Samish Island Conservation Area Restoration

Feasibility Study and Conceptual Restoration Ideas Report - DRAFT

Prepared for

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1 Introduction

At the request of Skagit Land Trust (SLT) and Padilla Bay National Estuarine Research Reserve (PBNERR) Blue Coast Engineering LLC (Blue Coast), with support from Mott Macdonald and Shannon & Wilson, has completed Phase 1 of restoration planning for the Samish Island Conservation Area (SICA). Phase 1 included a site assessment and development of restoration concepts during the feasibility stage of the project. The SICA consists of seven Skagit County parcels (P47446, P47450, P47495, P47496, P133563, P47452, and P47454) and their adjacent County roads and associated utilities (Figure 1). The properties were purchased by PBNERR and SLT for conservation and restoration purposes; five of the site parcels (P133563, P47446, P47450, P47495, P47496) comprise the SLT-owned land, while two parcels (P47452 and P47454) comprise PBNERR-owned land.

The site assessment includes physical and biological technical studies as well as outreach to affected parties and partners. The goal was to characterize existing conditions and to develop conceptual restoration ideas (also called restoration concepts in this report), and in the process to identify site constraints, opportunities, and data gaps which will need to be filled to be able to develop designs for restoration alternatives in Phase 2 of the project. This report is organized as follows, with the associated team lead in parentheses:

- Section 2 provides a site overview, including data sources, collected data, documentation of site visits, and utilities and infrastructure (Blue Coast)
- Section 3 documents coastal processes and geomorphology (Blue Coast)
- Section 4 summarizes the assessment of upland, intertidal, and shoreline habitat (Shannon & Wilson)
- Section 5 summarizes the soil and geotechnical assessment (Shannon & Wilson) and hydrogeology (Mott Macdonald)
- Section 6 summarizes the data to date and gaps in the data (Blue Coast)
- Section 7 summarizes the conceptual restoration ideas identified to date (Blue Coast)
- Section 8 provides a set of evaluation criteria and the preliminary application of these criteria to evaluate the concepts (Blue Coast)
- Section 9 documents the communication and outreach with project partners and affected parties to date and the schedule of meetings for review of the content of this report.

1.1 Project Area Description

The SICA is located in northern Puget Sound within the Skagit and Samish River drainage basins. The project site is located on the isthmus connecting the mainland to the southern end of Samish Island and encompasses approximately 150 acres of upland and intertidal area (Figure 1). The low-lying land, also known as the isthmus of Samish Island, connects the historic Skagit River delta to Samish Island. The area is bounded by Samish Island to the north, Samish Bay (Alice Bay within Samish Bay) to the east, and Padilla Bay to the west. The project site is accessed by Samish Island Road, which is located along the eastern boundary of the site and provides the only road connection to Samish Island.

The project site has been shaped by regional changes related to agriculture and land-use over the past century. Free-flowing rivers and deposition of sediment shaped the project site. Historically, Padilla Bay on the west was connected through the barrier beach and salt marsh to Alice Bay on the east at the approximate location of the present-day S7amésh Seqelích (slough). Prior to diking in the late 19th century, the Skagit River was free to meander, and floodwaters and sediment reached the site, resulting in progradation of the delta westward towards Samish Island. In addition, the previously free-flowing south fork of the Samish River emptied into Alice Bay and also connected to the slough conveying water into Padilla Bay.

Diking of the Skagit River has severely limited freshwater flow and sediment input into Alice Bay, Samish Bay and Padilla Bay. Padilla Bay is now considered an "orphaned" estuary as a result of being cut off from both the Skagit River and the Samish River and receiving only limited freshwater input from four sloughs. Figure 2 shows the Dike District assessment areas of Skagit County which manage dikes and drainage around the Skagit River. The Samish River was forced to flow around the east side of Samish Island and now empties into the eastern side of Samish Bay near the town of Edison. Only minimal freshwater input currently reaches Alice Bay near the project site through a relict channel of the Samish River which collects surface water, storm water, and drainage from agricultural areas and discharge through a tide gate near Samish Sports Club (Figure 2).

1.2 Feasibility Study Objectives

The objective of this feasibility study was to identify opportunities and constraints for restoring the site to historic salt marsh conditions. As part of the Phase 1 feasibility stage of the project, we sought to identify any data/information gaps that would need to be filled during later phases of the project. In particular, the following data were collected to understand existing site conditions:

- Existing habitat types in the three categories of nearshore, estuarine marsh, and palustrine marsh based on desktop analysis and field surveys, as well as general understanding of fish and wildlife usage at the site.

- Coastal processes affecting the shorelines of Padilla Bay and Samish Bay and how these processes might change under restoration.
- Topography and elevations at the site and in relation to surrounding infrastructure.
- Infrastructure that currently exists at the site, including utilities, roads, drainage, and dikes, and how this infrastructure might be impacted by restoration.
- Soil types and geotechnical properties, including compaction, subsidence, and ability to reuse excavated soils for new infrastructure and fill, based on borings and test pit excavations.
- Surface water and groundwater conditions, including salinity, presence and depth of saline water, depth of groundwater under varying conditions and seasons, and influence of tides on groundwater at the site, based on field measurements.

An understanding of these existing conditions is being used to develop restoration concepts for estuary and salt marsh restoration at the site.

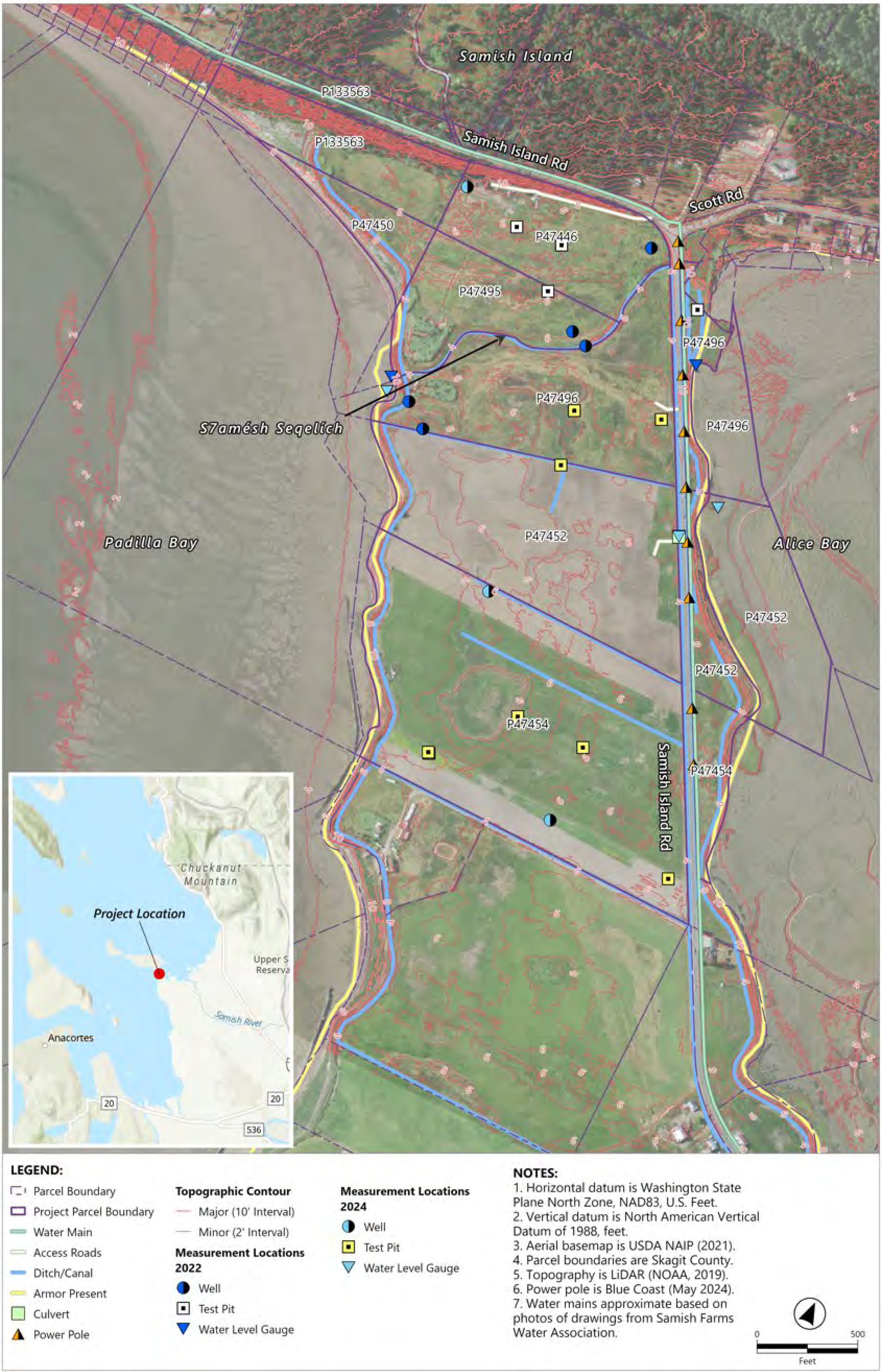


Figure 1. Samish Island Conservation Area site map & vicinity map.

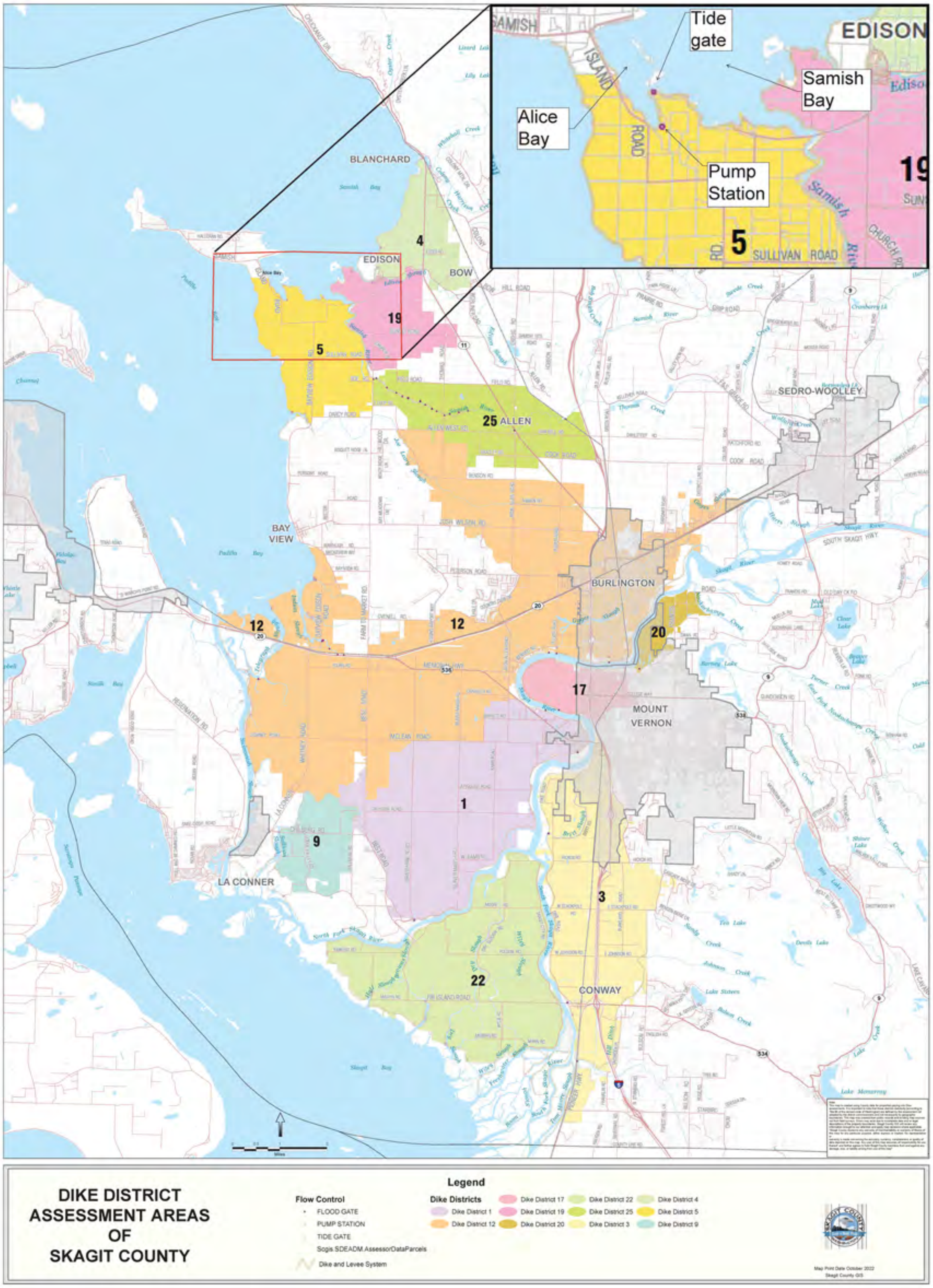


Figure 2. Dike District assessment areas of Skagit County. Inset shows vicinity of project site (adapted from Skagit County).

2 Site Overview

This section of the report provides a description of the project site, including the site topography, a summary of the shoreline assessment, a summary of the drainage and flood protection infrastructure, a description of additional infrastructure and utilities, and a review of historical maps and photographs.

2.1 Site Drainage and Flood Protection Infrastructure

Within the project site, the first dikes were constructed of earthen materials and installed in the early 1900s along portions of the Alice Bay and Padilla Bay shoreline south of the slough to protect leased farmed land and the primitive road. There was also an east-to-west-oriented earthen berm constructed south of the slough to prevent tides from inundating the land being farmed in this area (Hansen 1999); however, the slough channel remained open and allowed water to flow between Padilla Bay and Samish Bay/Alice Bay under a bridge and inundate the northern portion of the Samish Isthmus.

The slough was filled in the 1930s in conjunction with a new County road (see Section 2.6, below). In the 1950s and 1960s, the County improved the coastal dikes along Alice Bay to protect the road using quarry rock from Williams Point on Samish Island. The local quarry rock is still evident on most of the coastal dikes within the project area. It is sedimentary rock, fractures easily, and was haphazardly placed. The south end of the Alice Bay shoreline consists of a dike repaired in 2023 after overtopping occurred in December 2022. The new dike has been widened and is armored with granite riprap rock on the waterward face and crushed gravel on the crest.

On the Padilla Bay side, a post and timber wall anchored with sandbags was installed in the 1970s as an emergency measure to protect the road from coastal storm events. After 1 year, the temporary structure was reportedly replaced with Williams Point quarry rock to armor the dike; remnants of the timber posts remain in place. The old earthen dike is still evident along the very northern-most stretch of the Padilla Bay shoreline along the SLT parcels and is often overtopped by coastal storms, as evidenced by the observed scarps (discussed in Section 2.4). The remainder of the coastal dikes on the Padilla Bay side within the project area are constructed as earthen berms armored by the Williams Point quarry rock.

The coastal dikes surround farmland that is drained through a series of primarily east-west-oriented ditches (and also possibly by drainage tiles within the fields) located on the west side of Samish Island Road. Where they have been maintained, these east-west ditches connect to the north-south-oriented stormwater drainage ditch that runs along the west side of Samish Island Road. There are also drainage ditches along the east side of the road parallel to the coastal dikes along Alice Bay. One culvert under Samish Island Road was identified that connects the drainage ditch on the east side of the road with the drainage ditch on the west side of the road. This infrastructure is shown in Figure 1.

2.2 Data Sources

Blue Coast and the project team completed a desktop data review as part of the site assessment to build on previous or existing studies and avoid duplicating work that was previously completed. The desktop review included available databases, public sources, reports, and information provided by SLT to evaluate the existing site conditions. A list of the data used in the assessment is provided in Table 1.

Table 1. Data sources used in assessment.

Data	Year(s)	Source
Topography Survey Sheet (T-sheet)	1887	USGS
Skagit County Site Topographic Survey (drone survey)	2023	Skagit County
LiDAR Bare-Earth Digital Elevation Model (DEM). NOAA 3DEP LiDAR. Topographic Elevation.	August 13-14, 2019	NOAA
Skagit County GIS database	2024	Skagit County
Geologic Information Portal	2024	DNR
Coastal Atlas	2024	Ecology
Aerial Photographs (georeferenced)	1956, 1969, 1998, 2021	USGS & USDA NAIP
Aerial Photographs (not georeferenced)	1937, 1941, 1956, 1969, 1998	USGS
Oblique Aerial Photographs	1977, 1994, 2001, 2006, 2016	Ecology
Beach Strategies Phase 1 Geodatabase	2017	WDFW
Forage Fish Spawning Map	2024	WDFW
Puget Sound Seagrass Monitoring	2024	WA DNR
Water Level Datums	2024	NOAA-NOS, Swinomish Station #9448682 and NOAA VDatum
Hourly Wind Data, Whidbey Island Naval Air Station (NAS)	1945 to 2021	NCDC
Hourly Wind Data, West Point	1975 to 2021	NCDC

Data	Year(s)	Source
NERR Padilla Bay Buoy Data (meteorological and water quality)		NERR / NANOOS
Water Main Plan Set (photograph)	2004	Skagit County

Notes:
Ecology - Washington Department of Ecology
DNR - Washington Department of Natural Resources
NERR - National Estuarine Research Reserve
NANOOS - Northwest Association of Networked Ocean Observing Systems
NCDC - National Climate Data Center
NOAA - National Oceanic and Atmospheric Administration
NOS - National Ocean Service
USGS - United States Geological Survey
USDA NAIP - United States Department of Agriculture National Agriculture Imagery Program
WDFW - Washington Department of Fish and Wildlife

2.3 In-Situ Data Collection

Recent in-situ data collected at Samish Island since 2022 were reviewed. A summary of monitoring sites, dates of collection, and a brief description of each is provided in Table 2. Monitoring locations are shown in Figure 3.

Table 2. In-situ data collection summary at Samish Island.

Site and Instrument Name	Deployment Dates	Description
T-01: RBR Concerto 81109	09/26/2022 to 11/18/2022.	Tidal water level measurement at 10-minute intervals in Alice Bay.
T-02: RBR Concerto 81108	09/26/2022 to 11/18/2022.	Tidal water level measurement at 10-minute intervals in Padilla Bay.
T-03: RBR Concerto 81109	05/23/2024 to present.	Tidal water level measurement at 10-minute intervals in Alice Bay.
T-04: RBR Concerto 81109	05/23/2024 to present.	Tidal water level measurement at 10-minute intervals in Alice Bay.

Site and Instrument Name	Deployment Dates	Description
SB-01: Solinst 5 Junior M5, 2163378	09/26/2022 to 12/07/2022. 06/07/2024 to present.	Water level measurement at 30-minute intervals at the SW corner of the SLT parcel.
SB-02: Solinst 5 LTC M5, 1090801	09/26/2022 to 12/07/2022. 06/07/2024 to present.	Ground water level and electrical conductance measurement at 30-minute intervals at the NE corner of SLT parcel, then moved to the historic channel in the middle of the site on 06/07/2024.
Barologger / SB-02: Solinst Barologger 5, 2163451	09/26/2022 to 12/07/2022.	Barometric pressure measurement in 30-minute intervals, collected in the SB-02 well.
SW-02: HOBO WL SN21285988 and HOBO Conductivity SN20988055	09/26/2022 to 11/17/2022. 11/17/2022 to 12/07/2022. 12/7/2022 to 03/03/2024. 06/07/2024 to present.	Water surface elevation and salinity measurement at 30-minute intervals in the historic channel.
SW-03: HOBO SN21285990	09/26/2022 to 11/17/2022. 11/17/2022 to 12/07/2022. 03/06/2024 to 06/07/2024.	Water surface elevation measurement at 30-minute intervals in the main drainage ditch on the Padilla Bay side.
SW-04: HOBO SN21285990	06/07/2024 to present.	Water surface elevation measurement at 30-minute intervals in the ditch culvert by the Padilla Bay gate.
SP-1-24: Solinst 5 LTC M10, 018-1093649	06/07/2024 to present.	Water surface elevation measurement at 30-minute intervals in 15-ft augured well in the north end of the site.
B-1p-24: Solinst 5 LTC M20, 019-1093332	06/07/2024 to present.	Water surface elevation measurement at 30-minute intervals in the drilled 50.4 ft well in the north end of the site.
SP-2-24: Solinst 5 LTC M10, 018-1093652	06/07/2024 to present.	Water surface elevation measurement at 30-minute intervals in 15-ft augured well in the middle of the site.
B-2p-24: Solinst 5 LTC M20, 019-1090257	06/07/2024 to present.	Water surface elevation measurement at 30-minute intervals in the drilled 51.5 ft well in the middle of the site.

Site and Instrument Name	Deployment Dates	Description
SP-3-24: Solinst 5 LTC M10, 018-1093650	06/07/2024 to present.	Water surface elevation measurement at 30-minute intervals in 15-ft augured well in the south end of the site.
B-3p-24: Solinst 5 LTC M20, 019-1093333	06/07/2024 to present.	Water surface elevation measurement at 30-minute intervals in the drilled 51.5 ft well in the south end of the site.
Barologger / B-3p-24: Solinst Barologger 5, 2163451	06/07/2024 to present.	Barometric pressure measurement in 30-minute intervals, collected in the B-3p-24 / B-30-24D 51.5 ft drilled well at the south end of the site.
P-1: HOBO Water Level 21285989	06/07/2024 to present.	Water surface elevation measurement at 30-minute intervals in the piezometer at the north end of the site near B-1p-24.
P-2: HOBO Water Level 21071862	06/07/2024 to present.	Water surface elevation measurement at 30-minute intervals in the piezometer in the middle of the site, near B-2p-24.
P-3: HOBO WL 21071863, Conductivity 21076247	06/07/2024 to present.	Water surface elevation and conductivity measurement at 30-minute intervals in the piezometer at the south end of the site, near B-3p-24.
TP-1-24 to TP-7-24	05/09/2024.	Multiple test pits hand-augured or excavated for surface sediment samples around the site.

Notes:

T = tidal water level measurement; SB = groundwater level measurement; SW = surface water measurement; SP = augured shallow well; B = boring well; P = piezometer; TP = test pit.

SP-1-24, SP-2-24, and SP-3-24 may be referred to as B-1p-24S, B-2p-24S, and B-3p-24S in some documents, respectively.

B-1p-24, B-2p-24, and B-3p-24 may be referred to as B-1p-24D, B-2p-24D, and B-3p-24D in some documents, respectively.

Figure 3. Samish Island Conservation Area data collection site map.

2.4 Site Topography and Elevation

A topographic site map and topographic profiles are provided in Figures 4 and 5. The topographic map is based on a Light Detection and Ranging (LiDAR) bare-earth Digital Elevation Model (DEM) acquired by NOAA in August 2019. The DEM has a horizontal resolution of 3.3 feet and vertical accuracy of 1.5 inches across most surfaces, but where there are rapid transitions in elevations—such as the side slopes of the dikes and channels—the errors are much higher. Blue Coast did a limited review of the DEM by spot-checking various locations throughout the project site using a Trimble R-10 Global Positioning System (GPS) receiver corrected in real time to a high-precision position using the Washington State Reference Network (WSRN) Continuous Operating Reference Station (CORS) accessed through cellular service. The Trimble R-10 typically provides a precision of approximately 0.5 inch in the horizontal and 1 inch in the vertical. Although the review of the DEM using the GPS elevations generally found good agreement, due to the presence of water, the bare-earth elevations in the wetlands may appear higher.

The low-lying land bounded by the dikes and roadway are relatively flat. Elevations within this area primarily range between 4 to 8 feet North American Vertical Datum of 1988 (NAVD88). Ditches within the diked area are typically on the lower end of that range at about 4 feet NAVD88. The dikes extend longitudinally along both shorelines with crest elevations ranging between 10 to 13 feet NAVD88. Side slopes on the dikes are typically about 2H:1V (horizontal to vertical) with steeper inclinations in some sections. At the north end of the project site, the topographic relief rises rapidly as the topography transitions from the diked area to the steep slopes surrounding Samish Island.

The western and eastern shorelines along Padilla Bay and Alice Bay are characterized by low-sloping tidal flats. The tide flats immediately adjacent to the western shoreline along Padilla Bay slope down from 6 feet NAVD88 at the toe of the nearshore beach slope to 2 feet NAVD88 over approximately 1,500 feet. The majority of the tide flat is between 2 to 4 feet NAVD88. The western shoreline varies in characteristics from north to south with wide vegetated back beach along the north end, and narrow fringing salt marsh interspersed with pocket beaches in the middle and southern end (elevation 8 to 10 feet NAVD88). The tide flats along the eastern shoreline in Alice Bay are generally higher with a wider fringing salt marsh (500 to 1,000 feet) between 4 to 6 feet NAVD88.

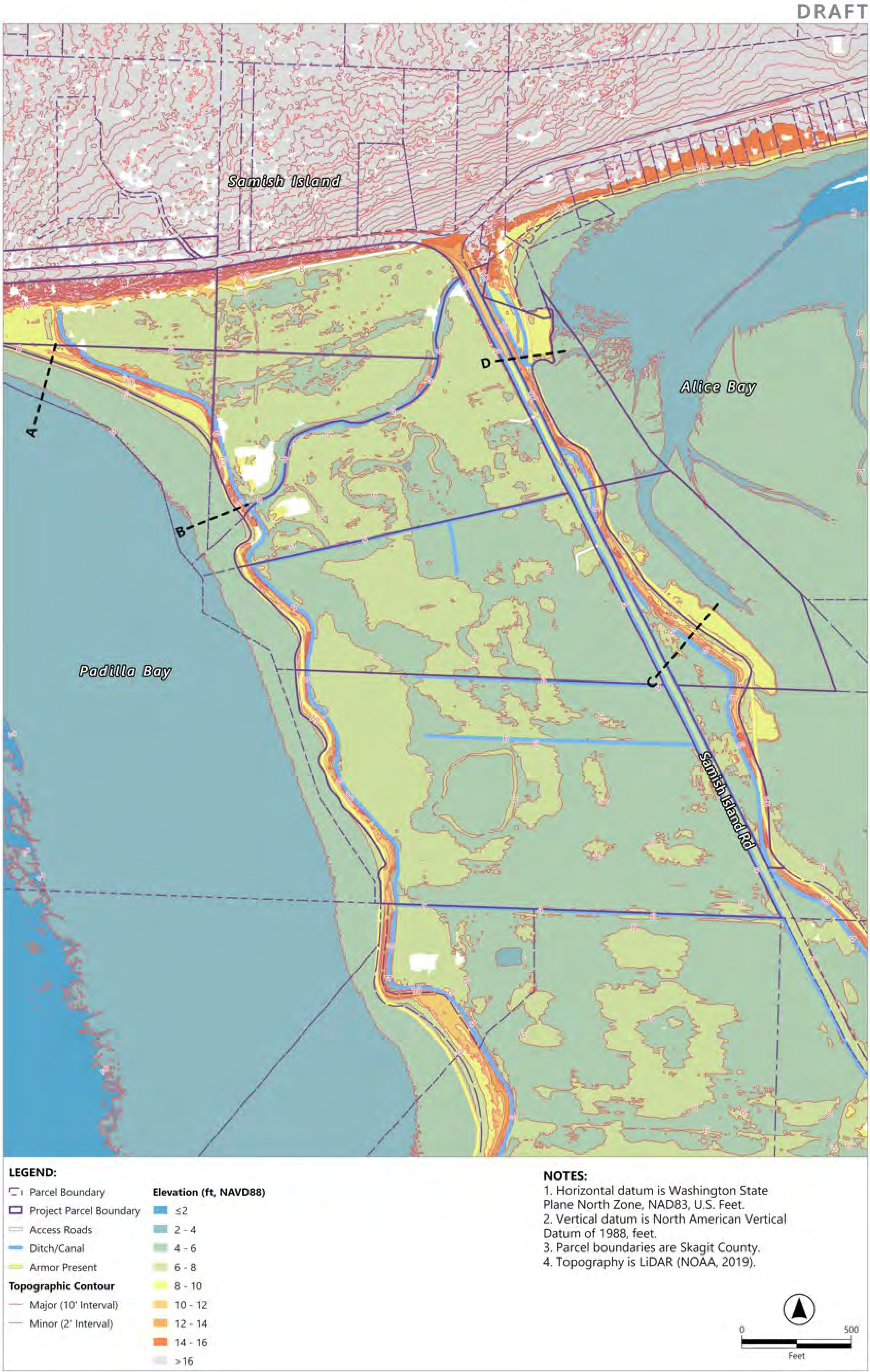


Figure 4. Samish Island Conservation Area topographic site map. Topographic profiles A through D are shown in Figure 5.

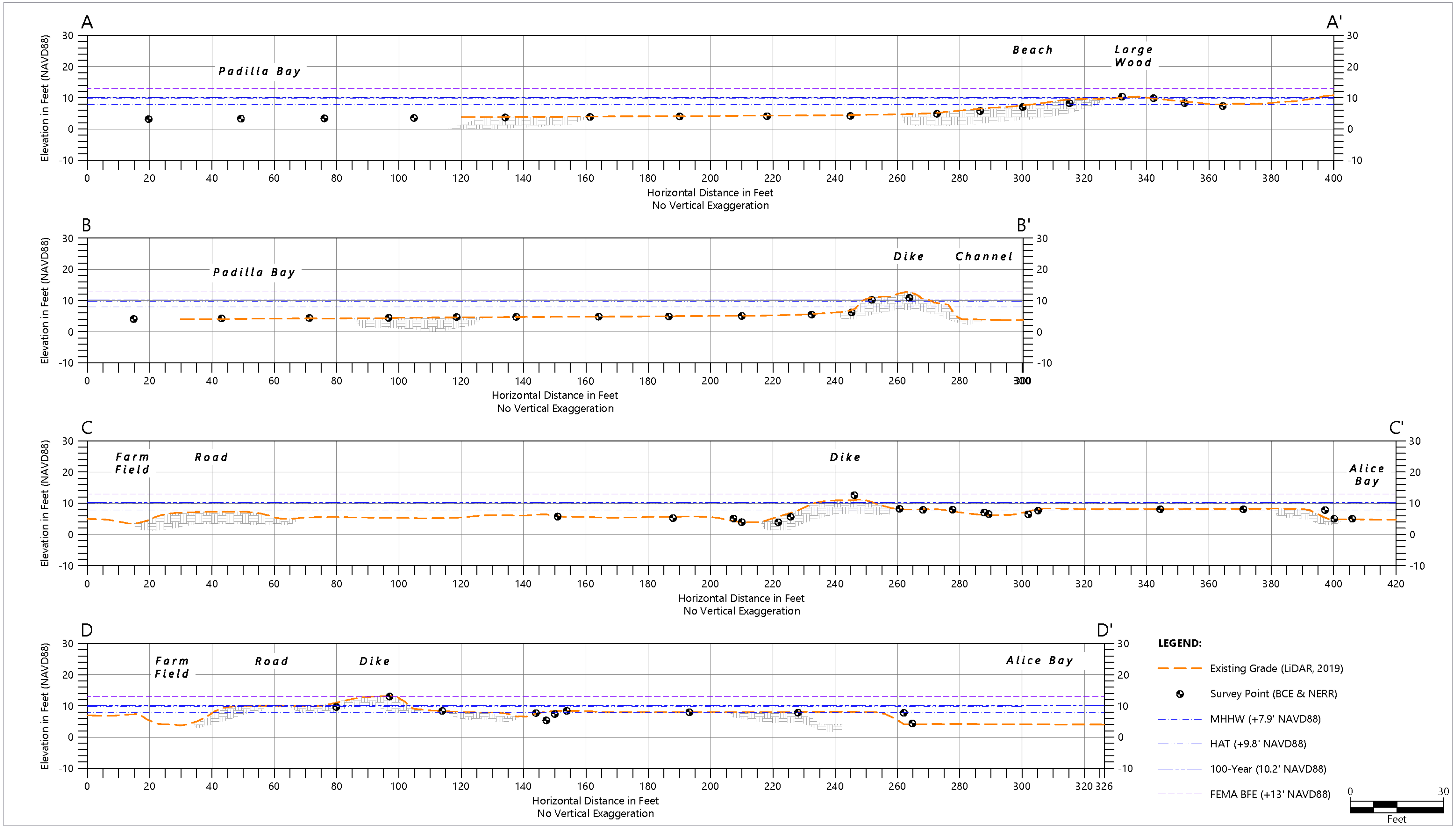


Figure 5. Samish Island Conservation Area topographic profiles. Profile locations are shown in Figure 4.

2.5 Shoreline Infrastructure and Assessment

A site visit was completed by Blue Coast on July 28, 2022, to document the shoreline infrastructure and condition. A second site visit was completed on March 6, 2024, to document the newly acquired parcels to the south (P133563, P47452, and P47454). Photographs from the site visit are included as part of Appendix A. Notes and observations from the site visits are provided below:

Eastern Shoreline (Alice Bay):

- The eastern shoreline along Alice Bay is armored with randomly placed (not stacked) armor stone and sandbags along the crest. Erosion of the bank was noted along a 10- to 15-foot length of the bank with a scarp (vertical bank indicating erosion) 1 to 2 feet in height.
- At the approximate center of the eastern shoreline there is a section of armoring consisting of a 100-foot length of Eco-blocks and quarry spalls.
- The south end of the shoreline consists of the recently rebuilt dike which is 2 to 3 feet in height above the tide flat and armored with granite riprap rock on the waterward face. The top of the dike consists of crushed gravel. The dike is several feet above Samish Island Road.

Western Shoreline:

- The western shoreline along Padilla Bay is backed by an older dike built from compacted soils and haphazardly placed riprap of poor-quality sedimentary rock. Several short lengths of the rock have slumped, leaving the soil bank exposed. Observations of scarps, 1.5 to 2.5 feet in height, were noted in several places in the soil bank.
- Small bedforms (sand waves 2-3 inches in length) are present across the upper tide flat and are evidence of wind-wave energy on the tide flat.
- Several (4) small wider beaches with more back beach along the western shoreline (Figure 9). Fine grained sandy sediment and flotsam (appearing to have a high organic content) have accumulated in these pockets, particularly behind the pile dike training wall.
- The very southern end of the western shoreline along Padilla Bay is armored with riprap that appears to be in good condition. Armoring along the bank on the private property to the south of the project site was placed by the drainage district in 2023.

In 2023, Blue Coast established photograph monitoring points at 10 locations along the shoreline. Photograph monitoring is useful for documenting change along the shoreline. It is recommended to take photographs at these locations facing the shoreline from the same location on the beach at different times of the year. May and October are good times to evaluate the lowest (May) and highest (October) beach elevations that tend to occur in a year. In May, beaches exhibit the fully developed winter profile and lowest annual elevation because sediment had been mobilized and transported by winter storm events and king tides. Conversely, beaches tend to exhibit the fully developed summer profile and highest annual elevation in early October due to the preceding months of lower energy wind-waves and lower high tides It is also useful to take photographs from these locations after storm events. A time series of photographs taken at the monitoring locations and a table of the locations are provided in Appendix C.

2.6 Drainage and Flood Control Infrastructure Near Site

There are some reports of a historic tide gate within the dike at the eastern extent of the slough, where it meets Alice Bay, but there have been no observations of the tide gate by our team and its exact location has not been confirmed. To the south of the study area, we understand that water drained from farmland and collected by the stormwater ditches is routed to a pump station maintained by Dike District 5 located at the head of Alice Bay (see Figure 2), towards a tide gate at the Samish Sports Club, where it is discharged into Samish Bay. The natural flow of surface water in this area appears to be to the north; therefore, the pump station is required to move water through the ditch system and out to Samish Bay. This infrastructure is important to understand as it could be impacted by actions taken to restore saltwater influence at the site.

2.7 Utilities and Roads

A desktop review and limited site surveys were completed to identify and document infrastructure at the site. The desktop review included available GIS information and as-built surveys available from Skagit County to identify roadways, culverts, and stormwater features. A summary of infrastructure (other than drainage and flood protection infrastructure) is provided below.

Roadways

One road goes through the site – Samish Island Road. It runs on the east side of the site, along Alice Bay. The first road ("old road") was built between 1885 and 1900. It was not diked along the northernmost shoreline of Alice Bay. A wooden bridge approximately 300 feet long used to span across the slough. The old road was reported to often be under tidal influence and quite muddy (Hansen 1999). By 1932, the County began building a new straight road. Material from the old road was used to fill the outlet of the slough so the bridge was no longer necessary. The old road and earthen berms on the Alice Bay side prevented tidal inundation from the east, and coastal dikes built by the Squires family were built along the shorelines of Padilla Bay.

Stormwater Infrastructure

A drainage ditch parallels the west side of Samish Island Road to provide infiltration and transport of surface water from the road. As discussed in Section 2.5, this drainage ditch serves several purposes, including transport of water drained from the farmland and routed to a pump station where it is discharged into Samish Bay through the tide gate at Samish Sports Club. One east-west-oriented culvert under the road has been identified that conveys water from the east side of the road to the west side of the road.

Water Mains

The water main plan set was obtained from the Samish Farms Water Association, digitized, and added to the basemap (Figure 1), and provides some information on design invert elevation but the depth of burial is not documented and will be surveyed in Phase 2. The water main runs parallel on the east side of Samish Island Road to the junction of Scott Road. The water main then runs under Scott Road to the north side of Scott Road, takes a 90 degree turn and runs along the north side of Samish Island Road after the intersection with Scott Road. There are one or more domestic taps that run east to west under Samish Island Road within the project area that are used to provide water to the former home sites.

Electrical and Communication Lines

Electrical and communication lines are above ground within the project site. Utility poles were surveyed and added to the basemap (Figure 1). Electrical and communication lines run along the east side of Samish Island Road.

2.8 Historical Maps and Photographs

Historical maps and aerial photographs show changes to the site over time and are summarized below for 1887 (t-sheet), 1937, 1941, 1956, 1969, and 1998. Maps and photographs are included in Appendix C.

1887 T-Sheet

Historically, Padilla Bay and Alice Bay were connected by a channel through the low-lying salt marsh between Samish Island and the Skagit River Delta, in the approximate location of the present-day The slough, as shown by the 1887 t-sheet (USGS 2022b). The channel was widest at the northeast outlet and drained several connecting channels within the salt marsh. Historical reports indicate the channel was deep enough for tugboats to use; the old road crossed the channel with a wooden bridge that was likely approximately 300 foot span (Hansen 1999). At the time of the 1887 mapping, extensive diking for the river and shoreline had already occurred (visible to the south of the project site), fixing in place much of the land for farming.

1937 & 1941 Aerial Photographs

The 1937 and 1941 aerial photographs show dikes and drainage channels located on the project site in approximately their present-day locations. The slough and several dendritic channels draining into it from the north are visible in the location of the former natural channel. The slough channel immediately west of the road was filled in prior to the 1937 photograph (likely in 1932) to construct the roadway across it (Hansen 1999). Agricultural activities are evident north and south of the slough during this time period.

Along the western shoreline of the site, a row of timber pilings is visible in the tide flat a short distance offshore of the shoreline. These pilings were originally installed as a wave barrier to protect the earthen dikes from wave energy. The shoreline appears to have accumulated wood and sediment behind the pilings.

On the eastern shoreline, Samish Island Road is visibly completed connecting the isthmus to Samish Island. Along the northeast shoreline, a short dike is visible on the eastern edge of a small peninsula of salt marsh, and a small drainage basin and channel are located between the road and the dike.

1956 Aerial Photograph

The 1956 geo-referenced aerial photograph shows clearly the agricultural fields on a majority of the project site. Other notable features include a small length of channel filled with water between the road and a dike along the eastern shoreline. Wood accumulated in the back beach (between the top of the beach and the dike) along the western shoreline is also visible. Along Padilla Bay, the shoreline appears to have accreted behind the wave barrier and formed a short spit or tombolo in the former location of the natural channel mouth.

1969 Aerial Photograph

The 1969 geo-referenced aerial photograph clearly shows the slough channel and dendritic channel draining into it from the north. Also highly visible is the meandering channel that crisscrosses the southern property boundary (where a straight, east-west aligned channel is located at present day). A significant amount of wood and sediment appears to be accumulated on the shoreline, and a salt marsh bench is visible behind the pilings along the southwest shoreline; however, the shoreline appears to have retreated since the 1956 photograph.

1998 Aerial Photograph

The 1998 geo-referenced aerial photograph shows a change in the vegetation on the project parcels, indicating that most agricultural activities have ceased. The photograph also shows further retreat (erosion) of the southwest shoreline landward of the timber piling wall. This is likely a result of some of the timber piles being removed (cut off at the mudline), which might have occurred in the 1970s when rock was first installed along the Padilla Bay dikes (exact date unknown). Landward retreat of the shoreline is likely the result of erosion and disruption of sediment supply along the shoreline due to the diking of the shoreline.

2.9 Surface Water

Surface water flows onto the project site from several sources including precipitation falling directly on the site, runon from the upland watershed on Samish Island, and Samish River flooding events. In addition, groundwater flow from higher elevation upland areas and high groundwater on the site can contribute to flooding and surface water flows at low lying coastal sites such as SICA. In addition, the site is adjacent to the Samish River which flows into Alice and Samish Bays and during high river events has been known to produce overland flooding which reaches the SICA region. In the past, breaches of dikes surrounding the Skagit River have also generated overland surface water flow which has reached the project site.

A detailed modeling study was conducted by Northwest Hydraulic Consultants (NHC) for Skagit County to evaluate potential options for reducing riverine flood risks within the Lower Skagit River Basin which includes the Samish River (NHC 2023). Several riverine flooding events were identified in this report which are surmised to potentially have affected the project site including February 2018, November 2021 and January 2019. These events were focused on breaches of the Skagit Reiver dikes which generated overland surface water flow, and this flooding reached the entrance to Samish Island. A model which covers Samish and Padilla Bay, Edison Slough and Joe Leary Slough vicinity was developed to look for opportunities to improve flood drainage (NHC 2023). This modeling showed the maximum flood depth was achieved through a Skagit River dike breach in the Sterling vicinity and resulted in a flood wave that would flow primarily northwest where flood waters would be impounded by the coastal dikes along the shorelines of Samish Bay, predominantly to the west side of the Samish River. Simulated flood depths in the Samish vicinity ranged from 0.5 to 6.0 feet, and the maximum inundation durations in the Samish Area was approximately 34 days. Diking District 5 has mentioned that the project site acts as storage for flood waters during these events, which is demonstrated by the NHC modeling.

Numerical modeling of surface water with the project site boundaries including inputs from the coastal flooding, Samish River, and overland flow will be conducted during the next phase of this project to understand how restoration at the project site could change the flow of water onto and off the site.

3 Coastal Processes

This section of the report quantifies water levels (tides, storm surge, sea level rise), winds, and wind-waves to characterize water level inundation and shoreline erosion at the site. A summary of the geomorphology, which includes the geology and shoreforms, is also provided. This information will be used to evaluate the coastal processes acting on the site and assist in determining the most appropriate restoration options.

3.1 Water Levels

Water levels in Puget Sound are influenced by astronomical tides (mixed semi-diurnal), localized, short-term fluctuations due to meteorological conditions (storm surge), and long-term changes in mean sea level resulting from climatic variation and vertical land motion. Reference vertical datums and projections for sea level rise are provided in this section to understand the frequency and level of inundation along the shoreline at the SICA.

Preliminary water level measurements were recorded in Alice Bay and Padilla Bay for approximately six weeks to identify potential differences in tidal elevations. These measurements indicate there might be slightly higher tides in Alice or Samish Bay as compared to Padilla Bay, but additional measurements are planned to quantify this difference. The length of time of site specific measurements is not long enough to determine tidal datums. Therefore, characteristic tidal datum elevations from the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service (NOS) water level station #9448682 at Swinomish, Washington (7 miles to the south), for the 1983 to 2001 tidal epoch were downloaded and utilized for the project site. In addition, the NOAA VDatum tool[1] provides site-specific estimates of tidal datums and a conversion from Mean Lower Low Water (MLLW) datum to NAVD88.

The NOAA VDatum estimates, and Swinomish gauge data were in good agreement with each other (within 0.25 feet); therefore, the Vdatum site-specific estimates are used for the site (Table 3). The estimates are an average of the water level datums from the Padilla Bay and Samish Bay shorelines, which were within 0.1 foot of each other.

NOAA-NOS analysis provides extreme water levels at the Seattle station relative to the 1983 to 2001 epoch with projections to 2018 based on the linear historic trend in mean sea level. The extreme water levels (1-year, 2-year, 50-year, and 100-year annual exceedance probability [AEP]) based on the analysis are provided in Table 3 for Samish Island (extrapolated from Seattle). The extreme water levels range from 9.0 feet NAVD88 for the 1-year return interval to 10.2 feet NAVD88 for the 100-year return interval. The water levels presented in Table 3 include fluctuations due to astronomical tide, storm surge, atmospheric effects, wind, and wave setup; however, they do not include wave run-

[1] https://vdatum.noaa.gov/vdatumweb/

up, which is calculated in Section 3.2 to provide estimates of total water levels at the site and inform the conceptual restoration ideas. Figure 6 is provided to illustrate a comparison of the water levels in the two datums (tidal and survey).

Table 3. Summary of water level elevations at Samish Island based on the NOAA Vdatum tool and NOAA-NOS Swinomish station (#9448682).

Datum / Elevation	Elevation (ft MLLW)	Elevation (ft NAVD88)
FEMA Base Flood Elevation (BFE)	13.6	13.0
100-year water level (1% AEP)[1]	10.8	10.2
10-year water level (10% AEP)[1]	10.5	9.9
2-year water level (50% AEP)[1]	10.1	9.5
1-year water level (100% AEP)[1]	9.5	8.9
Highest Astronomical Tide (HAT)[2]	10.4	9.8
Mean Higher High Water (MHHW)	8.5	7.9
Mean High Water (MHW)	7.8	7.1
Mean Tide Level (MTL)	5.1	4.5
Mean Sea Level (MSL)	4.9	4.3
Mean Low Water (MLW)	2.4	1.8
North American Vertical Datum 1988 (NAVD88)[3]	0.6	0.0
Mean Lower Low Water[2]	0.0	-0.6

Notes: [1]Extrapolated from NOAA-NOS Seattle station (#9497130) extreme water level trend analysis. AEP = Annual Exceedance Probability; [2]NOAA-NOS Swinomish station (#9448682); [3]Conversion based on NOAA VDatum online tool for the site location.

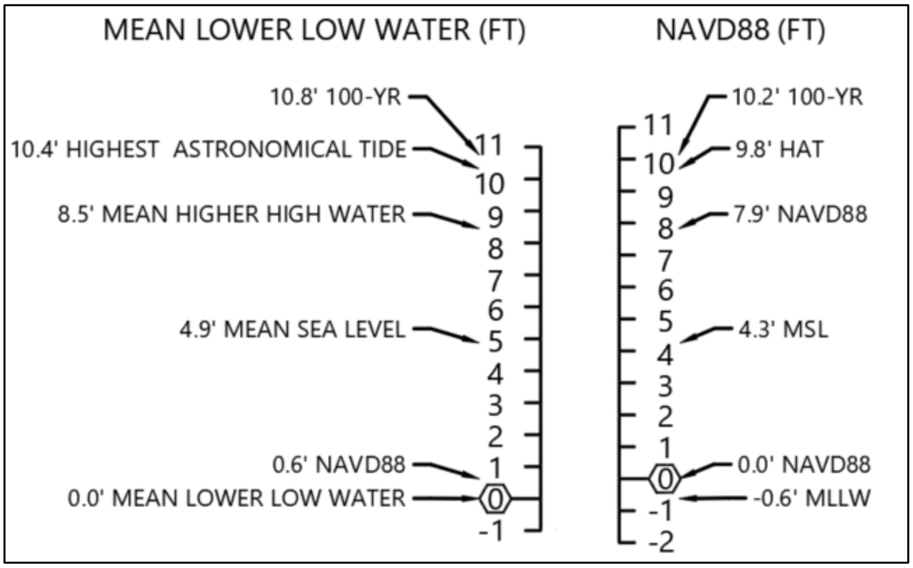


Figure 6. Graphic comparison of water level elevations in tidal (MLLW) and survey (NAVD88) datum at the site.

3.1.1 Sea Level Rise

Long-term mean sea level in Puget Sound is predicted to increase versus historical rates of sea level rise (SLR) because of climate-change-related impacts. Local SLR is the result of the combined effects of global sea level rise and local factors such as vertical land deformation (e.g., tectonic movement, isostatic rebound, and subsidence). Available evidence points towards subsidence of the Samish River delta due to the compaction of sediments and the lack of new sedimentation due to diking (CGS 2005). A recent study by Davis et all (2024) and previous work by Kuhlman (2011) of surface elevation change at 19 study sites in Padilla Bay found that sediment accretion is not keeping pace with the current rate of SLR.

Miller et al. (2018) provides projections of local SLR at coastal locations in Puget Sound and Washington for various planning horizons. The projections incorporate the latest assessments of global SLR due to low (Representative Concentration Pathway [RCP] 4.5) and high (RCP 8.5) greenhouse gas scenarios and local estimates of vertical land motion. The median estimates for SLR (Table 4) in year 2050, 2070, and 2100 at the project site range from 0.6 to 2.0 feet. These estimates will be considered in calculations of total water level at the site, which will guide restoration design. While there is considerable uncertainty in the SLR predictions because of the many unknowns related to future socioeconomic development assumptions as well as climate policies, Blue Coast recommends using the more conservative (RCP 8.5) greenhouse gas scenario for planning purposes.

Table 4. Projected median sea level rise for different time periods and greenhouse gas scenarios for the coastal area near Samish Island.

Year	Greenhouse Gas Scenario	Sea level rise magnitude (feet), central estimate (50% probability exceedance)
2050	Low (RCP 4.5)	0.6
2050	High (RCP 8.5)	0.7
2070	Low (RCP 4.5)	1.0
2070	High (RCP 8.5)	1.1
2100	Low (RCP 4.5)	1.6
2100	High (RCP 8.5)	2.0

Notes: Estimates from Miller et al. (2018)

3.1.2 Water Level Inundation

A frequency analysis was completed using a 10-year dataset of 6-minute tide predictions for the Swinomish NOAA-NOS station (#9448682) from January 1, 2022, to December 31, 2031. Frequency of occurrence and percent exceedance curves were calculated for the dataset using 1-foot elevation bin sizes (Table 5, Figure 7). The water levels are tidal predictions only and do not include storm surge, wind, and wave setup components associated with storm events. The analysis indicates that the most frequently occurring water levels on an annual basis (expressed as % of the year) are between 4 to 8 feet NAVD88 during the next 10 years. Projections of SLR (which are not included in tidal predictions) are added to the tidal predictions in Table 5 to highlight how SLR will impact the water level frequency. The analysis indicates that astronomical tides would exceed 10 feet NAVD88 over 60 hours per year when SLR is factored in, compared to 0 hours per year without SLR. The frequency of tidal inundation at various elevations has implications for design for salt marsh vegetation and for habitats.

Flood inundation maps (Appendix D) were created using the LiDAR DEM to show the inundation of the existing site under various water level scenarios based on the water level analysis. The maps show the landward extent of saltwater inundation at the site under existing conditions for various water elevations: Mean Higher High Water (MHHW), Highest Astronomical Tide (HAT), the 100-yr water level, and the Base Flood Elevation (BFE). These water levels are still water levels only and do not include wave run-up or setup associated with storm events. The mapping also assumes a simplified “bathtub” approach, which does not consider the dynamics of water motion and shows any land elevation below the flood elevation to be inundated. These maps show the interior of the site at current elevations below MHHW and higher water surface elevations.

Table 5. Frequency of occurrence and percent exceedance statistics for Swinomish tide predictions (NOAA-NOS station #9448682, January 1, 2022, to December 31, 2031).

1-foot bin elevation range (feet NAVD88)	Percent Time of Exceedance (%)[1]	Frequency of Occurrence (%)	Percent Time of Exceedance (%)[1], Future, add 1.1 feet SLR	Frequency of Occurrence (%), add 1.1 feet SLR
-5 to -4	100.0	0.0	100.0	0.0
-4 to -3	100.0	0.4	100.0	0.0
-3 to -2	99.6	1.4	100.0	0.4
-2 to -1	98.1	3.3	99.6	1.3
-1 to 0	94.9	4.8	98.3	3.1
0 to 1	90.0	5.7	95.3	4.7
1 to 2	84.3	6.1	90.6	5.7
2 to 3	78.2	6.9	84.9	6.1
3 to 4	71.3	8.3	78.8	6.8
4 to 5	63.0	11.1	72.0	8.1
5 to 6	51.9	14.4	64.0	10.8
6 to 7	37.5	17.8	53.2	14.0
7 to 8	19.7	13.7	39.1	17.7
8 to 9	6.0	5.4	21.4	14.4
9 to 10	0.6	0.6	7.0	6.2
10 to 11	0.0	0.0	0.8	0.8

Notes: [1]Exceedance is calculated based on lower bin range; The water levels are tidal predictions only and do not include storm surge, wind and wave setup components associated with storm events.

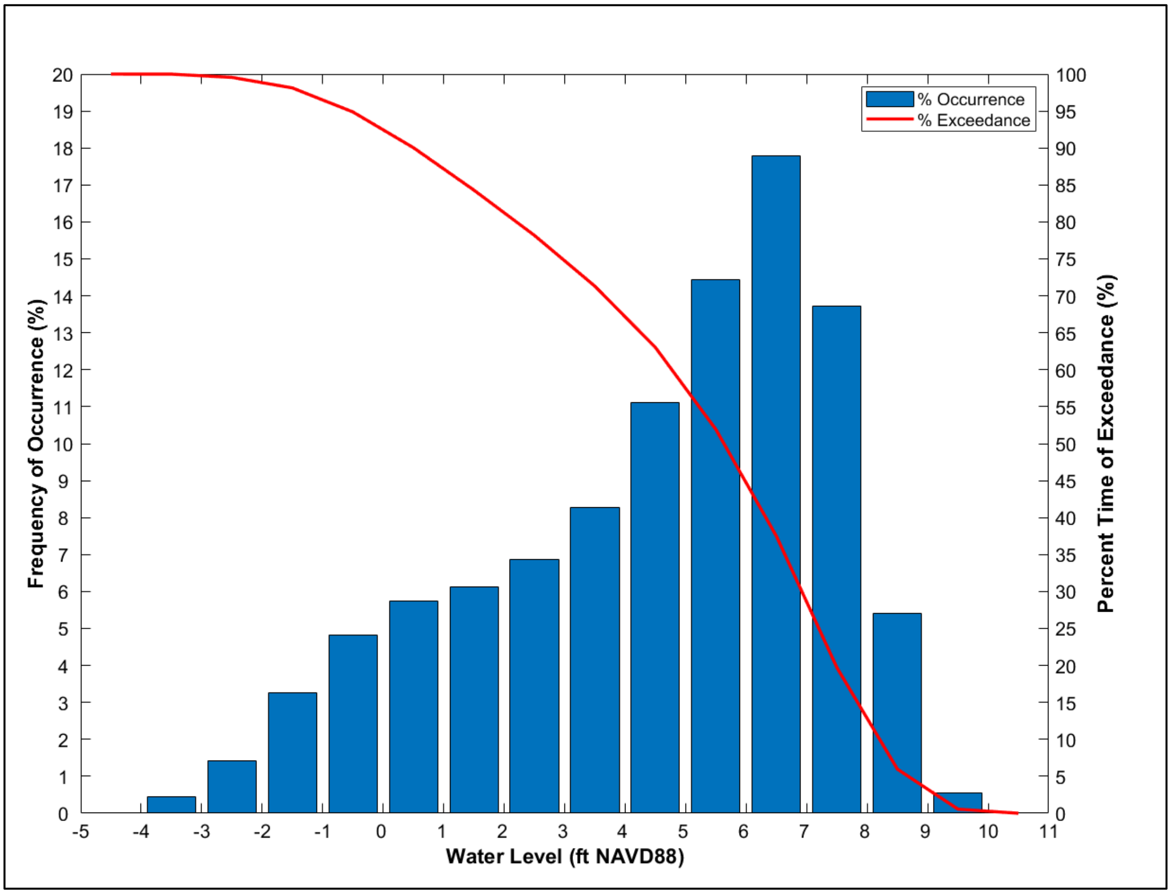


Figure 7. Frequency of occurrence histogram and percent exceedance curve for Swinomish Point tide predictions (NOAA-NOS station #9448682, January 1, 2022, to December 31, 2031).

3.1.3 FEMA Flood Mapping

The Federal Emergency Management Agency (FEMA) and the National Flood Insurance Program (NFIP) issued preliminary Flood Insurance Rate Maps (FIRM) for Skagit County (FEMA FIRM 2010), which includes the project site and is based on the Flood Insurance Study (FIS) for Skagit County (FEMA FIS 2010). The FIRM maps show special flood hazard zones characterized by extreme water levels called the Base Flood Elevation (BFE) and provide the level of risk for flooding for that zone. Generally, shorelines always fall within a high-risk coastal zone; the FIRM provides another method of calculating extremal water levels for a project site.

Both the west- and east-facing portions of the project site are located along coastal BFE VE zones as designated by FEMA and are coastal areas subject to velocity hazards (wave action) and an increased chance of flooding due to storm waves and tidal surges. The BFE coastal VE zone is subject to inundation by the 1% annual chance flood and includes wave run-up and is at an elevation of 13 feet NAVD88 (13.6 feet MLLW). The interior of the site (within the dikes) is considered an AE zone, which is more sheltered, and not subject to a velocity hazard. The AE zone flood elevation is also 13 feet NAVD88. The flood elevation is consistent with the total water levels (see Section 3.3) calculated for the site.

3.2 Wind and Wind-Waves

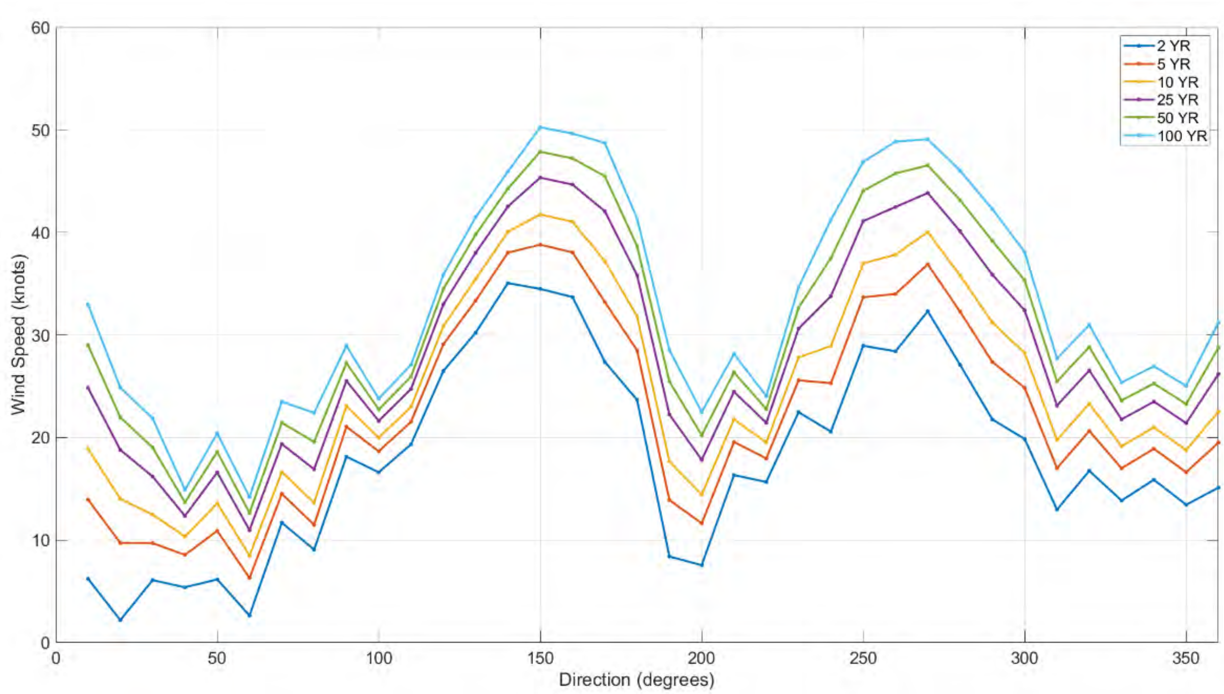
Wind-waves and related wave run-up (the landward extent of wave uprush on the beach) contributes to coastal erosion and flooding at the project site. Wind-waves are formed in response to the force of the wind acting over the water surface. The height and period of wind-generated waves depends on wind duration (i.e., time period of the windstorm), fetch (i.e., distance over which wind is acting) and water depth. Generally, the longer the windstorm lasts and the larger the fetch distance, the larger the height and longer the period of the wave generated. Wave growth at the project site on the south end of Samish Island is limited by the water depth due to the extensive tide flats on the adjacent shorelines.

The prevailing wind direction over the region is from the south and southwest in the winter and west and northwest during the summer. The strongest winds are typically from the south during winter storm events. The wind climate at the site was characterized using wind records from two long-term meteorological stations: Whidbey Island Naval Air Station (NAS) (1945 to 2021) and West Point (1975 to 2021).

An extreme value analysis of the wind record from every 10° direction bin was completed for the two stations to identify extreme wind events between the 2-year to 100-year return interval (Figure 8). The comparison shows the bimodal wind distribution at each station, aligning with the local topography along the Strait of Juan de Fuca at Whidbey Island (west to east) and south towards Admiralty Inlet. At West Point in Seattle, the wind distribution is aligned along the axis of Puget Sound (north to south). The strongest wind events for both stations are from the south between 50 to 60 knots. Local wind directions at Samish Island should be expected to vary from those measured at West Point and Whidbey NAS based on the local topography but will generally align with a similar bimodal distribution.

A wind-wave hindcast following the United States Army Corps of Engineers (USACE) methodology (Leenknecht et al. 1992) was completed to estimate extreme wind-wave parameters at the site using the maximum West Point winds, as a conservative estimate. The longest fetch distance for the western shoreline at the project site measures approximately 6.8 miles at 190° to the southwest across Padilla Bay. The longest fetch distance for the eastern shoreline at the project site measures approximately 3.2 miles at 60° to the east across Alice Bay and Samish Bay. The wind-wave estimate assumed a water depth of 10 feet (high tide)

Whidbey NAS



West Point (Seattle)

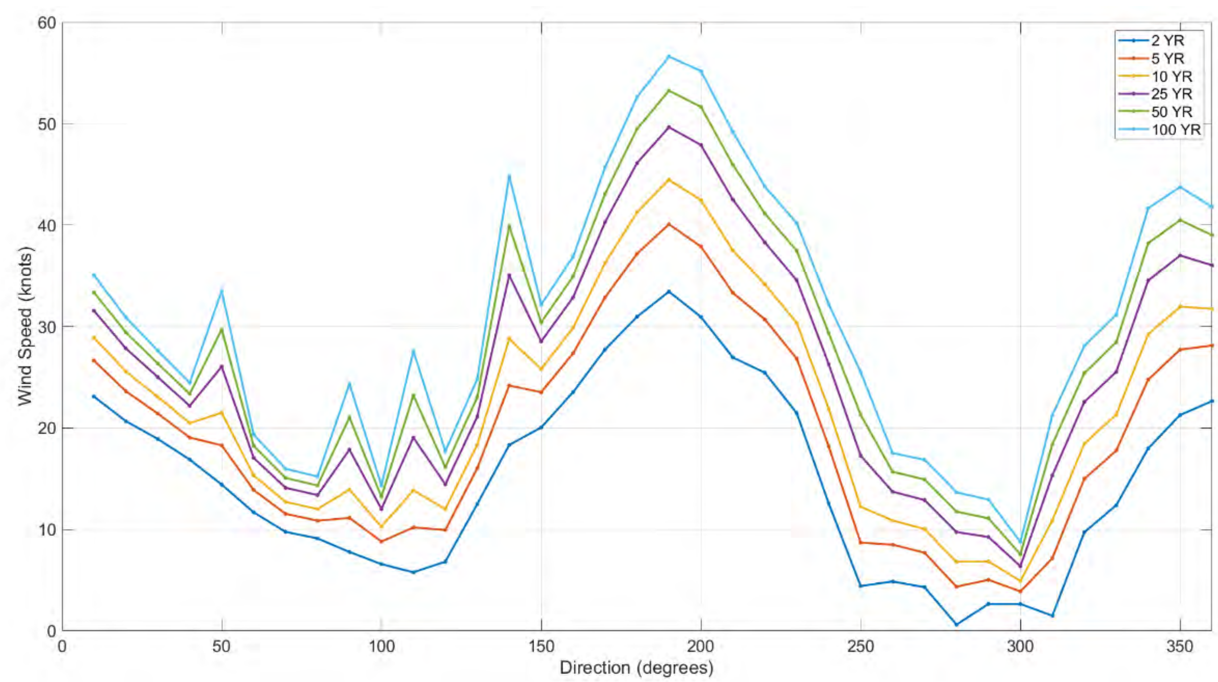


Figure 8. Extreme value wind speeds calculated in 10-degree direction sectors for Whidbey NAS and West Point (Seattle) meteorological stations.

The resulting 100-year wave parameters are a significant wave height equal to 3.9 feet and peak wave period equal to 3.9 seconds for the western shoreline (Table 6). Wave parameters along the eastern shoreline are lower due to the shorter fetch and lighter winds from the east.

The resulting wave run-up ($R_{2\%}$) on the beach, assuming an average nearshore slope of 12H:1V on the upper beach,[2] ranges from 1.4 to 2.1 feet at MHHW tidal elevation on the western shoreline and 0.4 to 0.6 feet on the eastern shoreline (Table 6). Wind-wave energy is attenuated at lower water levels by the wide, expansive tide flats; the largest wave energy on the shoreline occurs at higher water levels.

Table 6. Extremal wind speeds and wind-wave hindcast estimate for Samish Island.

Return Period (years)	Wind Direction	Wind Speed (knots)	Significant wave height (H_s, feet)	Peak wave period (T_p, seconds)	Range of wave run-up ($R_{2\%}$, feet)
100	Southwesterly (western shoreline)	57	3.9	3.9	1.4 to 2.1
100	Easterly (eastern shoreline)	19	1.1	2.1	0.4 to 0.6

3.3 Total Water Levels

Total water levels (TWL) provide an understanding of the coincidence of high water levels and storm-induced wind-waves and the resulting inundation along the shoreline. Extreme high water levels described by return period intervals such as 1-year, 50-year or 100-year (Table 3) include fluctuations due to astronomical tide, storm surge, atmospheric effects, wind, and wave setup; however, they do not include wave run-up as compared to tidal datums such as MHHW, which are only astronomical tides. The TWL on the Padilla Bay side of the site are calculated by summing a stillwater elevation, wind-wave run-up, and projected SLR out to 2070 (Table 7). MHHW (tidal elevation without atmospheric effects) is used for the typical daily water level, and the 100-year return period water level including the other components is used as the basis for an extreme stillwater scenario. For the existing condition (no SLR), the range in TWL varies between 9.7 and 12.0 feet NAVD88 (10.3 and 12.6 feet MLLW). The TWL for the 100-year water level and wind-wave scenario is within 1 foot of the FEMA BFE flood elevation (13 feet NAVD88) for the project site.

The TWL on the Alice Bay/Samish Bay side are calculated by summing the stillwater elevation, projected sea level rise out to 50 years (2070), and 0.5 feet of wind-wave runup as a factor of safety (although wind-waves are assumed to be minimal due to the short fetch and protected nature of the

[2] Based on surveyed beach profiles for the west shoreline collected during the July 28, 2022, site visit

shoreline). The TWL for Alice Bay under existing conditions ranges between 8.4 and 10.7 feet NAVD88 (10.0 and 11.3 feet MLLW) as shown in Table 8.

Table 7. Total water levels (100-YR return interval) for Samish Island on Padilla Bay shoreline.

Scenario	Stillwater level (feet NAVD88)	100-YR Wind-wave run-up (feet)[1]	Total water level (feet NAVD88)
MHHW	7.9	1.8	9.7
Existing 100-YR water level (low probability event)	10.2	1.8	12.0
MHHW+ SLR	9.0 (MHHW + 1.1 feet SLR[2])	1.8	10.8
Existing 100-YR water level + SLR (low probability event)	11.3 (100-YR + 1.1 feet SLR[2])	1.8	13.1

Notes: [1]12:1 H:V beach slope input to wave run-up calculation; [2]SLR prediction for 2070, high GHG emissions scenario

Table 8. Total water levels (100-YR return interval) for Samish Island on Alice Bay shoreline.

Scenario	Stillwater level (feet NAVD88)	100-YR Wind-wave run-up (feet)	Total water level (feet NAVD88)
MHHW	7.9	0.5 (factor of safety[2])	8.4
Existing 100-YR water level (low probability event)	10.2	0.5 (factor of safety[2])	10.7
MHHW+ SLR	9.0 (MHHW + 1.1 feet SLR[1])	0.5 (factor of safety[2])	9.5
Existing 100-YR water level + SLR (low probability event)	11.3 (100-YR + 1.1 feet SLR[1])	0.5 (factor of safety[2])	11.8

Notes: [1]SLR prediction for 2070, high GHG emissions scenario. [2]Wind-waves are predicted to be small in Alice Bay due to protective nature of bay, but assuming 0.5 ft of run-up to be conservative on water levels.

3.4 Geomorphology

The Samish Island project site is low-lying marshland and shoreline comprised mostly of tidal and beach deposits. Beach deposits are described as moderately to well-sorted sand and gravel, typically well-rounded, and shell fragments. Tidal flat deposits in Padilla Bay and Alice Bay are composed of fine sand, silt, and clay (Dragovich et al. 1998). A shallow system of dendritic channels drains across the tidal flats into deep troughs (up to 300 feet depth).

The shorelines along the project site are sediment-supply limited as a result of the diking of the Skagit River and along the Padilla and Samish Bay shorelines. The closest available source of sediment to the shorelines is from the erosion of unconsolidated (glacial drift) feeder bluffs, located approximately 0.25 mile to the west on the south side of Samish Island (Figure 9 & Appendix A,

Figure A-7). These bluffs are comprised of Vashon Stade advance outwash and overlying till deposits. Long-term mean retreat rates are in the range of 1 to 4 inches per year for the bluffs surrounding Padilla Bay (Keuler 1979 as cited in Bulthuis 2010), which is in line with average bluff retreat rates in Puget Sound. Observations from the site visit on July 28, 2022, noted armoring along the toe of portions of the bluff closest to the site, including timber and concrete bulkhead walls in front of several structures immediately west of the project site and an Eco-block wall placed along the toe of the bluff to west of the structures. Published mapping (CGS 2017) also indicates a short length of feeder bluff (<0.25 miles) along the southeastern shoreline of Samish Island between the project site and Scotts Point (Figure 98).

The length of shoreline in which sediment can move alongshore transported by wind-waves without interruption is called a littoral drift cell. Littoral drift mapping (Figure 9) shows much of the shoreline (western and eastern) to the south has no appreciable drift due to the low wave energy and the limited sediment supply. Along the project site, published mapping of the net littoral drift direction is conflicted, likely due to the limited drift indicators and limited sediment supply. Mapping by Keuler (1979) shows drift to be away from the site: to the west towards Kirby Spit on the western shoreline and to the east towards Scotts Point on the eastern shoreline. Mapping completed as part of the 2017 Beach Strategies Phase 1 project (CGS 2017) shows drift on the western shoreline to be towards the site (to the east) (drift cell #SKSA005 and # SKSA004).

Previous site-specific analysis by CGS (2005) agrees with net drift direction away from the site, although small accretionary pockets on the upper beach were noted along the northwest shoreline. These were also noted during the site visit in 2022 by Blue Coast on the upper beach where the dike is set further back from the shoreline (Appendix A, Figure A-10).

CGS (2005) analysis of shoreline change found the inter-tidal areas of Padilla Bay and Alice Bay to be dominantly erosional, at both the MLLW and MHW elevations (up to 200 feet since 1887 in Padilla Bay). This is due to the lack of overall sediment supply to the system. The eastern shoreline is more stable than the western shoreline, and remnant salt marsh on the eastern shoreline is a good indicator of the stability. Anecdotal reports have suggested that Alice Bay is becoming shallower over the last 50 years (CGS 2005), in contrast to the overall erosional trend; however, no evidence was available to confirm these anecdotes. High-resolution bathymetric data are not available for either Padilla Bay or Samish Bay (including Alice Bay) (Bulthuis 2010).

3.4.1 Subsidence

Subsidence is gradual settling and sinking of the ground surface and is an important consideration for the restoration efforts at the site because it influences future water surface elevations and salt marsh establishment. Subsidence typically is the result of slow settlement, consolidation, and desaturation of natural deposits or from sudden land level changes. The project team observed several isolated low spots on the surface and indications of historic low spots of accumulated material within the borings and test pits. Several of the test pits showed 2 to 3 feet of silt with sand overlying lean clay and silty sand which indicates consolidation of the silts and clays. In addition, local subsidence can be caused by the decay of organic material and/or loss of material due to groundwater flowing across the site.

The project team evaluated published literature regarding the nearest active faults and subsidence studies to better understand subsidence at Samish Island. Surface elevation change in Padilla Bay was documented to be subsiding or eroding at 19 study sites between 2002 and 2010 (Kuhlman 2011), likely due to the lack of sediment supply to the system. Sediment elevation tables located throughout Padilla Bay measured a mean erosion rate of 0.22 cm/year at 18 of the sites. These results contrast with previous studies using geochemistry (radioisotope methods) that have had variable results but generally documented accretion in Padilla Bay on decadal, century, and millennial timescales. The surface elevation change results documented by Kuhlman (2011) are considered reflective of projected long-term elevation changes in the bay based on a relative elevation model developed by Kairis (2008). The model projects a net accretion deficit (erosion) of 0.46 cm/year.

Figure 9 Samish Island coastal geomorphology map.

4 Habitat and Species

The information provided in this report related to existing habitat conditions is based on available data and observations made during multiple visits to the site by Blue Coast and Shannon & Wilson (SW) staff. This section will also discuss data collection efforts related to habitat and species use, much of which is still ongoing.

The physical features and historical land use described in the other sections of this report have created a mosaic of habitats, some areas of which are relatively natural and some that are more heavily impacted by human use. The drainage and flood protection structures (dikes, ditches, constructed pond areas, etc.) have created unnatural hard transitions between many of the habitats. Restoration efforts at this site will aim to increase and improve saltwater marsh habitat and improve nearshore habitat and the interconnection between these and other habitats on site and on adjacent lands.

Vegetation characterization across the site was completed by SW with assistance from Blue Coast staff. On-site vegetation was characterized on the northern half of the project site (SLT Parcels) on August 11, 2022, and on the southern half of the project site (PBNERR Parcels) on May 22, 2024. This work was completed by walking around the site and making observations and doing limited wetland test pits; it does not constitute an official wetland delineation. Vegetation characterization was divided into seven vegetation zones: roadside areas, dikes, upland fields, grasslands, saltwater (intertidal) marsh, inland ditches, and inland wetlands. These seven zones are discussed in Sections 4.1 through 4.3 as applicable. A complete plant inventory is provided in Appendix E.

4.1 Nearshore and Saltwater Marsh Habitat

The nearshore habitat along much of the western project shoreline is generally intact to the ordinary high-water mark (OHWM)/high tide line (HTL) with a narrow backshore zone that has large wood and some salt-tolerant vegetation. The OHWM is defined under Washington State Shoreline Management Act through Department of Ecology (Ecology) as a biological vegetation mark and is delineated in the field based on the presence of wood and vegetation and varies somewhat in elevation across the shoreline. Since the OHWM has not been formally delineated following Ecology protocols at the project site yet, the high tide line which is typically close in elevation to OHWM is being used as a proxy for OHWM during this phase of the project. There is a larger backshore area in the northwestern corner of the site. There are also old pilings present slightly offshore. The dike is setback slightly from OHWM/HTL along most of the shoreline, which is heavily covered by invasive vegetation (primarily Himalayan blackberry) that is creating a significant barrier between the nearshore intertidal habitat and the interior of the site (Figures 1 and 10). On the eastern shoreline (Alice Bay), there are areas of saltwater marsh habitat in the transition between the nearshore and dike (Figures 1 and 10).

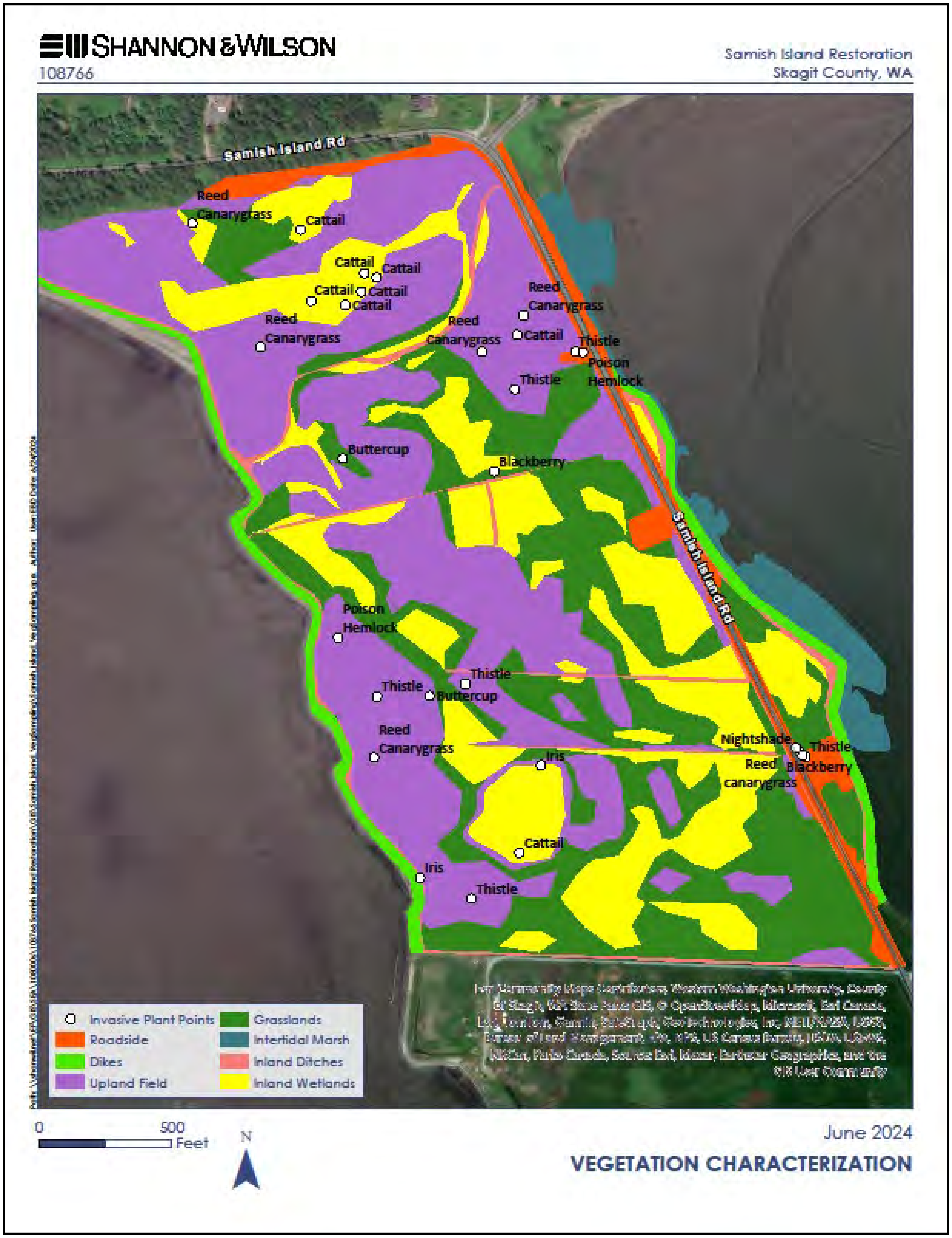


Figure 10. Samish Island vegetation characterization map.

Both the Padilla Bay and Alice Bay shorelines have extensive mudflats that are exposed during low tides. There are deeper drainage channels off the mudflats that hold water at low tide, but do not connect with the nearshore at the site. Based on aerial imagery and site observations, submerged aquatic vegetation is not growing in this upper intertidal mudflat area.

Saltwater (intertidal) marsh habitat is currently located solely on the Alice Bay side of the project area. Dominant plant species include salt grass, spear saltbush, saltmarsh sandspurry, pickleweed, and seaside arrowgrass (Appendix E). The lowest areas of the Alice Bay marsh are inhabited by salt grass, seaside arrowgrass, and pickleweed In the limited backshore areas on Padilla Bay there is some salt-tolerant vegetation and large woody debris accumulation. It has also been observed on both shorelines that significant wrack (vegetation from offshore) accumulates around MHHW.

4.2 Inland Wetland Habitat

Portions of the interior of the site (landward of the dikes) have been categorized as inland wetlands and inland ditches. The term palustrine has sometimes been used to describe these wetlands, although these wetlands likely exceed the salinity criteria for palustrine marshes, which do not exceed 0.5 parts per thousand (ppt); for simplicity, they are referred to here as inland wetlands.

Within the submerged portions of the on-site ditches, sparse emergent vegetation was observed. However, western ditch-grass, as well as unidentified algae species, were observed within the ditch between the Alice Bay dike and Samish Island Road. Western ditch-grass is a seagrass that prefers low to intermittent salinities. Also, within the shallower ditches between Samish Island Road and the Padilla Bay dike, pickleweed, seacoast bulrush, and narrowleaf cattail were observed within the submerged portion of the ditches. Brass buttons, spear saltbush, saltmarsh sandspurry, and salt grass were observed along the fringes of the shallow ditches.

Based on the observed plant community in the inland wetland vegetation zone, these areas may have a mixohaline (brackish) salinity regime (typically 0.5-30 ppt). Hydrology within this area predominantly sources from surface water from the ditches, as well as a high groundwater table. Dominant plant species within the inland wetlands include spear saltbush, salt grass, pickleweed, brass buttons, saltmarsh sandspurry, soft rush, spikerush, seacoast bulrush, toad rush, Pacific silverweed, and water foxtail. Within the inland wetland area are several seasonally ponded areas. Dominant vegetation within the seasonal ponds included hardstem bulrush, seacoast bulrush, and narrowleaf cattail.

4.3 Upland Habitat

Upland habitat areas include vegetation categories of roadside areas, dikes, upland fields, and grasslands.

Roadside areas are characterized by common roadside herbaceous weeds and cool-season grasses. The highest concentration of invasive plant species is located in this vegetation zone. Dominant species include field horsetail, red clover, white clover, ox-eye daisy, rose species, Himalayan blackberry, pineapple weed, Canada thistle, cow parsnip, ox-eye daisy, common mustard, sheep sorrel, sour dock, cleavers, and various cool-season grasses.

The Alice Bay and Padilla Bay dikes provide vertical structure in the predominantly flat study area. These upland bands include herbaceous, shrub, and tree species. This dike vegetation zone includes abundant invasive plant cover. Dominant vegetation along the top and sides of the dikes include snowberry, common mustard, cow parsnip, Nootka rose, unknown rose species, common burdock, Himalayan blackberry, evergreen blackberry, field horsetail, reed canarygrass, ox-eye daisy, cleavers, various fruit trees, red elderberry, yarrow, serviceberry, and cool-season grasses.

The upland field vegetation zone is composed of the upland field fringes along the dikes, higher elevation areas, as well as the pond berms. Vegetation is dominated by cool-season grasses and a high diversity of weedy vegetation, most of which is introduced. In addition to the grasses, dominant species include sheep sorrel, common mustard, red and white clover, Canada thistle, common plantain, cow parsnip, creeping buttercup, sour dock, reed canarygrass, poison hemlock, and yarrow.

The grassland zone is characterized by cool-season grasses and acts as a transition zone between the adjacent inland wetlands and upland fields. This zone is dominated by salt grass, creeping bentgrass, redtop, tall fescue, velvetgrass, spear saltbush, and soft rush.

4.4 Invasive Species

Invasive plant species are concentrated within upland areas of the study area (roadside, dike, and upland field zones). While many of the on-site plant species listed in the plant inventory are introduced, not all are considered invasive. Invasive species are those that aggressively spread and out-compete native plant species, and/or otherwise cause harm to native flora and fauna. These species are included on the Washington State Noxious weeds list. Table 9 displays the invasive plant species observed on site and provides a description of the locations. Figure 10 also shows the locations of these invasive plants.

Table 9. Invasive Plant Species on Samish Island Project Site.

Family	Scientific Name	Common Name	Location
Apiaceae	*Conium maculatum*	Poison hemlock	Located throughout the upland field zone. There are sparse patches along dikes.
Asteraceae	*Cirsium arvense*	Canada thistle	Located throughout the upland field zone. There are small patches in roadside zone.
Asteraceae	*Cirsium vulgare*	Bull thistle	Scattered throughout roadside and upland field zones.
Fabaceae	*Cytisus scoparius*	Scotch broom	Sparsely scattered along dikes.
Rosaceae	*Rubus armeniacus*	Himalayan blackberry	Large and small patches (sometime thickets) are located along dike. Sparsely scattered throughout upland field zone.
Rosaceae	Rubus laciniatus	Evergreen blackberry	Sparsely scattered along dikes.
Solanaceae	Solanum dulcamara	Bittersweet nightshade	One small patch along roadside.
Apiaceae	Conium maculatum	Poison hemlock	Located throughout the upland field zone. There are sparse patches along dikes.
Iridaceae	Iris pseudacorus	Yellow flag	Located along the Padilla Bay dike ditch, and within the southern pond.
Poaceae	Phalaris arundinacea	Reed canarygrass	Small patches are located throughout the roadside zone. Sparsely scattered within the upland field zone.
Typhaceae	Typha angustifolia	Narrowleaf cattail	Located within the ponds, and along the inland ditches between Padilla Bay and Samish Island Road.

4.5 Species Use

A list of species currently using the site was identified based on several site visits by Blue Coast staff, online data, and sampling conducted by PBNERR as described in this section.

4.5.1 Fish

The project site is relatively close to both the Skagit and Samish river basins. Based on discussion and data provided by Eric Beamer (Skagit River Systems Cooperative [SRSC]), it is reasonable to assume that most Pacific Northwest salmonid species would be found along the Samish and Padilla Bay shorelines at the site, although there has been no data collection at this exact location. There is a potential that the wide, shallow mudflat area may result in a reduced abundance of fish along the project shoreline as compared with areas sampled in other parts of Samish and Padilla Bays. There are plans for future data collection at the site.

Forage fish sampling by the Washington Department of Fish and Wildlife (WDFW) has occurred once (in 2002) near the northwest corner of the site, with no fish detected (WDFW 2024a). Summer surf smelt spawning has been documented on Samish Island along Padilla Bay, west of the project site. Surf smelt are also documented as spawning along most of the northern coast of Samish Island. Herring are documented spawning in Samish Bay on the east side of the project site.

There are currently some areas, primarily along the western shoreline, with suitable substrate for surf smelt and/or sand lance spawning on the beach. The presence of the dike and additional armoring in front of the dike does limit this potential spawning area. As noted previously, there is also typically a significant accumulation of wrack on the shoreline that limits the ability for sampling to occur as the methodology requires the gathering and sifting of beach sediments. Along the Alice Bay shoreline, mudflats generally come up to the saltmarsh leaving no suitable spawning substrate. It should also be noted that the wide, shallow mudflat may be a deterrent to fish passage but there is no data to support or refute this.

Forage fish sampling was conducted by PBNERR, along the Padilla Bay shoreline in 2023 once each month from June through September. No fish were detected during this sampling. The sampling that was previously completed by WDFW and PBNERR does not indicate that forage fish never spawn along the shoreline as the sample size is too small. There are plans to continue this sampling in 2024.

4.5.2 Birds

Bird surveys have been conducted on the SLT parcels since 2022, completed by volunteers with the Audubon Society. Additional monitoring began in March 2024 by PBNERR staff on both SLT and PBNERR parcels. The surveys are using the Salish Sea Estuaries Avian Monitoring Framework, which was developed by the Stillaguamish Tribe of Indians, Ecostudies Institute, The Audubon Society, and WDFW. These surveys are being conducted by walking around the site and do not encompass offshore waterfowl. Sampling for 11 months of 2022 observed 72 species on the SLT parcels. None of the observed species are known to be federally listed under the Endangered Species Act.

4.5.3 Other

WDFW's Priority Habitat and Species data was reviewed for the project site. Waterfowl and great blue heron were identified as species, but no other species were listed in the immediate project area (WDFW 2024b). Based on observations during site visits, the site is used by upland species, including black-tailed deer, rabbits, garter snakes, and smaller rodents such as voles and field mice. Due to the salinity of waters on the project site it is not likely that amphibians would use the site for breeding but may be present in the vicinity.

5 Soil, Hydrogeology, and Geotechnical Assessment

Mott McDonald and Shannon & Wilson jointly developed a subsurface exploration program to characterize the subsurface soil and groundwater conditions, map the plow plan depth and characteristics across the project site, and evaluate the existing dikes. The objective of this assessment was to determine the depth of compact soil layers which will impact channel excavation, characterize the geotechnical properties of site soils to determine if appropriate for reuse, evaluate subsidence, and complete a cursory overview of the existing hydrogeology.

5.1 Groundwater Conditions

Existing hydrogeologic monitoring from the SICA includes data for ditches, shallow groundwater, and tidal stage. On the SLT property, between September and December 2022, monitoring data were collected from three shallow piezometers (completed to depths of 4.4 to 10.4 feet), two drainage ditch locations, and two tidal monitoring stations (Figure 3). Time series of water-level measurements were recorded at all locations (with the exception of piezometer SB-01), while conductivity measurements were recorded at paired groundwater-surface water monitoring locations SB-02 and SW-2. Measurements were recorded at 30-minute intervals (Table 2).

SLT site soils encountered during piezometer installation generally consisted of surficial silts and clays overlying a silty sand unit that the piezometers were screened in. The ditch network has no direct connection to marine water, and direct water sources to the ditches are thought to include precipitation and runoff, groundwater discharge, and possibly (during high-tide periods) localized dike seepage or overtopping. Occasional dike breaches have historically been observed in winter months; however, further site monitoring and evaluation is needed to define their frequency, location, and associated inundation extent and duration.

SLT site water-level monitoring data indicate that ditch water levels have a muted response to daily tidal variations during summer months (Figure 11) and have little to no tidal response following the onset of seasonal rains. Shallow groundwater elevation data from the SLT site exhibit a consistent daily tidal response, and during the late-summer period shallow groundwater elevations are lower than ditch water levels. Following the onset of seasonal rains, groundwater elevations at SB-2 increased and become higher than ditch water level elevations at SW-2. This seasonal change in the relationship between groundwater and surface water elevations suggests that “losing” conditions (where ditch water is lost to groundwater through infiltration) occur during the late summer and “gaining” conditions (where groundwater discharges to the ditch) occur during the winter wet season.

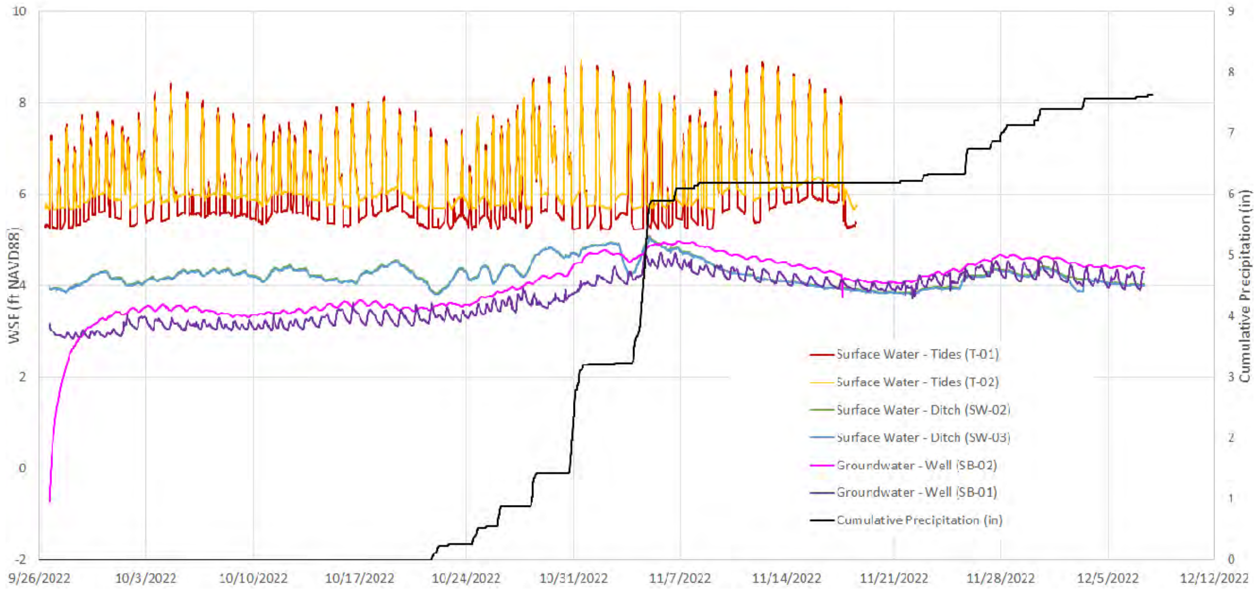


Figure 11. Time series of surface water, groundwater, and precipitation data at the SLT site in 2022.

Surface water salinity data from SW-2 exhibit a strong diurnal signal during the late summer period (Figure 12), which potentially reflects evapotranspiration loss. Shallow groundwater salinity data from paired piezometer SB-2 does note exhibit diurnal variations in salinity. Shallow groundwater salinity in the late summer to early winter observation period was consistently lower than surface water concentrations; however, the relative difference between surface water and shallow groundwater concentrations decreases in the wet season.

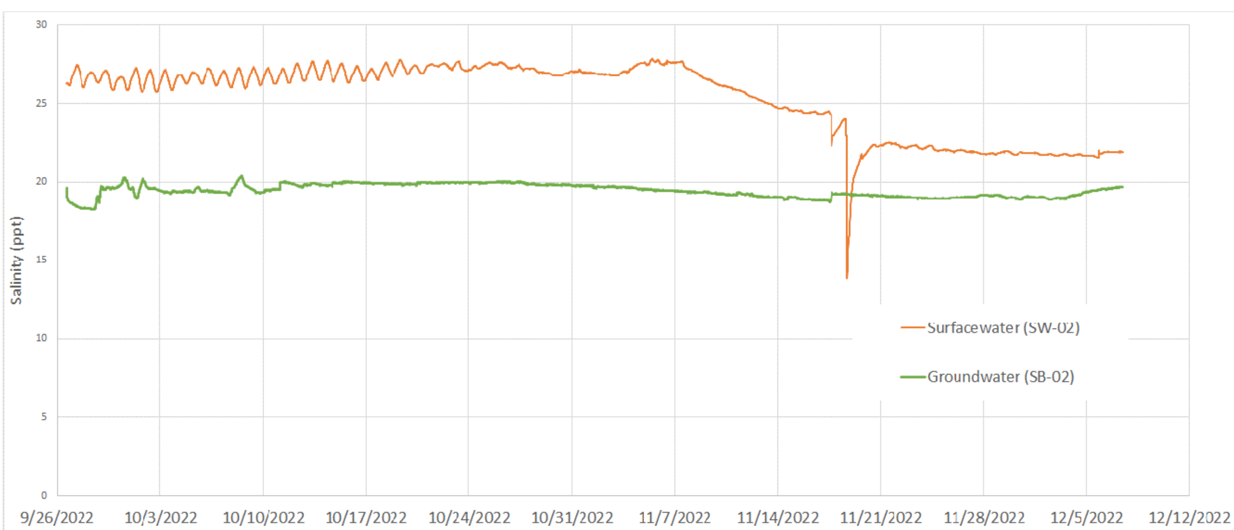


Figure 12. Time series of salinity at monitoring station SW-1 in 2022.

Additional hydrogeologic monitoring stations were installed across the site properties in May 2024, and include three well pairs (to characterize subsurface materials, salinity, and groundwater levels at depths of roughly 15 and 45 feet below ground surface) and seven shallow piezometers (to more broadly characterize shallow soil conditions and near-surface water levels and salinities).

Initial interpretations of hydrogeologic data manually collected in May and June 2024 include the following:

- Subsurface materials encountered at the monitoring well pair (B-1p-24) installed on the north SLT parcel included glacial till, which appears to be an extension of mapped geologic materials from Samish Island, which was also confirmed in the well logs from Samish Island to the north.
- Subsurface materials encountered at the deep and shallow monitoring well pairs on the central and south properties were primarily beach and tidal flat deposits (sands, silty sand, or silts and clays).
- Initial water level elevation measurements for each well pair indicate that an upward hydraulic gradient (e.g. flow of water) is present between the deep well (roughly 45 feet in depth) and shallow well completions (roughly 15 feet in depth). Additional site monitoring data which are currently being collected will provide an understanding about whether a consistent upwelling condition exists year-round and how these water levels and gradients relate to observed shallow piezometer and ditch water levels.
- Manual specific conductance measurements (which are an effective proxy for salinity) from early June 2024 at the northernmost well pair (B-1p-24) were substantially lower in concentration than all other groundwater and surface water specific conductance measurements taken. This suggests freshwater upwelling is potentially occurring in parts of the northern parcel and is likely due to its proximity and apparent geologic unit similarities to neighboring Samish Island.

Automated water level and specific conductance monitoring in addition to the collection of periodic manual measurement snapshots is ongoing and will help further characterize existing site conditions and temporal changes due to seasonality and tide.

5.2 Soil and Geotechnical Site Characterization

A geotechnical site characterization report, completed by Shannon & Wilson and provided in Appendix F of this report, is summarized in this section. The site characterization documents the site reconnaissance and subsurface exploration program. The report provides a general overview of the site conditions and a geotechnical evaluation of the roadway and dike conditions.

5.2.1 Soil

The soil stratigraphy at the site is variable from north to south. Boring SB-01 was drilled near the northeast corner of the site, near where the slough was filled by human activity for the road and agriculture. The soil encountered at this location consists of approximately 8 feet of soft organic soil underlain by about 2 feet of very loose sandy silt. At about 10 feet below ground surface (bgs) the soil transitions to a medium dense silty sand.

Near the center of the north end of the site (boring B-1p-24), about 5 feet of topsoil and very soft silt with sand and trace organics was encountered. Underlying the surficial soil is about 7 feet of medium dense to dense gravel with sand and cobbles. Between about 12 and 15 feet bgs, the soil transitions to a dense sandy silt with gravel. Around 15 feet bgs, the soil becomes very dense and consists of sandy silt, sandy silt with gravel, silty gravel with sand, and sand with gravel. In the opinion of Shannon & Wilson, this would be consistent with the glacial till mapped to the north. Beneath the glacial till, around 38 feet bgs, the soil becomes very dense poorly graded sand with silt and poorly graded gravel with silt and sand. This material is interpreted to be advance outwash; soil that typically underlies glacial till and is deposited as the glacier advances.

Away from the far northern extents of the project site (all explorations to the south of B1 and SB02), about 3 to 7 feet of very soft to soft silt and clay and very loose to loose sandy silt and silt with sand at the surface was encountered. Trace to abundant organics were found throughout these deposits and consist of roots, grass, wood debris, bark, and lumber. Underlying the surficial soil is loose to medium dense sand with silt, silty sand, and sandy silt with wood fragments and trace organics. These soils are consistent with the beach deposits mapped in the Project area indicating most of the site was historically tidally influenced and overwashed by wind-waves.

In boring B-2p-24, near center of project site, a deposit of very soft to medium stiff clayey silt and silt was observed between 20 and 33 feet bgs. This deposit had trace organics and shell fragments. The fine-grained sediment was likely deposited by low-energy water in a localized topographic depression at the site although it does not correspond with any mapped ponded areas in the t-sheets. Other depression fillings may be present across the Project area.

5.2.2 Geotechnical

During the site reconnaissance, cracking, potholes, depressions, and leaning utility poles were documented along Samish Island Road. Cracks in the roadway are both longitudinal and transverse, typically formed due to poorly constructed joints, shrinkage of the asphalt, and the reflective cracking from an underlying layer.

The evaluation of the dikes was limited by dense vegetation on the crest of the dikes and ponded water along the landward side of some portions of the dike. Where accessible, the crest of the dike appears firm and flat with no obvious cracking or deterioration. There are some signs of overtopping, and sections of the waterward face of the dike have been eroded and the riprap has slumped off (see Section 2.4).

As discussed above, the project area was previously used for agricultural development that included tilling. Plow pan can develop from routine tilling with plows and results in a subsurface horizon or soil layer that has a lower porosity than the soil directly above or below it. As a result, plow pans can restrict root penetration. Signs of plow pan approximately at 2 feet bgs were found while excavating all of the test pits.

Laboratory testing of the soil samples is in progress. Once completed, the boring logs will be updated, soil units across the site will be identified, and a summary of the potential for reuse of the soil for other project elements will be completed.

6 Site Constraints & Data Gaps

During this initial project phase, we have collected data in several key areas as discussed in the earlier sections of this report. However, this is the first phase of a multiphase project, and we have several known and potentially unknown gaps in the current data and information. In addition, there have been preliminary conversations with several project partners and affected parties (section 9) which has assisted in the identification of constraints at the project site and data gaps. This section attempts to summarize the constraints for restoration, key gaps in the data, and areas of work for the future to be able to develop design criteria which would be necessary for completing preliminary engineering design for restoration.

6.1 Site Constraints

The constraints for restoration of salt marsh at the project site generally fall into three major categories; the infrastructure that supports Samish Island residential community, the infrastructure that supports the agriculture practices on lands south of the site, and the flow and storage of surface water during river flooding events.

6.1.1 Samish Island Road & Community Infrastructure

As described in detail in Section 2, the only access road to Samish Island runs through the project site and this access must be maintained and would be improved as part of a restoration scenario. SLT has heard from the community through informal conversations that reducing the flooding of this road is one of their primary concerns and would be well received. There was no formal study conducted by transportation engineers of the road, potential for raising the road, or potential for creating channels under the road as part of this initial phase of the project. Shannon & Wilson reviewed the conditions of the road for indications of damage related to water saturation and settlement and found considerable wear (Section 5.2.2 and Appendix F). A transportation study will be conducted during the next phase of the project to identify the information necessary to determine the potential for raising the road and providing openings under the road for tidal exchange and fish passage. We also understand Skagit County is conducting studies to evaluate river flood reduction options and resiliency of the roads in the County which could inform changes on Samish Island Road.

There are also several utilities including power, communication, and water supply which need to be either maintained in place or improved as part of a restoration design. The studies required and responsible parties for designing these elements (such as Puget Sound Energy for power) will be identified during the next phase of this project and some of these studies will be completed.

6.1.2 Dike Infrastructure

The coastal dikes along the Padilla Bay and Alice Bay shorelines are of varying age and condition leaving Samish Island Road and agriculture lands vulnerable to coastal overtopping and Samish River flooding events. In the short term, at community request, SLT and PBNERR will do temporary repairs (such as sandbagging) to deter flooding at extreme water levels while a long-term solution for the road is identified. Conceptual options for replacing the coastal dikes with other protection measures as part of the roadway prism (Section 7) should be considered as one of the long-term solutions which will assist in achieving the restoration goals. In addition, the Project team has assumed an east to west setback levee along the boundary of the restored project area will be necessary to prevent tidal inundation of properties south of the SICA. When designed, this setback levee will be evaluated for seepage and groundwater exchange between the restored project area and the adjacent private properties.

The project will evaluate removing portions or all the coastal dikes along the shorelines of SICA on Padilla Bay and Alice Bay to facilitate tidal inundation and salt marsh creation. Under these scenarios, the road would be protected by setback dikes or levees directly adjacent to the road or the road would be elevated to a level where these protections are not necessary, thereby functioning as a dike. Protecting the privately owned land and agriculture practices on these lands is also a requirement for any restoration scenario. As such the Project team will work with Dike District 5 to design connections between the remaining coastal dikes on adjacent properties and the new infrastructure on the project site. These connections will be needed to prevent coastal overtopping and tidal flow within the project site boundaries from reaching properties outside the project boundaries. Any future coastal dikes and setback levees will be designed to meet County and Diking District Standards.

6.1.3 Surface Water, Drainage, and Flood Storage

Surface water flows onto the project site from several sources as described in Section 2.9. Blue Coast has a cursory understanding of the surface water flow to the site based on conversations with the Dike District 5, Skagit County, and review of previous modeling studies and technical reports. Blue Coast understands the drainage infrastructure handles typical flows from stormwater runoff from Samish Island Road and drainage of the agricultural land, and potentially groundwater seepage into the ditches. We also understand the conveyance of water which reaches the site during extreme weather events from both the Samish River and breaching of dikes around the Skagit River has previously overwhelmed the drainage infrastructure and has taken over 30 days to drain during these types of events.

This feasibility study is being used to inform the scope of numerical modeling of surface water within the project site boundaries including inputs from the coastal flooding, Samish River, and overland flow. Numerical modeling will be conducted during the next phase of this project. The primary objective of the modeling will be to understand how restoration at the project site could change the flow of water onto and off the site and surrounding areas and could affect the storage of flood water during extreme Samish River flood events. The project team understands a restoration project must demonstrate there will not be an increase in the drainage requirements of the adjacent agriculture lands to be accepted. In addition, the project team will need to assess any changes to the flow of surface water and stormwater which could impact the volume of water handled by the pump stations and tide gates managed by Dike District 5.

Based on our discussions with Dike District 5 and adjacent farmers, the current groundwater is saline and therefore salinity intrusion is not a primary concern since the existing groundwater cannot be used for irrigation.

6.2 Data Gaps

Several gaps in the available date were identified as part of this study and these gaps will need to be filled prior to developing final design plans for any restoration scenario. This is not an exhaustive and detailed list of data gaps, but rather the gaps which need to be filled during the next phase of the project.

6.2.1 Sediment Inputs and Site Elevation

The overall elevation of the project site is relatively low and the elevations across most of the site are below MHHW. This is important because it limits the range of salt marsh vegetation which can colonize in these areas under the current elevations. While the SICA does currently have elevations which support some saltmarsh vegetation, to provide the habitat for the largest range of saltmarsh vegetation, creation and sustenance of a wider range of elevations including higher elevations is preferred. In addition, encouraging natural sediment delivery to the site to maintain elevations over time is also preferred to provide resilience from future increases in water levels.

Historically, sediment was delivered to the site by the Skagit River on the west side and Samish River on the east side. The historic tidal influence across this site brought sediments, wood, and seed source to the area which promoted a wide range of saltmarsh habitat. There is evidence of these habitats in the geotechnical borings and test pits. Under current conditions, the site has been cut off from these sources of sediment and delivery mechanisms. In addition, the previous agriculture practices and weight of the soils atop of the historic silts and clays has consolidated the soils at the site and is contributing to overall subsidence and gradual lowering of the site elevations over time.

The diking and realignment of the Skagit River has permanently cut off this river source of sediment to Padilla Bay and the resulting subsidence and erosion of the tide flats has been well documented. However, there are no direct measurements of erosion of the shoreline immediately adjacent to the site, and the rates are too small to be detected in aerial imagery. There is anecdotal evidence of accretion in Samish and Alice Bays, but the rate of accretion has not been documented.

There are feeder bluffs to the northwest of SICA on the Padilla Bay shoreline and to the northeast on the Samish Bay/Alice Bay shorelines of Samish Island. Feeder bluffs discharge sediment during sloughing and slides and are important sediment source for shorelines. These feeder bluffs could supply sediment to the shorelines and to SICA if tidal inundation was restored. Additional work will be conducted during the next phase of the project to more precisely determine sediment sources, sediment sinks, and potential for sediment delivery under various restoration scenarios.

6.2.2 Coastal Processes

The analysis of coastal processes in this report has been limited to publicly available data and very limited field measurements of tides which reach the shorelines of Padilla Bay and Alice Bay and beach elevation measurements. During the next phase of this project, wind-waves and water levels will be measured in deeper water depths of both bays to better quantify the contributions of wind-waves to total water levels on both sides of the project area. In addition, the water level measurements will provide data on the potential differences in tidal elevations on the Padilla Bay and Samish Bay sides which could affect tidal exchange between the two bays if the historic slough or a similar channel was reestablished. These measurements will also be used to calibrate a set of numerical models being developed to predict water levels and wind-waves at the site under current conditions and changes to existing conditions under various restoration concepts. In addition, this modeling will be used to inform the potential for sediment delivery under existing conditions through littoral drift under wind-waves to the shorelines and to the interior of the site under various restoration scenarios.

Blue Coast will also conduct regular beach profile monitoring to document shoreline change along both bays as part of the next phase of the project. In addition, a site visit will be conducted to adjacent properties with feeder bluffs in both bays as permissions allow to determine the potential volume of sediment discharged from the feeder bluffs which is beach building material and to validate the littoral drift cell mapping.

6.2.3 Groundwater Flow

In May 2024, geotechnical drilling and groundwater wells were installed within the site boundaries and they are currently collecting data, which will not be available for analysis and reporting until early 2025. Preliminary data indicates there is upward flow of groundwater on the project site at least seasonally and at some locations. The groundwater sampling to date has been within the project boundaries and it has been recommended by project partners and technical advisors that at least one groundwater well should be installed to the south of the proposed restoration area and setback levee. This additional groundwater well, installed if allowed by a neighbor, would provide information to assist in understanding the potential for upwelling of groundwater south of the proposed setback levee and south of the restoration area. In addition, the current scope of work for this phase of the project does not include groundwater modeling. Depending on the findings of the current groundwater study, groundwater modeling might be recommended and would be conducted as part of the next phase of the project.

6.2.4 Watershed Analysis & Surface water Flow

This project phase did not include a site specific watershed model to quantify surface water runoff to the project site. An analysis of the volume of water running onto the site from the adjacent watershed will be conducted during the next phase of the project and used as an input to the surface water model. Numerical modeling of surface water with the project site boundaries including inputs from the watershed, coastal flooding, Samish River, and overland flow will be conducted during the next phase of the project to understand how restoration at the project site could change the flow of water onto and off of the site. In addition, this modeling will be used to understand the storage of water from Samish River flooding at the site during extreme events and how restoration might affect this storage capacity.

6.2.5 Transportation

A transportation study to identify the information necessary to determine the potential for raising the road, possible size and number of openings under the road for tidal exchange and fish passage, and other limiting factors and design considerations for the road will be conducted during the next phase of the project. We also understand Skagit County is conducting studies to evaluate river flood reduction options and resiliency of the roads in the County which could inform changes on Samish Island Road.

6.2.6 Utilities

Limited information is available on the location of utilities along Samish Island Road. Blue Coast was provided photos of the water main as-built and we have provided an approximate location of this water main on Figure 1, but we do not have the depth of burial of the water main. There are communication and power lines overhead, but we have not determined the owners and operators of these utilities who would likely be responsible for the design to move and reinstall these utilities. A private utility locate will be conducted during the next phase of this project.

7 Restoration Concepts

The primary high-level objective for restoration at SICA is to restore saltmarsh habitat that provides ecological benefits for a variety of species, restore natural processes along the shorelines and the historic estuary, develop sustainable community access and infrastructure to Samish Island and neighboring properties. The primary objective of the feasibility study is to gather sufficient existing information to develop restoration concepts which are potentially feasible to implement and to gather feedback and comments from project partners, affected parties, and the community on these ideas.

Based on the existing information for the site and the restoration feasibility objectives, a set of five conceptual restoration ideas are presented in this section of the report for consideration by project partners, affected parties, and the public. These restoration concepts are shown in Figures 13 through 17 as diagrams for the purposes of discussion and are not intended to be engineering designs at this stage of the project.

7.1 Restoration Concept 1 - No Restoration Action

The No Restoration Action concept has been developed to demonstrate how the site would potentially evolve if a restoration project was not implemented, and other solutions were not developed for the road and dikes. The elements of a No Restoration concept are shown in Figure 13 and include the following:

- No substantive changes to the Padilla Bay and Alice Bay dikes are identified.
    - Coastal overtopping of the Padilla Bay dikes will continue to occur at water levels above 8.6 feet NAVD88, which is between MHHW and HAT (or King Tide) shown as Area 1 in Figure 13.
    - Coastal overtopping of the Alice Bay dikes will continue to occur at water levels above 9.7 feet NAVD88, which is equal to HAT (or King Tide) shown as Area 2 in Figure 13.
    - Temporary and minimal measures will be implemented to deter flooding during extreme water level events per requests from the community.
- No changes to Samish Island Road will be completed, therefore coastal flooding from the Alice Bay shoreline, such as occurred in December 2022, will be possible approximately once per year under current water levels. The frequency of flooding is expected to increase by approximately 10% in the future with an increase in sea level and water levels could exceed the existing elevation of the Alice Bay dikes for approximately 60 hours per year.

- Ditches and drainage will remain as they currently are, and coastal overtopping will continue to add to stormwater ditches. They will eventually overwhelm the current drainage system.

- The spread of the existing invasive species is a major concern. Both organizations have management plans and invasive species management will be an ongoing expense.

- The access and parking areas will be in the existing footprint but are expected to degrade over time as a result of flooding events. Each organization's management plan describes possible public access opportunities.

7.2 Restoration Concept 2 – Barrier Embayment

A barrier embayment, also known as a pocket estuary, is a semi-enclosed bay protected from wave energy by a barrier beach or barrier spit. These systems typically contain one primary tidal channel allowing tidal exchange between the embayment and the larger body of salt water. If there is a significant freshwater source, then the system would be considered a barrier estuary where freshwater and saltwater mix. If there is no freshwater source, then the system would be a barrier lagoon. The potential for freshwater mixing at the site is low since we understand from adjacent landowners the groundwater under existing conditions is saline. For restoration concept 2, we have provided two ideas which have a small and large footprint of a barrier embayment and provide an opportunity to restore saltmarsh habitats.

7.2.1 Restoration Concept 2a

Restoration concept 2a is the minimum footprint for which restoration might be considered at SICA, The elements are shown in Figure 14 and include the following:

- The removal of 2,700 feet of the Padilla Bay dike armor.

- Excavation of the primary tidal channel into Padilla Bay and the interior network of tidal channels for fish habitat.

- The placement of material to create varying elevations of marsh habitat and addition of native plantings across 75 acres. Saltwater inundation across the site would also reduce the need for management of invasive species.

- The improvement of about 2,000 feet of Samish Island Road in a way that precludes the need for portions of the adjacent Padilla Bay and Alice Bay coastal dikes and including protection to prevent overtopping of the road for future water levels.

- The relocation or modification of the utilities adjacent to the road as needed including power, communication, and water.

- The construction of an east to west setback levee 900 to 1300 feet from the southern boundary of the project area.
- The addition of a new parking area and coastal access adjacent to the east to west setback levee.
- Complete a rebuild of the remaining 900 feet of the Padilla Bay coastal dike within the project area to connect to the existing Dike District 5 dikes on Padilla Bay.
- The removal of the Alice Bay private coastal dikes which are adjacent to the new road as well as improving the Alice Bay dikes in other locations to connect to the existing Dike District 5 dikes on Alice Bay.

7.2.2 Restoration Concept 2b

Restoration concept 2b is the maximum footprint for which restoration might be considered at SICA, The elements are shown in Figure 15 and include the following:

- The removal of 3,300 feet of Padilla Bay dike armor.
- Excavation of the tidal channel into Padilla Bay and the interior network of tidal channels for fish habitat.
- The placement of material to create varying elevations of marsh habitat and addition of plantings across 108 acres. Saltwater inundation across the site would also reduce the need for management of invasive species.
- The improvement of about 3,500 feet of Samish Island Road in a way that precludes the need for portions of the adjacent Padilla Bay and Alice Bay coastal dikes and including protection to prevent overtopping of the road for future water levels.
- The relocation or modification of the utilities adjacent to the road as needed including power, communication, and water.
- The construction of an east to west setback levee 150 feet from the southern boundary of the project area.
- The addition of a new parking area and coastal access adjacent to the east to west setback levee.
- Complete a rebuild of the remaining 300 feet of the Padilla Bay coastal dike within the project area to connect to the existing Dike District 5 dikes on Padilla Bay.

- The removal of Alice Bay private coastal dikes adjacent to the new road as well as improving the Alice Bay dikes in other locations to connect to the existing Dike District 5 dikes on Alice Bay

7.3 Restoration Concept 3 – Reconnect Bays

Historically, Padilla Bay on the west was connected through the barrier beach and salt marsh to Alice Bay on the east at the approximate location of the present-day S7amésh Seqelích (slough). There is also evidence of other small channels into the project site from both bays. This system allowed tidal exchange, sediment exchange and fish passage between the two bays. For restoration concept 3, we have provided two ideas which have the same small and large footprint options as shown in restoration concept 2 but allow connection between the two bays at one or more locations to restore saltmarsh habitats. The primary difference between restoration concepts 3a and 3b is the acreage and footprint of restoration.

7.3.1 Restoration Concept 3a

Restoration concept 3a is the minimum footprint for restoration of a slough which might be considered at SICA, The elements are shown in Figure 16 and include several elements which are consistent with restoration concept 2a (in italics) and some new elements (not in italics) which differentiate restoration concept 3a as a slough from the embayment idea for restoration concept 2a.

- *The removal of 2,700 feet of the Padilla Bay dike armor.*
- *Excavation of the primary tidal channel into Padilla Bay and the interior network of tidal channels for fish habitat.*
- *The placement of material to create varying elevations of marsh habitat and addition of native plantings across 75 acres. Saltwater inundation across the site would also reduce the need for management of invasive species.*
- *The improvement of about 2,000 feet of Samish Island Road in a way that precludes the need for portions of the adjacent Padilla Bay and Alice Bay coastal dikes and including protection to prevent overtopping of the road for future water levels.*
- *The relocation or modification of the utilities adjacent to the road as needed including power, communication, and water.*
- *The construction of an east to west setback levee 900 to 1300 feet from the southern boundary of the project area.*
- *The addition of a new parking area and coastal access adjacent to the east to west setback levee.*

- *Complete a rebuild of the remaining 900 feet of the Padilla Bay coastal dike within the project area to connect to the existing Dike District 5 dikes on Padilla Bay.*
- Increase the elevation of the entire or parts of Samish Island Road and provide open channel(s) to Alice Bay.
- The removal or breach of the Alice Bay coastal dikes to allow for tidal exchange and improving the Alice Bay dikes in other locations to connect to the existing Dike District 5 dikes on Alice Bay.

7.3.2 Restoration Concept 3b

Restoration concept 3b is the maximum footprint for restoration of a slough which might be considered at SICA, The elements are shown in Figure 17 and include several elements which are consistent with restoration concept 2b (in italics) and some new elements (not in italics) which different restoration concept 3b as a slough as compared to the embayment idea for restoration concept 2b.

- *The removal of 3,300 feet of Padilla Bay dike armor.*
- *Excavation of the tidal channel into Padilla Bay and the interior network of tidal channels for fish habitat.*
- *The placement of material to create varying elevations of marsh habitat and addition of plantings across 108 acres. Saltwater inundation across the site would also reduce the need for management of invasive species.*
- *The improvement of about 3,500 feet of Samish Island Road in a way that precludes the need for portions of the adjacent Padilla Bay and Alice Bay coastal dikes and including protection to prevent overtopping of the road for future water levels.*
- *The relocation or modification of the utilities adjacent to the road as needed including power, communication, and water.*
- *The construction of an east to west setback levee 150 feet from the southern boundary of the project area.*
- *The addition of a new parking area and coastal access adjacent to the east to west setback levee.*
- *Complete a rebuild of the remaining 300 feet of the Padilla Bay coastal dike within the project area to connect to the existing Dike District 5 dikes on Padilla Bay.*

- Increase the elevation of the entire or parts of Samish Island Road and provide open channel(s) to Alice Bay.
- The removal or breach of the Alice Bay coastal dikes to allow for tidal exchange and improving the Alice Bay dikes in other locations to connect to the existing Dike District 5 dikes on Alice Bay.

As discussed previously, these are high level restoration concepts which will have many more elements if moved into restoration alternatives. Some of the elements not included in this discussion are changes to stormwater infrastructure, potential surface water control devices (tide gates), changes to utilities, detailed interior network of channels, detailed grading and varying elevations, and detail native planting plan.

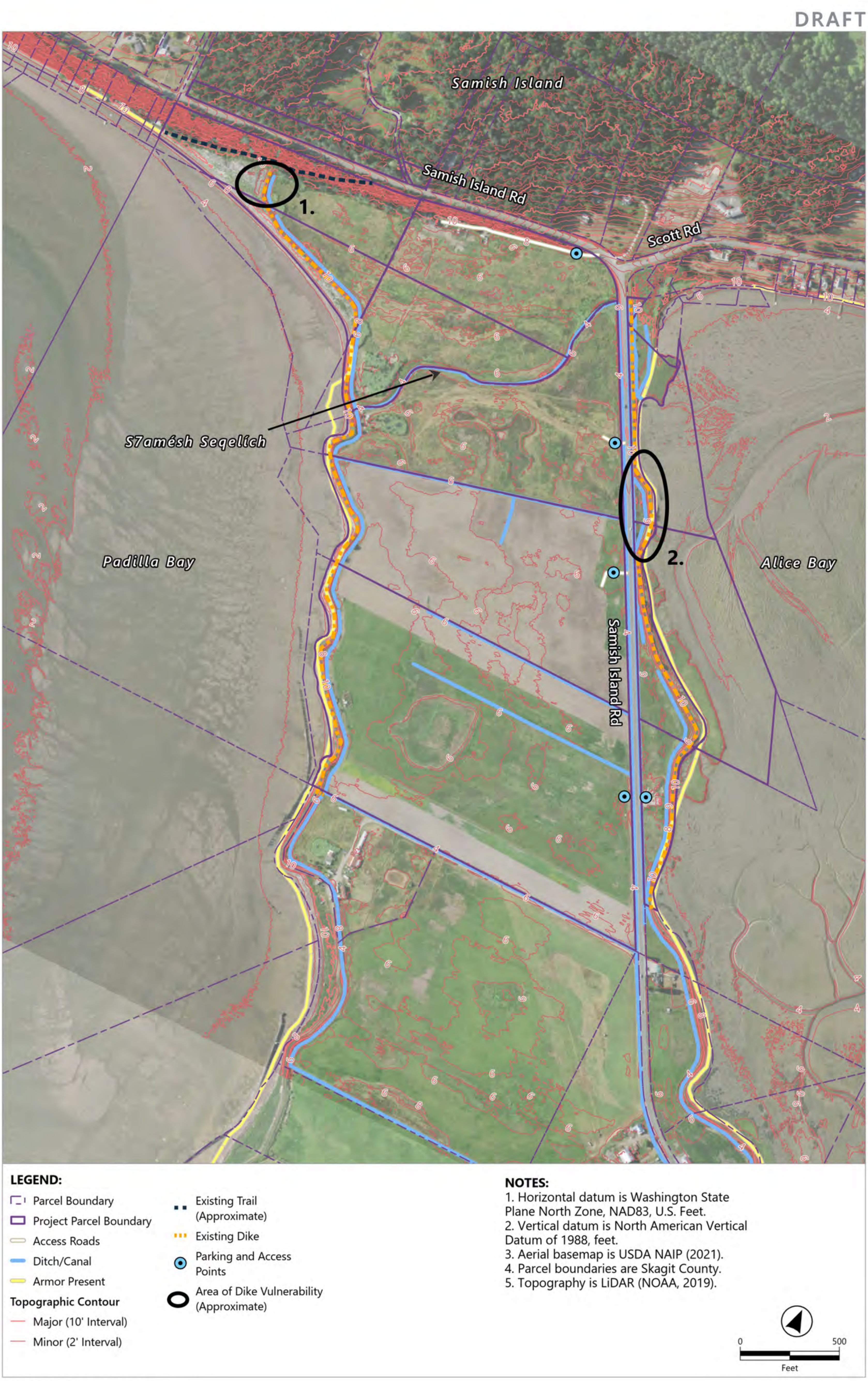


Figure 13. Restoration Concept 1 for no restoration action.

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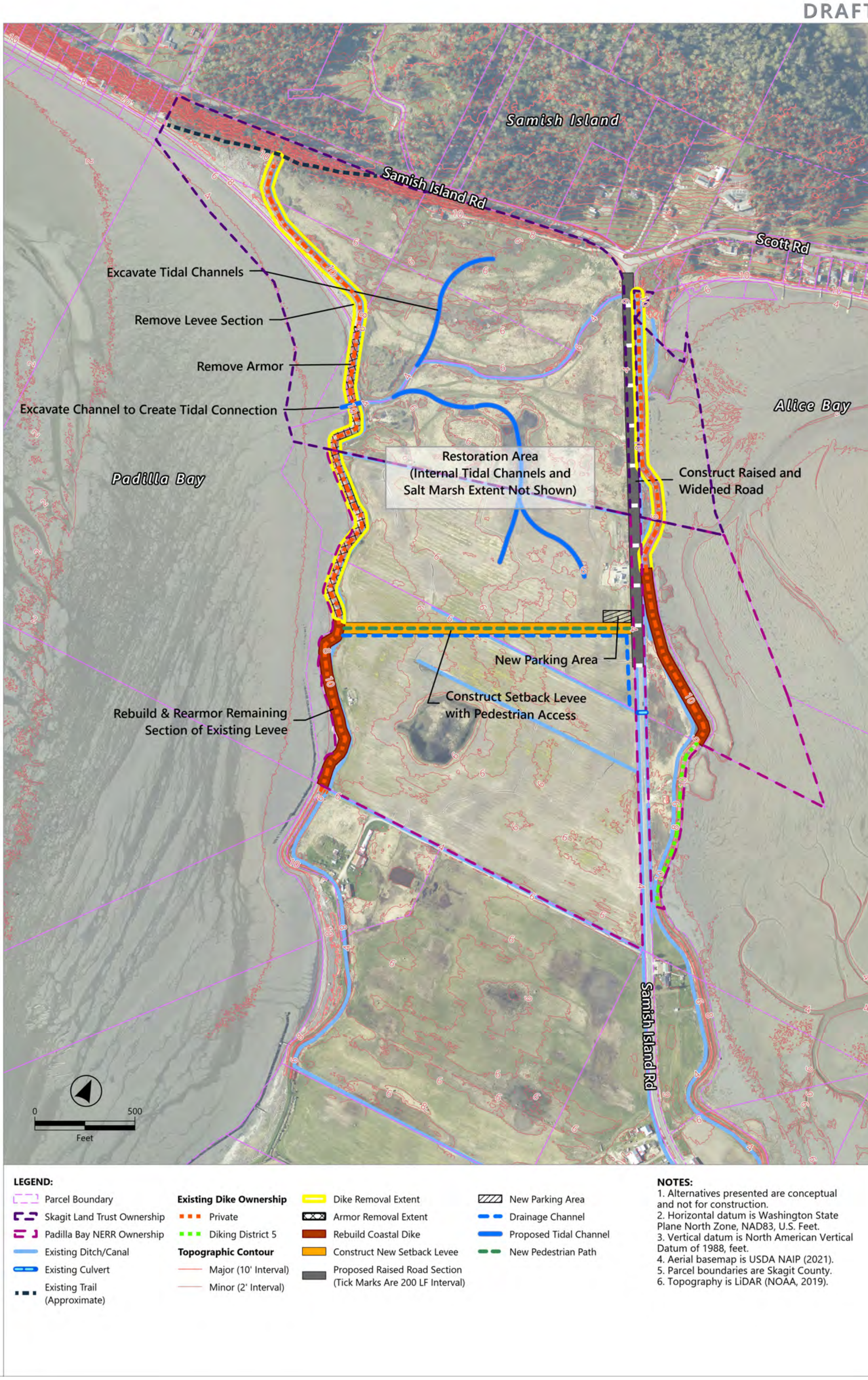

Figure 14. Restoration Concept 2a for a small barrier embayment.

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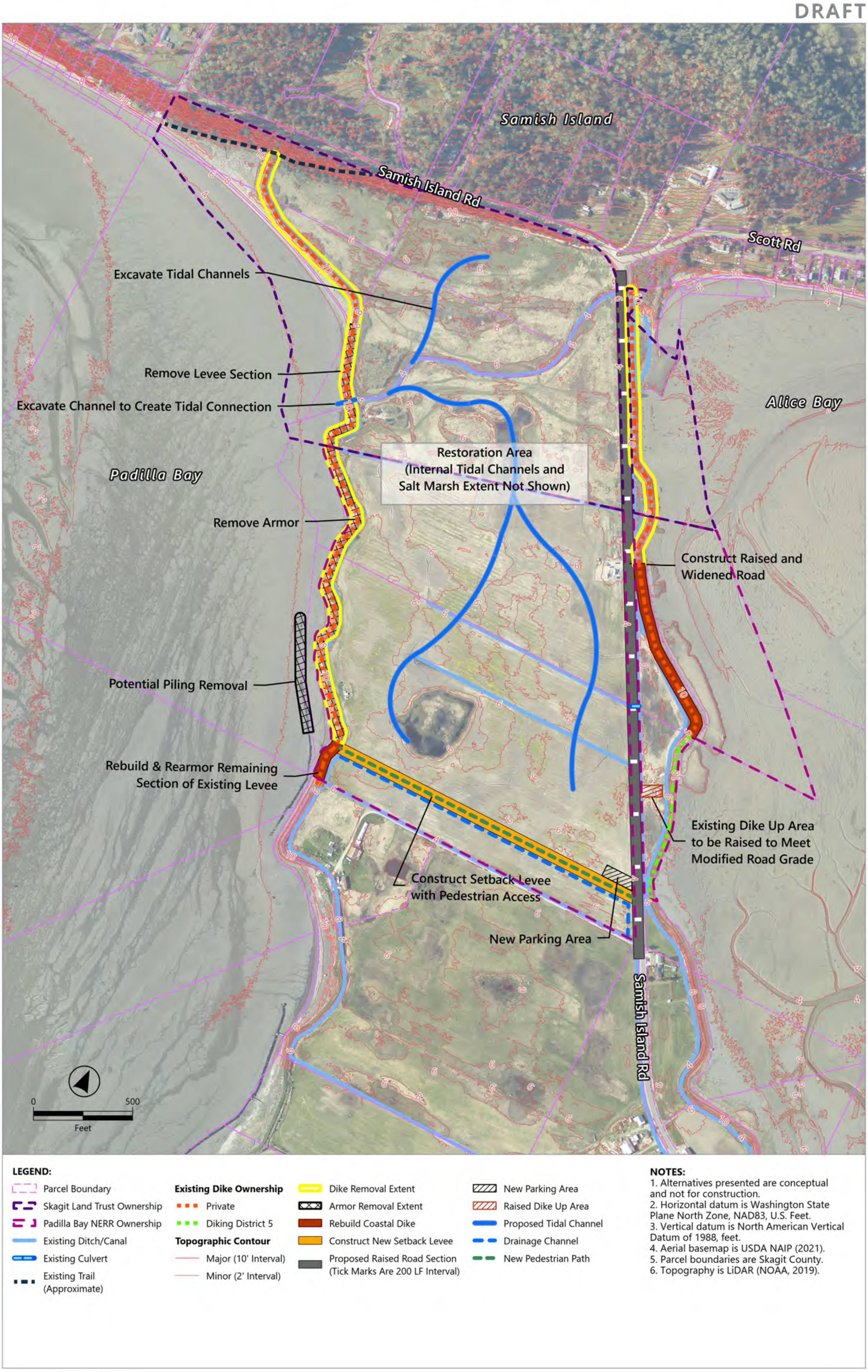

Figure 15. Restoration Concept 2b for a large barrier embayment.

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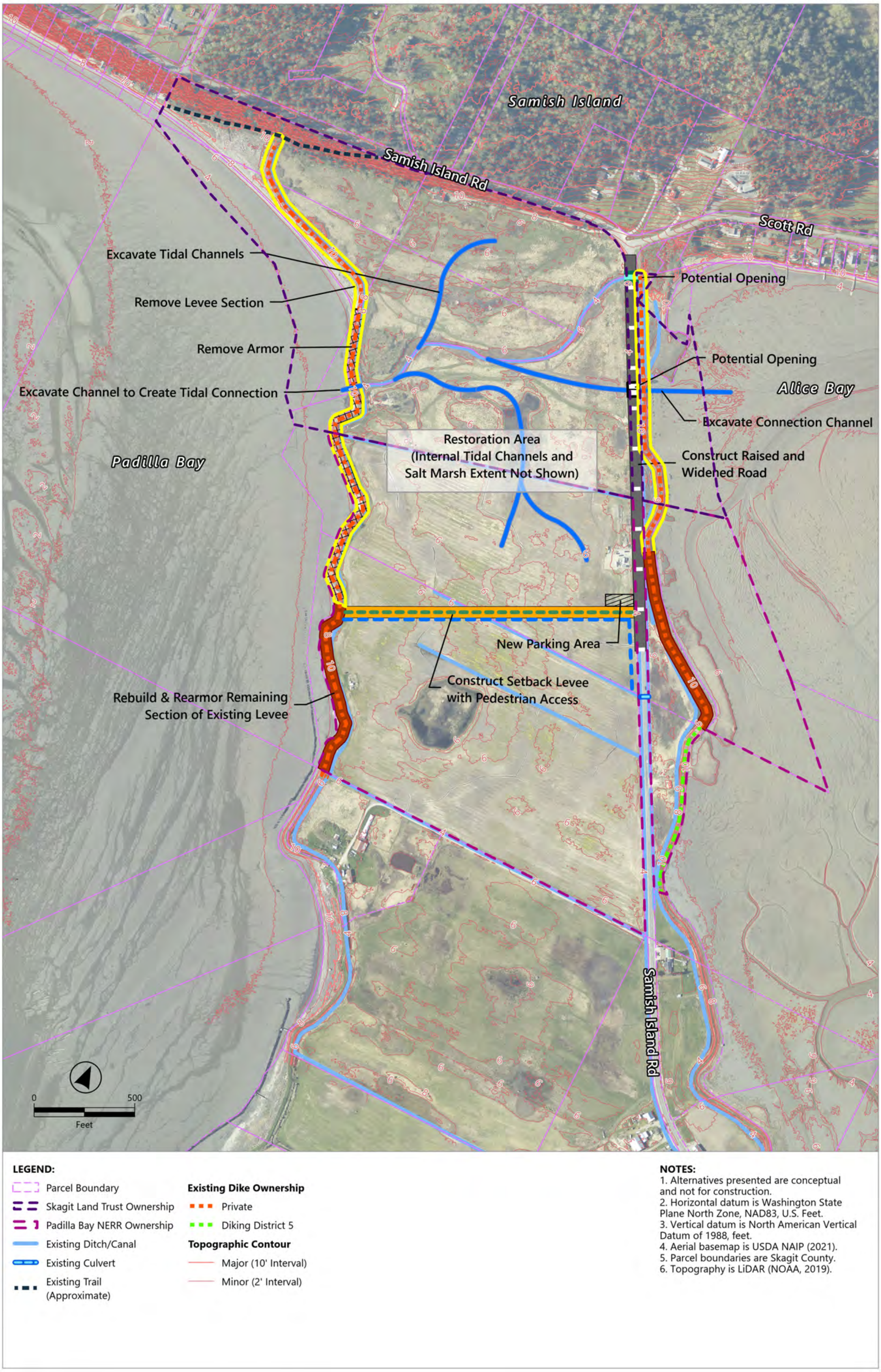

Figure 16. Restoration Concept 3a for a small slough.

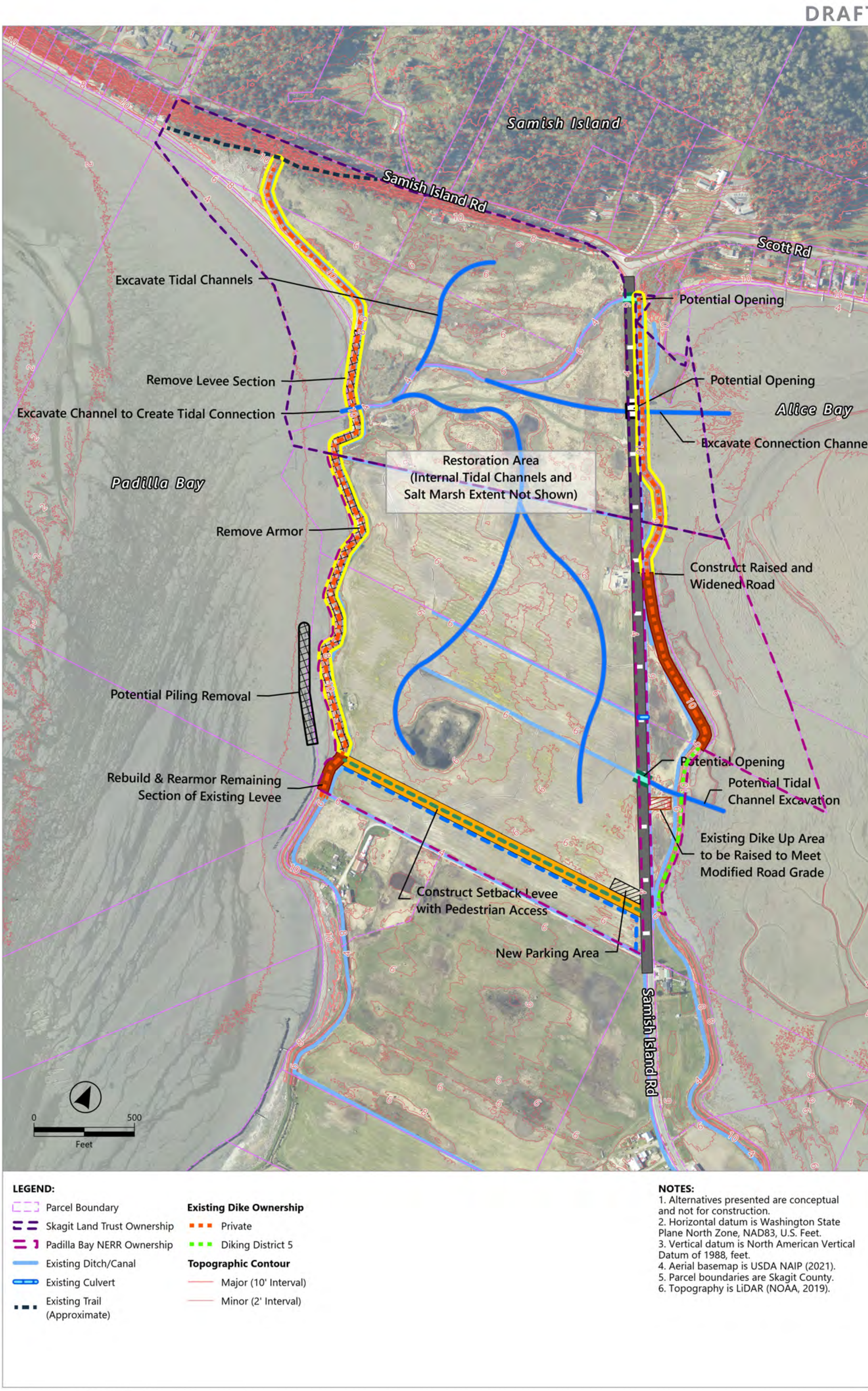

Figure 17. Restoration Concept 3b for a large slough.

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8 Evaluation of Restoration Concepts

To evaluate the restoration concepts against each other, a set of criteria were developed to rank each concept high, low or moderate. These are draft evaluation criteria and have not yet been applied to evaluate the restoration concepts.

Category 1: Ecological Benefits

1. Improvement of spawning habitat for forage fish.
2. Increase in channel habitat for fish (inundated channel).
3. Increase in feeding, roosting, and sheltering habitat for waterbirds, crabs, and other wetland species.
4. Increase in fringing saltmarsh along shoreline.
5. Increase in interior salt marsh habitat.
6. Deter invasive species.

Category 2: Restoration of shoreline & estuarine processes

1. Re-connection of sediment supply to shoreline (Restore littoral drift).
2. Develop salinity gradients.
3. Increase in water quality (temperature and dissolved oxygen) from tidal flushing.
4. Restored tidal hydraulic and hydrologic-connectivity (unhindered exchange of water, sediment, nutrients, organisms, and organic matter between the site and bay).
5. Increased primary productivity to support estuarine food web.

Category 3: Changes to Dikes and Drainage

1. Reduction of need for dike maintenance within project boundaries compared to existing.
2. Reduction of water being contributed to drainage ditches along road compared to existing.
3. Potential for impacts to drainage on adjacent farmland

Category 4: Community Resilience

1. Reduction of road closures due to coastal flooding and maintenance of road within project boundaries compared to existing.

2. Increased resiliency of utilities (power, water, and fiber optic) to sea level rise impacts.
3. Increased opportunities for people to reconnect with the cultural values of tidal wetlands.

Category 5: Implementation Feasibility

1. Support from general public.
2. Compatibility with County, Dike District, and Drainage Consortium infrastructure planning process.
3. Overall capital costs.
4. Compatibility with goals of restoration-focused funding sources.
5. Compatibility with goals of resiliency funding sources.

Restoration concepts will be evaluated qualitatively and ranked against each other for the metrics listed above as low, moderate-low, moderate, moderate-high, or high after completion of the communication and outreach plan outlined in Section 9.

Table 10. Evaluation Matrix – Placeholder for future table with one example of application

Category	Concept 1 (No Restoration Action)	Concept 2a (Small Embayment)	Concept 2b (Large Embayment)	Concept 3a (Small Slough)	Concept 3b (Large Slough)
Ecological Benefits 1.1 Forage Fish Habitat	Low for restoration concept 1 because of shoreline degradation from interaction between armor and coastal processes covering and inhibiting forage fish habitat.	Low-Moderate for restoration concept 2a; 2,700 linear feet of Padilla Bay armor removal to restore coastal processes and forage fish habitat,	Moderate for restoration concept 2b; 3,300 linear feet of Padilla Bay armor removal to restore coastal processes and forage fish habitat	High - Moderate for restoration concept 3a; 2,700 linear feet of Padilla Bay armor removal to restore coastal processes and forage fish habitat and connection to Alice Bay to allow forage fish migration.	High for restoration concept 3b; 3,300 linear feet of Padilla Bay armor removal to restore coastal processes and forage fish habitat and connection to Alice Bay to allow forage fish migration

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9 Communication and Outreach

All meetings as of the date of this report have been informal and did not include a full review of the information in this report. This section lists those informal meetings between the project leadership team (Blue Coast, PBNERR, and SLT), project partners, and affected parties. It also includes a table of additional meetings which are currently scheduled. This section will be updated after the scheduled meetings in Table 11. The project sponsors, PBNERR and SLT have had many more meetings and conversations with project partners and affected parties which are not detailed in this report.

- There have been two specific meetings between the technical Project Team and Skagit County Dike District #5 commissioners on August 8, 2022 and February 12, 2024 to discuss the dike and drainage district infrastructure that might be effected by a potential restoration scenario. The February 12, 2024 meeting also included the Skagit County Drainage and Irrigation Districts Consortium Executive Director.
- There are two primary families which own the agriculture land south of the Project site and onsite meetings with these families were organized by Skagit County Dike District 5 commissioners.
    - The project leadership team met with members of the Nelson family onsite on March 12, 2024.
    - The project leadership team have extended offers to meet with members of the Raymond family onsite in March and May 2024, but no meetings with the Raymond family have occurred to date.
- The project leadership team met with Skagit County Public Works Department on March 25, 2024. As mentioned previously, SLT has had several earlier meetings with Skagit County Public Works Department.
- The project leadership team have had several conversations and email exchanges with the members of the Samish Indian Nation on topics included cultural resources, fisheries, and land use.
- Blue Coast and PBNERR have met with Skagit River Systems Cooperative (SRSC) on three occasions between the start of the project in 2022 and now to discuss fish habitat and fish sampling. The conversations between SRSC and PBNERR are continuing for the fish sampling for this project.
- PBNERR and SLT met with the Samish Community in 2022 and 2024. In addition, the Samish Island Resilient Access Community (SIRAC) reviewed the grant application for Phase 2 of the project.

Table 11 lists the scheduled meetings for the more robust review of the information in this report by project partners and affected parties.

Table 11. Project Partner and Affected Party Outreach Meetings.

Organization	Date	Meeting Purpose
Phase 1 Technical Advisory Committee	August 22, 2024	This group was assembled originally to provide guidance on the scope of work for phase 1. Members are invited to review the results of this report. The group includes staff from Samish Indian Nation, US Geological Society, WDFW, Ducks Unlimited, and Washington Sea Grant
Skagit County Public Works and Dike District #5	September 5, 2024	This meeting is for the key partners who have significant infrastructure and vested interest in the Project to review the Project information and ideas to date, provide feedback, comments, and questions which will inform future work.
Raymond and Nelson Families	TBD	This meeting is for the affected parties who own land which borders the project area to the south and could be directly affected by restoration to review the Project information and ideas to date, provide feedback, comments, and questions which will inform future work
Public	October 10, 2024	This meeting is being held for local residents and generally interested members of the public to review and comment on the conceptual restoration ideas for the Project Site.

10 Next Steps

This report summarizes Phase 1 of a multiphase project which began in June 2022 and will be completed by December 31, 2024 where the primary goal was to understand the potential for restoring coastal processes and ecological function at the site. The groundwater and surface water data collection initiated during Phase 1 will continue until approximately May 2025, and be reported on during Phase 2 of this project.

The proposed scope for Phase 2 (pending additional funding) will contain much more detailed work which is relevant to addressing the questions and concern of key partners and affected parties. The following bullets summarize the milestones for Phase 2.

- PBNERR will be receiving an additional grant through Department of Ecology in August 2024 to complete data collection on waves, water levels, bathymetry and topography and to start developing a numerical modeling framework and to calibrate the model for existing conditions.
- SLT has applied for grants for funding which could be available in the middle of 2025 to conduct additional technical studies to fill data gaps and refine restoration concepts into restoration alternatives for the following elements: estuary restoration; transportation improvements; modifications to utilities and stormwater; and design of setback levees, coastal dikes, and drainage improvements. This funding is not guaranteed.
- Communication and outreach to project partners, affected parties, and the public will be conducted at regular intervals to gather feedback, answer questions, and refine the scope of Phase 2 as applicable.

11 Closure

This document has been prepared by Blue Coast Engineering LLC in accordance with generally accepted scientific and engineering practices and is intended for specific application to the Samish Island Conservation Area in Skagit County, WA. The contents of this document are not to be relied upon or used, in whole or in part, by or for the benefit of others without specific written authorization from Blue Coast Engineering LLC. No other warranty, expressed or implied, is made. Blue Coast Engineering LLC. and its officers, directors, employees, and agents assume no responsibility for the reliance upon this document or any of its contents by any parties other than the Skagit Land Trust and Padilla Bay National Estuarine Research Reserve. The information in this document is to be used for planning purposes and is not intended for design or construction.

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