Samish Island Conservation Area Restoration

Feasibility Study and Conceptual Restoration Ideas Report

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 project planning for the Samish Island Conservation Area (SICA). SLT and PBNERR initiated this project with the goal of restoring tidal wetlands to the site, and to do so in a way that improved community resilience by reducing the vulnerability of infrastructure to coastal storms. "Coastal resiliency" is a term that refers to the ability of both habitats and human communities to adapt to change and be able to absorb and recover from disturbances like storms. This report summarizes the results of Phase 1, the goal of which was to evaluate the feasibility of habitat restoration, and to identify the major ecological, structural, and community resilience issues that would need to be addressed in future project phases.

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.

This project phase was funded in part by the Washington Department of Fish and Wildlife (WDFW) Estuary and Salmon Restoration Program, who "*provides funding and technical assistance to organizations working to restore shoreline and nearshore habitats critical to salmon and other species in Puget Sound.*" This project phase was also funded by the National Oceanic and Atmospheric Administration (NOAA) Office of Coastal Management Bipartisan Infrastructure Law and the Inflation Reduction Act focused on "*making America's coasts more resilient to climate change and other coastal hazards through natural infrastructure projects that conserve, restore, and acquire coastal lands to increase flood protection for communities. These same projects also support other priorities, including recreation, plant and animal habitat, coastal economies, community engagement—particularly with historically underserved communities—and a regional approach for the wise management of ocean and coastal resources.*"

This report provides a site assessment using existing and collected data that were used to develop conceptual restoration ideas, which were then evaluated for feasibility of implementation based on available information. Work conducted consisted of physical and biological technical studies, as well as outreach to affected parties and partners, that were used to characterize existing conditions, develop conceptual restoration ideas (also called restoration concepts), and identify site constraints and restoration opportunities, including the potential for the project to affect or improve community infrastructure and resilience. These constraints, opportunities, and identified data gaps should be addressed in Phase 2 to develop designs for restoration alternatives.

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 inventory of 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 collected to date and data gaps (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 restoration 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 (Blue Coast)
- Section 10 provides the recommended next steps for the project to be completed in Phase 2.

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 Samish Island with the greater Skagit-Samish River delta. 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 lies at the northern end of the PBNERR, designated to protect the largest eelgrass meadow in the lower 48 states. Eelgrass and the adjacent tide flat and tidal marsh habitats support tremendously productive food webs for a broad range of fish, crabs, shellfish, herons, waterfowl, shorebirds, and other species. Of the great diversity of species that are supported, many are economically or culturally important to the community, such as Dungeness crabs, salmon, littleneck clams, and waterfowl. Most animal species need a mix of habitats during their lifetimes, and Padilla

Bay’s connectivity with adjacent tide flats, tidal marshes, and deeper channels makes it particularly productive and important.

Coast Salish peoples, including the Samish Indian Nation, Swinomish Indian Tribal Community, Lower Skagit Tribe, Nuwhaha Tribe, Upper Skagit Tribe, and Sauk Suiattle Tribe occupied the area for thousands of years before European contact. History from the Samish Indian Nation indicate A7ts'íqen, formed in the early 1800s, was a large Samish village located at the east end of Samish Island near the mouth of a slough that connected Samish Bay and Padilla Bay. A significant longhouse was located there. History books describe canoes traveling through the slough to access the longhouse, which stood on what is now called Alice Bay. In the mid-1870s, the planks and beams of the longhouse were taken by settlers while the Samish people were away for seasonal harvests, forcing many Samish people from A7ts'íqen to move to Guemes Island (Palmer-McGee n.d. [Samish Nation timeline]). Some continued to live on Samish Island, including Chief Harry Samish. History books describe many canoes in the slough on the day Chief Harry Samish died.

Free-flowing rivers and deposition of sediment shaped the project site. Historically, Padilla Bay on the west was connected through the barrier beach and saltmarsh to Alice Bay on the east at the approximate location of the present-day S7amésh Seqelích (slough). The greater Skagit-Samish delta is made up of three lobes with the oldest being the north lobe encompassing the Samish flats, including the project site. This lobe first developed between about 6,000 and 2,300 years ago (J. Riedel, pers. comm.) when the primary Skagit channels flowed to this area. The lobe gradually prograded westward, contributing to the broad, shallow tide flats in Padilla Bay. The north lobe continued building in elevation until tidal wetlands eventually reached Samish Island, separating Padilla Bay and Samish Bay except for the connecting slough. Lahars from a Mount Baker volcanic eruption about 2,000 years ago likely began to shift the Skagit main channels further south into the west lobe towards south Padilla Bay (J. Riedel, pers. comm.). As elevations on the west lobe built, the main channels shifted further south to form the south lobe on Skagit Bay where the main channels continue to flow today.

The Samish River flows to Samish Bay, delivering freshwater and sediment about half a mile east of Alice Bay and 1 mile from the project site. Over the centuries, even as the main Skagit channels shifted to different lobes, smaller side distributary channels continued to flow towards both the north and west lobes, feeding large wetlands including Olympia Marsh on the Samish flats, which contributed flows to both the Samish River and Joe Leary Slough (Collins and Sheikh 2002, J. Riedel pers. comm.). Although flows predominantly went to the south lobe, winter floods in particular continued to push significant flows and sediment towards all three lobes until the late 19th century when levees began to be built to constrain Skagit River flows to the south lobe (Grossman et al. 2020). Though normal surface flows are now fully constrained by levees to the main channel that feeds the south lobe, hydraulic models show that during major floods that overtop or breach the levees, flows continue towards all three lobes (e.g., Hammann et al. 2016, skagitclimatescience.org/flood-scenario-map/, NHC 2023). The frequency of such flows is projected to increase substantially in coming decades, due to warming temperatures (Hamman et al. 2016).

The natural migration of the Skagit River's main channels away from the north lobe, followed by late-19th century diking, have substantially reduced freshwater flow and sediment input into Alice Bay, Samish Bay, and Padilla Bay. The reduction in sediment delivery to these areas has two primary direct impacts: subsidence of land, which can decrease habitat resiliency to sea level rise and increase the risk of natural hazard flooding, and disturbance of tidal and offshore habitats, impacting fish and estuarine wildlife (Grossman et al. 2020). Padilla Bay is now considered an "orphaned" estuary as a result of being largely cut off from both the Skagit and Samish Rivers and receiving only limited freshwater input from the four sloughs. Minimal freshwater input currently reaches Alice Bay near the project site through a relict blind tidal channel that now collects surface water, storm water, and drainage from agricultural areas and discharges through a tide gate near Samish Sports Club (Figure 2).

Figure 1 shows site conditions, including infrastructure, interior drainage, and locations of hydrologic and geotechnical data collection. Figure 2 shows the Dike District assessment areas of Skagit County that manage dikes and drainage around the Skagit River.

1.2 Feasibility Study Objectives

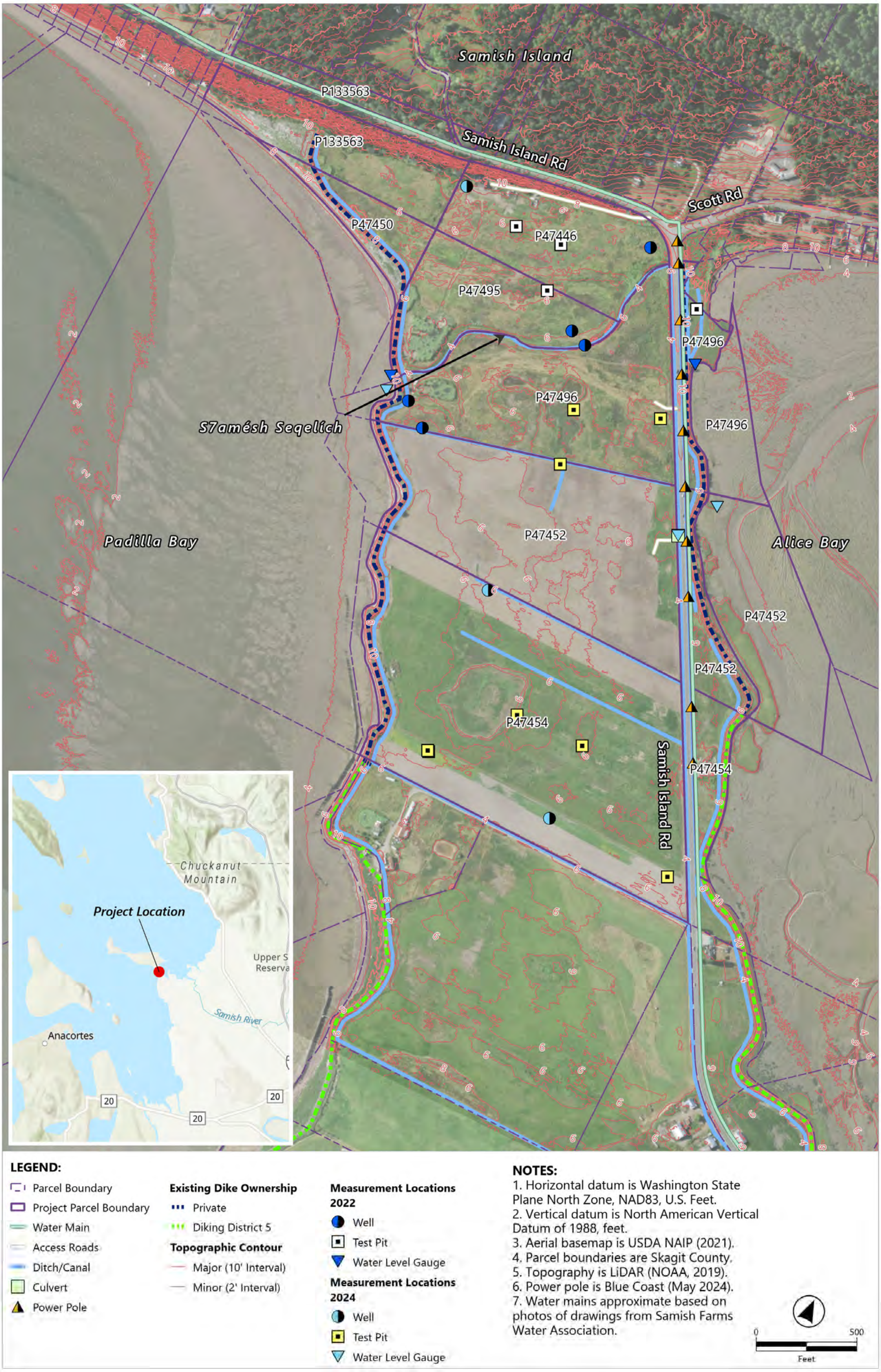
The objective of this feasibility study was to identify opportunities and constraints for restoring the site to historic saltmarsh conditions.

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. 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 conditions.
- 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 affected by restoration.

- Soil types and geotechnical properties, including compaction, subsidence, and ability to reuse excavated soils for new infrastructure and as 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 was used to develop restoration concepts for estuary and saltmarsh restoration at the site. In addition, a series of meetings with the public, project partners, and affected parties were conducted to identify concerns and determine design considerations for evaluating conceptual alternatives.



NOTES:
1. Horizontal datum is Washington State Plane North Zone, NAD83, U.S. Feet.
2. Vertical datum is North American Vertical Datum of 1988, feet.
3. Aerial basemap is USDA NAIP (2021).
4. Parcel boundaries are Skagit County.
5. Topography is LiDAR (NOAA, 2019).
6. Power pole is Blue Coast (May 2024).
7. Water mains approximate based on photos of drawings from Samish Farms Water Association.

Figure 1. Samish Island Conservation Area site and vicinity maps.

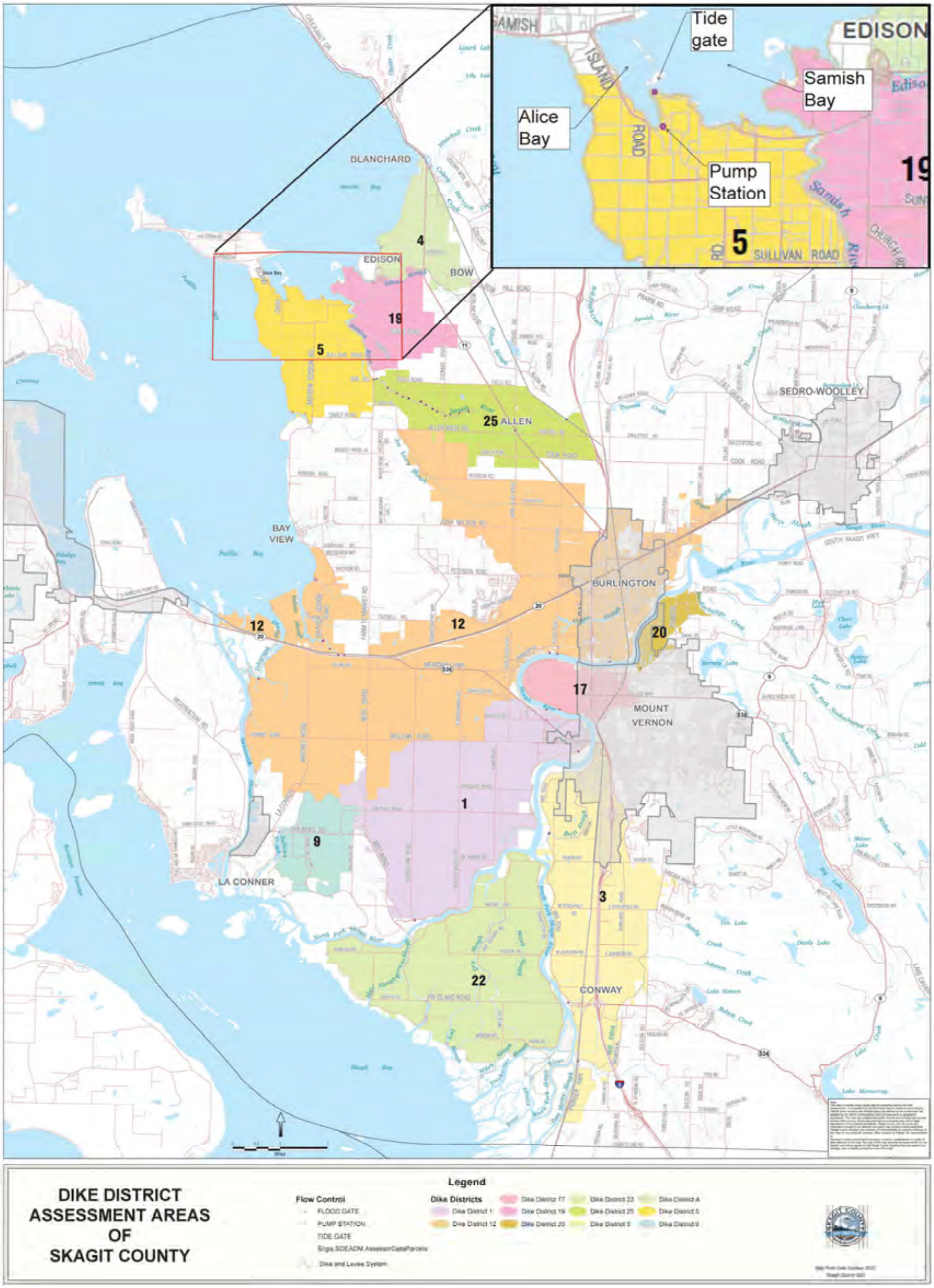


Figure 2. Dike District assessment areas of Skagit County. Inset shows vicinity of project site (adapted from Skagit County).

2 Site Overview

This section of the report provides a description of the project site, including 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 farmland 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, as shown on record drawings from Skagit County (Skagit County 1931) and the Squires-County agreement and right-of-way records and deed (Skagit County 1932). Additional history of the slough is described in more detail in Section 2.8. From that time through at least 1970, the County improved the coastal dikes along some sections of Alice Bay to protect the road (Skagit County 2024). Quarry rock sourced from Williams Point on Samish Island is evident on most of the coastal dikes within the project area. It is sedimentary rock, fractures easily, and appears to not have been placed rock-by-rock as is current standard practice for coastal structures for stability. The south end of the Alice Bay shoreline on land now owned by the State of Washington consists of a dike partly within Dike District #5. Dike District #5 upgraded their dike in 2022 before the coastal flood that occurred that December. After the December event, both Dike District #5 and SLT (which formerly owned the land now held by the State) repaired portions of the dike. The new dike has been widened and is armored with granite riprap 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 on Figure 1.

2.2 Data Sources

Blue Coast and the project team completed a desktop data review 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 and PBNERR 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

Data	Year(s)	Source
Hourly Wind Data, Whidbey Island Naval Air Station (NAS)	1945 to 2021	NCDC
Hourly Wind Data, West Point	1975 to 2021	NCDC
NERR Padilla Bay Buoy Data (meteorological and water quality)		NERR / NANOOS
Water Main Plan Set (photograph)	2004	Skagit County

Notes:
Ecology - Washington State 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 on 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.

Site and Instrument Name	Deployment Dates	Description
T-04: RBR Concerto 81109	05/23/2024 to present.	Tidal water level measurement at 10-minute intervals in Alice Bay.
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.	Groundwater 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 at 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.

Site and Instrument Name	Deployment Dates	Description
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.
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 at 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.

NOTES:
1. Horizontal datum is Washington State Plane North Zone, NAD83, U.S. Feet.
2. Vertical datum is North American Vertical Datum of 1988, feet.
3. Aerial basemap is USDA NAIP (2021).
4. Parcel boundaries are Skagit County.
5. Topography is LiDAR (NOAA, 2019).
6. 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
7. Water mains approximate based on photos of drawings from Samish Farms Water Association.

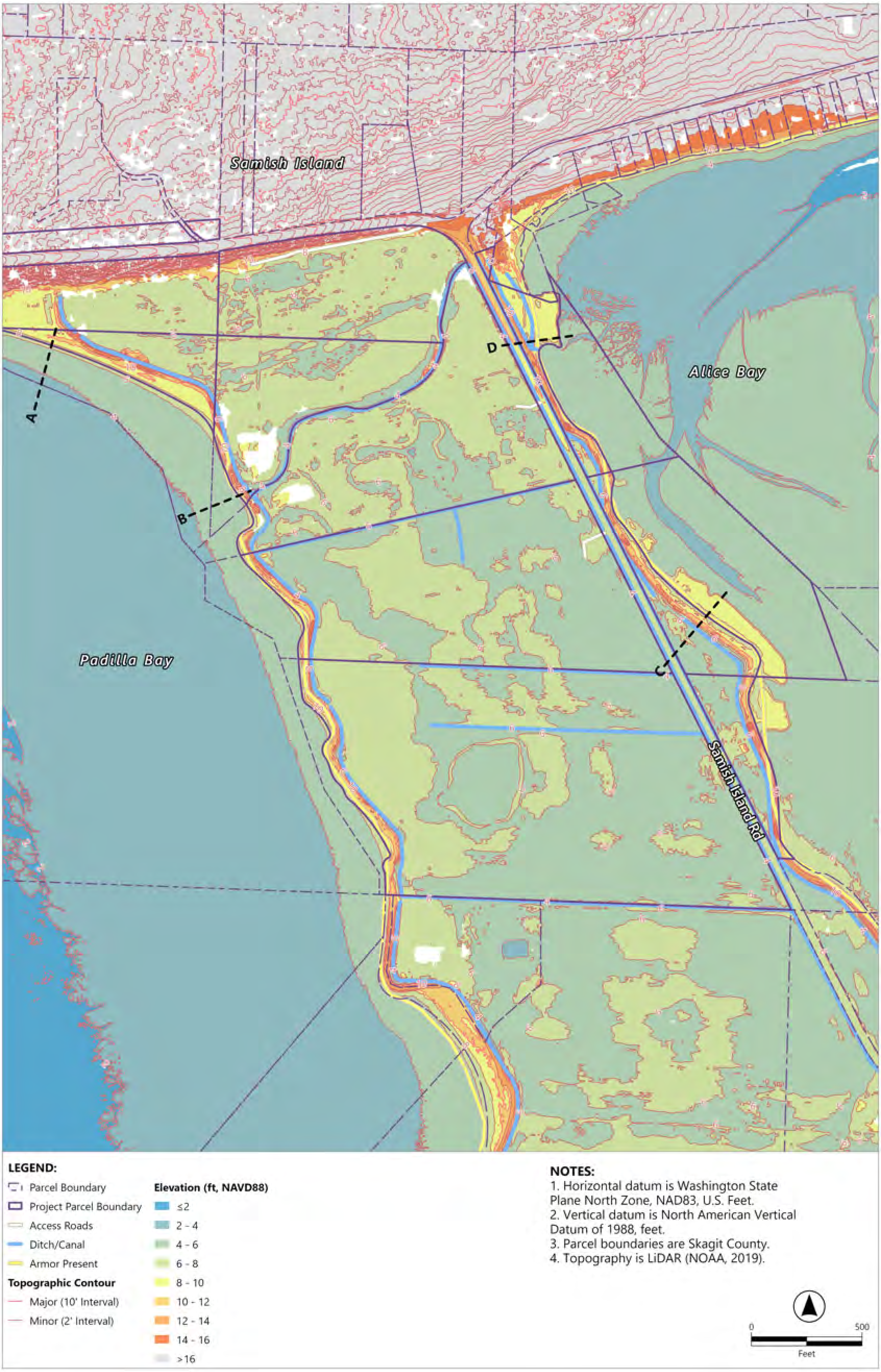
Figure 3. Samish Island Conservation Area data collection site map.

2.4 Site Topography and Elevation

A topographic site map and topographic profiles are provided on 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 saltmarsh 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, between 4 to 6 feet NAVD88, with a wider fringing saltmarsh (500 to 1,000 feet) at 8 to 10 feet NAVD88.



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3. Parcel boundaries are Skagit County.
4. Topography is LiDAR (NOAA, 2019).

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

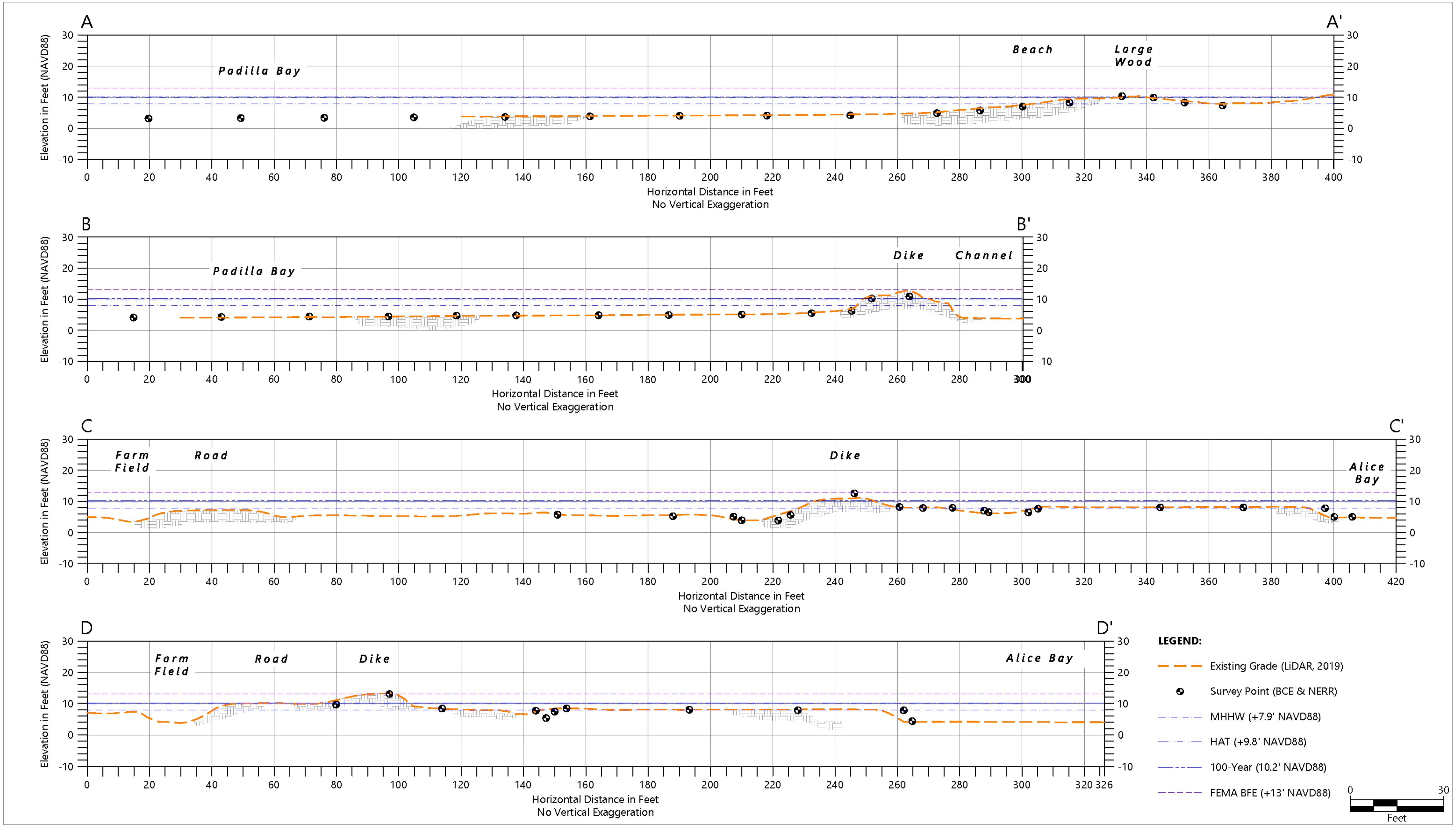

Figure 5. Samish Island Conservation Area topographic profiles. Profile locations are shown on Figure 4.

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 and dike ownership is shown on Figure 1:

Eastern Shoreline (Alice Bay):

- The eastern shoreline along Alice Bay is armored with randomly placed (not stacked) armor stone. 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 two 100- to 150-foot lengths of Eco-blocks and quarry spalls that were placed as emergency repairs and remain in place.

- The south end of the shoreline consists of the recently repaired dike, which is 2 to 3 feet in height above the saltmarsh 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 not well-stacked 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 (four) small wider beaches with more back beach are present 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. The dike south of the project site is within Diking District 5 and was repaired by them 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, towards a tide gate at the Samish Sports Club, where it is discharged into Samish Bay (see Figure 2). 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—on the east side of the site, along Alice Bay. This road provides the only land-based access for about 480 homes and many businesses on Samish Island. The history of the road was gathered through review of documents from Skagit County Road History search website (Skagit County 2024) under “Samish Island Road 30910” (Skagit County 1931, 1932).

In 1885, Samish Island settlers petitioned Skagit County to build a road towards the west point of Samish Island (Williams Point) as well as south towards the existing Samish Island Road coming from Edison. The first road (“old road”) was built between 1885 and 1900 (Skagit County Road Packet 30910). The road 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 1931, the County began building a new straight road (Skagit County 1931). Material from the old road was used to fill the outlet of the slough so the bridge was no longer necessary. The new road and earthen berms on the Alice Bay side were constructed by the County (Skagit County 1931) to prevent 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 2.6, 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 the 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; however, 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.

Wastewater

Based on an initial desktop review of Skagit County records, the properties surrounding the project area have on-site septic systems for treatment and handling of wastewater. Most of the residential parcels are at an elevation well above the elevations of the project area and therefore shallow septic systems will not be affected by the project. However, septic systems for the parcels located south of the project area will be reviewed in more detail during Phase 2 of the project.

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 slough through the low-lying saltmarsh on the project site. The remnant slough has been recently renamed S7amésh Seqelích by the Samish Indian Nation. The slough, as shown by the 1887 T-sheet (USGS 2022b), was widest near the northeast outlet and drained several connecting channels within the saltmarsh. 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). In addition to the main slough, there were multiple smaller blind tidal channels penetrating into the site from both the Padilla Bay and Samish Bay sides. At the time of the 1887 mapping, all of the project site was still a mix of saltmarsh and tidal channel. Extensive diking had already occurred from the south boundary of the project site to the south.

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 section of pilings is visible on the eastern edge of a small peninsula of saltmarsh which is likely remnants of the old road, and a small drainage basin and channel are located between the road and the dike.

1956 Aerial Photograph

The 1956 geo-referenced aerial photograph clearly shows 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 of the northernmost parcel (where a straight, east-west-aligned channel is located present day). A significant amount of wood and sediment appears to be accumulated on the shoreline and a saltmarsh bench is visible behind the pilings along the southwest shoreline; however, the shoreline appears to have retreated since the 1956 aerial photograph.

1998 Aerial Photograph

The 1998 geo-referenced aerial photograph shows a change in the vegetation on the project parcels, suggesting a reduction in agricultural activities. 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, runoff 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 surface water ponding and flows to the ditch drainage network. The Samish River has been known to produce overland flooding that reaches the SICA and levee breaches on the Skagit River have generated overland surface water flow that has reached the project site (NHC 2023).

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 that are surmised to potentially have affected the project site including in February 2018 and November 2021. These events included breaches or overtopping of Skagit and Samish River dikes that generated overland surface water flow; this flooding reached the entrance to Samish Island. A model that covers the Samish flats northwest of Burlington and extending to Samish Bay and Padilla Bay, including Edison Slough and Joe Leary Slough, was developed to look for opportunities to improve flood drainage (NHC 2023). This modeling evaluated a 100-yr flood and incorporated both Skagit and Samish flows, and a Skagit River dike breach in the Sterling vicinity upstream of Burlington. This modeled event 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 and Padilla Bay, predominantly west 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. Dike 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 within 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, and 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 6 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 and there may be a phase lag (time difference) between the two bays; additional measurements will be conducted during Phase 2 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 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 preliminary analysis at 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 were 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-

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[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). These water levels do not include wave runup, which is considered in Section 3.2.

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.

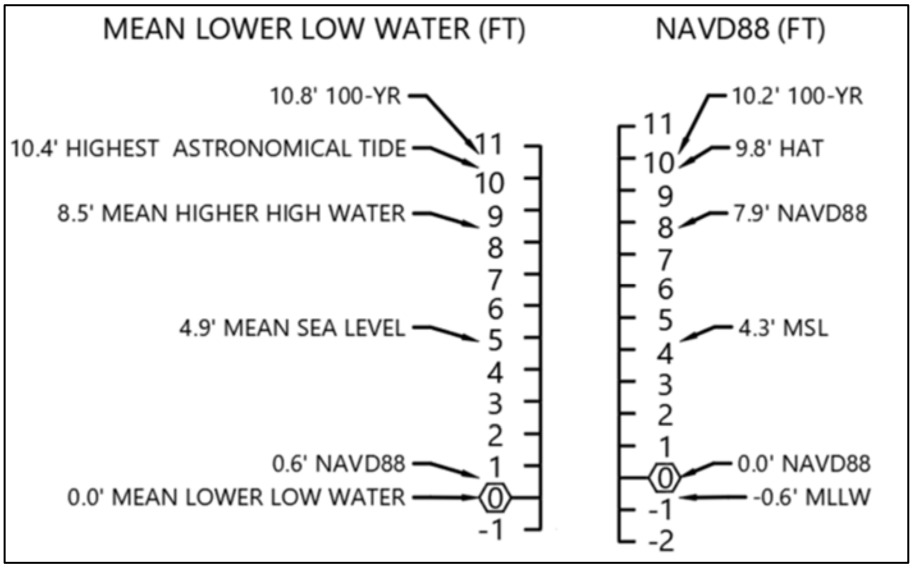


Figure 6. Graphic comparison of water level elevations in tidal (MLLW) and survey (NAVD88) datum at the site.

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 SLR 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 al. (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 relative 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 during Phase 2. While there is considerable uncertainty in the relative SLR predictions because of the many unknowns related to future socioeconomic development assumptions as well as climate policies, using the RCP 8.5 greenhouse gas scenario for planning purposes would provide a conservative approach. During Phase 2 of the project, the appropriate relative SLR projection for use in design will be chosen based on discussion and input with PBNERR, SLT, the County, Drainage Consortium, Dike District #5, and other members of the Technical Advisory Committee.

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
	High (RCP 8.5)	0.7
2070	Low (RCP 4.5)	1.0
	High (RCP 8.5)	1.1
2100	Low (RCP 4.5)	1.6
	High (RCP 8.5)	2.0

Notes: Estimates from Miller et al. (2018)

3.1.2 Coastal 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 restoration design of saltmarsh vegetation and nearshore 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.

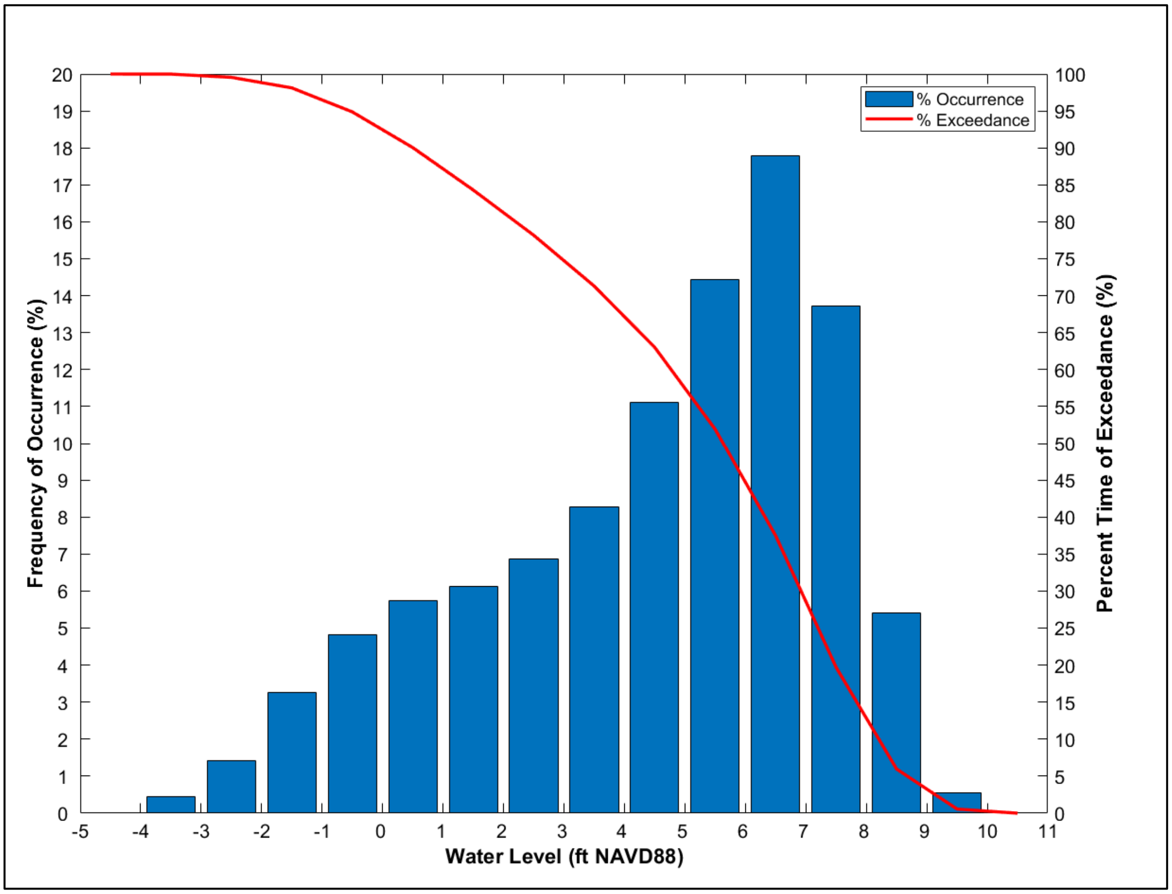


Figure 7. Frequency of occurrence histogram and percent exceedance curve for Swinomish station tide predictions (NOAA-NOS station #9448682, January 1, 2022, to December 31, 2031). Values include tidal components only and do not include storm surge, wind, wave setup, or sea level rise.

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 shorelines 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

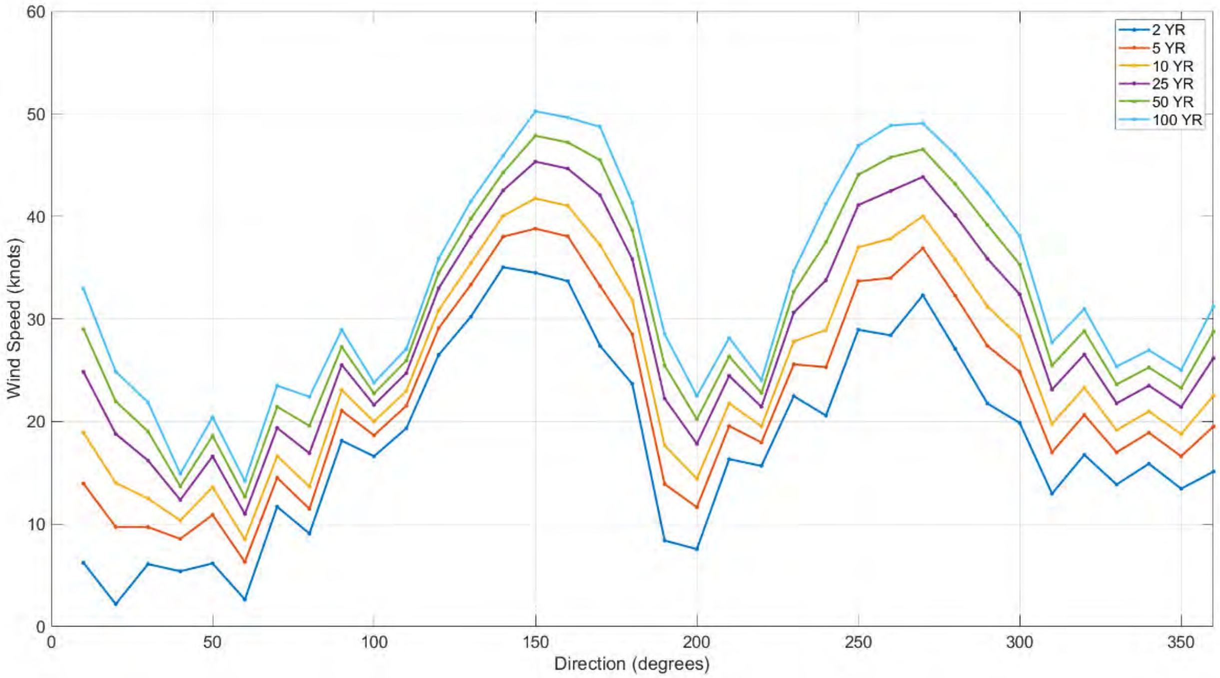
Wind-waves and related wave run-up (the landward extent of wave uprush on the beach) contributes to coastal erosion and flooding at the project site. Wind-waves are formed in response to the force of the wind acting over the water surface. The height and period of wind-generated waves depends on wind 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 (~60-70 mph). 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)

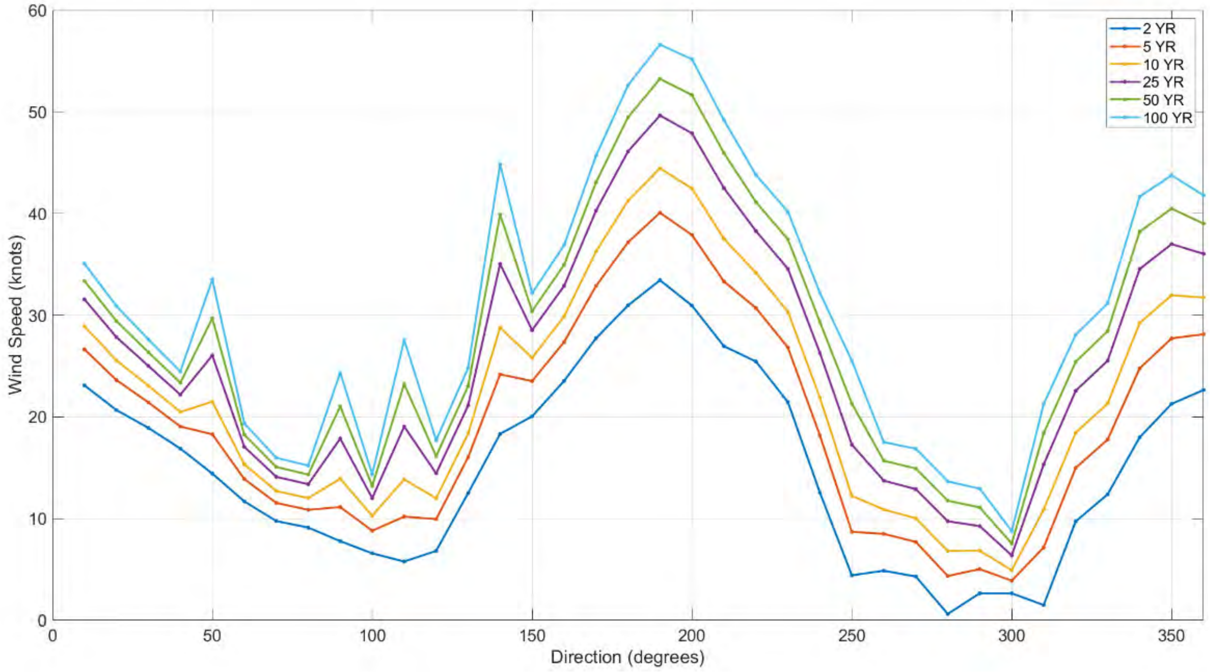


Figure 8. Extreme value wind speeds calculated in 10-degree direction sectors for Whidbey NAS and West Point (Seattle) meteorological stations.

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 SLR 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 shoreline).

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

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 land comprised of hydric soils (NRCS 2020) 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 and diversion of the Skagit River and Samish Rivers (Grossman et al. 2020), and interruption of sediment transport and scour in front of hard armor along the Padilla Bay and Samish Bay shorelines by development and coastal dikes. The closest available source of sediment to the Padilla Bay shoreline under existing conditions 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 and 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 areas of armoring along the toe 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 9).

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 Blue Coast's 2022 site visit 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; the presence of remnant saltmarsh 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 the gradual settling and sinking of the ground surface, typically the result of slow settlement, consolidation, and desaturation of natural deposits or from sudden land level changes. Subsidence is an important consideration for the restoration efforts at the site because it influences future water surface elevations and saltmarsh establishment. On the interior of the coastal dikes, 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 during intervals when the groundwater table is lowered through drainage of the land, resulting in consolidation.

The project team evaluated published literature regarding the nearest active faults and subsidence studies to better understand subsidence in Padilla Bay (outside the coastal dikes). 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.

NOTES:
1. Horizontal datum is Washington State Plane North Zone, NAD83, U.S. Feet.
2. Vertical datum is North American Vertical Datum of 1988, feet.
3. Aerial basemap is USDA NAIP (2021).
4. Parcel boundaries are Skagit County.
5. Topography is LiDAR (NOAA, 2019).
6. Drift cell direction and shoretype are WDFW (2017) Beach Strategies.
7.Drift cell direction indicates direction when shore-facing.

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 staff. This section will also discuss data collection efforts related to habitat and species use, much of which is 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 saltmarsh 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 Shannon & Wilson 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.

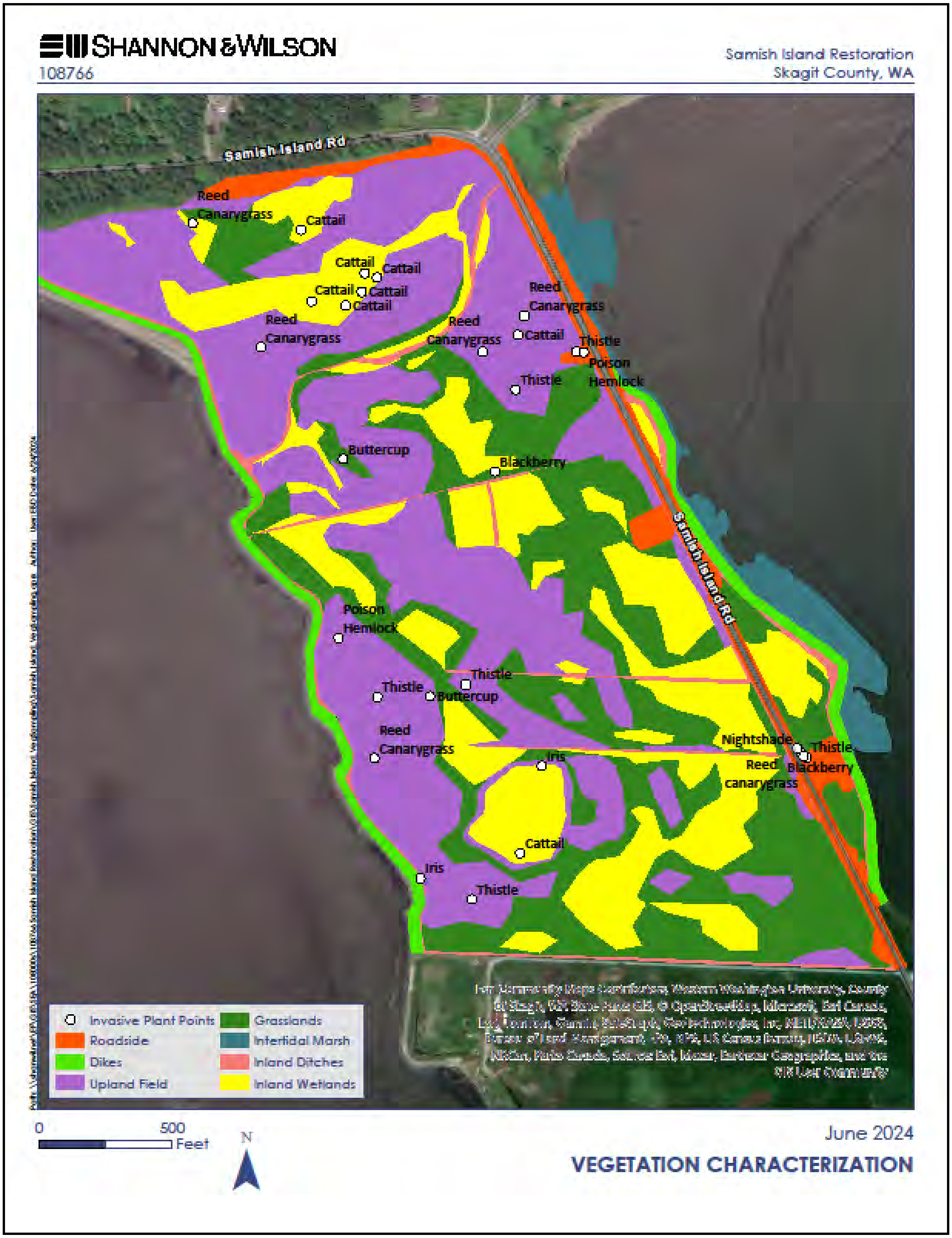
4.1 Nearshore and Saltmarsh Habitat

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 the Washington State Shoreline Management Act through the Washington State 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 at the project site has not yet been formally delineated following Ecology protocols, the HTL (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 for motile marine organisms 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 saltmarsh habitat in the transition between the nearshore and dike (Figures 1 and 10).

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.



Esri Community Maps Contributors, Western Washington University, County of Skagit, WA State Parks GIS, © OpenStreetMap, Microsoft, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS, NRCan, Parks Canada, Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Figure 10. Samish Island vegetation characterization map.

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 includes 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 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 onsite 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 the dikes.
Asteraceae	*Cirsium arvense*	Canada thistle	Located throughout the upland field zone. There are small patches in the roadside zone.
Asteraceae	*Cirsium vulgare*	Bull thistle	Scattered throughout the 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 dikes. Sparsely scattered throughout the upland field zone.
Rosaceae	*Rubus laciniatus*	Evergreen blackberry	Sparsely scattered along dikes.
Solanaceae	*Solanum dulcamara*	Bittersweet nightshade	One small patch along the roadside.

Family	Scientific Name	Common Name	Location
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 Bay 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 Bay and Padilla Bay. There are plans for future data collection at the site to better understand species and abundance of fish. However, in general there are more fish produced from the Skagit than the Samish River. In addition to salmonids, many other ecologically important marine fish species utilize the Padilla Bay nearshore and saltmarsh habitats in the area, not the least of which include three-spined stickleback, several sculpin species, shiner perch, multiple species of gunnel, plainfin midshipman, white-spotted greenling, juvenile starry flounder, and other flatfish.

Forage fish sampling by 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 from 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 priority species, but no other priority 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.

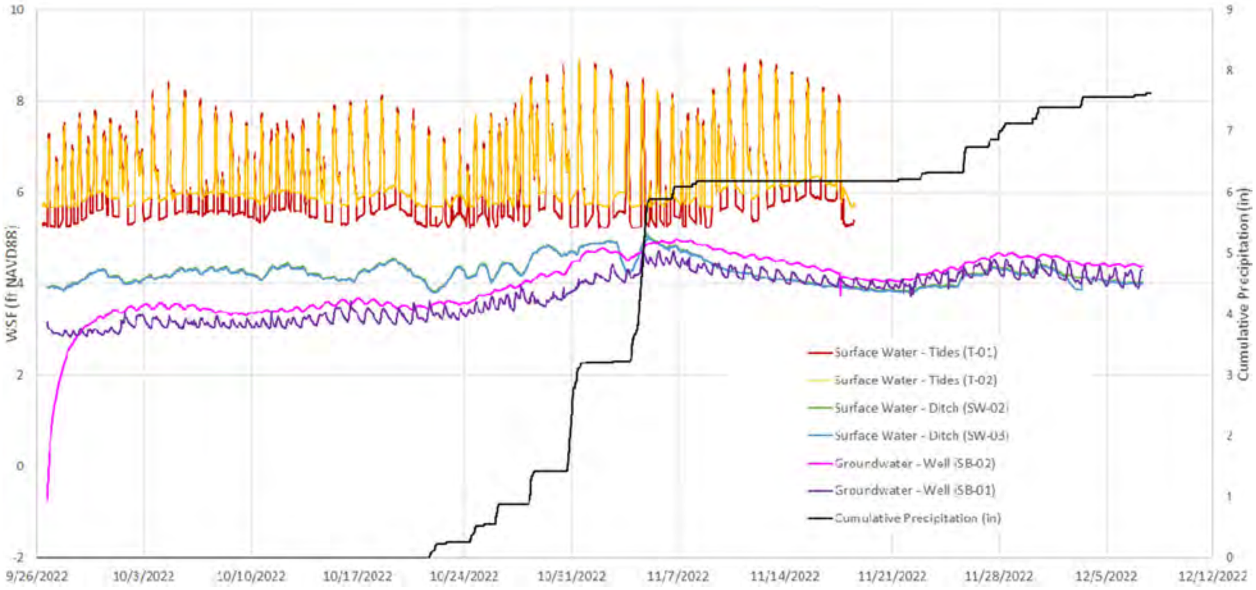


Figure 11. Time series of surface water, groundwater, and precipitation data at the SLT site in 2022.

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.

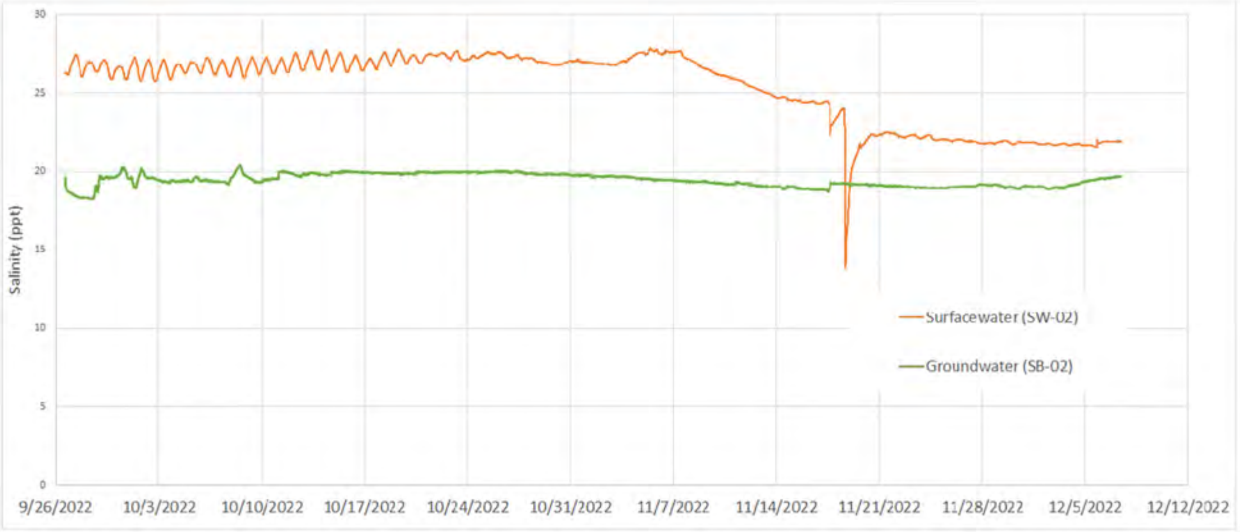


Figure 12. Time series of salinity at monitoring station SW-1 in 2022.

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 and was confirmed in 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 (roughly 15 feet in depth). Additional site monitoring data that 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, at 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 B-1p-24 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 at most sites. 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 2.5).

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.

The material likely to be encountered when excavated is either organic soil or a soil with a high fines content. Neither is good for re-use to construct levees, coastal dikes, or roadway prism. It can be used as topsoil or possibly a shell placed over the levee/dike/roadway prism for grass and plantings, depending on the design standards used for the project.

6 Design Considerations & 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 conversations and meetings with the public, project partners, and affected parties (Section 9) that has assisted in the identification of considerations for restoration design at the project site. This section summarizes the design considerations for restoration, key gaps in the data, and additional work needed to develop criteria necessary for completing preliminary engineering design for restoration in a future project phase.

6.1 Design Considerations

The design considerations for restoration of saltmarsh at the project site generally fall into three major categories: the infrastructure that supports the 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 Samish River flooding events. In addition, consideration of potential impacts to surrounding land uses are a consideration for all engineering design projects. Land uses at the project site consist of single family residential, aquaculture, agriculture, birding, hunting, kayaking, and other recreational activities.

6.1.1 Samish Island Road & Community Infrastructure

As described in detail in Section 2.7, 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 and public meetings 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 developed in consultation with Skagit County Public Works and then conducted during the next phase of the project to determine potential options for raising the road and providing openings under the road for tidal exchange and connectivity for fish and other marine species. We also understand that Skagit County has conducted studies to evaluate river flood mitigation options (NHC 2023) and the Skagit Council of Governments is evaluating transportation system resilience, which could inform changes on Samish Island Road during future phases of this project.

There are several utilities (e.g., power, communication, and water supply) that need to either be 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, when 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 flood impacts because of coastal overtopping or dike breaching. In addition, Samish River flooding events can have flood impacts within the project boundaries because the water is impounded by the coastal dikes. In the short term and at community request, SLT and PBNERR will perform temporary repairs (such as sandbagging) to deter flooding at extreme coastal water levels while a long-term solution for the road and other flood mitigation measures are identified in collaboration with affected parties. Conceptual options for replacing the coastal dikes with other protective measures as part of the roadway prism (Section 7) and rebuilding some portions of the dikes to current Dike District #5 standards will be considered as one of the long-term solutions that will assist in achieving the restoration goals. In addition, the Project team has assumed that an east-to-west setback levee/dike along the southern boundary of the restored area will be necessary to prevent tidal inundation of properties south of the SICA. When designed, this setback levee/dike will be evaluated for seepage and groundwater exchange between the restored project area and the adjacent private properties, which are predominantly used for agriculture.

The project will evaluate removing portions or most of the coastal dikes along the shorelines of SICA on Padilla Bay and Alice Bay to facilitate tidal inundation and saltmarsh restoration. Under these scenarios, the road would be protected by setback dikes directly adjacent to the road or the road would be elevated to a level where these protections are not necessary. Protecting the privately owned land and agriculture practices on lands south of the project 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 restoration 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 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 that reaches the site during extreme weather events from both the Samish River and Skagit River can overwhelm the drainage infrastructure, as occurred during a major flooding event in February 2018. The previous modeling study was focused on the effects of a Skagit River dike breach in the Stirling vicinity under a 100-year event, which showed the Samish area would take over 30 days to drain (NHC 2023).

This feasibility study is being used to inform the scope of numerical modeling of surface water within the project site boundaries, consisting of 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. 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, and preliminary groundwater and surface water data collected on the project site, the current groundwater is saline; therefore, salinity intrusion is not a primary concern since the existing groundwater cannot be used for irrigation.

6.1.4 Aquaculture Operations

There are several shellfish growers with operations in Alice Bay. Shellfish operations are sensitive to changes in water quality and bathymetry. During the next phase of the project, data collection and numerical modeling will be used to evaluate existing circulation and sediment transport patterns within Alice Bay and to inform potential changes in bathymetry and suspended sediment potential as a result of restoration project implementation. The project team will review existing water quality data and develop a plan for augmenting this data if necessary to determine how water quality might change as the result of a restoration project.

6.1.5 Other Considerations

The Samish Island isthmus and surrounding waters are used by Samish Island residents and the surrounding community for several recreational and cultural activities, including birding, kayaking, walking, hunting, harvest of marine resources, and education. PBNERR maintains education, professional training, research, and biocultural restoration programs that are being extended to the project site. Restoration design will consider the potential changes to the site and surrounding area that would have an impact on these uses.

6.2 Data Gaps

Several gaps in the available data were identified as part of this study and these gaps will need to be filled prior to developing design plans for any restoration scenario. This is not an exhaustive and detailed list of data gaps, but rather those that 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 saltmarsh vegetation that can colonize in these areas under the current elevations. While the SICA does currently have elevations which support some saltmarsh vegetation, to provide 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 and Samish Rivers. The historic tidal influence across this site brought sediments, wood, and seed 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 largely 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 natural shifting of the main channels and subsequent diking of the Skagit River has permanently cut off this river source of sediment to Padilla Bay. The resulting subsidence and erosion of the tide flats has been well documented. It is possible that erosion of the tide flats could be a source of sediment to a restored saltmarsh onsite, which may act as a filter to trap resuspended sediment during high tides. 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 Bay and Alice Bay, but the rate of accretion has not been documented. Another potential future source of sediment to the site may result from increased erosion of channels near the site due to greater hydraulic energy from the increased tidal prism associated with site restoration.

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, very limited field measurements of tides that 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. 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. This modeling will 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 conduct regular beach profile monitoring to document shoreline change along both bays as part of the next phase of the project. In addition, site visits with shellfish growers, Alice Bay shoreline residents, and Padilla Bay shoreline residents are being scheduled to understand the localized processes along the shorelines outside the project area. One goal in conducting these site visits to adjacent properties with feeder bluffs in both bays is to determine the potential volume of sediment discharged from the feeder bluffs and to validate the littoral drift cell mapping.

6.2.3 Groundwater Flow

In May 2024, geotechnical drilling and installation of groundwater wells were completed within the site boundaries. Collection of groundwater data is ongoing and expected to be available for analysis and reporting in 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 proposed east-west setback levee/dike. This additional groundwater well installation (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. 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 within 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 will be developed in consultation with Skagit County Public Works to identify the information necessary to determine the potential for raising Samish Island Road, possible size and number of openings under the road for tidal exchange and connectivity for fish and other marine species, and other limiting factors and design considerations. We also understand Skagit County is evaluating river flood mitigation options (NHC 2023) and the Skagit Council of Governments is studying transportation system resilience across 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 relocate 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 objectives for restoration at SICA are to restore saltmarsh habitat that provides ecological benefits for a variety of species, restore natural processes along the shorelines and the historic estuary, increase opportunity for people to reconnect with the cultural and community values of tidal wetlands, and 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 that 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 on Figures 13 through 17 as diagrams for the purposes of discussion—they are not intended to be engineering designs. It is important to recognize that these conceptual ideas are not the same as alternative restoration designs but are intended to identify broad ideas for the sake of identifying the key opportunities, constraints, design considerations, and data gaps that will need to be addressed in Phase 2, which is when alternative designs will be developed. Restoration alternatives will be developed and evaluated in Phase 2 and may contain any combination of the various elements from the general concepts presented here and will also involve extensive input and review from partners, affected parties, and technical advisors, as well as benefiting from additional studies to fill key data gaps.

In addition to the restoration objectives, the overarching project also has the objective to not make any existing conditions within the project area worse, and to improve conditions within the project area, when possible, by increasing the resiliency of transportation, utilities, drainage, and diking infrastructure. It is important to note that once the concepts are moved into an engineering design phase, all project elements or affected infrastructure will need to be designed and constructed to current design standards (manuals) and codes as prescribed by Federal, State, County, and local entities (Dike District #5 and Drainage Consortium).

Any restoration project will require many more specific engineering and ecological design elements than is being discussed in this report, but the concepts were developed with the overarching goal of avoiding or minimizing any potential impacts to surrounding land and water usage while reducing the requirement for emergency response and repairs. During the next phase of the project, concepts will be evaluated using numerical models to quantify the potential impacts to site conditions within the project boundaries, directly adjacent to, and farther afield, depending on the element. <u>During the alternative's evaluation process in the next project phase, concepts will be refined into design plans</u>

and options will be developed to either avoid or minimize impacts. This will be an iterative process with evaluating concepts, refining concepts into design options, presenting the new design options to project partners and affected parties, gathering feedback, and re-evaluating and re-design of the restoration options until consensus has been built to choose a preferred design alternative.

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. Identified funding sources for habitat restoration include funding for improved infrastructure such as setback dikes; however, if no restoration is pursued then these funding sources for infrastructure improvements will not be available. The elements of a No Restoration concept are shown on 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 (similar to a King Tide) shown as Area 1 on 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 (similar to King Tide) shown as Area 2 on 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. 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% by 2070 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 and increased precipitation will continue to add to stormwater ditches. These sources of water will likely overwhelm the current drainage system more frequently as these types of events increase in frequency.
- 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; 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 on Figure 14 and include the following:

- The removal of 2,700 feet of the Padilla Bay dike armor to restore coastal processes, support fringing saltmarsh, and support forage fish spawning habitat along the shoreline.

- Excavation of the primary tidal channel into Padilla Bay and the interior network of tidal channels to support healthy marsh development and associated ecological processes such as food web support and 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 that currently occur onsite.

- 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 associated protection to prevent overtopping of the road.

- 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 1,300 feet from the southern boundary of the project area (approximately 1,800 feet in length).

- 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.
- Removal of a portion of the Alice Bay private coastal dikes that are adjacent to the new road and improvement of 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 on Figure 15 and include the following:

- The removal of 3,300 feet of Padilla Bay dike armor to restore coastal processes, support fringing saltmarsh, and support forage fish spawning habitat along the shoreline.
- Excavation of the tidal channel into Padilla Bay and a larger interior network of tidal channels to support healthy marsh development and associated ecological processes such as food web support and 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 that currently occur onsite.
- 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 associated protection to prevent overtopping of the road.
- 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 (approximately 1,800 feet in length).
- 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.

- Removal of the entire length of Alice Bay private coastal dikes adjacent to the new road and improvement of 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 saltmarsh 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 draining into the project site from both bays. This system allowed tidal exchange, sediment and organic matter exchange, and connectivity for fish and other marine organisms 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 on Figure 16 and include several elements which are consistent with Restoration Concept 2a (in *italics*) and some new elements (not in italics) that 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 to restore coastal processes, support fringing saltmarsh, and support forage fish spawning habitat along the shoreline.*

- *Excavation of the primary tidal channel into Padilla Bay and the interior network of tidal channels* to support healthy marsh development and associated ecological processes such as food web support and *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 that currently occur onsite.*

- *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 associated protection to prevent overtopping of the road.*

- *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 1,300 feet from the southern boundary of the project area (approximately 1,800 feet in length).*
- *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.*
- Provide open channel(s) to Alice Bay using bridges or culverts at up to two locations.
- Removal or breach of the Alice Bay coastal dikes within the restored area to allow for tidal exchange and improvement of 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

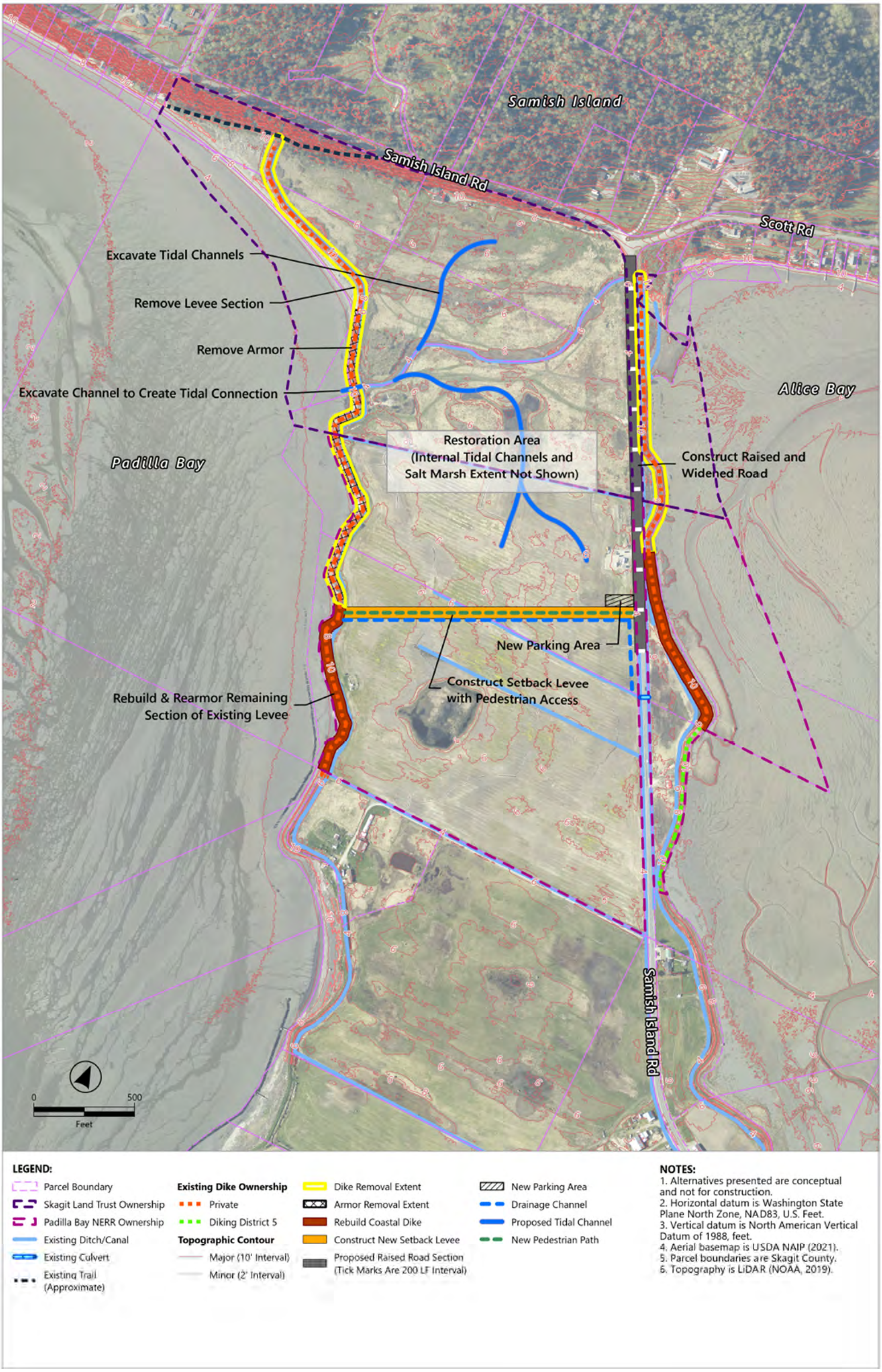
Restoration Concept 3b is the maximum footprint for restoration of a slough which might be considered at SICA. The elements are shown on Figure 17 and include several elements which are consistent with Restoration Concept 2b (in *italics*) and some new elements (not in italics) that differentiate Restoration 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 to restore coastal processes, support fringing saltmarsh, and support forage fish spawning habitat along the shoreline.*
- *Excavation of the tidal channel into Padilla Bay and a larger interior network of tidal channels* to support healthy marsh development and associated ecological processes such as food web support and *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 that currently occur onsite.*
- *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 associated protection to prevent overtopping of the road.*
- *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 (approximately 1,800 feet in length).*

- *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.*
- Provide open channel(s) to Alice Bay using bridges or culverts at up to three locations.
- The removal or breach of the entire length of Alice Bay coastal dikes within the restoration area to allow for tidal exchange and improvement of the Alice Bay dikes in other locations to connect to the existing Dike District #5 dikes on Alice Bay.

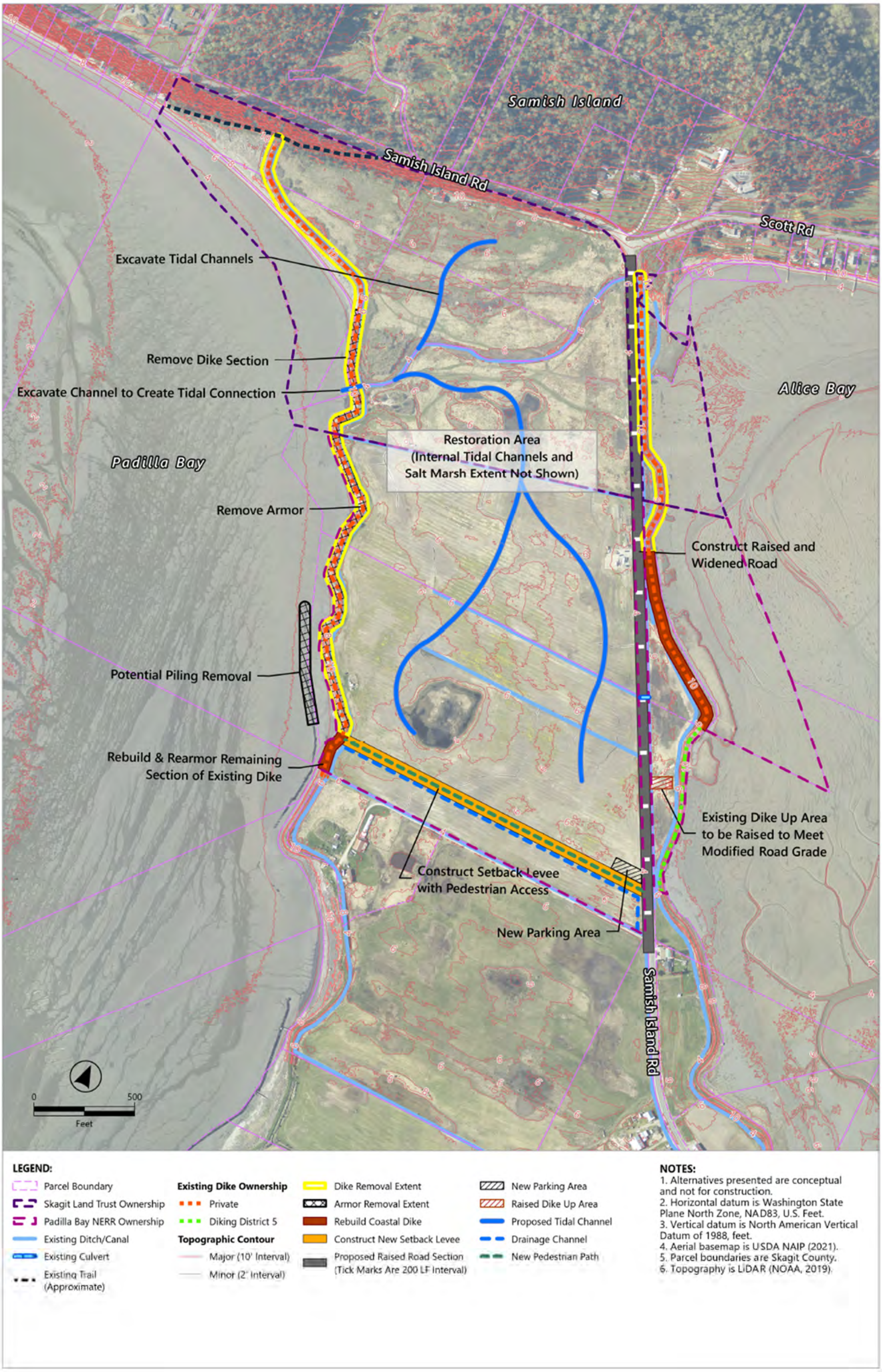
As discussed previously, these are high-level restoration concepts that will have many more elements if moved into restoration alternatives. Some of the elements not included in this discussion are changes to stormwater infrastructure, potential surface-water control devices (tide gates), changes to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

Figure 13. Restoration Concept 1 for no restoration action.



NOTES:
1. Alternatives presented are conceptual and not for construction.
2. Horizontal datum is Washington State Plane North Zone, NAD83, U.S. Feet.
3. Vertical datum is North American Vertical Datum of 1988, feet.
4. Aerial basemap is USDA NAIP (2021).
5. Parcel boundaries are Skagit County.
6. Topography is LiDAR (NOAA, 2019).

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



NOTES:
1. Alternatives presented are conceptual and not for construction.
2. Horizontal datum is Washington State Plane North Zone, NAD83, U.S. Feet.
3. Vertical datum is North American Vertical Datum of 1988, feet.
4. Aerial basemap is USDA NAIP (2021).
5. Parcel boundaries are Skagit County.
6. Topography is LiDAR (NOAA, 2019).

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

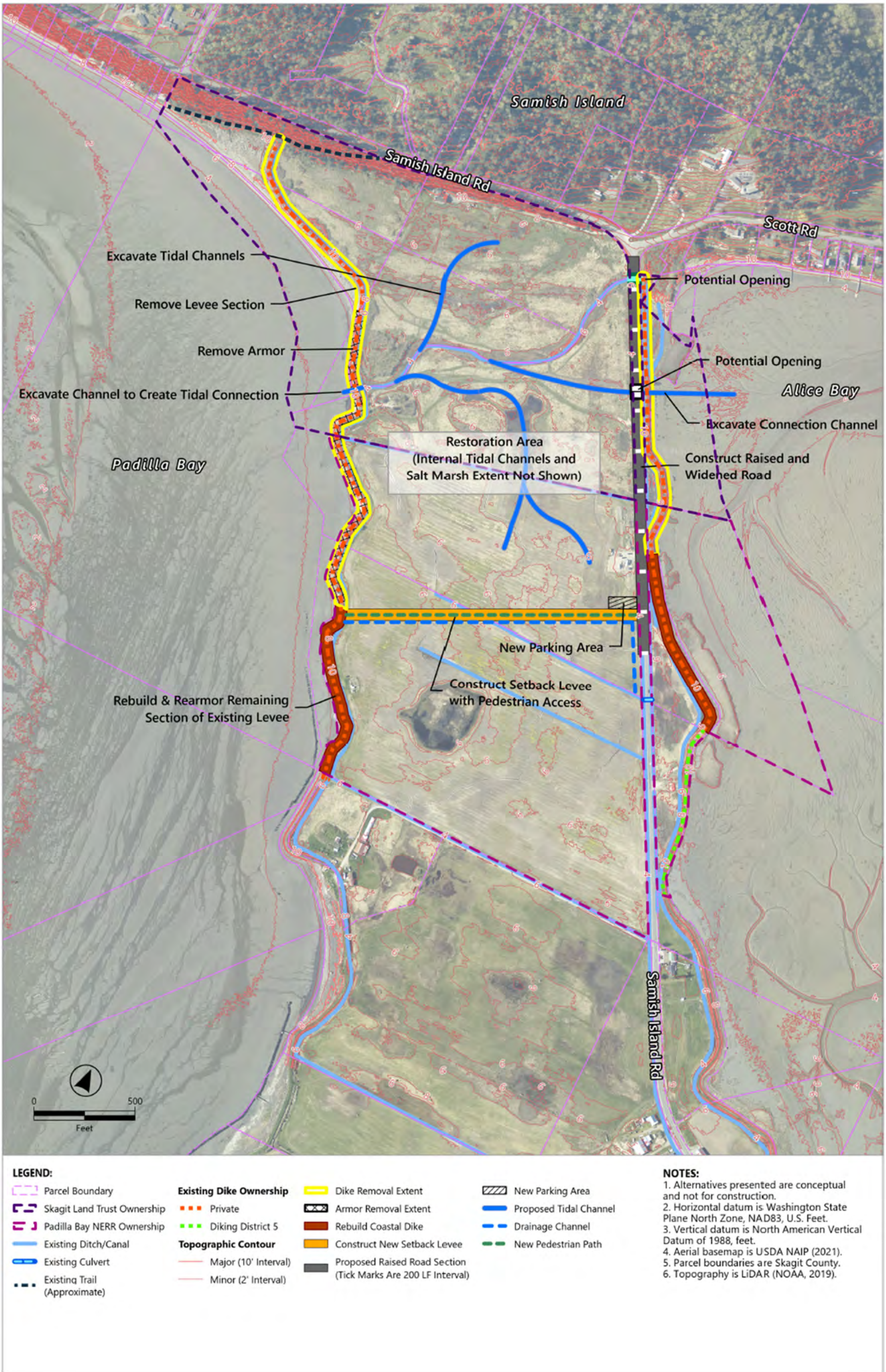
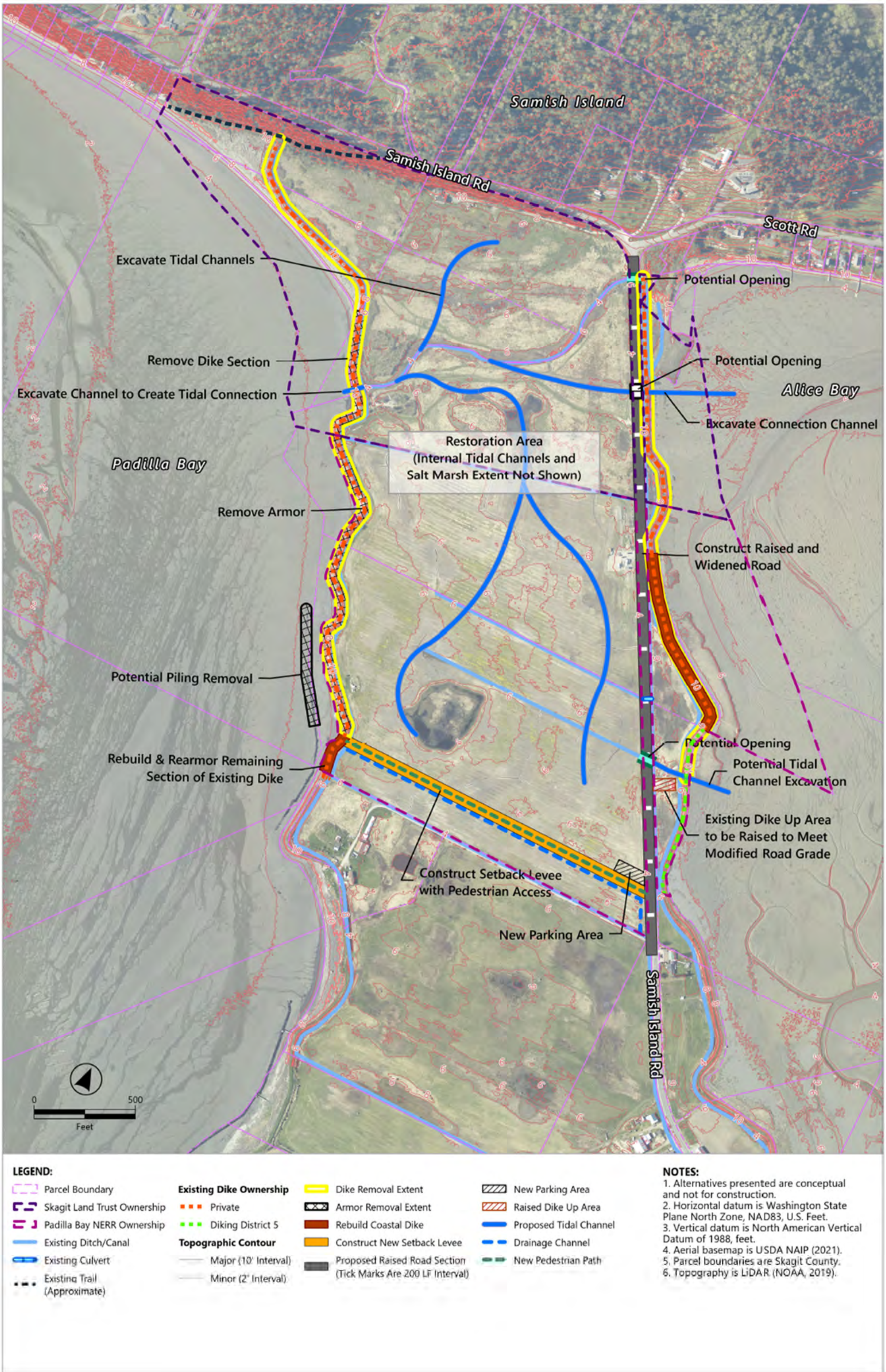


Figure 16. Restoration Concept 3a for a small slough.



NOTES:
1. Alternatives presented are conceptual and not for construction.
2. Horizontal datum is Washington State Plane North Zone, NAD83, U.S. Feet.
3. Vertical datum is North American Vertical Datum of 1988, feet.
4. Aerial basemap is USDA NAIP (2021).
5. Parcel boundaries are Skagit County.
6. Topography is LiDAR (NOAA, 2019).

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

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. The evaluation criteria were developed based on the restoration objectives (Categories 1 and 2), the design considerations described in Section 6 (Categories 3 and 4), and the ability to build consensus and acquire funding to implement the project (Category 5). This evaluation of restoration concepts is qualitative at this stage of the project; during the next phase of the project, these concepts will be evaluated quantitatively using numerical models and explicit design criteria. The quantitative alternative evaluation process in the next project phase will be iterative: concepts will be refined into designs options, the new design options will be presented to project partners and affected parties, feedback will be gathered, and design options will be re-evaluated and re-designed until consensus has been built to choose a preferred design alternative. No preferred concept has been selected at this time.

The evaluation criteria fall into five categories with several criteria under each category.

Category 1: Ecological Benefits

1. Improvement of spawning habitat for forage fish along the shorelines
2. Increase in channel habitat for fish (inundated channel)
3. Increase in feeding, roosting, and sheltering habitat for waterbirds, crabs, and other estuarine species
4. Increase in fringing saltmarsh along shorelines of Alice Bay and Samish Bay (as opposed to the interior of the site)
5. Increase in interior saltmarsh habitat
6. Deter invasive plant species

Category 2: Restoration of Shoreline & Estuarine Processes

1. Reconnection 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 bays)
5. Increased primary productivity to support estuarine food web

Category 3: Changes to Dikes and Drainage

1. Reduction of emergency response/repairs to dikes within project boundaries compared to existing
2. Reduction of water on a daily basis and avoidance of flood events contributing water to drainage ditches along road compared to existing
3. Avoidance of impacts to drainage on adjacent farmland (no increase to required 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 SLR impacts
3. Increased opportunities for people to reconnect with the cultural and community values of tidal wetlands

Category 5: Implementation Feasibility

1. Support from Samish Island community, shellfish growers, and agricultural landowners based on feedback during the public meeting and onsite meetings
2. Compatibility with County, Dike District #5, and Drainage Consortium infrastructure planning process and standards
3. Overall capital costs to construct
4. Compatibility with goals of restoration-focused funding sources
5. Compatibility with goals of resiliency funding sources coupled with ecological restoration

Restoration concepts were evaluated qualitatively and ranked against each other for the metrics listed above as low, moderate-low, moderate, moderate-high, or high. In some cases, only low, moderate, and high were used if one or more concepts were of equal value and could not be differentiated at this stage of the project.

Since this is an early phase of the project and there are still many gaps in the data, a series of assumptions were made to complete ranking of the concepts. The assumptions to be validated during the next design phase include:

- There are engineering solutions that can be developed to raise Samish Island Road above extreme water levels and to capture, treat, and convey stormwater off the raised Samish Island Road.
- Most of the groundwater and surface water within the restoration area will be captured and drained through the tidal channels within the restored area, thereby reducing the overall contribution of water to the existing drainage ditch from these parcels.
- An east-to-west setback levee/dike can be designed and located with some additional drainage infrastructure to avoid groundwater changes on the agricultural land to the south of the project area.
- There are engineering solutions/infrastructure that can be designed to capture and convey surface water from Samish River flooding events, which under existing conditions flows toward and is stored within the restoration area.
- Tidal exchange with both Padilla Bay and Samish Bay provides more benefits than risks since it has the greatest potential for increasing water quality (temperature and DO), delivering sediment and nutrients to the site, will promote saltmarsh growth, and supports marine and estuarine species in both bays.

Based on the qualitative evaluation criteria and ranking in Table 10, the concepts are ranked from highest to lowest by category and overall. It is important to recognize that no restoration alternatives have been developed or selected at this point. Restoration alternatives will be developed and evaluated in Phase 2 based on this evaluation of the general concepts along with extensive review and input from partners, affected parties, and technical advisors, and with the benefit of additional studies to fill key data gaps.

Category 1: Ecological Benefits

1. Concept 3b, large slough, ranked first for ecological benefits because of the large area of restoration for tidal channels and saltmarsh, and the potential for the most connections to Padilla Bay and Alice Bay to provide habitat for fish and other estuarine species on the east and west sides of the site.
2. Concept 2b, large embayment, and Concept 3a, small slough, ranked similarly (tied for second) for ecological benefits. While the large embayment (Concept 2b) provides more acreage of interior tidal channels and saltmarsh, it only provides tidal connection to Padilla Bay. The small slough (Concept 3a) is smaller in interior restoration area but provides connections to both Padilla Bay and Alice Bay.

3. Concept 2a, small embayment, ranked third for ecological benefits since it has the smaller restoration area and is not connected to Alice Bay but is connected to Padilla Bay.

4. Concept 1, no restoration action, ranked fourth for ecological benefits since the existing wetlands are degraded, there are small areas of saltmarsh, and the site primarily supports birds and terrestrial species, but not waterbirds, fish, or other estuarine species.

Category 2: Restoration of Shoreline & Estuarine Processes

1. Concept 3b, large slough, ranked the highest for restoration of process because it has the potential for the greatest amount of shoreline armor and fill removal to restore sediment supply from the feeder bluffs to the barrier beaches, the most tidal channels to provide tidal exchange and mixing with both Padilla Bay and Alice Bay, and the greatest potential for sediment delivery to the site with the most connections to Padilla Bay and Samish Bay.

2. Concept 3a, small slough, ranked second as it has similar attributes to the large slough, but this concept is likely to have fewer tidal channels between Alice Bay and the restored area, which will reduce the potential for tidal exchange. In addition, the length of restored shoreline is likely to be shorter along both Padilla Bay and Alice Bay.

3. Concept 2b, large embayment, ranked third since it only provides tidal exchange with Padilla Bay but provides the maximum potential for restoring shoreline processes along Padilla Bay and more potential for restoring shoreline processes along Alice Bay than Concept 2a.

4. Concept 2a, small embayment, ranked fourth for restoration of process as it is similar to Concept 2b, but the restored shoreline length is shorter.

5. Concept 1, no restoration action, ranked fifth for restoration of processes since tidal inundation and sediment supply will continue to be blocked, water quality on the interior of the site will continue to be poor, and it does not support an estuarine food web.

Category 3: Changes to Dikes and Drainage

1. Concept 3b, large slough, and Concept 2b, large embayment, both ranked high for the potential changes to dikes and drainage that would improve the function and resiliency of this infrastructure and reduce the emergency and annual maintenance measures required of the infrastructure. However, these Concepts only ranked moderate in the sub-category of avoiding impacts to drainage on adjacent farmland because there is less distance between the east-to-west setback levee/dike and the property boundary.

2. Concept 3a, small slough, and Concept 2a, small embayment, both ranked moderate for this category due to somewhat less potential for reduction of water being contributed to

drainage ditches because of the smaller restoration area and the greater length of dikes that will remain in place, leading to the potential need for more maintenance and repairs in the long-term. However, these Concepts ranked higher than Concepts 2b and 3b for the higher potential to avoid impacts to adjacent farmland because of the larger distance between the east-to-west setback levee/dike and the property boundary

3. Concept 1, no restoration action, ranked lowest since existing conditions would persist and there would be a continued need for emergency repairs, monitoring, and maintenance of this infrastructure to decrease the potential for coastal overtopping and flood impacts to the adjacent farmland. In addition, the drainage infrastructure would continue to receive surface water and groundwater from the SICA parcels where there is not a need for drainage.

Category 4: Community Resilience

1. Concept 3b, large slough, and Concept 2b, large embayment, both ranked high for community resilience because these options would require improvements to the longest length of road, the longest reach of utilities, and provide the greatest potential for people to reconnect with cultural and community values of tidal wetlands.

2. Concept 3a, small slough, and Concept 2a, small embayment, both ranked moderate for this category due to the shorter length of road and utilities improvements and the smaller area of tidal wetlands for the community to reconnect with.

3. Concept 1, no restoration action, ranked lowest since existing conditions would persist for longer and improvements to the road and utilities are likely to take longer to develop under typical funding mechanisms such as a County capital improvement project. In addition, the community would remain disconnected from the cultural and community values of tidal wetlands.

Category 5: Implementation Feasibility

1. Concept 3b, large slough, and Concept 2b, large embayment, both ranked high for implementation feasibility because they both rank high for compatibility with goals of restoration and resiliency funding sources and high or moderate high for compatibility with County, Dike District, and Drainage Consortium planning processes. The public expressed somewhat more support for the large slough concept but were also supportive of the large embayment. Although capital costs for the large slough are anticipated to be the highest (rank as low indicates more costly) and the large embayment ranked third in costs, the highest ranking in category 5 indicates the benefits will outweigh the costs for these two options.

2. Concept 3a, small slough, and Concept 2a, small embayment, both ranked moderate for this category because the smaller restoration area will result in a reduction in the length of infrastructure improvements. Therefore, it is not as compatible with the County, Dike District, and Drainage Consortium planning processes and will not be as competitive for restoration and resiliency grant funding. These Concepts were generally supported by the public. Capital costs for the small slough are predicted to rank second-most costly and the small slough the lowest cost of the restoration concepts.

3. Concept 1, no restoration action, ranked lowest in terms of costs, but also ranked lowest in terms of compatibility with the County, Dike District, and Drainage Consortium planning processes and public support. The Samish Island community has expressed a strong desire for planning and actions to be initiated now. Since this concept does not incorporate restoration, it would not be eligible for restoration funding or resiliency grant funding with an ecological focus.

Overall Ranking

1. Concept 3b, large slough, ranked the highest overall because it provides the largest restored area and connections to both Padilla Bay and Alice Bay, yielding the greatest potential for ecological benefits and restoration of shoreline and estuarine processes. The large slough is also one of the highest ranked for changes to dikes and drainage, community resilience, and implementation feasibility. While there are many unknowns about the potential effects of reconnecting the two bays, at this stage of the project, it has been assumed reconnection of the bays will provide more benefits than risks.

2. Concept 2b, large embayment, ranked second since it still provides the maximum restoration area but only provides tidal exchange with Padilla Bay. The large embayment provides the maximum potential for restoring shoreline processes along Padilla Bay and more potential for restoring shoreline processes along Alice Bay than Concepts 3a and 2a. The large embayment ranked moderate to moderate high for changes to dikes and drainage, community resilience, and implementation feasibility.

3. Concept 3a, small slough, ranked third (although close to second) as it has similar attributes to the large slough, but this Concept is likely to have fewer connections between Alice Bay and the restored area, which will reduce the potential for restoration of processes and ecological benefits. The small slough ranked moderate to moderate high for changes to dikes and drainage, community resilience, and implementation feasibility.

4. Concept 2a, small embayment, ranked fourth as it provides the smallest restoration area, and is only connected to Padilla Bay. It therefore has a lower rank for restoration of processes and

ecological benefits. The small embayment provides the least potential for improvements to infrastructure, beneficial changes to dikes and drainage, community resilience and implementation feasibility.

5. Concept 1, no restoration action, ranked fifth (last) since this concept does not have restoration actions, so it is not providing ecological benefits or restoration of shoreline and estuarine processes, does not provide infrastructure improvements, is not supported by the Samish Island community, and would not be eligible for restoration or resiliency funding sources.

Table 10. Evaluation Matrix to Compare Phase 1 (Preliminary) Restoration Concepts

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 Shoreline degradation from interaction between armor and coastal processes covering and inhibiting forage fish habitat.	Moderate 2,700 linear feet of Padilla Bay armor removal to restore coastal processes and forage fish habitat.	High 3,300 linear feet of Padilla Bay armor removal to restore coastal processes and forage fish habitat	Moderate Same as Concept 2a as Alice Bay shoreline is not expected to provide forage fish habitat.	High Same as Concept 2b as Alice Bay shoreline is not expected to provide forage fish habitat.
Ecological Benefits 1.2 Channel habitat for fish (inundated channel).	Low Fish cannot access the site under existing conditions because of dikes and fill placement.	Moderate An open channel to Padilla Bay will provide fish connectivity and access to a network of tidal channels across 75 acres of land to provide fish refuge habitat.	High An open channel to Padilla Bay will provide fish connectivity and access to a network of tidal channels across 108 acres of land to provide fish refuge habitat	Moderate Same as Concept 2a since most of the fish coming by the site are expected to enter from Padilla Bay.	High Same as Concept 2b since most of the fish coming by the site are expected to enter from Padilla Bay.
Ecological Benefits 1.3 Feeding, roosting, and sheltering habitat for waterbirds, crabs, and other estuarine species.	Low-Moderate Birds, waterbirds, terrestrial species, and other small animals currently use the site.	Moderate Increases habitat diversity and carrying capacity for waterbirds, increases diversity of waterbirds, provides habitat for estuarine invertebrates and mammals, many terrestrial species and other small animals will continue to use the site, and saltwater species will have access to the site.	Moderate-High Same as Concept 2a, but the larger area provides more carrying capacity for usage by a diversity of estuarine species.	Moderate- High Same as Concept 2a, but now species from both Samish Bay and Padilla Bay will have access to the site, and a corridor between bays.	High Same as Concept 2a, but now species from both Samish Bay and Padilla Bay will have access to the site, a corridor between bays, and the larger area provides more carrying capacity for usage by a diversity of estuarine species.
Ecological Benefits 1.4 Fringing saltmarsh along shoreline	Low The majority of saltmarsh along the shorelines of Padilla Bay and Alice Bay has been eroded or altered over time as a result of the coastal dikes.	Low-Moderate Removal of 2,700 feet of the Padilla Bay dike armor will provide opportunity for saltmarsh development along the western shoreline.	Moderate Removal of 3,300 feet of Padilla Bay dike armor will provide opportunity for saltmarsh development along the western shoreline.	Moderate- High Same as Concept 2a and removal of some quantity of armor along the Alice Bay shoreline will provide opportunity for saltmarsh habitat.	High Same as Concept 2b and potential for removal of larger quantity of armor along the Alice Bay shoreline will provide opportunity for saltmarsh habitat.
Ecological Benefits 1.5 Interior saltmarsh habitat	Low There are small pockets of saltmarsh on the interior of the site currently, but it is not accessible by aquatic species.	Moderate An open channel to Padilla Bay and material placement across 75 acres of interior area will create varying elevations of saltmarsh habitat.	Moderate An open channel to Padilla Bay and material placement across 108 acres of interior area will create varying elevations of saltmarsh habitat.	Moderate- High Same as Concept 2a, plus additional connections to Alice Bay provides more opportunity for seed and recruitment of saltmarsh.	High Same as Concept 2b, plus additional connections to Alice Bay provides more opportunity for seed and recruitment of saltmarsh.
Ecological Benefits 1.6 Deter invasive vegetation species	Low The high salinity and high elevation of the groundwater table is deterring invasive species in some areas of the site.	Moderate Tidal inundation across 75 acres of interior area will deter the growth of many invasive vegetation species.	Moderate Tidal inundation across 108 acres of interior area will deter the growth of many invasive vegetation species.	Moderate- High Same as Concept 2a, plus additional connections to Alice Bay provides more opportunity for seed and recruitment of native species to outcompete invasives.	High Same as Concept 2b, plus several connections to Alice Bay provides more opportunity for seed and recruitment of native species to outcompete invasives.
Restoration of Processes 2.1 Re-connection of sediment supply to shoreline	Low Coastal dikes, pilings, and fill in the nearshore are preventing sediment supply and littoral drift along the shoreline	Low-Moderate Removal of armor and fill along the Padilla Bay shoreline will restore sediment supply and littoral drift to the project site.	Moderate Removal of additional length of armor and fill along the Padilla Bay shoreline will restore sediment supply and littoral drift to the project site.	Moderate-High Same as Concept 2a plus potential for removal of armor and fill along the Alice Bay shoreline to restore sediment supply and littoral drift to both shorelines.	High Same as Concept 2b plus potential for additional length of armor and fill removal along the Alice Bay shoreline to restore sediment supply and littoral drift to both shorelines.
Restoration of Processes 2.2 Develop salinity gradients.	Low Since tidal inundation is blocked by the presence of coastal dikes, there is no opportunity to develop a salinity gradient.	Low-Moderate An open channel to Padilla Bay will allow tidal flow into and out of the site, mixing with surface water to develop salinity gradients across 75 acres.	Moderate An open channel to Padilla Bay will allow tidal flow into and out of the site, mixing with surface water to develop salinity gradients across 108 acres.	Moderate-High Same as Concept 2a plus one to two tidal channels into Alice Bay, which is connected to the Samish River, will provide more opportunity for salinity gradients to develop.	High Same as Concept 2b plus up to three tidal channels into Alice Bay, which is connected to the Samish River, will provide the most opportunity for salinity gradients to develop.

Category	Concept 1 (No Restoration Action)	Concept 2a (Small Embayment)	Concept 2b (Large Embayment)	Concept 3a (Small Slough)	Concept 3b (Large Slough)
Restoration of Processes 2.3 Increase in water quality (temperature and dissolved oxygen [DO])	Low Surface water on the site is stagnant and relatively high in temperature, particularly in the summer, and DO is predicted to be low.	Low-Moderate An open channel to Padilla Bay will allow tidal flow into and out of the site, mixing with surface water to moderate temperatures and increase DO across 75 acres.	Moderate An open channel to Padilla Bay will allow tidal flow into and out of the site, mixing with surface water to moderate temperatures and increase DO across 108 acres.	Moderate-High Same as Concept 2a plus one to two tidal channels into Alice Bay, will allow tidal exchange and through flow increasing mixing with surface water to moderate temperatures and increase DO across 75 acres.	High Same as Concept 2b plus up to three tidal channels into Alice Bay will allow tidal exchange and through flow increasing mixing with surface water to moderate temperatures and increase DO across 108 acres.
Restoration of Processes 2.4 Tidal hydraulic and hydrologic connectivity	Low Since tidal inundation is blocked by the presence of coastal dikes, there is no tidal connectivity nor hydrologic conductivity.	Low-Moderate An open channel to Padilla Bay will allow exchange of water, sediment, nutrients, organisms, and organic matter between the site and Padilla Bay.	Moderate An open channel to Padilla Bay will allow exchange of water, sediment, nutrients, organisms, and organic matter between more of the site and Padilla Bay.	Moderate-High An open channel to Padilla Bay and Alice Bay will allow exchange of water, sediment, nutrients, organisms, and organic matter between Padilla Bay and Alice Bay through the site.	High An open channel to Padilla Bay and more than one into Alice Bay will allow exchange of water, sediment, nutrients, organisms, and organic matter between Padilla Bay and Alice Bay through the site.
Restoration of Processes 2.5 Primary productivity to support estuarine food web.	Low The site does not currently support an estuarine food web.	Moderate Tidal exchange with Padilla Bay will support estuarine food web across 75 acres.	Moderate-High Tidal exchange with Padilla Bay will support an estuarine food web across 108 acres.	Moderate- High Tidal exchange with Padilla Bay and Alice Bay will increase primary production across the 75 acres to support a larger estuarine food web.	High Tidal exchange with Padilla Bay and Alice Bay will increase primary production across the 108 acres to support the largest estuarine food web
Dikes and Drainage 3.1 Reduction of emergency response/repairs for dikes within project boundaries.	Low Coastal dikes will remain in place and the need for emergency repairs will continue to be high.	Moderate - High Removal or improvement of Padilla Bay coastal dikes will reduce need for emergency repairs on western shoreline and Alice Bay dikes will be consolidated with road.	High Additional removal or improvement of Padilla Bay dikes will reduce the need for emergency repairs on western shoreline and longer length of Alice Bay dikes will be consolidated with road.	Moderate - High Same Concept 2a	High Same as Concept 2b.
Dikes and Drainage 3.2 Reduction of water being contributed to drainage ditches along road.	Low Drainage at the site will remain in existing condition.	Moderate 75 acres of the site will no longer be connected to the drainage ditches, reducing drainage needs.	High 108 acres of the site will no longer be connected to the drainage ditches reducing drainage needs.	Moderate Same as Concept 2a.	High Same as Concept 2b.
Dikes and Drainage 3.3 Avoidance of impacts to drainage on adjacent farmland	High Drainage will remain as is and there will be no changes to adjacent farmland drainage.	Moderate-High An east-to-west setback levee with a buffer of 900 to 1,300 feet with remaining project area as a buffer has the highest potential for avoiding impacts to farmland drainage.	Moderate An east-to-west setback levee with a buffer of 150 feet has a lower potential for avoiding impacts to farmland drainage.	Moderate - High Same as Concept 2a.	Moderate Same as Concept 2b
Community Resilience 4.1 Reduction of road closures due to coastal flooding and maintenance of road within project boundaries compared to existing.	Low The road and potential for closures will remain the same as existing conditions.	Moderate Improvement of up to 2,000 feet of Samish Island Road would prevent coastal flooding of that portion of the road under existing and future water levels.	High Improvement of up to 3,500 feet of Samish Island Road would prevent coastal flooding of that portion of the road under existing and future water levels.	Moderate Same as Concept 2a	High Same as Concept 2b
Community Resilience 4.2 Increased resiliency of utilities (power, water, and fiber optic) to sea level rise impacts.	Low The utilities will remain the same as existing conditions.	Moderate Improvement of utilities along up to 2,000 feet of Samish Island Road would provide resiliency under future water levels.	High Improvement of utilities along up to 3,500 feet of Samish Island Road would provide resiliency under future water levels.	Moderate Same as Concept 2a	High Same as Concept 2b

Category	Concept 1 (No Restoration Action)	Concept 2a (Small Embayment)	Concept 2b (Large Embayment)	Concept 3a (Small Slough)	Concept 3b (Large Slough)
Community Resilience 4.3 Increased opportunities for people to reconnect with the cultural and community values of tidal wetlands	Low Access to the site will remain limited as it is under existing conditions.	Moderate Restoration of saltmarsh across 75 acres will provide extensive opportunities to reconnect people with tidal wetlands.	High Restoration of saltmarsh across 108 acres will provide extensive opportunities to reconnect people with tidal wetlands.	Moderate Same as Concept 2a	High Same as Concept 2b
Implementation Feasibility 5.1 Support from general public.	Low Samish Island residents are concerned about road closure under existing conditions.	Moderate There is overall support for restoration of saltmarsh and improvement of infrastructure based on comments at the public meeting.	Moderate There is overall support for restoration of saltmarsh and improvement of infrastructure based on comments at the public meeting.	High Most of the public expressed additional support for the reconnection of the bays at the public meeting.	High Most of the public expressed additional support for the reconnection of the bays at the public meeting
Implementation Feasibility 5.2 Compatibility with County, Dike District, and Drainage Consortium infrastructure planning process.	Low The existing conditions pose threats to infrastructure. Recommendations have been made for improvements to the infrastructure, but funding is limited.	Moderate-High Improvement of a moderate length of coastal dikes, roads, and drainage will extend the life of this infrastructure.	High Improvement of a maximum length of coastal dikes, roads, and drainage will extend the life of this infrastructure.	Moderate Improvement of a moderate length of coastal dikes, roads, and drainage will extend the life of this infrastructure. Installation of one or more bridges and culverts will increase County infrastructure operation and maintenance.	Moderate-High Improvement of a maximum length of coastal dikes, roads, and drainage will extend the life of this infrastructure. Installation of one or more bridges and culverts will increase County infrastructure operation and maintenance.
Implementation Feasibility 5.3 Overall capital costs (ranking is reversed so low is more costly and high is least costly).	High Ongoing maintenance costs will be expensive and reliant on emergency funding measures, but the incremental costs of this are lower than the major infrastructure changes required for restoration.	Moderate-High The minimal area of restoration and shortest length of infrastructure improvements makes this the lowest cost restoration concept.	Moderate The maximum area of restoration and length of infrastructure improvements, but no added bridges or culverts makes this a moderate-cost restoration concept.	Low-Moderate The minimal area of restoration and length of infrastructure improvements, plus added bridges and/or culverts makes this a low-moderate-cost restoration concept since the costs may not outweigh the benefits.	Low The maximum area of restoration and length of infrastructure improvements, plus added bridges and/or culverts makes this the highest cost restoration concept, therefore ranks lowest in this category.
Implementation Feasibility 5.4 Compatibility with goals of restoration-focused funding sources.	Low No restoration funding would be available to support the site under existing conditions.	Moderate-High The moderate area of restoration at the site would support a diverse number of species and saltmarsh habitat and compete well for ecosystem restoration funding.	High The larger area of restoration at the site would support a diverse number of species and saltmarsh habitat and compete well for ecosystem restoration funding.	Moderate-High Same as Concept 2a	High Same as Concept 2b
Implementation Feasibility 5.5 Compatibility with goals of resiliency funding sources	Low No resiliency funding would be available to support the site under existing conditions (designs for improvements to infrastructure would be compatible, but improvements to infrastructure without restoration are not a goal of this project).	Moderate-High The changes to infrastructure including removal of unnecessary coastal dikes, improvement for remaining coastal dikes, raising the road, and improving utilities would be competitive for resiliency funding	High The larger changes to infrastructure for this concept including removal of additional lengths of coastal dikes, improvement for remaining coastal dikes, raising more of the road and improving utilities would be even more competitive for resiliency funding	Moderate-High Same as Concept 2a	High Same as Concept 2b
OVERALL RANKING (1 to 5 from low to high)	**LOW (1)**	**LOW-MODERATE (2)**	**MODERATE-HIGH (4)**	**MODERATE (3)**	**HIGH (5)**

This alternative evaluation process is preliminary, and in Phase 2, the concepts will be refined into designs options, the new design options will be presented to project partners and affected parties, feedback will be gathered, and design options will be re-evaluated and re-designed until consensus has been built to choose a preferred design alternative. No preferred concept has been selected at this time.

9 Communication and Outreach

A series of meetings (both informal and formal) have been conducted to gather feedback, questions, and comments on the site assessment and restoration concepts. This section lists those meetings between the project leadership team (Blue Coast, PBNERR, and SLT), project partners, affected parties and the public. Many additional public tours and on-site meetings were held without Blue Coast present with the Drainage and Irrigation Districts Consortium; Dike District #5; Skagit County Public Works; the Samish Island Resilient Access Committee; Representative Rick Larsen and staff; and Dr. Richard Spinard and staff of NOAA. Approximately 175 islanders and Skagit County residents have toured the site with SLT and/or PBNERR.

The following bullets list the informal meetings which were held during the project studies:

- Two specific meetings were held between the project leadership team, Skagit County Public Works Department, Dike District #5 commissioners on August 8, 2022, and February 12, 2024, to discuss the dike and drainage district infrastructure that might be affected by a potential restoration scenario. The February 12, 2024, meeting also included the Executive Director of the Skagit County Drainage and Irrigation Districts Consortium.
- SLT and PBNERR met with the Skagit County Public Works Department and Dike District #5 on March 23, 2024, April 24, 2023, and June 7, 2023.
- The project leadership team met with the Skagit County Public Works Department on March 25, 2024 to discuss Phase 2 of the project.
- The project leadership team including Blue Coast met with WDFW, Skagit County Public Works Department, Drainage Consortium onsite at Wiley Slough on August 20, 2024.
- There are two primary families which own the agriculture land south of the project site. Onsite meetings with these families were organized by Skagit County Dike District #5 commissioners:
    - The project leadership team met with a member of the Nelson family and staff onsite on March 12, 2024.
    - The project leadership team has 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 have had several conversations and email exchanges with the members of the Samish Indian Nation on topics including 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 November 2024 to discuss fish habitat and fish sampling. The conversations between SRSC and PBNERR are ongoing for the fish sampling for this project.

- PBNERR and SLT met with the Samish Island Community in 2023 at the invitation of the Samish Island Resilient Access Committee (SIRAC).

- The project leadership team held a public meeting with the Samish Island community in 2024 for a presentation by Blue Coast. In addition, SIRAC reviewed the grant application for Phase 2 of the project.

- The project leadership team met with h with residents and property owners on Scott Road on January 10, 2025, to walk beaches adjacent to the project site and answer questions about the site assessment and feasibility report.

- The project leadership team is planning to meet with a representative of Taylor Shellfish and Penn Cove Shellfish in spring 2025 when the operations can be observed during a low tide.

Table 11 lists the meetings for the robust review of the information in this report by project partners and affected parties. The Phase 1 technical advisory committee raised several technical issues which are described in Section 6 (Design Considerations & Data Gaps) and have yet to be evaluated but otherwise supported the project. The public generally expressed support for the project. During these meetings the following general issues and concerns were raised, which will be evaluated during the next project phase:

<u>Drainage</u>

- The adjacent landowners, surrounding community, Dike District #5 and Drainage consortium have expressed concerns over the potential for a restoration project to add additional water (surface and ground) to the adjacent agricultural lands and to the drainage infrastructure.

- Dike District #5 and the Drainage consortium have requested project concepts be evaluated to determine the changes to the surrounding areas when a Samish River flooding event occurs. Previous work has shown that Samish River flood events tend to flow overland to the north, and the northern portion of the project site acts as storage of this water until it can infiltrate.

- While the agricultural community has expressed some concern over the loss of agricultural land in this area, some of the parcels within the proposed restoration area have not been farmed for many years and the drainage infrastructure is degrading. While other parcels have been farmed more recently, these parcels have not been rentable since 2023 due to salinity issues.

Exchange Between Bays

- During the public meeting that was also attended by shellfish farmers, there were questions asked about the exchange of water between Padilla Bay and Samish Bay affecting water quality (primarily Samish Bay having lower water quality that could reduce water quality in Padilla Bay).
- Public meeting attendees expressed general concern about introducing organisms such as invasive species or disease/parasites from one bay to the other that are not currently present in the respective bays.
- Property owners along Alice Bay shoreline expressed concern about erosion along their property as a result of reopening the slough.
- The community asked if reopening the slough could change the Samish River flow pathways as well as the other smaller channels within Alice Bay.
- Shellfish growers requested evaluation of sediment transfer as a result of reopening the slough and if this would affect access to and sedimentation within shellfish beds on the northeast side of Samish Island.
- Public was interested in the slough providing opportunity for kayaking from one bay to the other and potentially for adding a public kayak launch location.
- Concerns were expressed over infilling of the channel(s) post implementation and inability to keep the channels open long-term without maintenance.

Habitat and Species

- Public expressed concerns about the low elevations of the site under existing conditions and how saltmarsh would develop and be sustained within the restoration area.
- Public has expressed concerns about changes to waterbird habitat and behavior as a result of project implementation.

Other

- Parties who own or manage land along the feeder bluffs along Padilla Bay and Samish Bay expressed concern about the erosion of these feeder bluffs being made worse by a restoration project implementation.

- Concerns over funding for and ability to maintain the new infrastructure after project implementation by the appropriate agency/party.
- How this project fits into long-term County plans for Samish Island Road through the project area and above the feeder bluff.

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, USGS, WDFW, Ducks Unlimited, and Washington Sea Grant.
Skagit County Public Works and Dike District #5	September 5, 2024	This meeting was 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 that will inform future work.
Public	October 10, 2024	This meeting was held for local residents, business owners, 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 was completed in 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 will be reported on during Phase 2 of this project.

The proposed scope for Phase 2 (pending additional funding) will contain much more detailed work relevant to addressing the questions and concerns of key partners and affected parties (Section 9). The following bullets summarize the milestones for Phase 2:

- PBNERR received an additional grant through Ecology in August 2024 to complete data collection on waves, water levels, bathymetry, and topography and to develop a numerical modeling framework to evaluate watershed runoff, waves, water levels, hydrodynamics, and hydraulics for existing conditions. The numerical models will be calibrated using the collected data.

- SLT has applied for grants for funding 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; offsite groundwater monitoring; and design of setback levees, coastal dikes, and drainage improvements. This work is dependent on receiving funding through competitive grant processes and 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. In particular, Dike District #5, the Drainage and Irrigation Districts Consortium, and Skagit County will be invited to review methods, data, and results of work during Phase 2 of the project.

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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Appendix A

Site Photographs

Figure A-1. Northeast shoreline, salt marsh and drainage channel at left, tide flat in foreground (July 2022 photo). View looking north.

Figure A-2. Eastern shoreline, salt marsh in foreground and rock armoring in background (July 2022 photo). View looking south.

Figure A-3. Scarp along salt marsh on eastern shoreline (July 2022 photo).

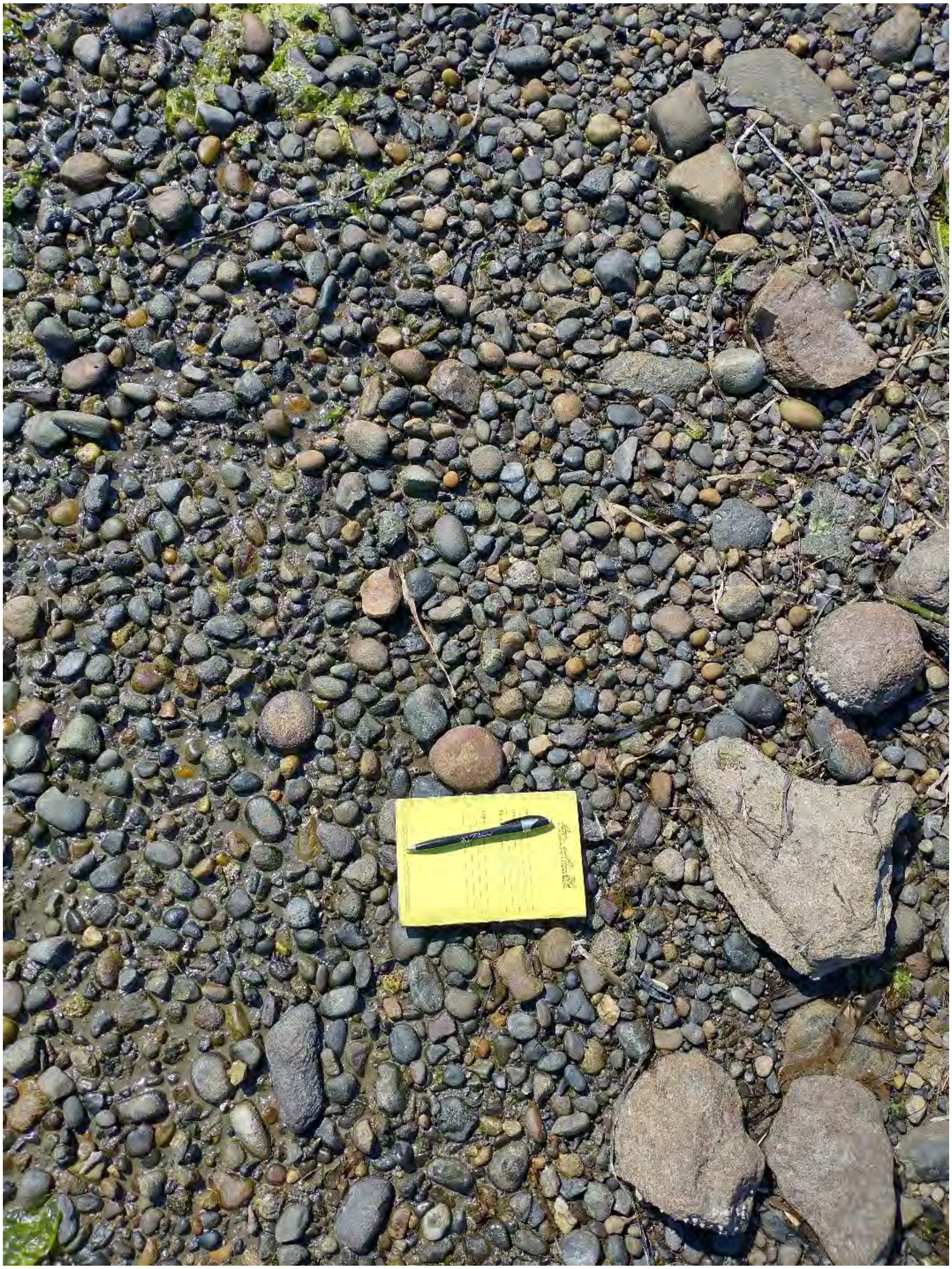


Figure A-4. Sand and gravel beach deposits on the northeast shoreline (July 2022 photo).

Figure A-5. Rock armoring along the eastern shoreline (July 2022 photo). View looking south.

Figure A-6. Northwest shoreline looking towards feeder bluffs on Samish Island (July 2022 photo).

Figure A-7. Exposed feeder bluff sediments on Samish Island, to the west of the project site (July 2022 photo).

Figure A-8. Sand and gravel beach deposits on the northwest shoreline (July 2022 photo).

Figure A-9. Tide flat deposits along the Padilla Bay shoreline with a noted high sand content (July 2022 photo).

Figure A-10. Sand and gravel beach along the western shoreline (Padilla Bay) with dike in background (July 2022 photo). View looking south.

Figure A-11. Rock armoring and wood accumulation along the western shoreline (July 2022 photo).

Figure A-12. View from western shoreline towards Padilla Bay tide flat. Cut pilings are visible in the foreground (July 2022 photo). View to the west.

Figure A-13. View to the south of the eastern shoreline along Alice Bay (March 2024 photo).

Figure A-14. Scarp along the eastern shoreline in Alice Bay (March 2024 photo).

Figure A-15. View to the north along the eastern shoreline. Dike/armoring is in the center of the photograph and drainage channel is visible between the armoring and road to the left (March 2024 photo).

Figure A-16. View to the north of the dike along the southeastern shoreline (March 2024 photo).

Figure A-17. Scarp along salt marsh on western shoreline (March 2024 photo).

Figure A-17. View to the south of the southwestern shoreline. Pile dike wall is to the right (March 2024 photo).

Appendix B

Photo Monitoring Points

Figure B-1. Site overview map of photo monitoring points, showing photo location and direction.

Figure B-2. SA_01. Photo taken on January 17, 2023, after a large king tide event.

Figure B-3. SA_01. Photo taken on January 26, 2024.

Figure B-4. SA_01. Photo taken on June 12, 2024.

Figure B-5. SA_02. Photo taken on January 17, 2023.

Figure B-6. SA_02. Photo taken on January 26, 2024.

Figure B-7. SA_02. Photo taken on June, 2024.

Figure B-8. SA_03. Photo taken on January 17, 2023.

Figure B-9. SA_03. Photo taken on January 26, 2024.

Figure B-10. SA_03. Photo taken on June 12, 2024.

Figure B-11. SA_04_E. Photo taken on January 17, 2023.

Figure B-12. SA_04_E. Photo taken on January 26, 2024.

Figure B-13. SA_04_E. No photo available for the June 12, 2024 photo collection date.

Figure B-14. SA_04_N. Photo taken on January 17, 2023.

Figure B-15. SA_04_N. Photo taken on January 26, 2024.

Figure B-16. SA_04_N. No photo available for the June 12, 2024 photo collection date.

Figure B-17. SA_04_S. Photo taken on January 17, 2023.

Figure B-17. SA_04_S. Photo taken on January 26, 2024.

Figure B-18. SA_04_S. No photo available for the June 12, 2024 photo collection date.

Figure B-19. SA_05_N. Photo taken on January 17, 2023.

Figure B-20. SA_05_N. Photo taken on January 26, 2024.

Figure B-21. SA_05_N. Photo taken on June 12, 2024.

Figure B-22. SA_05_S. Photo taken on January 17, 2023.

Figure B-23. SA_05_S. Photo taken on January 26, 2024.

Figure B-24. SA_05_S. Photo taken on June 12, 2024.

Figure B-25. SA_06_N. Photo taken on January 17, 2023.

Figure B-26. SA_06_N. Photo taken on January 26, 2024.

Figure B-27. SA_06_N. Photo taken on June 12, 2024.

Figure B-28. SA_06_S. Photo taken on January 17, 2023.

Figure B-29. SA_06_S. Photo taken on January 26, 2024.

Figure B-30. SA_06_S. Photo taken on June 12, 2024.

Figure B-31. SA_07_N. Photo taken on January 17, 2023.

Figure B-32. SA_07_N. Photo taken on January 26, 2024.

Figure B-33. SA_07_N. Photo taken on June 12, 2024.

Figure B-34. SA_07_S. Photo taken on January 17, 2023.

Figure B-35. SA_07_S. Photo taken on January 26, 2024.

Figure B-36. SA_07_S. Photo taken on June 12, 2024.

Figure B-37. SA_08. Photo taken on January 17, 2023.

Figure B-38. SA_08. Photo taken on January 26, 2024.

Figure B-39. SA_08. Photo taken on June 12, 2024.

Figure B-40. SA_09_N. Photo taken on January 17, 2023.

Figure B-41. SA_09_N. Photo taken on January 26, 2024.

Figure B-42. SA_09_N. Photo taken on June 12, 2024.

Figure B-43. SA_09_S. Photo taken on January 17, 2023.

Figure B-44. SA_09_S. Photo taken on January 26, 2024.

Figure B-45. SA_09_S. Photo taken on June 12, 2024.

Figure B-46. SA_10_S. Photo taken on January 17, 2023.

Figure B-47. SA_10_S. Photo taken on January 26, 2024.

Figure B-48. SA_10_S. Photo taken on June 12, 2024.

Figure B-49. SA_10_W. Photo taken on January 17, 2023.

Figure B-50. SA_10_W. Photo taken on January 26, 2024.

Figure B-51. SA_10_W. Photo taken on June 12, 2024.

Appendix C

Historical Maps & Photographs

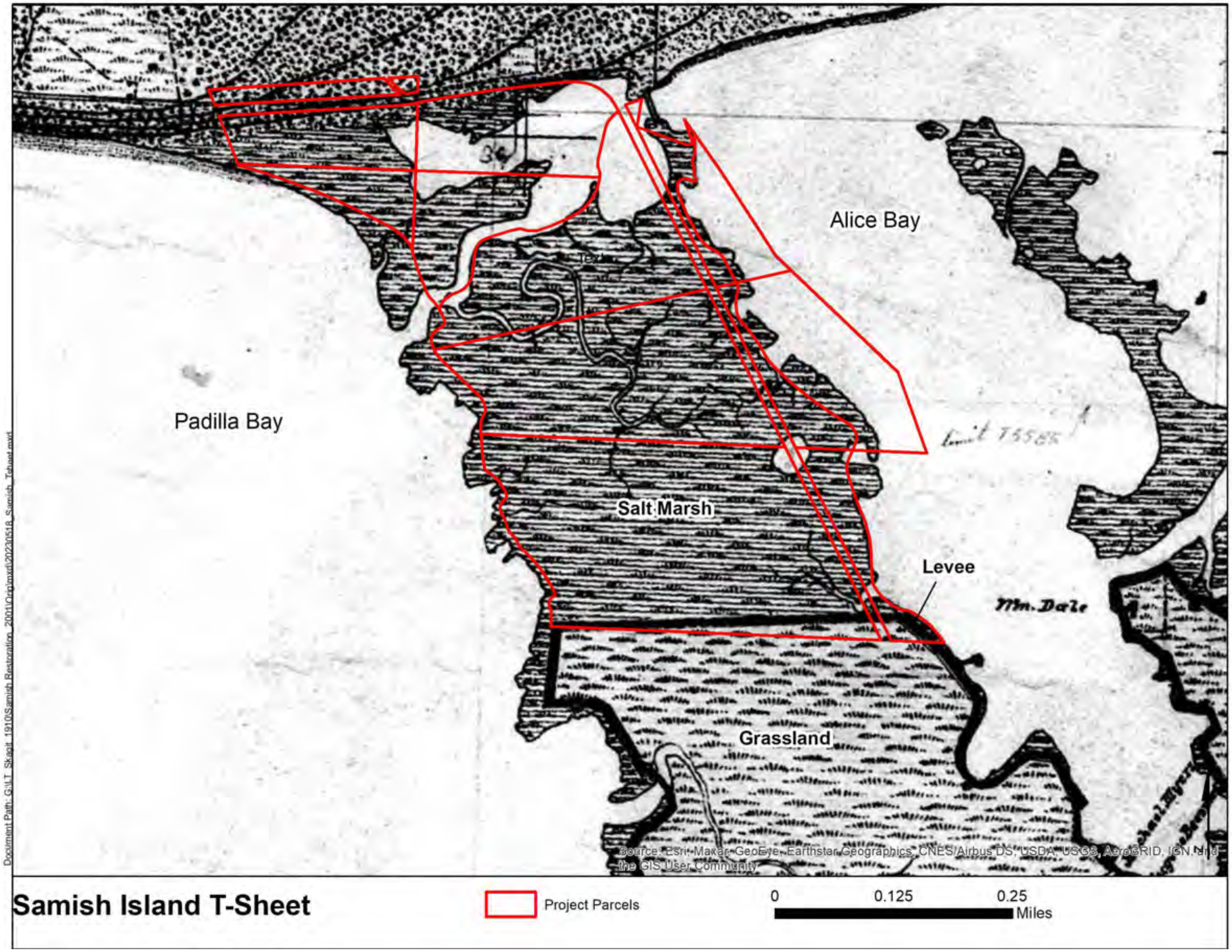


Figure C-1. 1887 topographic survey (T-sheet).

Figure C-2. 1937 aerial photograph (Skagit County).

Figure C-3. 1941 aerial photograph (USGS Earth Explorer).

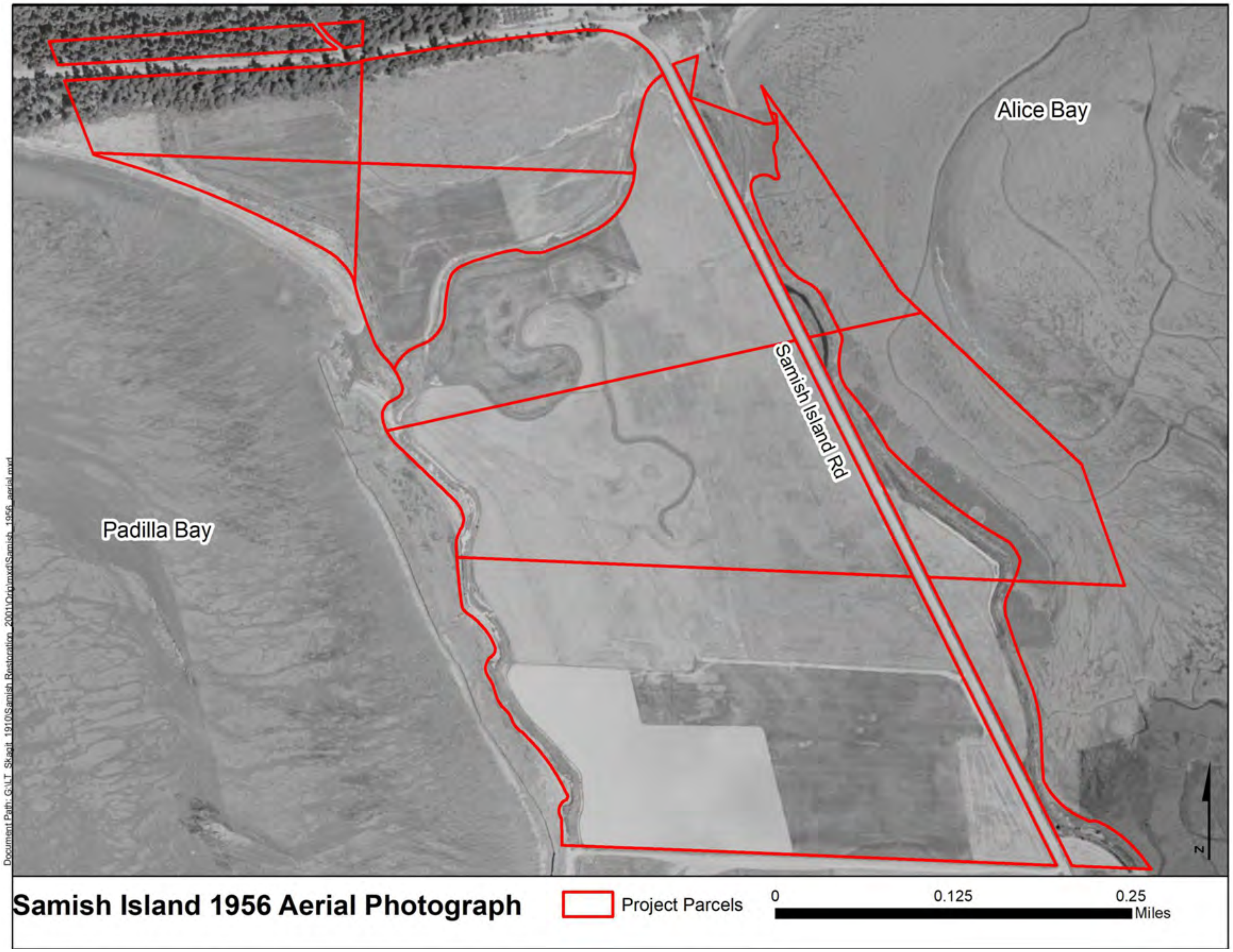


Figure C-4. 1956 aerial photograph (USGS Earth Explorer).

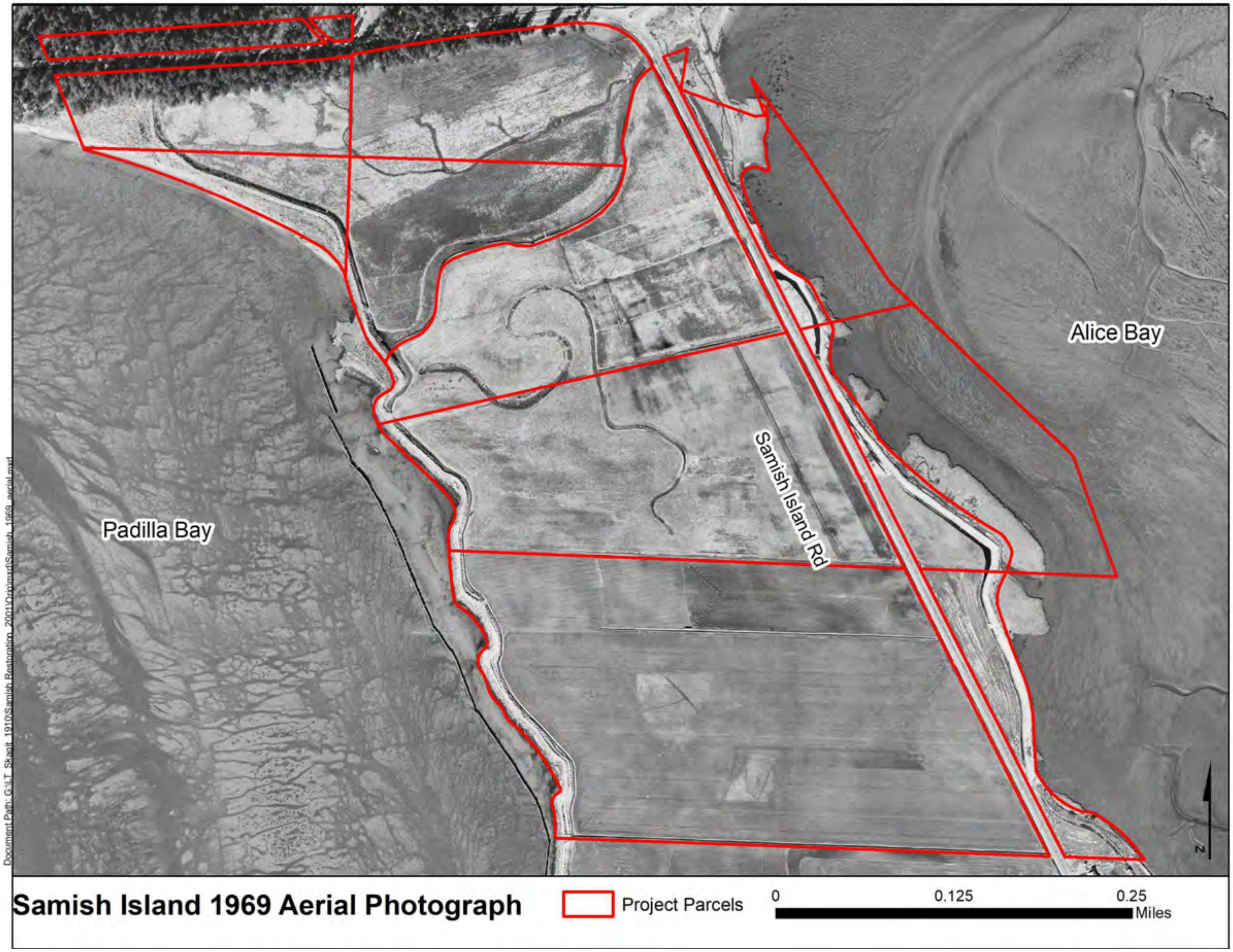


Figure C-5. 1969 aerial photograph (USGS Earth Explorer).

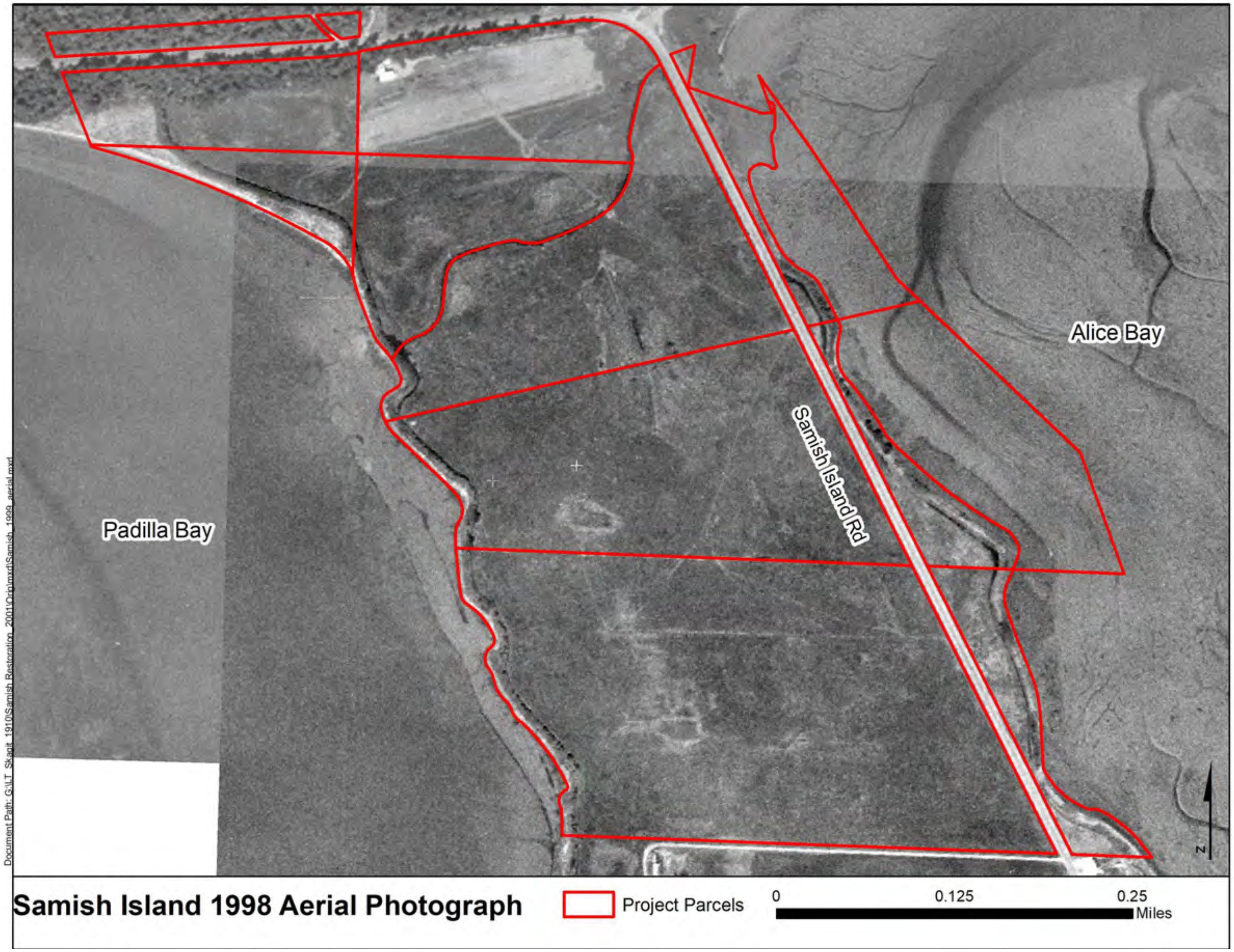
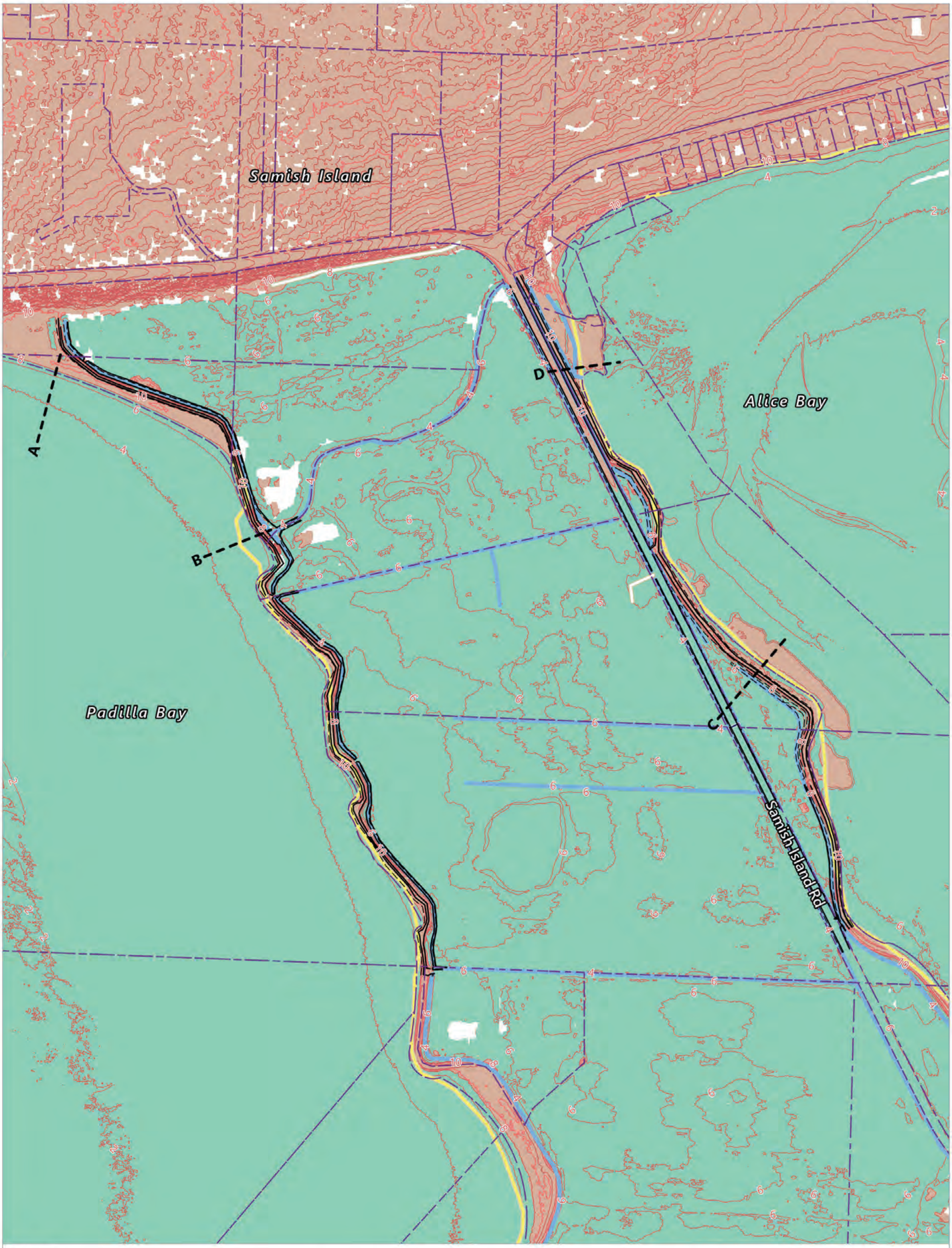


Figure C-6. 1998 aerial photograph.

Figure C-7. 2016 oblique aerial photograph (Ecology 2022).

Appendix D

Flood Inundation Maps



LEGEND:

- Parcel Boundary
- Access Roads
- Ditch/Canal
- Armor Present

Survey Breaklines (Skagit Co.)

- Culvert
- Toe
- Top

Topographic Contour

- Major (10' Interval)
- Minor (2' Interval)

Elevation (ft, NAVD88)

- 🟩 ≤MHHW (+7.9' NAVD88)
- 🟫 >MHHW (+7.9' NAVD88)

NOTES:

1. Horizontal datum is Washington State Plane North Zone, NAD83, U.S. Feet.
2. Vertical datum is North American Vertical Datum of 1988, feet.
4. Parcel boundaries are Skagit County.
5. Topography is LiDAR (NOAA, 2019).
6. Survey breaklines acquired from Skagit County site survey (April 2023).

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Feet

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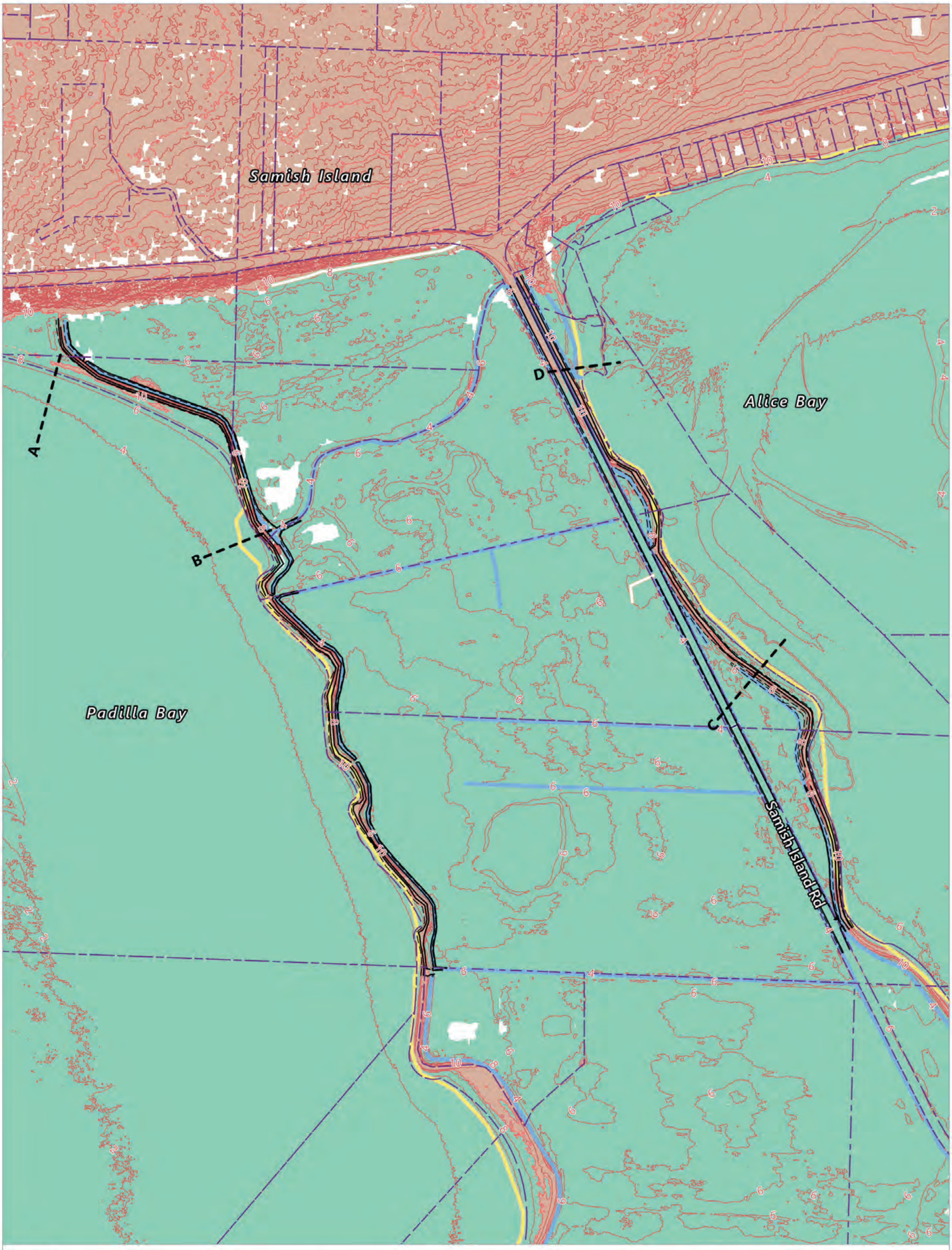
Filepath: G:\LT_Skagit_1910\Samish Restoration_2001\Maps\Samish Island\Samish Island.aprx

BLUE COAST
ENGINEERING

Figure 3a
Inundation/Water Level Map – Mean Higher High Water (+7.9' NAVD88)



LEGEND:

- Parcel Boundary
- Access Roads
- Ditch/Canal
- Armor Present

Survey Breaklines (Skagit Co.)

- Culvert
- Toe
- Top

Topographic Contour

- Major (10' Interval)
- Minor (2' Interval)

Elevation (ft, NAVD88)

- 🟩 ≤HAT (+9.8' NAVD88)
- 🟫 >HAT (+9.8' NAVD88)

NOTES:

1. Horizontal datum is Washington State Plane North Zone, NAD83, U.S. Feet.
2. Vertical datum is North American Vertical Datum of 1988, feet.
4. Parcel boundaries are Skagit County.
5. Topography is LiDAR (NOAA, 2019).
6. Survey breaklines acquired from Skagit County site survey (April 2023).

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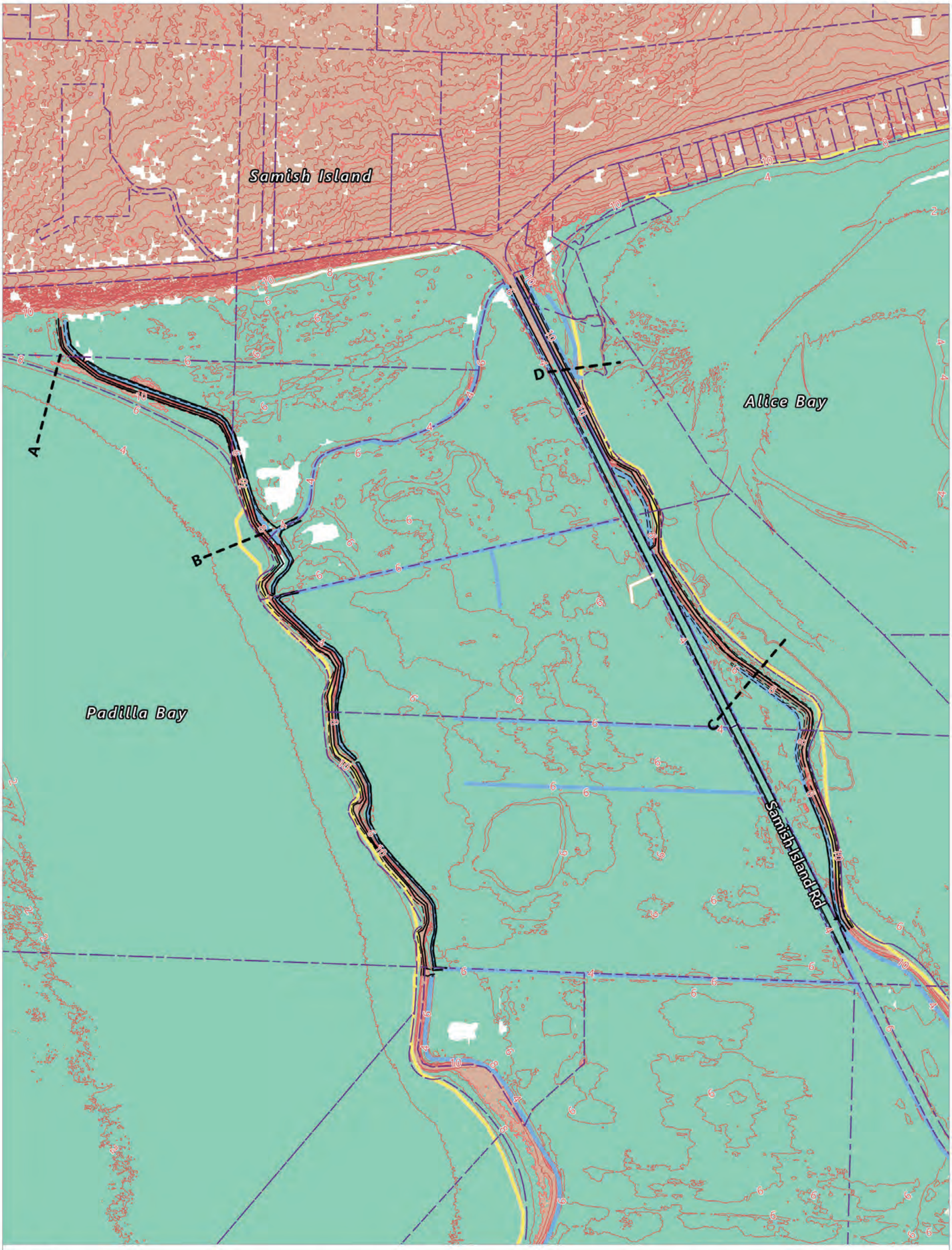
Figure 3b
Inundation/Water Level Map – Highest Astronomical Tide (+9.8' NAVD88)



LEGEND:

- Parcel Boundary
- Access Roads
- Ditch/Canal
- Armor Present

Survey Breaklines (Skagit Co.)

- Culvert
- Toe
- Top

Topographic Contour

- Major (10' Interval)
- Minor (2' Interval)

Elevation (ft, NAVD88)

- 🟩 ≤100-Yr (+10.2' NAVD88)
- 🟫 >100-Yr (+10.2' NAVD88)

NOTES:

1. Horizontal datum is Washington State Plane North Zone, NAD83, U.S. Feet.
2. Vertical datum is North American Vertical Datum of 1988, feet.
4. Parcel boundaries are Skagit County.
5. Topography is LiDAR (NOAA, 2019).
6. Survey breaklines acquired from Skagit County site survey (April 2023).

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Feet

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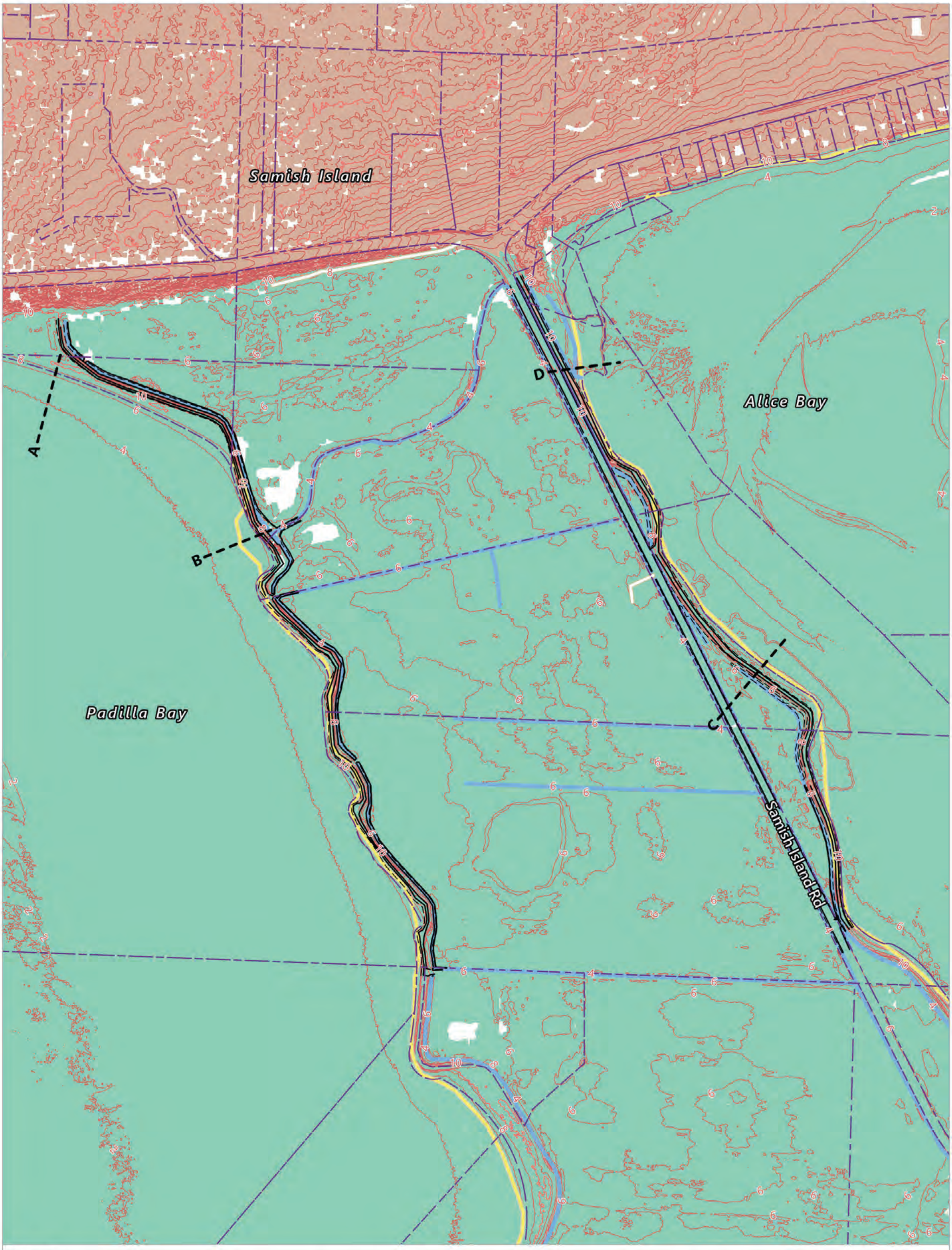
Figure 3c
Inundation/Water Level Map – 100-Year (+10.2' NAVD88)



LEGEND:

- ▭ Parcel Boundary
- ▭ Access Roads
- 🟦 Ditch/Canal
- 🟨 Armor Present

Survey Breaklines (Skagit Co.)

- - - Culvert
- — — Toe
- —— Top

Topographic Contour

- —— Major (10' Interval)
- —— Minor (2' Interval)

Elevation (ft, NAVD88)

- 🟩 ≤FEMA BFE (+13.0' NAVD88)
- 🟫 >FEMA BFE (+13.0' NAVD88)

NOTES:

1. Horizontal datum is Washington State Plane North Zone, NAD83, U.S. Feet.
2. Vertical datum is North American Vertical Datum of 1988, feet.
4. Parcel boundaries are Skagit County.
5. Topography is LiDAR (NOAA, 2019).
6. Survey breaklines acquired from Skagit County site survey (April 2023).

0 500

Feet

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BLUE COAST
ENGINEERING

Figure 3d

Inundation/Water Level Map – FEMA Base Flood Elevation (+13.0' NAVD88)

Samish Island Assessment and Conceptual Design

Appendix E

Plant Inventory (Shannon & Wilson)

Complete Species List

Group	Family	Accepted Name	Common Name	Invasive (Noxious Weeds List)	Introduced	Dominant within Zone
Ferns and Lycophytes	Dennstaedtiaceae	Pteridium aquilinum	Bracken fern			
Ferns and Lycophytes	Equisetaceae	Equisetum arvense	Field horsetail			X
Dicots	Adoxaceae	Sambucus racemosa	Red elderberry			X
Dicots	Amaranthaceae	Salicornia pacifica	Pickleweed			X
Dicots	Amaranthaceae	Atriplex patula	Spear saltbush			X
Dicots	Apiaceae	Daucus carota	Queen Anne's lace		X	
Dicots	Apiaceae	Conium maculatum	Poison hemlock	X	X	X
Dicots	Apiaceae	Heracleum maximum	Cow parsnip			X
Dicots	Asteraceae	Achillea millefolium	Yarrow			X
Dicots	Asteraceae	Ambrosia chamissonis	Silver bursage			
Dicots	Asteraceae	Anaphalis margaritacea	Pearly everlasting			
Dicots	Asteraceae	Arctium minus	Common burdock		X	X
Dicots	Asteraceae	Artemisia suksdorfii	Suksdorf's sagewort			
Dicots	Asteraceae	Bellis perennis	English daisy		X	
Dicots	Asteraceae	Bidens cernua	Nodding beggar-ticks			
Dicots	Asteraceae	Cirsium arvense	Canada thistle	X	X	X
Dicots	Asteraceae	Cirsium vulgare	Bull thistle	X	X	
Dicots	Asteraceae	Cotula coronopifolia	Brass buttons		X	X
Dicots	Asteraceae	Crepis capillaris	Smooth hawksbeard		X	
Dicots	Asteraceae	Grindelia integrifolia	Coastal gumweed			
Dicots	Asteraceae	Hypochaeris radicata	Hairy cat's-ear		X	
Dicots	Asteraceae	Lactuca serriola	Prickly lettuce		X	
Dicots	Asteraceae	Lapsana communis	Nipplewort		X	
Dicots	Asteraceae	Leucanthemum vulgare	Ox-eye daisy		X	X

Group	**Family**	**Accepted Name**	**Common Name**	**Invasive (Noxious Weeds List)**	**Introduced**	**Dominant within Zone**
Dicots	Asteraceae	Matricaria discoidea	Pineapple weed		X	X
Dicots	Asteraceae	Senecio vulgaris	Common groundsel		X	
Dicots	Asteraceae	Sonchus asper ssp. asper	Prickly sowthistle		X	
Dicots	Asteraceae	Tanacetum vulgare	Common tansy		X	
Dicots	Asteraceae	Taraxacum officinale	Common dandelion		X	X
Dicots	Berberidaceae	Mahonia aquifolium	Tall Oregongrape			
Dicots	Betulaceae	Alnus rubra	Red alder			
Dicots	Brassicaceae	Brassica rapa	Common mustard		X	
Dicots	Brassicaceae	Capsella bursa-pastoris	Shepherd's purse		X	
Dicots	Brassicaceae	Cardamine sp.	Bittercress species		?	
Dicots	Brassicaceae	Lepidium virginicum	Tall pepperweed			
Dicots	Caprifoliaceae	Lonicera ciliosa	Orange honeysuckle			
Dicots	Caprifoliaceae	Lonicera involucrata	Black twinberry			
Dicots	Caprifoliaceae	Symphoricarpos albus	Common snowberry			X
Dicots	Caryophyllaceae	Spergularia salina	Saltmarsh sandspurry			X
Dicots	Cornaceae	Cornus stolonifera	Red-osier dogwood			
Dicots	Dipsacaceae	Dipsacus fullonum	Teasel		X	
Dicots	Fabaceae	Cytisus scoparius	Scotch broom	X	X	X
Dicots	Fabaceae	Lathyrus spp.	Peavine species		X	
Dicots	Fabaceae	Lotus corniculatus	Birdsfoot trefoil		X	
Dicots	Fabaceae	Trifolium pratense	Red clover		X	X
Dicots	Fabaceae	Trifolium repens	White clover		X	X
Dicots	Fabaceae	Vicia spp.	Vetch species		?	X
Dicots	Grossulariaceae	Ribes sanguineum	Red-flowered currant			
Dicots	Lamiaceae	Lamium purpureum	Red dead-nettle		X	
Dicots	Montiaceae	Claytonia sibirica	Candyflower			
Dicots	Onagraceae	Chamaenerion angustifolium	Fireweed			

Group	**Family**	**Accepted Name**	**Common Name**	**Invasive (Noxious Weeds List)**	**Introduced**	**Dominant within Zone**
Dicots	Onagraceae	Epilobium ciliatum	Watson's willow-herb			X
Dicots	Plantaginaceae	Plantago lanceolata	English plantain		X	X
Dicots	Plantaginaceae	Plantago major	Common plantain		X	X
Dicots	Plantaginaceae	Plantago maritima	Seaside plantain			
Dicots	Polygonaceae	Rumex acetosella	Sheep sorrel		X	X
Dicots	Polygonaceae	Rumex crispus	Sour dock		X	X
Dicots	Polygonaceae	Rumex occidentalis	Western dock			
Dicots	Ranunculaceae	Ranunculus repens	Creeping buttercup		X	X
Dicots	Rosaceae	Amelanchier alnifolia	Serviceberry			X
Dicots	Rosaceae	Holodiscus discolor	Ocean spray			X
Dicots	Rosaceae	Malus fusca	Pacific crabapple			
Dicots	Rosaceae	Potentilla anserina ssp. pacifica	Pacific silverweed			X
Dicots	Rosaceae	Prunus spp.	fruit trees		X	X
Dicots	Rosaceae	Rosa sp.	Rose species		X	X
Dicots	Rosaceae	Rosa nutkana	Nootka rose			X
Dicots	Rosaceae	Rubus laciniatus	Evergreen blackberry	X	X	X
Dicots	Rosaceae	Rubus parviflorus	Thimbleberry			
Dicots	Rosaceae	Rubus spectabilis	Salmonberry			
Dicots	Rosaceae	Rubus armeniacus	Himalayan blackberry	X	X	X
Dicots	Rosaceae	Spiraea douglasii	Hardhack			
Dicots	Rubiaceae	Galium aparine	Cleavers			X
Dicots	Rubiaceae	Galium trifidum	Small bedstraw			X
Dicots	Sapindaceae	Acer circinatum	Vine maple			
Dicots	Scrophulariaceae	Verbascum thapsus	Common mullein		X	
Dicots	Solanaceae	Solanum dulcamara	Bittersweet nightshade	X	X	
Dicots	Urticaceae	Urtica dioica	Stinging nettle			

Group	**Family**	**Accepted Name**	**Common Name**	**Invasive (Noxious Weeds List)**	**Introduced**	**Dominant within Zone**
Monocots	Cyperaceae	Bolboschoenus maritimus	seacoast bulrush			X
Monocots	Cyperaceae	Eleocharis palustris	Spikerush			X
Monocots	Cyperaceae	Schoenoplectus acutus	Hardstem bulrush			X
Monocots	Iridaceae	Iris pseudacorus	Yellow flag	X	X	
Monocots	Juncaceae	Juncus bufonius	Toad rush			X
Monocots	Juncaceae	Juncus effusus	Soft rush			X
Monocots	Juncaginaceae	Triglochin maritima	seaside arrow-grass			X
Monocots	Poaceae	Bromus commutatus	Meadow brome		X	
Monocots	Poaceae	Dactylis glomerata	Orchard grass		X	
Monocots	Poaceae	Distichlis spicata	Seashore salt grass			X
Monocots	Poaceae	Elymus repens	Creeping ryegrass		X	
Monocots	Poaceae	Leymus mollis	American dunegrass			X
Monocots	Poaceae	Phalaris arundinacea	Reed canarygrass	X	X	X
Monocots	Poaceae	Poa macrantha	Sand-dune bluegrass			
Monocots	Poaceae	Poa pratensis	Kentucky bluegrass		X	X
Monocots	Poaceae	Polypogon monspeliensis	Rabbit's-foot grass		X	
Monocots	Poaceae	Alopecurus geniculatus	Water foxtail			X
Monocots	Poaceae	Agrostis gigantea	black bentgrass, redtop		X	X
Monocots	Poaceae	Agrostis stolonifera	Creeping bentgrass		X	X
Monocots	Poaceae	Holcus lanatus	Velvetgrass		X	X
Monocots	Poaceae	Hordeum brachyantherum	Meadow barley			
Monocots	Poaceae	Festuca rubra	Red fescue			X
Monocots	Poaceae	Schedonorus arundinaceus	Tall fescue		X	X
Monocots	Ruppiaceae	Ruppia maritima	Western ditch-grass			X
Monocots	Typhaceae	Typha angustifolia	Narrowleaf cattail	X	X	X

Appendix F
Geotechnical Characterization Report
(Shannon & Wilson)

SUBMITTED TO:
Blue Coast Engineering
18320 47th Place NE
Lake Forest Park, WA 98155

BY:
Shannon & Wilson
400 N 34th Street, Suite 100
Seattle, WA 98103

(206) 632-8020
www.shannonwilson.com

GEOTECHNICAL CHARACTERIZATION REPORT
Samish Island Restoration Project
SKAGIT COUNTY, WASHINGTON

SHANNON & WILSON

August 20, 2024

Shannon & Wilson No: 108766-002.5

Submitted To:

Blue Coast Engineering
18320 47th Place NE
Lake Forest Park, WA 98155
Attn: Jessica Côté

Subject: GEOTECHNICAL CHARACTERIZATION REPORT, SAMISH ISLAND RESTORATION PROJECT, SKAGIT COUNTY, WASHINGTON

Shannon & Wilson prepared this report and participated in this project as a subconsultant to Blue Coast Engineering LLC. Our scope of services was specified in our Master Subconsultant Agreements with Blue Coast Engineering effective May 31, 2022, and December 12, 2023. This report presents the results of our site reconnaissance and subsurface exploration program and was prepared by the undersigned.

We appreciate the opportunity to be of service to you on this project. If you have questions concerning this report, or we may be of further service, please contact us.

Sincerely,

SHANNON & WILSON

PATRICIA EMILY BENNETT
20122738

Patricia Bennett

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1 INTRODUCTION

This report summarizes Shannon & Wilson's geotechnical characterization in support of the Samish Island Restoration Project (Project) in Skagit County, Washington. Shannon & Wilson provided geotechnical engineering services to observe existing site conditions and evaluate the site geology. Tasks included review of existing geologic information and performing a site reconnaissance, geotechnical explorations, and laboratory testing. In this report, we present a summary of the subsurface and site conditions observed.

1.1 Site Description

The site is located in Skagit County, Washington, south of Samish Island. The Project area is identified by the following Skagit County Assessor tax parcel numbers: P47446, P47450, P47495, P47496, P133563, P47452 and P47454. Figure 1 shows the Project site vicinity map.

Samish Island Road is a two-lane road that is the only access point for Samish Island residents and runs along the north and east side of the Project. The road has a history of flooding, and the existing road grade elevation is approximately 8 feet based on the North American Vertical Datum of 1988 (NAVD88). South of the Project is farmland. Alice Bay and Padilla Bay bound the Project to the east and west, respectively. The existing dike along the western side of the Project area used to be privately owned and maintained but has recently been acquired by the Skagit Land Trust.

1.2 Project Description

The goal of the Project is to restore marine shoreline habitat to the site by removing portions of the existing dike and constructing tidal channels and salt marsh habitat. A portion of the remaining dike will be rebuilt and a new setback dike will be constructed east-to-west across the site to protect the neighboring properties from tidal and storm waves. The Project could also consist of raising and widening portions of Samish Island Road and may include installing new culverts and a new bridge. At the time this report was prepared, Blue Coast Engineering was evaluating four design concepts.

2 GEOLOGIC SETTING

The Project site is within the northern portion of the Puget Lowland. The Puget Lowland is an elongated topographic basin between the Cascade Mountains to the east and the Olympic Mountains and Vancouver Island ranges to the west. Samish Island, north of the

Project, is part of the San Juan Island archipelago. The Project location is at the western margin of the Samish delta, such that Samish Island appears to be connected to the mainland by the prograding delta.

Northwestern Washington was subjected to six or more glacial advances and retreats over the past 2 million years (Booth and others, 2003), each depositing a complex sequence of glacial and nonglacial sediments. The most recent glacial advance was during the Vashon Stade of the Fraser Glaciation. During the Vashon Stade (20,000 to 10,000 years ago), advancing ice from the Cordilleran ice sheet diverged into two lobes around the Olympic Mountains, the Puget lobe and the Juan de Fuca lobe. Soils deposited prior to or during the glacier's advance were overridden and consolidated by the weight of the ice sheet. During the Puget lobe's occupation of the Puget Lowlands, subglacial meltwater streams cut a series of deep, roughly north-south trending troughs, including arms of the Puget Sound, large freshwater lakes, and major river valleys (Collins and Montgomery, 2011).

After reaching its southern extent south of Olympia, Washington, the glacier stagnated and then retreated northward. During the retreat of the Puget lobe, which had fully retreated north of Bellingham by 14,000 years ago (Kovanen and Easterbrook, 2001), the ice sheet blocked major drainages, creating a series of proglacial lakes in the Puget Sound. During the Everson Interstade, the lobe retreated through the northern half of the Puget Lowland, buoying the retreating and thinning ice, resulting in marine and estuarine conditions (Dragovich, 1998).

A complex history of sea level fluctuations and isostatic rebound followed as the glacial ice retreated further northward, the landscape once dominated by glacial ice giving way to Holocene alluvial and mass-wasting processes. Post glacial activity, the Skagit River valley was filled via fluvial, estuarine, and deltaic prosses, and volcanic sediments and lahars from Glacier Peak (Dragovich, 1998). Human development of transportation corridors and other infrastructure has further modified the landscape in the Project area.

Published geologic mapping (Lapen, 2000) shown in Exhibit 2-1 indicates the Project site is underlain by beach deposits (Qb). The beach deposits are described as sand and gravel along the shorelines and includes tidal flat deposits composed of fine sand, silt, and clay. Nearby units consist of alluvium (Qa), glaciomarine drift from the Everson Interstade (Qgdm_e), and glacial till (Qgt). Glacial deposits mantle older metamorphic bedrock consisting of Darrington Phyllite (Jph_d), exposed along the northwest shoreline of Samish Island.

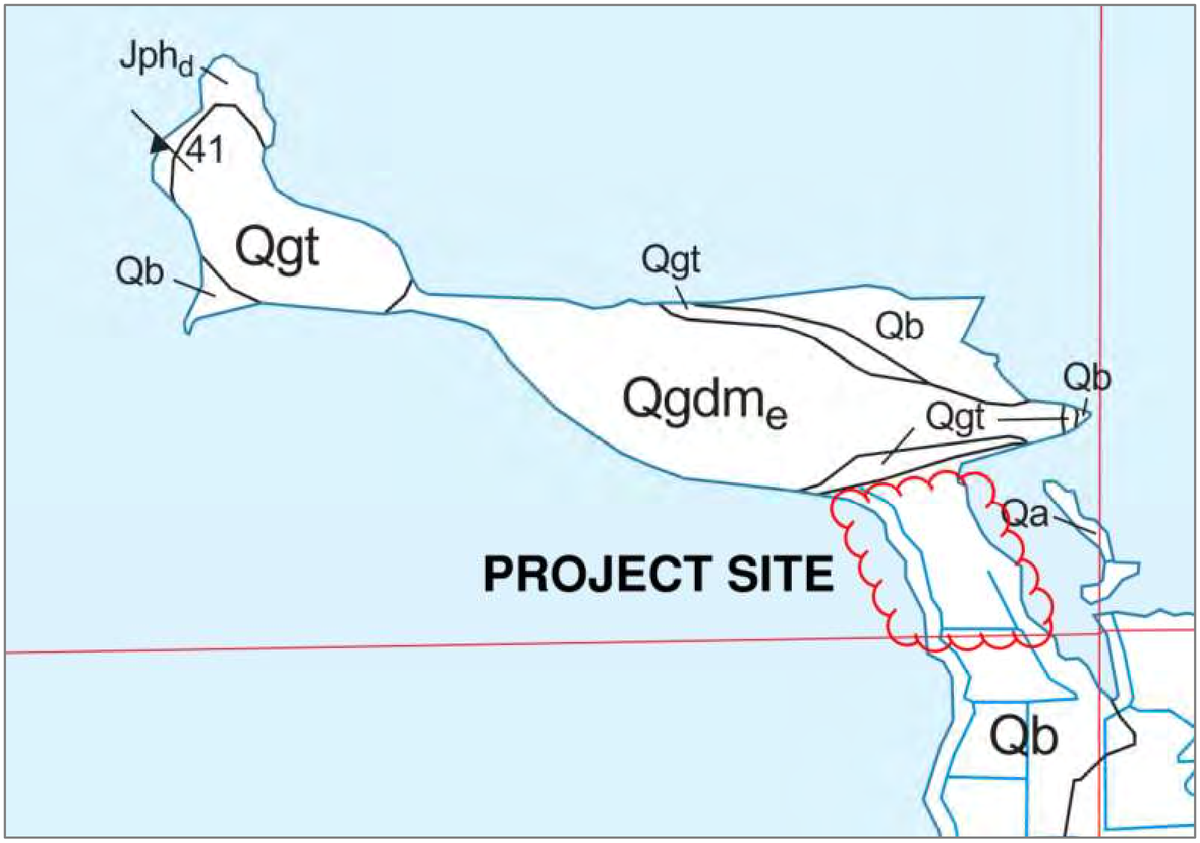

Exhibit 2-1: Project Site Geology

Samish Island used to be separated from the mainland by a channel. The channel was approximately a quarter of a mile wide and connected Alice Bay to the east with Padilla Bay to the west. In 1932, Skagit County filled the S7amésh Seqelích (hereafter referred to as the Slough) and salt marsh area between Alice Bay and Padilla Bay to construct Samish Island Road (Samish Island Community Center, 2024). The T-sheet, shown in Exhibit 2-2, indicates the historical site conditions before the private dikes were developed along the shoreline of the Project area and the salt marsh was filled (Gilbert, 1887).

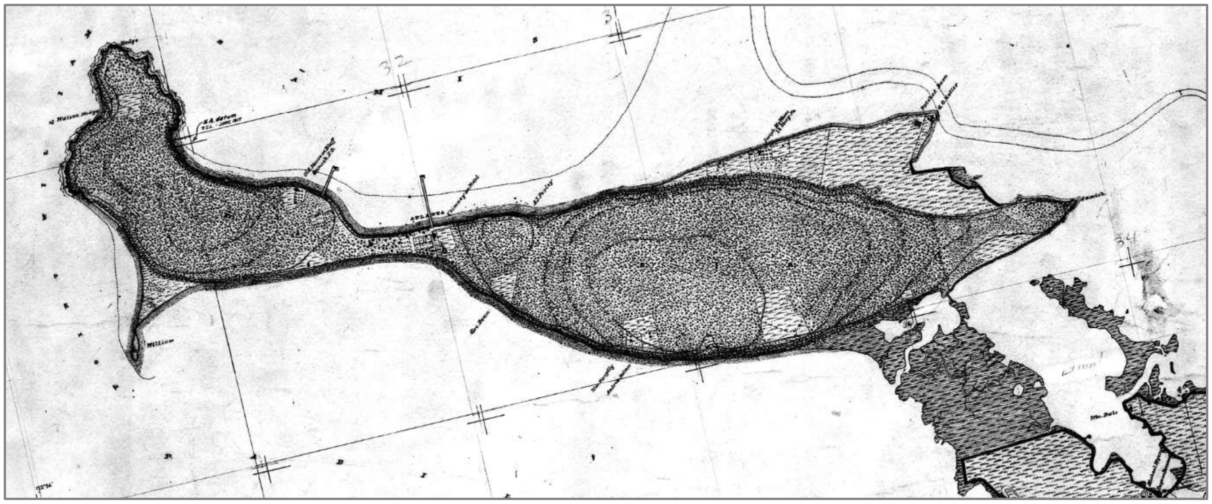

Exhibit 2-2: Historical T-Sheet of Site Conditions

3 FIELD RECONNAISSANCE

We completed a field reconnaissance in the Project area on September 9, 2022, and April 10, 2024. Our reconnaissance was performed along Samish Island Road, along the crest and slope of the existing Padilla Bay dike, and the land area of the general Project site. Slope and crest access around the existing dike was limited due to steep slopes, vegetation, and safety concerns. The reconnaissance did not include a review of the existing Alice Bay dike.

Using a global position system (GPS)-based data collection application, we recorded observations including the extents and conditions of the existing dike, Samish Island Road, and the existing structures within the Project land area. GPS points collected during our field reconnaissance are accurate to within about 3 feet.

During our field reconnaissance we documented observed damage to the existing dike and Samish Island Road. Data points we collected in the field are shown in Figures 2A and 2B and include the following:

- Cracking in the asphalt along Samish Island Road. Cracking includes longitudinal, transverse, and alligator cracks in the pavement.
- Depressions or potholes in the pavement.
- Dike Erosion: shallow face erosion likely caused by surface water runoff or high tide. Erosion was typically noted along the top of the dike.
- Toppled Riprap: face rock moved downslope and beyond the toe of the dike or revetment.
- Undermining: erosion below or behind the toe of the riprap.

- Existing culverts in the land area
- Ditches in the land area

3.1 General Site Conditions

Generally, the observed ground conditions are firm and flat. In the northern portion of the Project area, the ground becomes hummocky and soft. As discussed in Section 2, the northern portion of the site (approximately Parcels P47446 and P47495) used to be a part of the Slough. The softer ground conditions to the north are consistent with the Slough being filled to create access to Samish Island.

There is a wetted ditch approximately 6 feet wide along the southern boundary of Parcel P47496. The ditch is shown in Exhibit 3-1. At the time of our site visits, there were areas of standing ponded water across the site.

Exhibit 3-1: Wetted Ditch, Approximately 6 Feet Wide

We observed three culverts at the site (shown in Figures 2A and 2B at Points A, B, and C). The culverts at Points A and C were heavily vegetated, and we were unable to inspect the conditions of the culvert. The culvert at Point B is comprised of wood and is made of three sections totaling approximately 17 feet in length. The culvert is approximately 4.5 feet in diameter, and we measured 3 feet and 9 inches from the top of the culvert to the sludge beneath the water surface. The interior of the culvert appeared to be in good condition, although the top of the culvert was exposed and cracking on the western end. Exhibit 3-2 shows the culvert at Point B.

Exhibit 3-2: Culvert at GPS Point B

We observed several isolated low spots within the site that may indicate areas of subsidence. These locations are shown in Figures 2A and 2B at GPS points D through I.

3.2 Existing Roadway Conditions

3.2.1 General Description

Samish Island Road is a two-lane road maintained by Skagit County and is the only point of access for residents living on Samish Island. The road was flooded on December 27, 2022, and closed for approximately four hours (Skagit County Public Works Engineering, 2024). The flood resulted in minor shoulder damage, which was repaired with additional gravel by Skagit County Operations staff. The roadway is paved with asphalt with gravel shoulders. A wet ditch was observed along the southbound lane and a dry ditch observed along the northbound lane. Our site reconnaissance only includes the portion of Samish Island Road east adjacent to the Project area, which is approximately 3,500 feet long.

The site reconnaissance in September 2022 documented the roadway conditions adjacent to Parcel 47496. The site reconnaissance in April 2024 updates the area previously documented in 2022 and includes the portions of Samish Island Road adjacent to Parcels P47452 and P47454. During our site reconnaissance, we documented cracking, potholes, depressions, and leaning utility poles.

3.2.2 Observed Damages

We documented localized distress points along Samish Island Road, shown in Figures 2A and 2B. We documented depressions and rutting within the southbound and northbound lanes that vary between 4 to 150 feet long that may be the result of wear and tear.

Approximately ¼-inch-wide longitudinal cracks were observed along the length of the road. The cracks typically range from 4 to 15 feet long. Most of the cracks run along the road alignment and are in the southbound lane. Towards the northern end of the site, we noticed more longitudinal cracks and some transverse cracks, shown in Exhibit 3-3, that extended across the southbound and northbound lanes of Samish Island Road. Longitudinal and transverse cracking are not typically load-related failures and can form due to poorly constructed joints, shrinkage of the asphalt, and the reflective cracking from an underlying layer.

Exhibit 3-3: Transverse Crack in Samish Island Road

We noticed fewer cracks within the northbound lane of Samish Island Road, and the asphalt pavement appears to be in better condition. The utility poles along the southern portion of the road lean towards the east, as shown in Exhibit 3-4. The leaning utility pole locations are shown in Figures 2A and 2B.

Exhibit 3-4: Leaning Utility Pole, Looking North

3.3 Existing Padilla Bay Dike Conditions

3.3.1 General Description

Dense vegetation on the crest of the dike and ponded water along the landward side limited our observations of the dike. The crest of the dike and waterward side can only be accessed at a few locations. We were able to access the waterward side at Point L. Alternative access points are documented at Point Q. Where observed, the top of the dike was relatively flat, with low grassy vegetation and blackberries.

The dike is approximately 3,200 feet in length. Portions of the waterward slope face of the dike are armored by angular stacked rock (riprap). Where present, the riprap slopes generally ranged from about 1 Horizontal to 1 Vertical (1H:1V) to 1.5H:1V. During our site reconnaissance, we observed and documented the dike conditions from the waterward side, as the landward side was typically too heavily vegetated to access. Portions of the crest of the dike are also heavily vegetated.

Along the southern portion of the dike, we observed driftwood along the waterward face and dike crest. It is not clear whether the driftwood was placed as part of the dike armoring or accumulated naturally. The landward side is covered with dune grass and there is a ditch running along the edge of the dike. At different segments, the crest of the dike is overgrown with blackberries. Exhibit 3-5 shows some of the driftwood documented during the site reconnaissance.

Exhibit 3-5: Driftwood Along Dike

We noticed a row of timber piles, a possible pile dike, placed offshore from the dike starting from Point R and extending southward, shown in Exhibit 3-6. The piling is approximately 40 to 100 feet from the waterward face of the dike. At Point Q, we noticed a culvert on the landward side of the dike but were unable to locate the culvert opening on the waterward side. The end of the Project area is at Point S.

Exhibit 3-6: Timber Piling, Looking West

3.3.2 Observed Damages

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. The approximate damaged locations to the dike are shown in Figures 2A and 2B.

The northern portion of the dike, indicated as a red line in Figure 2A, slopes downward to beach elevation and is heavily vegetated with blackberries. There is no visible riprap on this portion of the dike. Along select segments of the dike, there is some bulkhead and piling supporting the riprap, shown in Exhibit 3-7. Seepage was observed through the bulkhead as indicated in Figure 2A near Point M.

Exhibit 3-7: Piling Supporting Riprap

From GPS Point L, there is erosion along the dike, as shown in Exhibit 3-8. There is an approximately 2.5-foot-tall vertical face with no riprap. Similar deterioration is documented along the length of the dike and is shown in Figures 2A and 2B. Typically, the exposed soil where riprap has eroded or fallen away is 1 to 2 feet tall. There are isolated locations of slumped soil near where the driftwood is piled along the waterward side. At GPS Point R, the crest of the dike is undercut.

Exhibit 3-8: Dike Erosion at GPS Point L

4 SUBSURFACE EXPLORATION

To evaluate the subsurface and groundwater conditions, Shannon & Wilson conducted two geotechnical investigations at the Project site. The location of the borings, hand borings, test pits, and standpipe piezometers completed in support of the exploration program are shown in Figure 3.

4.1 Boring Logs

Four (4) borings were performed using hand-auguring techniques to characterize the subsurface conditions at the Project site in 2022. Shannon & Wilson completed the borings on September 26, 2022, and installed standpipe piezometers in select locations. In 2024, Shannon & Wilson subcontracted Holocene Drilling, Inc. of Puyallup, Washington, to drill three (3) additional borings using mud rotary techniques. The borings were developed as standpipe groundwater monitoring wells, and a paired shallow groundwater monitoring well was installed adjacent to the new boring.

The designations, depths, and dates for the borings completed in 2022 and 2024 are summarized in Exhibit 4-1 and Exhibit 4-2, respectively. A GPS unit was used to document the boring coordinates and ground surface elevation during drilling in 2022. Blue Coast Engineering provided surveyed coordinates and elevations for the borings and standpipe piezometers completed in 2024.

Exhibit 4-1: Summary of 2022 Exploration Logs

Boring ID	Latitude	Longitude	Elevation (Feet)	Boring Depth (Feet)	Piezometer Screen Zone Below Grade (Feet)	Date Completed
SB-01	48.5667	-122.4994	5.6	10.4	9.3 to 10.3	9/26/22
SB-02	48.5652	-122.5001	4.8	7.4	7.2 to 8.0 [1]	9/26/22
SB-03	48.5631	-122.5019	4.5	4.4	3.8 to 4.4	9/26/22
SB-04	48.5639	-122.4973	6.6	7.5	NA	9/26/22

NOTES:

Horizontal datum is World Geodetic System 1984 (WGS84). Vertical Datum is North American Vertical Datum of 1988 (NAVD88).

1 Well pushed into soil below bottom of boring.

NA = Not Applicable

Exhibit 4-2: Summary of 2024 Exploration Logs

Boring ID	Latitude	Longitude	Elevation (Feet)	Boring Depth (Feet)	Piezometer Screen Zone Below Grade (Feet)	Date Completed
B-01p-24	48.5663	-122.5033	6.7	50.4	39.0 to 44.0	5/22/24
B-02p-24	48.5615	-122.4992	6.5	51.5	45.0 to 50.0	5/21/24
B-03p-24	48.5591	-122.4960	5.5	51.5	45.0 to 50.0	5/20/24
SP-1-24 [1]	48.5663	-122.5033	6.5	15.0	9.5 to 14.5	5/22/24
SP-2-24 [1]	48.5615	-122.4992	6.5	15.0	10.0 to 15.0	5/21/24
SP-3-24 [1]	48.5591	-122.4960	5.5	15.0	10.0 to 15.0	5/20/24

NOTES:

Horizontal datum is World Geodetic System 1984 (WGS84). Vertical Datum is North American Vertical Datum of 1988 (NAVD88).

1 Paired shallow groundwater monitoring well. Shannon & Wilson did not document the subsurface conditions or collect samples during installation.

A representative from Shannon & Wilson was present during the field explorations to observe the drilling and sampling operations, retrieve representative soil samples for subsequent laboratory testing, and prepare descriptive field logs. The samples were placed in jars and returned to our laboratory for additional visual classification and index testing.

The boring logs are presented in Appendix A. A boring log is a written record of the subsurface conditions encountered in the boring. It graphically shows the geologic units (layers) encountered in the boring and the Unified Soil Classification System symbol of each geologic layer. It also includes the natural water content, penetration resistance, percent fines, and the Atterberg Limits of soil samples at various depths within the boring where tests were performed. Other information shown in the boring logs includes ground surface elevation, types and depths of sampling, descriptions of obstructions and debris encountered in the borings, and observed drilling problems and soil behavior related to caving, raveling, and heave. A soil description and log key for the boring logs is included in Appendix A.

For borings B-01p-24 through B-03p-24, investigation-derived waste (IDW) from the borings consisting of soil cuttings and groundwater produced by the drilling processes was removed from the site by the drilling subcontractor. For the boreholes completed in 2022, the IDW consisted of soil cuttings and was either used to backfill the borehole or spread on-site. Contamination was not encountered in our borings based on visual or olfactory means.

4.2 Test Pits

Seven (7) test pits were excavated to characterize the subsurface conditions at the Project site. Shannon & Wilson subcontracted Jim Sullivan of Bow, Washington, to excavate the test pits on May 9, 2024. Four (4) test pits were installed with a standpipe piezometer. Mott MacDonald was on-site and installed three additional piezometers using a hand-auger. The completed test pits were backfilled with the excavation spoils. The designation and depth for each test pit are documented in Exhibit 4-3.

Exhibit 4-3: Summary of Test Pits

Test Pit ID	Latitude	Longitude	Elevation (feet)	Test Pit Depth (feet)	Installed Piezometer
TP-1	48.5642	-122.4993	5.8	6.0	No
TP-2	48.5447	-122.4976	5.3	6.0	No
TP-3	48.5635	-122.4990	4.9	6.0	Yes
TP-4	48.5602	-122.4976	5.4	6.0	No
TP-5	48.5602	-122.4961	5.6	6.0	Yes
TP-6	48.5592	-122.4989	6.4	7.5	Yes
TP-7	48.5591	-122.4933	5.5	6.0	Yes

NOTE:
Horizontal datum is World Geodetic System 1984 (WGS84). Vertical Datum is North American Vertical Datum of 1988 (NAVD88).

Blue Coast Engineering provided surveyed coordinates and elevations for the test pits. A test pit log was produced for each test pit and includes a photograph of the fully excavated test pit (compiled in Appendix A).

4.3 Soil Sampling

Soil samples from the 2024 borings were obtained in conjunction with the Standard Penetration Test (SPT) at the depths shown in the boring logs. SPTs were performed in accordance with ASTM Designation D1586, Standard Method for Penetration Testing and Split-Barrel Sampling of Soils (ASTM, 2018). SPTs were typically performed every 2.5 feet to the bottom of the borehole. The SPT consists of driving a 2-inch-outside-diameter, split-spoon sampler a distance of 18 inches into the bottom of the borehole with a 140-pound hammer falling 30 inches.

The number of blows required for the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value). The N-value is an empirical parameter that provides a means for evaluating the relative density, or compactness, of granular soils and the consistency, or stiffness, of cohesive soils. N-values are plotted at the midpoint of the sample depths in the boring logs in Appendix A. The relative soil density is determined based on the raw N-value in accordance with ASTM D1586.

During the 2022 exploration program, SPT data was not collected. Samples were collected from hand borings using a 1-inch-diameter auger for evaluation. We collected a composite sample, labeled Lower Sand, from hand borings SB-01 through SB-04. An additional grab sample, labeled GS-01, was collected near GPS Point L from the dike in 2022.

Representative grab samples were collected from select layer intervals during test pit excavations.

Soil samples from the subsurface explorations were labeled, sealed, and taken to the Shannon & Wilson laboratory for additional visual classification and laboratory testing.

4.4 Laboratory Testing

Geotechnical laboratory tests were performed by Shannon & Wilson on selected samples retrieved from Project borings and test pits to classify the soil and determine index and engineering properties of the materials. Laboratory tests included water content determinations, grain-size analyses, and Atterberg Limits tests. Laboratory tests were performed in accordance with applicable ASTM standards. Laboratory test results are presented in Appendix B and incorporated into the logs in Appendix A, as appropriate.

4.5 Groundwater Monitoring

Groundwater data will be collected from the following locations:

- Standpipe piezometers installed in test pits TP-3, TP-5, TP-6, and TP-7

- Borings B-01p-24 through B-03p-24
- Standpipe piezometers SP-1-24 through SP-3-24
- Additional standpipe piezometers, numbered P-1 through P-3, installed by Mott MacDonald

It is our understanding that Mott MacDonald will conduct the groundwater monitoring, analysis, and reporting program.

5 SUBSURFACE CONDITIONS

5.1 Soil Characterization

The soil stratigraphy at the site is variable from north to south. The northern boring, B-01p-24, is in close proximity to Samish Island and has denser materials associated with glacial deposits that mantle Samish Island. Borings B-02p-24 and B-03p-24 to the south encountered normally consolidated materials associated with prograding delta and marine/estuarine environments.

B-01p-24 is near the former Slough and a previously demolished building. B-01p-24 encountered about 5 feet of topsoil and very soft silt with sand and trace organics. Underlying the surficial soil is about 7 feet of medium dense to dense gravel with sand and cobbles. Between about 12 and 15 feet below ground surface (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. We interpret these materials as 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. We interpret this material as advance outwash; soil that typically underlies glacial till that was deposited as the glacier advanced.

B-02p-24 encountered about 7 feet of very soft elastic silt and silt with sand, trace wood and organic debris was present. Below that, medium dense poorly graded sand with silt and silty sand graded to loose silt with sand to about 20 feet bgs. Between about 20 to 33 feet bgs, the boring encountered very soft silt and silty clay and medium stiff silt with trace shells, organics, and variable amounts of sand, likely representing an estuarine environment. Loose to medium dense sand, silty sand, and sandy silt layers with shell, organics, and wood, graded finer with depth to the bottom of the boring.

B-03p-24 encountered topsoil and very soft silt to about 5 feet bgs. Below that, layers of loose to medium dense silty sand and poorly graded sand extended to the bottom of the boring. Shells and organics were not observed in these soil samples.

Hand borings (SB-01 through SB-04) and test pits (TP-1 through TP-7) represent the upper 4 to 10 feet of surficial soils across the project site. SB-01 and SB-02 are near the former Slough shown in Exhibit 2-2. In general, surficial soils across the site consisted of about 1 foot to 2 feet of silt over a medium to high plasticity elastic silt. In some test pit locations, the upper silt layer was marked by a sharp contact of oxidized and/or organic layer with the underlying elastic silt. 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. The historic beach deposits were likely tidally influenced.

Portions of the surficial soils will be excavated to regrade the site and construct the new tidal channels. Based on the conditions documented in the explorations, the excavated material will likely consist of either silt, elastic silt, or silty sand with organic material and wood debris. These soils are not a suitable material for reuse within the proposed new setback levee or roadway prism, as the high fines content and plasticity can make this material difficult to place and compact when wet or during wet conditions. Additionally, the proposed setback levee and roadway prism should be generally free of organic material and wood debris to avoid unwanted future settlement and the creation of seepage pathways. The excavated material can be reused as a topsoil, as part of the salt marsh habitat grading, or as a shell placed over the levee and roadway prism to support grass and plantings.

5.2 Plow Pan

The Project site was previously used for agricultural development that included tilling. Plow pan can develop from routine tilling from 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. We observed signs of plow pan approximately 2 feet bgs while excavating the test pits, as shown in Exhibit 5-1.

Exhibit 5-1: Plow Pan Observed in TP-1

5.3 Subsidence

Subsidence is a gradual settling or sinking of the ground surface that is not typically associated with horizontal movement. During our site reconnaissance visits in 2022 and 2024, we documented localized low spots within the Project site, as discussed in Section 3.1 and shown in Figures 2A and 2B. Test pits TP-1, TP-3, and TP-4 were located near the observed low spots. The soil conditions consist of approximately 2 to 3 feet of silt with sand overlying elastic silt and silt with sand to silty sand. Organics, such as wood debris and roots, were documented within the test pits. Seepage was observed within the test pits at approximately 2 feet bgs. In TP-1, we observed additional seepage at 5 feet bgs and artesian boils at the base of the test pit.

Localized subsidence may be caused by the settlement and consolidation of the silt at the Project site, decay of organic material, or loss of material due to groundwater flowing across the site.

6 POTENTIAL VARIATION

Our geologic site characterization is based on the existing subsurface information and the field exploration and laboratory testing program described previously. Our interpretations are specific to the locations and depths noted in the exploration logs in Appendix A and may not be applicable to all areas of the Project. No number of explorations can precisely predict the characteristics, quality, or distribution of subsurface and site conditions. Potential variation includes, but is not limited to the following:

- The conditions between and below explorations may be different.
- The passage of time or intervening causes (both natural and manmade) may result in changes to site and subsurface conditions.
- Groundwater levels at the site fluctuate due to tidal influences and seasonal variations and may be higher than observed during the exploration activities.
- Contaminated soil was not noted in the documents that we reviewed, nor were contaminated soils encountered during our field investigation. However, contaminated soils may be present in areas where soil explorations were not performed.
- Penetration tests in gravelly soils may be unrealistic. Actual soil density may be lower than estimated from the penetration test if the test was performed on gravel or cobble.

If conditions different from those described herein are encountered during future design or construction, we should review our description of the subsurface conditions and reconsider our site characterization where necessary.

7 CLOSURE

This report was prepared for the exclusive use of Blue Coast Engineering, Skagit Land Trust, and the Padilla Bay National Estuarine Research Reserve for the characterization of the Project site as it relates to the geotechnical and geological aspects discussed in this report.

Unanticipated soil and groundwater conditions are commonly encountered and cannot be fully determined by merely performing a site reconnaissance or taking samples from a limited number of explorations. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. Therefore, a contingency fund is recommended to accommodate such potential extra costs.

The scope of our services did not include any environmental assessment or evaluation regarding the presence or absence of wetlands, or hazardous or toxic materials; in the soil, surface water, groundwater, or air; on, below, or around the site. Shannon & Wilson has qualified personnel to assist you with these services should they be necessary.

We have prepared the enclosed "Important Information About Your Geotechnical Report" to assist you and others in understanding the use and limitations of this report. Please read this document to learn how you can lower your risks for this project.

8 REFERENCES

ASTM International, 2018, Standard test method for standard penetration test (SPT) and split-barrel sampling of soils, D1586-18e1: West Conshohocken, Pa., ASTM International, Annual book of standards, v. 04.08, soil and rock (I): D420 - D5876, 26 p., available: www.astm.org.

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Samish Island Restoration Project
Skagit County, Washington

VICINITY MAP

August 2024
108766-002.5

SHANNON & WILSON, INC.

FIG. 1

Filename: C:\Users\jrs\CAD Group Dropbox\JDrive_SEA\108766\002.5\108766-002.5 Vicinity Map.dwg Date: 06-10-2024 Login: JRS

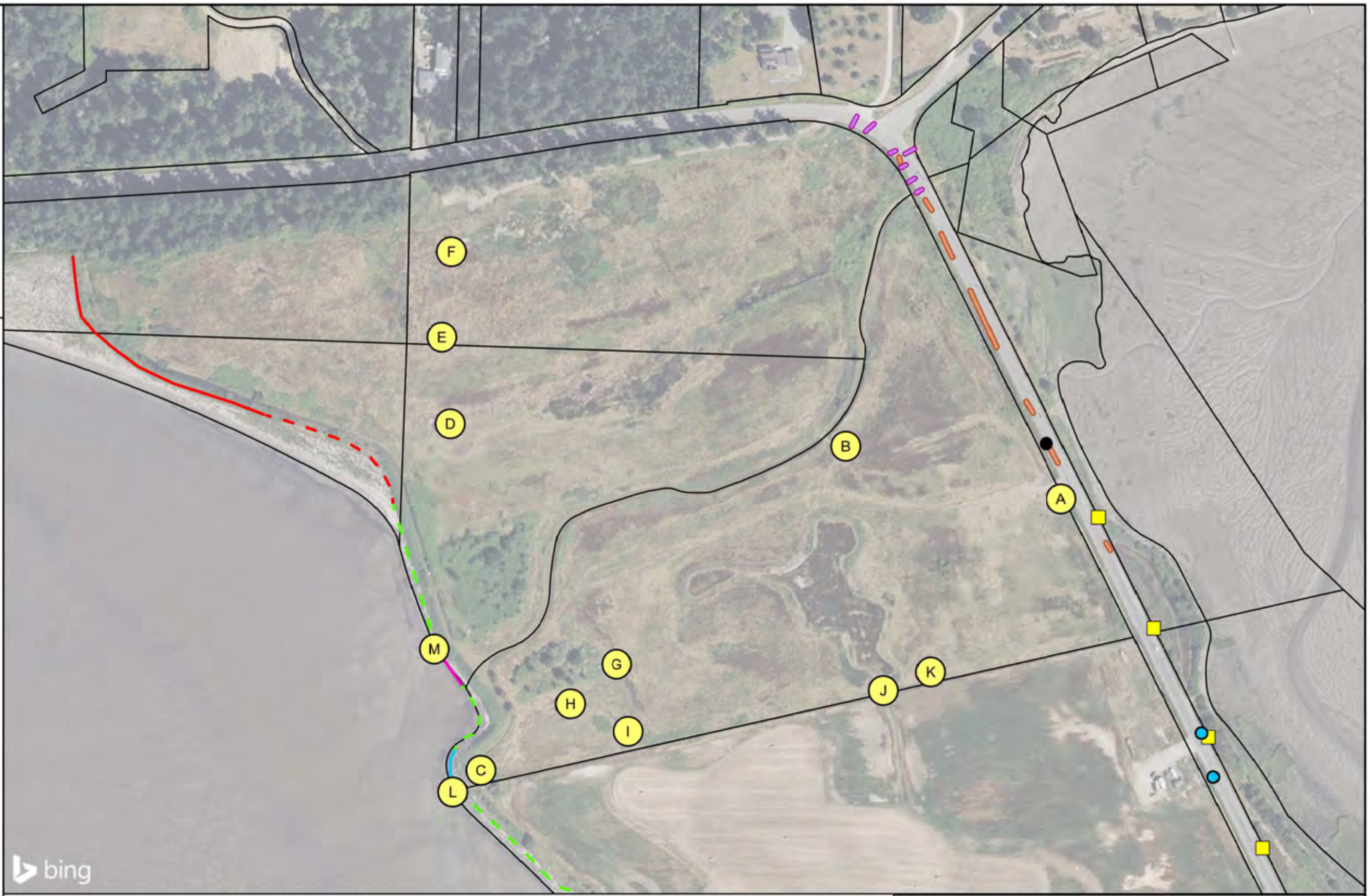
LEGEND

Observations

- No visible riprap.
- No visible riprap - no access to dike.
- Riprap - Large, visible on waterside levee slope, no access to dike.
- Riprap - Large upper slope, small lower slope, visible on waterside dike slope.
- Bulkhead & Piling Extent - bulkhead and riprap supported by piles, bulkhead is moist.
- Longitudinal Road Crack
- Transverse Road Crack
- Dike crest is overgrown with blackberries.
- Driftwood along waterside levee slope and along the dike crest, signs of overtopping.
- ● Bump or rise in road.
- 🟨 Leaning Utility Pole
- ● Pothole
- Ⓐ Observations

OBSERVATION & NOTES

A. Culvert – heavily vegetated, can't access to inspect
B. Culvert – round, wood, approx. 17-ft long, 4.5-ft diameter, good condition
C. Culvert – heavily vegetated, can't access to inspect
D. Change in material, low spot, less grass
E. Change in material, low spot, dry, cracking, less grass
F. Change in material, low spot, dry, cracking, less grass
G. Board Crossing, wooden board crossing low point, old channel
H. Low Spot
I. Low spot
J. Old ditch – goes across property boundary
K. Ditch
L. The top 2.5-ft of levee is exposed, near vertical, approximately 30 feet long
M. Top 3-ft of levee eroded, bare soil, no rock, observed signs of seepage along bulkhead.
N. Slumping along the waterward side of dike
O. Deteriorated piles and old cribbing
P. Isolated arch of soil, approximately 15-feet long and 1-ft tall
Q. Culvert – potential access point to dike
R. Start of off-shore timber piling. The crest of the dike is undercut.
S. End of project



Samish Island Restoration Project
Skagit County, WA

RECONNAISSANCE MAP

August 2024

108766

SHANNON & WILSON

FIG. 2A

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LEGEND

Observations

- No visible riprap.
- No visible riprap - no access to dike.
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- 🟨 Leaning Utility Pole
- ● Pothole
- Ⓐ Observations

OBSERVATION & NOTES

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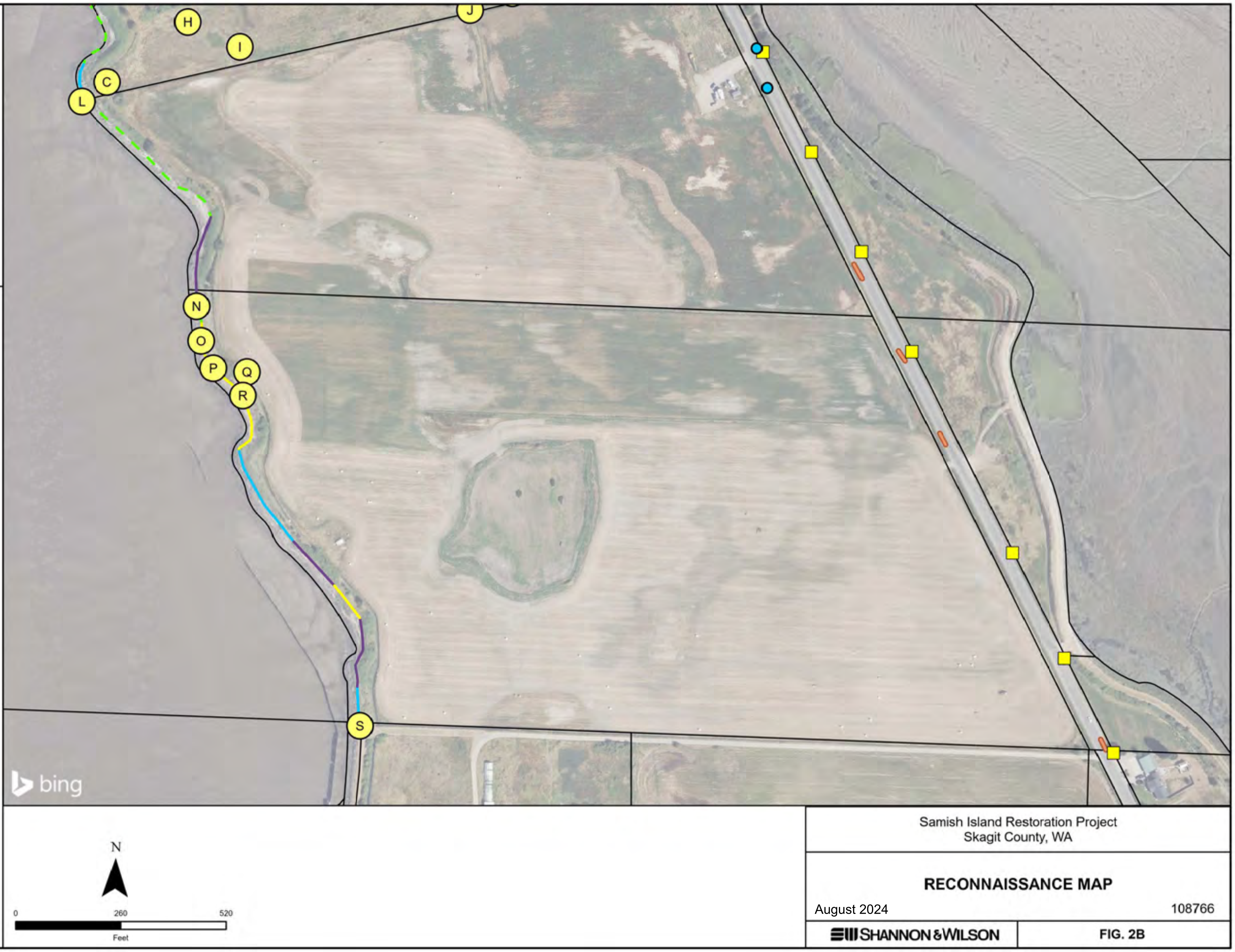
E. Change in material, low spot, dry, cracking, less grass
F. Change in material, low spot, dry, cracking, less grass
G. Board Crossing, wooden board crossing low point, old channel
H. Low Spot
I. Low spot
J. Old ditch – goes across property boundary
K. Ditch
L. The top 2.5-ft of levee is exposed, near vertical, approximately 30 feet long
M. Top 3-ft of levee eroded, bare soil, no rock, observed signs of seepage along bulkhead.
N. Slumping along the waterward side of dike
O. Deteriorated piles and old cribbing
P. Isolated arch of soil, approximately 15-feet long and 1-ft tall
Q. Culvert – potential access point to dike
R. Start of off-shore timber piling. The crest of the dike is undercut.
S. End of project



Samish Island Restoration Project
Skagit County, WA

RECONNAISSANCE MAP

August 2024
108766

SHANNON & WILSON

FIG. 2B

LEGEND

B-01p-24 SP-1-24 P-1 ◉	Designation and Approximate Location for Boring *(Shannon & Wilson, 2024)*, Standpipe Piezometer *(Shannon & Wilson, 2024)*, and Standpipe Piezometer *(Mott MacDonald, 2024)*
TP-1 ▨	Test Pit Designation and Approximate Location *(Shannon & Wilson, 2024)*
SB-01 ▲	Hand Auger Boring Designation and Approximate Location *(Shannon & Wilson, 2022)*

0 400 800

Scale in Feet

Samish Island Restoration Project
Skagit County, Washington

EXPLORATION PLAN

August 2024 108766-002.5

SHANNON & WILSON, INC.

FIG. 3

Appendix A

Exploration Logs

CONTENTS

- Shannon & Wilson Boring and Test Pit Logs

SOIL CLASSIFICATION

Shannon & Wilson uses a soil identification system modified from the Unified Soil Classification System (USCS) as described on this Key.
Soil descriptions are based on visual-manual procedures (ASTM D2488) and available laboratory index test results (ASTM D2487).

Exhibit A: Unified Soil Classification System (USCS)[1]

Major Divisions			Symbol / Graphic	Typical Identifications (USCS Group Names)[2,4]
COARSE-GRAINED SOILS *(> 50% of soil is retained on the No. 200 sieve[3])*	**GRAVELS** *(< 50% of coarse fraction retained on the No. 4 sieve[3])*	**Gravel** *(< 5% fines[3])*	GW	Well-graded Gravel; Well-Graded Gravel with Sand
			GP	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(> 12% fines[3])*	GM	Silty Gravel; Silty Gravel with Sand
			GC	Clayey Gravel; Clayey Gravel with Sand
	SANDS *(≥ 50% of coarse fraction retained on the No. 4 sieve[3])*	**Sand** *(< 5% fines[3])*	SW	Well-graded Sand; Well-graded Sand with Gravel
			SP	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(> 12% fines[3])*	SM	Silty Sand; Silty Sand with Gravel
			SC	Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(≥ 50% of soil passes the No. 200 sieve[3])*	**SILTS AND CLAYS** *(liquid limit < 50)*	**Inorganic**	ML	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly, Lean Clay
		Organic	OL	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly, Organic Silt or Clay
	SILTS AND CLAYS *(liquid limit ≥ 50)*	**Inorganic**	MH	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly, Elastic Silt
			CH	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly, Fat Clay
		Organic	OH	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly, Organic Silt or Clay
HIGHLY ORGANIC SOILS	*Primarily organic matter, dark in color, and organic odor*		PT	Peat or other Highly Organic Soils (see ASTM D4427)

***NOTE:** For gravels and sands with 5 to 12% fines[3], the following are added to the Group Name:*
with Silt and/or Clay or Silty Clay.
Dual Symbols are used:
GW-GM, GP-GM, SW-SM, SP-SM
GW-GC, GP-GC, SW-SC, SP-SC

EXHIBIT A NOTES:
1. Adapted, with permission, from USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488.
2. Borderline symbols (symbols separated by a slash) indicate that the soil characteristics are close to the defining boundary between two groups (e.g., CL/ML = Lean Clay to Silt; SP-SM/SM = Sand with Silt to Silty Sand).
3. No. 4 size = 4.75 millimeters (mm) = 0.187 inch; No. 200 sieve size = 0.075 mm = 0.003 inch. Particles smaller 0.075 mm are termed "fines".
4. Poorly graded indicates a narrow range or missing grain sizes. Well-graded indicates a full-range and even distribution of grain sizes.
5. If cobbles and/or boulders are observed, "with cobbles" or "with boulders" or "with cobbles and boulders" is added to the Group Name.

Exhibit B-1: Standard Penetration Test (SPT)

Term	Description
Hammer	140-pound weight with a 30-inch free fall. Hammer types vary (e.g., automatic, rope and cathead). If available, the hammer type and energy ratio (E-ratio) is noted on the boring log.
Sampler	Barrel I.D. / O.D. = 1.5 inches / 2 inches (liner not used) Barrel Length = 30 inches; Shoe I.D. = 1.375 inches
N-Value (N)[1]	Sum of the count of hammer blows to penetrate the second and third 6-inch increments in blows per foot (bpf). **Refusal**: 50 blows for 6 inches or less or 10 blows for 0 inch.

Exhibit B-2: Relative Density/Consistency Based on SPT

COHESIONLESS SOILS		COHESIVE SOILS	
N[2] (bpf)	Density Term	N[2] (bpf)	Consistency Term
0 - 4	Very Loose	0 - 2	Very Soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium Dense	4 - 8	Medium Stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very Dense	15 - 30	Very Stiff
		> 30	Hard

EXHIBIT B NOTES:
1. N-values shown on boring logs are as recorded in the field and have not been corrected for hammer energy, overburden, or other factors. Where the hammer E-ratio is available, the N-value normalized to a ratio of 60% (N_{60}) is listed.
2. Based on ASTM Standard D1586. Relative densities/consistencies noted on the boring logs are based on uncorrected N-values.

Exhibit C: Soil Structure[1]

Term	Description
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Fissured	Breaks along definite planes or fractures with little resistance.
Homogeneous	Same color and appearance throughout.
Interbedded	Alternating layers at least 1/4 inch thick of varying material or color. *Singular: bed*
Laminated	Alternating layers less than 1/4 inch thick of varying material or color. *Singular: lamination*
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.

EXHIBIT C NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit D: Soil Plasticity[1]

Term	Description
Nonplastic	Cannot roll a 1/8-inch thread at any water content.
Low Plasticity	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.
Medium Plasticity	A thread is easy to roll and not much time in rolling is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.
High Plasticity	It takes considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.

EXHIBIT D NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit E: Soil Moisture Content[1]

Term	Description
Dry	Absence of moisture, dusty, dry to the touch.
Moist	Damp but no visible water.
Wet	Visible free water, from below water table.

EXHIBIT E NOTE:
1. Adapted, with permission, from ASTM D2488 (Figure 2).

Exhibit F: Soil Cementation[1]

Term	Description
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

EXHIBIT F NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit G: Percentages

Term	Percent[1]
Trace	<5
Few	5 to 10
Little	15 to 25
Some	30 to 45
Mostly	>50

EXHIBIT G NOTE:
1. Percent estimated by weight for sand and gravel, and by volume for cobbles, organics, and other non-soil material (e.g., rubble, debris).

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LOG KEY

SOIL CLASSIFICATION *(continued)*

See Page 1 for Soil Classification Exhibits A through G

Exhibit H: Particle Angularity and Shape[1]

Term	Description
Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width to thickness ratio > 3.
Elongated	Width to thickness ratio < 3.

EXHIBIT H NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit I: Additional Descriptive Terms

Term	Description
Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling action.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

SOIL CLASSIFICATION REFERENCES:
ASTM International, [current edition], Annual book of standards, v. 04.08, soil and rock (I): D420 - D5876, available: www.astm.org.
U.S. Army Corps of Engineers, 1953, The unified soil classification system: Vicksburg, Miss., Waterways Experiment Station, Technical Memorandum 3-357, 2 v., March.

SYMBOLOGY AND GRAPHICS

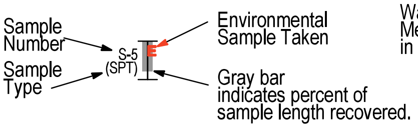
Exhibit J: Sample and Run Graphics

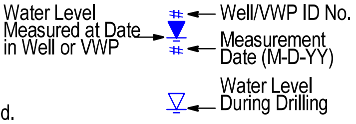
Graphic	Description	Graphic	Description	Graphic	Description
⌶	SPT split spoon (2.5-inch OD)	⌶	Split spoon (SS) (diameters vary)	■	Core run (typically rock)
⧗	Grab (GB) from cuttings or excavation	‖	Modified California (MC) sampler	▯	Sheath (SH) (used for geoprobes)
⌶	Tube (TB) (e.g., Shelby, piston)	⌇	Sonic core (SC) run (typically soil)		

Exhibit K: Hole Backfill and Instrument Graphics

Graphic	Description	Graphic	Description	Graphic	Description
▧	Bentonite-cement grout	▦	Surface cement seal	▥	Blank pipe or instrument casing
▨	Bentonite grout	░	Sand filter pack	☰	Perforated or slotted pipe
▩	Bentonite chips	▧	Slough *(hole caved)*	■	VWP and electric lead

Exhibit L: Other Log Symbols





ROCK CLASSIFICATION

Shannon & Wilson uses a rock classification system modified from the system recommended by the International Society for Rock Mechanics (ISRM). Copyright limitations prevent us from reproducing summary tables from the ISRM system on this Key. General descriptions are provided in Exhibit M.

Exhibit M: General Rock Descriptive Terms - ISRM

Term	General Description
Strength	Ranges from extremely weak (q_u = 36 to 135 psi) to extremely strong (q_u > 36,250 psi), and is based on the ability to break the rock with a hammer or scrape the rock with a knife.
Weathering	Ranges from fresh (no visible signs of weathering) to completely weathered, based on observed degree of discoloration, decomposition, and/or disintegration. When the rock material has completely converted to soil, it is termed a residual soil.
Fabric	Describes the rock structure based on observed layering, tendency to break, and distribution of minerals (e.g., massive, bedded, foliated).
Roughness	For discontinuities: Includes rough, smooth, and slickensided, and includes other descriptive terms (e.g., stepped, undular, irregular, planar).
Spacing	For discontinuities: Ranges from extremely close (< 1 inch) to extremely wide (> 20 feet).
Persistence	For discontinuities: Ranges from very low to very high.
Other	Description of discontinuities (joints, fractures, bedding planes, etc.), observations of potential displacement, gouge, shear, etc.

REFERENCE: Brown, E. T., ed., 1981, Rock characterization, testing & monitoring: International Society of Rock Mechanics (ISRM) suggested methods: Oxford, Pergamon Press, 211 p.

Exhibit N: Rock Name Graphics

No rock names defined for this Project

Exhibit O: Recovery and RQD Equations[1]

Term	Equation
Core Recovery (REC) in %	$100\% \times \frac{\text{Length of Core Recovered}}{\text{Length of Core Run}}$
Rock Quality Designation (RQD) in %	$100\% \times \frac{\text{Length of Core in Pieces > 4 in}}{\text{Length of Core Run}}$

REFERENCE: Loehr, J. E.; Lutenegger, A.; Rosenblad, B.; and Boeckmann, A., 2016, Geotechnical site characterization: U.S. Federal Highway Administration Report FHWA NHI-16-072, Geotechnical Engineering Circular no. 5, 1 v.

ACRONYMS AND ABBREVIATIONS

ATD	at time of drilling
bpf	blows per foot
dia, diam	diameter
Elev.	elevation
ENV	environmental sample
ETR	energy transfer ratio (hammer)
FC	fines content (< 0.075 mm)
FeO	iron oxide
ft or '	foot or feet
gal	gallons
GP	geoprobe
GWT	groundwater table
HSA	hollow-stem auger
ID	inside diameter or identification
in or "	inch
incl	inclinometer
ksf	kips per square foot
lbs	pounds
LL	liquid limit
mm	millimeter
N	field (uncorrected) SPT N-value
N_{60}	SPT N-value corrected for 60% ETR
NA, n/a	not applicable or not available
NE	northeast
NP	nonplastic
NR	no recovery
NW	northwest
OC	organic content
OD	outside diameter
OW	observation well
pcf	pounds per cubic foot
PI	plasticity index
PID	photoionization detector
PL	plastic limit
PMT	pressuremeter test
PP	pocket penetrometer reading
ppm	parts per million
psi	pounds per square inch
PT	nonstandard penetration test N-value
REC	recovery
REF	refusal
RQD	rock quality designation (ASTM D6032)
SC	sonic core
SE	southeast
SPT	Standard Penetration Test (ASTM D1586)
SW	southwest
TP	test pit
tsf	tons per square foot
TV	tor vane reading
UCS, q_u	unconfined compressive strength
USCS	Unified Soil Classification System
VST	vane shear test
VWP	vibrating wire piezometer
WC	natural water content
WOH	weight of hammer
WOR	weight of rods

Samish Island Restoration Project
Skagit County, Washington

B-01p-24
Page 1 of 2

EXPLORATION INFORMATION

Total Depth:	50.4 feet
Top Elevation:	6.7 feet
Vertical Datum:	NAVD88
Latitude:	48.5663246 degrees
Longitude:	-122.5032520 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	May 22, 2024
Hole Finish Date:	May 22, 2024

DRILLING INFORMATION

Drilling Method:	Mud Rotary
Drilling Company:	Holocene
Drill Rig Equipment:	Diedrich D-50
Hole Size:	n/a
Rod Type/Dia.:	n/a
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	96%
Well Tag No.:	BQB 683

BASIC LEGEND
(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

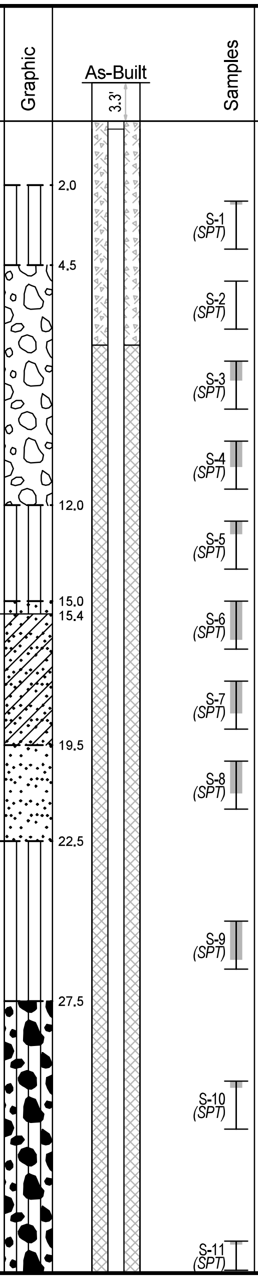
Symbols

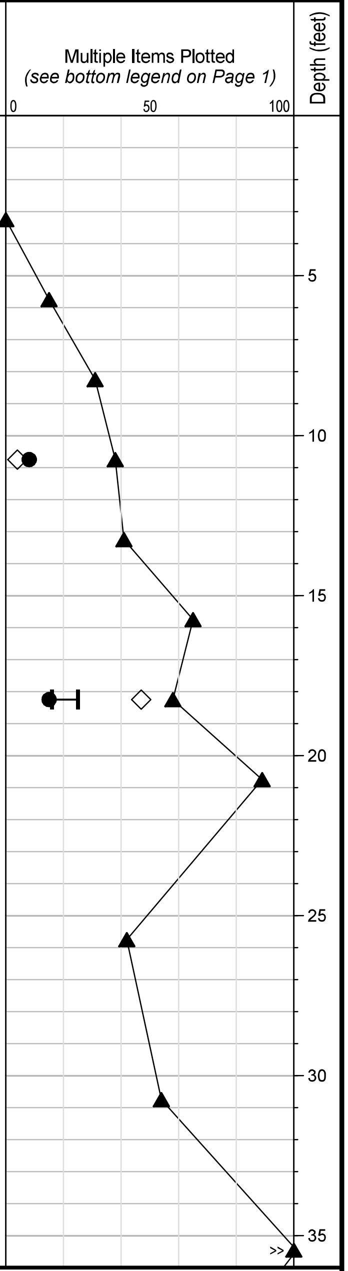
Sample Number → S-5; Sample Type → (SPT); Gray bar indicates percent of sample length recovered.

Water Level During Drilling → ▽

Water Level Measured at Date in Well or VWP → ▼ ← ID No. / Measurement Date (M-D-YY)

Depth (feet)	Material Description and Other Observations	Samples	Field Data	Lab Data
0	***TOPSOIL***			
2.0	Very soft, brown to yellow-brown, ***SILT WITH SAND*** (ML); wet; fine sand; trace organics.	S-1 (SPT)	N = 0,0,0 (0 bpf)	
4.5	Medium dense to dense, gray, ***POORLY GRADED GRAVEL WITH SAND AND COBBLES*** (GP); wet; fine to coarse, rounded to subrounded gravel; fine to coarse sand; trace silt.	S-2 (SPT)	N = 12,7,8 (15 bpf) NR	
		S-3 (SPT)	N = 9,16,15 (31 bpf)	
		S-4 (SPT)	N = 13,18,20 (38 bpf)	WC=8% FC=4%
12.0	Dense, gray, ***SANDY SILT WITH GRAVEL*** (ML); moist; fine to coarse, subrounded to subangular gravel; fine to medium sand.	S-5 (SPT)	N = 2,16,25 (41 bpf)	
15.0	Very dense, gray-brown, ***SILTY SAND*** (SM); moist; fine to medium sand; trace iron oxide staining.	S-6 (SPT)	N = 19,29,36 (65 bpf)	
15.4	Very dense, yellow-brown to olive gray, ***CLAYEY SAND*** (SC); moist; trace fine gravel; fine to coarse sand; diamict.	S-7 (SPT)	N = 14,29,29 (58 bpf)	WC=15% FC=47% LL/PI=25/9
19.5	Very dense, light gray-brown, ***POORLY GRADED SAND WITH GRAVEL*** (SP); moist; fine, rounded to subrounded gravel; fine to coarse sand; homogeneous.	S-8 (SPT)	N = 35,41,48 (89 bpf)	
22.5	Dense, gray, ***SANDY SILT WITH GRAVEL*** (ML); moist; fine, subrounded to subangular gravel; fine to medium sand; trace coarse sand; diamict.	S-9 (SPT)	N = 14,19,23 (42 bpf)	
27.5	Very dense, gray, ***SILTY GRAVEL WITH SAND*** (GM); wet; fine, rounded to subrounded gravel; fine to coarse sand; diamict.	S-10 (SPT)	N = 12,23,31 (54 bpf)	
		S-11 (SPT)	N = 42,50/5"	





Elev.(feet): 5, 0, -5, -10, -15, -20, -25

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit ├─●─┤ Liquid Limit

FINAL

Logged by:	MEH
Review by:	SAW
Version:	1

Job#: 108766 | Template Ver:1 | File: 108766.GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 7/9/24

Samish Island Restoration Project
Skagit County, Washington

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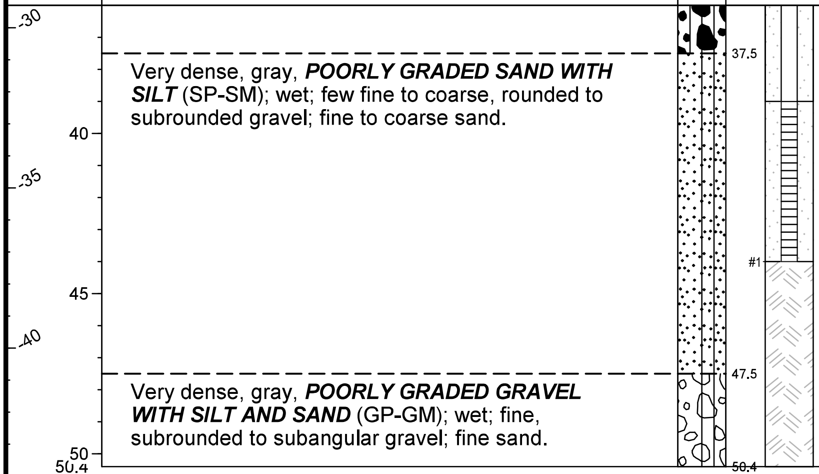
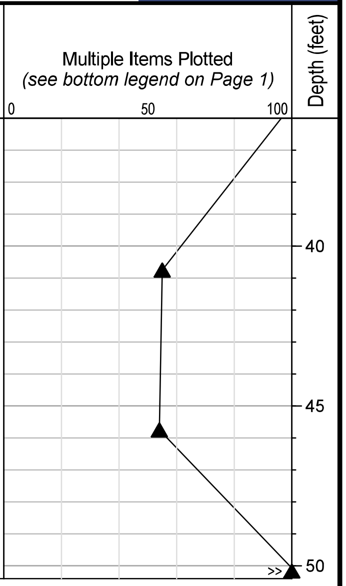
See Page 1 for Hole Information and Notes

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Samples	Field Data	Lab Data
				(50/5" bpf)	
	37.5	Very dense, gray, ***POORLY GRADED SAND WITH SILT*** (SP-SM); wet; few fine to coarse, rounded to subrounded gravel; fine to coarse sand.			
	40		S-12 (SPT)	N = 39,30,25 (55 bpf)	
	45		S-13 (SPT)	N = 17,27,27 (54 bpf)	
	47.5	Very dense, gray, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); wet; fine, subrounded to subangular gravel; fine sand.			
	50.4		S-14 (SPT)	N = 50/4" (50/4" bpf)	

BOTTOM OF HOLE AT 50.4 FEET





Samish Island Restoration Project
Skagit County, Washington

B-02p-24
Page 1 of 2

EXPLORATION INFORMATION

Total Depth: *51.5 feet*
Top Elevation: *6.5 feet*
Vertical Datum: *NAVD88*
Latitude: *48.5615120 degrees*
Longitude: *-122.4991957 degrees*
Horizontal Datum: *WGS [GCS1984]*
Hole Start Date: *May 21, 2024*
Hole Finish Date: *May 21, 2024*

DRILLING INFORMATION

Drilling Method: *Mud Rotary*
Drilling Company: *Holocene*
Drill Rig Equipment: *Diedrich D-50*
Hole Size: *5 inch*
Rod Type/Dia.: *n/a*
Hammer Wt. / Drop: *140 lbs/30 inches*
Hammer ETR: *96%*
Well Tag No.: *BQB 682*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

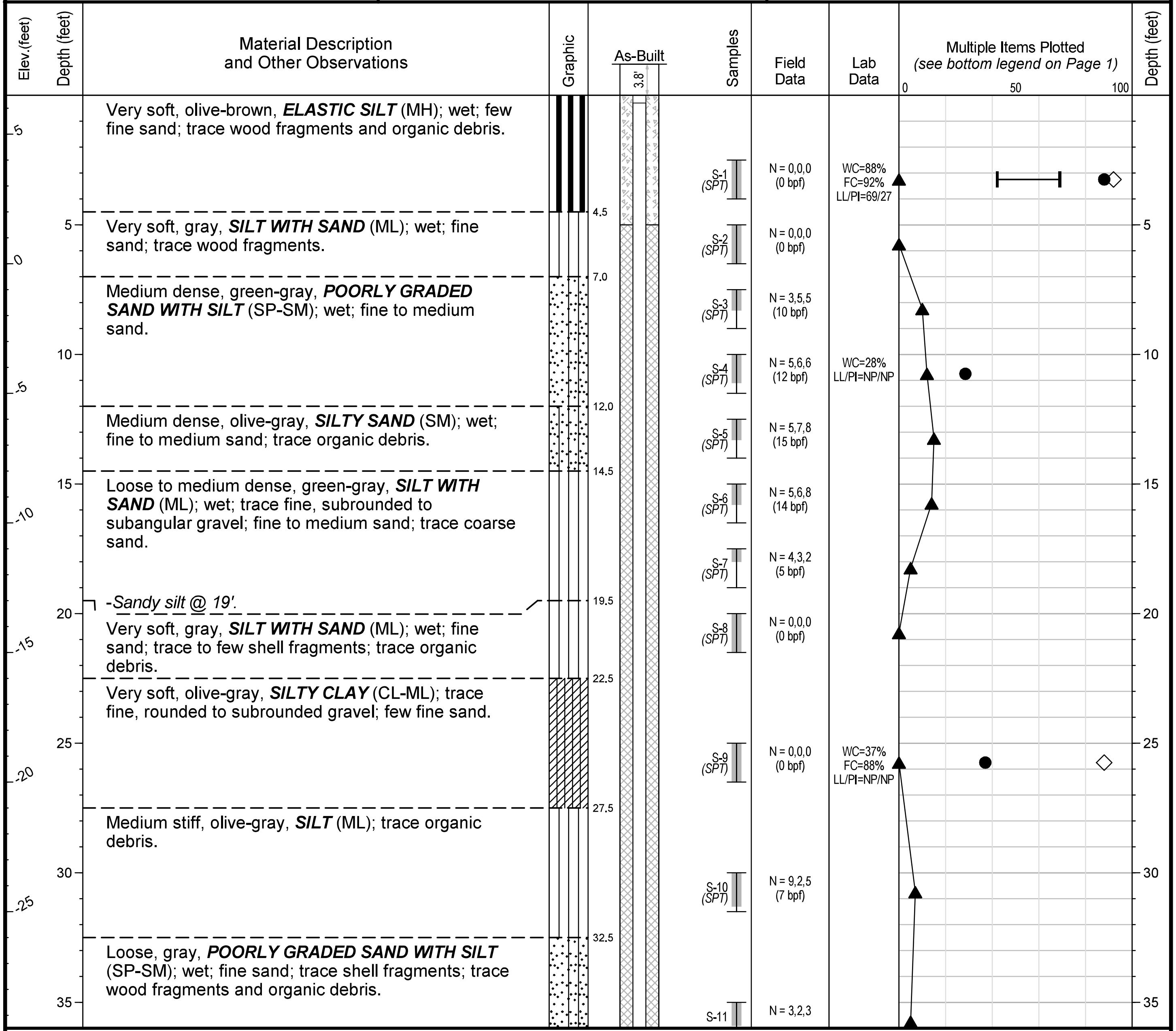
Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number → S-5
Sample Type → (SPT)
Gray bar indicates percent of sample length recovered.

Water Level During Drilling → ▽
Water Level Measured at Date in Well or VWP → ▼
ID No. / Measurement Date (M-D-YY)



Depth (feet)	Material Description and Other Observations
0 – 4.5	Very soft, olive-brown, ***ELASTIC SILT*** (MH); wet; few fine sand; trace wood fragments and organic debris.
4.5 – 7.0	Very soft, gray, ***SILT WITH SAND*** (ML); wet; fine sand; trace wood fragments.
7.0 – 12.0	Medium dense, green-gray, ***POORLY GRADED SAND WITH SILT*** (SP-SM); wet; fine to medium sand.
12.0 – 14.5	Medium dense, olive-gray, ***SILTY SAND*** (SM); wet; fine to medium sand; trace organic debris.
14.5 – 19.5	Loose to medium dense, green-gray, ***SILT WITH SAND*** (ML); wet; trace fine, subrounded to subangular gravel; fine to medium sand; trace coarse sand. *-Sandy silt @ 19'.*
19.5 – 22.5	Very soft, gray, ***SILT WITH SAND*** (ML); wet; fine sand; trace to few shell fragments; trace organic debris.
22.5 – 27.5	Very soft, olive-gray, ***SILTY CLAY*** (CL-ML); trace fine, rounded to subrounded gravel; few fine sand.
27.5 – 32.5	Medium stiff, olive-gray, ***SILT*** (ML); trace organic debris.
32.5 –	Loose, gray, ***POORLY GRADED SAND WITH SILT*** (SP-SM); wet; fine sand; trace shell fragments; trace wood fragments and organic debris.

Samples	Field Data	Lab Data
S-1 (SPT)	N = 0,0,0 (0 bpf)	WC=88% FC=92% LL/PI=69/27
S-2 (SPT)	N = 0,0,0 (0 bpf)	
S-3 (SPT)	N = 3,5,5 (10 bpf)	
S-4 (SPT)	N = 5,6,6 (12 bpf)	WC=28% LL/PI=NP/NP
S-5 (SPT)	N = 5,7,8 (15 bpf)	
S-6 (SPT)	N = 5,6,8 (14 bpf)	
S-7 (SPT)	N = 4,3,2 (5 bpf)	
S-8 (SPT)	N = 0,0,0 (0 bpf)	
S-9 (SPT)	N = 0,0,0 (0 bpf)	WC=37% FC=88% LL/PI=NP/NP
S-10 (SPT)	N = 9,2,5 (7 bpf)	
S-11	N = 3,2,3	

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit ├●┤ Liquid Limit

FINAL

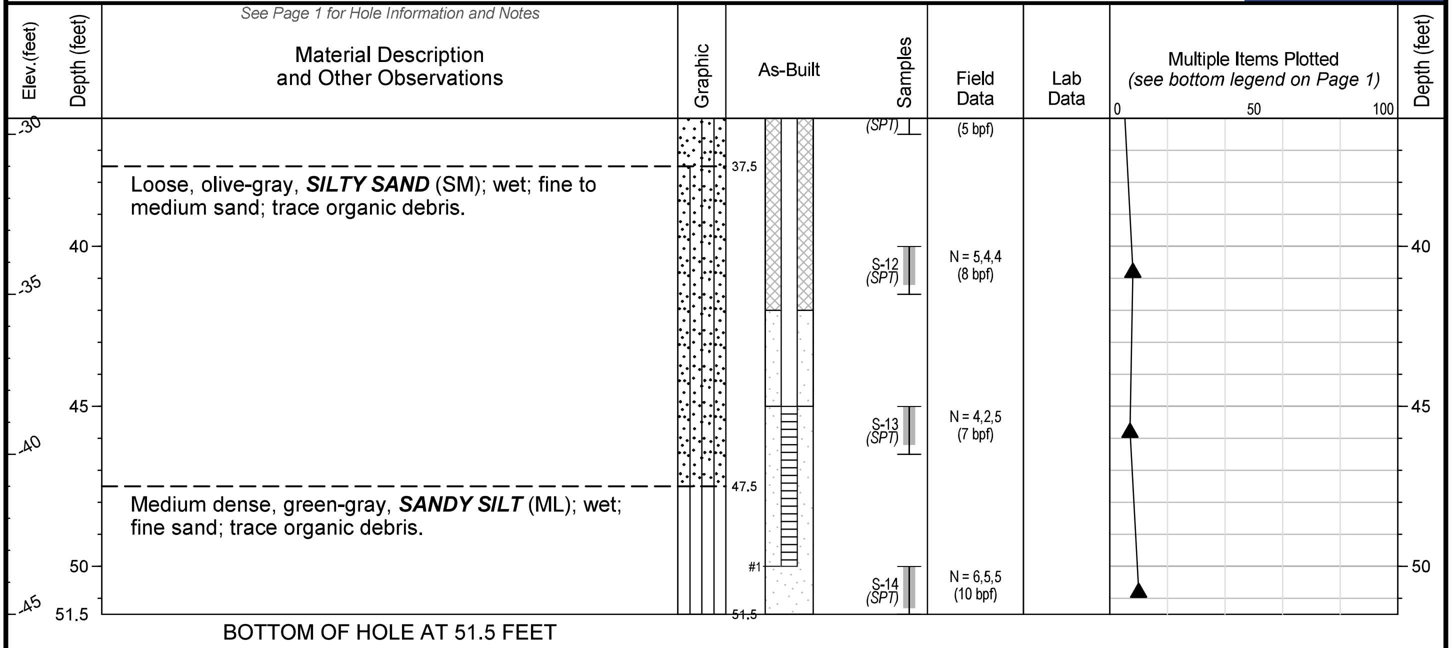
Logged by:	LAV
Review by:	SAW
Version:	1

Job#: 108766 | Template Ver:1 | File: 108766.GPJ | Library: SW GINT LIBRARY.GLB | Rpt: BORING LOG | Date: 7/9/24

Samish Island Restoration Project
Skagit County, Washington

B-02p-24

See Page 1 for Hole Information and Notes



Depth (feet)	Material Description and Other Observations
37.5	Loose, olive-gray, ***SILTY SAND*** (SM); wet; fine to medium sand; trace organic debris.
47.5	Medium dense, green-gray, ***SANDY SILT*** (ML); wet; fine sand; trace organic debris.

BOTTOM OF HOLE AT 51.5 FEET

Samples	Field Data
(SPT)	(5 bpf)
S-12 (SPT)	N = 5,4,4 (8 bpf)
S-13 (SPT)	N = 4,2,5 (7 bpf)
S-14 (SPT)	N = 6,5,5 (10 bpf)

Job#: **108766** | Template Ver:1 | File: 108766.GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: **7/9/24**

BORING LOG

Samish Island Restoration Project
Skagit County, Washington

B-03p-24

Page 1 of 2

EXPLORATION INFORMATION

Total Depth:	*51.5 feet*
Top Elevation:	*5.5 feet*
Vertical Datum:	*NAVD88*
Latitude:	*48.5590978 degrees*
Longitude:	*-122.4959973 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*May 20, 2024*
Hole Finish Date:	*May 20, 2024*

DRILLING INFORMATION

Drilling Method:	*Mud Rotary*
Drilling Company:	*Holocene*
Drill Rig Equipment:	*Diedrich D-50*
Hole Size:	*n/a*
Rod Type/Dia.:	*n/a*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*96%*
Well Tag No.:	*BQB 679*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

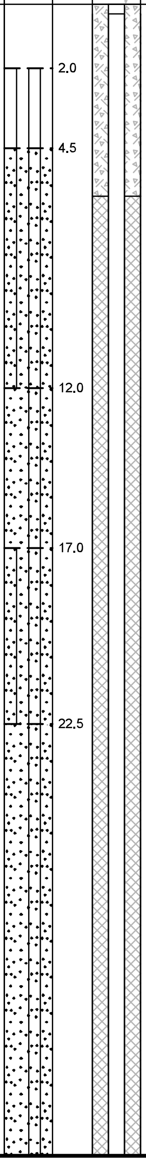
Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

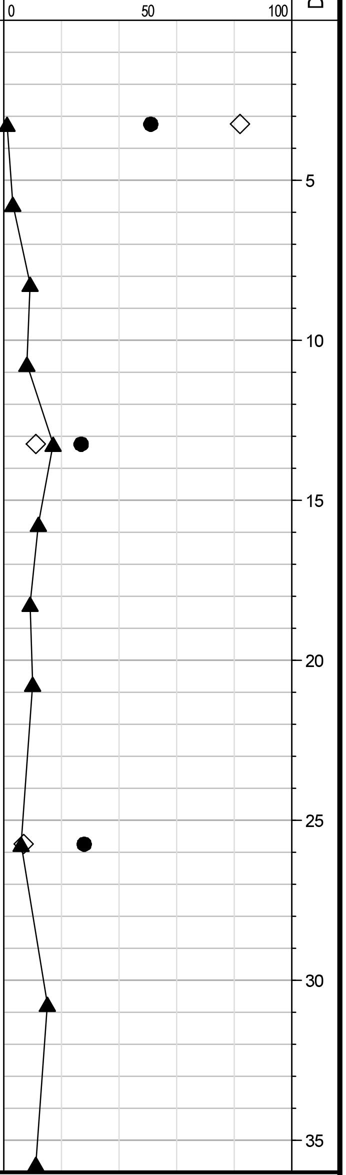
Sample Number → S-5
Sample Type → (SPT)
Gray bar indicates percent of sample length recovered.

Water Level During Drilling → ▽
Water Level Measured at Date in Well or VWP → ▼
ID No.
Measurement Date (M-D-YY)



Elev.(feet)	Depth (feet)	Material Description and Other Observations	As-Built	Samples	Field Data	Lab Data
5		***TOPSOIL***				
		Very soft, green-gray to olive-gray, ***SILT WITH SAND*** (ML); moist; fine sand; trace organic debris.	2.0	S-1 (SPT)	N = 0,0,1 (1 bpf)	WC=51% FC=82%
0	5	Very loose to loose, green-gray, ***SILTY SAND*** (SM); wet; fine sand.	4.5	S-2 (SPT)	N = 2,2,1 (3 bpf)	
				S-3 (SPT)	N = 4,3,6 (9 bpf)	
-5	10			S-4 (SPT)	N = 4,1,7 (8 bpf)	
		Medium dense, green-gray, ***POORLY GRADED SAND WITH SILT*** (SP-SM); wet; fine to medium sand.	12.0	S-5 (SPT)	N = 0,6,11 (17 bpf)	WC=27% FC=11%
-10	15			S-6 (SPT)	N = 4,7,5 (12 bpf)	
		Loose, green-gray, ***SILTY SAND*** (SM); wet; fine to coarse sand; fining upward sequence.	17.0	S-7 (SPT)	N = 0,2,7 (9 bpf)	
-15	20			S-8 (SPT)	N = 2,3,7 (10 bpf)	
		Loose to medium dense, gray, ***POORLY GRADED SAND WITH SILT*** (SP-SM); wet; fine to medium sand.	22.5			
-20	25			S-9 (SPT)	N = 4,3,3 (6 bpf)	WC=28% FC=7%
		-Trace coarse sand @ 26.5'.				
-25	30			S-10 (SPT)	N = 7,7,8 (15 bpf)	
-30	35			S-11	N = 5,5,6	

Multiple Items Plotted
(see bottom legend on Page 1)



▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
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- Report text contains limitations and information needed to contextually understand this log.

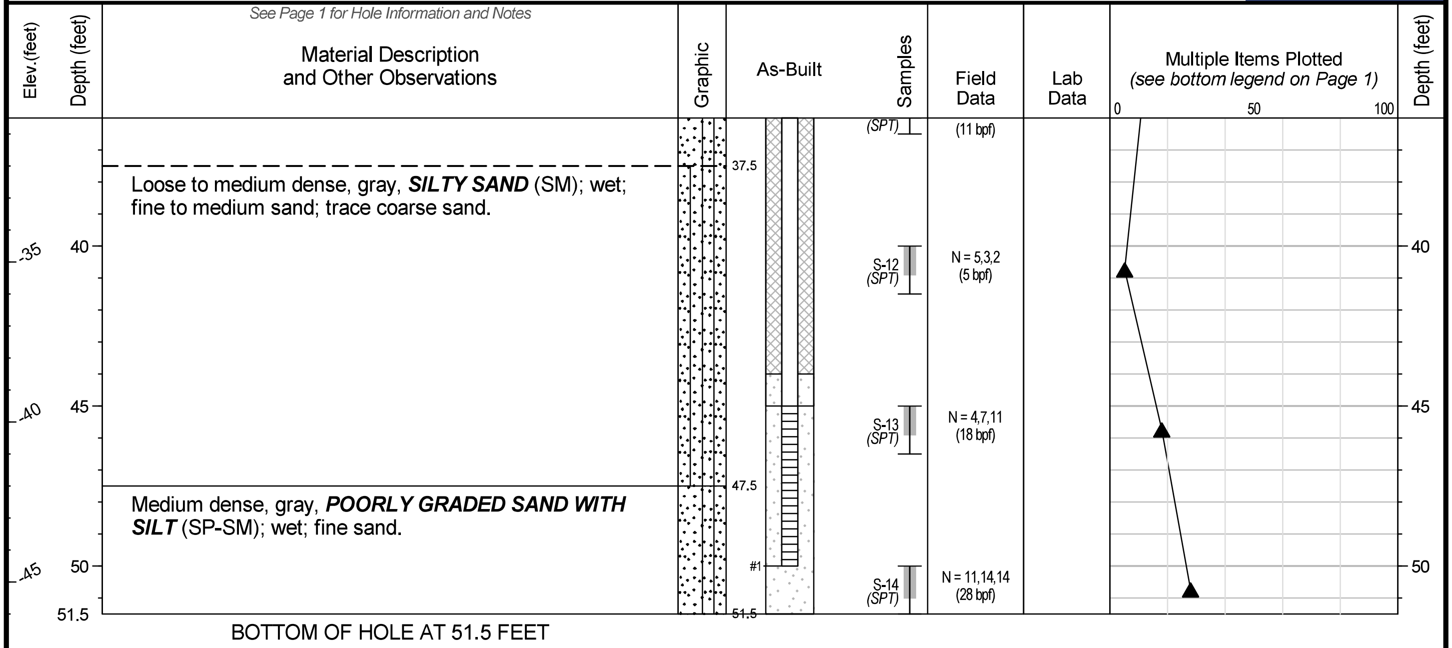
FINAL

Logged by:	LAV
Review by:	SAW
Version:	1

Samish Island Restoration Project
Skagit County, Washington

B-03p-24
Page 2 of 2

See Page 1 for Hole Information and Notes



Elev.(feet)	Depth (feet)	Material Description and Other Observations	Samples	Field Data	Lab Data
			(SPT)	(11 bpf)	
	37.5	Loose to medium dense, gray, ***SILTY SAND*** (SM); wet; fine to medium sand; trace coarse sand.			
-35	40		S-12 (SPT)	N = 5,3,2 (5 bpf)	
-40	45		S-13 (SPT)	N = 4,7,11 (18 bpf)	
	47.5	Medium dense, gray, ***POORLY GRADED SAND WITH SILT*** (SP-SM); wet; fine sand.			
-45	50		S-14 (SPT)	N = 11,14,14 (28 bpf)	
	51.5	BOTTOM OF HOLE AT 51.5 FEET			

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BORING LOG

Samish Island Restoration Project
Skagit County, Washington

SP-1-24
Page 1 of 1

EXPLORATION INFORMATION

Total Depth: *15.0 feet*
Top Elevation: *6.5 feet*
Vertical Datum: *NAVD88*
Latitude: *48.5663173 degrees*
Longitude: *-122.5032516 degrees*
Horizontal Datum: *WGS [GCS1984]*
Hole Start Date: *May 22, 2024*
Hole Finish Date: *May 22, 2024*

DRILLING INFORMATION

Drilling Method: *Hollow Stem Auger*
Drilling Company: *Holocene*
Drill Rig Equipment: *n/a*
Hole Size: *n/a*
Well Tag No.: *BQB 684*

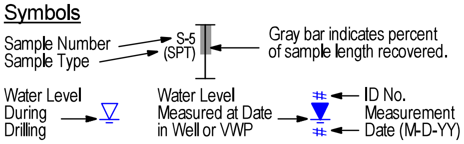
BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

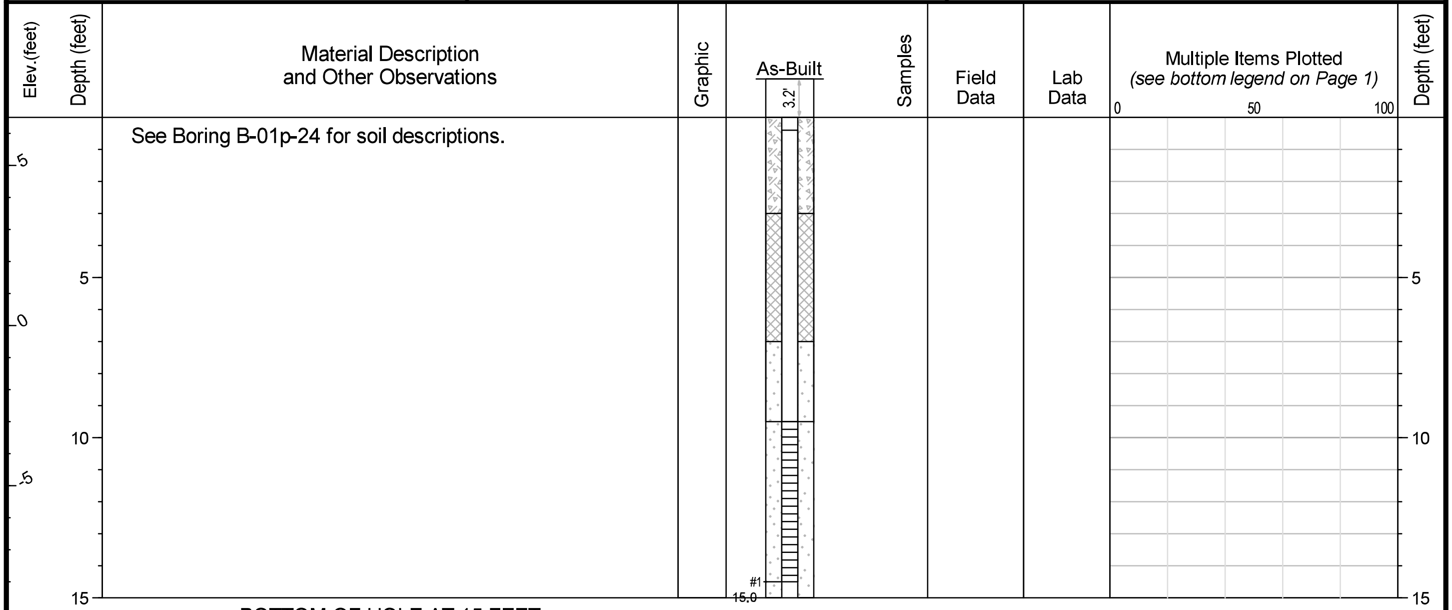
N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols



Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	As-Built	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1)	Depth (feet)

See Boring B-01p-24 for soil descriptions.



BOTTOM OF HOLE AT 15 FEET

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf

FINAL

Logged by:	MEH
Review by:	SAW
Version:	1

Job#: 108766 | Template Ver:1 | File: 108766.GPJ | Library: SW GINT LIBRARY.GLB | Rpt: BORING LOG | Date: 8/15/24

Samish Island Restoration Project
Skagit County, Washington

SP-2-24

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EXPLORATION INFORMATION

Total Depth: *15.0 feet*
Top Elevation: *6.5 feet*
Vertical Datum: *NAVD88*
Latitude: *48.5615210 degrees*
Longitude: *-122.4991994 degrees*
Horizontal Datum: *WGS [GCS1984]*
Hole Start Date: *May 21, 2024*
Hole Finish Date: *May 21, 2024*

DRILLING INFORMATION

Drilling Method: *Hollow Stem Auger*
Drilling Company: *Holocene*
Drill Rig Equipment: *n/a*
Hole Size: *n/a*
Well Tag No.: *BQB 681*

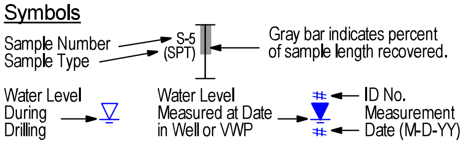
BASIC LEGEND

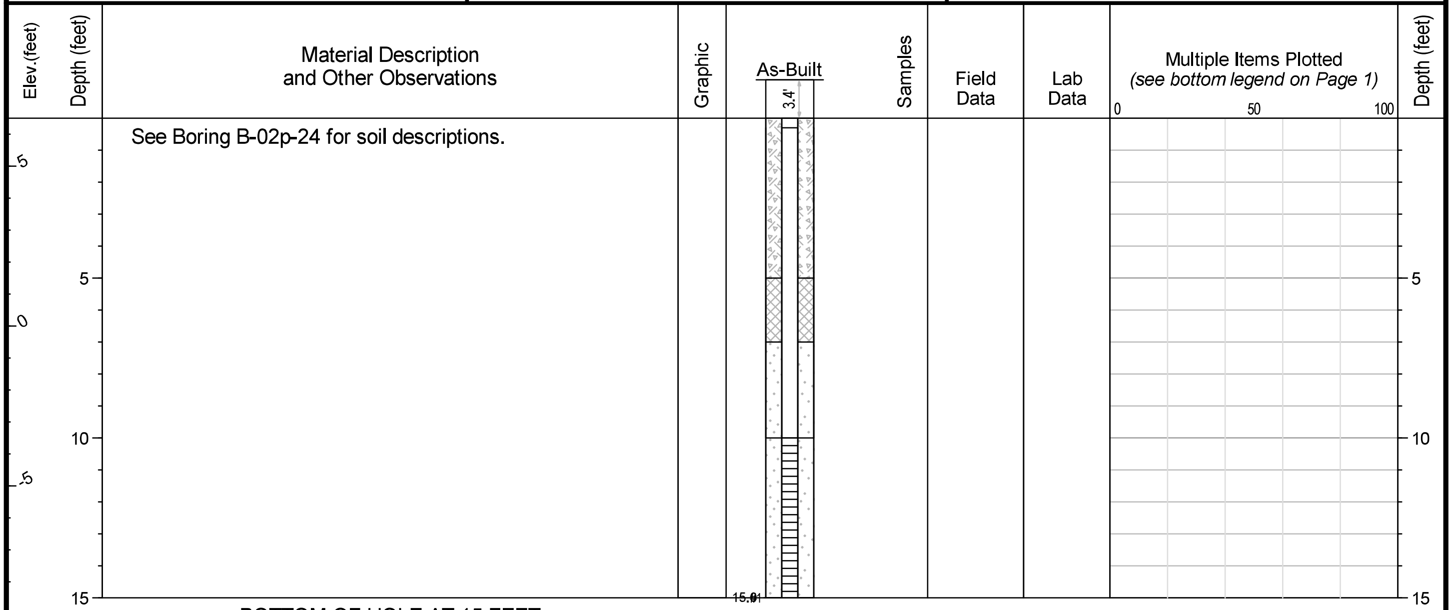
(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols





See Boring B-02p-24 for soil descriptions.

BOTTOM OF HOLE AT 15 FEET

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf

FINAL

Logged by:	LAV
Review by:	SAW
Version:	1

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BORING LOG

Samish Island Restoration Project
Skagit County, Washington

SP-3-24
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*15.0 feet*
Top Elevation:	*5.5 feet*
Vertical Datum:	*NAVD88*
Latitude:	*48.5591013 degrees*
Longitude:	*-122.4959863 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*May 20, 2024*
Hole Finish Date:	*May 20, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Holocene*
Drill Rig Equipment:	*n/a*
Hole Size:	*n/a*
Well Tag No.:	*BQB 680*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

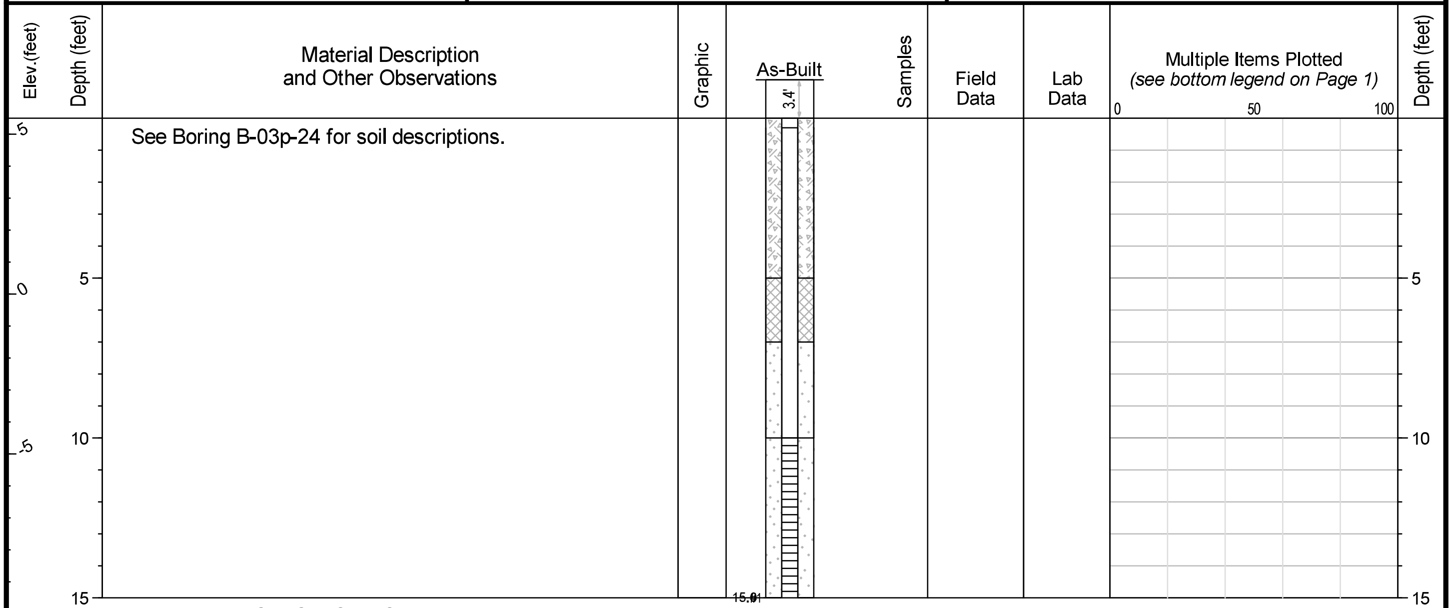
Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number → S-5
Sample Type → (SPT)
Gray bar indicates percent of sample length recovered.

Water Level During Drilling → ▽
Water Level Measured at Date in Well or VWP → ▼
ID No.
Measurement Date (M-D-YY)



See Boring B-03p-24 for soil descriptions.

BOTTOM OF HOLE AT 15 FEET

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf

FINAL

Logged by:	LAV
Review by:	SAW
Version:	1

Job#: 108766 | Template Ver:1 | File: 108766.GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 8/15/24

SHANNON & WILSON

BORING LOG

Samish Island Restoration Project
Skagit County, Washington

SB-01
Page 1 of 1

EXPLORATION INFORMATION

Total Depth: *10.4 feet*
Top Elevation: *~6 feet*
Vertical Datum: *NAVD88*
Latitude: *48.56670 degrees*
Longitude: *-122.49940 degrees*
Horizontal Datum: *WGS [GCS1984]*
Hole Start Date: *September 26, 2022*
Hole Finish Date: *September 26, 2022*

DRILLING INFORMATION

Drilling Method: *Hand Auger*
Drilling Company: *unknown*
Drill Rig Equipment: *n/a*
Hole Size: *n/a*

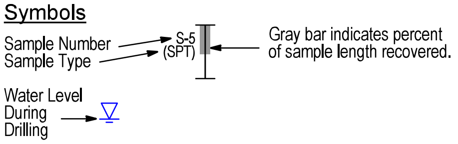
BASIC LEGEND

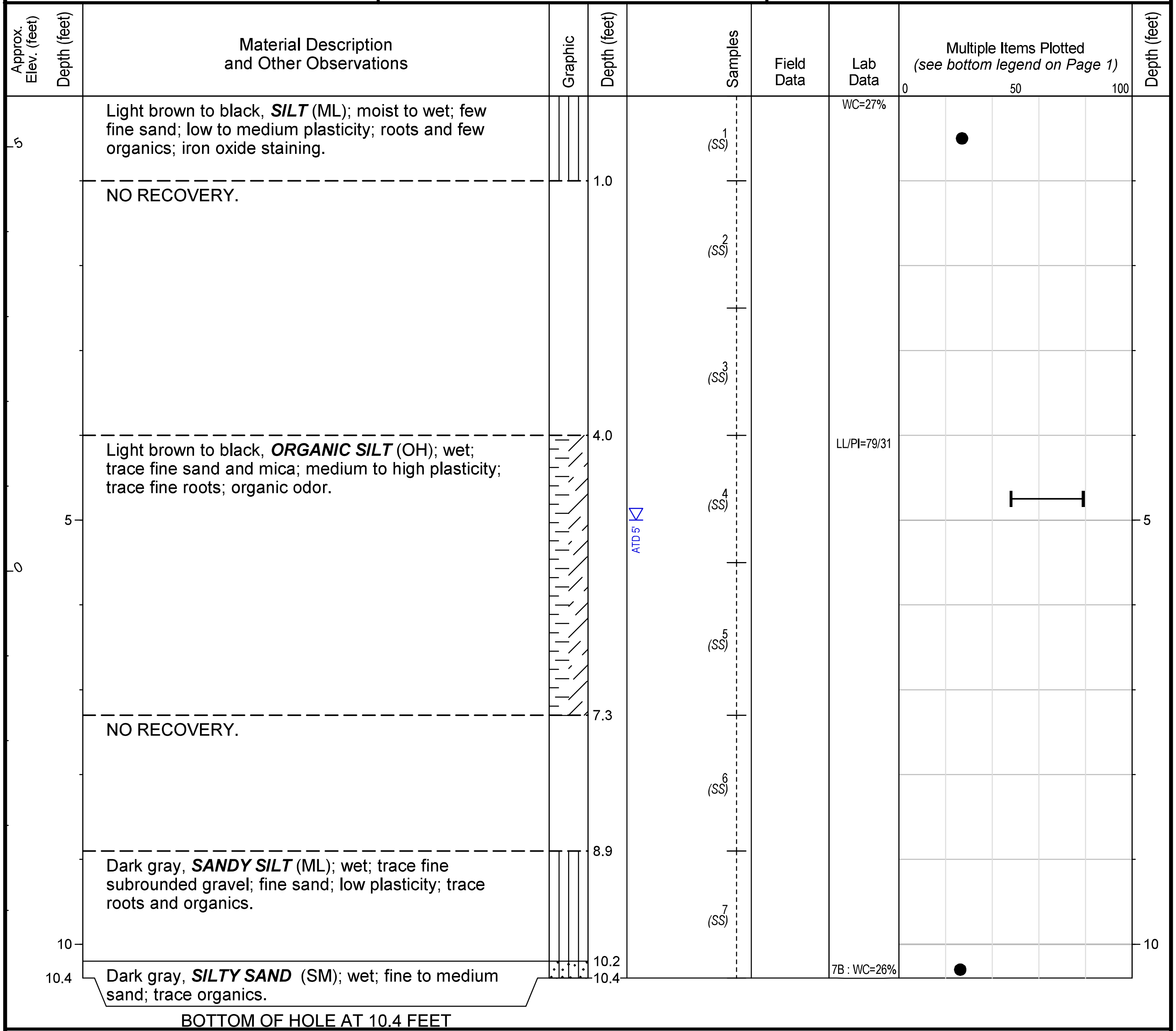
(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols





Depth (feet)	Material Description and Other Observations	Lab Data
0–1.0	Light brown to black, ***SILT*** (ML); moist to wet; few fine sand; low to medium plasticity; roots and few organics; iron oxide staining.	WC=27%
1.0–4.0	NO RECOVERY.	
4.0–7.3	Light brown to black, ***ORGANIC SILT*** (OH); wet; trace fine sand and mica; medium to high plasticity; trace fine roots; organic odor.	LL/PI=79/31
7.3–8.9	NO RECOVERY.	
8.9–10.2	Dark gray, ***SANDY SILT*** (ML); wet; trace fine subrounded gravel; fine sand; low plasticity; trace roots and organics.	
10.2–10.4	Dark gray, ***SILTY SAND*** (SM); wet; fine to medium sand; trace organics.	7B : WC=26%

BOTTOM OF HOLE AT 10.4 FEET

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC%
Plastic Limit ├─●─┤ Liquid Limit

FINAL

Logged by:	MPB
Review by:	SAW
Version:	1

SHANNON & WILSON BORING LOG

Samish Island Restoration Project
Skagit County, Washington

SB-02
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EXPLORATION INFORMATION

Total Depth: *7.4 feet*
Top Elevation: *~5 feet*
Vertical Datum: *NAVD88*
Latitude: *48.56520 degrees*
Longitude: *-122.50010 degrees*
Horizontal Datum: *WGS [GCS1984]*
Hole Start Date: *September 26, 2022*
Hole Finish Date: *September 26, 2022*

DRILLING INFORMATION

Drilling Method: *Hand Auger*
Drilling Company: *unknown*
Drill Rig Equipment: *n/a*
Hole Size: *n/a*

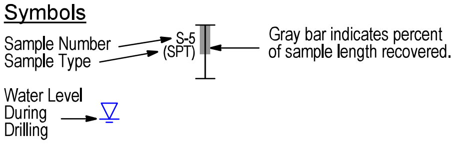
BASIC LEGEND

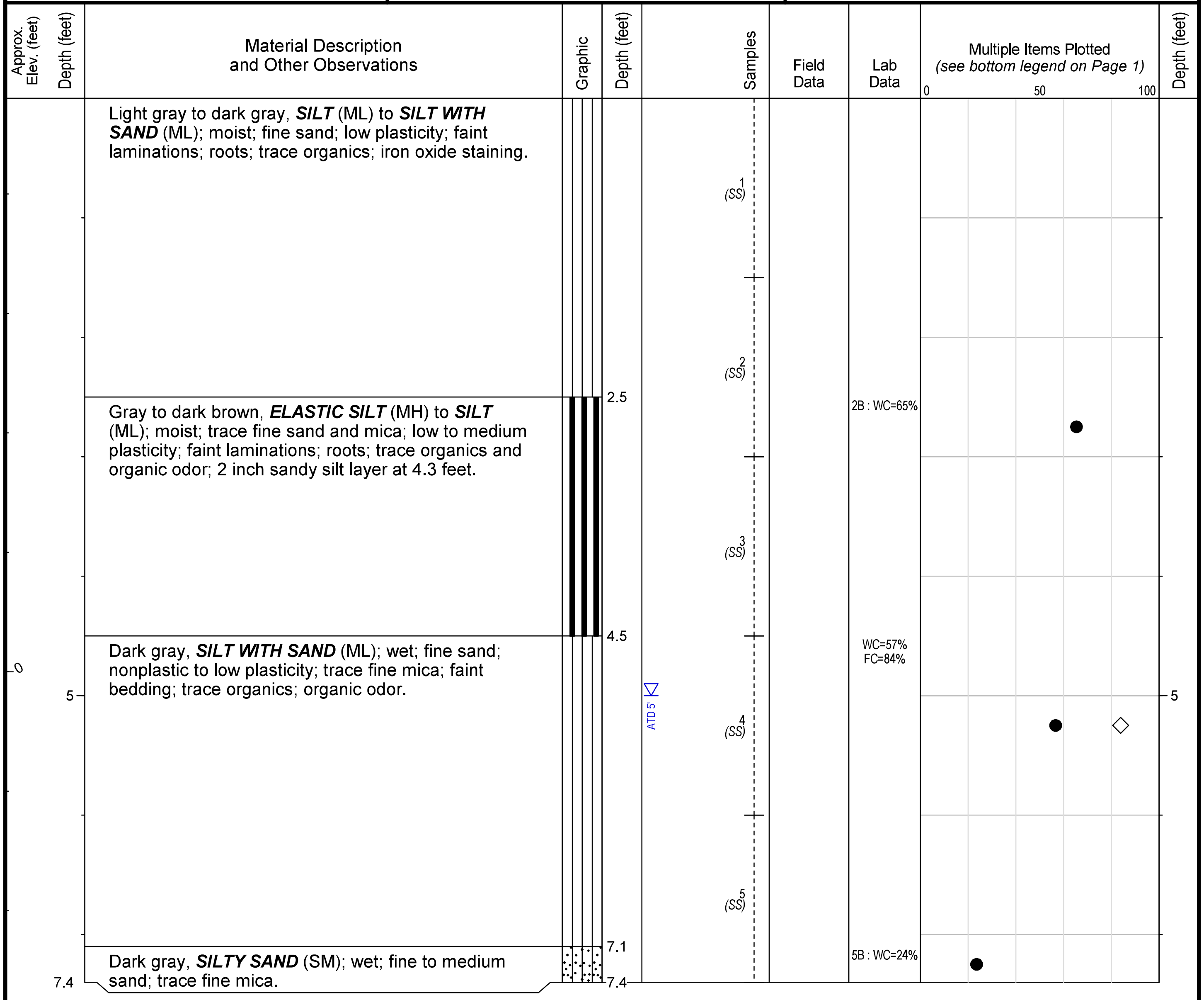
(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols





Light gray to dark gray, ***SILT*** (ML) to ***SILT WITH SAND*** (ML); moist; fine sand; low plasticity; faint laminations; roots; trace organics; iron oxide staining.

2.5

Gray to dark brown, ***ELASTIC SILT*** (MH) to ***SILT*** (ML); moist; trace fine sand and mica; low to medium plasticity; faint laminations; roots; trace organics and organic odor; 2 inch sandy silt layer at 4.3 feet.

2B : WC=65%

4.5

Dark gray, ***SILT WITH SAND*** (ML); wet; fine sand; nonplastic to low plasticity; trace fine mica; faint bedding; trace organics; organic odor.

WC=57%
FC=84%

7.1

Dark gray, ***SILTY SAND*** (SM); wet; fine to medium sand; trace fine mica.

5B : WC=24%

7.4

BOTTOM OF HOLE AT 7.4 FEET

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%

FINAL

Logged by:	MPB
Review by:	SAW
Version:	1

Job#: 108766 | Template Ver:1 | File: 108766.GPJ | Library: SW GINT LIBRARY.GLB | Rpt: BORING LOG | Date: 7/9/24

BORING LOG

Samish Island Restoration Project
Skagit County, Washington

SB-03
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EXPLORATION INFORMATION

Total Depth: *4.4 feet*
Top Elevation: *~5 feet*
Vertical Datum: *NAVD88*
Latitude: *48.56310 degrees*
Longitude: *-122.50190 degrees*
Horizontal Datum: *WGS [GCS1984]*
Hole Start Date: *September 26, 2022*
Hole Finish Date: *September 26, 2022*

DRILLING INFORMATION

Drilling Method: *Hand Auger*
Drilling Company: *unknown*
Drill Rig Equipment: *n/a*
Hole Size: *n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

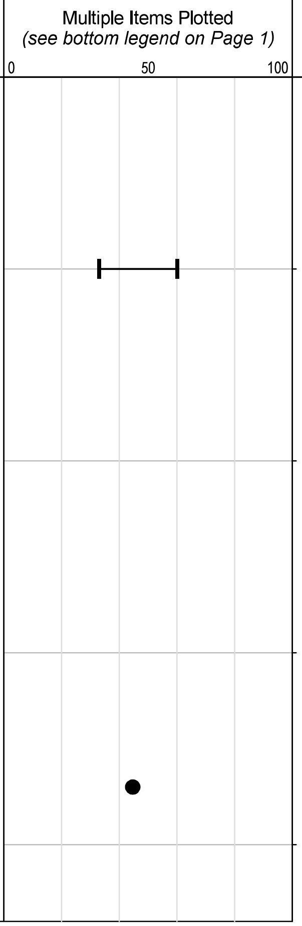
N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number → S-5
Sample Type → (SPT)
Gray bar indicates percent of sample length recovered.

Water Level During Drilling → ∇

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Depth (feet)	Samples	Field Data	Lab Data
		Light brown, ***SILT*** (ML); moist; trace fine sand; low to medium plasticity; black laminations; iron oxide staining; fine roots.	0.5			
		Gray, ***ELASTIC SILT*** (MH); moist; trace fine sand; medium plasticity; iron oxide staining.	1.5	1 (SS)		1B : LL/PI=60/27
		Gray, ***SILT*** (ML); moist; fine sand; low plasticity; trace to few organics and wood.	2.0			
		Gray, ***SANDY SILT*** (ML); moist; fine sand; low plasticity; trace to few organics.	2.6	2 (SS)		
4.4		Dark gray, ***SILTY SAND*** (SM); wet; fine sand; low plasticity; trace clay pockets.	4.4	3 (SS)		WC=45%



BOTTOM OF HOLE AT 4.4 FEET

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC%
Plastic Limit ├─●─┤ Liquid Limit

FINAL

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BORING LOG

SB-04

Page 1 of 1

Samish Island Restoration Project
Skagit County, Washington

EXPLORATION INFORMATION

Total Depth: *7.5 feet*
Top Elevation: *~7 feet*
Vertical Datum: *NAVD88*
Latitude: *48.56390 degrees*
Longitude: *-122.49730 degrees*
Horizontal Datum: *WGS [GCS1984]*
Hole Start Date: *September 26, 2022*
Hole Finish Date: *September 26, 2022*

DRILLING INFORMATION

Drilling Method: *Hand Auger*
Drilling Company: *unknown*
Drill Rig Equipment: *n/a*
Hole Size: *n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

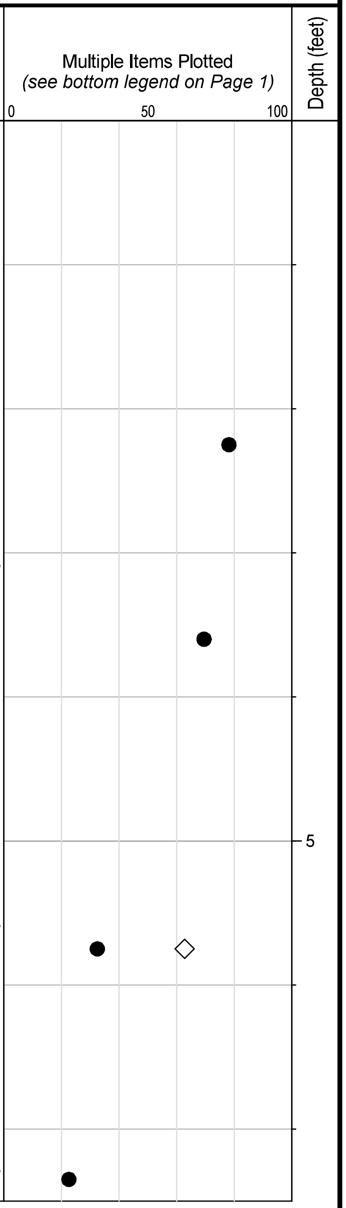
Symbols

Sample Number → S-5
Sample Type → (SPT)
Gray bar indicates percent of sample length recovered.

Water Level During Drilling → ▽

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Depth (feet)	Samples	Field Data	Lab Data
		Light gray to dark gray with mottling, ***SILT*** (ML); moist to wet; trace fine sand and mica; low plasticity; trace clay pockets; few roots and organics.		1 (SS)		
5		Gray and dark brown, ***ELASTIC SILT*** (MH); moist to wet; trace fine sand and mica; low to medium plasticity; trace clay pockets; few organic silt pockets; trace roots and organics.	1.5	2 (SS)		WC=78%
				3 (SS)		3A : WC=69%
	5	Dark gray, ***SILT*** (ML); wet; trace fine sand and mica; low to medium plasticity; trace organics and wood.	4.5	▽ ATD 5' 4 (SS)		
0		Dark gray, ***SANDY SILT*** (ML); moist; fine sand and trace mica; nonplastic to low plasticity; local iron-oxide staining; sandy lenses; trace organics, wood and reeds.	5.5	5 (SS)		4B : WC=32% FC=63%
	7.5	Dark gray, ***SILTY SAND*** (SM); moist; fine sand; interbedded silt layers.	7.2 7.5			5B : WC=23%

BOTTOM OF HOLE AT 7.5 FEET



NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%

FINAL

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Samish Island Restoration Project
Skagit County, Washington

TP-1

Date Completed: May 9, 2024
Top Elevation: 5.9 feet
Vertical Datum: NAVD88
Excavation Company/Equipment: Sullivan Grading / CAT Excavator 312CL
Latitude: 48.5642000 degrees
Longitude: -122.4993000 degrees
Horizontal Datum: WGS [GCS1984]
Maximum Depth: 6 feet
TP Top Length: 8.25 feet
TP Top Width: 3.4 feet

BASIC LEGEND *(See separate LOG KEY for additional symbols, acronyms, and definitions)*

Abbreviations

TP	Test pit
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
LL/PL	Liquid limit / plastic limit

Symbols

Sample Number → S-5 ▨
Observed Seepage → ○~
Observed Water Level → ∇

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Samples	Test Results
5 4	1 2	Brown, ***SILT WITH SAND*** (ML); moist to wet (local seeps at bottom); fine sand; low plasticity; some organics (roots, grass, and woody debris), buried lumber at base; massive, crumbly structure. *-Ring dike around pond.* *-Lumber at 2.5 feet bgs.* *-Sharp contact at 2.5 feet bgs.*		TP-1-S1	WC=84%
3	3	Gray to olive-gray, ***ELASTIC SILT*** (MH); moist to wet (local seepage); trace fine sand; medium to high plasticity; little organics (roots and woody debris); locally crumbly structure with iron oxide staining. *-Sharp contact at 4.0 feet bgs.*		○~ 2.5 TP-1-S2	WC=78% FC=98% LL/PI=97/55
2 1 0	4 5 6	Gray, ***SILT WITH SAND*** (ML); moist to wet (prominent seepage at several locations); fine sand; nonplastic; trace organics (roots and woody debris); massive. *-Prominent groundwater seep out of a hole in the sidewall of the pit at approximately 5 feet bgs, the flow was approximately 1 to 2 gpm.* *-Artesian boils at base of test pit, the flow was approximately 0.5 to 1 gpm.*		TP-1-S3 ○~ 5 ○~ 6	WC=34% FC=74%

BOTTOM OF HOLE AT 6 FEET

Test Pit Diagram or Photograph
North Side of Test Pit

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations and definitions.
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- Relative consistency or relative density estimates were made with a T-probe and observations of excavation action.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to understand this log.

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Version:	1

TEST PIT LOG

Samish Island Restoration Project
Skagit County, Washington

TP-2

Date Completed: *May 9, 2024*
Top Elevation: *5.3 feet*
Vertical Datum: *NAVD88*
Excavation Company/Equipment: *Sullivan Grading / CAT Excavator 312CL*

Latitude: *48.5647000 degrees*
Longitude: *-122.4976000 degrees*
Horizontal Datum: *WGS [GCS1984]*

Maximum Depth: *6 feet*
TP Top Length: *6.5 feet*
TP Top Width: *3.4 feet*

BASIC LEGEND *(See separate LOG KEY for additional symbols, acronyms, and definitions)*

Abbreviations

TP	Test pit
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
LL/PL	Liquid limit / plastic limit

Symbols

Sample Number → S-5
Observed Seepage → O~
Observed Water Level → ∇

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Samples	Test Results
5	0	Brown, ***SILT WITH SAND*** (ML); moist to wet (seeping at bottom); fine sand; trace clay; abundant roots; crumbly structure. *-Sharp contact at 1.1 feet bgs.*			
4	1	Olive-gray to gray, ***ELASTIC SILT*** (MH); moist to wet (locally seeping at cracks); trace fine sand; fining-upward; medium to high plasticity; some organics (roots and woody debris); massive, crumbly structure; trace iron oxide staining. *-Gradational contact at 3.0 feet bgs.*		TP-2-S1 O~ 1.8	WC=54% FC=93% LL/PI=66/25
3	2.5	Gray, ***SANDY SILT*** (ML); moist to wet (locally seeping at cracks); fine sand; trace clay; nonplastic; few organics (roots); massive. *-Piping seep at approximately 5 feet bgs, the flow is approximately 1 to 1.5 gpm.*		O~ 5 TP-2-S2	WC=29% FC=67%

BOTTOM OF HOLE AT 6 FEET

Test Pit Diagram or Photograph
East Side of Test Pit

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations and definitions.
- Groundwater level, if indicated above, is for the date of excavation and may vary.
- Relative consistency or relative density estimates were made with a T-probe and observations of excavation action.
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- Report text contains limitations and information needed to understand this log.

FINAL

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SHANNON & WILSON

TEST PIT LOG

Samish Island Restoration Project
Skagit County, Washington

TP-3

Date Completed: May 9, 2024
Top Elevation: 4.9 feet
Vertical Datum: NAVD88
Excavation Company/Equipment: Sullivan Grading / CAT Excavator 312CL

Latitude: 48.5635000 degrees
Longitude: -122.4990000 degrees
Horizontal Datum: WGS [GCS1984]

Maximum Depth: 6 feet
TP Top Length: 6.5 feet
TP Top Width: 3.4 feet

BASIC LEGEND *(See separate LOG KEY for additional symbols, acronyms, and definitions)*

Abbreviations

TP	Test pit
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
LL/PL	Liquid limit / plastic limit

Symbols

Sample Number → S-5	▭
Observed Seepage →	♂
Observed Water Level →	∇

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Samples	Test Results
4	1	Brown, ***SILT WITH SAND*** (ML); moist to wet (seeping at bottom); fine sand; trace clay; abundant roots; crumbly structure. *-Gradational contact at 1.1 feet bgs. Seepage at base of topsoil.*			
3	2	Olive-gray to gray, ***ELASTIC SILT*** (MH); moist to wet (locally seeping at cracks); trace fine sand; fining-upward; medium plasticity; little organics (roots and woody debris); massive, crumbly structure; trace iron oxide staining. *-Gradational contact at 2.5 feet bgs.*		TP-3-S1	WC=53% FC=95% LL/PI=55/18
2 1 0 -1	3 4 5 6	Gray, ***SANDY SILT*** (ML); moist to wet (locally seeping at cracks); fine sand; trace clay; nonplastic; trace organics (woody debris); massive.		TP-3-S2	WC=30% FC=69%

BOTTOM OF HOLE AT 6 FEET

Test Pit Diagram or Photograph
South Side of Test Pit

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations and definitions.
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- Relative consistency or relative density estimates were made with a T-probe and observations of excavation action.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to understand this log.

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SHANNON & WILSON

TEST PIT LOG

Samish Island Restoration Project
Skagit County, Washington

TP-4

Date Completed: *May 9, 2024*
Top Elevation: *5.4 feet*
Vertical Datum: *NAVD88*
Excavation Company/Equipment: *Sullivan Grading / CAT Excavator 312CL*
Latitude: *48.5602000 degrees*
Longitude: *-122.4976000 degrees*
Horizontal Datum: *WGS [GCS1984]*
Maximum Depth: *6 feet*
TP Top Length: *6.5 feet*
TP Top Width: *3.4 feet*

BASIC LEGEND *(See separate LOG KEY for additional symbols, acronyms, and definitions)*

Abbreviations

TP	Test pit
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
LL/PL	Liquid limit / plastic limit

Symbols

Sample Number → S-5
Observed Seepage → ○ʷ
Observed Water Level → ∇

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Samples	Test Results
5		Gray-brown, ***SILT*** (ML); moist to wet (seeping at base); trace fine sand; abundant organics (roots, woody debris), especially near base contact; crumbly texture.			
4	1	*-Zone of reddish brown oxidized organics with groundwater seepage at 1.6 feet bgs. Seepage flow was less than 0.5 gpm. Sharp lower contact.*		○ʷ 1.6'	
3	2	Olive-brown, mottling ***ELASTIC SILT*** (MH); moist to wet (seeping at local cracks); trace fine sand; medium plasticity; little organics (roots and woody debris); massive, crumbly to tight structure.		TP-4-S1	
2	3	*-Gradational contact, approximately 0.5 feet thick, at 3.8 feet bgs.*			
1	4	Gray, ***SILTY SAND*** (SM); moist to wet (local seepage); fine sand; trace organics (woody debris); massive.			
0	5			TP-4-S2	WC=32% FC=49%
	6				

BOTTOM OF HOLE AT 6 FEET

Test Pit Diagram or Photograph
South Side of Test Pit

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations and definitions.
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- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to understand this log.

FINAL

Logged by:	CXK
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Version:	1

SHANNON & WILSON

TEST PIT LOG

Samish Island Restoration Project
Skagit County, Washington

TP-5

Date Completed: *May 9, 2024*
Top Elevation: *5.6 feet*
Vertical Datum: *NAVD88*
Excavation Company/Equipment: *Sullivan Grading / CAT Excavator 312CL*

Latitude: *48.5602000 degrees*
Longitude: *-122.4961000 degrees*
Horizontal Datum: *WGS [GCS1984]*

Maximum Depth: *6 feet*
TP Top Length: *8 feet*
TP Top Width: *3.4 feet*

BASIC LEGEND *(See separate LOG KEY for additional symbols, acronyms, and definitions)*

Abbreviations

TP	Test pit
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
LL/PL	Liquid limit / plastic limit

Symbols

Sample Number → S-5
Observed Seepage → ○w
Observed Water Level → ▽

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Samples	Test Results
	0–1	Brown, ***SILT*** (ML); moist; trace fine sand; abundant roots; crumbly structure. *-Sharp contact 1 foot bgs.*			
	1–1.8	Gray, ***SILT*** (ML); moist to wet (seepage at base); trace, fine to coarse sand; abundant roots, trace woody debris; mottled oxidation. *-Zone of oxidized organics/peat directly above a sharp contact at 1.8 feet bgs.*		○w 1.8	
	1.8–3.6	Gray, ***ELASTIC SILT*** (MH); moist; few fine sand; medium plasticity; little organics (roots, bark, and woody debris); massive. *-Gradational contact at 3.6 feet bgs.*		TP-5-S1	WC=42%
	3.6–6	Gray, ***SILT*** (ML); moist to wet (local seepage); trace organic debris; massive.			

Elevation scale: 5, 4, 3, 2, 1, 0
Depth scale: 1, 2, 3, 4, 5, 6

BOTTOM OF HOLE AT 6 FEET

Test Pit Diagram or Photograph
South Side of Test Pit

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations and definitions.
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TEST PIT LOG

Samish Island Restoration Project
Skagit County, Washington

TP-6

Date Completed:	*May 9, 2024*	Latitude:	*48.5592000 degrees*	Maximum Depth:	*7.5 feet*
Top Elevation:	*6.4 feet*	Longitude:	*-122.4989000 degrees*	TP Top Length:	*6.75 feet*
Vertical Datum:	*NAVD88*	Horizontal Datum:	*WGS [GCS1984]*	TP Top Width:	*3.4 feet*

Excavation Company/Equipment: *Sullivan Grading / CAT Excavator 312CL*

BASIC LEGEND *(See separate LOG KEY for additional symbols, acronyms, and definitions)*

Abbreviations

TP	Test pit
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
LL/PL	Liquid limit / plastic limit

Symbols

Sample Number → S-5
Observed Seepage → Ọw
Observed Water Level → ∇

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Samples	Test Results
6	0–1	Brown, ***SILT*** (ML); moist; trace fine sand; bioturbated; few to little roots; crumbly texture.			
5	1–2	Yellow-brown to gray, ***ELASTIC SILT*** (MH); moist; mottled yellow-brown to gray, iron oxide staining/mottling; trace to few roots. *-Sharp contact 1 foot bgs.*		TP-6-S1	WC=62% FC=100%
4	2–3	Olive-brown to gray, ***ELASTIC SILT*** (MH); moist to wet (seeping at basal contact); fining upward and transition from olive-gray to gray; crumbly texture at base where seeping; roots at base.		Ọw 3	
3 2 1	3–5.5	Gray, ***SILT*** (ML); moist; few organics and woody debris; massive. *-Groundwater seep at 3 feet bgs, the flow was less than 0.5 gpm.*		Ọw 5.5	
0 -1	5.5–7.5	Gray, ***SILTY SAND*** (SM); moist to wet (significant local seepage); trace fine to medium sand; massive. *-Groundwater seep at 5.5 feet bgs, the flow was greater than 2 gpm.*		TP-6-S2	

BOTTOM OF HOLE AT 7.5 FEET

Test Pit Diagram or Photograph
East Side of Test Pit

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations and definitions.
- Groundwater level, if indicated above, is for the date of excavation and may vary.
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- Report text contains limitations and information needed to understand this log.

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TEST PIT LOG

Samish Island Restoration Project
Skagit County, Washington

TP-7

Date Completed: May 9, 2024
Top Elevation: 5.5 feet
Vertical Datum: NAVD88
Excavation Company/Equipment: Sullivan Grading / CAT Excavator 312CL

Latitude: 48.5591000 degrees
Longitude: -122.4933000 degrees
Horizontal Datum: WGS [GCS1984]

Maximum Depth: 6 feet
TP Top Length: 6.5 feet
TP Top Width: 3.4 feet

BASIC LEGEND *(See separate LOG KEY for additional symbols, acronyms, and definitions)*

Abbreviations

TP	Test pit
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
LL/PL	Liquid limit / plastic limit

Symbols

Sample Number → S-5 ▨
Observed Seepage → ○
Observed Water Level → ∇

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Samples	Test Results
5	0 – 1	Brown, ***SILT*** (ML); moist; trace fine sand; abundant roots and organic material; crumbly texture.			
4	1	*-Sharp contact 1 foot bgs.*			
3	1 – 3	Yellow-brown to gray, ***ELASTIC SILT*** (MH); moist to wet (seeping at base); trace fine rounded gravel; trace fine to medium sand; low plasticity; organics (roots); graded gray to yellow-brown/mottled at base; crumbly at base; oxidized at base.		TP-7-S1	WC=75% FC=94% LL/PI=73/29
	3	*-Highly oxidized zone with abundant organics directly above a sharp contact at 3 feet bgs.*		○ 3	
2, 1	3 – 5.5	Gray, ***SILT*** (ML); moist; trace fine sand; few to little organics, woody debris; massive.			
	5.3	*-Large cave in at about 5.3 feet bgs.*			
0	5.5	*-Groundwater seepage at 5.5 feet bgs, the flow was approximately 1 to 2 gpm.*		○ 5.5	
	5.5 – 6	Gray, ***SILTY SAND*** (SM) to ***SANDY SILT*** (ML); moist to wet (local seepage); fine sand; trace organics (~1 - 2' diameter log); massive.			
	6	BOTTOM OF HOLE AT 6 FEET			

Test Pit Diagram or Photograph
South Side of Test Pit

NOTES:
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APPENDIX B: LABORATORY TESTING

Appendix B

Laboratory Testing

CONTENTS

- Shannon & Wilson Laboratory Test Results

Table B-1 - Summary of Laboratory Test Results

Exploration Designation	Top Depth	Sample Number	Sample Type	SPT Blow Count	USCS	Water Content	Organic Content	Gravel Percent	Sand Percent	Fines Percent	Clay-size Percent	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c	Liquid Limit, LL	Plastic Limit, PL	Non-Plastic	Soil Description
	(feet)			(bpf)		(%)	(%)	(%)	(%)	(%)	(%)			(%)	(%)		
B-01p-24	10	S-4	SPT	38	GP	8.1		72*	24*	4*		64.3	4.4				POORLY GRADED GRAVEL with SAND
B-01p-24	17.5	S-7	SPT	58	SC	15.0		5*	48*	47*				25	16		SILTY SAND
B-02p-24	2.5	S-1	SPT	0	MH	88.0			8	92	16			69	42		ELASTIC SILT
B-02p-24	10	S-4	SPT	12	SP	28.4											POORLY GRADED SAND
B-02p-24	25	S-9	SPT	0		37.0		1	11	88	8						ELASTIC SILT
B-03p-24	2.5	S-1	SPT	1		51.0	2.9		18	82	13						ELASTIC SILT with SAND
B-03p-24	12.5	S-5	SPT	17	SP-SM	26.8			89	11		4.5	0.9				POORLY GRADED SAND with SILT
B-03p-24	25	S-9	SPT	6	SP-SM	27.9		0	93	6.9		4.2	1.2				POORLY GRADED SAND with SILT
GS-01	0	S-1	GB			17.5		3*	7*	90*	20*						ELASTIC SILT with SAND
Lower Sand	0	S-1	SS			30.2		3*	66*	32*							SM
SB-01	0	S-1	SS		SP	27.0	7.9										POORLY GRADED SAND
SB-01	4	S-4	SS											79	48		OH
SB-01	10.2	S-7	SS		SP	26.3											POORLY GRADED SAND
SB-02	2.5	S-2	SS		SP	65.3	1.7										POORLY GRADED SAND
SB-02	4.5	S-4	SS			56.6			16	84	9						ML
SB-02	7.1	S-5	SS		SP	23.5											POORLY GRADED SAND
SB-03	0.5	S-1	SS											60	33		MH
SB-03	3	S-3	SS		SP	44.7											POORLY GRADED SAND
SB-04	1.5	S-2	SS		SP	78.1	6.2										POORLY GRADED SAND
SB-04	3	S-3	SS		SP	69.5	5.6										POORLY GRADED SAND
SB-04	5.5	S-4	SS			32.4				63							ML
SB-04	7.2	S-5	SS		SP	22.6											POORLY GRADED SAND
TP-1	0.5	TP-1-S1	GB		SP	84.1											POORLY GRADED SAND
TP-1	3	TP-1-S2	GB		MH	78.1			2	98	40			97	42		ELASTIC SILT
TP-1	4	TP-1-S3	GB			33.8			26	74							ELASTIC SILT with SAND
TP-2	1.1	TP-2-S1	GB		MH	53.7			7	93	16			66	41		ELASTIC SILT
TP-2	5.4	TP-2-S2	GB			29.4			33	67							SANDY ELASTIC SILT

Table B-1 - Summary of Laboratory Test Results

Exploration Designation	Top Depth	Sample Number	Sample Type	SPT Blow Count	USCS	Water Content	Organic Content	Gravel Percent	Sand Percent	Fines Percent	Clay-size Percent	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c	Liquid Limit, LL	Plastic Limit, PL	Non-Plastic	Soil Description
	(feet)			(bpf)		(%)	(%)	(%)	(%)	(%)	(%)			(%)	(%)		
TP-3	1.1	TP-3-S1	GB		MH	52.5			5	95	16			55	37		ELASTIC SILT
TP-3	5	TP-3-S2	GB			30.0			31	69							SANDY ELASTIC SILT
TP-4	5	TP-4-S2	GB		SM	31.6			51	49							SILTY SAND
TP-5	3	TP-5-S1	GB		SP	42.4											POORLY GRADED SAND
TP-6	1.2	TP-6-S1	GB			61.7			0	100							SANDY ELASTIC SILT
TP-7	2.2	TP-7-S1	GB			75.2			6	94	20						SANDY ELASTIC SILT
TP-7	2.5	TP-7-S1	GB		SP									73	44		POORLY GRADED SAND

NOTES:

* Sample specimen weight did not meet required minimum mass for the test; bpf = blows per foot; SPT = 2-inch Outside Diameter Split-Spoon Sample; SS = Split-Spoon
The "Lower Sand" sample is a combined sample from SB-01, SB-02, SB-03, and SB-04 from 2.6 to 10.2 feet below the ground surface.

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GRAIN SIZE DISTRIBUTION TEST RESULTS

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Skagit County, Washington

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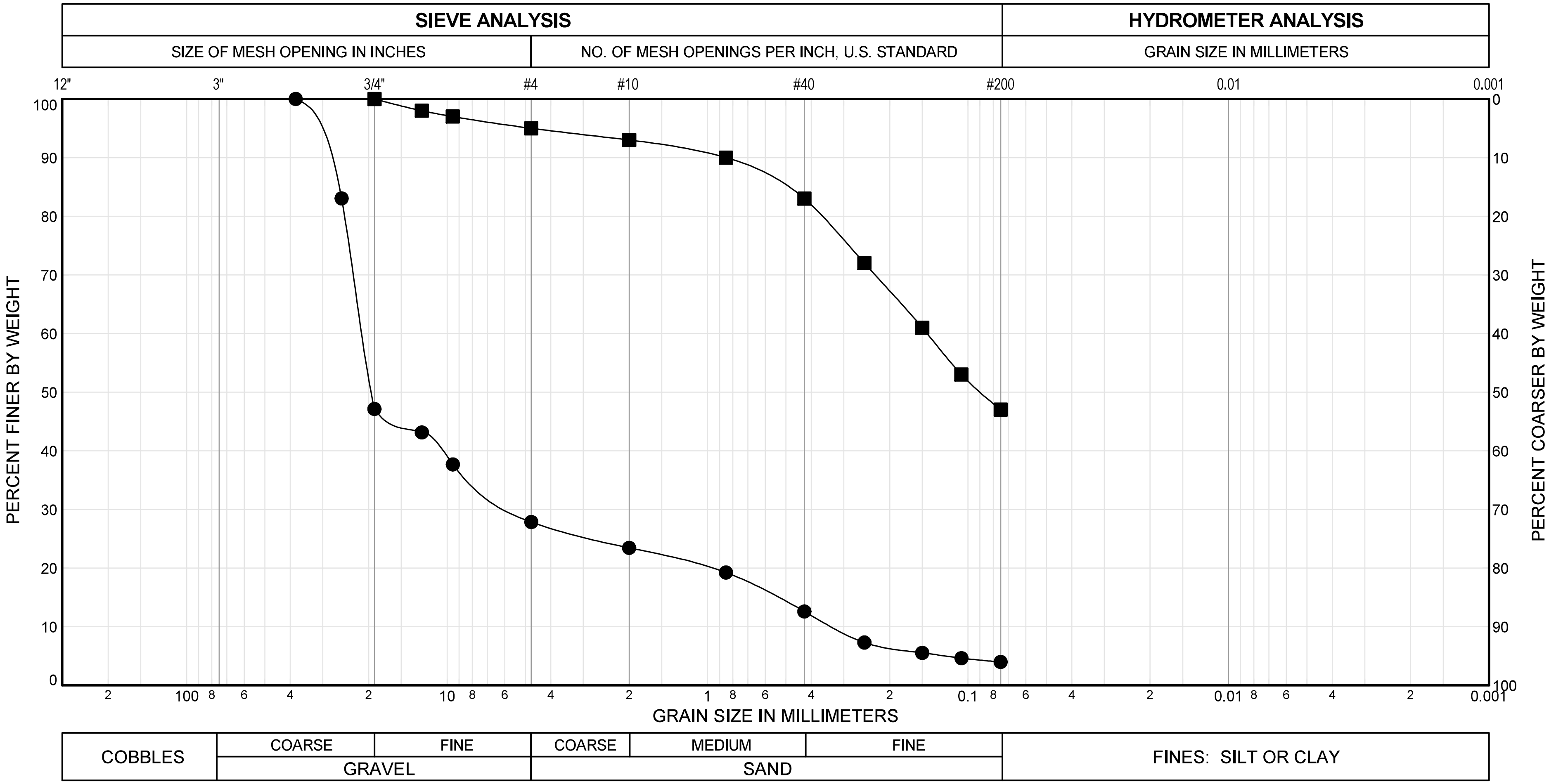

	EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
●	B-01p-24, S-4	10.0	POORLY GRADED GRAVEL with SAND	GP	72	24	4	8.1	AWP DJB	D6913	*The sample did not meet test standard's minimum requirements*
■	B-01p-24, S-7	17.5	CLAYEY SAND	SC	5	48	47	15.0	DJB DJB	D6913	*The sample did not meet test standard's minimum requirements*

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

GRAIN SIZE DISTRIBUTION TEST RESULTS

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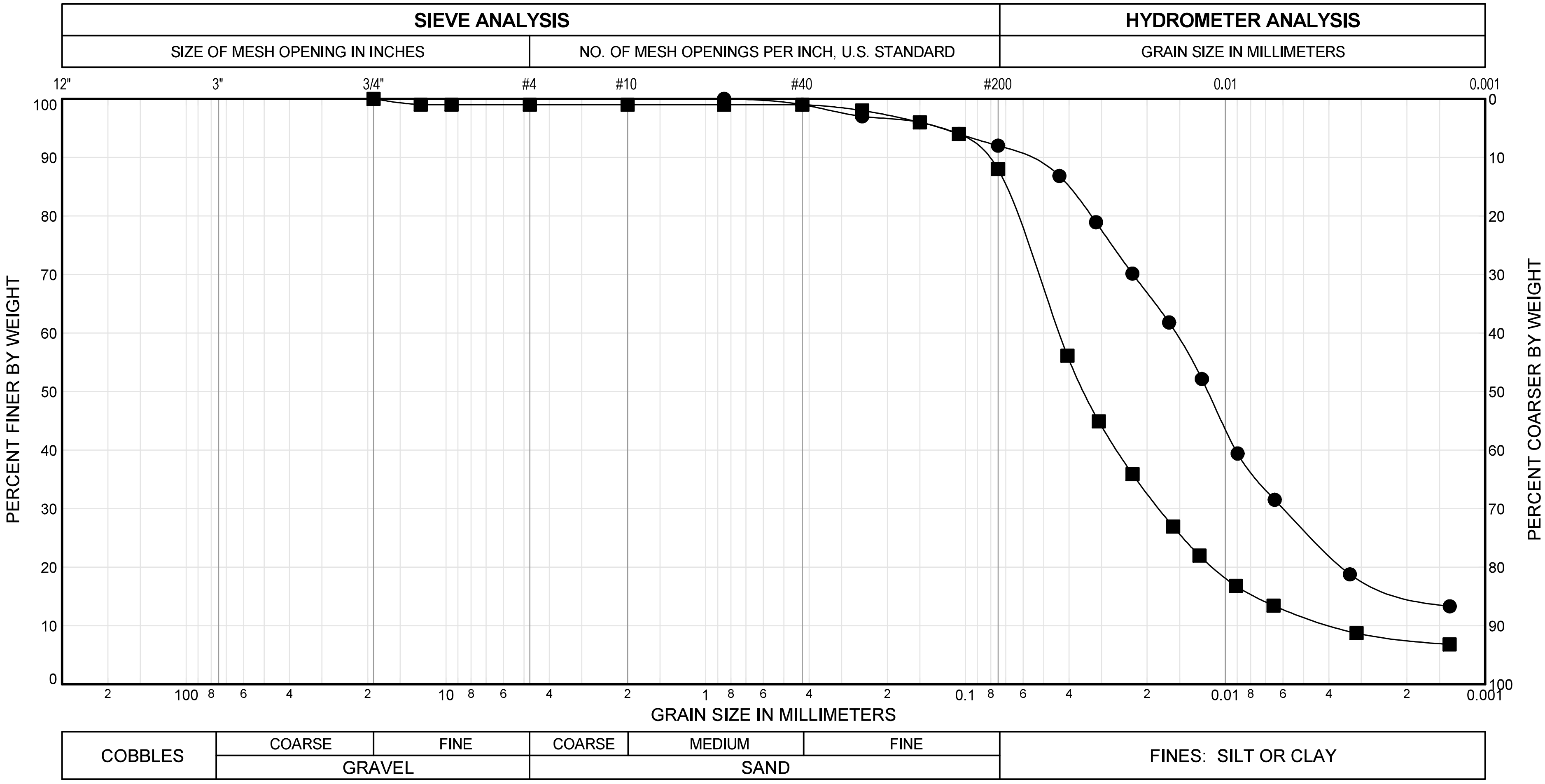

	EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	CF %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
●	B-02p-24, S-1	2.5	ELASTIC SILT	MH	0	8	92	16	88.0	TDT DJB	D6913 D7928	
■	B-02p-24, S-9	25.0	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		1	11	88	8	37.0	SJD DJB	D6913 D7928	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

GRAIN SIZE DISTRIBUTION TEST RESULTS

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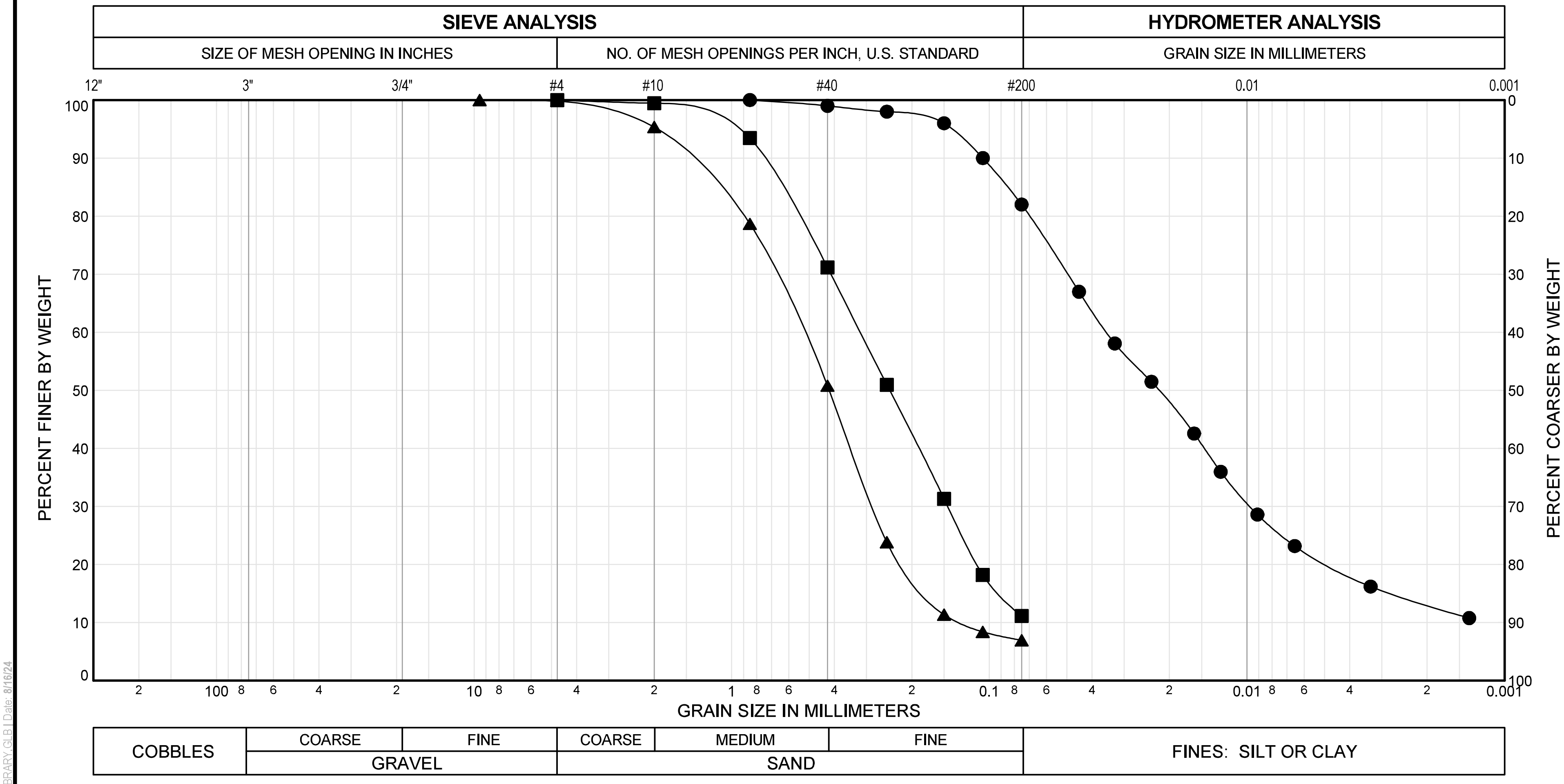

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● B-03p-24, S-1	2.5	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		0	18	82	51.0	SJD DJB	D6913 D7928	
■ B-03p-24, S-5	12.5	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		0	89	11	26.8	APA DJB	D6913	
▲ B-03p-24, S-9	25.0	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		~0	93	7	27.9	SJD DJB	D6913	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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GRAIN SIZE DISTRIBUTION TEST RESULTS

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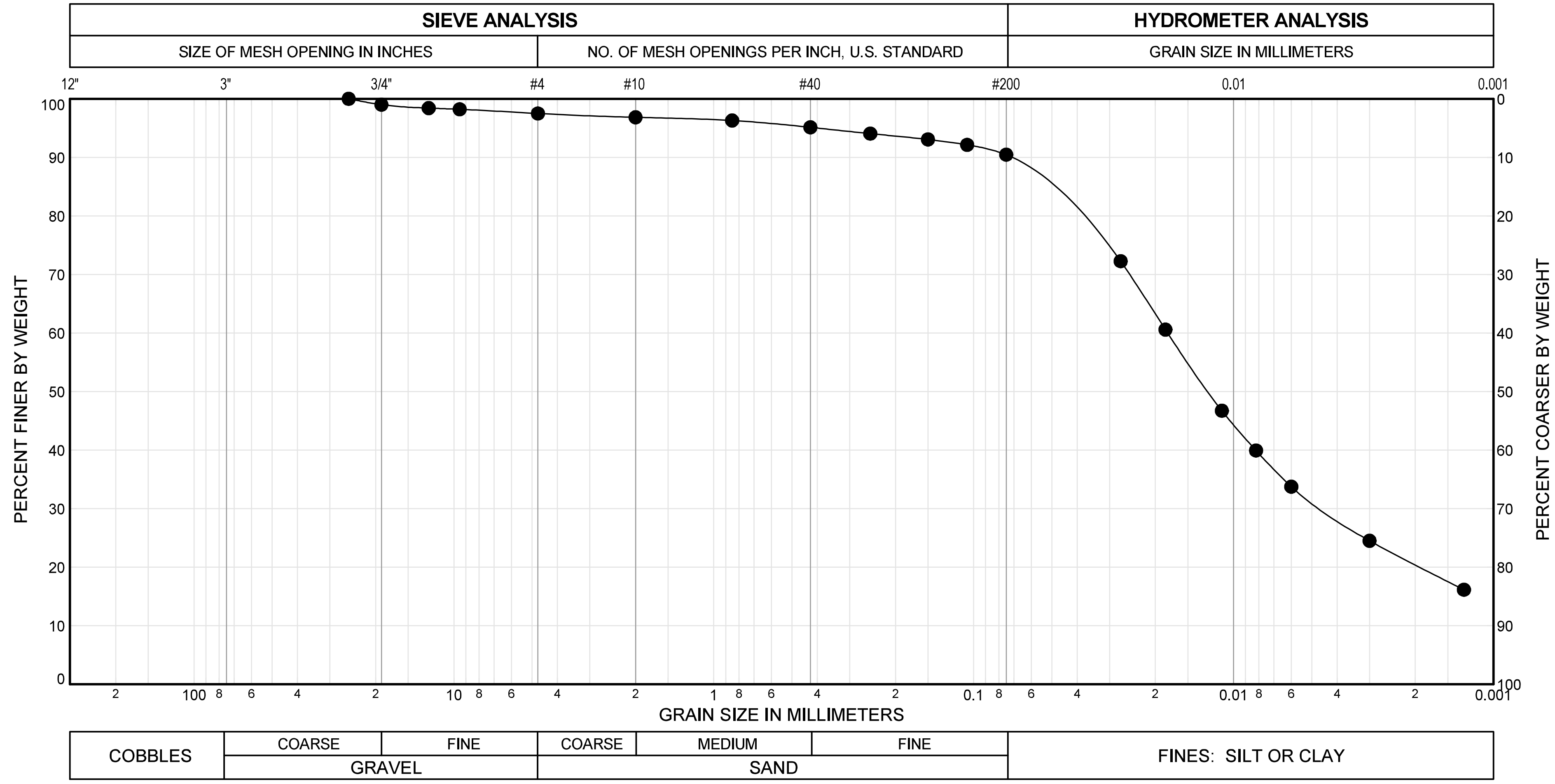

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	CF %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● GS-01, S-1	0.0	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		3	7	90	20	17.5	KCV MXM	D422	*The sample did not meet test standard's minimum requirements*

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

GRAIN SIZE DISTRIBUTION TEST RESULTS

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Lower Sand

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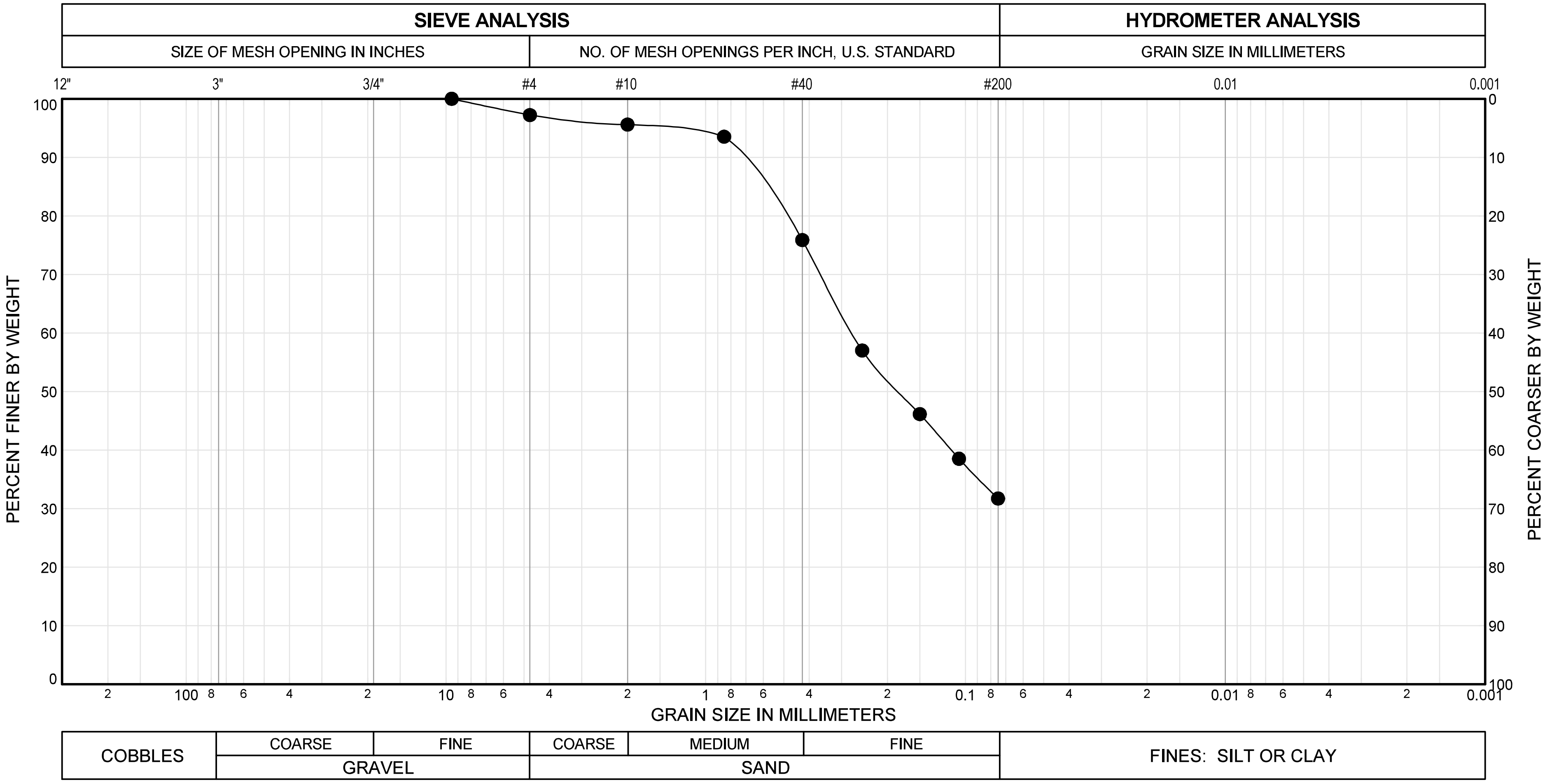

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● Lower Sand, S-1	0.0	SM *		3	66	32	30.2	SJD MXM	D6913	*The sample did not meet test standard's minimum requirements*

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

GRAIN SIZE DISTRIBUTION TEST RESULTS

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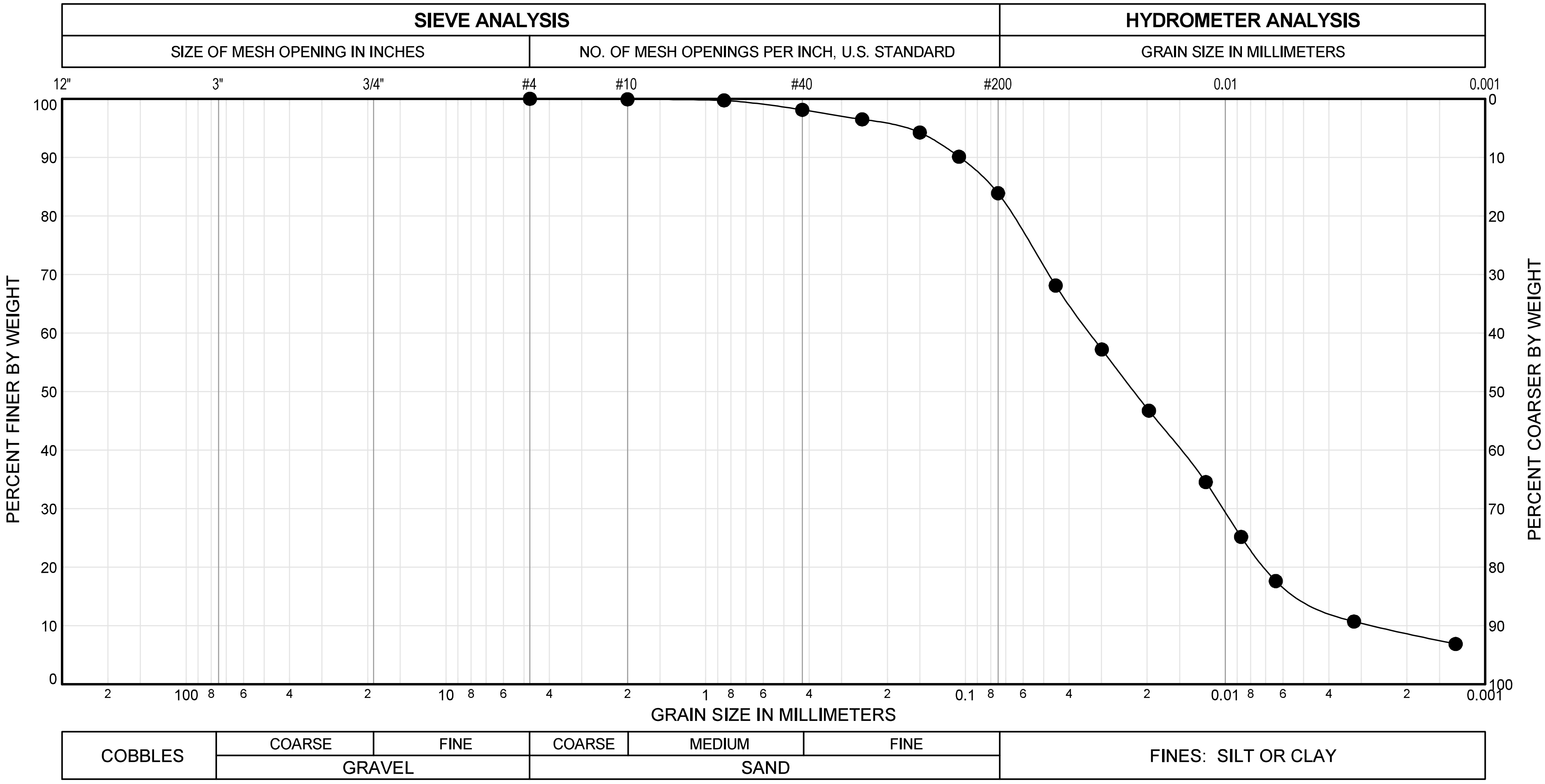

	EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	CF %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
●	SB-02, S-4	4.5	ML *		0	16	84	9	56.6	SJD MXM	D422	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

GRAIN SIZE DISTRIBUTION TEST RESULTS

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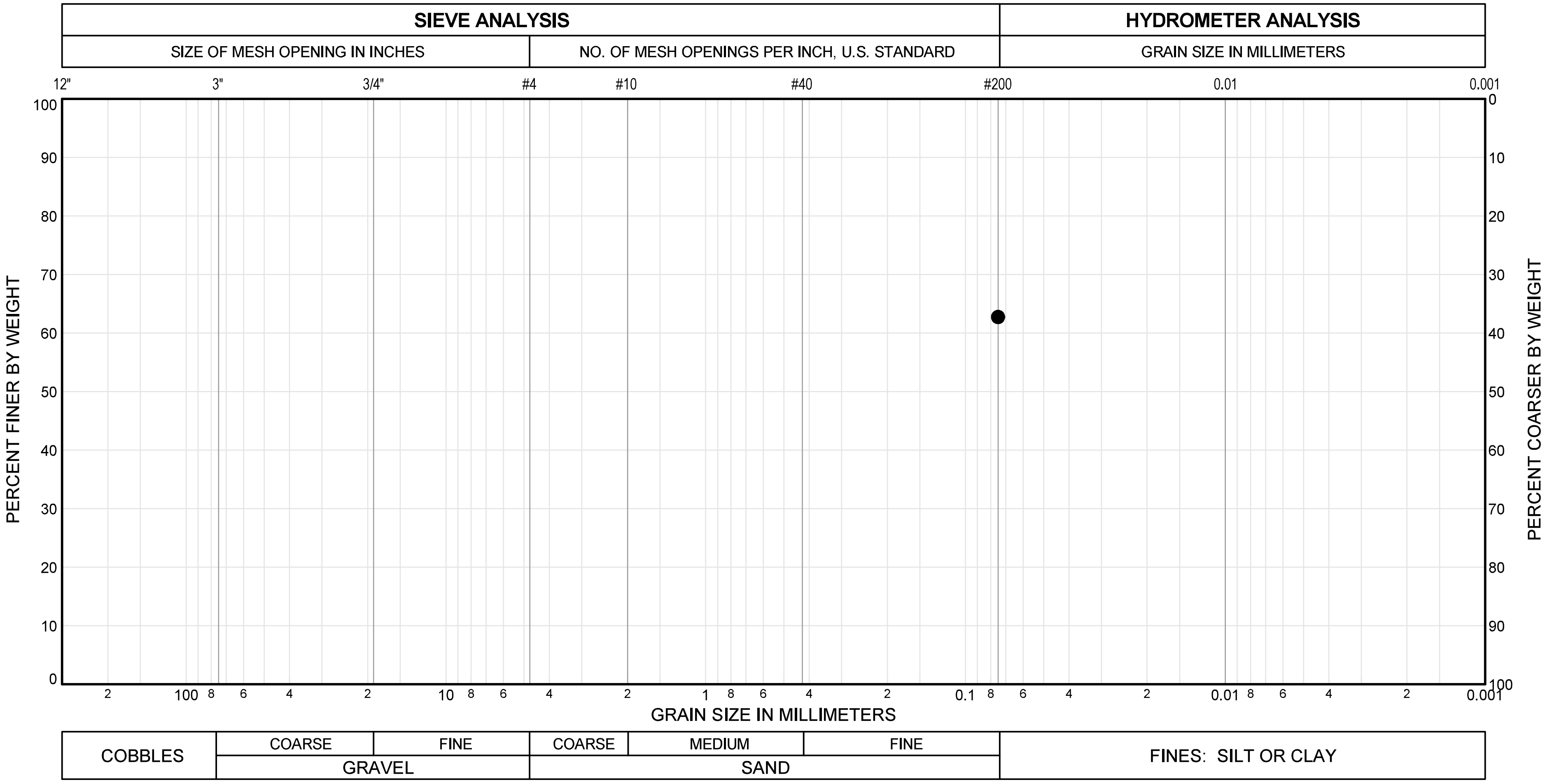

	EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
●	SB-04, S-4B	5.5	ML *				63	32.4	SJD MXM	D1140	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

GRAIN SIZE DISTRIBUTION TEST RESULTS

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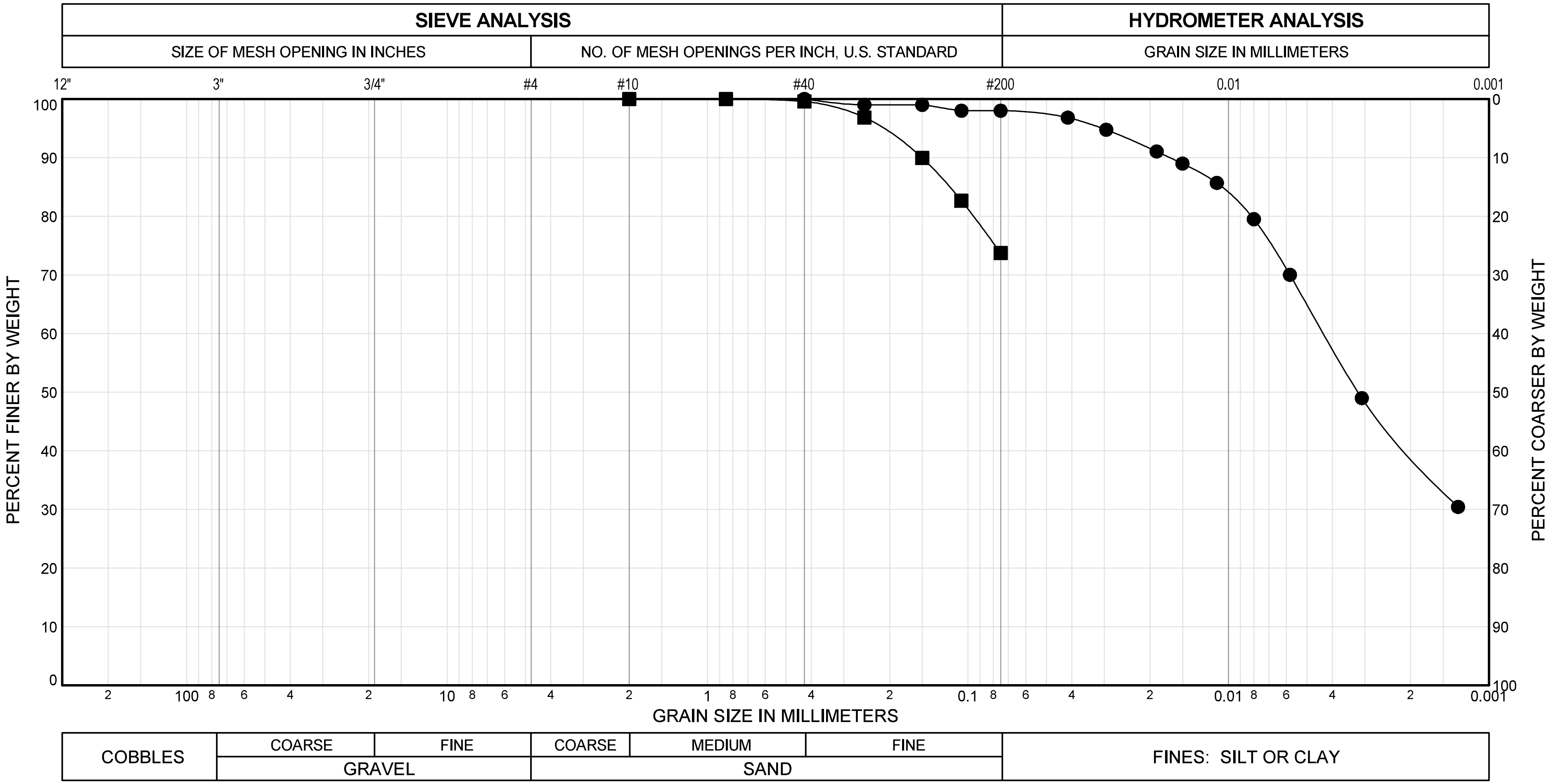

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● TP-1, TP-1-S2	3.0	ELASTIC SILT	MH	0	2	98	78.1	SJD DJB	D6913 D7928	
■ TP-1, TP-1-S3	4.0	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		0	26	74	33.8	SJD DJB	D6913	*Mostly Organics on No. 20, Some Organics on No. 40 to No. 100, Little Organics on No. 140, Few Organics On the remainder.*

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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GRAIN SIZE DISTRIBUTION TEST RESULTS

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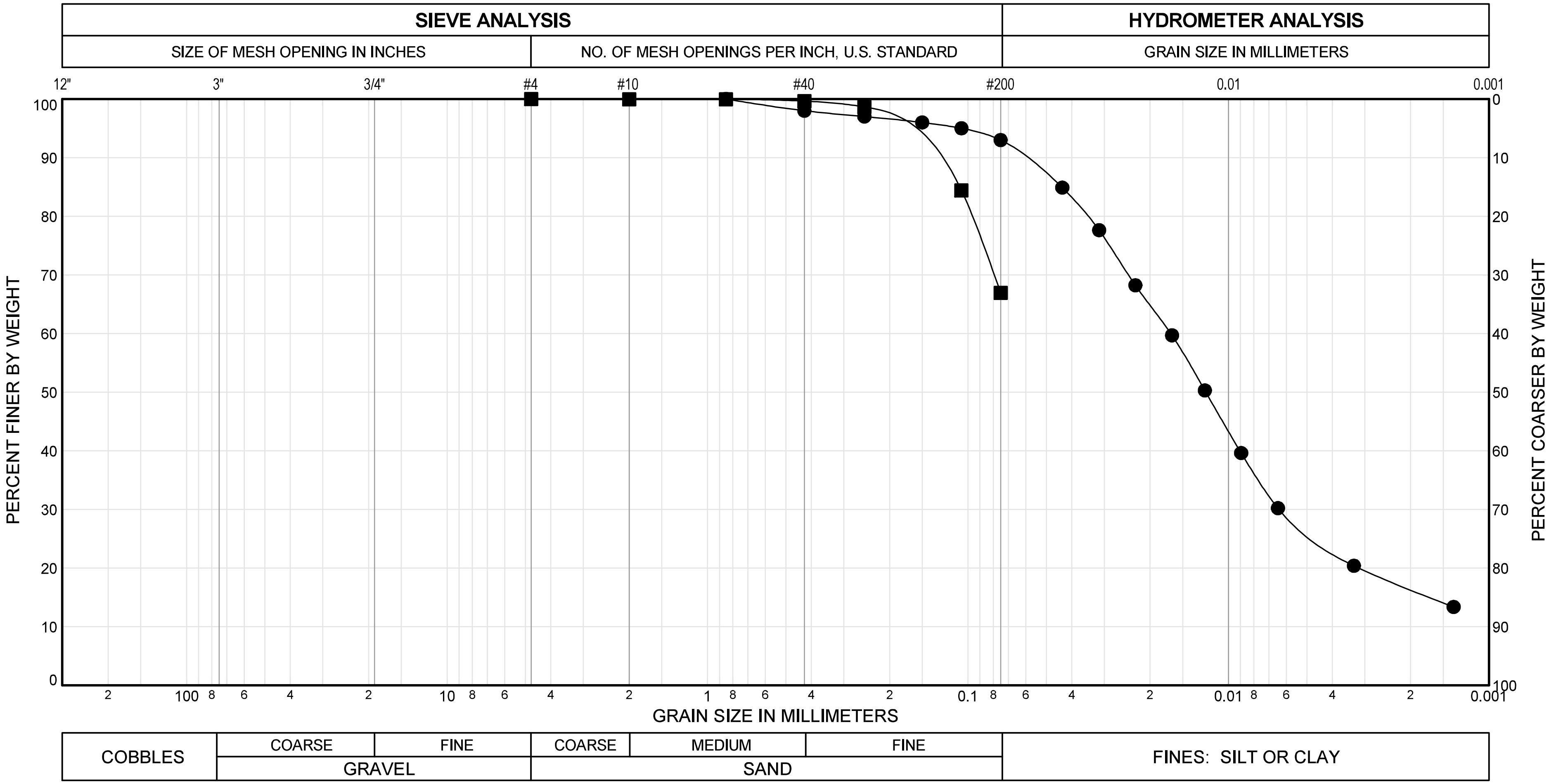

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●	TP-2, TP-2-S1	1.1	ELASTIC SILT	MH	0	7	93	53.7	SJD DJB	D6913 D7928	
■	TP-2, TP-2-S2	5.4	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		0	33	67	29.4	AWP DJB	D6913	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

GRAIN SIZE DISTRIBUTION TEST RESULTS

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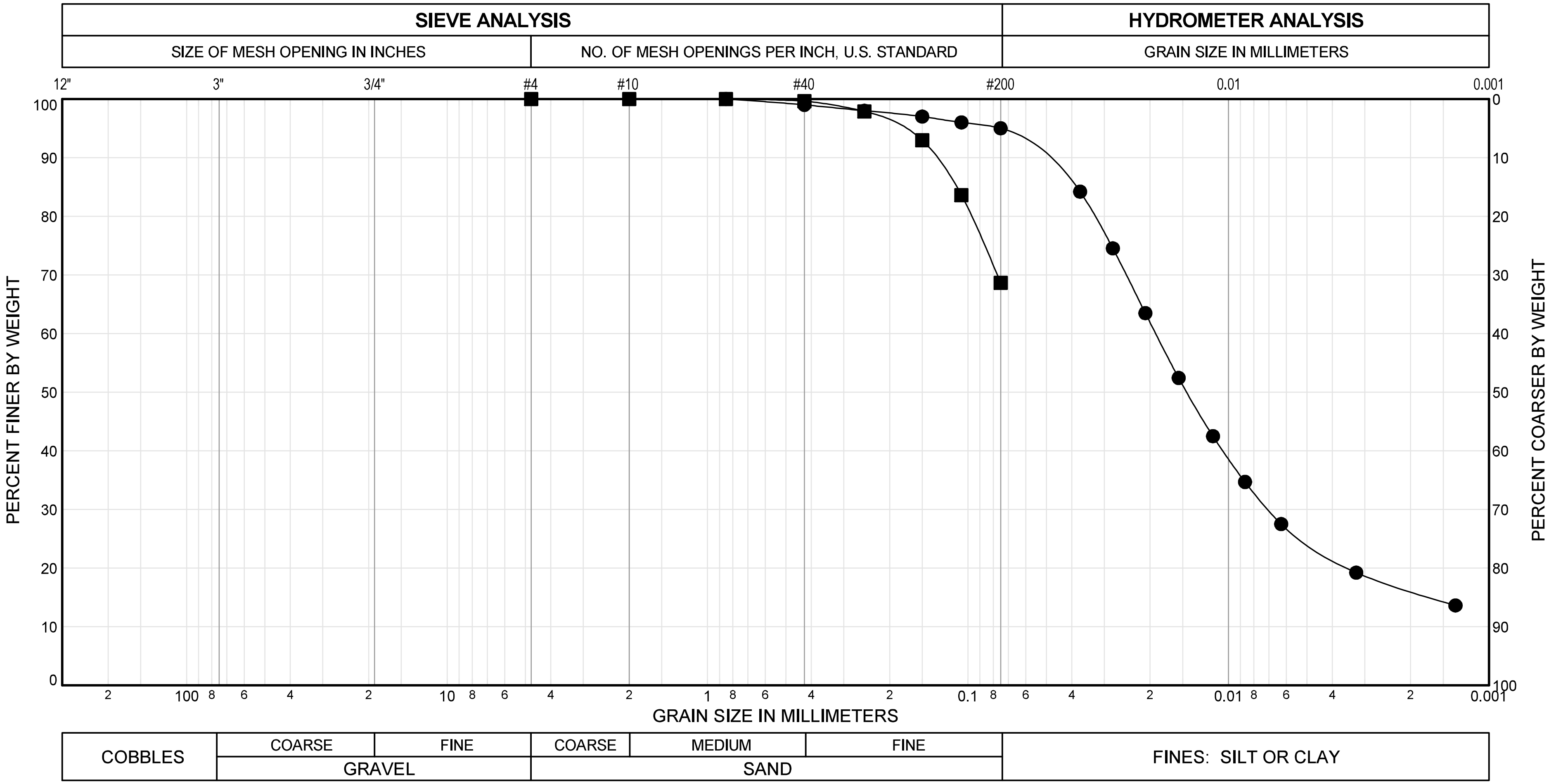

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●	TP-3, TP-3-S1	1.1	ELASTIC SILT	MH	0	5	95	52.5	SJD DJB	D6913 D7928	
■	TP-3, TP-3-S2	5.0	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		0	31	69	30.0	SJD DJB	D6913	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

GRAIN SIZE DISTRIBUTION TEST RESULTS

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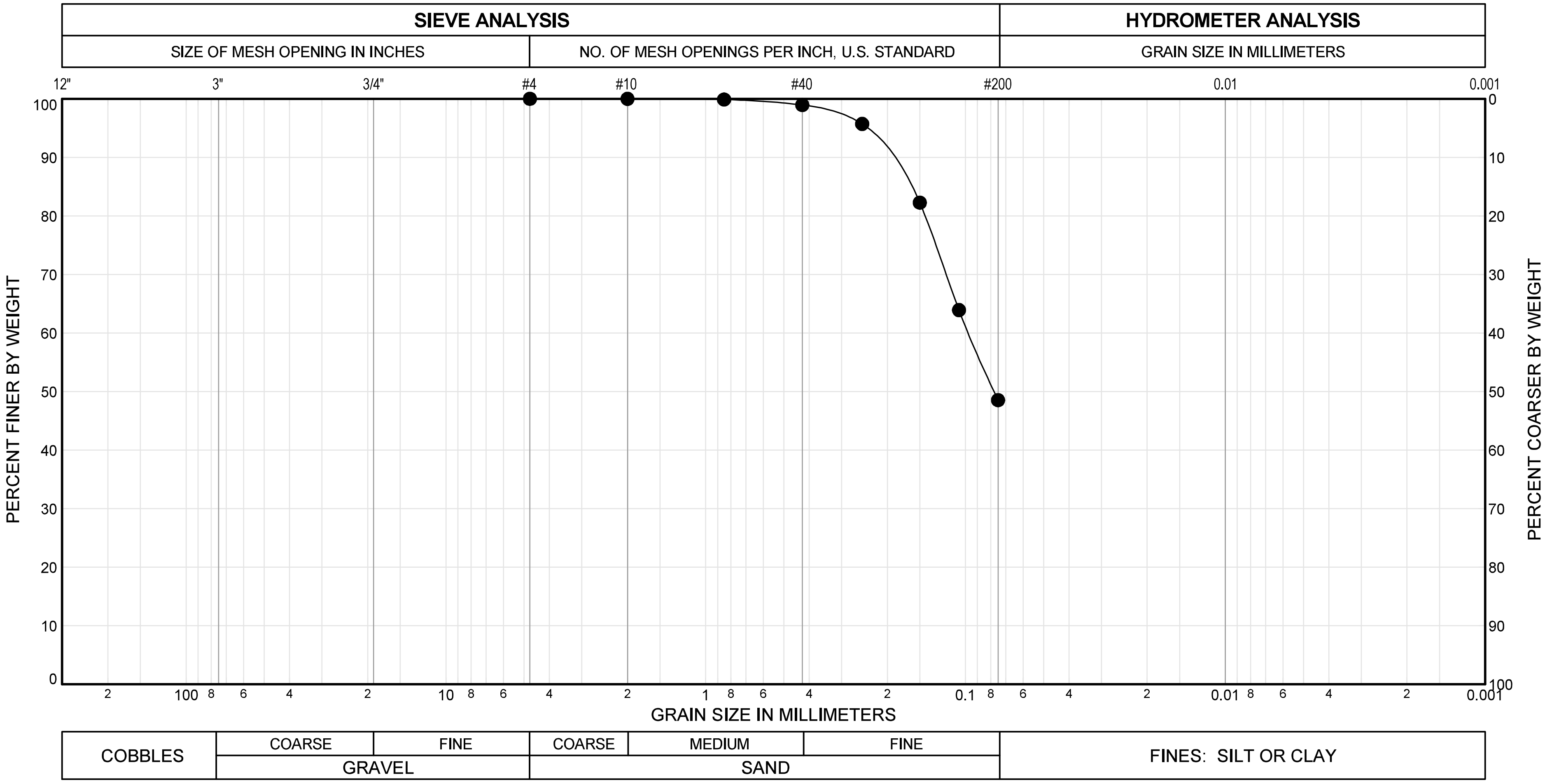

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● TP-4, TP-4-S2	5.0	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		0	51	49	31.6	AWP DJB	D6913	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

GRAIN SIZE DISTRIBUTION TEST RESULTS

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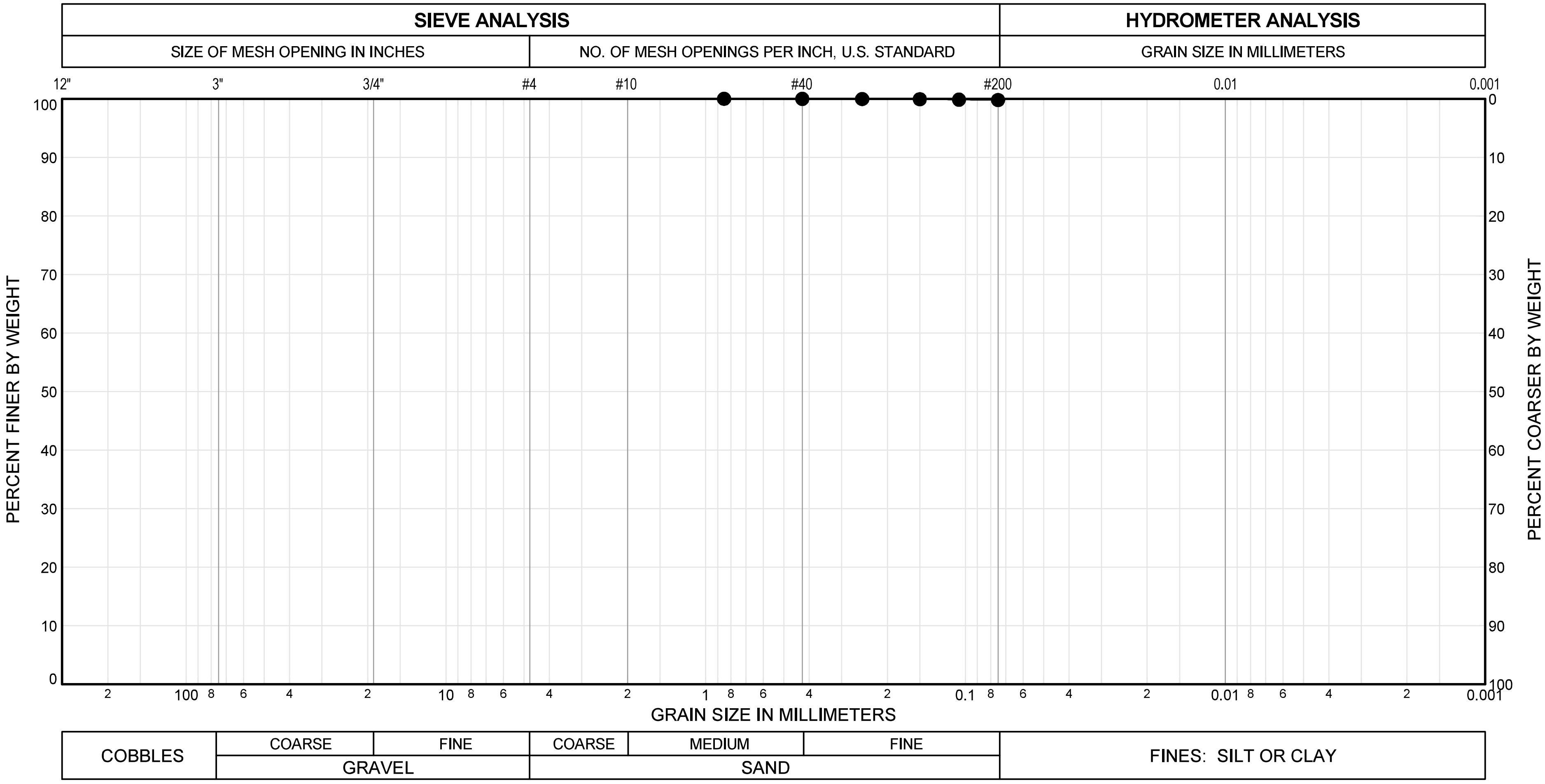

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● TP-6, TP-6-S1	1.2	*Sieve analysis only - no Atterberg Limits:* *Group Name not estimated*		0	~0	100	61.7	AWP DJB	D6913	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

GRAIN SIZE DISTRIBUTION TEST RESULTS

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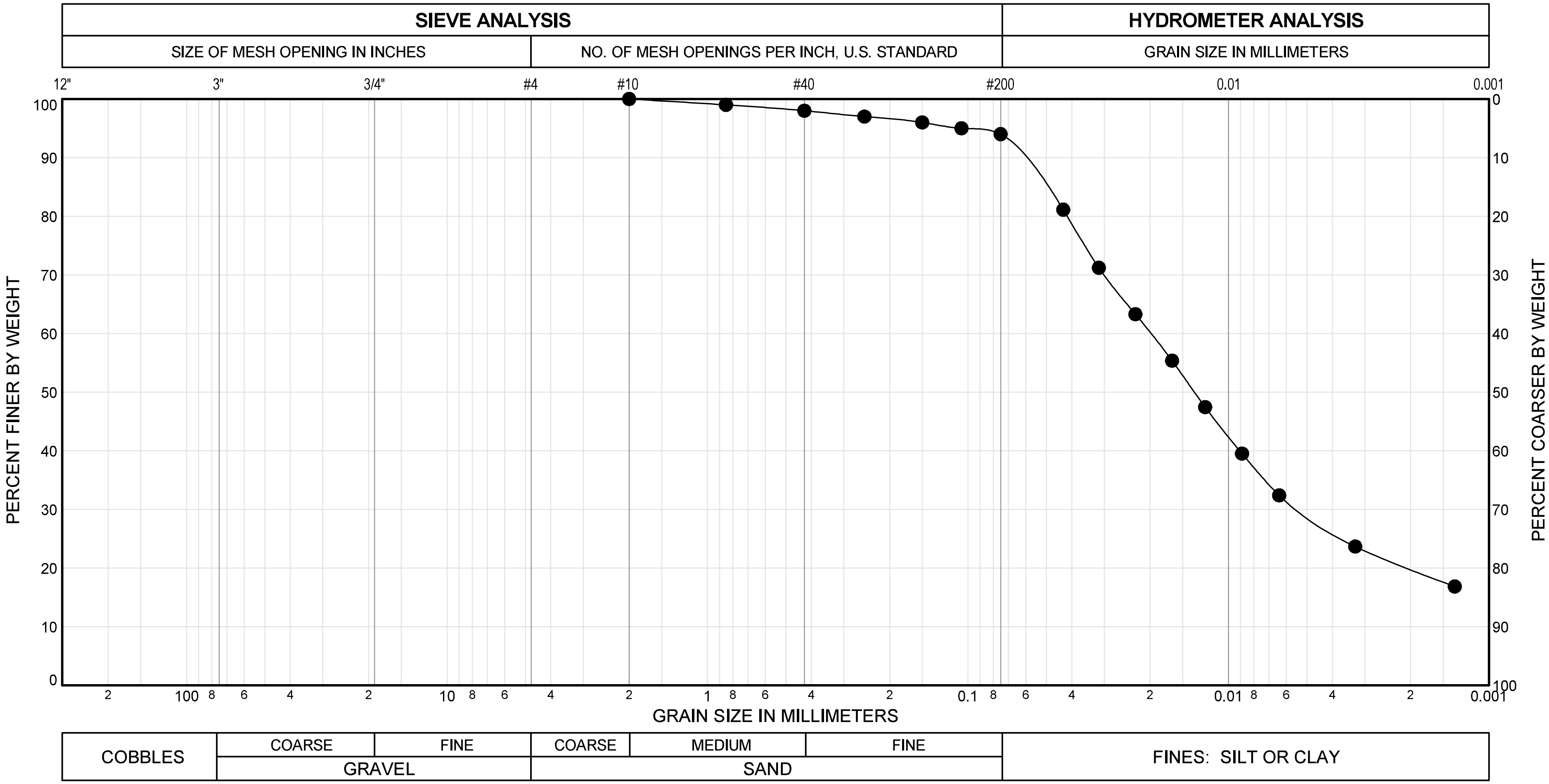

	EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	CF %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
●	TP-7, TP-7-S1	2.2	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		0	6	94	20	75.2	SJD DJB	D6913 D7928	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the the grain size distribution.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

ATTERBERG LIMITS TEST RESULTS

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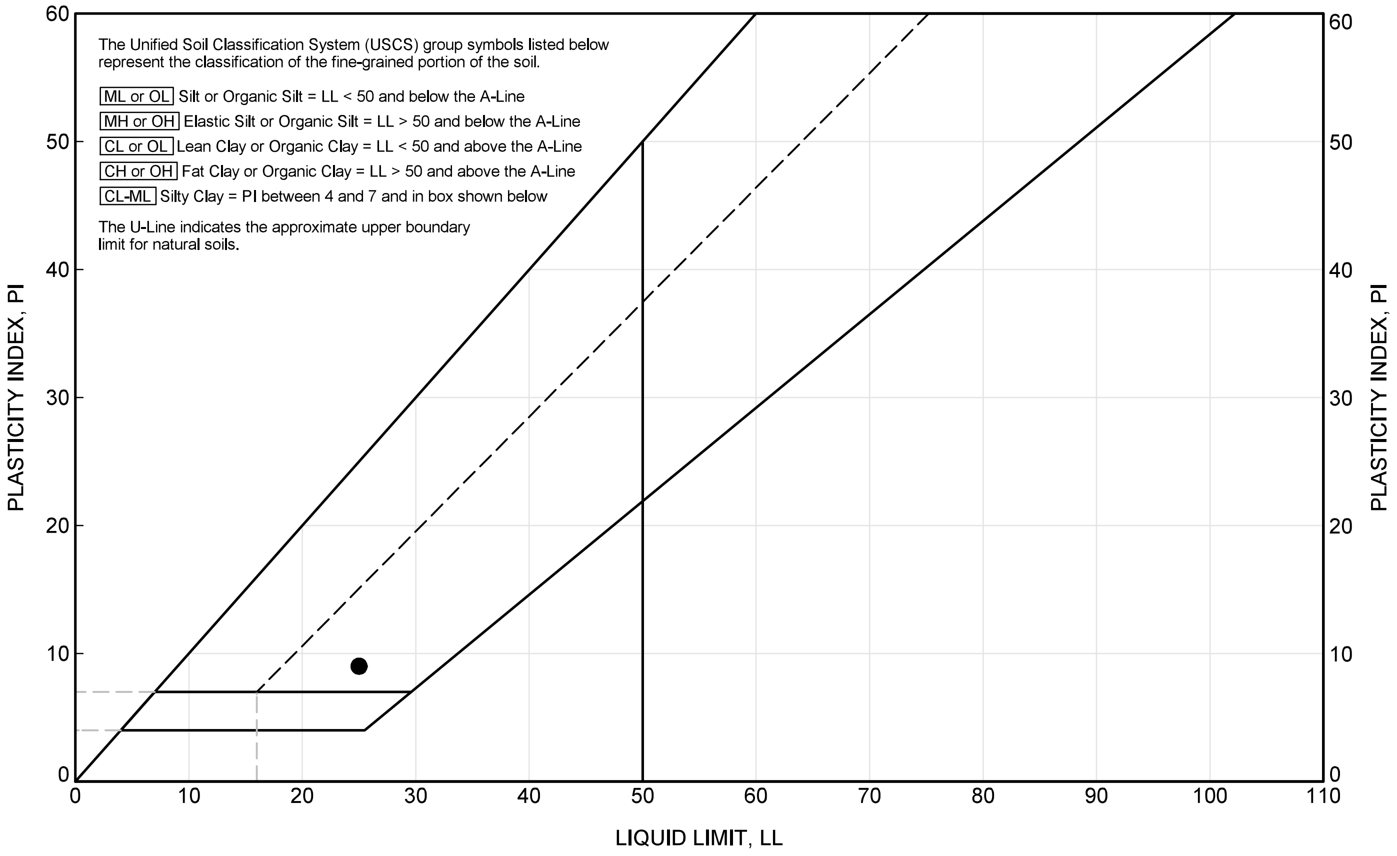

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● B-01p-24, S-7	17.5	CLAYEY SAND	SC	25	16	9	47	15.0	TDT DJB	D4318	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the Atterberg Limits test results.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

ATTERBERG LIMITS TEST RESULTS

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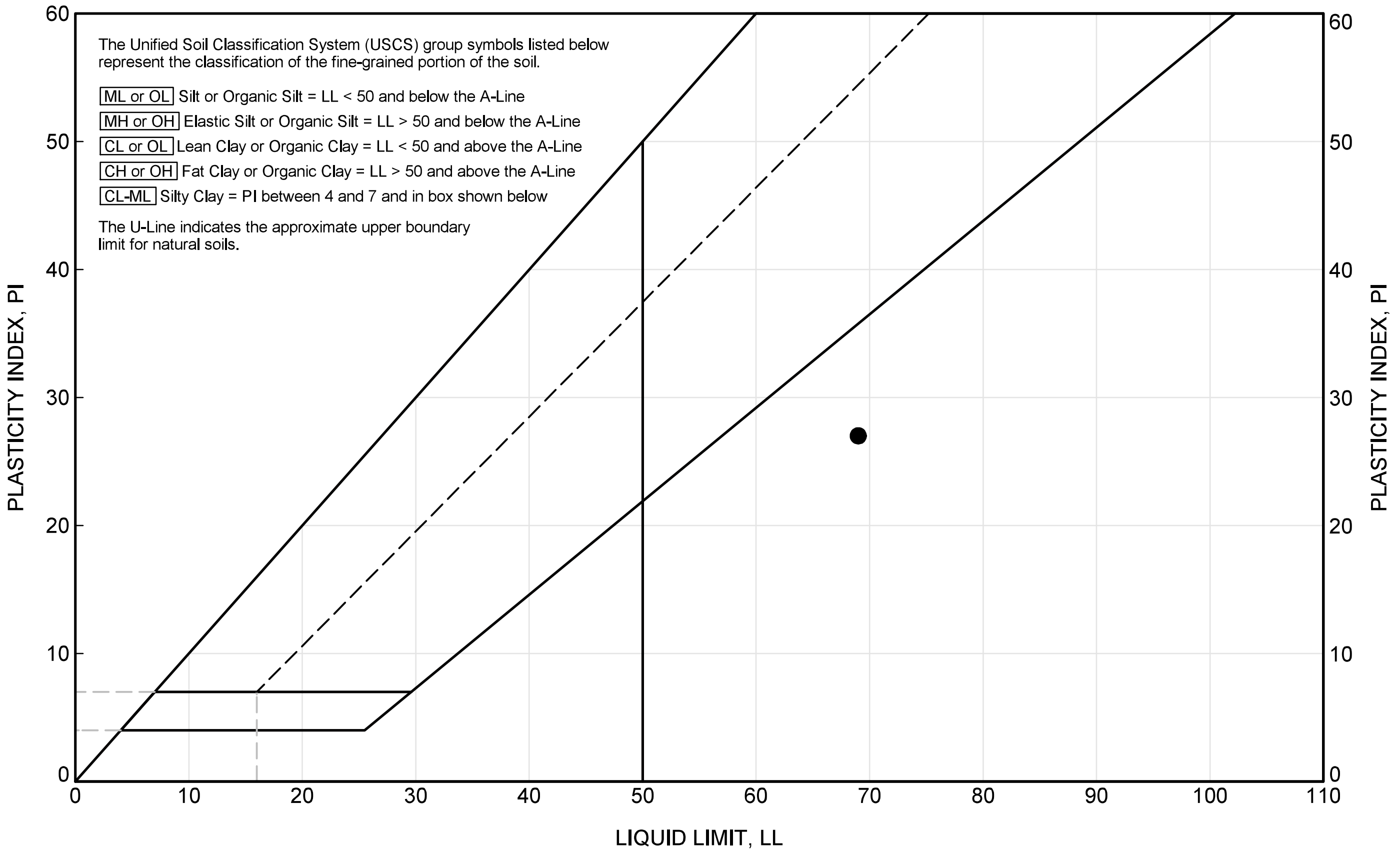

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● B-02p-24, S-1	2.5	ELASTIC SILT	MH	69	42	27	92	88.0	TDT DJB	D4318	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the Atterberg Limits test results.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

ATTERBERG LIMITS TEST RESULTS

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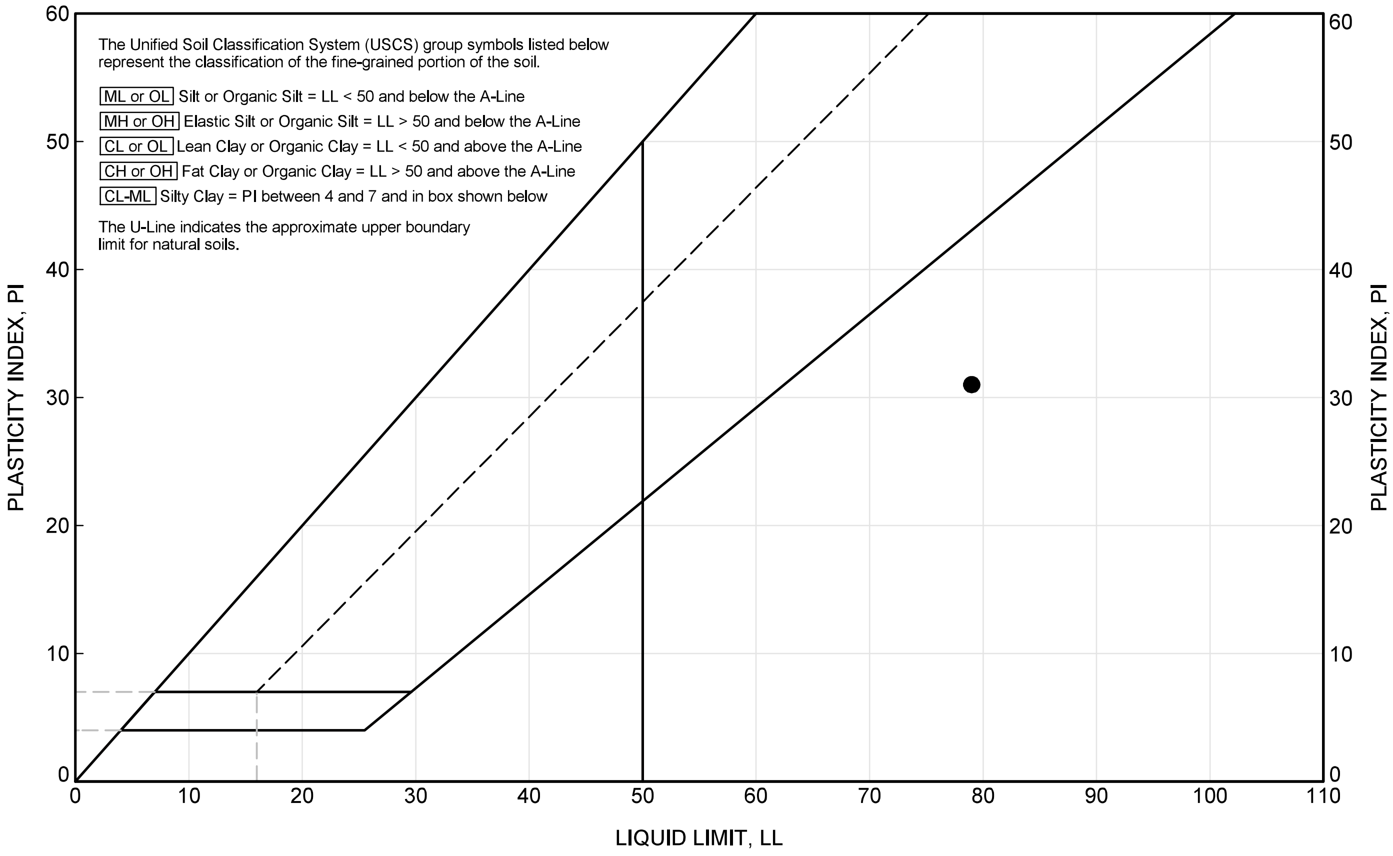

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● SB-01, S-4	4.0	OH		79	48	31			KCV MXM	D4318	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the Atterberg Limits test results.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

ATTERBERG LIMITS TEST RESULTS

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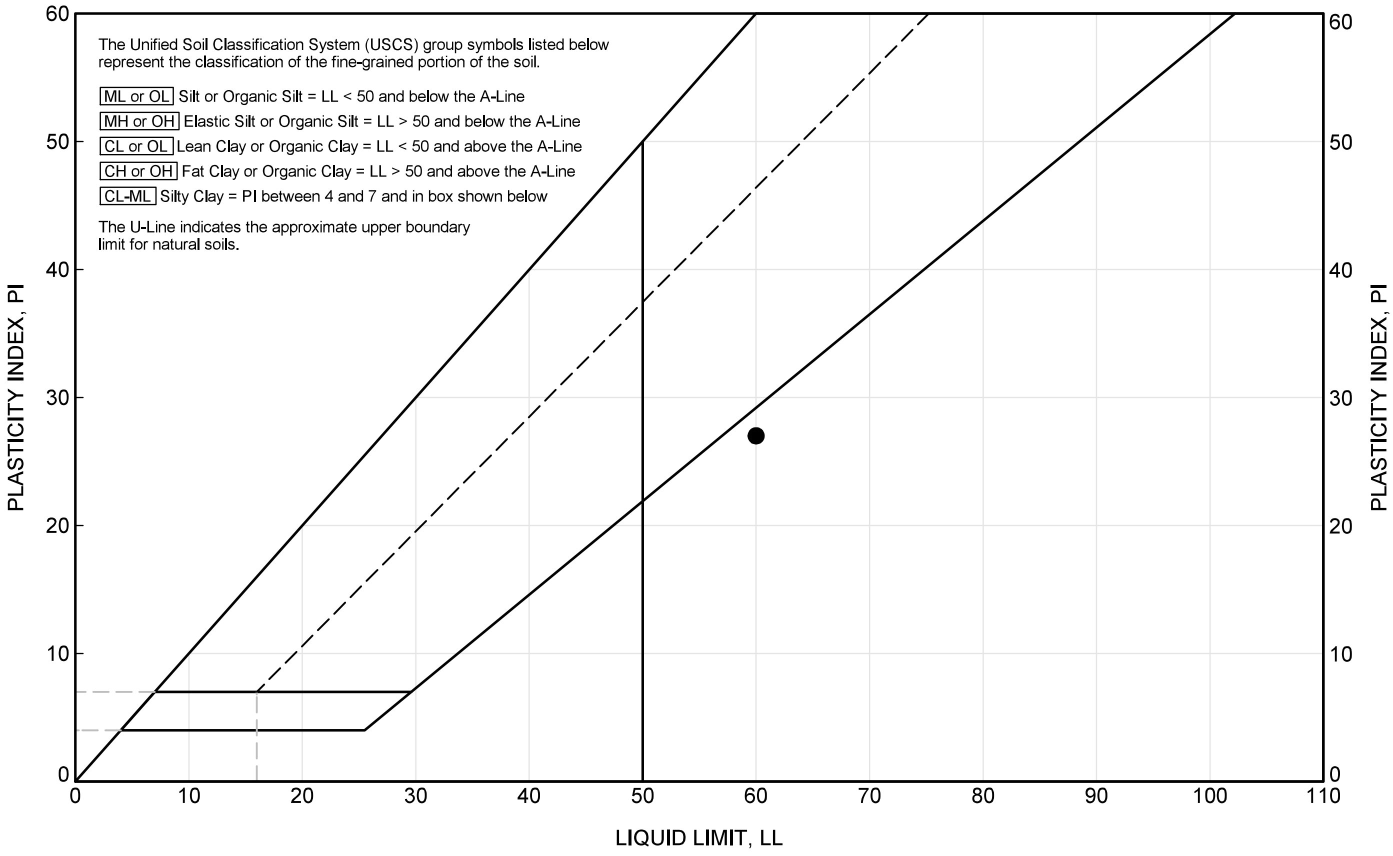

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● SB-03, S-1B	0.5	MH		60	33	27			KCV MXM	D4318	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the Atterberg Limits test results.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

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ATTERBERG LIMITS TEST RESULTS

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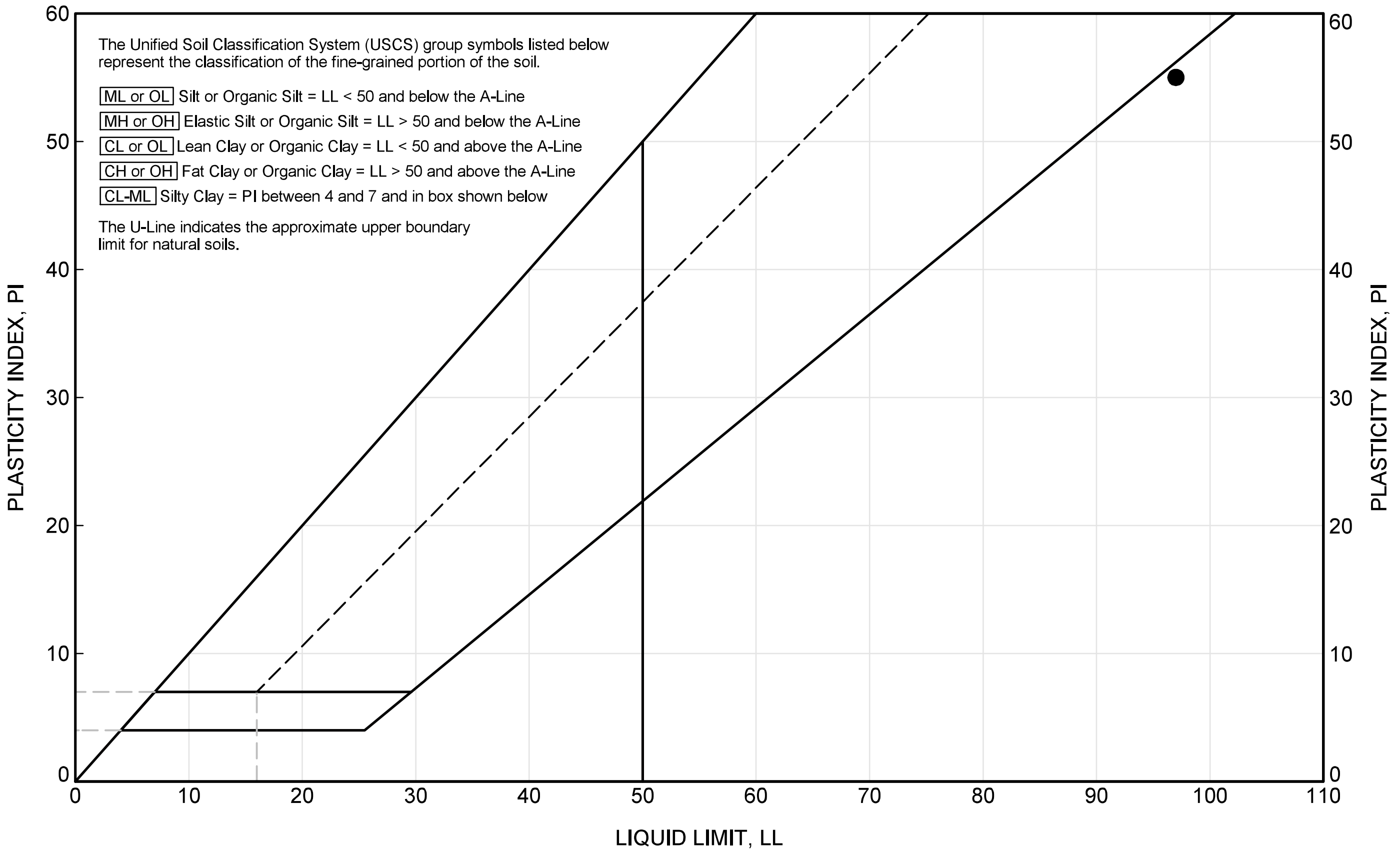

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● TP-1, TP-1-S2	3.0	ELASTIC SILT	MH	97	42	55	98	78.1	SJD DJB	D4318	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the Atterberg Limits test results.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by;
USCS = Unified Soil Classification System symbol

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ATTERBERG LIMITS TEST RESULTS

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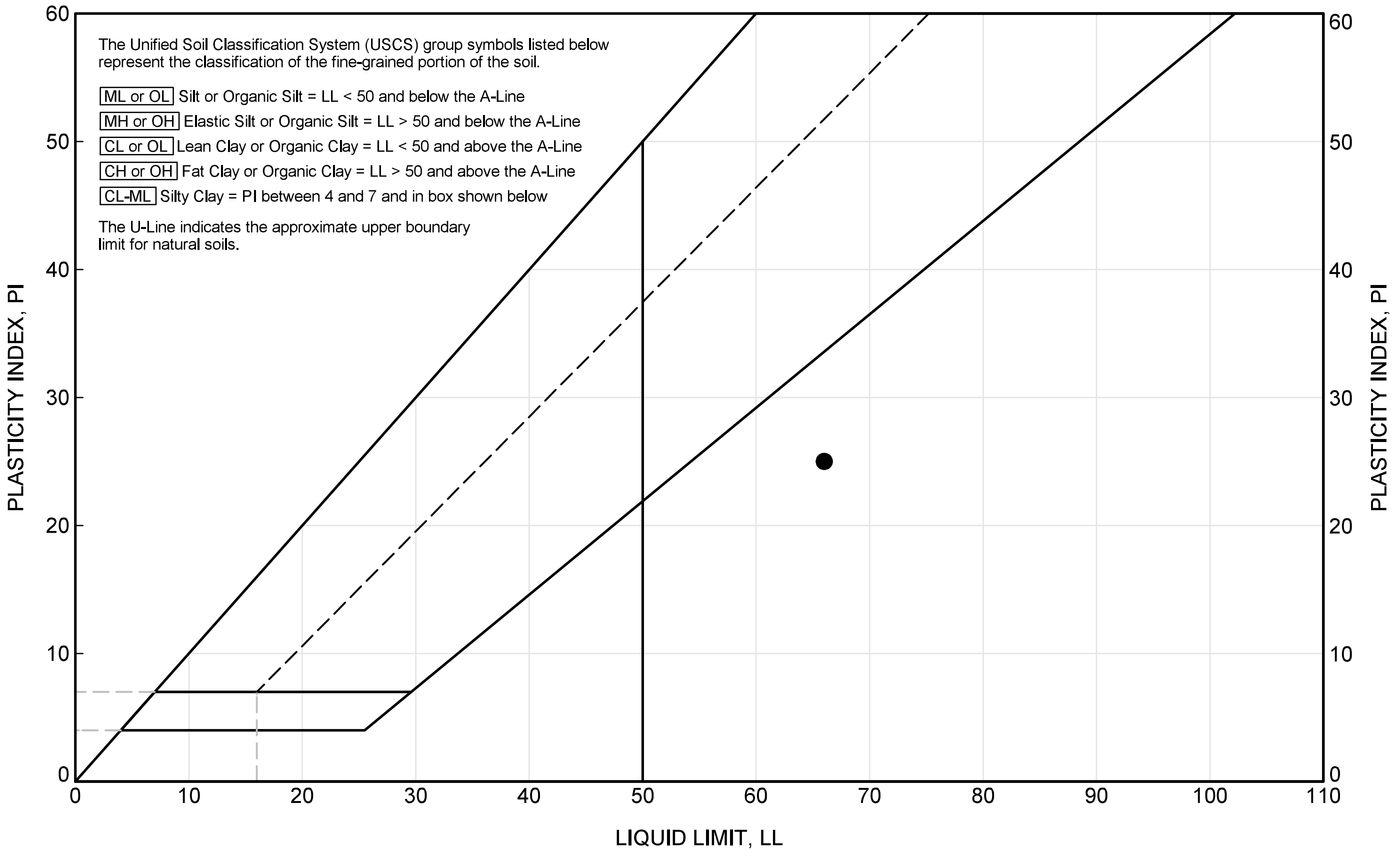

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● TP-2, TP-2-S1	1.1	ELASTIC SILT	MH	66	41	25	93	53.7	TDT DJB	D4318	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the Atterberg Limits test results.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

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ATTERBERG LIMITS TEST RESULTS

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TP-3
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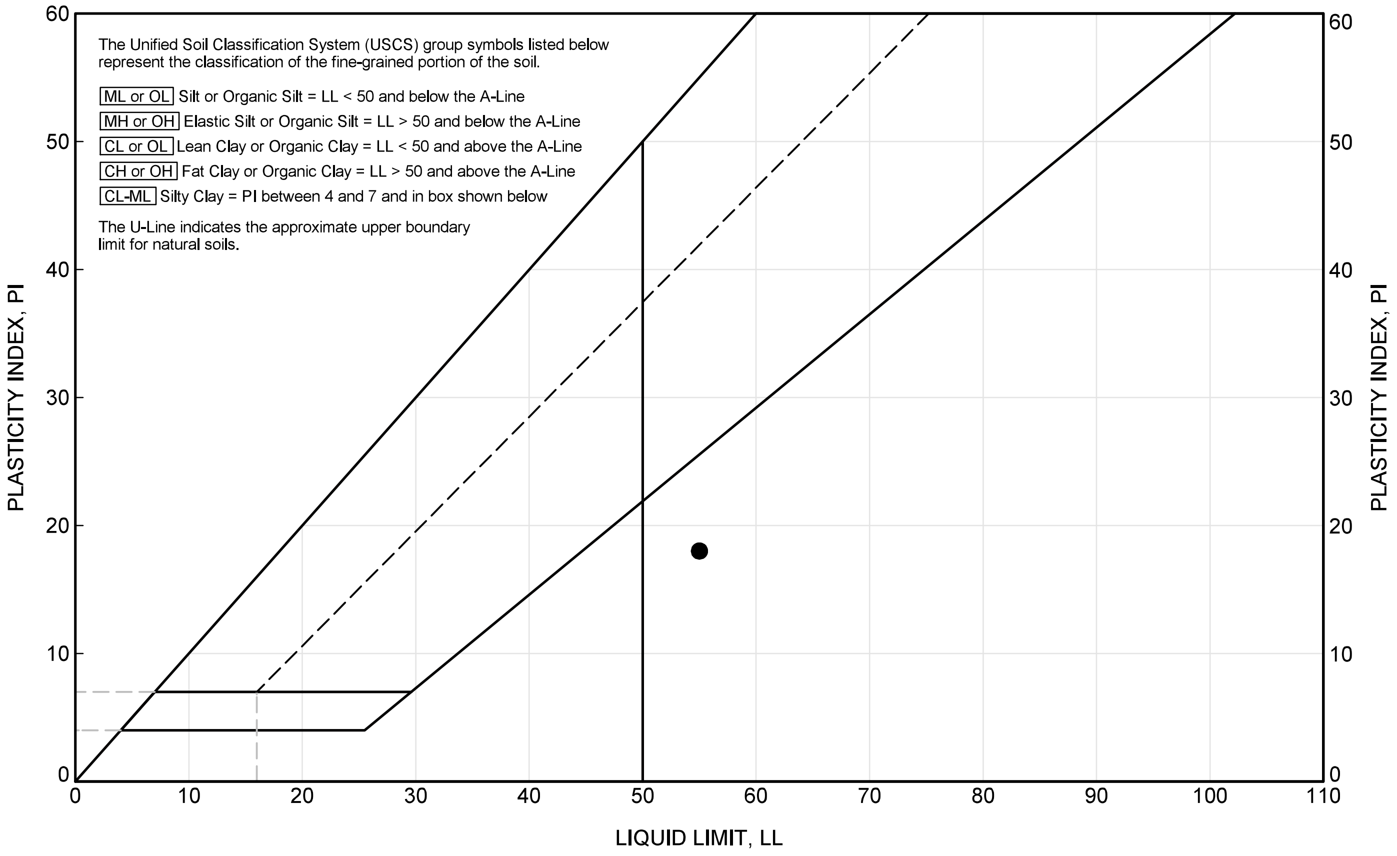

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● TP-3, TP-3-S1	1.1	ELASTIC SILT	MH	55	37	18	95	52.5	TDT DJB	D4318	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the Atterberg Limits test results.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by;
USCS = Unified Soil Classification System symbol

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ATTERBERG LIMITS TEST RESULTS

Samish Island Restoration Project
Skagit County, Washington

TP-7
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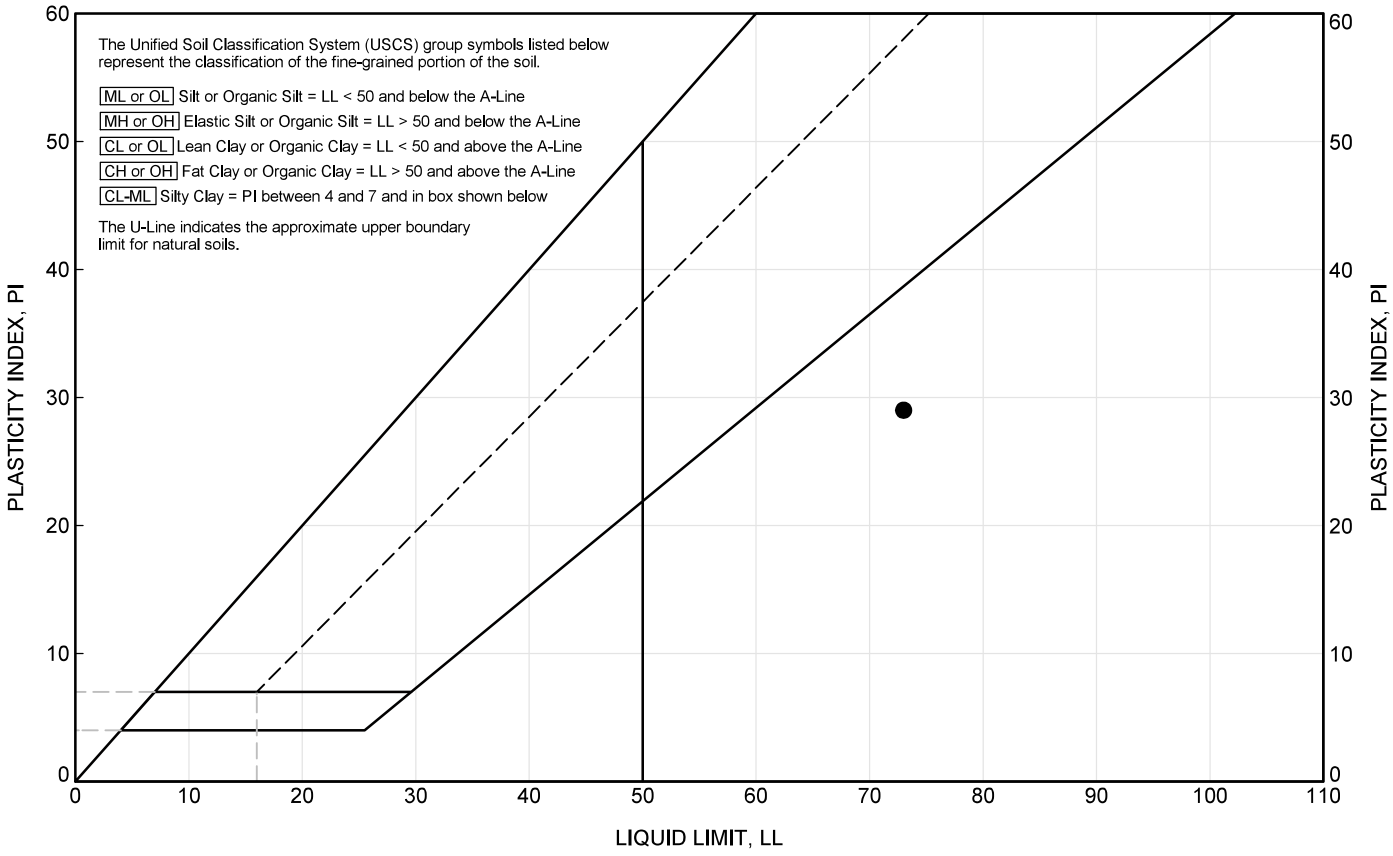

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● TP-7, TP-7-S1	2.5	*Atterberg Limits only - no sieve analysis: Group Name not estimated*		73	44	29			TDT DJB	D4318	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the Atterberg Limits test results.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

IMPORTANT INFORMATION

Important Information

About Your Geotechnical Report

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland.