and vegetation will be necessary, along with long-term upkeep of signs and permanent fences to prevent unauthorized access or damage to the marsh and its vegetation.

Upland Alternatives

Alternative C is projected to necessitate the highest maintenance among the three evaluated alternatives, primarily because of the extensive use of elevated boardwalks and the construction of a bridge. Conversely, Alternative A, with its limited access to the marsh, is expected to incur the lowest maintenance costs among all the evaluated alternatives.

5.7 Construction Cost

Marsh Restoration

The construction costs associated with marsh restoration for Concepts 1 and 2 are comparable, attributable to the similarity in the proposed features of the restored marsh. Nevertheless, Concept 2 incurs slightly higher costs due to the greater volume of excavation required. This cost discrepancy could escalate significantly if contaminated soil is discovered beneath the proposed excavation and grading areas.

Upland Alternatives

Alternative A emerges as the most cost-effective option among those evaluated, with construction costs significantly increasing for Alternative B. However, for Alternative C, the costs escalate almost fourfold compared to Alternative A. This considerable cost disparity is primarily attributed to the extensive use of elevated boardwalks and the construction of a bridge within Alternative C (see **Table 5-1**).

TABLE 5-1
SUMMARY OF COST ESTIMATES

Alternatives	Total Cost
Marsh Restoration	
Concept 1	$820,000
Concept 2	$855,000
Upland Improvements	
Alternative A	$930,000
Alternative B	$1,800,000
Alternative C	$3,640,000

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CHAPTER 6
Discussion

6.1 Inlet Design Recommendations

Based on the findings from the analyses described above, as well as the project team's experience with the management and restoration design of other tidal inlets, ESA recommends that the design of the Herring's House inlet consider the following changes:

- **Over-excavation of the inlet channel**: To enhance the inlet's resilience against short-term closure due to sedimentation, we recommend over-excavating the channel. This approach will allow for sediment capture until an equilibrium condition is attained.
- **Sediment placement strategy**: Material excavated from the channel should be placed east of the inlet mouth, along the shoreline. This strategic placement moves sediment to the downdrift side of the littoral transport system, reducing the likelihood of sediment being transported back into the inlet.
- **Pilot channel dredging**: A pilot channel should be dredged through the mudflat to enhance tidal inundation and interaction at the project site. This will improve the flow regime, promoting the overall health of the estuarine ecosystem.

6.2 Proposed Future Work

ESA identified several areas that will require further investigation prior to the development of the preferred alternative design plans. These areas are listed below.

6.2.1 Permitting Requirements

Before proceeding with the design of a preferred alternative, a study of the permitting requirements is needed. This should include identifying any potential permitting issues. The project will likely require federal, state, and local permits.

6.2.2 Cultural Resources

The location has a high sensitivity for cultural resources. Additional review will be necessary to identify and evaluate the potential impacts of cultural resources. The project might be required to comply with municipal, state, or federal regulations that require consideration of the potential effects of the project's cultural resources. If ground disturbance is planned within the boundaries of a recorded archaeological site, a state excavation permit may be required. from the Department of Archaeology and Historic Preservation (DAHP)

6.2.3 Contaminated Soils

Historical records show that contaminated soils may be present below grade at the project site. Additional studies are needed to locate and evaluate the extent of contamination within the proposed excavation areas. This will inform future design phases and guide decisions on soil management for the preferred alternative.

6.2.4 Marsh and Upland Vegetation

A more detailed study of the proposed re-vegetation of the marsh and the upland by a biologist will be needed to advance the preferred alternative design further.

6.2.5 Coastal Resilience

This study has highlighted several vulnerabilities related to sea-level rise and coastal resilience within the park. A more comprehensive analysis of sea-level rise impacts on upland vegetation and potential coastal inundation is recommended. Any proposed solutions for the preferred alternative must be evaluated in this context to ensure long-term sustainability.

CHAPTER 7
References

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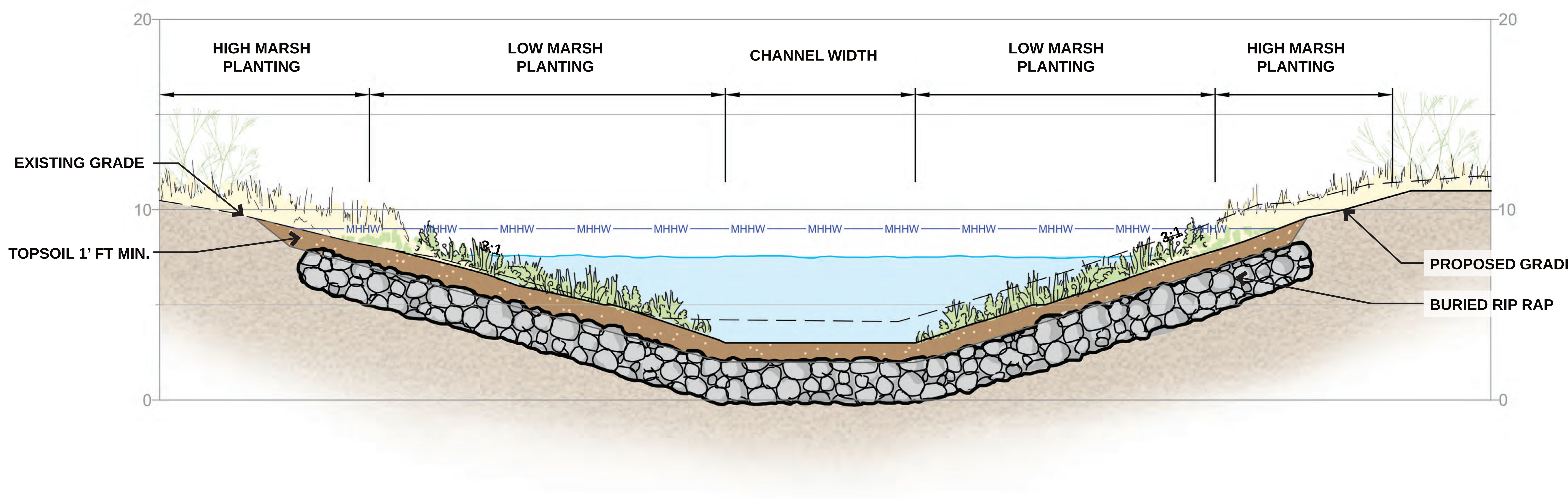
APPENDIX A

Marsh Conceptual Restoration Design

Herring's House

Marsh Restoration Concept Plan 1

ESA



Section A-A': Channel Cross Section (Not to Scale)

Herring's House

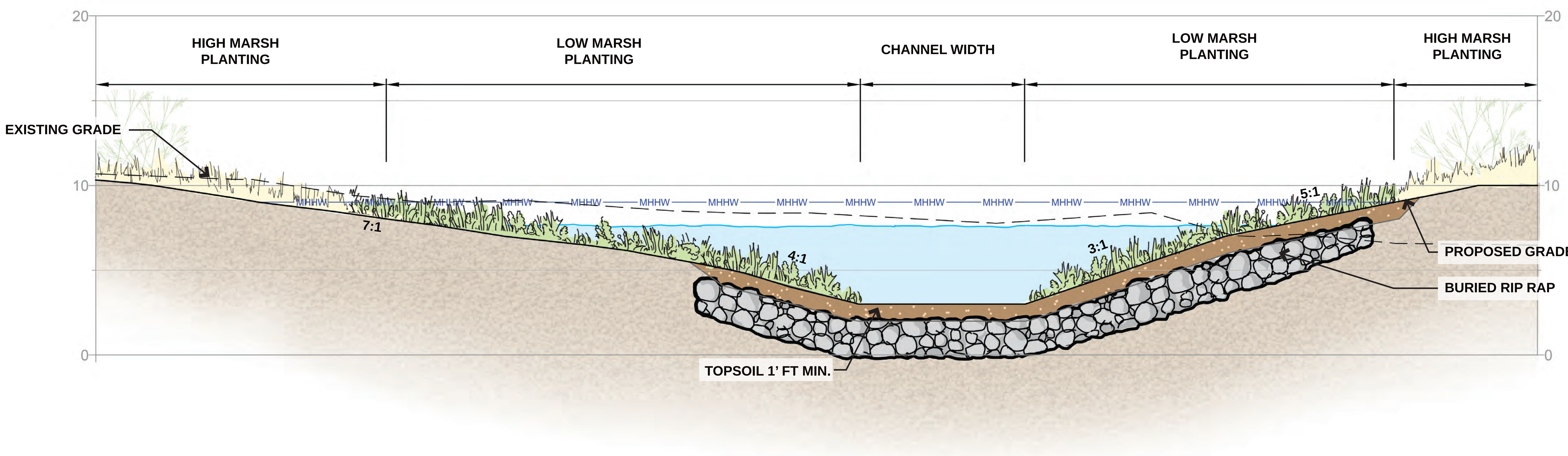
Main Channel Concept 1

ESA

Herring's House

Marsh Restoration Concept Plan 2

ESA



Section B-B': Channel Cross Section (Not to Scale)

Herring's House

Main Channel Concept 2

ESA

APPENDIX B

Marsh Restoration Quantities and Costs

Herring's House Park - MARSH RESTORATION CONCEPT 1
Estimate of Probable Construction Cost — By: PDQ
Date: 1/24/2020 — Checked: DB

ITEM NO.	ITEM DESCRIPTION	QTY	UNIT		UNIT PRICE		COST
SITE PREPARATION						**$**	**23,800**
1	TREE REMOVAL	3	EA	$	300.00	$	900
2	CLEARING AND GRUBING	9200	SF	$	0.75	$	6,900
3	HIGH VISIBILITY FENCE	200	LF	$	5.00	$	1,000
4	CONSTRUCTION SURVEY	1	LS	$	15,000.00	$	15,000
EROSION CONTROL						**$**	**150,000**
5	TEMPORARY EROSION AND SEDIMENT CONTROL	1	LS	$	20,000.00	$	20,000
6	INSTALL, MAINTAIN AND REMOVE TURBIDITY CURTAIN	1	LS	$	120,000.00	$	120,000
7	STABILIZED CONSTRUCTION ENTRANCE	1	EA	$	10,000.00	$	10,000
EARTHWORK AND CHANNEL INLET						**$**	**207,200**
8	EXCAVATION AND STOCKPILE	1,600	CY	$	40.00	$	64,000
9	HAUL AND DISPOSE EXCESS RIPRAP	120	CY	$	70.00	$	8,400
10	HAUL AND DISPOSE EXCESS AND UNSUITABLE MATERIAL	1,290	CY	$	40.00	$	51,600
11	EXISTING CHANNEL FILL	50	CY	$	40.00	$	2,000
12	ROCK FOR EROSION CONTROL AND SCOUR PROTECTION REUSED RIPRAP	520	CY	$	30.00	$	15,600
13	TOPSOIL MATERIAL	1,100	CY	$	40.00	$	44,000
14	PILOT CHANNEL EXCAVATION	360	CY	$	60.00	$	21,600
SITE RESTORATION						**$**	**105,500**
15	PLANTING AREA	16,000	SF	$	5.00	$	80,000
16	HAND SEEDING	6,500	SY	$	3.00	$	19,500
17	TREES - 6'-8' HT.	12	EA	$	500.00	$	6,000
	DIRECT ITEM SUBTOTAL					$	486,500
	BONDING AND INSURANCE	2%				$	9,730
	GENERAL CONDITIONS	10%				$	48,650
	MOBILIZATION/DEMOBILIZATION	10%				$	48,650
	CONTINGENCY	40%				$	194,600
	CONTRACTOR OVERHEAD AND PROFIT	6%				$	29,190
	SALES TAX (not included, 10.1%)					$	-
	CONSTRUCTION TOTAL	(Rounded)				**$**	**820,000**

NOTES:
1. Cost does not include permitting, engineering design, management, or other soft costs.
2. Costs provided in 2024 dollars.
3. This estimate represents upland/public acces related work only.
4. Cost do not reflect geotechinical study or input.
5. Cost do not include any utilty alterations or upgrades.
6. Sales tax is not included.

Herring's House Park - MARSH RESTORATION CONCEPT 2

Estimate of Probable Construction Cost — By: PDQ

Date: 1/24/2020 — Checked: DB

ITEM NO.	ITEM DESCRIPTION	QTY	UNIT	UNIT PRICE	COST
SITE PREPARATION					**$ 29,500**
1	TREE REMOVAL	7	EA	$ 300.00	$ 2,100
2	CLEARING AND GRUBING	15200	SF	$ 0.75	$ 11,400
3	HIGH VISIBILITY FENCE	200	LF	$ 5.00	$ 1,000
4	CONSTRUCTION SURVEY	1	LS	$ 15,000.00	$ 15,000
EROSION CONTROL					**$ 155,000**
5	TEMPORARY EROSION AND SEDIMENT CONTROL	1	LS	$ 25,000.00	$ 25,000
6	INSTALL, MAINTAIN AND REMOVE TURBIDITY CURTAIN	1	LS	$ 120,000.00	$ 120,000
7	STABILIZED CONSTRUCTION ENTRANCE	1	EA	$ 10,000.00	$ 10,000
EARTHWORK AND CHANNEL INLET					**$ 218,000**
8	EXCAVATION AND STOCKPILE	1,800	CY	$ 40.00	$ 72,000
9	HAUL AND DISPOSE EXCESS RIPRAP	200	CY	$ 70.00	$ 14,000
10	HAUL AND DISPOSE EXCESS AND UNSUITABLE MATERIAL	820	CY	$ 40.00	$ 32,800
11	EXISTING CHANNEL FILL	800	CY	$ 40.00	$ 32,000
12	ROCK FOR EROSION CONTROL AND SCOUR PROTECTION REUSED RIPRAP	360	CY	$ 30.00	$ 10,800
13	TOPSOIL MATERIAL	900	CY	$ 40.00	$ 36,000
14	PILOT CHANNEL EXCAVATION	340	CY	$ 60.00	$ 20,400
SITE RESTORATION					**$ 105,500**
15	PLANTING AREA	16,000	SF	$ 5.00	$ 80,000
16	HAND SEEDING	6,500	SY	$ 3.00	$ 19,500
17	TREES - 6'-8' HT.	12	EA	$ 500.00	$ 6,000
	DIRECT ITEM SUBTOTAL				$ 508,000
	BONDING AND INSURANCE	2%			$ 10,160
	GENERAL CONDITIONS	10%			$ 50,800
	MOBILIZATION/DEMOBILIZATION	10%			$ 50,800
	CONTINGENCY	40%			$ 203,200
	CONTRACTOR OVERHEAD AND PROFT	6%			$ 30,480
	SALES TAX (not included, 10.1%)				$ -
	CONSTRUCTION TOTAL	(Rounded)			**$ 855,000**

NOTES:

1. Cost does not include permitting, engineering design, management, or other soft costs.
2. Costs provided in 2024 dollars.
3. This estimate represents upland/public acces related work only.
4. Cost do not reflect geotechinical study or input.
5. Cost do not include any utilty alterations or upgrades.
6. Sales tax is not included.

APPENDIX C

Upland Conceptual Design

Herring's House

Upland Alternative - A

ESA

Herring's House

Upland Alternative - B

ESA

Herring's House

Upland Alternative - C

ESA

APPENDIX D

Upland Quantities and Costs

Herring's House Park - UPLAND ALTERNATIVE 'A'
Estimate of Probable Construction Cost — By: TTF, MAC
Date: 1/24/2020 — Checked: PDQ

ITEM NO.	ITEM DESCRIPTION	QTY	UNIT	UNIT PRICE	COST
SITE PREPARATION					**$ 51,800**
1	CLEARING AND GRUBBING	47000	SF	$ 0.50	$ 23,500
2	TREE REMOVAL	1	LS	$ 300.00	$ 300
3	CONSTRUCTION SURVEY AND STAKING	1	LS	$ 20,000.00	$ 20,000
4	TARGETED INVASIVE REMOVAL	16000	SF	$ 0.50	$ 8,000
EROSION CONTROL					**$ 71,000**
5	EROSION/WATER POLLUTION CONTROL	1	LS	$ 15,000.00	$ 15,000
6	HIGH VISIBILITY FENCE	1350	LF	$ 4.00	$ 5,400
7	FILTER FENCE	2600	LF	$ 6.00	$ 15,600
8	TREE AND VEGETATION PROTECTION ALLOWANCE	1	LS	$ 10,000.00	$ 10,000
9	STRAW WADDLE	1200	LF	$ 2.50	$ 3,000
10	STABILIZED CONSTRUCTION ENTRANCE	1	EA	$ 10,000.00	$ 10,000
11	UTILITY PROTECTION ALLOWANCE	12	MO	$ 1,000.00	$ 12,000
DEMOLITION & TEMPORARY STRUCTURES					**$ 45,830**
12	SAW CUT	140	LF	$ 2.00	$ 280
13	ASPHALT PATH	9,250	SF	$ 3.00	$ 27,750
14	BELOW GRADE STRUCTURE AT OVERLOOKS	3	LS	$ 2,500.00	$ 7,500
15	GUARDRAIL AT OVERLOOKS	100	LF	$ 8.00	$ 800
16	BENCH	4	EA	$ 550.00	$ 2,200
17	GRAVEL PATH	4,200	SF	$ 1.50	$ 6,300
18	CONCRETE PAD	300	SF	$ 2.50	$ 750
19	PRESERVE AND PROTECT KIOSK	1	EA	$ 250.00	$ 250
EARTHWORK					**$ 45,900**
20	IMPORTED FILL	560	CY	$ 40.00	$ 22,400
21	IMPORTED TOPSOIL AMMENDMENT	100	CY	$ 40.00	$ 4,000
22	ROUGH GRADING	30,000	SF	$ 0.25	$ 7,500
23	FINE GRADING	30,000	SF	$ 0.40	$ 12,000
PLANTING					**$ 112,770**
24	PLANTING AREA	18,500	SF	$ 3.00	$ 55,500
25	IRRIGATION - MODIFY EXISTING SYSTEM	18,500	SF	$ 1.00	$ 18,500
26	FINE COMPOST	115	CY	$ 40.00	$ 4,600
27	SEEDING	6,890	SY	$ 3.00	$ 20,670
28	TREES - 6'-8' HT.	22	EA	$ 500.00	$ 11,000
29	TREE LIMBING	1	LS	$ 2,500.00	$ 2,500
SITE RESTORATION					**$ 224,800**
30	CONCRETE CURB	130	LF	$ 35.00	$ 4,550
31	CONCRETE PAVING	10,000	SF	$ 12.00	$ 120,000
32	*SPECIALTY CONCRETE PAVING*	*0*	*SF*	*$ 15.00*	*$ -*
33	GRAVEL PAVING - 1/4" MINUS	2,850	SF	$ 5.00	$ 14,250
34	*BOARDWALK*	*0*	*SF*	*$ 120.00*	*$ -*
35	BIRD BLIND	2	EA	$ 5,000.00	$ 10,000
36	*BOARDWALK OVERLOOK*	*0*	*EA*	*$ 15,000.00*	*$ -*
37	*BOARDWALK GUARDRAIL*	*0*	*LF*	*$ 100.00*	*$ -*
38	*OVERLOOK GUARDRAIL*	*0*	*LF*	*$ 200.00*	*$ -*
39	AT GRADE OVERLOOK	4	EA	$ 10,000.00	$ 40,000
40	SIGNAGE ALLOWANCE	1	LS	$ 10,000.00	$ 10,000
41	*PREFABRICATED BRIDGE*	*0*	*LF*	*1000*	*$ -*
42	*BRIDGE HEADWALLS*	*0*	*LF*	*250*	*$ -*
43	BENCH	6	EA	$ 1,500.00	$ 9,000
44	SPLIT RAIL FENCE	220	LF	$ 50.00	$ 11,000
45	PICNIC TABLE	2	EA	$ 3,000.00	$ 6,000
	DIRECT ITEM SUBTOTAL				$ 552,100
	BONDING AND INSURANCE	2%			$ 11,042
	GENERAL CONDITIONS	10%			$ 55,210
	MOBILIZATION/DEMOBILIZATION	10%			$ 55,210
	CONTINGENCY	40%			$ 220,840
	CONTRACTOR OVERHEAD AND PROFT	6%			$ 33,126
	SALES TAX (not included, 10.1%)				$ -
	CONSTRUCTION TOTAL	(Rounded)			**$ 930,000**

NOTES:

1. Cost does not include permitting, engineering design, management, or other soft costs.
2. Assume no stormwater treatment is required for existing parking lot.
3. Assume additional fire/emergency access turnaround not required.
4. Costs provided in 2024 dollars.
5. This estimate represents upland/public acces related work only.
6. Cost do not reflect geotechinical study or input.
7. Cost do not include any utilty alterations or upgrades.
8. Cost assume no interruption to traffic patterns.
9. Sales tax is not included.

Herring's House Park - UPLAND ALTERNATIVE 'B'
Estimate of Probable Construction Cost — By: TTF, MAC
Date: 1/24/2020 — Checked: PDQ

ITEM NO.	ITEM DESCRIPTION	QTY	UNIT	UNIT PRICE	COST
SITE PREPARATION					**$ 73,050**
1	CLEARING AND GRUBBING	71000	SF	$ 0.50	$ 35,500
2	TREE REMOVAL	1	LS	$ 300.00	$ 300
3	CONSTRUCTION SURVEY AND STAKING	1	LS	$ 30,000.00	$ 30,000
4	TARGETED INVASIVE REMOVAL	14500	SF	$ 0.50	$ 7,250
EROSION CONTROL					**$ 71,000**
5	EROSION/WATER POLLUTION CONTROL	1	LS	$ 15,000.00	$ 15,000
6	HIGH VISIBILITY FENCE	1350	LF	$ 4.00	$ 5,400
7	FILTER FENCE	2600	LF	$ 6.00	$ 15,600
8	TREE AND VEGETATION PROTECTION	1	LS	$ 10,000.00	$ 10,000
9	STRAW WADDLE	1200	LF	$ 2.50	$ 3,000
10	STABILIZED CONSTRUCTION ENTRANCE	1	EA	$ 10,000.00	$ 10,000
11	UTILITY PROTECTION ALLOWANCE	12	MO	$ 1,000.00	$ 12,000
DEMOLITION & TEMPORARY STRUCTURES					**$ 45,830**
12	SAW CUT	140	LF	$ 2.00	$ 280
13	ASPHALT PATH	9,250	SF	$ 3.00	$ 27,750
14	BELOW GRADE STRUCTURE AT OVERLOOKS	3	LS	$ 2,500.00	$ 7,500
15	GUARDRAIL AT OVERLOOKS	100	LF	$ 8.00	$ 800
16	BENCH	4	EA	$ 550.00	$ 2,200
17	GRAVEL PATH	4,200	SF	$ 1.50	$ 6,300
18	CONCRETE PAD	300	SF	$ 2.50	$ 750
19	PRESERVE AND PROTECT KIOSK	1	EA	$ 250.00	$ 250
EARTHWORK					**$ 67,150**
20	IMPORTED FILL	355	CY	$ 40.00	$ 14,200
21	IMPORTED TOPSOIL AMMENDMENT	300	CY	$ 40.00	$ 12,000
22	ROUGH GRADING	63000	SF	$ 0.25	$ 15,750
23	FINE GRADING	63000	SF	$ 0.40	$ 25,200
PLANTING					**$ 118,670**
24	PLANTING AREA	20,500	SF	$ 3.00	$ 61,500
25	IRRIGATION - MODIFY EXISTING SYSTEM	20,500	SF	$ 1.00	$ 20,500
26	FINE COMPOST	125	CY	$ 40.00	$ 5,000
27	SEEDING	6,890	SY	$ 3.00	$ 20,670
28	TREES - 6'-8' HT.	17	EA	$ 500.00	$ 8,500
29	TREE LIMBING	1	LS	$ 2,500.00	$ 2,500
SITE RESTORATION					**$ 693,550**
30	CONCRETE CURB	130	LF	$ 35.00	$ 4,550
31	CONCRETE PAVING	7,000	SF	$ 12.00	$ 84,000
32	*SPECIALTY CONCRETE PAVING*		*SF*	*$ 15.00*	*$ -*
33	GRAVEL PAVING - 1/4" MINUS	4,500	SF	$ 5.00	$ 22,500
34	BOARDWALK	3,000	SF	$ 120.00	$ 360,000
35	BIRD BLIND	2	EA	$ 8,500.00	$ 17,000
36	BOARDWALK OVERLOOK	3	EA	$ 15,000.00	$ 45,000
37	BOARDWALK GUARDRAIL	850	LF	$ 100.00	$ 85,000
38	OVERLOOK GUARDRAIL	100	LF	$ 200.00	$ 20,000
39	AT GRADE OVERLOOK	3	EA	$ 7,500.00	$ 22,500
40	SIGNAGE ALLOWANCE	1	LS	$ 15,000.00	$ 15,000
41	*PREFABRICATED BRIDGE*		*LF*	*1000*	*0*
42	*BRIDGE HEADWALLS*		*LF*	*250*	*0*
43	BENCH	8	EA	$ 1,500.00	$ 12,000
44	SPLIT RAIL FENCE		LF	$ 50.00	$ -
45	PICNIC TABLE	2	EA	$ 3,000.00	$ 6,000
	DIRECT ITEM SUBTOTAL				$ 1,069,250
	BONDING AND INSURANCE	2%			$ 21,385
	GENERAL CONDITIONS	10%			$ 106,925
	MOBILIZATION/DEMOBILIZATION	10%			$ 106,925
	CONTINGENCY	40%			$ 427,700
	CONTRACTOR OVERHEAD AND PROFT	6%			$ 64,155
	SALES TAX (not included, 10.1%)				$ -
	CONSTRUCTION TOTAL (Rounded)				**$ 1,800,000**

NOTES:

1. Cost does not include permitting, engineering design, management, or other soft costs.
2. Assume no stormwater treatment is required for existing parking lot.
3. Assume additional fire/emergency access turnaround not required.
4. Costs provided in 2024 dollars.
5. This estimate represents upland/public acces related work only.
6. Cost do not reflect geotechinical study or input.
7. Cost do not include any utilty alterations or upgrades.
8. Cost assume no interruption to traffic patterns.
9. Sales tax is not included.

Herring's House Park - UPLAND ALTERNATIVE 'C'
Estimate of Probable Construction Cost — By: TTF, MAC
Date: 1/24/2020 — Checked: PDQ

ITEM NO.	ITEM DESCRIPTION	QTY	UNIT	UNIT PRICE	COST
SITE PREPARATION					**$ 58,550**
1	CLEARING AND GRUBBING	51000	SF	$ 0.50	$ 25,500
2	TREE REMOVAL	8	EA	$ 300.00	$ 2,400
3	CONSTRUCTION SURVEY AND STAKING	1	LS	$ 30,000.00	$ 30,000
4	TARGETED INVASIVE REMOVAL	1300	SF	$ 0.50	$ 650
EROSION CONTROL					**$ 71,000**
5	EROSION/WATER POLLUTION CONTROL	1	LS	$ 15,000.00	$ 15,000
6	HIGH VISIBILITY FENCE	1350	LF	$ 4.00	$ 5,400
7	FILTER FENCE	2600	LF	$ 6.00	$ 15,600
8	TREE AND VEGETATION PROTECTION ALLOWANCE	1	LS	$ 10,000.00	$ 10,000
9	STRAW WADDLE	1200	LF	$ 2.50	$ 3,000
10	STABILIZED CONSTRUCTION ENTRANCE	1	EA	$ 10,000.00	$ 10,000
11	UTILITY PROTECTION ALLOWANCE	12	MO	$ 1,000.00	$ 12,000
DEMOLITION & TEMPORARY STRUCTURES					**$ 45,830**
12	SAW CUT	140	LF	$ 2.00	$ 280
13	ASPHALT PATH	9,250	SF	$ 3.00	$ 27,750
14	STRUCTURE AT OVERLOOKS	3	LS	$ 2,500.00	$ 7,500
15	GUARDRAIL AT OVERLOOKS	100	LF	$ 8.00	$ 800
16	BENCH	4	EA	$ 550.00	$ 2,200
17	GRAVEL PATH	4,200	SF	$ 1.50	$ 6,300
18	CONCRETE PAD	300	SF	$ 2.50	$ 750
19	PRESERVE AND PROTECT KIOSK	1	EA	$ 250.00	$ 250
EARTHWORK					**$ 49,350**
20	IMPORTED FILL	295	CY	$ 40.00	$ 11,800
21	IMPORTED TOPSOIL AMMENDMENT	110	CY	$ 40.00	$ 4,400
22	ROUGH GRADING	51,000	SF	$ 0.25	$ 12,750
23	FINE GRADING	51,000	SF	$ 0.40	$ 20,400
PLANTING					**$ 122,370**
24	PLANTING AREA	21,500	SF	$ 3.00	$ 64,500
25	IRRIGATION - MODIFY EXISTING SYSTEM	21,500	SF	$ 1.00	$ 21,500
26	FINE COMPOST	130	CY	$ 40.00	$ 5,200
27	SEEDING	6,890	SY	$ 3.00	$ 20,670
28	TREES - 6'-8' HT.	16	EA	$ 500.00	$ 8,000
29	TREE LIMBING	1	LS	$ 2,500.00	$ 2,500
SITE RESTORATION					**$ 1,817,550**
30	CONCRETE CURB	130	LF	$ 35.00	$ 4,550
31	CONCRETE PAVING	7,000	SF	$ 12.00	$ 84,000
32	SPECIALTY CONCRETE PAVING	2,500	SF	$ 15.00	$ 37,500
33	*GRAVEL PAVING - 1/4" MINUS*	*0*	*SF*	*$ 5.00*	*$ -*
34	BOARDWALK	10,000	SF	$ 120.00	$ 1,200,000
35	BIRD BLIND	2	EA	$ 8,500.00	$ 17,000
36	BOARDWALK OVERLOOK	1	EA	$ 10,000.00	$ 10,000
37	BOARDWALK GUARDRAIL	2,000	LF	$ 100.00	$ 200,000
38	OVERLOOK GUARDRAIL	50	LF	$ 200.00	$ 10,000
39	AT GRADE OVERLOOK	2	EA	$ 7,500.00	$ 15,000
40	SIGNAGE ALLOWANCE	1	LS	$ 20,000.00	$ 20,000
41	PREFABRICATED BRIDGE	120	LF	1500	$ 180,000
42	BRIDGE HEADWALLS	80	LF	250	$ 20,000
43	BENCH	9	EA	$ 1,500.00	$ 13,500
44	*SPLIT RAIL FENCE*	*0*	*LF*	*50*	*$ -*
45	PICNIC TABLE	2	EA	$ 3,000.00	$ 6,000
	DIRECT ITEM SUBTOTAL				$ 2,164,650
	BONDING AND INSURANCE	2%			$ 43,293
	GENERAL CONDITIONS	10%			$ 216,465
	MOBILIZATION/DEMOBILIZATION	10%			$ 216,465
	CONTINGENCY	40%			$ 865,860
	CONTRACTOR OVERHEAD AND PROFT	6%			$ 129,879
	SALES TAX (not included, 10.1%)				$ -
	CONSTRUCTION TOTAL	(Rounded)			**$ 3,640,000**

NOTES:
1. Cost does not include permitting, engineering design, management, or other soft costs.
2. Assume no stormwater treatment is required for existing parking lot.
3. Assume additional fire/emergency access turnaround not required.
4. Costs provided in 2024 dollars.
5. This estimate represents upland/public acces related work only.
6. Cost do not reflect geotechinical study or input.
7. Cost do not include any utilty alterations or upgrades.
8. Cost assume no interruption to traffic patterns.
9. Sales tax is not included.